Advances in Meteorology

Artificial Intelligence for Meteorology Applications

Lead Guest Editor: Wei Fang
Guest Editors: Qiguang Wang and Victor S. Sheng

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In addition, our investigation has also shown that one or more of the following human-subject reporting requirements has not been met in this article: ethical approval by an Institutional Review Board (IRB) committee or equivalent, patient/participant consent to participate, and/or agreement to publish patient/participant details (where relevant).

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Research Article

Deep Learning-Based English-Chinese Translation Research

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Neural machine translation (NMT) has been bringing exciting news in the field of machine translation since its emergence. However, because NMT only employs single neural networks to convert natural languages, it suffers from two drawbacks in terms of reducing translation time: NMT is more sensitive to sentence length than statistical machine translation and the end-to-end implementation process fails to make explicit use of linguistic knowledge to improve translation performance. The network model performance of various deep learning machine translation tasks was constructed and compared in English-Chinese bilingual direction, and the defects of each network were solved by using an attention mechanism. The problems of gradient disappearance and gradient explosion are easy to occur in the recurrent neural network in the long-distance sequence. The short and long-term memory networks cannot reflect the information weight problems in long-distance sequences. In this study, through the comparison of examples, it is concluded that the introduction of an attention mechanism can improve the attention of context information in the process of model generation of the target language sequence, thus translating restore degree and fluency higher. This study proposes a neural machine translation method based on the divide-and-conquer strategy. Based on the idea of divide-and-conquer, this method identifies and extracts the longest noun phrase in a sentence and retains special identifiers or core words to form a sentence frame with the rest of the sentence. This method of translating the longest noun phrase and sentence frame separately by the neural machine translation system, and then recombining the translation, alleviates the poor performance of neural machine translation in long sentences. Experimental results show that the BLEU score of translation obtained by the proposed method has improved by 0.89 compared with the baseline method.

1. Introduction

Machine translation has been touted as a way to break down language barriers since the beginning of computers. Its fundamental concept is to employ the computer's processing power and storage capacity to assist or replace translators in accomplishing difficult translation jobs, resulting in automatic language conversion [1]. People are accustomed to calling the language before translating the source language, and the translated language is therefore the target language.

Machine translation is one of the most beautiful ideas of scientists and even mankind since the birth of computers. Under the urgent needs of world such as economic development and cultural exchange, machine translation is becoming more and more vibrant. Machine translation has experienced a tortuous development path, and numerous philosophers have devoted their efforts to it and made great progress. However, because of the current situation, there are still many problems to be solved in machine translation. The research of neural machine translation represents the combination of cognitive science and artificial intelligence. It uses the sequential to sequence model to transform the complex translation process into end-to-end, and at the same time, it also drives the research progress of other sequential to sequence tasks.

Machine translation has both theoretical and practical values and has experienced considerable development since its inception. At present, the application of deep learning methods makes neural machine translation mainstream. The

neural machine translation provides the following advantages over statistical machine translation:

(1) End-to-end learning does not depend on too many prior assumptions. In the era of statistical machine translation, model design makes more or fewer assumptions about the process of translation. The phrase-based models, for example, assume that both the source and target languages are sliced into sequences of phrases, with some alignment between them. This hypothesis has both advantages and disadvantages. On the one hand, the hypothesis draws on the relevant concepts of linguistics and helps the model to integrate them into prior human knowledge. On the other hand, the more assumptions there are, the more constrained the model is. If the assumptions are correct, the model can describe the problem well. But if the assumptions are wrong, then the patterns can be biased. Deep learning does not rely on prior knowledge nor does it require the manual design of features. The model learns directly from the mapping of input and output (end-to-end learning), which also avoids possible deviations caused by assumptions to a certain extent.

(2) The continuous space model of neural networks has a stronger representation ability. A basic problem in machine translation is how to represent a sentence. The statistical machine translation regards the process of sentence generation as the derivation of phrases or rules, which is essentially a symbol system in discrete space. Deep learning transforms traditional discrete-based representations into representations of continuous space. For example, a distributed representation of the real number space replaces the discrete word representation, and the entire sentence can be described as a vector of real numbers. Therefore, the translation problem can be described in continuous space, which greatly alleviates the dimension disaster of the traditional discrete space model. More importantly, the continuous space model can be optimized by gradient descent and other methods, which have good mathematical properties, and is easy to implement.

However, the effect of machine translation is far from reaching that of human translation, and neural machine translation still has a long way to go. At present, the research of neural machine translation still faces many challenges and needs to be improved. Therefore, the research on neural machine translation has a high academic significance.

With the advent of personal computers and the shift of translation memory tools for translators, machine translation has been applied in practice. In recent years, the trend is to combine some of the traditional methods of statistical machine translation (SMT) with those of neural networks or purely based on neural networks. In particular, the neural network-based end-to-end machine translation, which abandons the complicated procedures of traditional statistical machine translation, directly uses parallel corpus as input and output for end-to-end training, can better deal with the problem of long-distance dependence, and has become the mainstream of major companies and institutions. It has become a major research direction for decades to come.

Theoretically, machine translation involves many disciplines and is a typical interdisciplinary research topic. Research on machine translation is of great theoretical significance and can help promote the development of linguistics, computational linguistics, artificial intelligence, machine learning, and even cognitive linguistics. In addition, the research on machine translation can facilitate the development of other natural language processing tasks, such as named entity recognition, emotion analysis, automatic text generation, and so on. In terms of application, no matter the public, government enterprises, or national institutions, machine translation technology is urgently needed. Machine translation plays an important role in many fields.

Looking back on the history of translation, manual translation has been the mainstream way of translation since ancient times. However, with the growing maturity of computer technology and the rapid development of the Internet, machine translation technology has gradually entered the stage of history. Machine translation (MT), as the name implies, is a technology that uses the efficient computing power of computers to convert and express information between two languages [2]. Up to now, the development of MT technology has stepped from the stage of academic research to the stage of practical application. Machine translation is also the main force to promote the vigorous development of translation in the world.

However, since NMT only uses a single neural network to translate the natural language, it has two disadvantages in reducing translation time: NMT is more sensitive to sentence length than statistical machine translation and the end-to-end implementation process is not clear. Use language knowledge to improve translation performance. We constructed the network model performance of various deep learning machine translation tasks and compared them in English and Chinese bilingual directions. The attention mechanism was used to solve the problem of gradient disappearance and gradient explosion in the recurrent neural network of long-distance sequences, which alleviated the problem of neural machine with the problems of translations that do not perform well in long sentences.

2. Related Work

The history of machine translation dates all the way back to the late ninth century. Arabian cryptographers invented the systematic language translation techniques used in modern machine translation, such as frequency analysis, probability and statistical information, and cryptanalysis [3]. Rene Descartes proposed a universal language in the late 1620s, which gave rise to the concept of machine translation [4, 5]. In 1956, the first conference on machine translation was held, ushering in a new era of machine translation research.

Since then, scientists from all over the world have begun to investigate the machine translation technique. Although the Association for Machine Translation and Computational Linguistics (AMTCL) and the Advisory Committee on Automatic Language Processing (ALPAC) were founded concurrently in the United States, machine translation technology has made few advances in the decade since.

In 1972, the Defense Research and Engineering Agency announced the successful translation of an English military manual into Vietnamese using its Logos machine translation system, reestablishing the feasibility of machine translation. Following this, several researchers made significant advancements in machine translation technology. In the late 1980s, the advancement of computer hardware quality resulted in a decrease in computing costs, and the emergence of various machine translation methods signaled the rapid advancement of machine translation, as well as the beginning of various machine translation contests. Machine translation evolved gradually from academic research to practical applications. From its inception to its development, machine translation has grown in popularity due to its tremendous research potential and commercial value.

Hinton et al. proposed deep learning in 2006 [6], and since then, it has been quickly growing in the fields of image processing [7] and speech recognition [8]. In recent years, researchers have discovered that deep learning can help with statistical machine translation problems such as linear inseparability, a lack of proper semantic representation, difficulty in designing characteristics, making full use of the local context, data sparsity, and error propagation [9].Thus, the machine translation research based on deep learning has become a hot topic of research.

At the moment, the combination of deep learning and machine translation mainly exists in two forms: first, take the advantages of deep learning and makeup statistics on the shortcomings of machine translation methods in key modules such as the language model [10], translation model [11], reordering model [12], and word alignment [13]; second, take the advantages of deep learning and makeup statistics on the shortcomings of machine translation methods in key modules such as the language model, translation model, reordering model, and word alignment. For example, the deep learning pioneer and the professor of the University of Montreal, Yoshua Bengio created a neural network-based language model in 2003, which effectively solves the problem of data sparsity that plagues the traditional methods. The neural machine translation (NMT) is totally based on the deep learning from start to finish. Machine translation professionals and scholars have given close attention to it because of its simple approach and unique methods, as well as its capacity to produce translations that are comparable to or even better than traditional methods. The end-to-end neural machine translation has come a long way in just a few years because of the combined efforts of academics from all over the world. It not only pioneered theories and methodologies but also outperformed competitors in bilingual translation tasks like English-French, English-German, and Chinese-English [14].

Baidu claimed to have released the world's first neural network translation system as early as 2015, and with the real development of neural network machine translation taking only one or two years, neural network machine translation quickly swept academic and industrial circles. In 2017, Brown et al. [15], a Google brain team researcher, proposed the transformer model, an entirely attention-based model. This is a novel architecture that is entirely based on the attentional mechanism and does not make use of recurrent neural networks. This has the advantage of allowing for direct extraction of global connections, as the attentional mechanism assumes that the distance between each input and output word is equal to one, whereas the recurrent neural network requires gradual recursion [16]. The transformer not only outperformed other existing algorithms in machine translation tasks but also significantly outperformed them in other language comprehension tasks. This model, on the other hand, performs poorly on smaller, more structured language comprehension tasks or on simple algorithmic tasks. As a result, Brown et al., a Google researcher, focused on the shortcomings of the transformer and extended it into a general computing model with a new and efficient time-parallel loop that outperformed the standard transformer in a wide variety of algorithm tasks as well as in a large number of large-scale language understanding tasks [17, 18].

3. Basic Principles of Deep Learning Translation

The language model is the basis of natural language processing. Its function is to express natural language into a mathematical form that can be processed by the computer. In 2003, Koehn et al. [19] first used a neural network to build a language model, which became the beginning of the application of neural networks in the field of natural language processing. Let V be the thesaurus, and for sentence $Y = \{y_1, y_2, \ldots, y_T\}$, the language model is approximately equal to a series of parameters θ such that the following formula is satisfied.

$$P(Y;\theta) = P(y_1, y_2, \ldots, y_T;\theta). \tag{1}$$

The autoregressive language model is the essence of neural machine translation (NMT). In regressive language generation, the output words are decoded one by one, and the previous decoding results are used as input for decoding the current words. The mathematical model thus constructed is

$$P(Y|X;\theta) = \prod_{t=1}^{T+1} P(y_t|y_{0\sim t-1}, X;\theta). \tag{2}$$

In general, the maximum likelihood estimation method is used to train the autoregressive machine translation model, with the cross-entropy loss as the loss function. The following maximizing formula is used in the neural machine translation training process, where N is the number of parallel corpus pairs.

$$L^{ML}(\theta) = \frac{1}{N}\sum_{n=1}^{N}\sum_{t=1}^{T+1}\log\ p\left(y_t^n | y_{0\sim t-1}^n; \theta\right). \tag{3}$$

Greedy search means that when the model is decoded word by word, each word is selected with the maximum probability. If the output sequence of the decoder is $\widehat{Y} = \{\widehat{y}_1, \widehat{y}_2, \ldots, \widehat{y}_T\}$, the process of yt output by greedy search of the decoder at time T is shown in the following formula, where V represents the target language word list.

$$\widehat{y}_t = \arg\max_{y\in V} \log\ p\left(y | \widehat{y}_{0\sim t-1}, x_{1-T}; \theta\right). \tag{4}$$

The beam search can alleviate the above problems to a certain extent and make the translation results closer to the global optimal. Different from greedy search, which selects the word with the largest generation probability at every moment, cluster search first determines a beamwidth, saves the results of the number of cluster widths in each decoding process, and selects them in order of probability. In essence, cluster search may be similar to greedy search, but cluster search expands the search space by caching candidate sequences of cluster width and selecting the one with the highest comprehensive probability as the output, thereby making the translation results more diverse and approaching the global optimal. Combined with the following formulas, the process of cluster search decoding is briefly explained here:

$$\begin{aligned} C_{t-1} &= \left\{\widetilde{y}_{0\sim t-1}^{(1)}, \widetilde{y}_{0\sim t-1}^{(2)}, \ldots, \widetilde{y}_{0\sim t-1}^{(K)}\right\}, \\ C_{t-1} &= \left\{\widetilde{y}_{0\sim t-1}^{(1)}, \widetilde{y}_{0\sim t-1}^{(2)}, \ldots, \widetilde{y}_{0\sim t-1}^{(K)}\right\} \\ &= \operatorname*{argsort}_{y\in V} \sum_{t=0}^{t} \log\ p\left(y_t | y_{0\sim t-1}, x_{1\sim T}; \theta\right), \\ \widehat{Y} &= \arg\max_{Y_1,\ldots,Y_K} \left(\frac{1}{Y}\right)^{\alpha} \log\ p\left(Y | X; \theta\right), \end{aligned} \tag{5}$$

where C_{t-1} is the input sentence, and $\widehat{Y}$ is the output sequence of the decoder.

Figure 1 shows the machine translation process of a sequential model consisting of a two-layer cyclic network. It can be seen that words or sentences are parsed into vectors in a continuous space in the whole process. In this way, semantic connections between the words can be grasped, reflecting the advantages of neural networks.

The group in embedding is to divide each word in a sentence into groups according to certain or multiple grouping methods, after which each word in the sentence has its corresponding one or more groups.

Set definition language based on minimum unit WordUnit = {word|char|letter|subword}, in which the smallest unit of English can be a word, letter, or subword (subword part of words can have an independent meaning, such as reproducing the "re"). The smallest unit of Chinese is a word or character. The smallest units of processing covered in this article are words. If each word in a sentence is divided into groups in a certain way, then all possible corresponding groups form a set GroupUnit = {group}. If not limited to the classification principle of one group, all possible corresponding groups can form multiple group units, namely, GroupUnit1 and GroupUnit2.

Suppose that the sentence S after the participle can be expressed as an ordered set, namely:

$$S = \{w_1, w_2, \ldots, w_t\}. \tag{6}$$

The wi ∈ WordUnit, $(I = 1, 2, \ldots, T)$, for each corresponding word in the sentence.

If the division mode of pair group is f, then

$$f(S) = \{g_1, g_2, \ldots, g_t\}. \tag{7}$$

Gi ∈ GroupUnit, $(I = 1, 2, \ldots, T)$, for each word in the sentence. Its subscripts correspond to the words in the original sentence S.

The so-called embedding is the distributed representation of one_hot into a multidimensional continuous vector. The set of embeddings corresponding to different words represented by one_hot in WordUnit is

$$E = \{e_1, e_2, \ldots, e_t\}, \tag{8}$$

where EI ∈ E is a vector with dimension m. Each word WI has a corresponding m-dimensional continuous vector representation EI, which is commonly known as word embedding.

The only difference between the deep learning model using group embedding and the common deep learning model is that the group embedding information and the word embedding of the original corpus are used as the input of the model. The input of the ordinary model without group embedding g is the word embedding of each word in the sentence, namely:

$$\text{Input} = \{e_1, e_2, \ldots, e_t\}. \tag{9}$$

The input of the model using group embedding is

$$G\_\text{input} = \{C(e_1, g\_e_1), C(e_2, g\_e_2), \ldots, C(e_t, g\_e_t)\}. \tag{10}$$

Functions such as Sigmoid have many advantages and are very suitable to be used as activation functions. Therefore, under the condition of not changing the activation function, the mean square error function can be replaced and cross-entropy can be used as the loss function. If cross-entropy is used as the loss function, the loss function for a certain word translation can be

$$C_i(\theta) = -\sum_{x_i}\left[y(x_i)\ln\ a + (1 - y(x_i))\ln(1 - a)\right]. \tag{11}$$

In comparison to the mean square error function, cross-entropy training has a number of advantageous properties and has been widely used to train a variety of models.

After preprocessing, each sentence with translation will have an end-of-sentence character. The translation is complete when the end-of-sentence character is encountered. The true length of a sentence is the distance between the first and last characters. Then, the result of the position decoding unit will

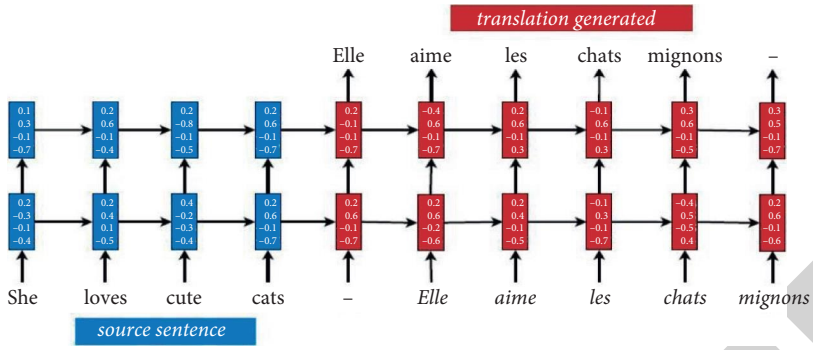

Figure 1: Sequence model of the two-layer cyclic network.

Table 1: Parameter settings.

The parameter types	Parameter
Vocabulary size	8000
Word vector dimension	512
Batch size	1024
Network layer	6
Dropout	0.2
Vector	0.1
The optimizer	Adam

undergo masking, and its loss function value will be excluded from the final sentence's loss function value. The loss function for the entire sentence that needs to be translated is as follows:

$$C = \frac{1}{t}\sum_{i=1}^{t} C_i(\theta). \tag{12}$$

In the process of neural network training, multiple sentences are translated at a time, that is, one batch of sentences. Then, the loss function of a translation process can be expressed as

$$\text{Loss} = \frac{1}{n}\sum_{n} C. \tag{13}$$

As we know from the previous introduction, the loss function of the sentence to be translated is

$$C = \frac{1}{t}\sum_{i=1}^{t} w_i C_i(\theta). \tag{14}$$

To set the different weight of loss functions for words at different positions during training, a constant greater than 1 is introduced as a weight attenuation factor. Assuming that the sentence target translation length is T, the loss weight of the i^{th} word is

$$\text{Weight} = \frac{1}{\text{factor} + i - 1}. \tag{15}$$

4. Experimental Results and Analysis

Based on the principle of comparative experiments on different network models, the software and hardware environment and other experimental parameters were set as invariable

Table 2: BLEU-4 score table of the translation model.

Model	Val	Test 1	Test 2
The mavericks translation	22.34	22.02	20.76
RNN	22.94	22.22	20.88
LSTM	23.56	22.7	22.57
BiRNN	22.37	22.25	22.05
RNN + attention	25.44	25.24	24.56
LSTM + attention	26.32	25.84	25.69
BiRNN + attention	25.6	25.43	25.52
Transformer	28.38	27.92	27.2

Table 3: Word list size comparison experiment.

Vocabulary size	Val	Test 1	Test 2
8000	28.38	27.92	27.2
16000	20.49	20.05	29.27
32000	26.58	26.22	25.56

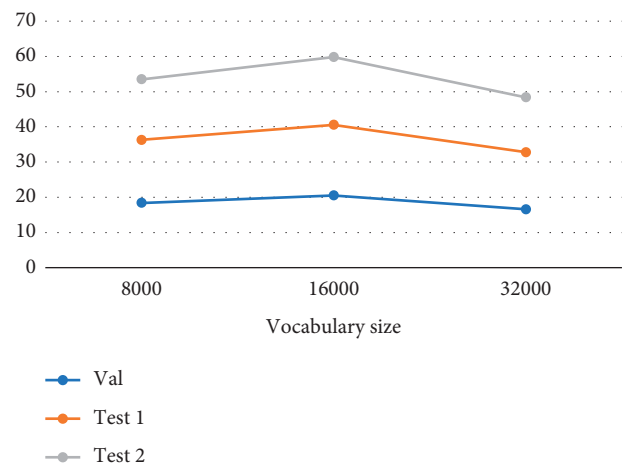

Figure 2: BLEU-4 line chart.

Table 4: Experimental results of machine translation based on the attenuation weight loss function model.

	Baseline	Factor = 2	Factor = 3	Factor = 4
BLEU score	27.24	27.42	27.42	27.33
Improve the ratio	—	2.63%	2.63%	2.22%

Table 5: Experimental results of Chinese sentiment analysis.

Training set size	1000		500		300	
Methods	The part of speech is embedded	Baseline	The part of speech is embedded	Baseline	The part of speech is embedded	Baseline
Train the number of iterations to the optimal	5	12	8	11	13	19
The identification accuracy	79.97%	94.09%	91.53%	90.11%	92.1%	79.97%

conditions in addition to the network model as the changing condition. This experiment uses Python3.7 in Ubuntu and is developed based on deep learning frameworks TensorFlow and Tensor2Tensor. The hardware is a single Nvidia TITAN GPU. Table 1 provides some parameter settings.

It was decided to use the statistical machine translation model as the baseline system and compare it to the neural network model, both of which were developed in the same environment and with the same parameter settings as the baseline system. The attentional mechanism algorithm and the transformer model were added for comparison, and the recurrent neural network model (RNN), long and short-term memory network model (LSTM), and bidirectional recurrent neural network model (BiRNN) were built for training using the above parameters. The translation quality measuring index BLEU-4 was chosen as the basis for this study. This experiment yielded the results given in Table 2.

The table provides the BLEU-4 score of this experiment. This experiment demonstrates the effectiveness of the machine translation model based on the deep learning neural network and obtains the performance of several networks in machine translation tasks according to the comparative experiment. The results obtained from the validation set and the two test sets show that the BLEU score of several neural network-based translation models exceeds the baseline system, and the transformer has the highest BLEU-4 score.

The LTNN translation model outperformed all other models without an attention mechanism, followed by bidirectional and unidirectional recurrent neural network models. From the control group of the four networks incorporating an attention mechanism, each translation model's performance improved significantly after incorporating an attention mechanism, and the addition of the attention mechanism significantly narrowed the gap with the baseline.

From the aforementioned results, we can conclude that the transformer model is the best. To provide a reference for the following experimental parameters according to the data scale in this study, a parameter comparison experiment is designed based on the transformer model. This study mainly explores the influence of the thesaurus size setting on model performance. The experimental design is as follows: under the condition that other parameters remain unchanged, the thesaurus size is modified to 16000 and 32000, respectively, and two models are obtained based on transformer framework retraining and tested on two test sets, respectively, for comparison. The experimental results are given in Table 3.

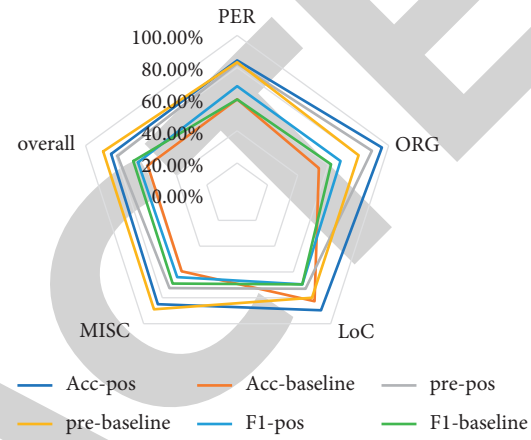

Figure 3: Experimental results of English NER.

It can be seen from table that the model with a vocabulary size of 16000 has an average improvement of 2.3 points in BLEU-4 compared with the model with a vocabulary size of 8000, while the model with a vocabulary size of 32000 has a decrease of 1.67 points compared with the model with a vocabulary size of 8000. Figure 2 shows a line chart, through which we can more intuitively see the influence of thesaurus size settings on model performance.

The following analysis can be obtained from the experimental results. The size of the word list has a certain effect on the performance of the neural machine translation model, but it does not increase linearly with the size of the word list. When the size of the word list exceeds a certain size, the model performance is reduced. The reason may be that the BPE algorithm for rare word processing has some limitations. For example, some illegal characters may be added to the word table when the set of the word table is too large, thus affecting the translation performance. Therefore, it can be concluded that adjusting the size of thesaurus appropriately in a certain range according to the size of the dataset is helpful to improve the performance of the model.

As can be seen from Table 4, after the loss weight of words at the beginning of a sequence is improved by using the loss function based on attenuation weight, the effect of translation can be improved to some extent by setting different attenuation factors' values of weight. Compared with the traditional model using unweighted loss function, the BLEU score of the translation improved up to 1.63% (factor 2 or 3). The reason for the improvement is that the new loss function can make the model more inclined to translate the earlier words so that the information used in the later words is more accurate in the process of translation.

Table 6: Experimental results of English named entity recognition.

	Acc		Pre		Fl	
	POS (%)	Baseline (%)	POS (%)	Baseline (%)	POS (%)	Baseline (%)
PER	84.35	59.95	82.42	93.2	88.18	59.85
ORG	95.49	93.9	98.92	90.12	98.19	91.95
LoC	89.58	82.58	82.91	89.92	89.48	89.49
MISC	84.98	99.48	82.35	98.83	83.94	98.95
Overall	83.13	98.98	88.83	98.38	85.4	98.53

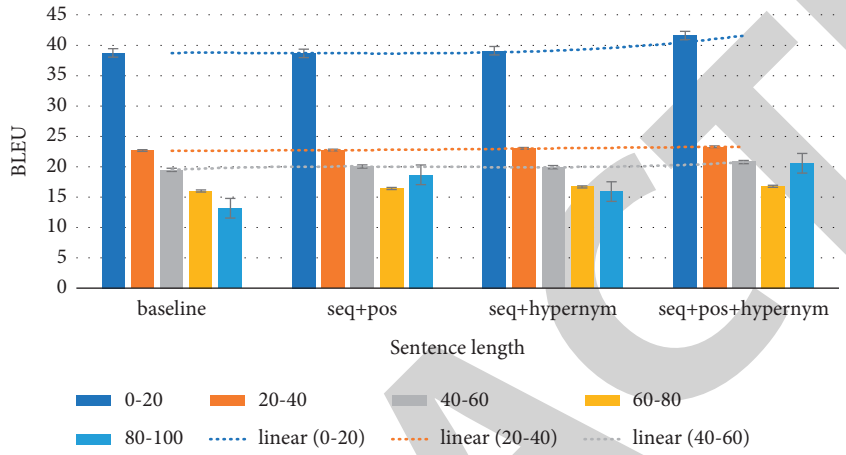

Figure 4: Sentence length sensitivity of multisequence encoding and baseline method.

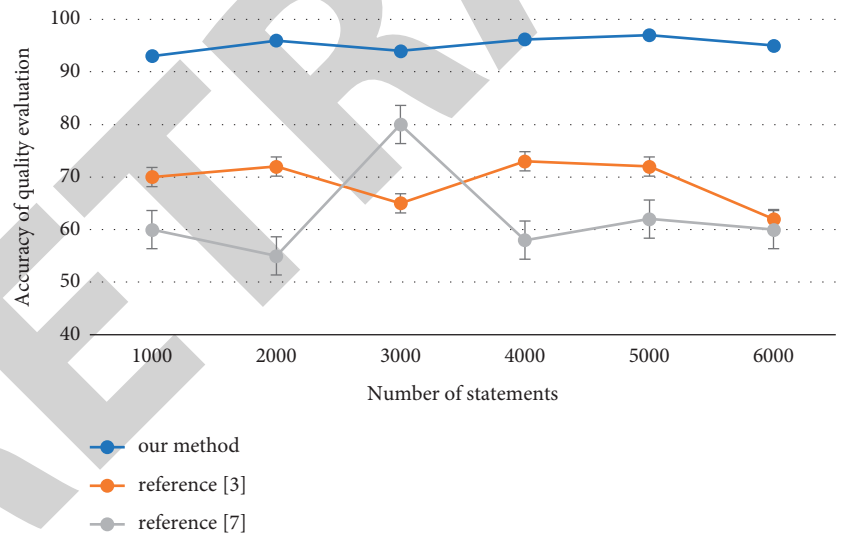

Figure 5: Quality evaluation efficiency of the three methods under different numbers of statements.

It can be seen from the results in Table 5 that in the training set scale of 1000, 500, and 300 samples, the model using group embedding has a faster convergence speed. At the same time, in these three training sets, the fewer the training samples, the higher the accuracy of the model using group embedding compared with the ordinary model. The experimental results of English named entity recognition are represented by the radar diagram in Figure 3. Through the radar chart, we can more intuitively see the influence of thesaurus size settings on model performance.

In addition, as given in Table 6, the effect of named entity recognition is significantly enhanced when parts of speech information is embedded in the recognition process. Convenient improvement is most noticeable in the recall rate, which is particularly high. Because of the addition of group embedding information, the model is able to correctly identify a large number of previously unrecognized entities. Due to the overlap between the information required by a named entity recognition task and the results of parts of speech tagging, this is the case in the majority of cases. As a

result, when used in conjunction with parts of speech information, group embedding can significantly improve the recognition effect in tasks such as named entity recognition.

It is investigated in this study whether the multisequence coding approach and the traditional method are sensitive to sentence length. This is done by testing the source language sentences in the test dataset according to the distribution of sentence length and evaluating the translation separately. Figure 4 shows the BLEU score of translation in the baseline and multisequence coding systems for different phrase length distributions of test data in the baseline and multisequence coding systems.

In Figure 4, it can be seen that when a sentence's length exceeds 20, the translation quality of both the baseline and multisequence coding methods shows a significant decline in quality, as can be seen in the graph. The SEQ + POS method, SEQ + HEAD method, and SEQ + POS + HEAD method all resulted in a reduction of 16.07, 15.91, 16.07, and 18.30 points in the BLEU score of translation when compared to the baseline technique. In general, as the length of a phrase increases, the multisequence coding method outperforms the baseline method in terms of translation performance.

This time, the quality evaluation efficiency of the three models was compared in order to better analyze their application value. The results of this comparison are shown in Figure 5, which shows the results of the comparison.

In Figure 5, it can be seen that no matter how many sentences are used, whether it is 1000 or 2000 or 3000 or 4000 or 6000, the quality assessment efficiency of the proposed model is significantly higher than that of the other two methods, while still maintaining the precision of the quality assessment. The highest efficiency in quality assessment is greater than 95% in some cases. It can, to a certain extent, demonstrate the viability of the model under consideration.

5. Conclusion

Artificial intelligence technology has exploded in popularity in recent years. It has made significant strides in the image, voice, and video fields. Although natural language processing is dubbed the crown jewel of artificial intelligence, it remains difficult to comprehend and process the natural language, and machine translation's representative application is still far from ideal. The advent of deep learning is unquestionably a watershed moment for machine translation. While traditional neural machine translation models treat each word in the target language sentence equally, the current word's decoding depends on the result of the previous word's decoding. As a result, this study proposes an attenuating weight loss function, which assigns different weights to each word in the training set. The earlier a word is translated, the greater is its weight, and training tends to allow for accurate translation of the first word in order to ensure the accuracy of previous information when translating the subsequent word. While the coding model based on pos embedding improves the efficiency of translation model convergence, the translation effect is not significantly improved. However, the proposed coding model based on parts of speech embedding can significantly improve the performance of the two tasks of emotion analysis and named entity recognition. This result may be because translation requires a sizable corpus and linguistic knowledge of the parts of speech, so the information can be learned automatically during model training from a sizable corpus.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Retraction

Retracted: Nitrogen Inversion Model in a Wetland Environment Based on the Canopy Reflectance of Emergent Plants

Advances in Meteorology

Received 13 September 2023; Accepted 13 September 2023; Published 14 September 2023

This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope

(2) Discrepancies in the description of the research reported

(3) Discrepancies between the availability of data and the research described

(4) Inappropriate citations

(5) Incoherent, meaningless and/or irrelevant content included in the article

(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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[1] D. Wu, D. Zhao, Y. Zhu, C. Shen, and H. Xue, "Nitrogen Inversion Model in a Wetland Environment Based on the Canopy Reflectance of Emergent Plants," *Advances in Meteorology*, vol. 2022, Article ID 8800371, 9 pages, 2022.

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Research Article

Nitrogen Inversion Model in a Wetland Environment Based on the Canopy Reflectance of Emergent Plants

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Reuse of reclaimed water in constructed wetlands is a promising way to conserve water resources and improve water quality, and it is playing a very important role in wetland restoration and reconstruction. This study utilized reflectance spectra of wetland vegetation to estimate nitrogen content in water in the Beijing Bai River constructed wetland, a typically constructed wetland that uses reclaimed water. Canopy reflectance spectra of two dominant plants in the wetland, including reed and cattail, were acquired using a spectrometer (350–2500 nm). Simultaneously, water samples were collected to measure water quality. To establish the appreciate relationship between total nitrogen content (TN) and reflectance spectra, both simple and multiple regression models, including simple ration spectral index (SR), normalized difference spectral index (ND), stepwise multiple linear regression (SMLR) model, and partial least squares regression (PLSR), were adopted in this study. The results showed that (1) compared with simple regression models (SR and ND), multiple regressions models (SMLR and PLSR) could provide a more accurate estimation of TN concentration in the wetland environment. Among these models, the PLSR model had the highest accuracy and was proven to be the most useful tool to reveal the relationship between the spectral reflectance of wetland plants and the total nitrogen consistency of wetland at the canopy scale. (2) The inversion effect of TN concentration in water is slightly better than that of wetland vegetation, and the reflection spectrum of the reed can predict TN concentration more accurately than that of cattail. The finding not only provides solid evidence for the potential application of remote sensing to detect water eutrophication but also enhances our understanding of the monitoring and management of water quality in urban wetlands using recycled water.

1. Introduction

Water scarcity is one of the primary reasons for wetland loss and degradation in China [1]. At present, as a steady source of water, recycled water plays an important role in alleviating water scarcity in urban areas and restoring wetland functions [2]. However, the chemical characteristics of recycled water might cause many adverse effects to restrict the application of recycled water wetlands [3–5]. With the increasing use of recycled water in urban wetlands, monitoring the status of plant growth and eutrophication in large constructed wetlands is of great significance for wetland management [6]. Currently, remote sensing has become an important technique of environmental monitoring due to its various advantages [7]. Many researchers have successfully used multi-spectral remote sensing images to obtain physiological and biochemical parameters of plants and to monitor and evaluate the status of plant growth [8–10]. However, traditional multi-spectral sensors have a low spectral resolution and they are difficult to identify the diagnostic characteristics of spectral absorption of plants. In contrast, hyperspectral remote sensing has a very narrow electromagnetic spectrum and can obtain more useful information from targeted objects, and has been widely used in monitoring the status of plant growth [11–14]. In addition, some researchers used ground-measured spectra to investigate the relationship between physiological and biochemical parameters and reflection spectral characteristics

of plants, and then to establish inversion algorithms of physiological and biochemical parameters to study the status of plant growth [15–18]. However, most of the studies above are focused on open water instead of water covered with surface vegetation. Because the growth status and photosynthetic efficiency of wetland plants are closely related to the wetland environment, some researchers attempted to employ reflectance spectra of wetland plants to monitor environmental changes in wetlands [19].

Nitrogen content is an important indicator to reflect the status of plant growth, and it can be estimated using canopy reflectance spectroscopy with good accuracy [18–22]. Additionally, some previous work suggested that there is a certain relationship between the nitrogen content in wetland plants and the nitrogen concentration in water [23, 24], which implied that the spectral reflectance characteristics of wetland plants can be used to indirectly estimate the nitrogen concentration in water. In this study, to further explore the relationship between spectral characteristics of the wetland plant canopy and environmental TN content (TN content in water and TN content in plants): (1) We collected the reflectance spectra of the plant canopy and measured the total nitrogen (TN) content in water and plants in Beijing Bai River wetland; (2) Several multiple regression models were employed to estimate TN contents in plants (*Phragmites australis* and *Typha angustifolia*) and TN contents in water from the spectral reflectance data; (3) This study is expected to provide scientific evidence for the potential application of remote sensing to monitor nitrogen in wetland and to provide the strategic thinking for wetland restoration and reuse of recycled water in urban wetlands.

1.1. Study Area. The Beijing Bai River constructed wetland is located in Miyun County and is about 50 m away from the outlet of the Miyun wastewater treatment plant that is located on the left bank of the Bai River. The constructed wetland uses reclaimed water as a supplemental water source. The wastewater treatment plant adopts the membrane bioreactor (MBR) treatment process with an initial treatment capacity of up to $1600\,m^3 \cdot a^{-1}$. The actual processing capacity of sewage treatment reached 9.19 million·m^3. The quality of reclaimed water meets the class I emission standard of "Discharge standard of water pollutants" in China (DB11/307–2005). The reclaimed water is mainly used in landscapes along the Chaobai River and for other municipal use. To eliminate health risks possibly caused by reclaimed water, a surface flow artificial wetland is constructed to improve water quality by removing organic matter and nutrients (such as nitrogen and phosphorus). To form the river landscape, a dam is set up upstream of the drainage outlet in the wetland. A gate dam is also set up in the river landscape located in the wetland downstream. The area of the surface flow constructed wetland is about 21,000 m^2. Wetland vegetations include emergent plants, phytoplankton, and submerged plants. Among them, emergent plants are the dominant vegetation accounting for approximately 70% of the total wetland area. Such plants include Typha, reeds, water lilies, and cress.

2. Experimental Methods

2.1. Collection of Reflectance Spectra of Wetland Vegetation and Environmental Data. Reeds (*Phragmites australis*) and cattails (*Typha angustifolia*) were two main plants found in the wetland and were subjected to the spectral reflectance measurement. Based on the spatial distribution of two plants in the wetland, we set 32 reed spectral sampling points and 26 cattail points. Wetland plant canopy spectral measurements were performed in July 2016 using the ASD Fieldspec®3 portable spectroradiometer (Analytical Spectral Device, Inc., USA). The probe has a 10° field-of-view, and the spectral range is 350–2500 nm. The spectral resolution is 3 nm at 700 nm, 8.5 nm at 1400 nm, and 2100 nm at 6.5 nm, respectively. The spectral sampling interval is 1.4 nm for 350–1000 nm and 2 nm at 1000–2500 nm, respectively. Field measurements were performed under clear calm weather conditions at 10 : 00–14 : 00, which were calibrated using a whiteboard at least once per 20 min. Simultaneously, leaves of two plants were collected and water at ~0.1 m under the water surface was sampled. Next, leaves were fixed at 105°C for 30 min, dried to constant weight at 80°C then digested in H_2SO_4-H_2O_2. TN contents in leaves were measured using the KD method [25]. To determine water quality, TN contents in water were measured using ultraviolet spectrophotometry and ammonium molybdate spectrophotometry, respectively, after alkaline potassium persulfate digestion.

2.2. Data Processing

2.2.1. Pre-Processing of Spectral Data. The reflectance spectra of plants measured at each sampling site were averaged to remove water vapor absorption bands and noisy bands. Spectral resampling was performed to reduce data redundancy (the spectrum resampling resolution of the instrument automatic output was 1 nm), and the sampling interval was 5 nm, and the data were smoothed using the Savitzky–Golay method [26, 27].

2.2.2. Calculation of Hyperspectral Index. Constructing a spectral index can maximize the information derived from the reflectance spectra of plants and minimize the impacts of external factors [28, 29]. In this study, we constructed all of the ratios formed by two-band reflectance values (equation 1) and normalized difference (equation 2) over the wavelength range of 400–2350 nm (except bands that had been removed) and analyzed their relationship with environmental TN concentrations.

$$SR = \frac{\rho_{\lambda 1}}{\rho_{\lambda 2}}, \tag{1}$$

$$ND = \frac{\rho_{\lambda 1} - \rho_{\lambda 2}}{\rho_{\lambda 1} + \rho_{\lambda 2}}, \tag{2}$$

where SR is the spectral ratio index, ND is the normalized spectral index, $\rho_{\lambda 1}$ is the band reflectance of $\lambda 1$, and $\rho_{\lambda 2}$ is the band reflectance of $\lambda 2$. $\lambda 1 \neq \lambda 2$.

Table 1: TN contents in water and plants.

TN contents	Species	Number of samples	Mean	Minimum	Maximum	Confidence limit of the mean (95%)
TN in water (mg/L)	Reed	32	1.51	0.64	2.23	0.23
	Cattail	26	1.04	0.52	1.77	0.21
TN in plants (%)	Reed	32	4.47	2.58	5.50	0.22
	Cattail	26	3.23	2.40	5.30	0.25

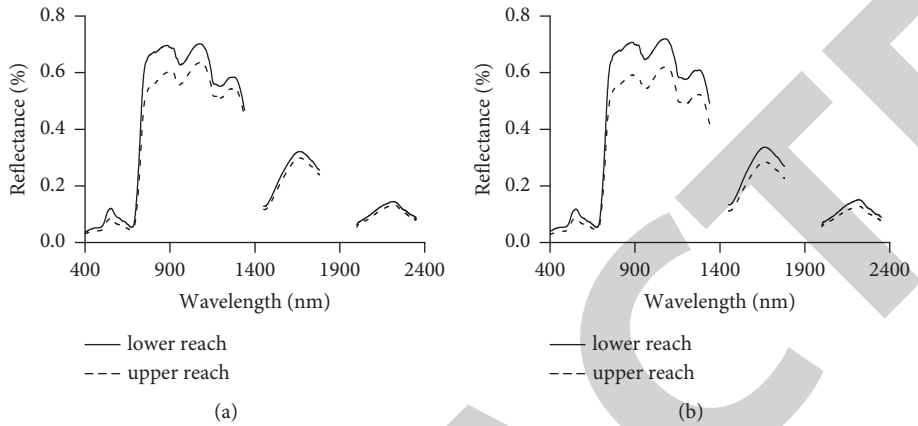

Figure 1: Reflectance of reeds (a) and cattails (b) at upper reach and lower reach of the Bai River.

2.2.3. Model Construction and Accuracy Validation. Models were constructed through three kinds of approaches: (1) regression models of two types of spectral indices and environmental TN content using linear regression, (2) regression models of pretreated spectra and environmental TN content using stepwise multiple linear regression (SMLR) [30–32], and (3) regression models of pretreated spectra and environmental TN content using partial least squares regression (PLSR). The accuracy of these models was examined by a single removal cross-validation validation method [33, 34]. The evaluation indicators were the cross-validation coefficient of the determinant (R_{Cv}^2) and the cross-validation root mean square error ($RMSE_{cv}$). 1 : 1 relationship diagram between measured and estimated values was drawn.

3. Results and Analysis

3.1. Analysis of Biochemical Parameters. TN contents in both water and plants were analyzed (see Table 1). The fluctuation range of TN contents in water at sampling sites where reeds were sampled was 1.51 ± 0.23(mg/L) with the average 95% confidence interval (CL), and the range of TN contents in water at sampling sites where cattails were sampled was 1.04 ± 0.21(mg/L). As for TN contents in plants, the fluctuation range of the reed was 4.47 ± 0.22 (%) and the range of the cattail was 3.23 ± 0.25 (%). These fluctuations provided a good foundation for studying the relationship between reflectance spectra of plants and environmental nitrogen contents. It also showed that TN content in reeds was higher than that in cattails, suggesting that reeds had a higher ability to absorb nitrogen than cattails.

At the same time, in order to explore the difference of vegetation spectra in different wavelength ranges under different eutrophication environments, spectral reflectance data were averaged at sampling sites at the upper reach and lower reach, respectively (see Figure 1). The spectral reflectance of both reeds and cattails at the upper reach, either in the visible light region or in the near-infrared region, was lower than those at the lower reach. This change laid the foundation for studying the relationship between reflectance spectra of plants and wetland environmental nitrogen content.

3.2. Construction of Regression Models and Evaluation of Model Accuracy

3.2.1. The Spectral Index Model. The spectral indices SR and ND of water bodies and plants were constructed (equations 1 and 2), and the correlation coefficients of the spectral indices were calculated (see Figure 2). It was found that ratio indices were almost equivalent to normalized indices in inversion models for both TN in water and TN in plants. Although there was a significantly high correlation ($p < 0.01$), the overall correlation was not high, especially for the spectral index constructed by the reflectance spectra of cattails. Different types of wetland plants had their own specific band combinations to obtain a relatively better correlation. In reeds, the better compositional band of the model for TN in water was the combination of 1085–1115 nm and 965–995 nm, and the better compositional band of the model for TN in the plant was the combination of 775–905 nm and 740–880 nm and the combination of 1285–1300 nm and 1180–1215 nm, respectively. In cattails, the better compositional band of the model for TN in water was the combination of 1690–1705 nm and 1625–1640 nm, and the better compositional band of the model for TN in

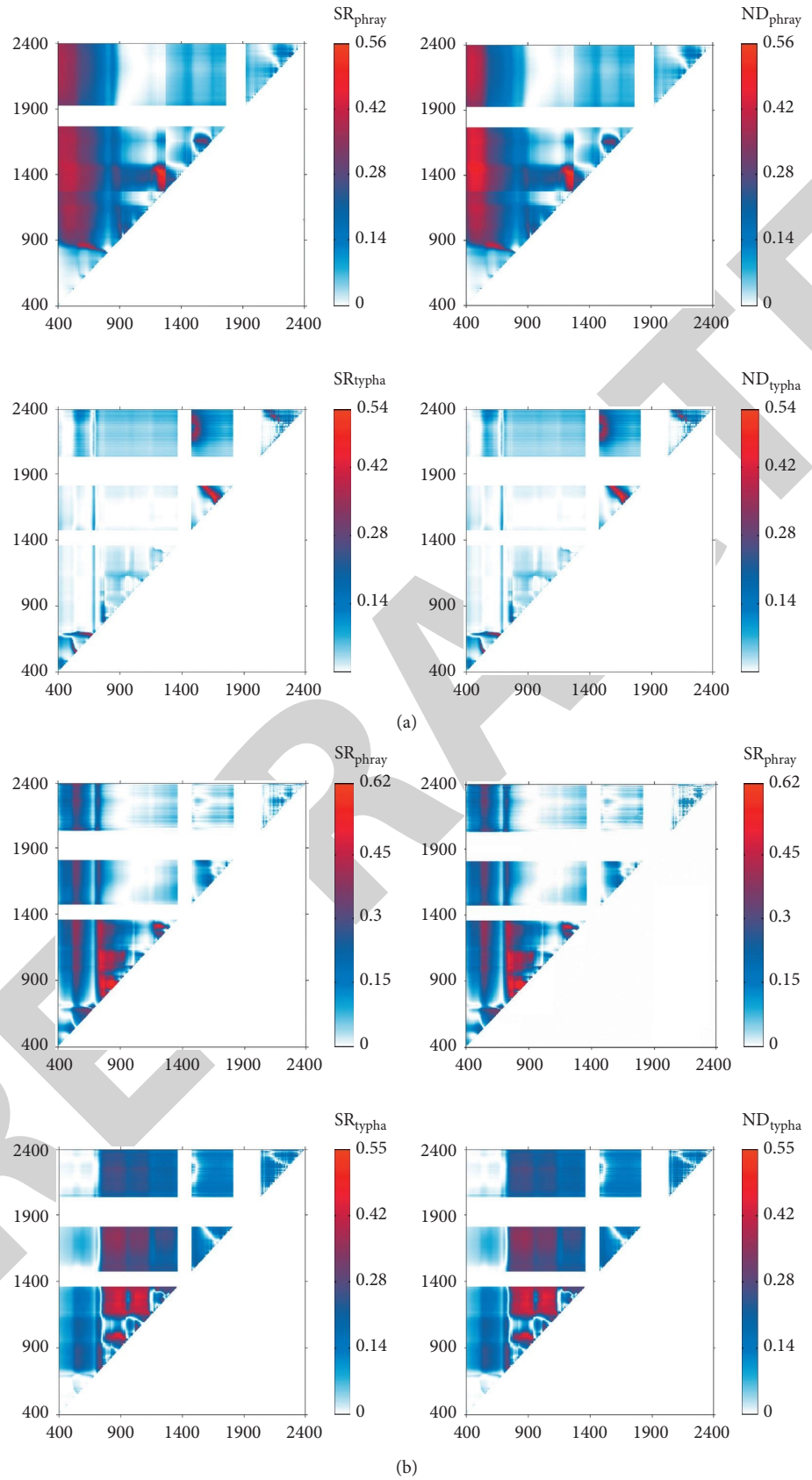

Figure 2: 2-D correlation plots illustrating coefficient of determination between spectral indices and TN contents in water (a) and plants (b).

Table 2: Band position and performance of different models for predicting TN concentration.

TN contents	Species	Models	Selected bands (nm)	R_{Cv}^2	$RMSE_{cv}$
TN in water	Reed	SR	1105/975	0.56	0.27
		ND	1105/975	0.57	0.27
		SMLR	500, 765, 960, 1125	0.75	0.22
		PLSR	—	0.83	0.20
	Cattail	SR	1705/1630	0.54	0.28
		ND	1705/1630	0.54	0.28
		SMLR	405, 520, 615, 1125, 1180	0.75	0.25
		PLSR	—	0.78	0.23
TN in plants	Reed	SR	820/825	0.62	0.33
		ND	820/825	0.62	0.33
		SMLR	580, 715, 1000, 1155, 1295	0.75	0.27
		PLSR	—	0.81	0.24
	Cattail	SR	1130/1120	0.55	0.35
		ND	1105/975	0.56	0.34
		SMLR	420, 720, 865, 900, 935	0.61	0.32
		PLSR	—	0.66	0.28

Note. The higher the R_{Cv}^2 value, the better the fitting effect between the predicted value and the measured value of each model. The lower the $RMSE_{cv}$ value, the higher the accuracy of each model.

the plant was the combination of 975–1000 nm and 885–895 nm and the combination of 1255–1275 nm and 1005–1040 nm, respectively.

For two kinds of parameters composed by reflectance spectra of reeds, the indices for the best correlation with TN contents in water were SR (1105, 755) and ND (1105, 755), while the indices for the best correlation with TN contents in cattails were SR (820, 825) and ND (820, 825), respectively. On the other hand, for two kinds of parameters composed of reflectance spectra of cattails, the indices for the best correlation with TN contents in water were SR (1130, 1120) and ND (1130, 1120), while the indices for the best correlation with TN contents in plants were SR (1705, 1630) and ND (1705, 1630), respectively. Then, a linear regression model was constructed based on optimal spectral indices and environmental TN, and the values of R_{Cv}^2 and $RMSE_{Cv}$ were calculated (see Table 2). It is found that the R_{Cv}^2 values of the SR model and the ND model for TN contents in water constructed by reflectance spectra of reeds were 0.56 and 0.57, respectively, and the $RMSE_{Cv}$ values were 0.27 and 0.27, respectively. Furthermore, the R_{Cv}^2 values of the SR model and the ND model for TN contents in plants were 0.62 and 0.62, respectively, and the $RMSE_{Cv}$ values were 0.33 and 0.33, respectively. However, the R_{Cv}^2 values of the SR model and the ND model for TN contents in water constructed by reflectance spectra of cattails were the same, that is, 0.54, and the $RMSE_{Cv}$ values were 0.28. The R_{Cv}^2 values of the SR model and the ND model for TN contents in plants were 0.55 and 0.56, respectively, and the $RMSE_{Cv}$ values were 0.35 and 0.34, respectively. Therefore, the listed data could show the predictive ability of the models (see Table 2). The estimated nitrogen contents in water and plant by the models based on reflectance spectra of cattails did not fit the measured values as indicated by low R_{Cv}^2 values of <0.57. In contrast, the estimated nitrogen contents in water and plant by the models based on reflectance spectra of reeds did fit the measured values with the high R_{Cv}^2 values of > 0.56. In particular, the ND model had better accuracy than other predictive models.

3.2.2. SMLR Model. For different types of wetland plants, the models were constructed with some bands that were selected from all bands based on pretreated reflectance spectra using the stepwise regression method. However, using a large number of bands when building models easily led to the "multi-collinearity" among different band reflection parameters. To attack this problem, the variance inflation factor was used as a collinearity diagnostic indicator [35]. If the value of the variance inflation factor were higher than 10, which suggested the presence of severe multi-collinearity among the factors. After calculation, since the variance inflation factors of all variables in the models were less than 10, there was no multi-collinearity in this study.

Selected bands were then used to construct the linear models for TN contents in water and TN contents in wetland plants. Compared to the two-band spectral index model, the stepwise multiple linear regression models had higher R_{Cv}^2 values and low $RMSE_{Cv}$ values, suggesting that the model accuracy was improved (see Table 2)). The relationship between measured values and estimated values in cross-validation of the SMLR model was plotted (see Figure 3), and it revealed that the models based on reflectance spectra of reeds had higher accuracy than those based on reflectance spectra of cattails.

3.2.3. PLSR Model. Firstly, TN concentrations in wetlands and pretreated spectral reflectance of plants were mean-centered, and then the relationship between TN content in the wetland and reflectance spectra of different wetland plants was established using the PLSR model. According to the principle of cross-validation, the composition dimensions extracted from reeds and cattails were both 6. Compared to the two-band spectral index model, the PLSR model

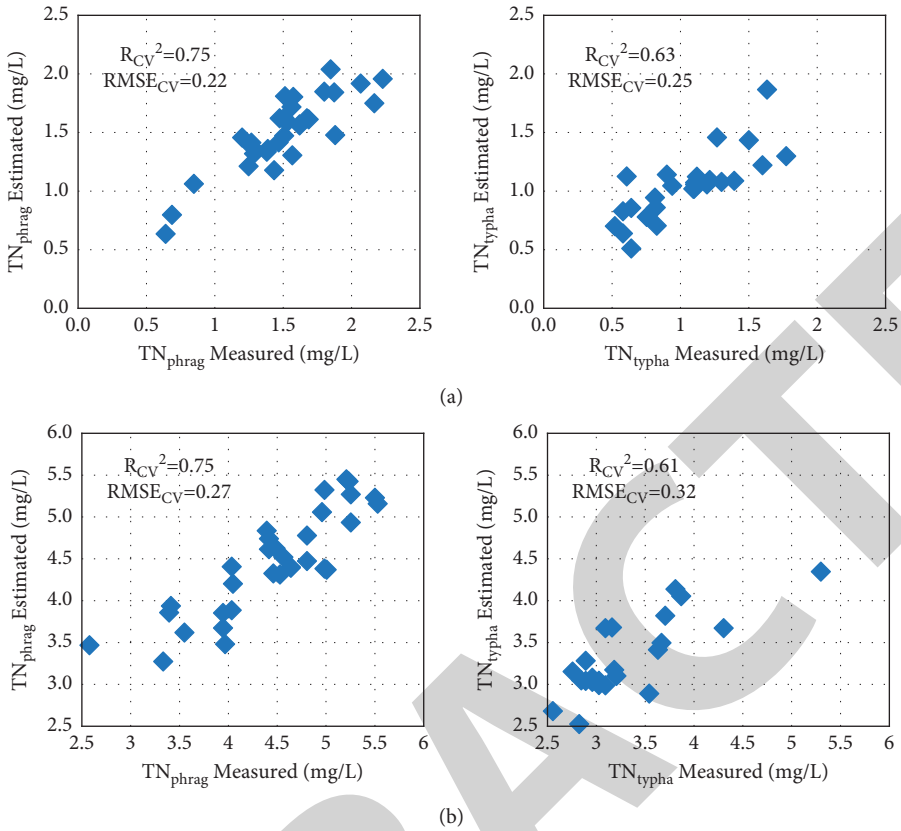

Figure 3: Relationship between measured values and estimated values in cross validation of SMLR model for TN content in water (a) and TN content in plants (b).

established by reflectance spectra of reeds and cattails had an increased R_{Cv}^2 value and decreased $RMSE_{Cv}$ value. For the model of TN in water, the R_{Cv}^2 value was increased by 0.27 and 0.24, respectively, and the $RMSE_{Cv}$ value was reduced by 0.07 and 0.05, respectively; and for the model of TN in plants, the R_{Cv}^2 value was increased by 0.19 and 0.11, respectively, and the $RMSE_{Cv}$ value was reduced by 0.09 and 0.07, respectively. Compared to the SMLR model, the R_{Cv}^2 value of the model for TN in water was increased by 0.08 and 0.03, respectively, and the $RMSE_{Cv}$ value was reduced by 0.02 and 0.02, respectively. The R_{Cv}^2 value of the model for TN in plants was increased by 0.06 and 0.05, respectively, and the $RMSE_{Cv}$ value was reduced by 0.07 and 0.04, respectively. It showed that the model accuracy was greatly improved. The relationship between measured values and estimated values in cross-validation of the PLSR model was plotted (see Figure 4), and it revealed that the model based on reflectance spectra of reeds still had higher accuracy.

4. Discussion and Conclusion

The plant spectrum can not only directly reflect the status of plant growth but also indirectly reflect environmental changes occurring in the field. Many studies showed that monitoring spectral responses of plants to the environment could detect changes in various environmental factors, such as nitrogen contents in soil, salt content, and mineral resources [5, 10, 36]. In addition to the application of plant spectra in crops and minerals, this study also demonstrated that reflectance spectra of wetland plants could be practically used to detect environmental TN contents. Because TN contents of wetland plants have a certain relationship with TN concentrations in water, different models of TN in water and TN in plants have a convergence effect. In contrast to complex laboratory experiments to measure environmental parameters, environmental TN contents can be obtained through a simple band-to-band ratio-oriented calculation of wetland canopy reflectance. The method is timely and rapid; especially, it can complement the disadvantage of remote sensing which is limited to detecting eutrophication in open water. Therefore, it is expected to serve as a useful method to obtain information about water eutrophication in an entire area of water more comprehensively.

This study used three methods to establish regression models for wetland plant reflectance, TN contents in water, and TN contents in plants. After comprehensive comparison of various models, the following conclusions were made: (1) In terms of the model accuracy, the accuracy of the SMLR and PLSR equations was higher than that of the two-band spectral index regression equation. Since the two-band spectral index model only used two bands of the spectra and did not derive rich spectral information from hyperspectral data over the whole spectral range, it likely failed to obtain important information [34, 37]. By comparison, the other

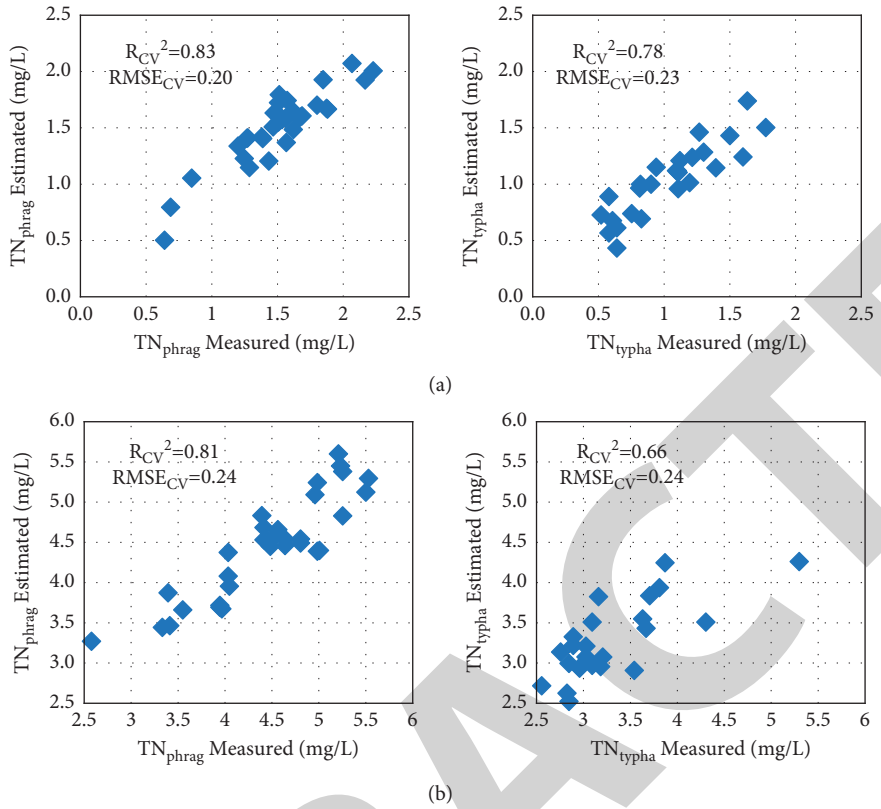

Figure 4: Relationship between measured values and estimated values in cross validation of PLSR model for TN contents in water (a) and TN contents in plants (b).

two models had more spectral parameters, and the accuracy had also been improved to a certain degree. Among them, PLSR considered spectral parameters of each wavelength point over a whole spectrum, solving the problems in multiple linear regressions, such as too many variables and repeated correlation, consequently producing the highest accuracy. So far, many studies have successfully used this method to conduct spectral analysis to estimate elemental contents in soil and physiological parameters of crops and pasture [10, 38, 39]. This study also proved that a more accurate predictive model of environmental TN content can be obtained using this method. (2) In terms of the wetland plant type, different types of wetland plants showed different model accuracies, and the models for reflectance spectra of reeds had generally higher accuracy than those for cattails. It has been reported that reed had a higher nitrogen absorption capacity than cattail [24], indicating that reed can better reflect the characteristics of the environment, which may be the reason for the higher precision of the regression model. Besides, both reed and cattail are plants that are widely distributed in water, and they can survive in eutrophic water, and they are also widely used for water purification in constructed wetlands. It is of practical significance to detect eutrophication by measuring the reflectance spectra of these two wetland plants, and it has the great potential to monitor the water purification performance of wetlands treating reclaimed water.

Since TN concentrations in our study area represent mild and moderate eutrophication, this study only proved that it was feasible to use reflectance spectra of wetland plants to estimate low and middle concentrations of environmental TN. Considering that severe eutrophication may cause saturated absorption of nitrogen in wetland plants, thereby affecting the response of wetland plant spectrum to TN in water to a certain extent, it is needed to further explore the applicability of the methods and models used in this study in severe eutrophicated water.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

Acknowledgments

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Retraction

Retracted: Research on the Optimization of Agricultural Industry Structure Based on Genetic Algorithm

Advances in Meteorology

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope

(2) Discrepancies in the description of the research reported

(3) Discrepancies between the availability of data and the research described

(4) Inappropriate citations

(5) Incoherent, meaningless and/or irrelevant content included in the article

(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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Research Article

Research on the Optimization of Agricultural Industry Structure Based on Genetic Algorithm

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Due to the complexity and importance of optimizing and adjusting the crop planting structure in the Jianghuai hilly Tangba irrigation area between the upper reaches of the Huaihe River from Xinyang to the lower reaches of the Huaihe River in China, and based on experimental results from the Feidong Badou Irrigation Experiment Station, the farmland was modeled using rainfall and runoff data from the Tangba irrigation area. By examining the water balance of submerged irrigation, an optimization model of the agricultural industry structure was developed using genetic algorithms, and the model was solved using an accelerated genetic algorithm. Developing the research findings may provide scientific and technological support for adjusting the planting structure and formulation of irrigation systems in the Jianghuai Hills and Tangba irrigation area between the upper reaches of the Huaihe River and Xinyang, as well as significant practical guiding significance and application value.

1. Introduction

China is a largely agricultural country, with the planting sector dominating the economy. The agricultural economy serves as a critical basis and fundamental assurance for the development of the national economy, and it is growing rapidly. An acceptable crop plan has significant practical implications for food production management, as well as for the assessment of food and agricultural security [1–5]. The optimization and adjustment of crop planting structure have long been a significant research topic in agricultural geography and agricultural sustainable development, and it has attracted considerable interest from academics both at home and abroad, according to a recent study. Agricultural remote sensing technology has been widely employed in crop planting research since the 1970s and 1980s and has produced a number of productive research outcomes. By developing the LACIE plan, for example, the USA has built a global agricultural monitoring and operating system that allows it to observe and analyze the growing status of crops at all stages of its growth cycle [6, 7]. Agronomic structure study has traditionally centered on the optimization and adjustment of crop planting structure in my home nation of Brazil. In the 1990s, Yang Guangli and colleagues proposed a broad strategy for the growth of my country's planting sector, which was later adopted. Actively promote the successful coupling of modern technology and agricultural machines to maximize resource use and efficiency. In conclusion, the rationality of crop planting structure not only directly affects the high yield and bumper harvest of agriculture, as well as the improvement of farmers' income levels, but it also plays a critical role in the development of the agricultural economy [8, 9].

Total factor productivity is expected to grow as a result of supply-side structural reform, which is intended to drive structural adjustment through reform. Increased agricultural total factor productivity is one of the most visible evidence of agricultural progress. This is one of the most important indicators of agricultural modernization (TFP) [10–13]. Due to the combined limits of the law of declining marginal returns of production factors and the resource environment, it will be impossible to maintain agricultural growth only on the basis of factor inputs in the future. It is critical to the long-term development of agricultural

production and production systems. Theoretically, in the case of multi-output, in addition to technological progress, technological efficiency changes, and scale efficiency changes, mixed efficiency changes are also the driving force behind the growth of total factor productivity. In practice, however, mixed efficiency changes are rarely observed. The term "mixing efficiency" refers to the increase or reduction in total output as a result of a change in the output mixing structure under the conditions of specific input and technologically possible processes. The efficiency of the mixing process is referred to as mixing efficiency. Farming structure adjustment consists of modifying the structure of agricultural production, resulting in a change in total agricultural output. This change in total agricultural output, in turn, affects the increase of agricultural total factor productivity [14, 15]. The price mechanism has an impact on the adjustment of the agricultural structure of the country. A more reasonable agricultural product supply can be produced if the production structure of agricultural goods is modified in response to resource and environmental limits as well as market demand. As a result, the total factor productivity of agriculture can be increased. Since 1978, the agricultural output structure of China has undergone a significant transformation. According to the United Nations Food and Agriculture Organization, agricultural production accounted for 80.0% of total output value in 1978. Forestry contributed 3.4%, animal husbandry contributed 15.0%, and fishery contributed 1.6% to the total output value in 1978, according to the UN Food and Agriculture Organization. The proportion of agricultural output value in the total output value of agriculture, forestry, animal husbandry, and fishery decreased from 52.3% in 1978 to 52.3% in 2016 [16–20].

Over the past few years, intelligent algorithms have emerged that include the genetic algorithm, particle swarm algorithm, neural network, and others. These algorithms belong to a class of probabilistic global optimal search algorithms, which are becoming increasingly popular [21–25]. When it comes to model application, many researchers have merged intelligent algorithms with multi-objective optimization. The optimal design plan of the agricultural planting structure in the Yanzhou plain parallel irrigation project was determined using a genetic algorithm, and a fuzzy optimization model was developed with the goal of making full use of water resources, increasing the output value of the planting industry, and increasing investment income [26, 27].

The Jianghuai hilly area is located between the Jianghuai and Huaihe Rivers, and the overall conditions of agricultural production in this area are considered to be relatively favorable. Over the years, rice and wheat wheels have been the primary crops, with a variety of other cereals and soybean cultivation serving as supplementary crops [28, 29]. It is one of the most important grains and oil-producing regions in the province of Anhui. Ponds and dams, particularly in the watershed ridge area of the Jianghuai hills, have a long history of serving as water storage and irrigation facilities. During the Warring States Period, there was a popular belief that the water was being used to irrigate crops. Statisticians estimate that as of the end of 2010, there were 479,200 ponds and dams throughout the Jianghuai hills, with a total capacity of 2.758 billion ml [21, 30]. Although the majority of existing pond and dam projects were built in the 1950s and 1960s with lax construction standards and a lack of clearly defined management systems, the result has been significant siltation and waste, reducing the irrigation and water storage capacity of the pond and dam projects significantly. The mismatch of water resource structure and availability in the region exacerbates the conflict between supply and demand for water resources, resulting in considerable losses in the agricultural sector [31]. Thus, one of the most critical tactics for resolving the conflict between water availability and demand in this region is through crop planting structure optimization and adjustment, which is one of the most effective approaches now accessible. It has the ability to significantly increase high and reliable agricultural yields while also enhancing farmer revenue in this region [32, 33]. Additionally, it will be critical in eradicating poverty. To demonstrate the issue, this study will utilize an example of a typical pond dam irrigation area in the Jianghuai hills. The findings of the tests conducted at the Feidong Badou Irrigation Test Station will be utilized to conduct a water balance analysis of the study area's pond dam irrigation system, with the results reported in the following section. By utilizing the objective function of the crop planting structure optimization adjustment model, it was possible to construct the most appropriate crop planting structure for the study area's current working conditions, which served as a theoretical foundation for adjusting the regional industrial structure and formulating the irrigation system in the study area.

There is still much space for improvement in Jianghuai's planting sector, and optimizing the planting structure not only promotes sustainable agricultural development and efficient water usage but also significantly enhances the agricultural economy. The balanced analysis of farmland submerged irrigation water is carried out in this article using the test results of Feidong Badou Irrigation Experiment Station. A genetic algorithm-based optimization model of agricultural industry structure is constructed using the simulation of rainfall and runoff in Tangba irrigation area. Developing efficient water use and ensuring per capita food demand are critical practical guiding principles.

2. History, Incentives, and Policies of China's Agricultural Structural Adjustment

The stages of China's agricultural structural adjustment are roughly divided into the following five stages: 1979–1984, 1985–1991, 1992–1997, 1998–2003, and 2004–2016.

1979–1984—The direct cause of the structural adjustment at this stage was that the production team took on too heavy a task of requisitioning grain, and the farmers' enthusiasm for production was severely dampened. In 1981, the "Report on Actively Developing Diversified Operations in Rural Areas" put forward the policy of "Never relax grain production and actively develop diversified operations," to make the production structure of grain and cash crops reasonable, and to promote the overall promotion of

agriculture, forestry, animal husbandry, and sideline fishing. In 1984, the output of grain, cotton, oilseeds, and meat increased at a rate of 5.0%, 19.3%, 14.8%, and 10.3% respectively. This time, the agricultural structure adjustment was the government used administrative means to require farmers to plant what and how much and did not follow the resource endowments and comparative advantages of each region. Therefore, the adjustment of agricultural structure in this period may restrain the growth of agricultural total factor productivity [4, 7].

1985–1991—After the adjustment of the agricultural structure in the previous period, it became difficult to sell grain and cotton. In 1985, it continued to implement the policy of never relaxing grain production and actively developing diversified operations, and decided to support the development of animal husbandry, aquaculture, and forestry. In 1986, it was emphasized that in adjusting the industrial structure, the relationship between grain production and diversification should be properly handled. The agricultural structure adjustment in this period is still the government using powerful administrative means to ask farmers to plant what and how much, rather than guiding them through the price mechanism. Therefore, the adjustment of the agricultural structure during this period may still not bring about the growth of agricultural total factor productivity.

1992–1997—After entering the 1990s, the market demand changed, and the demand for high-quality agricultural products increased. To this end, the 1992 "Decision on the Development of High-yield, High-Quality, and High-Efficiency Agriculture" proposed to continue to adjust and optimize the structure of agricultural production in a market-oriented manner and made it clear that no matter planting, forestry, animal husbandry, and aquaculture, it is necessary to expand high-quality products. Production is placed in a prominent position, and as the focus of structural adjustment, we should pay close attention to it. In accordance with the policy of developing high yield, high-quality, and high-efficiency agriculture, all localities encourage farmers to adjust their production structure and develop high-value-added agricultural products according to market demand. In the new economic environment, the market mechanism has played a decisive role in agricultural production. Therefore, the adjustment of agricultural structure in this period promoted the growth of agricultural total factor productivity [13, 16].

1998–2003—The general decline in agricultural prices in 1997 and 1998 triggered this agricultural restructuring. In 1999, "Several Opinions on the Current Adjustment of Agricultural Production Structure" proposed that the main content of agricultural structure adjustment is to adjust and optimize the structure of crops and varieties of planting, optimize regional layout, and develop animal husbandry and agricultural product processing industry. In 2000 and 2002, the "Opinions on Doing a Good Job in Agriculture and Rural Economy" put forward the development of pollution-free vegetables and green food, and the improvement of the quality and safety of agricultural products, which has gradually become an important part of agricultural structural adjustment. Therefore, the agricultural structural adjustment during this period may further promote the growth of agricultural total factor productivity.

2004–2016—Beginning in 2004, the restoration of grain production and the improvement of comprehensive grain production capacity have become the focus and foundation of agricultural structural adjustment. From 2004 to 2006, it was proposed that the agricultural structure should be adjusted and optimized in accordance with the requirements of high yield, high quality, high efficiency, ecology, and safety. In 2014, a new national food security goal was proposed to ensure the basic self-sufficiency of grains and absolute security of rations. However, the grain price policy has restricted the process of agricultural structural adjustment. The continuous high level of grain prices has led to the deformity of the agricultural structure. The reform of grain prices began in 2015, but the timing was relatively late. Therefore, the agricultural structural adjustment during this period may hinder the growth of agricultural total factor productivity.

In recent years, sophisticated algorithms such as the genetic algorithm, particle swarm algorithm, and neural network have emerged. These algorithms are part of a growing class of probabilistic global optimal search algorithms [21–25]. Numerous academics have combined intelligent algorithms with multi-objective optimization when it comes to model application. A genetic algorithm was used to determine the optimal design plan for the agricultural planting structure in the Yanzhou plain parallel irrigation project, and a fuzzy optimization model was developed with the goal of maximizing water resource utilization, increasing the output value of the planting industry, and increasing investment income.

3. The Proposed Method

This article uses the SCS model to design the flood model. The model has the characteristics of a simple calculation process, fewer required parameters, easy acquisition of data and data, and few requirements for observation data. It is especially suitable for areas with no data or lack of data. The basic relationship between rainfall and runoff established based on SCS is

$$R = \begin{cases} \dfrac{(P - \alpha S)^2}{P + (1 - \alpha S)}, & P \geq \alpha S, \\ 0, & P < \alpha S. \end{cases} \tag{1}$$

Generally, it is set $\alpha = 0.2$ for experimental agriculture in the USA, but because of the relatively uniform rainfall distribution over time, approximately 70% of the rainfall enters the soil through infiltration. In contrast, the rainfall season in China varies greatly, and there are concentrated heavy rainstorms, only approximately 40% of the precipitation enters into the soil through infiltration, according to the World Bank. As a result, when employing this model, the value is less than 0.2, and in most cases, it is less than 0.05 The particular value is calibrated based on the hydrological

data of the watershed, or the value of a similar hydrological area is transferred. For example, in this study, $\alpha = 0.15$ was entered as the specific value.

Due to the large variation range of S value, it is inconvenient to take the value, so the dimensionless parameter CN is introduced, its value range is $[0, 100]$, and the empirical relationship is defined as

$$S = \frac{28000}{\mathrm{AMC}} - 280, \tag{2}$$

where AMC is a dimensionless parameter that reflects the comprehensive characteristics of Antecedent Moisture Condition (AMC), vegetation, slope, soil type, and land use status in the early stage of the basin, and can better reflect the impact of underlying surface conditions on yield.

For the wet state level, the CN values of different wet states have the following mutual conversion relationship.

$$\begin{aligned} \mathrm{AMC}_1 &= \mathrm{AMC}_2 - \frac{20 \times (100 - \mathrm{AMC}_2)}{100 - \mathrm{AMC}_2 + \exp[2500 - 0.065(100 - \mathrm{AMC}_2)]}, \\ \mathrm{AMC}_3 &= \mathrm{AMC}_2 \times \exp[0.065 \times (100 - \mathrm{AMC}_2)]. \end{aligned} \tag{3}$$

The addition of a genetic algorithm to multi-objective functions where the objective function and constraints are both linear functions reduces the likelihood of slipping into the local optimum and makes global optimization more feasible. Figure 1 illustrates the functional organization chart. The multi-objective optimal solution problem can be described as follows:

$$\min[f_1(x), f_2(x), \ldots, f_m(x)], \tag{4}$$

$$\text{s.t.} \begin{cases} \text{lower bound} \le x \le \text{upper bound}, \\ \mathrm{Aeq} \cdot x = \mathrm{beq}, \\ A \cdot x \le b. \end{cases} \tag{5}$$

The calculation of the water demand WD_c of each stage of the crop is obtained by multiplying the reference crop evaporation D_0 at the same stage and the crop coefficient of the corresponding stage, and the formula is as follows:

$$\mathrm{WD}_c = \beta_c \times \mathrm{WD}_0, \tag{6}$$

where WD_0 is the evapotranspiration at a certain growth stage of the reference crop and β is the evapotranspiration at a certain growth stage of the reference crop.

Then we calculated the WD_0, the formula is as follows:

$$\mathrm{WD}_0 = \frac{0.437\Delta(\mathrm{Radiation}_n - \mathrm{Soil\,Heat}) + \sigma(1000/(T + 300))\mathrm{Speed}_2(\mathrm{SVP} - \mathrm{AVP})}{\Delta + \sigma(1 + 0.35\mathrm{Speed}_2)}, \tag{7}$$

where $\mathrm{Radiation}_n$ stands for sunshine, Soil Heat stands for surface temperature, Speed_2 stands for irrigation rate stands.

Due to a lack of comprehensive surface runoff observation and hydrological data in the study area, this article calculates effective rainfall using the simplified approach of typical annual rainfall with varying frequencies that are frequently used in production practice. The calculating formula is as follows:

$$\mathrm{rain}_e = \varpi \mathrm{rain}, \tag{8}$$

where ϖ is the effective utilization coefficient of rainfall, which is related to factors such as total rainfall, intensity, and duration, soil properties, crop growth, ground cover, and planned wet layer depth.

The water consumption of rice seedlings, soaked fields, and infiltration are all calculated based on the experimental results of the Piaoshihang irrigation area and the Badou irrigation experimental station in the Jianghuai hilly area. In addition, the Jianghuai hilly areas are mostly hilly areas, and the groundwater is generally buried deep, and the utilization of groundwater is generally not considered.

The main body of water storage irrigation in the pond dam irrigation system is the pond dam. According to the principle of water balance [12], we can get

$$\begin{aligned} \mathrm{Storage}_i = \mathrm{Storage}_i + \mathrm{Income}_i - \mathrm{Irrigation}_i \\ -\mathrm{Loss}_i - \mathrm{Discharge}_i, \end{aligned} \tag{9}$$

where $\mathrm{Storage}_i$ is the water storage volume of the pond dam irrigation system at the end of the ith period, Income_i is the inflow of the pond dam irrigation system in the ith period, $\mathrm{Irrigation}_i$ is the irrigation volume of the pond dam irrigation system in the ith period, $\mathrm{Discharge}_i$ is the discharge amount in the ith period of the pond dam irrigation system, and Loss_i is the loss amount in the ith period.

The Loss_i consists of Water surface evaporation WSE_i and penetration Pene_i

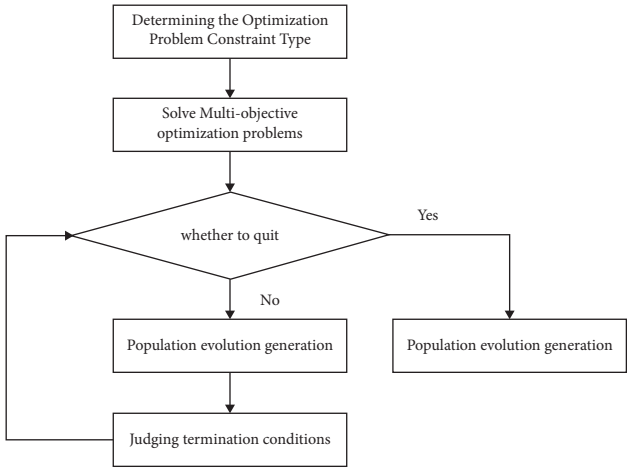

Figure 1: Chromosome initialization.

$$\text{Loss}_i = \text{WSE}_i + \text{Pene}_i. \tag{10}$$

In this study, the calculation of pond water volume and benefit adjustment is carried out in a monthly period. The specific calculation process is as follows:

(1) When $\text{Storage}_i + \text{Income}_i - \text{Irrigation}_i - \text{Loss}_i \geq \text{Storage}_{\max}$, the pond and dam system will abandon water, at this time, $\text{Irrigation}_i = \text{RX}_i$, $\text{Storage}_i = \text{Storage}_{\max}$. Among them, $\text{Storage}_{\max}$ is the water storage capacity of the pond, RX_i is the irrigation water demand of the crop i period, the specific formula is as follows:

$$\text{Irrigation}_i = \text{RX}_i = \frac{\sum_{j=1}^{n} R_{ij}}{\tau_i}, \tag{11}$$

where R_{ij} is the net irrigation water demand of the jth crop of the pond dam irrigation system in the i period, τ_i is the effective utilization coefficient of the irrigation water in the i period of the pond dam irrigation system.

(2) When $\text{Storage}_i + \text{Income}_i - \text{Irrigation}_i - \text{Loss}_i \geq 0$, $\text{Irrigation}_i = \text{RX}_i$, $\text{Storage}_i = \text{Storage}_i + \text{Income}_i - \text{Irrigation}_i - \text{Loss}_i$ the pond and dam system are irrigated normally.

(3) When $\text{Storage}_i + \text{Income}_i - \text{Irrigation}_i - \text{Loss}_i < 0$, the water supply of the pond and dam system cannot meet the needs of crop irrigation, and all the water stored in the pond and dam is used for irrigation. At this time, $\text{Storage}_i = 0$, $\text{Irrigation}_i = \text{Storage}_i + \text{Income}_i - \text{Loss}_i$.

The annual midday crop flood and drought ratio was used as the variable, and the minimum water abandonment, the minimum water shortage, and the maximum rice planting ratio were used as the objective functions, based on the aforementioned analysis of farmland irrigation water balance in Tangba Irrigation District.

The pond and dam irrigation system should minimize water scarcity, minimize wastewater generation, and maximize rice sown area under the premise of meeting numerous constraints, in accordance with the principle of maximizing the use of water resources in the study area and reaping the maximum benefit from regional crop planting. It is classified as a problem of multi-objective optimization. Converting the multi-objective optimization problem to a single-objective optimization problem simplifies modeling and calculation for solving the optimization model. The objective function relationship that follows is the result of a careful analysis.

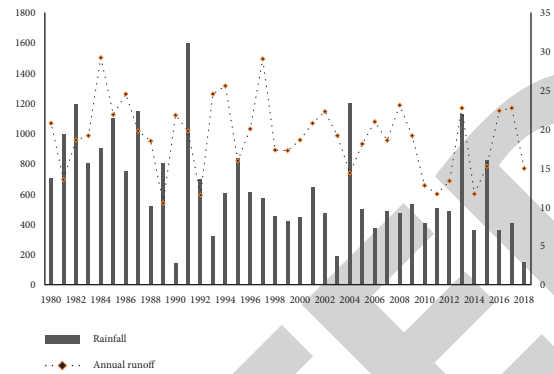

Figure 2: The annual runoff simulation results.

$$O = \min\left(\frac{\sum_{j=1}^{n} N_j + \sum_{j=1}^{n} \text{Discharge}_j}{\sum_{j=1}^{n} \text{RSA}}\right), \tag{12}$$

where RSA is the rice sown area, then the research goal of this article can be transformed into a single-objective optimization problem, and then the final model can be obtained by solving equations (4) and (5).

4. Experiment Results

Badou Town is located on the crest of the Jianghuai watershed in Anhui Province's northern Feidong County. It is a portion of the Jianghuai watershed. It encompasses 10,000 hectares of lush land and is home to 75,000 people, 71,000 of whom work in agriculture. It is a typical Midwest farming village. Surface runoff storage on a large scale is problematic in this area due to the fragmented topography and sparse vegetation, as well as the terrain's and vegetation's poor control and storage capabilities.

Guaranteed irrigation rates are low. In Badou Town's pond dam water storage irrigation area (Tangba Irrigation Land), there are 7,500 hm^2 of irrigation area with a total capacity of 93,200 cubic meters. The land is primarily planted with rice (middle rice or one-season late rice), corn, rapeseed, and wheat, with rice serving as the principal rotation crop (rape).

Rice cultivation is typically 0.5 the size of other autumn crops. Due to a lack of available water, the area is prone to drought, and the soil is barren. This irrigation system, which is located in the low-yield region of the Jianghuai hills, is characteristic of the pond and dam irrigation systems found across the Jianghuai hills. Rice agriculture is predominant in this region's Chongtian and Chongtian regions. According

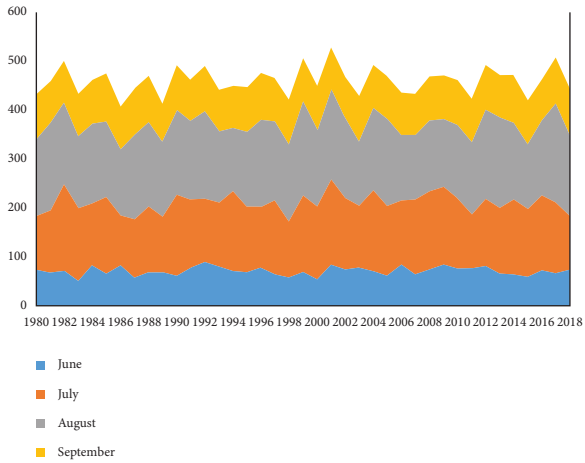

Figure 3: Monthly demand for middle rice.

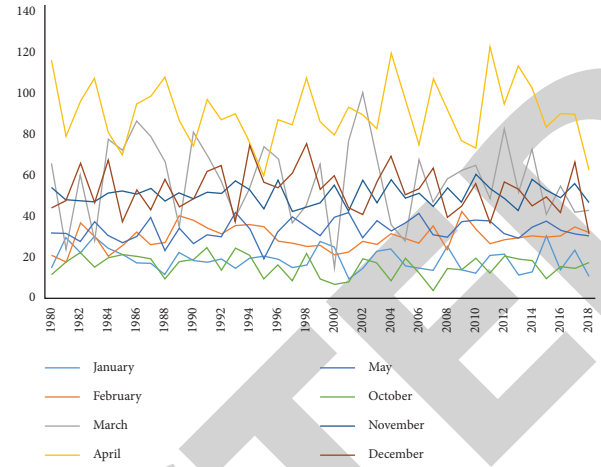

Figure 4: Monthly demand for middle rape.

to the survey's findings, Chongtian accounts for roughly 20% to 25% of total cultivated land area, whereas collapsed fields account for approximately 35% to 45%. The hillock is roughly comparable in size to Chongtian in terms of percentage. Around 7% of the total are small reservoirs and ponds.

Local villagers have been cultivating rice for generations, and the paddy field can be considered the permanent rice planting area in this area, accounting for around 20% of the total cultivated land area in this area. Rice can be successfully produced in this region. Rice planting area ratios typically range between 40% and 50% of the total planting area in ordinary years. High-collapse land often has a good soil texture and fertility level, making it suitable for a wide variety of agricultural plants. It is probable that the planting area will reach 60% or 70%.

The data in this article comes from the China Geographical Statistical Yearbook. The annual runoff simulation results are shown in Figure 2.

According to the research results of the contour map of water demand of major crops in Anhui Province, the standard crop coefficients and correction formulas of 84 crops recommended by FAO, and the irrigation experimental data of the Aoshihang Irrigation Experiment Station in Anhui Province and the Feidong Badou Irrigation Experiment Station for many years, determine the growth period of the main planted crops and the monthly crop coefficient β in the area where each station is located, calculate the reference crop evapotranspiration WD_0 by formula (7), and then calculate the water demand WD_c of different types of crops, as shown in Figures 3 and 4.

Figures 3 and 4 show that the research area's reasonable planting structure under the current pond capacity of 93,200 m^3/km^2 is as follows:

(1) When rainfall frequency exceeds 90%, the appropriate planting ratio of rice in the midday season is 0.11. Existing pond and dam projects are incapable of meeting agriculture water requirements during dry years. Rice should account for a lesser percentage of the crop.

(2) When rainfall occurs at a rate of 75% to 90%, the appropriate planting ratio of rice in the afternoon crop is 0.21.

(3) When rainfall occurs at a rate of 50% to 75%, the appropriate planting ratio for rice in the midday season is 0.36.

(4) When rainfall occurs at a rate of 20% to 50%, the appropriate rice planting ratio for the noon season crop is 0.54. Within this rainfall frequency range, this year's rainfall is quite abundant. If the rainfall distribution is reasonable, it should be possible to grow the maximum amount of rice possible in the area. Planting water requirements.

(5) When rainfall frequency is less than 20%, the suitable rice planting ratio for the noon season crop is 0.65, and this region is capable of meeting the water supply requirements for the maximum tolerable rice planting in the wet season.

Further, we tested the difference between the agricultural structure optimization scheme obtained by the traditional optimization method and the scheme obtained by the method in this article. We adopt MSE to judge the performance of different methods. The MSE of the traditional method is 66.73, while the method in this article is 16.52, which is significantly better than the traditional method.

5. Conclusion

There is still much space for improvement in Jianghuai's planting sector, and optimizing the planting structure not only promotes sustainable agricultural development and efficient water usage but also significantly enhances the agricultural economy. The balanced analysis of farmland submerged irrigation water is carried out in this article using the test results of Feidong Badou Irrigation Experiment Station. A genetic algorithm-based optimization model of agricultural industry structure is constructed using the simulation of rainfall and runoff in Tangba irrigation area.

Developing efficient water use and ensuring per capita food demand are critical practical guiding principles.

In the future, we will expand in two areas. First, we will extend the genetic algorithm to other areas of structural optimization. Second, we will introduce more advanced genetic algorithms to optimize the structure of the agricultural field.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares that he has no conflicts of interest.

Acknowledgments

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Retraction

Retracted: Interaction Design of Educational App Based on Collaborative Filtering Recommendation

Advances in Meteorology

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope

(2) Discrepancies in the description of the research reported

(3) Discrepancies between the availability of data and the research described

(4) Inappropriate citations

(5) Incoherent, meaningless and/or irrelevant content included in the article

(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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[1] Y. Xu, T. Neo, and H. Hew Soon, "Interaction Design of Educational App Based on Collaborative Filtering Recommendation," *Advances in Meteorology*, vol. 2022, Article ID 7768730, 8 pages, 2022.

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Research Article

Interaction Design of Educational App Based on Collaborative Filtering Recommendation

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With the advent of the 5G digital era, cell phones are becoming ubiquitous in all aspects of our lives, and the increasing demand for remote interaction makes the app interaction experience an indispensable part of our lives. Due to the operational characteristics of gesture interaction in the interface of a smart terminal application (app), this mode of human-computer interaction has become the mainstream mode of human-computer interaction. Educational app is the result of a combination between mobile Internet technology and education, which not only provides a more efficient and convenient method of learning for each subject but also expands the possibilities for teaching each subject through intelligent interaction. On this basis, this paper proposes an educational app design method based on collaborative filtering recommendations and investigates ways to improve the use of mobile apps to create an interactive teaching mode. Simultaneously, this paper combines user activity, item popularity, and time factors to comprehensively measure user visibility of items and incorporates them into the collaborative filtering recommendation algorithm in order to effectively mitigate the effects of data sparsity and user selection bias and improve recommendation results.

1. Introduction

Throughout the last few years, cellphones, as well as touch technology and even hardware interaction, have progressed at an exponential rate. As a result, mobile applications and interpersonal operational relationships have undergone significant transformations. The development trend of mobile has been further enhanced, and the development of smart terminals has grown more diverse, forcing the user interface to begin to demonstrate a greater variety of interaction features in the current increasing development process. In addition, the variety and ecological type of dynamic interaction have increased operational efficiency and so demonstrated significant significance. The development of intelligent terminals has seen a number of technological advancements and developments, the most notable of which is the introduction of the touch screen, which represents a watershed moment in the history of the industry [1–4]. At this point, China has just entered the first stage of the information and intelligent society, and the vast majority of users are utilizing smartphones, tablet PCs, and other intelligent terminal devices with touch screens as their primary means of communication. Designing interfaces for touch-based educational operations is an important issue in the development and research process of intelligent terminals, and how to improve the efficiency of intelligent terminal applications through gesture design has become the main concern of designers. Designers should abandon the traditional button design and use touch screen gesture design to improve the simplicity of intelligent terminal products and better meet the operational needs of operators to achieve a good user experience. This makes improving the interactivity of smart terminals even more critical in the future [5, 6].

Interaction is a necessary component of all teaching and learning activities, and it is also one of the most critical factors determining the success of those activities. According to the research findings, interactivity is a critical characteristic of the future classroom, and interaction is at the heart of the classroom's design and implementation. The

popularity of mobile terminal devices such as smartphones and iPads has resulted in the development of numerous educational apps that not only are indispensable tools and major platforms for learners' daily learning but also provide strong technical support for interactive teaching reforms across a range of subjects and promote changes and innovations in traditional teaching models [7, 8]. Educators, on the other hand, are confronted with the challenges of how to use mobile devices to expand the traditional learning area and how to develop an interactive model that is continuous and dynamic in order to stimulate students' learning in the way that is expected. Consequently, this research is devoted to developing a diverse intelligent interactive teaching mode using mobile apps, emphasizing the student-centered teaching concept, and developing an interactive teaching mode of autonomy, self-help, and self-assessment to meet the need for English teaching reform in the information age.

Recommended systems, which are becoming increasingly popular in the age of information explosion, play a critical role in alleviating information overload. They have been adopted by many online services, such as e-commerce sites, online news sites, and social media sites, and are a hot research topic in both academia and industry [9–12].

For recommender systems, collaborative filtering (CF) is one of the most commonly used and explored approaches currently available [13, 14]. Users' previous activity data is used to inform CF algorithms, which in turn analyze similarities between user behavior patterns to infer user preferences and create recommendations for them. User behavior data can be divided into two categories: explicit feedback data, such as ratings and reviews, and implicit feedback data, such as purchases, clicks, and other actions [15–19]. The first category includes explicit feedback data, such as ratings and reviews, and the second category includes implicit feedback data, such as purchases and clicks. When explicit feedback data is used in rating prediction scenarios, where missing ratings are projected based on observed rating data, it is referred to as explicit feedback data. TopN suggestions can alternatively be generated by categorizing all items according to their projected ratings and then ranking the results by size [20, 21]. However, it has been pointed out that when only the observable rating data is considered and due to the fact that the data that is not randomly absent is ignored, the recommendation impact is found to be insufficiently strong [22]. Implicit feedback data, on the other hand, takes into account both observable and missing data, and it has been extensively employed in TopN recommendation scenarios [23, 24]. It has the advantage of utilizing all negative preferences implied by missing data, but in comparison to explicit feedback, it lacks the ability to express user preferences openly and cannot convey the degree to which those preferences are held. The interaction design of an educational app based on CF recommendation in this paper also examines how to combine the benefits of implicit feedback and fully utilize missing data in order to improve the existing CF algorithm based on explicit feedback and enable it to be applied effectively to the TopN recommendation scenario [25].

2. Advantages of Mobile Apps

A new sort of information-based teaching tool built on third-party smartphones, tablets, and other mobile devices that can assist learners in learning and teachers in teaching is known as an application (app) programming interface. At the moment, the investigation into the use of mobile applications for educational purposes is growing increasingly wide. In his book Mobile Learning: A Global Perspective, Mike Sharples, an internationally renowned scholar in the field of mobile learning, clearly states that one of the real advantages of mobile learning is related to education, and it can provide support for people to learn various courses through mobile devices, and the future prospect of mobile learning applied to various courses is extremely promising. The following are the advantages of mobile learning in the context of teaching and learning.

2.1. Contextualization of Learning Content. Because of the contextualization feature of mobile apps, they can assist in the formation of learning circumstances as well as human-computer interaction, hence increasing the learning effectiveness. Incorporating context into learning content can assist learners in swiftly achieving the desired learning state, increasing their enjoyment of the process, and creating the illusion that learners are actually present when learning and experiencing the pleasures of learning. For example, many students will find the process of learning English words tedious and difficult to maintain their interest; however, through the use of an app such as Hundred Word Chop, which is designed with the context and relevance of mobile learning in mind, students can practice from visual, auditory, and multidirectional aspects through the situations created by pictures or short videos, making the process of memorizing words somewhat more interesting. The contextual feature of a mobile application is also very useful in the learning of phonetic sounds. For example, English Fun Dubbing app includes the capability of context generation, learners can practice copying a tiny piece of the contextual story by scoring it in real time, and learners can fix the sound training over and over again.

2.2. Intelligence of Data Collection. One of the most prominent manifestations of the intelligence of app can be found in two areas. As a result of this, the app will automatically identify, analyze, and integrate based on the learners' learning levels and study patterns and will push learning contents to students so that they can conveniently access the correct levels for ladder learning. However, one of the benefits of using a mixed learning approach is the opportunity to learn to teach. Teachers can use the intelligent assessment and data collection capabilities of the app to see student assessment data in the background, analyze, process, and categorize them, and then use this information to design secondary teaching and optimize classroom structure based on students' completion situation and weak points, among other things.

2.3. Individualization of One's Learning Style. Traditional classroom instruction is directed at a group of pupils in a single classroom with the same educational aim in mind. Individual differences in learning ability are the most difficult problems that educators and students face in their educational and teaching careers. Because each student's cognitive level, learning capacity, and learning style are unique, it is impossible to overcome this problem by maintaining a regular speed of classroom instruction in the classroom. Students, on the other hand, can adjust their learning progress, set learning goals independently according to their own level, and complete personalized, one-to-one task goals to make up for the shortcomings of traditional teaching through mobile apps, such as English learning apps like Hundred Words, Fluency, and so on.

2.4. The Efficiency of Multidimensional Interaction. Students can inspire deep learning through mutual contact and involvement in a mobile app, which distinguishes it from other types of learning environments. Peer dialogue and instructor interaction are important components of the learning process. Students who are guided by their teachers are more likely to retain and apply what they have learned. Teachers provide timely guidance, and peers communicate with one another to facilitate learning and communication among learners through online interaction. Students can discuss any difficulties they encounter in their independent learning through the mobile app's communication area, and teachers can provide timely guidance to students. Also being multidimensional, the interaction includes interactions between teachers and students, interactions between students, interactions between humans and computers, and interactions between the students themselves and their learning resources. Students' independent and in-depth learning is facilitated by the many types of interaction, which also contribute to the improvement of the effectiveness of learners' learning.

Data sparsity and user selection bias are significant obstacles to the use of explicit feedback mechanisms. In the real world, users tend to rate just a small number of products, with the majority of goods receiving no ratings at all. As a result, it is difficult for the model to accurately learn about the true preferences of users. More importantly, the rating data is vulnerable to user selection bias, which means that users are more likely to select products that would provide them with high satisfaction while ignoring ones that will provide them with low satisfaction. In other words, rating data is not missing at random; rather, it is the product of users' free choice to not provide them. Accordingly, most available rating data is overrated, with just a small amount of data being underrated, as demonstrated by the distribution of ratings in the dataset utilized in this work. As an alternative, research has revealed that, in the actual world, users are generally only interested in a tiny percentage of available options and that most available options are in fact boring or ineffective. That is, due to user selection bias, the accessible rating data do not represent a representative sample of all item ratings, and many things that may reveal users' negative preferences are underutilized as a result of a lack of ratings.

2.5. The Limitations of Displaying Feedback Methods. Due to the issues raised previously, the performance of CF algorithms based on explicit feedback is inconsistent in two scenarios: rating prediction and TopN suggestion. Not all algorithms that perform well in the rating prediction scenario will also perform well in the TopN recommendation scenario. According to some researchers, the primary distinction between these two scenarios is the quantity of training and testing data considered. As previously stated, rating prediction scenarios are only applicable to observed ratings, and current research prefers to predict only the items that users have actually evaluated in order to calculate the inaccuracy associated with anticipated ratings. On the other hand, TopN recommendation scenarios frequently require the estimation and ranking of all missing ratings. While learning user preferences solely from observed rating data can improve the accuracy with which real rated items are predicted, observed rating data is not a representative sample of all ratings and is therefore insufficient to accurately forecast all missing ratings in a given situation.

In summary, the existing CF algorithms tend to consider only the observed rating data, ignoring the effects of data sparsity and user selection bias, which makes it difficult to learn users' positive and negative preferences in a balanced way. Additionally, the predicted ratings and rankings of missing items are biased, resulting in poor TopN recommendation results for missing items. As a result, the primary question in this paper's research is how to successfully mine and exploit the user preferences implied by the absence of information.

3. Educational App Interaction Design Based on Collaborative Filtering Recommendation

3.1. Concept of Construction. Interaction is a method of generating relationships and bringing ideas into collision among people. Interactive teaching is a teaching mode developed on the basis of scaffolding theory and primarily applied to language teaching. It is comprised of three components: the teaching subject, the teaching environment, and the interactive relationship, which together form an organic whole of mutual influence and mutual promotion between the three components. Because of the rapid growth of information technology, the mode of contact has also changed in a significant degree as well. The intelligent interactive teaching mode is more conducive to the promotion of teaching activities when an app for mobile devices is used to support it. Teachers and students collaborate to develop bridges that allow them to communicate and negotiate using mobile devices. Interaction between teachers and students is encouraged in interactive classrooms so that teacher-student interaction and student-student interaction take place during every teaching session in order to promote effective learning and to address the issues of inefficient online learning and low participation rates in classroom learning among students. The growing usage of mobile application (app) programming interfaces in learning creates chances for cocreative learning between learners and other learners. Some scholars believe that learning sharing is the highest

form of the teaching and learning process and that the interaction between learners can compensate for the perceived psychological distance between them and increase the social presence of learners, both of which are important for the growth and development of the learners themselves.

3.2. Model Construction. There are many different types of learning apps available today, including resource-sharing apps such as Learning Pass and Rain Classroom. One type of game is one that focuses on vocabulary learning, such as Hundred Words or Fluency. Learning links inside and outside the classroom are rationally designed to actualize teacher-student engagement, student-student interaction, human-computer interaction, and online and offline multiple interaction models through the complete usage of various types of teaching mobile applications.

3.2.1. Interactive Application Mode. Students study freely through human-computer interaction, information input, and completion of self-assessment tasks through resource-sharing apps such as Learning Pass and Rain Classroom, which are available for free download from App Store. Teachers place difficult teaching problems in the discussion area and invite students to discuss them, allowing the entire team to participate in the discussion and learning. Teachers should respond quickly to students' opinions and questions, as well as to problems that arise during the discussion and learning. Throughout the entire learning process, students are learning collaboratively, and with the assistance of their classmates and teachers, they are able to break through the learning bottleneck and complete the process of knowledge internalization that has been initiated.

3.2.2. Model for Interactive Practice in a Context-Based Environment. This technique is defined by the creation of circumstances that pique students' interest while also helping them to attain their learning objectives. The unique application process consists of the following steps: creating a context, discussing the issue, gaining new knowledge, practicing the game, and evaluating and guiding the process. To begin, the teacher creates a situation using the app, which includes videos and visuals related to the topic in order to pique students' interest and increase their attention. After pupils are placed in a specific circumstance, they study and put their newfound information into practice. Students can access learning resources at their own level at any time through the app, practice and test without being constrained by space or time constraints, and completely benefit from the ease of mobile learning in its entirety. This mode enables learners to quickly enter the learning state and to practice repeatedly according to their own level, resulting in the resolution of personalized learning difficulties as they progress. Teachers can also access students' learning data in the background, allowing them to alter their teaching tactics in response to students' learning situations and assist students in solving challenging teaching difficulties in a timely manner.

3.2.3. Task-Based Collaborative Interactive Application Model. The model's application procedure consists of the following steps: assigning tasks, collaborating in groups, reporting results, and exchanging summaries. The task-based learning mode directs students' attention to achieving specific goals. Each group will collaborate and work together when the teacher assigns learning activities using the app. Once the students accept the tasks, they will collaborate and work together. During this process, members of the group discuss and learn, investigate in depth, formulate conclusions, and report back. Each group has the opportunity to provide feedback through pop-up windows, and the teacher examines and summarizes the reports submitted by the pupils. In the task-based interactive application paradigm, group results reporting is a critical aspect of the process, demonstrating the group's learning through results reporting and completing the process from language input to language output from the task-based interactive application.

3.2.4. Recommended Educational Resources Model Based on Student Characteristics. On the basis of their specific qualities, students are directed toward appropriate instructional materials. In most cases, preuse preferences are based on the consumers' preferences for exterior qualities of the item that can be obtained without actually using it, such as the movie's genre and the lead actor. It depends on the user's preferences for the item's internal elements, such as the movie storyline, that their postuse preferences would be influenced. Users' preuse preferences determine whether or not they engage with goods, and research conducted by a number of academics has indicated that users tend to rank items higher when their preuse preferences are high. Furthermore, their analysis reveals that ratings in data sources such as MovieLens and Netflix are skewed toward high scores due to user selection bias. In contrast, the majority of evaluations are low in the specially collected Yahoo data that was collected without any selection bias. Additional academic study has also revealed that low ratings are more likely than high ratings to be absent from the observed data, although the reverse is true. As a result, it is straightforward to conclude that objects with low preuse preferences also have low postuse preferences, that is, low ratings, when compared to other items. In contrast, ratings for goods with high preuse preference are overwhelmingly positive, which is consistent with the distribution of ratings in the dataset used in this paper and with the findings of this paper.

In the case of user-rated things, it may be easily deduced that their preuse preference is high because users must have been interested in them at the time of purchase in order to leave ratings. The problem is to accurately deduce the preuse preferences for the missing components from the available information. This is a one-class problem, which means that all of the available rating data are positive examples, and there are no negative samples available. In order to maintain the robustness of the model, this research makes use of learning based on the total data, which was discovered in the prior analysis. WRMF interprets all missing data as negative

samples and applies smaller uniform weights to the missing items because it believes that they have the same confidence level as negative samples; however, this is not compatible with the way data is really collected. In the present Web 2.0 era, many mobile apps offer popular items on their recommendation screens, and this is especially true for social media apps. In general, consumers are more likely to notice popular things than less popular ones. It has been suggested that nonuniform weighting of the missing items should be used based on item popularity. The more popular the items that are easily seen by users without the need for user interaction, the greater the confidence that they are negative samples and therefore should be given higher weights. However, the effects of variances in user characteristics as well as the time factor on popularity were not taken into consideration.

The weight design of current methods based on overall data learning is primarily based on the observation that the greater the likelihood that an item is seen by a user without user interaction, the greater the confidence that it is a negative example and thus the higher the weight assigned to the item. The trick is figuring out how to reliably determine whether or not the item was seen by the user. The present prevalent practice of relying on item popularity to infer the visibility of an item by a user is fraught with uncertainty. In reality, users with varying levels of activity have varying levels of visibility for the item.

The UTVCF algorithm will linearly combine item popularity and user activity during the user's active period to measure the item's point-in-time visibility to the user, with nonuniform weighting for missing items, based on the above analysis. The CF recommendation algorithm will be combined with the UTVCF algorithm in this paper.

First, the original rating matrix $R = (r_{ui})_{m\times n}$ is used to construct the preuse preference matrix $P = (p_{ui})_{m\times n}$. m is the number of users, n is the number of items, and r_{ui} is the rating of item i by user u. All rated items are positive samples, and the preuse preference is set to 1. All missing items are considered negative samples, and the preuse preference is set to 0. The equation is as follows:

$$p_{ui} = \begin{cases} 0, & r_{ui} = \text{null}, \\ 1, & r_{ui} \neq \text{null}. \end{cases} \tag{1}$$

Since the missing items are not all negative samples, we construct a weight matrix $W = (w_{ui})_{m\times n}$ for the scored items, we set their weights $w_{ui} = 1$ for the missing items, their weights represent the confidence that they are negative samples, and $w_{ui} \in (0, 1)$. The higher the weight, the higher the confidence that it is a negative sample.

Define the activity α_u of user u as the number of ratings of this user; that is, $\alpha_u = \sum_{i=1}^{n} p_{ui}$. The rating time is t_{ui}, and we define the active period as $(t_{\min}, t_{\max})$. $t_{\min}$ is the earliest rating time of user u, and $t_{\max}$ is the latest rating time. The prevalence of item β_i for user active period is the number of ratings of item i for time period $(t_{\min}, t_{\max})$; that is, $\beta_i = \sum_{i=1}^{n} p_{ui}$. The smoothing of α_u and β_i using the log function is normalized using the maximum value. Taking smoothing can smooth out the impact of a few extremely active users or popular items. The formula is as follows:

$$\widehat{\alpha}_u = \frac{\log(\alpha_u)}{\max(\log(\alpha))}, \qquad \widehat{\beta}_i = \frac{\log(\beta_i)}{\max(\log(\beta))}. \tag{2}$$

By weighting $\widehat{\alpha}_u$ and $\widehat{\beta}_i$, we have

$$W_{ui} = \begin{cases} 1, & p_{ui} = 1, \\ \eta\widehat{\alpha}_u + (1-\eta)\widehat{\beta}_i, & p_{ui} = 0. \end{cases} \tag{3}$$

The object function is as follows:

$$J = \sum_{u=1}^{m}\sum_{i=1}^{n} W_{ui}\left(p_{ui} - \widehat{r}_{ui}^2\right). \tag{4}$$

We use the least squares method to optimize the loss function; then, we have

$$\frac{\partial J}{\partial} = -2\sum_{i=1}^{n} yW_{ui}\left(p_{ui} - \widehat{r}_{ui}\right). \tag{5}$$

Then, we have

$$x = \frac{\sum_{i=1}^{n} yW_{ui}\left(p_{ui} - \widehat{r}^{ui}\right)}{\sum_{i=1}^{n} y^2 W_{ui}}, \qquad y = \frac{\sum_{i=1}^{n} xW_{ui}\left(p_{ui} - \widehat{r}^{ui}\right)}{\sum_{i=1}^{n} x^2 W_{ui}}. \tag{6}$$

We fill the missing items, and the fill items are calculated as

$$\text{Miss} = \overline{r}_u * \sigma. \tag{7}$$

3.2.5. Problem-Based Inquiry-Based Interactive Application Model. Students are guided to undertake independent inquiry learning through the use of this model, which is more commonly utilized for initial investigation of knowledge before class and growth of knowledge after class. Through the course of the process, students conduct independent adjustment learning through the use of a mobile application with questions and use the intelligent review function of the mobile application to provide timely feedback on students' learning effect. Teachers only gain an overall understanding of students' learning and provide assistance to students when necessary. Student learning is primarily accomplished through human-computer interaction and inquiry-based learning, which helps them achieve learning objectives and improve knowledge consolidation and transfer over time. Students are the organizers and decision-makers of their own learning in this application mode, and they can use the feedback and evaluation functions of the mobile app to learn once or more times according to their own learning habits and learning styles until they fully master the knowledge and achieve the goal of effective learning.

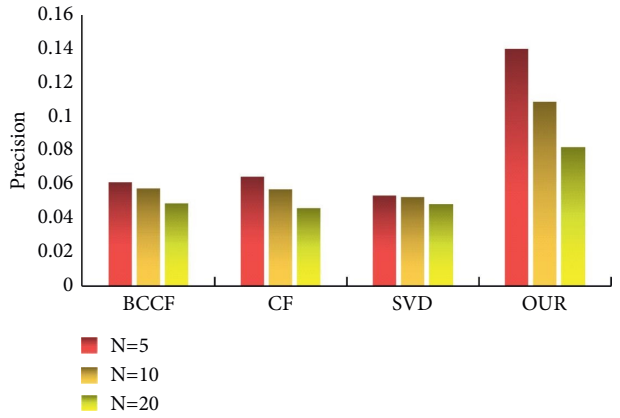

Figure 1: Comparison of precision on MovieLens 100 k.

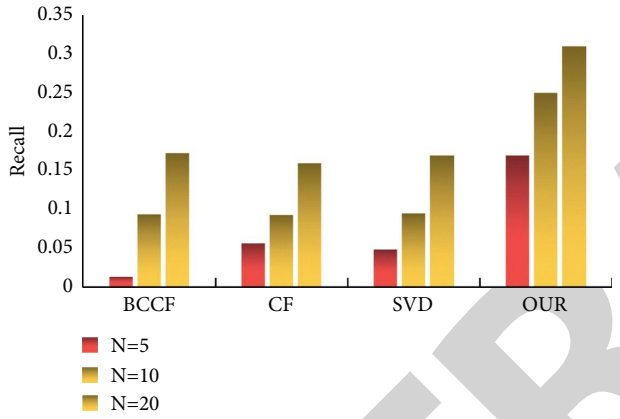

Figure 2: Comparison of recall on MovieLens 100 k.

4. Experiment Results

In this paper, we use MovieLens 100 k and MovieLens latest datasets, and the judging metrics are precision and recall, which are as follows:

$$\text{precision} = \frac{\sum_{u \in U} |R(u) \cap T(u)|}{\sum_{u \in U} |R(u)|}, \quad \text{recall} = \frac{\sum_{u \in U} |R(u) \cap T(u)|}{\sum_{u \in U} |T(u)|}. \tag{8}$$

The comparison algorithms in this paper are BCCF, CF, and SVD, and the comparison results on the two datasets are shown in Figures 1–4. From the figures, it can be seen that the proposed recommendation method outperforms the BCCF, CF, and SVD algorithms in both metrics on any dataset.

It can be seen that, with the increase of N, various indicators will also increase. The algorithm proposed in this paper has the highest indicators when $N = 5$, $N = 10$, and $N = 20$.

In addition, when the TopN is large ($N = 50$), this paper compares the proposed algorithm with BCCF, CF, and SVD algorithms, and it can be seen that the algorithm in this paper is still optimal even when N is large. Comparison of precision on MovieLens latest with $N = 50$ is shown in Figure 5.

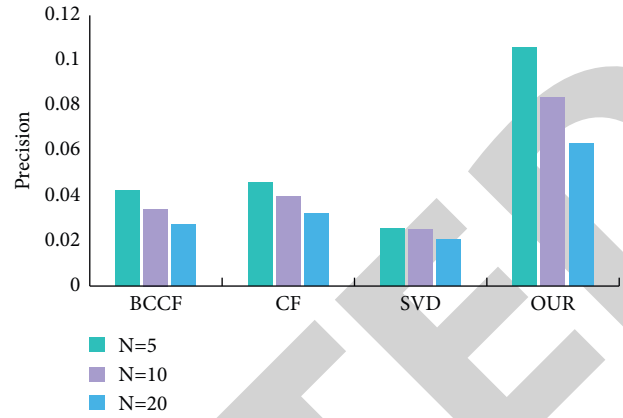

Figure 3: Comparison of precision on MovieLens latest.

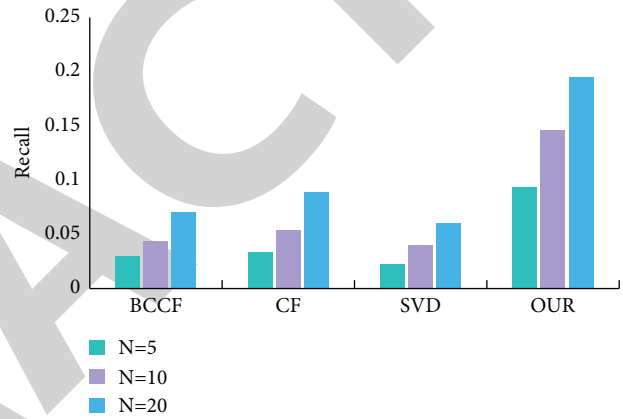

Figure 4: Comparison of recall on MovieLens latest.

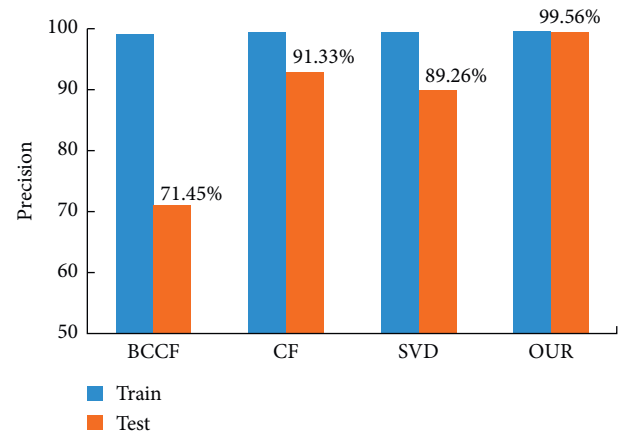

Figure 5: Comparison of precision on MovieLens latest with $N = 50$.

5. Conclusion

With the advent of the Internet era, mobile apps are widely used in the education industry. The biggest advantage of mobile apps is that they have interactive functions.

Educational apps are the product of the combination of mobile Internet technology and education, which can provide more efficient and convenient learning methods for each subject. Based on this, this paper proposes an educational app design method based on collaborative filtering recommendations and explores how to make better use of mobile apps to build an interactive teaching model. At the same time, this paper analyzes and demonstrates the impact of data sparsity and user selection bias on its TopN recommendation, aiming at the problem that the collaborative filtering algorithm based on explicit feedback only considers the existing rating data. In view of this problem, a general collaborative filtering recommendation algorithm framework is proposed, which can effectively alleviate the influence of data sparsity and user selection bias and make the recommendation results more accurate.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

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Retraction

Retracted: Detection Algorithm of Tennis Serve Mistakes Based on Feature Point Trajectory

Advances in Meteorology

Received 13 September 2023; Accepted 13 September 2023; Published 14 September 2023

This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope

(2) Discrepancies in the description of the research reported

(3) Discrepancies between the availability of data and the research described

(4) Inappropriate citations

(5) Incoherent, meaningless and/or irrelevant content included in the article

(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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[1] H. Tang, "Detection Algorithm of Tennis Serve Mistakes Based on Feature Point Trajectory," *Advances in Meteorology*, vol. 2022, Article ID 6584827, 8 pages, 2022.

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Research Article

Detection Algorithm of Tennis Serve Mistakes Based on Feature Point Trajectory

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To address the issue of high recognition error in conventional action error detection methods, this article proposes a game of tennis serve error action detection algorithm based on feature point trajectory. To begin, a feature detection model for tennis serve images is established, followed by segmentation of the tennis serve images' multiscale features. Second, the path of the tennis serving image is effectively corrected, thereby raising the bar for tennis training and competition. Additionally, a visual feature acquisition system for tennis serving action is being developed using remote video monitoring in order to correct the path of the serving image during play. The corner mark of the serving action error point is determined using this algorithm, and the optimal modeling of the tennis serving image's path correction is realized using the developed edge segmentation algorithm. The results of simulations demonstrate that the aforementioned algorithm improves real-time performance and accuracy, and that it can accurately track players' visual edge information feature points while they are serving, conduct real-time evaluation and guidance via an expert system, effectively correct the tennis serving image path, and enhance your capacity for service.

1. Introduction

Tennis as we know it today originated in England in the nineteenth century. Tennis is a beautiful and intense sport that has become increasingly popular throughout the world and is now regarded as the second most popular ball game in the world [1–4]. Tennis serves and receives are critical components of a tennis match's structure. To be considered a good ball, the service must be delivered in the diagonal serving area of the court. The ability to master the serving action in tennis is extremely important for improving one's overall performance in the game. Tennis serving is a difficult technology to master, but it can have a surprising impact on the path correction and optimization of tennis serve images if done correctly. This method of tennis serve image path correction and optimization is extremely important, and it is represented by a diagram [5–11].

A tennis service error recognition model is being developed as a result of the advancement of digital image technology [12], which is combined with image information processing and information recognition technology. To process the image information of tennis service movement, an image information fusion method is used, and a character analysis model of tennis service movement error is established. Image information fusion method using a combination of feature analysis and image edge contour detection, we were able to analyze the error information from a game of tennis serve action and improve the ability of the tennis action feature analysis method [12–14].

In recent years, advances in computer image processing technology have resulted in image acquisition and analysis technology that is based on computer vision analysis and image processing is applied to the acquisition and evaluation of moving scene images, among other applications. A significant amount of progress has been made in sports science and technology in recent years, owing to the advancement of modern electronics, computer science and technology, and other related fields of study [15, 16]. Application of high-tech means to sports training and competition scene judgment can allow for a more in-depth analysis of the movements and technical characteristics of sporting activities. Referees at training and competitions provide accurate data support for

the athletes. The motion range detection method is used for the tennis serve action in the traditional method; however, this method is not applicable to sports items such as the tennis serve action, whose motion range exhibits multidimensional characteristics of landing and rotation [17–25].

Tennis service error recognition methods used in the traditional method are classified into three categories: those based on feature discrimination and reconstruction, those based on joint feature analysis, and those based on multidimensional pixel feature analysis. Create a high-resolution feature analysis model for tennis serve action error recognition and then use multidimensional pixel reconstruction to detect tennis serve action errors during the serve action. On the other hand, the traditional method for tennis serve error recognition has a low capability for feature discrimination and a low capability for detection and recognition, which are both disadvantages of the method. In this regard, a number of enhancements and redesigns have been made to related literature. Several researchers, for example, have proposed a multidimensional feature vector space reconstruction of tennis serve image path correction and optimization modeling method under computer vision, which employs the critical node control method to extract limb features and improve the action's performance [26–28]. The algorithm, on the other hand, requires a significant amount of calculation and has limited applicability. It is also proposed a method for tennis service image path correction and optimization modeling that is based on the positioning of the bottom line hitting position on the tennis service image path [29–35]. The method makes use of fuzzy inference control technology to perform feature analysis and real-time monitoring of the player's service movement, while the computer vision system is integrated with the remote video monitoring system. While this system is susceptible to nonlinear distortion during the visual perception of the technical action characteristics data associated with the tennis serve action, its data collection accuracy is not as high as it could be [36, 37].

This paper proposes an algorithm for detecting tennis serve errors based on the trajectory of feature points, which addresses the issues raised previously. To begin, using remote video monitoring, a visual feature acquisition model of the tennis serve action is constructed. The visual image collected by the data acquisition system is used as a source of information for feature analysis in this paper, and an image processing method is used to design an edge segmentation algorithm for this visual image collection. The tennis serve error action detection method in this paper is based on the corner mark of the serve action's error point. The simulation results demonstrate that the method has superior performance, and an effective conclusion is drawn.

2. Tennis Hitting Technique Theory

This section investigates the serving style of tennis superstar Federer, which will aid us in the development of a tennis serve model in the future, as well as the implementation of the detection of tennis serve errors.

Despite the fact that Federer has been competing in professional men's tennis for more than two decades and has achieved excellent competitive results, particularly as he has progressed through the stages of his career, he is still ranked among the world's top ten players. A combination of scientific training and logistical support keeps it operating at peak performance; on the other hand, its various technologies are constantly being improved and optimized. The serving technology has been sculpted over many years to be simple and practical, as well as beautiful to watch in action and extremely stable. It has the ability to score directly or gain an advantage in the game. As a result, the video clips of Federer's serve from 2019 Wimbledon final were chosen for analysis and the generation of kinematic parameters, and the serve technology was investigated using the kinematic parameters. Provide a technological reference while also improving the overall quality of service.

2.1. An Examination of the Position and Posture. Step-up and platform-style serving positions are the two types of tennis serving positions. The platform-type station technology has the potential to provide greater stability as well as a greater ground level reaction force. In terms of serving stance, Federer prefers to use the platform stance. It is necessary to use a specific method, which is as follows: the left foot is approximately 40 degrees away from the bottom line, the right foot is almost parallel to the bottom line, both feet are in a fixed position, and the distance between the feet is approximately the width of one shoulder. It is possible that Federer's selection of this position will result in increased ground reaction force, improved stability and concealment of the serve, and, as a result, an improved attack of the serve. Different service positions are one of the factors that contribute to the variation in the angle of the left shoulder joint when the ball leaves the hand. When the ball leaves Federer's hand, the angle of his left shoulder joint is 142.8 degrees.

On the top right front of the body, a reasonable tossing position should be established. When the torso rotates around and faces the net in order to swing a forward, it is possible for a ball to land directly in front of the racket, as shown in the image above. When you hit the ball, the body can produce a forward horizontal displacement and lengthen the forward swing, which is why you should hit it forward. It was at this point that Federer's left elbow angle measured 176°, and the height of the ball leaving his hand measured 1.92 m, indicating that his left elbow was fully stretched when throwing the ball and that he was capable of holding the ball horizontally between his knee and his eyes while throwing the ball. At the same time, the standard deviation of the two parameters, the speed with which the ball leaves the hand and the height with which the ball reaches its highest point, is small, which fully demonstrates the stability of the ball's throwing technique.

2.2. The Kinematics of the Knee Bending and Invoking Stages. While Federer completes the throwing motion of the ball, the knee joints of both legs are flexed, the hips are raised in front of the body, and the clap hand rotates around the shoulder joint as its axis of rotation. Drag your arm to one side and then back up to the crown of your head to finish the

entire action of throwing the ball and leading the racket. This position places Federer's clapping arm far away from the body, forming an angle of 85° with the body, and the right elbow angle is 65 percent, allowing him to turn the racquet head easily. The upward thrust of the lower body is the most direct source of tennis serve power on the court. When the extensor muscles of the lower limbs are stretched while in the state of eccentric contraction, the initial length of muscle contraction is increased, and elastic potential energy is stored, allowing for good kinetic energy support for subsequent movements. Federer puts the muscles of the lower limbs in a prestretched state by flexing the knee joint of the lower limb, which makes it easier for the feet to push the ground in the future when the knee joint is flexed. Using the flexion angle of the left and right knee joints, we can see that the left knee is larger than the right knee, indicating that the left leg is responsible for the majority of the body's stability when the knee is flexed in this position.

2.3. Kinematics of the Racket at its Lowest Point. Following the stretching of the legs upwards, the hand holding the racket causes the racket to sag naturally under the action of gravity, and the right elbow and forearm move in the opposite direction, the right elbow moves forward and upward, and the forearm and racket of the racket holding hand move down to make the racket. The head is at its lowest point, resulting in a reverse bow action that extends beyond the apparatus. If you look at the racket at its lowest point, the right elbow angle is 48°, the height of the lowest point of the racket head is 1.2 m, and the height of the body's center of gravity is also 1.2 m at this point. In tennis, the lowest point of the racket head is below the height of the center of gravity, which is called the center of gravity height. The group has been fully elongated in order to increase the explosive contraction force of the muscles in the grouping. The working distance of the racket, on the other hand, can be increased, and a faster swing speed can be achieved by increasing the acceleration distance between the racket and the ball.

2.4. An Examination of the Striking Posture. Federer's upper and lower limbs move towards each other as he hits the ball, and his body transitions from the reverse bow action beyond the equipment to the whipping action of the arm holding the clap hand. When hitting the ball, the speed of each joint is superimposed one after another, and the entire body is concentrated on the head of the racket, allowing the racket to achieve the fastest head speed possible and, as a result, hit the ball at the fastest possible speed at the hitting point. This process resulted in the angle of each joint part of Federer's body gradually increasing, as well as the lower limbs being fully stretched, in order to achieve the forward and upward extension of the torso, which allowed the whipping action of the arm with the clap hand against the ball to be successfully completed. When Federer's body is stretched, the angle of each joint part gradually increases, and the lower limbs can be fully stretched, allowing him to achieve both forward and upward stretching of the trunk, allowing him to complete the whipping action of holding the clap arm. At the moment Federer hit the ball, the left knee angle measured 174° and the right knee angle measured 175°. Each parameter was significantly larger than the other and indicated that the lower limbs were fully extended, which was conducive to the gradual upward transmission of power through the lower limb joints. With a right shoulder angle of 171° and a right elbow angle of 179°, it can be determined that the arm of the racket-holding hand is stretched relatively straight when hitting the ball, which is conducive to hitting the ball at an elevated point, thereby increasing the success rate and aggressiveness of serving.

3. Proposed Method

3.1. Image Information Collection of Tennis Service Ball Path. It is necessary to first construct a tennis visual acquisition model in order to achieve computer vision feature extraction of the tennis serve action. The design method for a remote video monitoring system is used in the development of the visual acquisition model. Compensation prediction can be used to delete unnecessary data from the time domain. The AD converter is used for digital-to-analog conversion of visual features during the transmission and acquisition of tennis serve action during the transmission and acquisition of tennis serve action. The hardware design of the visual feature acquisition system is based on MPEG-4, and the hardware uses the TMS320VC5509A for the main control circuit design of the visual feature acquisition system. With the MUX101 program-controlled switch, you can control two multiplications at the same time, as well as video image transmission. A chip called the AD8021 is used for pipeline operation in order to achieve anti-interference filtering of the video signal. The program-controlled amplifier VCA810 is used in the video acquisition of the tennis ball action, and it is controlled by the digital signal processor (DSP) to control the decoding and reading operands, which is beneficial in ensuring the real-time performance of the digital signal processing. Figure 1 depicts a visual acquisition model of the shape of a tennis serve action during play.

According to the analysis of Figure 1, the visual acquisition model of the tennis serve action body is primarily divided into the sensor signal acquisition module, the clock circuit module, the communication circuit module, the AD sampling module, and the DSP information processing module, among other components. It is primarily the clock generator liquid crystal display module that is included in the DSP module, and it is this module that is responsible for the actual reproduction of the visual characteristics of the tennis ball. Data buffers are implemented using flash and SDRAM.

When the tennis service ball image information is collected and the tennis service image path correction needs to be performed, the characteristics of rotating multidimensional features for the service action are presented for the service action. It is necessary to mark the corners of the error points in order to avoid confusion. It is necessary to use the critical node control method in order to achieve the extraction of limb features in the traditional method.

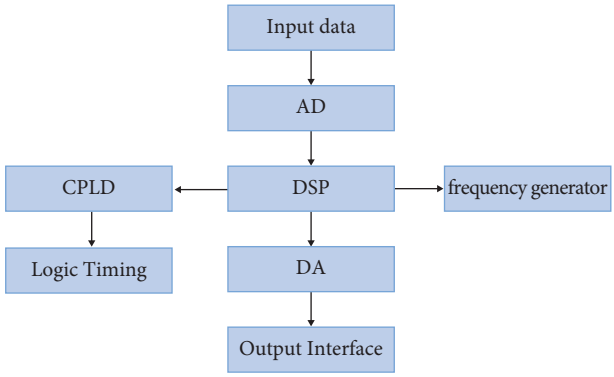


Figure 1: Visual acquisition flow chart.

Completed the path of the service image is corrected, but the error points in the service process are not marked, which reduces the accuracy of the path correction and causes it to be less accurate.

3.2. A Tennis Serve Error Detection Model. It is necessary to design the tennis serve action feature point extraction algorithm on the basis of the visual collection model of tennis serve action data and to combine the coding transformation, quantification, and change of the redundant coding of the predicted difference in order to improve the compression rate of the data stream in order to realize feature analysis. Making a decision on the ball's fault point, implementing the shape correction, and constructing the feature partition model of the edge contour feature point extraction of the shape are all important tasks.

$$P(I) = \alpha v_{id}(t) + \beta\left(p_{id} - x_{id}(t)\right). \tag{1}$$

After the encoder performs quantization and inverse quantization, it is possible to reconstruct the above process. Finally, using the edge contour viewpoint analysis, the communication coding error correction of the visual information feature transmission is accomplished, and the feature collection of the tennis serve action shape is completed. The multicontour 3D model of the tennis service player's multicontour 3D model of the scene modeling perspective switching motion equation is represented by the following equations:

$$\frac{\partial u(x,y)}{\partial t} = k\left[\frac{\partial G_x(x,y)}{\partial x} + \frac{\partial G_y(x,y)}{\partial y}\right]. \tag{2}$$

Various pieces of information, such as the position of the tennis player's body, the angular velocity of the tennis ball, and the rotation angle, are automatically collected by the sensor, and it is assumed that a set of position transformations relative to the root coordinate in the motion coordinate system has been established. For simplicity, let us assume that at time t, the body error of the action range of both the serving and receiving logic control units is

$$\eta = \frac{a}{a+b}\frac{E[D_1 + D_2]}{E[A_1 + A_2]}. \tag{3}$$

And then we have

$$E[D_1] = E[A_1] = \frac{1-p}{p}. \tag{4}$$

The detection model of the tennis serve action image is established in conjunction with the remote information recognition method, and the scale transformation method is used to collect the features of the tennis serve action image, resulting in the sparsity fusion model of the tennis serve action image being obtained. The fusion control function is composed of the following components:

$$F_c = \sum_{i=1}^{n} E_c A_i^c \lfloor r_c(l) - y_c(l) \rfloor, \tag{5}$$

where the edge scale component of the tennis serve action image is represented by the symbol A_i^c in the formula. It is possible to generate the order mixed cumulant of the tennis serve motion image G_{new} using the edge scale feature segmentation approach, which can be stated as

$$G_{\text{new}} = h(j)h^3(j+\lambda)\left(\frac{T^2}{\Delta^2}\right), \tag{6}$$

where $h(j)$ is the feature set. The fourth-order cumulative mixed feature quantity of the tennis serve image H_s is expressed as

$$H_s = -mf_s \sum_{i=1}^{n} (g_l - g_i)R_i. \tag{7}$$

The trend function is denoted by the letter f_s, while the directivity of image features is denoted by the letter g_l. The boundary feature quantity of the video collection image of tennis service action R_i is rebuilt on the basis of the collection results of the points of contour information of the video collection image of tennis service action, which is represented as follows:

$$R_i = 3A_i^3|\tau| \sum_{i=1}^{s} h_i^3(j), \tag{8}$$

where $|\tau|$ represents the frequency of the action and $h(j)$ is the feature set. The multimodal high-frequency components and low-frequency components of the video capture pictures of tennis serve actions are acquired as a consequence of the outcomes of multimodal state detection. It is possible to acquire edge scale information components for tennis serve activities from video capture pictures by combining the multiscale detection results of the video capture images of tennis serve actions with the edge scale information components for tennis serve actions.

$$SNR_i = Kr + \sum_{i=0}^{s} |\tau| A_i^3, \tag{9}$$

where SNR_i denotes the multiscale detection results. Then we have

$$K(a,b) = \sum_{i=0}^{s} h_b^2(j) mKrV. \tag{10}$$

In order to construct the world coordinate systems A and B, it is necessary to first construct the optimal state feature solution of the effect from the waist to the end of the arm, which is as follows:

$$\begin{aligned} &\min F(x) = \left(f_1(x), f_2(x), \ldots, f_m(x)\right)^T, \\ &\text{s.t. } g_i \le 0, \quad i = 1, 2, \ldots, n, \\ &\quad h_j \le 0, \quad j = 1, 2, \ldots, p. \end{aligned} \tag{11}$$

where *s.t.* denotes the condition.

This paper uses the visual image acquired by the data acquisition system as an information source for feature analysis, and the image processing technique is employed to create an edge segmentation algorithm for this visual image collection. The following is a description of the modified and optimized models, as well as the better design of the algorithm. The sensor g_c is used to automatically capture information about the player's body during the tennis serve motion, such as the player's location, angular velocity, and rotation angle of the body. The rectangular image blocks N_0 and N_1 represent the visual regions holding edges and action information in plenty, and the viewpoint switching motion equation of the serving action is built, which is then used to calculate the speed of the serving action.

$$\text{image}F = [\text{quater}(R)] \times \left[\text{quater}(Q_i) \times W_{ij}\right] - W_{ij}, \tag{12}$$

where image$F$ is viewpoint switching motion.

As a consequence, the optimization of the mistake recognition of the tennis serve action is accomplished in accordance with the picture segmentation results obtained. Figure 2 depicts the process of putting the plan into action.

4. Experiment Results

Experiments are carried out in order to evaluate the performance of the tennis serve error detection algorithm developed in this work, which is based on the feature point trajectory proposed in this study. The picture has a resolution of 560 by 480 pixels. When 100 test samples in each mode are included in a set of simulation data, a total of 100 8 test sets are created, and 20 and 50 of the 100 training samples in each mode are chosen at random from each set of simulation data. Alternatively, all 100 of them combine to generate a training set of 20×8, 50×8, and 100×8 samples, if appropriate.

Figure 3 depicts the initial collection of tennis serve action diagram, which is compiled over time. The serving action of tennis can be divided into throwing and hitting actions. We use professional sports cameras to record the standard serving actions of professional athletes.

It is possible to accomplish the error recognition of tennis serve action by using the image in Figure 3 as the study object, as shown in Figure 4. The image error recognition result is presented in Figure 4.

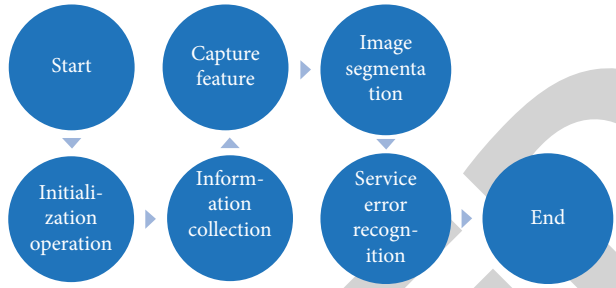
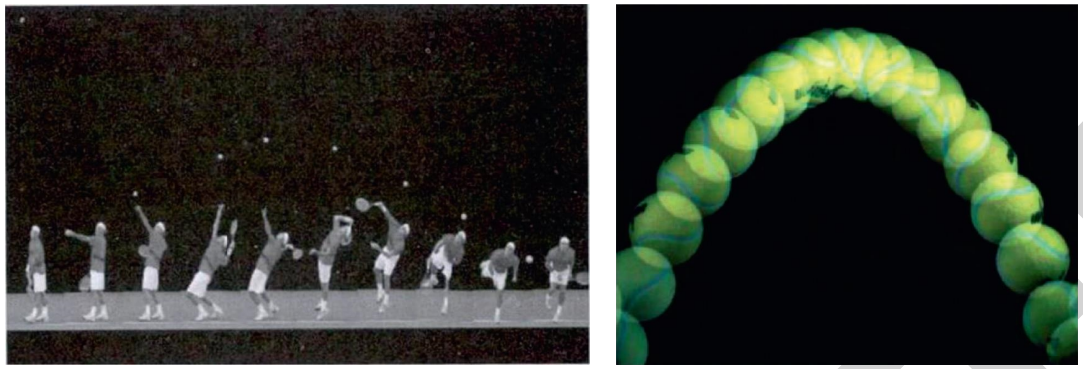


Figure 2: Algorithm flow.

Figure 3: Original tennis serve action.

Figure 4: Image error recognition result.

The image processing method is used to segment the edge of the gathered visual image, and it is on the basis of this that the corner points of the serve action error spots are identified, and the process of tennis serve image path correction optimization



(a) (b)

Figure 5: Correction results. (a) Tennis serve action correction results. (b) Tennis track.

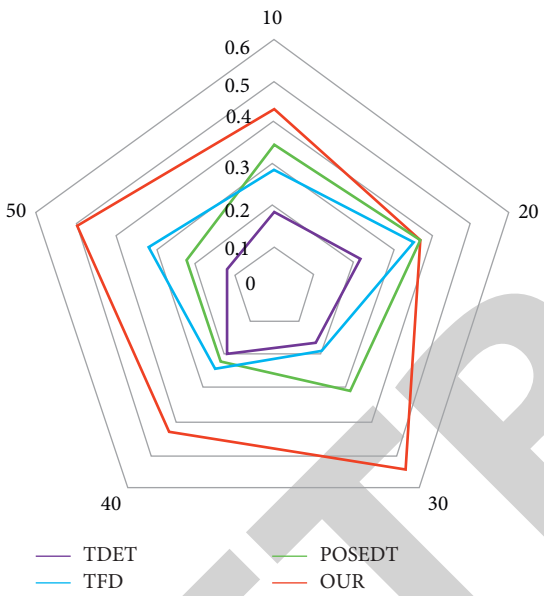


Figure 6: Comparison of the correct rate of service error detection by different algorithms.

and correction is carried out. According to the results reported in Figure 4, the rectified output is depicted in Figure 5. As shown in Figure 5, the approach described in this research is utilized to rectify the action shape of the tennis serving action in real time and with high precision, resulting in higher performance and real-time accuracy, providing tips and coaching, correcting improper serve trajectories, and improving serving capabilities.

Figure 6 depicts the results of a comparison between the improved method suggested in this article and the TDET, TFD, and POSEDT algorithms, respectively. It can be observed that the detection accuracy of this algorithm is substantially superior to the accuracy of the other three methods in this comparison.

5. Conclusion

This paper proposes a tennis serve error detection algorithm based on the trajectory of feature points. First, an error recognition model of tennis serve action is constructed, and the image information fusion method is used to process image information of tennis serve action. Second, through adaptive learning and scale transformation method, joint feature point location and fuzzy action of tennis serve action video captured images are carried out. Feature detection to realize the optimization of tennis serves error recognition. Finally, the expert system is used for real-time evaluation and guidance, which can effectively correct the tennis serve mistakes. The research shows that the method in this paper has a higher accuracy rate and better recognition performance for tennis serve error detection. In the future, we will apply the technique of this paper to other ball sports, such as badminton and table tennis.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares that he has no conflicts of interest.

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Retraction

Retracted: Automatic Capture Processing Method of Basketball Shooting Trajectory Based on Background Elimination Technology

Advances in Meteorology

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

In addition, our investigation has also shown that one or more of the following human-subject reporting requirements has not been met in this article: ethical approval by an Institutional Review Board (IRB) committee or equivalent, patient/participant consent to participate, and/or agreement to publish patient/participant details (where relevant).

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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[1] H. Fan, Y. Hu, and J. Zhang, "Automatic Capture Processing Method of Basketball Shooting Trajectory Based on Background Elimination Technology," *Advances in Meteorology*, vol. 2022, Article ID 7884528, 8 pages, 2022.

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Research Article

Automatic Capture Processing Method of Basketball Shooting Trajectory Based on Background Elimination Technology

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The analysis and prediction of the shooting trajectory can be used to partially correct the shooting. The traditional automatic basketball shooting trajectory capture algorithm has a low capture accuracy and a long capture time, and thus is incapable of displaying the shooting trajectory in real time. To address this issue, this study proposes an automatic basketball shooting trajectory capture algorithm based on background elimination. The image of the basketball shooting trajectory is captured using imaging technology; the image is then preprocessed in four steps: binary erosion, binary expansion, closing operation, and opening operation to create a smooth image. After removing the background from the preprocessed image using the background difference method, the edge contour features are extracted, the candidate target area is set based on the extraction result, and a diagonal matrix reflecting the length and width of the trajectory target is introduced to calculate the probability of the color of the area in the shooting trajectory, thereby characterizing the trajectory. The target's size changes in two directions to capture the basketball shooting trajectory automatically. The algorithm's simulation results indicate that it has a higher accuracy and a shorter capture time.

1. Introduction

Basketball is one of the most popular sports in the world. It has been introduced into China for more than a hundred years. Every year, the number of people participating in basketball in China has been increasing. The big reason is that compared with other sports, basketball has the characteristics of convenience and simplicity. Several people can carry out activities with one ball. In addition, basketball is not only a high-intensity competitive sport with antagonism and intensity, but also an ornamental fitness leisure sports [1]. Participating in basketball can not only strengthen the body but also cultivate responsiveness and flexibility. It can also establish multiperson mutual cooperation and a collective sense of honor. It is a sport suitable for men, women, young, and old. In a basketball game, the most important thing is the score, and the only way to score is shooting. There are many ways of shooting, which also need to vary from person to person. The conventional shooting methods include one hand low hand layup, one hand shoulder shot (jump shot), two hand shot, etc. Among these various shooting methods, the most basic and stable shooting method is one hand shoulder shooting [2]. One hand shoulder shooting is the basic shooting method . It is not only the most commonly used shooting method of basketball players, but also the most widely used by basketball participants. Since one hand shoulder shot has the characteristics of good stability and high accuracy, it is suitable for people who have just come into contact with basketball or those who often play basketball to learn to use one hand shoulder shot. In the world of basketball, no matter how new shooting moves appear and change, one hand shoulder shooting has always been irreplaceable. Whether we can win in the game depends on the final score of the game, and the number of scores is first linked to the number of shots, but the main guarantee is the shooting hit rate. The most direct application of the technical action of one hand shoulder shot in place in the game is reflected through the free throw, although in the formal basketball game, the shooting hit rate of athletes is affected by many factors, such as the

psychological quality of athletes, the competitive state at that time, the physical level, and the defensive strength of opponents [3]. But only the technical action factor is the most fundamental factor affecting the shooting percentage. Therefore, if athletes want to improve their shooting hit rate, get more scores and reflect their sports value, they must master and be able to use correct shooting techniques in various complex competition environments. In the process of basketball shooting, the shooting trajectory exists as a parabola. Therefore, it is necessary to automatically capture the basketball shooting trajectory and obtain the characteristic data of basketball shooting action, so as to lay a foundation for the improvement of players' technical level in shooting [4].

Reference [5] proposes a human motion space trajectory tracking algorithm based on an inertial sensor. The algorithm acquires real-time limb attitude information via an inertial sensor unit worn at the human joint point. Accelerometer, angular velocity sensor, and magnetometer comprise the inertial sensor. The microcontroller acquires sensor data and updates the quaternion using a low-pass filter and a Kalman filter. The Bluetooth module then transmits the preprocessed data to the computer in real time. It is demonstrated that the inertial sensor can track the spatial trajectory of human limb movement through experiments with various angles of limb movement. Based on binocular vision, reference [6] proposed an algorithm for determining the object's position and predicting its motion trajectory. Calibration, image preprocessing, target capture, feature matching, and three-dimensional reconstruction can be used to obtain more precise position coordinates for a moving object over a time interval, and the motion trajectory can be fitted with a polynomial.

The binocular camera's historical position coordinates are substituted into the polynomial to predict the position of the moving object the next time. The experimental results demonstrate that the algorithm is capable of rapidly calculating the position coordinates of a moving object and accurately predicting the position coordinates of the object at a later time, indicating that it has a high degree of universality and flexibility. However, the accuracy of the two methods mentioned above is low, resulting in a low capture effect. Reference [7] proposed an improved elm-based algorithm for tracking pole jump trajectory. To improve the accuracy, the limit learning machine is first regularized using structural risk minimization theory, and then the hidden layer parameters are optimized using the global optimization capability of the differential evolution algorithm. Finally, a model for pole jumps is established. Pole jump's experimental results demonstrate that the algorithm is capable of effectively overcoming the disadvantage of overfitting in limit learning machines and has a higher capacity for generalization. The simulation results demonstrate the effectiveness of the method. Reference [8] proposes an algorithm for capturing object motion data using an optical motion capture system. To begin, a fixed model is constructed using three-marker points to obtain the instantaneous coordinates of the corresponding marker points during object motion, and then the vector method is used to solve the object pose corresponding to each acquisition point of the measured object during object motion. The Kalman filter method is then used to eliminate the influence of system and environmental errors during the motion capture process to obtain a smooth object pose motion trajectory, and to calculate the object's velocity, acceleration, angular velocity, and angular acceleration at each acquisition point using the filtered data. Finally, an experiment is conducted to collect data on object motion using the cooperative robot. The proposed method for capturing object motion data is validated. However, the above two algorithms require a significant amount of time for automatic motion trajectory capture, resulting in a low motion trajectory capture efficiency.

In light of the shortcomings of the preceding algorithms, this article proposes an automatic basketball shooting trajectory capture algorithm based on background elimination and validates the algorithm's effectiveness and timeliness via simulation experiments. It not only addresses the shortcomings of the traditional algorithm, but also lays the groundwork for increasing the shooting hit rate in basketball.

2. Automatic Capture Algorithm of Basketball Shooting Trajectory Based on Background Elimination

2.1. Image Acquisition of Basketball Shooting Trajectory. In order to better complete the automatic capture of basketball shooting trajectory, it is necessary to collect the image data of basketball shooting trajectory in advance and complete the visual acquisition of basketball shooting trajectory according to imaging technology [9].

To represent the frame difference of the visual collection image of the basketball shooting track, $w$was set; p represents discrete sampling probability, then the edge information of single frame basketball shooting track image in T time is $L(x)$, and the calculation process is shown in formula.

$$L(x) = \left(l_1(x), l_2(x), \ldots, l_m(x)\right)^T. \tag{1}$$

In the sampling process of imaging sequence, it is assumed that q represents the high-frequency part of basketball shooting trajectory. In the imaging space, the binary image ρ of basketball shooting trajectory is obtained by using the spatial feature decomposition method, i.e.

$$\rho = L(x)(xc - y)^2 + pwq, \tag{2}$$

where, x and y represent the coordinates of image pixels and c represents image texture features. The texture data feature transmission model is built in the basketball shooting trajectory image, as shown in the formula

$$c(x, y) = \sum_i \rho\left[R(x_i, y_i) - R(x_i + p, y_i + q)\right]^2, \tag{3}$$

where, p and q describe the spatial position distribution probability function of basketball shooting trajectory image; x_i. y_i describes the spatial coordinate points of basketball

shooting trajectory; i represents the number of image pixels; R represents the foreground image. The pixel space is reconstructed according to formula (3), and scale decomposition and information data fusion operations are performed on the jumping action background image B and foreground image R, so as to obtain the basketball shooting track image distribution model [10], and then segment the basketball shooting track distribution module to obtain $(B/2) \times (R/2)$ the submodule. Then, the image data acquisition results of the basketball shooting track are as follows:

$$\begin{aligned} x' &= t \cos \phi \cos \varphi, \\ y' &= t \sin \phi, \\ z' &= -t \cos \phi \sin \varphi, \\ o' &= \omega_y \sin \gamma + \omega_z \cos \varepsilon, \end{aligned} \tag{4}$$

where, x', y', z', o' represents the collected image data of basketball shooting trajectory respectively; ε represents fused image information; ϕ represents the included angle of trajectory points; t represents the distribution characteristic results of some information feature points of basketball shooting trajectory [11].

2.2. Image Pre-Processing of Basketball Shooting Trajectory. Since the basketball shooting track image will be disturbed by the outside world during the acquisition process, resulting in cracks and unevenness in the basketball shooting track image, this article uses the morphological method to preprocess the collected basketball shooting track image, including binary corrosion, binary expansion, closed operation, open operation, and other steps [12].

2.2.1. Binary Corrosion. Corrosion and expansion are the two most basic mathematical morphology methods in morphological operation. All other morphological algorithms are based on the composite form of these two basic operations. Firstly, the corrosion of basketball shooting trajectory image is introduced. The main function of corrosion is to shrink the image on the basis of maintaining the edge contour of the original basketball shooting track image. This method can not only remove the impurities smaller than the structural elements in the basketball shooting track image, but also separate two objects with only a small connection [13].

For a given basketball shooting track image A and structural element B, the structural element B is used to corrode the binary basketball shooting track image A, which can be expressed by $A \Theta B$. The mathematical expression is defined as follows:

$$A \Theta B = \{z | (B)_z \in A\} \tag{5}$$

In the above formula, the structural element B originally located at the origin of the basketball shooting track image is moved in the whole Z^2 plane. If B can be completely included in A when the origin of B is translated to point Z.

2.2.2. Binary Expansion. The algorithm corresponding to binary corrosion is binary expansion, and binary expansion is also one of the most basic morphological methods. The principle of expansion is to expand the binary image on the basis of maintaining the original basketball shooting track image through structural elements [14]. The main function of expansion is to fill the gaps or holes in the binary basketball shooting trajectory image. At the same time, the isolated noise points in the binary image can be eliminated by expansion operation.

The structural element B is used to expand the basketball shooting track image A, which is represented by $A \oplus B$. The mathematical expression is defined as follows:

$$A \oplus B = \{z | (B')_z \cap A \neq \varnothing\}. \tag{6}$$

Assuming that there is a structural element B located at the original point of the basketball shooting track image, let B move on the Z^2 plane in the whole basketball shooting track image. When its own origin is translated to point Z, B overlaps at least one pixel of its own origin mapping $B\prime$ and basketball shooting track image A, Then all such B points in the basketball shooting trajectory image form a set, which is called the expansion operation of B to A [15].

2.2.3. Open Operation. If we want to smooth the object contour in the binary basketball shooting trajectory image, we can use the open operation of morphology [16]. Corrosion and expansion operations are not mutually inverse operations. In practical applications, corrosion and expansion operations often need to be combined to achieve the desired purpose. Then, the structural element is used to corrode the binary basketball shooting track image, and then the same structural element is used for the expansion operation. This method is called open operation [15].

For the binary basketball shooting track image A and structural element B, the mathematical representation method is $A \circ B$ and the specific expression is as follows:

$$A \circ B = (A \Theta B) \oplus B. \tag{7}$$

2.2.4. Closed Operation. To eliminate the small cracks or holes in the binary basketball shooting trajectory image, the closed operation in morphology can be used. Closed operation can not only connect the disconnected adjacent targets in the binary basketball shooting trajectory image, but also smooth the contour in the basketball shooting trajectory image.

The closed and open operations of morphology are dual operations. The operation process of closed operation is just opposite to that of open operation. This method first expands the binary basketball shooting track image and then corrodes the image [17]. The definition is as follows:

$$A \bullet B = (A \oplus B) \Theta B, \tag{8}$$

where, B represents the structural element, A represents the image, $A \bullet B$ represents B, and the image A is closed.

2.3. Background Elimination of Basketball Shooting Trajectory Image Based on Background Difference Method. The background difference method is used to eliminate the background of the preprocessed basketball shooting track image, the pixel points are classified by using the gray difference of the corresponding pixel points between different frame images, and the average value of the classified pixel points is taken as the background pixel value. The background difference method does not need to establish a separate model for the background and target in the scene, but directly reconstructs the background model for the scene containing moving targets. Selecting appropriate parameters can effectively avoid the mixing phenomenon so as to achieve a robust background image [18].

2.3.1. Pixel Classification. For the basketball shooting track image sequence, each pixel value of the frame basketball shooting track image was collected and it was obtained that $x_i(m)$ and m represent the value of the -th pixel in the i-th frame image. The m-th pixel value is calculated as follows:

$$p_i(m,q) = \begin{cases} 1, & \text{if } p_i(m,q-1) = 0, \\ & \left|x_i(m) - x_j(m)\right| \le T1, \\ 0, & \text{otherwise.} \end{cases} \tag{9}$$

First, $p_i(m,0)$ with an initial value of 0 is initialized. $T1$ determines whether the two pixel values are the threshold of the same class, and q is the mark of each class. If $p_i(m,q) = 1$, the gray values of $x_i(m)$ and $x_j(m)$ are similar, and it is judged to be the same class; otherwise, it is not the same kind.

2.3.2. Determines the Background Pixel Value. Class s can be obtained by pixel classification, and the number of pixels contained in each class is recorded as $(l_1, l_2, \ldots, l_s)$, then:

$$\sum_{p=1}^{s} l_s = N. \tag{10}$$

The number of pixels of class q and the corresponding average gray values are:

$$\begin{aligned} I_q(m) &= \sum_{i=1}^{N} p_q(m,q), \\ r_q(m) &= \frac{\sum_{i=1}^{N} x_i(m) p_i(m,q)}{l_q(m)}, \end{aligned} \tag{11}$$

where, $r_q(m)$ is the average gray value of all classes determined. Suppose class q is the background class, then there is $I_q(m) = \max(l_1, l_2, \ldots, l_s)$.

Through the above steps, the background image can be reconstructed from the image sequence with basketball shooting track.

Since the background will be affected by the sudden change of light and the stopping of moving objects in the background, the background is not static. The background image is always subtracted from the current frame. It is found that the effect is not ideal, so it is necessary to update the background. At present, the commonly used background updates are: real-time background update and regular update. Real time background update can meet the slow changing environment of light, while regular update can meet the sudden change of light and the change of background structure.

Real time background update: the pixel value of a point in the current frame with the background pixel value of the previous frame is compared to determine whether to update the background pixel. The calculation formula is:

$$B_i(m) = \begin{cases} B_i(m) * A + B_{i-1}(m) * (1-a), & \text{if } \left|x_i(m) - B_{i-1}(m)\right| \le T2, \\ B_{i-1}(m), & \text{otherwise,} \end{cases} \tag{12}$$

Where, $T2$ is the threshold for judging whether to update, $x_i(m)$ is the pixel value of point m in the previous i frame, $B_{i-1}(m)$ is the background pixel value of point m in the previous frame, a is the learning rate. The closer a is to 0, the slower the background update speed is, and the closer h is to 1, the faster the background update speed is.

2.4. Edge Contour Feature Extraction of Basketball Shooting Trajectory Image. Edge contour feature extraction on the above obtained target image is carried out, the image fusion model of basketball player's shooting trajectory is established, the state vector $x(t)$ of basketball shooting action feature is extracted and located, one-step or n-step prediction on the basketball shooting action image with k_1 and k_2 as the optimization coefficients is made, the feature quantity of basketball shooting action at time k is calculated, and the quantitative coding method is adopted. The output pixel feature quantity is $m_j\,(j = 1, 2, \ldots, m)\,\forall\, m_j \in M$ and the scale decomposition is carried out according to the sample similarity. Under the constraint of scale coefficient α, the likelihood function $W(k)$ of the edge contour distribution of basketball player shooting image is expressed as:

$$W(k) = \frac{Nc(x,y)\alpha k_1 m_j}{B_i(m) Q(k) k_2}, \tag{13}$$

where, $Q(k)$ is the gray vector information covariance of basketball player's shooting image. Combined with the gray pixel feature extraction method, the edge contour feature of basketball shooting track image is extracted and the fuzzy correlation feature component a, b, c, d of basketball player shooting motion image is expressed as:

$$\begin{cases} a = f_1 - u, \\ b = f_2 - u, \\ c = f_3 - u, \\ d = u. \end{cases} \tag{14}$$

Among them, u is the distribution scale of the contour curve, and the statistical shape models of basketball players' shooting images are f_1, f_2, f_3 respectively.

2.5. Automatic Capture of Basketball Shooting Trajectory. According to the edge contour features of the basketball shooting track image extracted above, the basketball shooting track is automatically captured. The candidate target area is set, a diagonal matrix that can reflect the length and width of the track target is introduced, and the probability of the area color in the shooting track is calculated, so as to characterize the change of the track target size in two directions and realize the automatic capture of the basketball shooting track.

Suppose that r_t represents the point set of the basketball arm shooting trajectory in the image, and the regional coordinates have been adjusted to take 0 as the center and have been normalized according to the regional size (l_x, l_y). The function $m$is set for each pixel value x_i and $m(x_i)$ is the pixel color value. Through epanechnikov kernel, the occurrence probability of area color e in shooting trajectory can be expressed as:

$$S_A = \frac{Z\sum_{i=1}^{n} r_t \delta[m(x_i) - e]}{S(i,j)W(k)}. \tag{15}$$

In (15), Z represents the normalization function and δ represents the Kronecker function.

It is assumed that the candidate trajectory target is r_t with y as the center. The probability expression of area color e in shooting trajectory can be expressed as:

$$p_u(y) = \frac{Z_i \sum_{i=1}^{n_h}\left(K^{-1}\left\|(y - x_i)\right\|^2 e\right)}{S_A S(i,j)}, \tag{16}$$

where Z_i represents the normalization factor and K represents the diagonal matrix, and its expression is:

$$K = p_u(y)\left[l_1^2, l_2^2\right] \tag{17}$$

where l_1 and l_2 represent the length and width of the trajectory respectively.

According to the above calculation and analysis, the similarity between the trajectory target and the candidate target is described by the Babbitt distance coefficient. The expression of Babbitt distance coefficient is shown in (18), and the distance between them is shown in (19):

$$\rho(y) = \sum_{u=1}^{m}\sqrt{\rho(y)\cdot q_u}, \tag{18}$$

$$d(y) = \sqrt{1 - \rho[p_u(y), q]}. \tag{19}$$

The larger the coefficient value, the smaller the distance value, that is, the higher the similarity between the trajectory target and the candidate target.

To sum up, the automatic capture of basketball shooting trajectory is to retrieve the new position corresponding to the target in the current frame, which can minimize the distance value with y as the independent variable. The retrieval starts from the target of the previous frame and queries in its neighborhood. Assuming that the target position in the previous frame is y_0, $\rho[p_u(y), q]$ at the target prediction position y_0 of the shooting track is expanded and the obtained linear approximation of $\rho[p_u(y), q]$ can be expressed as:

$$\rho[p_u(y), q] \approx \frac{1}{2}\sum_{u=1}^{m}\sqrt{p_u(y_0)\cdot q_u} + \frac{1}{2}\sum_{u=1}^{m} p_u(y)\sqrt{\frac{q_u}{p_u(y_0)}}. \tag{20}$$

Substituting (16) into (20) can obtain:

$$\rho[p(y), q] \approx \frac{1}{2}\sum_{u=1}^{m}\sqrt{p_u(y_0)\cdot q_u} + \frac{C_H}{2}\sum_{i=1}^{n_h} w_i\left(\left\|K^{-1}(y - x_i)\right\|^2\right). \tag{21}$$

In (21), w_i represents the weighted value. According to (21), the maximum value of this density evaluation within the neighborhood can be retrieved according to mean shift. In the whole process, the core moves from the current position y_0 to the new position y_1:

$$y_1 = \frac{\sum_{i=1}^{n_h} x_i w_i\left(\left\|K^{-1}(y - x_i)\right\|^2\right)}{\sum_{i=1}^{n_h} w_i\left(\left\|K^{-1}(y - x_i)\right\|^2\right)}\rho[p(y), q]. \tag{22}$$

By iterating the above process and constantly updating the shooting track target, the automatic capture result of basketball shooting track can be defined as:

$$Y = \left(y_0, y_1, \ldots, y_{n_0}\right) \tag{23}$$

In (23), Y represents the set of track pixels.

3. Simulation Experiment Analysis

To verify the effectiveness of the basketball shooting trajectory automatic capture algorithm based on background elimination in practical application, a simulation experiment is carried out. The hardware and software operating environment selected for the experiment are shown in Tables 1 and 2.

In this article, male and female basketball players are selected as the experimental objects to shoot respectively, and the automatic capture algorithm of basketball shooting trajectory based on background elimination proposed in this article. The human motion space trajectory tracking algorithm based on inertial sensor proposed in literature [5] and the algorithm of determining object position and predicting motion trajectory based on binocular vision proposed in literature [6] are adopted and the automatic capture algorithm of basketball shooting trajectory is carried out. The details of male and female basketball players are shown in Table 3.

For the sample number of basketball players' shooting motion images, 1200 groups of images are selected as the test set in the basketball players' shooting motion auxiliary training system. The test sample set size of basketball players' shooting motion images is 800, the training sample set is 120, the video feature sampling time of basketball shooting motion features is $T = 0.04s$, and the image gray average value is $\Delta = 2.5$. The image edge contour detection

Table 1: Experimental hardware and software environment.

Operating system	R&D software
Windows Win10	Microsoft visual studio 2010 OpenCV3.4 LIBSVM-3.21
Ubuntu	GCC and G++ OpenCV3.4

Table 2: PC related parameters.

CPU	Intel Pentium dual core T4500
Dominant frequency	2.3 GHz
Memory	4.00 G
USB interface	4.0

Table 3: Details of male and female basketball players.

Project	Details
Number of male athletes/person	50
Number of female athletes/person	50
Height range of male athletes/cm	177–192
Height range of female athletes/cm	173–187
Weight range of male athletes/kg	67–83
Weight range of female athletes/kg	54–73

coefficient is 0.67. According to the above simulation environment and parameter settings, the basketball player's shooting trajectory is extracted. The original player's shooting motion image is shown in Figure 1.

The morphological method is used to preprocess the collected basketball shooting trajectory image, and the binary image is obtained, as shown in Figure 2.

According to the analysis of Figure 2, the basketball shooting trajectory automatic capture algorithm based on background elimination proposed in this study can effectively and accurately process the basketball shooting trajectory.

To verify the effectiveness of this algorithm, the automatic capture algorithm of basketball shooting trajectory based on background elimination proposed in this article, the human motion space trajectory tracking algorithm based on inertial sensor proposed in literature [5] and the algorithm of determining object position and predicting motion trajectory based on binocular vision proposed in literature [6] are used to compare and analyze the automatic capture accuracy of basketball shooting trajectory, The comparison results are shown in Figure 3.

According to Figure 3, the accuracy of basketball shooting trajectory automatic capture algorithm based on background elimination proposed in this article can reach 100%, while the accuracy of basketball shooting trajectory automatic capture algorithm based on inertial sensor proposed in literature [5] is only 86%, and in literature [6], the proposed algorithm of determining object position and predicting motion trajectory based on binocular vision has the highest accuracy of only 80%. The automatic basketball shooting trajectory capture algorithm based on background

Figure 1: Original shooting image of athletes.

Figure 2: Image processing results.

elimination proposed in this article has the highest accuracy and the best trajectory capture effect.

To further verify the effectiveness of this algorithm, the automatic capture algorithm of basketball shooting trajectory based on background elimination proposed in this article, the human motion space trajectory tracking algorithm based on inertial sensor proposed in literature [5] and the algorithm of determining object position and predicting motion trajectory based on binocular vision proposed in literature [6] are adopted. The automatic capture time of basketball shooting trajectory is compared and analyzed, and the comparison results are shown in Table 4.

According to the data in Table 4, the time consumed by the automatic basketball shooting trajectory capture algorithm based on background elimination proposed in this article for automatic basketball shooting trajectory capture is within 8.92 s, and the time consumed by the human motion space trajectory tracking algorithm based on inertial sensor proposed in [5] for automatic basketball shooting trajectory

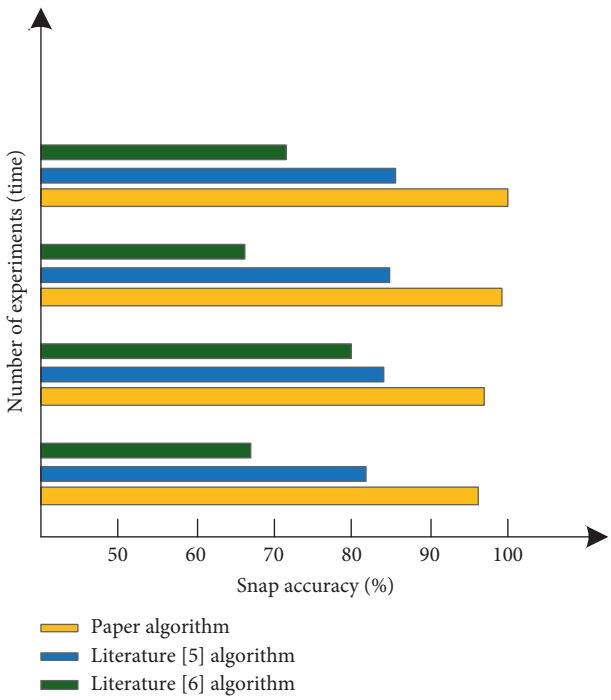

Figure 3: Comparison results of automatic capture accuracy of basketball shooting trajectory with different algorithms.

Table 4: Comparison results of automatic capture time of basketball shooting trajectory of three algorithms/s.

Number of experiments/time	Paper algorithm	Literature [5] algorithm	Literature [6] algorithm
10	8.12	15.12	18.22
20	8.22	15.36	18.63
30	8.30	15.99	19.10
40	8.42	16.95	19.11
50	8.51	17.22	19.89
60	8.66	17.88	20.25
70	8.70	18.22	23.42
80	8.72	18.55	23.85
90	8.83	19.22	24.56
100	8.92	20.00	25.58

capture is within 20.00 s, and in [6], the time consumed by the proposed algorithm of determining object position and predicting motion trajectory based on binocular vision for automatic capture of basketball shooting trajectory is within 25.58 s. The time consumed by the automatic capture algorithm of basketball shooting trajectory based on background elimination is the shortest and the efficiency of automatic capture of basketball shooting trajectory is the highest.

4. Conclusion

In China, as the level of computer science and technology continues to improve, subjects such as target image tracking and human dynamics have enabled the analysis and collection of basketball shooting action characteristic data, which has become a core subject of contemporary sports and computer application disciplines. The number of shooting scores determines the outcome of a shooting game. It is critical to master shooting technology and to constantly improve one's shooting percentage in the game. However, based on incomplete statistics, there are obvious differences in shooting ability between foreign excellent players and Chinese players, particularly a group of excellent players led by Kobe Bryant and Michael Jordan, whose hand hip following action is very obvious, whereas domestic basketball players' hand hip following action is subtle or nonexistent. In this case, tracking the basketball shooting trajectory and accurately correcting shooting deviation has become a significant impediment to the development of domestic basketball technology, attracting the attention of numerous experts and scholars. With the rapid development of basketball, and subsequent shooting of players during competition, motion capture of basketball trajectory has presented numerous challenges due to the uniqueness of its motion characteristics. The trajectory is frequently incomplete during the capture process, resulting in the low capture accuracy of basketball shooting trajectory. As a result, this article proposes an automatic basketball shooting trajectory capture algorithm based on background elimination. This algorithm can significantly improve the accuracy of trajectory capture. Following its widespread adoption and application, it has been shown to significantly improve the trajectory capture effect in basketball.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Retraction

Retracted: Evaluation Model of Eco-Environmental Economic Benefit Based on the Fuzzy Algorithm

Advances in Meteorology

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope

(2) Discrepancies in the description of the research reported

(3) Discrepancies between the availability of data and the research described

(4) Inappropriate citations

(5) Incoherent, meaningless and/or irrelevant content included in the article

(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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[1] M. Gao and X. Lu, "Evaluation Model of Eco-Environmental Economic Benefit Based on the Fuzzy Algorithm," *Advances in Meteorology*, vol. 2022, Article ID 4161723, 9 pages, 2022.

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Research Article

Evaluation Model of Eco-Environmental Economic Benefit Based on the Fuzzy Algorithm

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With the development of an ecological civilization gaining increasing attention in our country, an analysis of the environmental and economic impacts of all aspects of life has been developed gradually. However, because the study on the environmental and economic benefits of the tailwater diversion project is a weak link, the discussion on the environmental and economic benefits of the tailwater diversion project is novel. The variable fuzzy evaluation model is used to evaluate the comprehensive environmental and economic benefits of tailwater diversion engineering, in order to facilitate the exploration and application of tailwater diversion engineering. Simultaneously, by evaluating the method using the analytic hierarchy process and fuzzy optimum seeking method, linear comprehensive fuzzy optimization, average comprehensive fuzzy optimization, and variable fuzzy pattern recognition model of optimizing method, the results demonstrate that the method not only can be used to plan optimization but can also provide a good evaluation for each program, the result is reasonable and reliable, and applicable to the comprehensive benefits of water resource management.

1. Introduction

With the development of China's national economy, the degree of damage to the natural environment is deepening, which seriously violates the principle of sustainable development and people's growing material and cultural needs. However, in the new era, the economic development has also brought about a change in people's ideas, and the importance of environmental quality has been constantly improved. Especially in the construction process of water conservancy and hydropower projects, for the ecological environment, is undoubtedly a double-edged sword, in improving the surrounding microclimate at the same time, ecological destruction is inevitable. Therefore, it is of great significance to evaluate the ecological environment impact of hydraulic engineering.

From the definition of academic circles at home and abroad, the so-called "ecological dispatching" refers to the comprehensive reservoir dispatching mode that gives consideration to ecology. Criphin [1] mentioned that ecological dispatching means that reservoirs should meet both human's demand for water resources and the demand for water of the ecosystem as much as possible. Wang et al. believes that ecological operation is the optimal ecological benefit of reservoir while exerting various economic and social benefits, which is aimed at the ecological problems in macroscopic water resources allocation and operation. Dong et al. [2] put forward the "multiobjective ecological operation of reservoirs", that is, the operation mode of reservoirs taking into account the demands of river ecosystems on the premise of realizing the socio-economic objectives of flood control, power generation, water supply, irrigation, and shipping. However, the ecological benefits of reservoirs are often restricted by social and economic benefits. Therefore, ecological dispatching is the result of mutual optimization and balance between ecological environmental interests and social economic interests in a certain period. Under the current situation, we should coordinate flood control, prosperity, and ecology. While realizing social development and flood control safety, we should reduce the negative

impact of reservoirs and gradually restore the ecosystem. Under the condition of protecting the ecological health of rivers, rational exploitation and utilization can promote the harmony between human and water and realize the sustainable development of resources and environment. It is predicted that in the near future, reservoir ecological operation will be a balanced optimal operation problem with flood control as the constraint and river health as the objective, and the objective will be achieved by coordinating various profit factors.

Water conservancy workers have made some explorations in bringing the ecological functions of reservoirs into full play and alleviating the adverse effects of reservoirs on the ecological environment. Jia et al. [3] discussed the relationship between reservoir operation and nutrient reduction. Fu et al. [4] advocated the combination of hydrology and ecology. Yu et al. [5] proposed that ecological storage capacity should be established in order to maintain appropriate river flow, and the ecological storage capacity of Haizi Reservoir in Daxi, Xinjiang was calculated. Niu et al. [6] discussed the ecological dispatching of the Three Gorges Project.

The comprehensive benefit assessment of water resource exploitation and utilization measures is a multiobjective, multilevel process involving a large number of influencing factors and their complicated interrelationships. Furthermore, the impact of comprehensive benefits varies significantly across cities and regions due to varying climates and environments [7]. Wang et al. [8] developed a system for evaluating the overall benefits of urban water resource development and utilization measures and used an analytic hierarchy process to evaluate Tianjin. Jin et al. [9] developed a comprehensive evaluation model for urban flood control planning schemes, with analytic hierarchy processing serving as the evaluation model's specific modeling process. While existing evaluation models have demonstrated effective evaluation, the majority of them focus exclusively on quantitative indicators and ignore indicators that are difficult to quantify, such as technical, economic, and social benefits. Meanwhile, evaluation models frequently employ a hierarchical analytic process to solve multiobjective problems using a single evaluation model [10].

As a critical component of the eastern route of the south-to-north water diversion project, the tail-water diversion project not only protects the water quality along the main route but also significantly improves the region's ecological environment. To comprehensively assess the necessity and feasibility of engineering construction, this paper discusses the influence of east tail water diversion projects from the south to the north area, as well as regional environmental conditions. A fuzzy algorithm-based evaluation index system for the ecological environment's economic benefits is established, and environmental analysis and evaluation of tail water diversion projects' economic efficiency have certain research value.

2. Water Resources Ecological Dispatching Model

2.1. Objective Function. Generally, water ecological operation in the reservoir scheduling of economic benefit, social benefit, and ecological benefit of comprehensive benefit as the objective function, the economic benefits such as power generation, irrigation, shipping benefits, social benefits such as flood control, water supply, ecological environment including the ecological benefits and environmental benefits. Therefore, on the premise of sustainable development, it is necessary to seek the non-inferior conversion relationship between the benefits of each target, so as to determine the optimal operation mode of water resources. For the convenience of description, the large-scale multiobjective optimization decision model of water resources is described as follows:

$$\begin{cases} \max & W(x) = [E_1(x), E_2(x), \ldots, E_n(x)], \\ \text{s.t.} & \begin{cases} X \in S \\ X \geq 0 \end{cases}, \end{cases} \tag{1}$$

where $E_i(x)$ is the i th comprehensive utilization target, including economic, social, and environmental benefits, etc. X is a vector of all the independent variables; n is the number of comprehensive utilization targets; S is the set of constraint conditions for all comprehensive utilization requirements.

2.2. Constraints. Water balance constraint:

$$V_{t+1} = V_t + R_t - Q_t - D_t - F_t. \tag{2}$$

Reservoir capacity constraint:

$$V_{t\min} \leq V_t \leq V_{t\max}. \tag{3}$$

Constraint of discharge under reservoir:

$$Q_{t\min} \leq Q_t + D_t \leq Q_{t\max}. \tag{4}$$

Power station output constraint:

$$N_{t\min} \leq N_t \leq N_{t\max}. \tag{5}$$

All the above variables are non-negative variables, where V_{t+1} is the reservoir storage capacity at the end of t period; V_t is the initial reservoir storage amount in the period t; R_t is the water inflow into the reservoir in the period t; Q_t is the outflow flow of reservoir in the period t; D_t is the amount of abandoned water in the period t; F_t is the reservoir loss flow (including evaporation and leakage, etc.) in the period t; $V_{t\min}$ is the minimum amount of water storage that should be guaranteed in the t period. $V_{t\max}$ is the maximum allowable storage amount of reservoir in time period t (such as flood control limit in flood season); $Q_{t\min}$ is the minimum downstream discharge that should be guaranteed in the t period (to meet the

comprehensive water demand of the downstream of the reservoir); $Q_{t\max}$ is the maximum allowable discharge in the t period; N_t is the output of the power station in period t; $N_{t\min}$ is the minimum allowable output of the power station in period t; and $N_{t\max}$ is the maximum generating capacity of the power station in period t.

3. Evaluation Index System of Eco-Environmental Economic Benefit Based on the Fuzzy Algorithm

3.1. Fuzzy Theory. When using classical control theory or modern control theory to actual control, control quantity and controlled quantity need to be clearly defined, but in the actual situation, the control process is not clear. In order to solve that may occur in the process of some control problem of fuzzy not clear, the traditional control theory, robust control, optimal control and other improved methods, but no matter how to improve traditional control must be based on the mathematic model of controlled object, it is increased a lot of difficulty to control complex system, some systems cannot even build complex mathematical models that meet the control requirements.

In 1965, the American control expert Chad (LA. Zadeh) initiated and developed the fuzzy theory, which provided a new theoretical guidance for the study and treatment of fuzzy problems. Fuzzy control transforms the language of logic rules into relevant control quantities to control the system. It is more suitable for the control system with complex, unclear or nonlinear controlled objects, and is one of the main ways of intelligent control. Its basic idea is to use machine to simulate human control of the system after fuzzifying the controlled object and establishing relevant models. It is based on fuzzy mathematics, combined with advanced computer technology, using language rules to describe knowledge and experience, through fuzzy reasoning to deduce the advanced control strategy, can conveniently combine the experience and thinking of experts to establish knowledge model.

Compared with classical or modern control, fuzzy control does not require the establishment of a clear mathematical model of the controlled object, but a little prior knowledge of the controlled object cannot have a good design. It still needs to fully understand the characteristics of the controlled object, but the difference is that the control model must be formed by the induction of fuzzy information of the controlled process and the empirical summary of operation, which is also called the knowledge model. Fuzzy control is generally realized through the following steps:

3.1.1. Determining the Input and Output Variables of Fuzzy Control. The aim and significance of fuzzy control are analyzed, and the input and output variables of fuzzy control are determined.

3.1.2. Blur the Input and Output Variables. Membership function is generally used to fuzzier variables, and there are three main methods to determine membership function: fuzzy statistical method, third method, and increment method. There are also many membership functions, the more common are trapezoidal membership function, trigonometric membership function, Gaussian membership function, and so on.

3.1.3. Making Fuzzy Rules. Making appropriate fuzzy control rules is the key to design fuzzy control. Generally speaking, fuzzy control rules are based on the experience and knowledge of experts in the field to establish a fuzzy algorithm for the control object to achieve the control goal, and then established after simple verification.

3.1.4. Fuzzy Reasoning. The process of generating fuzzy output stage is fuzzy reasoning. After the establishment of fuzzy rules, the fuzzy input set and the premise of fuzzy rules are compared and matched by inference mechanism, and the membership degree of a series of input variables is determined. Then, the qualitative output membership function is obtained by applying the rules formulated in Step (3). Finally, the membership degree of fuzzy control output variables is obtained by fuzzy clustering.

3.1.5. Blur. The output of the fuzzy control must be a definite value before it can be implemented in detail, and the output result of Step (4) is a fuzzy set. Only by de-fuzzifying the output of fuzzy reasoning can the exact result be obtained. Common anti-fuzzy methods include maximum membership function method, weighted average method, and gravity center method.

The calculation of the maximum membership method is very simple. It directly takes the maximum membership function value of the output fuzzy set as the output, also known as the direct method. The direct method is more suitable for fuzzy system with less requirement of anti-fuzzy performance because it is rough and loses a lot of secondary information.

The weighted average method is suitable for the output fuzzy set with symmetric membership function and is widely used in fuzzy control system. Its calculation formula is as follows:

$$e^* = \sum_{j=1}^{n} \frac{\mu_{c_j}(e_j) e_j}{\sum_{j=1}^{n} \mu_{c_j}(e_j)}, \tag{6}$$

where e_j and $\mu_{c_j}(e_j)$ are the centroid and membership function values of each symmetric membership function, respectively.

The center of gravity method, also called center of area method, is the most reasonable and common anti-fuzzy method.

$$e^* \int \frac{\mu_c(e) e \mathrm{d}e}{e \int_e \mu_c(e) \mathrm{d}e}. \tag{7}$$

It can also be seen from the formula that this method does not lose the output information of fuzzy subset

elements. Although the calculation is more complex than the first two methods, it is also more accurate.

3.2. Variable Fuzzy Decision-Making Model. Fuzzy concepts (things, phenomena) under a certain combination of space-time conditions often have relativity or dynamic variability [11]. Accordingly, their membership degree and membership function should also be relative and dynamic. The variable fuzzy set theory is developed on the basis of relative membership degree definition. Variable fuzzy set includes fuzzy optimization model, fuzzy pattern recognition model, fuzzy clustering cyclic iteration model, fuzzy decision, recognition, and clustering unified model, etc.

3.2.1. Two-Level Variable Fuzzy Decision-Making Model. For two-level variable fuzzy decision-making, there are

$$u_j = \frac{1}{1+\left(d_{jg}/d_{jb}\right)^{\alpha}}. \tag{8}$$

Among them, $d_{jg} = \left\{\sum_{i=1}^{m}\left[w_i(1-r_{ij})^p\right]^{1/p}\right\}$, $d_{jb} = \left[\sum_{i=1}^{m}\left(w_i r_{ij}\right)^p\right]^{1/p}$. u_j for decision set (j $j = 1, 2, \ldots, n$; n is decision number) comprehensive relative superior degree; d_{jg} is the optimal distance of decision j; d_{jb} is the distance between decision j and inferiority; w_i is the weight of index i ($i = 1, 2, \ldots, m$); r_{ij} is the relative membership degree of eigenvalues of index i of sample j ($i = 1, 2, \ldots, m$; $j = 1, 2, \ldots, n$); α is the optimization criterion, $\alpha = 1$ is the least square criterion, $\alpha = 2$ is the least square criterion; p is the distance, $p = 1$ is the Hamming distance, and $p = 2$ is the Euclidean distance.

In general, α and p can be paired in one of four ways:

(1) $\alpha = 1, p = 1$

Formula (8) becomes

$$u_j = \sum_{i=1}^{m} w_i r_{ij}. \tag{9}$$

In this case, Formula (9) is a fuzzy comprehensive evaluation model, which is a linear model.

(2) $\alpha = 1, p = 2$

Formula (8) becomes

$$u_j = \frac{d_{jb}}{d_{jb}+d_{jg}}. \tag{10}$$

In d_{jg} and d_{jb} expressions, $p = 2$, that is, Euclidean distance, and formula (10) is the ideal point model.

(3) $\alpha = 2, p = 1$

Formula (8) becomes

$$u_j = \frac{1}{1+\left(\left(1-d_{jb}\right)/d_{jb}\right)} = \frac{1}{1+\left(1-\left(1/\sum_{i=1}^{m} w_i r_{ij}\right)\right)^2}. \tag{11}$$

In this case, Formula (11) is Sigmoid type, or S-type function, which can be used to describe the nonlinear characteristics or excitation functions of neurons in the neural network system.

(4) $\alpha = 2, p = 2$

Formula (8) becomes

$$u_j = 1/1+\left(\frac{d_{jg}}{d_{jb}}\right)^2 = 1/1+\frac{\sum_{i=1}^{m}\left[w_i\left(1-r_{ij}\right)\right]^2}{\sum_{i=1}^{m}\left(w_i r_{ij}\right)^2}. \tag{12}$$

In this case, Formula (12) is a fuzzy optimization model.

3.2.2. Variable Fuzzy Pattern Recognition Model. The two-level variable fuzzy decision model only involves the superior and inferior extremes. Through the subsequent case analysis, it is found that the evaluation results of this model are relatively poor, and there is a great difference between the relative superior membership degree of different model indexes in the same scheme. The utilization of water resources is a continuous and dynamic process of gradual development. It is necessary not only to evaluate its benefits but also to evaluate the utilization plan. Therefore, on the basis of analyzing the two-level variable fuzzy decision model, the variable fuzzy pattern recognition model is further analyzed [12]:

$$u_{hj}\begin{cases} 0, & h < a_j \text{ or } h > b_j, \\ \dfrac{1}{\sum_{k=a_j}^{b_j}\left\{\sum_{i=1}^{m}\left[w_{ij}\left(r_{ij}-s_{ih}\right)\right]^p / \sum_{i=1}^{m}\left[w_{ij}\left(r_{ij}-s_{ik}\right)\right]^p\right\}^{\alpha/p}}, & a_j \le h \le b_j,\ d_{hj} \ne 0, \\ 1, & d_{hj} = 0. \end{cases} \tag{13}$$

where h is the level; a_j is the level lower limit of decision j; b_j is the level upper limit of decision j; s_{ih} is the relative membership degree of standard eigenvalues of level h indicator i; and d_{hj} is the generalized weight distance of the difference between decision j and level h. The rest of the symbols are the same. There are also 4 combinations.

(1) $\alpha = 1, p = 1$

$$d_{hj} = \sum_{i=1}^{m} w_i\left(r_{ij} - s_{ik}\right). \tag{14}$$

(2) $\alpha = 1, p = 2$

$$d_{hj} = \left\{ \sum_{i=1}^{m} \left[w_i\left(r_{ij} - s_{ik}\right) \right]^2 \right\}^{1/2}. \tag{15}$$

(3) $\alpha = 2, p = 1$

$$d_{hj} = \left\{ \sum_{i=1}^{m} \left[w_i\left(r_{ij} - s_{ik}\right) \right] \right\}^{2}. \tag{16}$$

(4) $\alpha = 2, p = 2$

$$d_{hj} = \sum_{i=1}^{m} \left[w_i\left(r_{ij} - s_{ik}\right) \right]^2. \tag{17}$$

For the above four models, we define

$$z_j = \sum_{h=a_j}^{b_j} \left(d_{hj}\right)^{-1}, \tag{18}$$

has the optimal relative $u_{hj} = (d_{hj} \cdot z_j)^{-1}$.

4. Experimental Design and Results

4.1. Index System Construction

4.1.1. Evaluation Index Selection. The environmental impact of tail water diversion project of the eastern route of the south-to-north water diversion project is mainly reflected in the centralized treatment stage of sewage and wastewater, the reuse stage of the tail water up to standard and the stage of discharge into the receiving area. On the one hand, the tail water diversion project of the eastern route of the south-to-north water diversion project cuts off the inflow load of the main line of the south-to-north water diversion project, and centralizes the sewage into the sewage treatment plant for purification treatment through the sewage pipe network, avoiding the domestic sewage and industrial wastewater from entering the main line of the south-to-north water diversion project and ensuring the water quality of the main line of the water diversion project. On the other hand, the tail-water diversion project effectively solves the problem of tail-water in the region, improves the ecological environment of the region, and is conducive to improving the function of urban landscape and maintaining the stability of the ecosystem. In addition, after centralized treatment of tail water, the water quality of tail water can mostly meet the water quality standard of reclaimed water, which can be used as agricultural water and industrial water to realize the resource utilization of tail water. For part of the tail water that cannot be reused, it will be transported to the receiving water area by pipeline after being treated to the first-level discharge standard. By making full use of the sewage carrying capacity of the receiving water body, the safe discharge of the tail water can be realized within the allowable environmental capacity. Based on the basic principles of scientific nature, objectivity and operability, based on the analysis of the tail water diversion project, on the basis of the environmental impact, through on-the-spot investigation and consulting experts, selected to ensure water mains water, agricultural irrigation tail water recycle, tail water industry recycling efficiency, promoting the value of landscape and affecting biodiversity benefits as evaluation indexes.

4.1.2. Determination of Index Parameters. (1) *Ensure the water Quality Benefit of the Main Line*. According to the cost accounting method, the calculation formula of tailwater diversion project to ensure the water quality benefit of the main line is as follows:

$$E_1 = Q_{\mathrm{COD}} \times C_{\mathrm{COD}} + Q_{NH_3-N} \times C_{NH_3-N}. \tag{19}$$

Among them, E_1 is the water quality benefit generated by tailwater diversion project; Q_{COD} is the total amount of COD discharge reduced by the main water transport line after the implementation of tail water diversion project; C_{COD} is the unit treatment cost of COD in sewage treatment plant. Q_{NH_3-N} is the total amount of $NH_3 - N$ discharge reduced by the main water transport line after the implementation of the tailwater diversion project; C_{NH_3-N} is the unit treatment cost of sewage treatment plant $NH_3 - N$.

(2) *Agricultural Irrigation and Reuse Benefit of Tail Water*. According to the cost accounting method, the calculation formula of agricultural irrigation benefit of tail water diversion project is as follows:

$$E_2 = Q \times \left(P_1 - P_2\right). \tag{20}$$

Among them, E_2 represents the tailwater agricultural irrigation reuse benefit generated by tailwater diversion project; Q represents the irrigation water amount provided by tail-water diversion project for farmland; P_1 represents the corresponding price of tap water; and P_2 represents the market price of tail water after treatment.

(3) *Industrial Reuse Benefit of Tail Water*. According to the cost accounting method, the calculation formula of industrial reuse benefit of tail water diversion project is as follows:

$$E_3 = Q' \times \left(P_1' - P_2\right). \tag{21}$$

Among them, E_3 represents the industrial reuse benefit of tail water generated by tail water diversion project; $Q\prime$ represents the industrial water consumption provided by the tailwater diversion project; P_1' represents the corresponding tap water price; P_2 represents the market price of tail water after treatment.

(4) *Enhance Landscape Value Benefit*. It is assumed that since the completion of the project, the number and income of domestic tourists will increase to a certain extent due to the influence of tailwater diversion project, then the value of tourism income generated by the impact of landscape on foreign tourists is as follows:

$$E_w = \sum_{i}^{i+n} I_i \times \eta_i \times a, \tag{22}$$

where E_w represents the income value generated by foreign tourists; I_i is the income of domestic tourism in year i; η_i is the growth rate of the i th year; and a is the correlation adjustment coefficient.

If the potential tourism value of local citizens is considered, assuming that there are N_i thousand person-times of this city visiting the river landscape every year, and the ticket price is SET as C_i yuan/person-time according to the assumption, the potential tourism value of local citizens is as follows:

$$E_N = C_i \times N_i, \tag{23}$$

where E_N represents the potential tourism value of local citizens; C_i represents the set ticket price; and N_i stands for annual visits by local residents.

Therefore, the landscape value benefit generated by tailwater diversion project should be the sum of tourism income value of foreign tourists and potential tourism value of local citizens.

$$E_4 = E_w + E_N. \tag{24}$$

(5)*Impacts on Biodiversity Benefits.* As for the diversity value of biological species, scholars usually choose the public willingness to pay method to calculate the value of ecosystem maintaining biodiversity [13, 14]. The public's willingness to pay for biodiversity protection can be obtained by investigating the costs local people are willing to pay for biodiversity protection, and then correcting the characteristics that affect local biodiversity during the implementation of tailwater diversion project. The calculation formula is as follows:

$$E_5 = I \times N, \tag{25}$$

where E_5 represents the economic benefit of tailwater diversion project on biodiversity; I represents an individual's willingness to pay for the conservation of biodiversity; N represents the number of people willing to pay for biodiversity conservation.

According to the statistical bulletin of national economic and social development, the price bureau and the questionnaire results of biodiversity individuals' willingness to pay over the years, the total benefit of environmental and economic impact brought by the project is 124,269,300 yuan, as shown in Figure 1. It can be seen that the ensured water quality benefit affects the most, and the industrial reuse benefit of tailwater has a minimal impact.

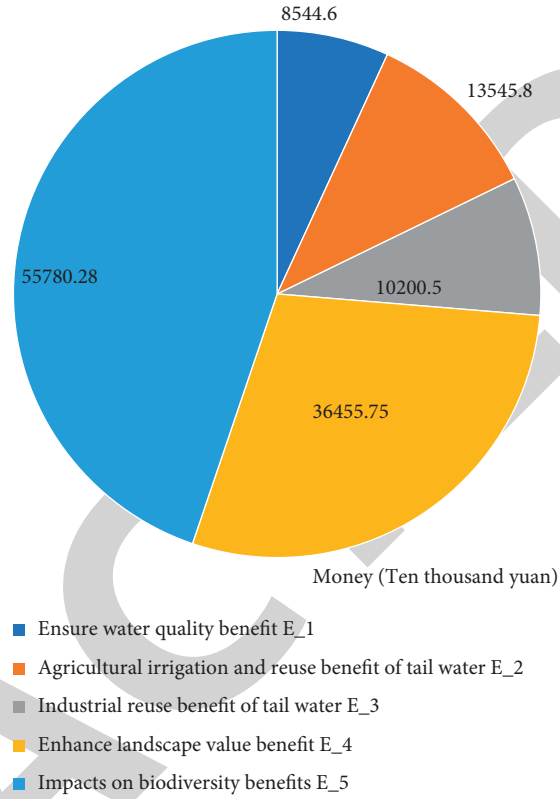

Figure 1: Tail water diversion engineering environment affecting economic profit and loss.

4.1.3. Grading of Evaluation. According to the actual situation of tailwater diversion project and referring to the research results of related water conservancy projects [15], this paper divides the tone operators of the evaluation of comprehensive environmental and economic benefits of tailwater diversion project in the eastern route of south-to-north water diversion project into four levels, which are high (level 1), high (Level 2), average (level 3), and low (level 4).

4.1.4. Evaluation Index Classification. In order to better evaluate the comprehensive environmental and economic benefits of the tailwater diversion project, this paper determines the classification of evaluation indexes of the comprehensive environmental and economic benefits of the tailwater diversion project in the eastern route of the south-to-north water diversion project based on the calculation results of environmental and economic benefits of related studies. Among them, project national economic evaluation (X1), tailwater agricultural irrigation reuse benefit (X3), and biodiversity impact benefit (X6) are all positioned as level 4, with values of 1, 2, 3, and 4 respectively.

4.2. Determination of Index Relative Membership Matrix. The standard interval matrix, range matrix and point value matrix of the environmental and economic comprehensive benefits of tail water diversion engineering in this area are as follows, respectively:

$$I_{ab} = \begin{bmatrix} [4,3] \\ [5000,3000] \\ [4,3] \\ [30000,20000] \\ [60000,50000] \\ [4,3] \\ [3,2.5] \\ [3000,2000] \\ [3,2.5] \\ [20000,15000] \\ [50000,20000] \\ [3,2.5] \\ [2.5,2] \\ [2000,1000] \\ [2.5,2] \\ [15000,5000] \\ [20000,10000] \\ [2.5,2] \\ [2,1] \\ [1000,0] \\ [2,1] \\ [5000,0] \\ [10000,0] \\ [2,1] \end{bmatrix}, \quad (26)$$

$$I_{c\,d} = \begin{bmatrix} [4,3] \\ [5000,2000] \\ [4,3] \\ [30000,10000] \\ [60000,\ 40000] \\ [4,3] \\ [3,2.5] \\ [2000,1000] \\ [3,2.5] \\ [10000,5000] \\ [40000,20000] \\ [3,2.5] \\ [2.5,2] \\ [1000,500] \\ [2.5,2] \\ [5000,2000] \\ [20000,10000] \\ [2.5,2] \\ [2,1] \\ [500,0] \\ [2,1] \\ [2000,0] \\ [10000,0] \\ [2,1] \end{bmatrix}, \quad (27)$$

$$M_{ih} = \begin{bmatrix} 4 & 2.78 & 2.18 & 1 \\ 5000 & 1333.33 & 1666.67 & 0 \\ 4 & 2.78 & 2.18 & 1 \\ 30000 & 13333.33 & 6666.67 & 0 \\ 60000 & 43333.33 & 16666.67 & 0 \\ 4 & 2.78 & 2.18 & 1 \end{bmatrix}. \quad (28)$$

According to the matrix I_{ab}, $I_{c\,d}$, and M_{ih}, the sample characteristic value x_{ij} is judged to be on the left or right side of M_{ih} point, and then the relative membership degree of the index to h grade $\mu A(x_{ij})_{ho}$ is calculated. From this, the relative membership matrix of the indicators at the level $h = 1, 2, 3, 4$ of the tailwater diversion engineering in this area can be obtained, and the row vector can be normalized, and the relative membership matrix after treatment can be obtained as follows:

$$U_j = \begin{bmatrix} 0.78 & 0.28 & 0 & 0 \\ 0.65 & 0.35 & 0 & 0 \\ 0.65 & 0.24 & 0 & 0 \\ 0 & 0.45 & 0.48 & 0.06 \\ 0.30 & 0.65 & 0.06 & 0 \\ 0.50 & 0.50 & 0 & 0 \end{bmatrix}. \quad (29)$$

4.3. Determination of Index Weight. When determining the main variable factors in the variable model parameter CB in the variable fuzzy evaluation method, this paper adopts the binary comparative fuzzy decision analysis method and superscalar multiple weighting method respectively as the basis for determining. The non-normalized weights of each index are, respectively, as follows:

$$\begin{aligned} \overline{\omega}_1 &= (0.24\ 0.28\ 0.25\ 0.11\ 0.08\ 0.16), \\ \overline{\omega}_2 &= (0.18\ 0.25\ 0.21\ 0.15\ 0.18\ 0.14). \end{aligned} \quad (30)$$

4.4. Comparative Analysis of Evaluation Results. According to the standard value vector $S = (1\ 0.8\ 0.6\ 0.3\ 0)$ corresponding to the excellent, good, medium, acceptable and bad, scheme grades is judged. The results of the five methods are shown in Figures 2 and 3.

Following the evaluation results, it is clear that the analytic hierarchy process, fuzzy optimum seeking method, linear comprehensive fuzzy optimization, the average extensive fuzzification model, and the variable fuzzy pattern recognition model used for optimizing the evaluation results are identical; the entropy weight fuzzy optimization evaluation result for the solution of 2, 3, and the evaluation results are consistent with the other four kinds of methods; only one program evaluation is carried out.

The primary reason for this discrepancy is the difference caused by the use of different weight vector calculation methods. Entropy weight method is used for multilevel and

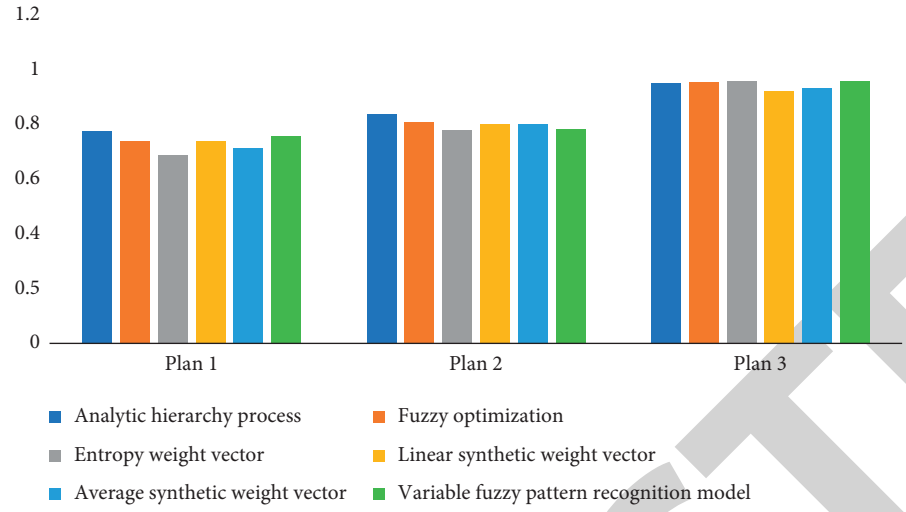

Figure 2: Comprehensive evaluation value of each program.

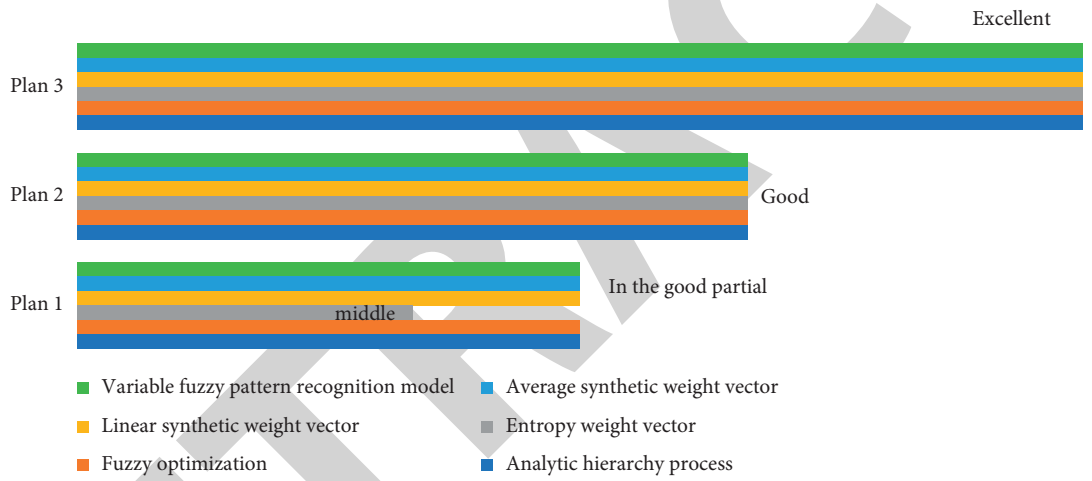

Figure 3: Evaluation levels of each program.

multiobjective comprehensive evaluation problems. The basic idea behind the method is that when the weight vector of each index is calculated at the input layer, the greater the difference between each index and its weight will be used to determine how important the weight is to be used. It is objective and reasonable to reflect the index's contribution to decision-making from the data itself and to eliminate the artificial factors that are used to determine the index's weight in the first place. According to [16], there is a significant difference between the calculation of weight vector in the middle layer, as well as a completely different situation between subjective weight and objective weight. Subjective weight and objective weight should be considered in conjunction with one another in order to completely eliminate this phenomenon. Although it is possible to determine the weight solely based on the difference degree of the index, that is, the entropy value, this approach does not provide a comprehensive solution. The subjective weight reflects the different emphasis placed on the evaluated things at various stages of the evaluation process. The linear synthesis method and the average synthesis method are both more scientific and reasonable methods of calculating the weight vector, and the final evaluation result is more accurate and representative of the real world.

5. Conclusion

The variable fuzzy evaluation model is used in this paper to evaluate the comprehensive environmental and economic benefits of tailwater diversion engineering, in order to facilitate the exploration and application of environmental and economic benefits of tailwater diversion engineering. The model is a variable fuzzy evaluation model and has its application in other fields.

(1) This article is based on an analysis of environmental impact, on the basis of tailwater diversion projects from guarantee water mains, tailwater recycling agricultural irrigation water quality, tailwater industry recycling, and improving landscape engineering value and its effect. According to the research findings, the tail-water diversion project's

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Retraction

Retracted: Research on Tourism Resource Evaluation Based on Artificial Intelligence Neural Network Model

Advances in Meteorology

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope

(2) Discrepancies in the description of the research reported

(3) Discrepancies between the availability of data and the research described

(4) Inappropriate citations

(5) Incoherent, meaningless and/or irrelevant content included in the article

(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] G. Li and J. Cheng, "Research on Tourism Resource Evaluation Based on Artificial Intelligence Neural Network Model," *Advances in Meteorology*, vol. 2022, Article ID 5422210, 9 pages, 2022.

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Research Article

Research on Tourism Resource Evaluation Based on Artificial Intelligence Neural Network Model

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The rational evaluation of tourism resources and the discovery of valuable potential tourism resources are important foundations for promoting the development of tourism industry. This paper systematically reviews the development history of China's ethnic tourism resource evaluation, analyzes the three different stages of tourism resource evaluation changes and their basic characteristics, and conducts research on tourism resource evaluation based on artificial intelligence neural network model to avoid the influence of subjective factors on the evaluation results to the greatest extent. This paper uses the literature comparison method, theoretical analysis method, and expert consultation method to construct an evaluation index system containing 5 primary indicators and 12 secondary indicators on the basis of which an evaluation model is designed focusing on the error values in the evaluation model, and the evaluation model is applied to the evaluation of tourism resources in several major cities, and its evaluation results and error ranges meet the requirements.

1. Introduction

The right appraisal of tourism resources is critical to the effective development of tourism destinations and the attraction of tourists to these places. Development methodologies, resource types suited for development, and other critical issues that must be addressed in the process of tourist practice are some of the most important considerations [1, 2]. Early on, geography and forestry scholars concentrated on the evaluation of tourism resources, and they gradually developed a series of classification and evaluation systems, theories, and methods, beginning with the physical and objective properties of natural resources. Some other scholars assessed tourism resources from both supply and demand perspectives, which is the method of determining the potential value of tourism resources in terms of tourists' demand, which was developed in the late 1950s. Land assessment approaches were therefore gradually introduced and improved upon in the 1980s and 1990s [3–7]. This resulted in the establishment of more mature evaluation systems that were applied to the development and management practices of tourism resources during this period. The initial development of domestic socioeconomic and tourism industries, the expansion of the domestic tourism source market, and the increase in tourists' experience requirements all occurred during this time period. As a result, the evaluation of tourism resources development is no longer a single technical evaluation, but a comprehensive technical evaluation and experiential evaluation of tourism resources from various aspects such as aesthetics, transportation, market, and location based on the absorption of information evaluation. Because of the increasing diversity and richness of tourism development, the evaluation of tourism resource development has gradually shifted from the perspective of the supplier to that of the demander, with greater attention paid to the dynamic demand of the tourism market as well as the introduction of the concept of tourism attraction; among them, more tourism scholars and tourism development practitioners are studying and evaluating tourism resources and product development in the twenty-

first century [8, 9]. As a rule, throughout the past 60 years, evaluation of tourism resource development has followed a three-stage process: element evaluation, complete evaluation, and social evaluation.

The appraisal of tourist resources is a process that is constrained by a number of elements and is heavily influenced by subjective judgments. The precision with which tourism resource evaluation results are produced has always been a matter of debate, owing to the large number of variables and high nonlinearity present in each evaluation model [10, 11].

For the purpose of error analysis, the artificial neural network model is a reverse operation method. It has a high level of fault tolerance. In an iterative process, the nonlinearity can effectively prevent the buildup of errors, which is extremely useful in terms of lowering the operation error rate. At the same time, the model can make full use of the adaptive ability of the neural network, which helps to improve the intelligence of the operation overall. Some researchers have developed 25 evaluation indicators for the BP neural network model based on the features of tourism resources, and they have applied the corresponding evaluation indicators to the evaluation of red tourism resources [12–17]. Other researchers have looked into the relationship between the error size and the evaluation outcomes [18, 19].

By conducting a systematic review of the comprehensive process of conceptual understanding and evaluation of tourism resources at home and abroad, this paper aims to demonstrate the characteristics of different periods of tourism resource development, from elemental evaluation to comprehensive social evaluation, in the context of socioeconomic development, and to further analyze the key driving factors and influence mechanisms behind the transition from elemental evaluation to comprehensive social evaluation [19]. It appears that, as a result of the dynamic evolution of tourism resource evaluation theories, methods, and perspectives both at home and abroad, the understanding of tourism resource development and evaluation is gradually deepening, and tourism development is increasingly integrated into the framework of tourism market development and social change [20–24].

Consequently, this paper examines and analyzes the process and mechanism of domestic tourism resource evaluation; on the one hand, it examines the evaluation and concept of tourism resource development from a dynamic perspective and understands the relationship between tourism development goals and different stages of socioeconomic development [25–27]. On the other hand, in the face of future tourism development, how to fully consider the needs of tourists who require different types of services is examined and analyzed. The direction of evaluation is really significant [28].

Artificial neural network as a new technology, with its own nonlinear mapping and learning classification and real-time optimization as pattern recognition, has been widely used in various evaluation problems, creating a new way of thinking for us to study problems such as nonlinear classification. In order to overcome the subjective influence of human factors on the evaluation results, as well as to establish a comprehensive and reasonable comprehensive evaluation index system, this paper introduces artificial neural networks into the evaluation system. The model has self-organizing and self-learning functions, and by training the network, it can make rank evaluation of tourism resources.

1.1. Our Contribution. The BP model is introduced into the evaluation system, which overcomes the subjective influence of human factors on the evaluation results and establishes a comprehensive and reasonable comprehensive evaluation index system.

We have organized the tourism resources, which is convenient for the modeling and use of BP model and is helpful for the establishment of electronic database of the resources in the future.

The experiment proves that the BP neural network model can evaluate the tourism resources more accurately and effectively, and it is a simple, fair, and objective evaluation method.

2. Dynamic Process and Characteristics of Tourism Resources

2.1. Concept and Connotation Development of Tourism Resources. During the early stages of tourism development, an often used concept is tourism resource, which refers to the general word for all natural and human resources that can be utilized for the development of tourism, which is a complex and inclusive broad system. During the late 1970s, experts in geography and economics were the first to enter the field of tourist research, which was primarily centered on the objective physical qualities of tourism resources for growth and evaluation. Since then, tourism has grown exponentially in China. Later, as more disciplines entered tourism research, a comprehensive definition was gradually developed from the perspective of the subject of tourism and the market concept. It is now believed that all material and nonmaterial factors that can motivate and attract tourists and satisfy their tourism needs, as well as those that can be exploited and generate economic, social, and environmental benefits, can be regarded as tourist resources.

In order to keep pace with the advancement of domestic and international research and the development of the practice of tourism resource assessment, the evaluation of tourism resource value gradually shifts away from emphasizing development practices and toward emphasizing meeting the needs of tourists and the marketplace. To put it simply, tourism resources are attractive to tourists in the shape of their objects, and their expressions have apparent commercial undertones, whereas the term tourism attraction can more intuitively explain its key characteristics. As a result, the term tourist attraction can eliminate some of the ambiguities introduced by the term tourism resource, and the concept of tourism attraction (object) is broadened, with greater emphasis placed on the attraction it creates for tourists. Tourism attraction (object) is defined as follows. According to some experts, tourist appeal is comprised of all

of the aspects that draw tourists away from their normal environment, including the landscape they see, the activities they participate in, and the experiences they recall from their travels. However, according to some academics, an attraction can be defined as the sum of all of the elements that draw people to a tourist location. Alternatively, some researchers view tourism attraction as a system composed of tourists and landscape markers, and they design a tourism attraction system composed of features such as tourists, core attractors, and markers to attract visitors. As several researchers have pointed out, tourism attractors are sites that have been built to meet the demands of tourists, and knowing natural and human resources and the image that tourists have of these resources is vitally important for tourism planning. Overall, the difference between tourism attractions and tourism resources is that the former places greater emphasis on the notion that tourism resources may only be classified as tourism attractions if they are accepted and attractive to tourists, while the latter does not. It goes without saying that the attractiveness of a tourism attraction cannot exist without the participation of tourists and the dissemination of information through various media, and it requires a variety of symbols and publicity to be recognized by tourists, including transportation, signage that is easily understood, advertising, and marketing, among other things.

The improvement of the expression and conceptual connotation of tourism resources and the introduction of the concept and theoretical perspective of tourism attraction have resulted from the development of domestic tourism research and its convergence with international research. When it comes to tourism attractions (objects), the term is most often used in conjunction with tourism resources, which include traditional natural and human resources, but it can also refer to a broader range of objects of tourism activities, such as man-made landscapes, festivals, and special events. One advantage of this approach is that it preserves all inherent characteristics of tourism resources while emphasizing all aspects which are attractive to tourists. It is also more realistic in terms of implementation. Tourism and daily leisure resources can also be grouped together for the sake of convenience in research operations, and these are referred to as recreation resources. While the definition of recreation resources is similar to that of tourism resources, the connotation of recreation resources will be slightly richer and more diverse than the connotation of tourism resources. Similar to the development process of the concept and connotation of tourism resources, the process and characteristics of tourism resources and tourism attraction evaluation also show significant differences depending on the period and stage of social development, and each stage of the evaluation process of tourism resources in China will be explained in detail below. The concept and connotation of tourism resources are developed through a series of stages.

2.2. Technical Evaluation Stage of Tourism Resource Elements (1970s to 1980s). The stage of experience and comprehensive evaluation is mainly to initially understand the concept and connotation of tourism resources, etc. Tourism resource evaluation and tourism development evaluation were both topics covered in the early work, with the former focusing on value judgments of resources and the latter including nonresource aspects such as development circumstances. There was some ambiguity in terms of the notion and connotation. The tourism industry, which is constrained by the effect of market development, is in the stage of supply determining demand. The system of definition and classification of tourism resources has not yet been fully developed. At this stage, tourism resources are primarily evaluated on a technical basis, with a strong emphasis on the physical and objective characteristics of tourism resources themselves. In this study, the evaluation is carried out using single or multiple element combinations, with a focus on practicality and an emphasis on quantitative treatment of evaluation, and it is intended to serve as a reference basis for the development of tourism resources by attempting to establish uniform standards for the classification and judgment of tourism resources. This stage does not consider factors such as tourist preferences, the natural environment in which the resources are located, or their position in the social system, and the background properties of the resources determine whether they can be converted into tourism resources and what type or level they can be classified as. The tourism supply determines demand behavior in the tourism market at this stage.

2.3. Experiential and Comprehensive Evaluation Stage (1980s to 1990s). At this period, the evaluation of tourism resources was more concerned with a hierarchical and comprehensive technical review from the perspectives of nature, human history, and aesthetics than it was with a more specific technical evaluation. While evaluating the tourism resources themselves, a wider evaluation system such as ecological environment, social and economic environment, transportation, and tourist source market has also been gradually established. In order to keep up with the rapid development of China's tourism industry and the expansion of both international and domestic tourism markets, the comprehensive and experiential evaluation stage no longer focuses solely on the conditions of tourism resources themselves but also on the incorporation of multidisciplinary experiences of tourism resources (for example, aesthetic experience) into the comprehensive evaluation of tourism resources. When considering tourist resource development, it adds to a more comprehensive understanding of tourism resources and encourages the entire integrated development of tourism destinations in terms of transportation, culture, and socioeconomics.

2.4. The Social Construction Stage of Tourism Resource Research (Since 2000). It is important to emphasize not only scientific evaluation of the relative objective physical attributes of tourism resources in the previous technical evaluation stage but also the creation of new symbolic values and attractions based on mainstream social values, in-depth excavation of cultural attributes, and the use of new

technologies and marketing techniques to promote the overall sustainable development of tourism. Travelogues, mass media, the construction of the attraction's image during the development process, institutional certification, and other means help to construct a certain symbolic value for the tourist attraction, and tourists consume this symbolic value and respond to the social ideals represented by the symbols of the tourist attraction through tourism consumption and tourism experience. The development of societal values and ideals occurs in a dynamic and cyclical manner throughout history, and the social construction of the symbolic significance of tourism attractions is similarly a dynamic and cyclical process. While museum tourism is a popular form of tourism in the Western world, it is just recently becoming more popular in China, owing to the country's various stages of social development and the gradual acceptance of such tourist attractions. There is now, however, a phenomenon of partial over-consideration in the field of tourism attraction as a symbolic form to gain approval from others, which leads tourism suppliers to develop and build a variety of tourism resources, tourist landscapes, and tourism products that satisfy the hunting and consumption psychology of tourists. Researchers, governments, and development agencies should pay close attention to and reflect on the phenomena of excessively catering to tourists' show-off mentalities, ignoring the objective natural, economic, cultural, and ecological conditions of tourist destinations, paying too much attention to media marketing and neglecting the quality improvement of scenic spots, depending on tourist resources and neglecting the creation of a good atmosphere for tourist experiences, and so on.

3. Method

3.1. ANN. Artificial neural networks (ANNs) are capable of approximating any continuous nonlinear functions with any precision, and they also have the potential to learn and adapt to new situations when faced with a complicated and unpredictable situation.

A typical neuro structure is shown in Figure 1.

In Figure 1, $X_1, X_2, \ldots, X_n$ represent the input of each neuron layer, $W_1, W_2, \ldots, W_n$ represent the weight of each neuron, b represents the bias of each layer, f represents the activation function, X_i represents the input from the neuron of i, and Y represents the output. The number of nodes in the input and output layers is determined by the actual requirements, and the layers are connected by a vector of weights. The hidden layer neurons comprise an adder and an activation function, which are both included in the input and output layers. A linear or nonlinear activation function is used to process the information that has been transmitted from the preceding layer in order to produce the output value of the neuron.

Pretend that there are K layers in the neural network, excluding the input layer (the number of layers $k > 1$), and that there are $m_0, m_1, \ldots, m_k$ nodes in each layer from the input layer all of which are connected to the output layer (the number of nodes in each layer is greater than one). The input vector has a dimension of m_0, and the output vector has a dimension of m, as defined by these formulas.

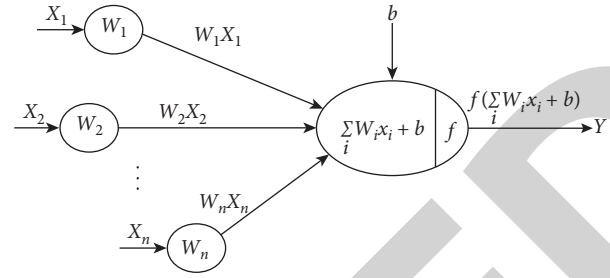

Figure 1: The structure of ANN.

Output layer:

$$X^{(0)} = \left[X_1^{(0)}, X_2^{(0)}, \ldots, X_{m0}^{(0)}\right]^T, \tag{1}$$

where $X^{(0)}$ is the output vector and $X_1^{(0)}, X_2^{(0)}, \ldots, X_{m0}^{(0)}$ are elements of the output vector.

Input layer:

$$Y^{(K)} = \left[Y_1^{(K)}, Y_2^{(K)}, \ldots, Y_{mK}^{(K)}\right]^T, \tag{2}$$

where $Y^{(K)}$ is the input vector and $Y_1^{(K)}, Y_2^{(K)}, \ldots, Y_{mK}^{(K)}$ are elements of the input vector.

The weight matrix and bias vector for each layer are as follows:

$$\begin{aligned} W^{(1)} &\in R^{m_1 \times m_0} b^{(1)} \in R^{m_1 \times 1}, \\ W^{(2)} &\in R^{m_2 \times m_1} b^{(1)} \in R^{m_2 \times 1}, \\ &\cdots, \\ W^{(K)} &\in R^{m_K \times m_{K-1}} b^{(1)} \in R^{m_K \times 1}. \end{aligned} \tag{3}$$

For hidden layer, we have

$$\begin{aligned} \text{net}_i^{(1)} &= \sum_{j=1}^{m0} W_{i,j}^{(1)} X_j^{(0)} + B_i^{(1)}, \left(1 \le i \le m_1\right), \\ \text{net}_i^{(1)} &= W^{(1)} X^{(0)} + b^{(1)}, \\ \text{net}^{(1)} &= \left[\text{net}_1^{(1)}, \text{net}_2^{(1)}, \ldots, \text{net}_{m1}^{(1)}\right], \\ Y^{(1)} &= \left[Y_1^{(1)}, Y_2^{(1)}, \ldots, Y_{m1}^{(1)}\right]. \end{aligned} \tag{4}$$

For k-th layer,

$$\begin{aligned} \text{net}_i^{(K)} &= \sum_{j=1}^{mK-1} W_{i,j}^{(K)} Y_j^{(K-1)} + B_i^{(K)}, \\ \text{net}_i^{(K)} &= W^{(K)} X^{(K-1)} + b^{(K)}. \end{aligned} \tag{5}$$

This can be accomplished by doing a forward layer-by-layer calculation on the $\text{net}_i^{(K)}$ and $Y^{(K)}$ values of each layer of the network, as well as the input and output vectors of each layer. It is possible to acquire the input value and output value of each neuron.

This paper's neural network comprises four layers: an input layer, an output layer, and two hidden layers. The number of neurons in each layer is defined by an isometric series, and the number of neurons in each hidden layer is determined by an isometric series. Because the sampling

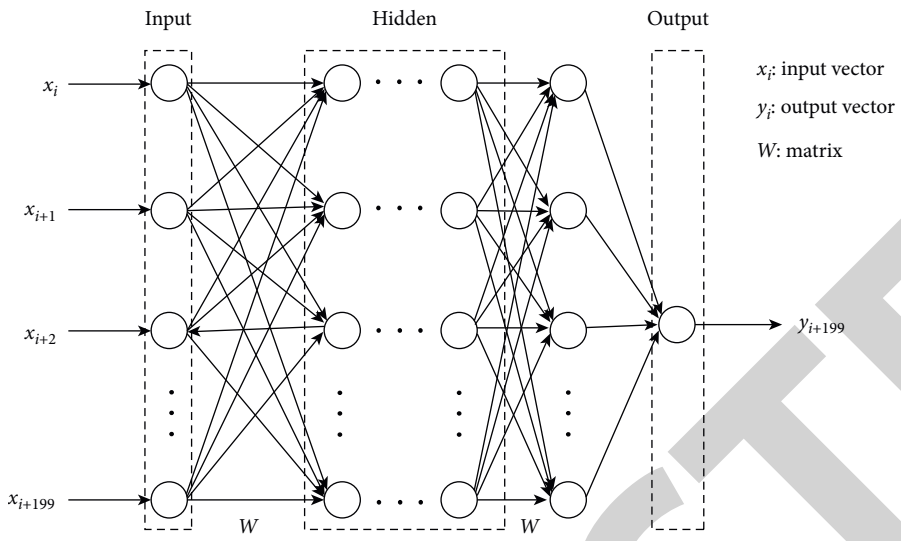

Figure 2: The structure of our ANN.

frequency of the sensor is 10 Hz and because the vertical wave has the greatest influence on the buoy motion, only the vertical wave data are used as an input parameter, resulting in a total of 200 neurons in the input layer, which is the maximum number of neurons that can be used in the input layer.

A critical question to address once the number of nodes in the input layer and the number of nodes in the output layer have been discovered is how to maximize the number of nodes in the hidden layer and the number of hidden layers after those numbers have been determined. Experimental evidence indicates that if the number of nodes in the hidden layer is too little, the network will not be able to perform the necessary learning and information processing functions. If there is an excessive number, the opposite is true. It will not only significantly increase the complexity of the network structure but also increase the likelihood that the network may fall into local minima during the learning process, resulting in a network with a very sluggish learning speed overall.

In general, one to two hidden layers are sufficient for a small dataset, and the neural network employed in this paper has two hidden layers, with 34 and 6 neurons in each layer, respectively. The first three layers employ the ReLU function, and the fourth layer employs a linear function.

Figure 2 shows the basic structure of the established neural network.

3.2. Evaluation Index System Establishment. The purpose of this study is to develop a tourism resource evaluation index system that is based on the principles of independence, quantification, and comprehensiveness, and that incorporates three analytical methods: the literature comparison method, the theoretical analysis method, and the expert consultation method.

Following a review of relevant literature, various types of literature are classified according to the statistical method used to identify them. For the most part, the theoretical

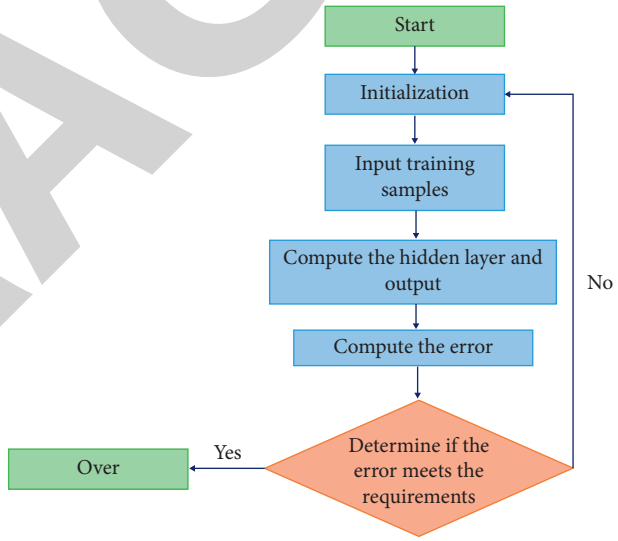

Figure 3: The flow of our method.

Table 1: Tourism resource evaluation index system.

Primary indicators	Secondary indicators
Historic	C1: historical status C2: relationship with important people C3: political significance
Artistic	C4: cultural heritage role C5: architectural integrity C6: artistic ornamentation
Regional	C7: transportation C8: economic level
Resource scale	C9: landscape market C10: portfolio of attractions
Hospitality level	C11: level of accommodation C12: dining level

Table 2: Weight distribution of each indicator.

Index	Weight
C1	0.12
C2	0.13
C3	0.02
C4	0.05
C5	0.20
C6	0.11
C7	0.12
C8	0.05
C9	0.02
C10	0.14
C11	0.03
C12	0.03

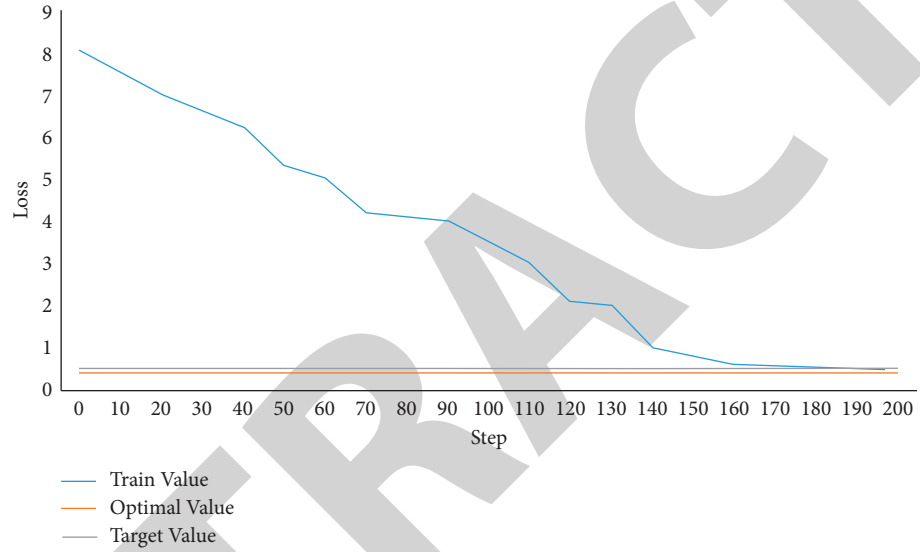

Figure 4: The iteration curve.

analysis technique begins with an examination of the elements that influence tourist resources, after which six assessment indexes are selected based on three influencing aspects: resource value, attraction scale, and tourism conditions. Figure 3 depicts a system of theoretical analysis assessment indexes for evaluation. The tourism resource evaluation index system illustrated in Table 1 was developed by combining the literature comparison approach with the theoretical analysis method, as well as by interviewing experts and soliciting their comments and ideas.

Combined with expert advice, the weight coefficients of each evaluation index in the quantitative evaluation of tourism resources were determined, and the weight distribution of each index is shown in Table 2.

4. Model Evaluation Result

The grade division is based on the size of the output value of the output layer, according to the weight distribution of the 12 evaluation indicators, and finally the evaluation value of tourism i resources of each city is calculated, and the closer the value is to 1, the higher the evaluation of tourism resources in the area is. Twelve pairs of sample data are selected, and the data have been normalized by the percentage system. A three-layer BP neural network is established, and MATLAP, a high-performance numerical computation visualization software program, is selected, with 6 neurons in the hidden layer, 1 nerve element in the output layer, and 9 nerve elements in the input layer, and the number of learning is 1000 times and the number of iterations is 500 times. The initial step size is 0.9, M is 400, the momentum coefficient is 0.9, and the allowable error is 0.001. To simplify the network structure, only 3 output nodes can be used to represent 5 state categories.

By learning the training network using the MATLAP neural network toolbox for the 10 sets of data before the test, we finally obtained and established the neural network evaluation model. The training steps and errors are shown in Figure 4. From Figure 4, the error is less than 0.001 when the training step reaches 160 steps, which is 0.00077.

The number of neurons in the input layer was set to 18, the number of neurons in the hidden layer was set to 14, and the number of neurons in the output layer was set to 1. The

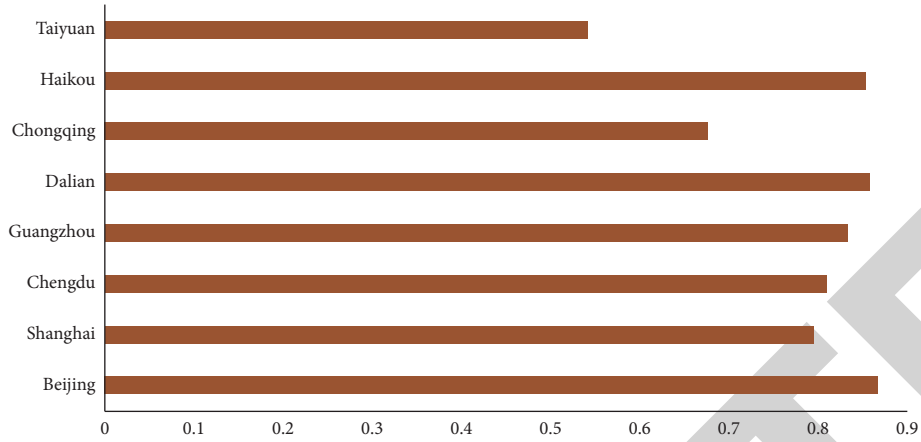

Figure 5: Evaluation results.

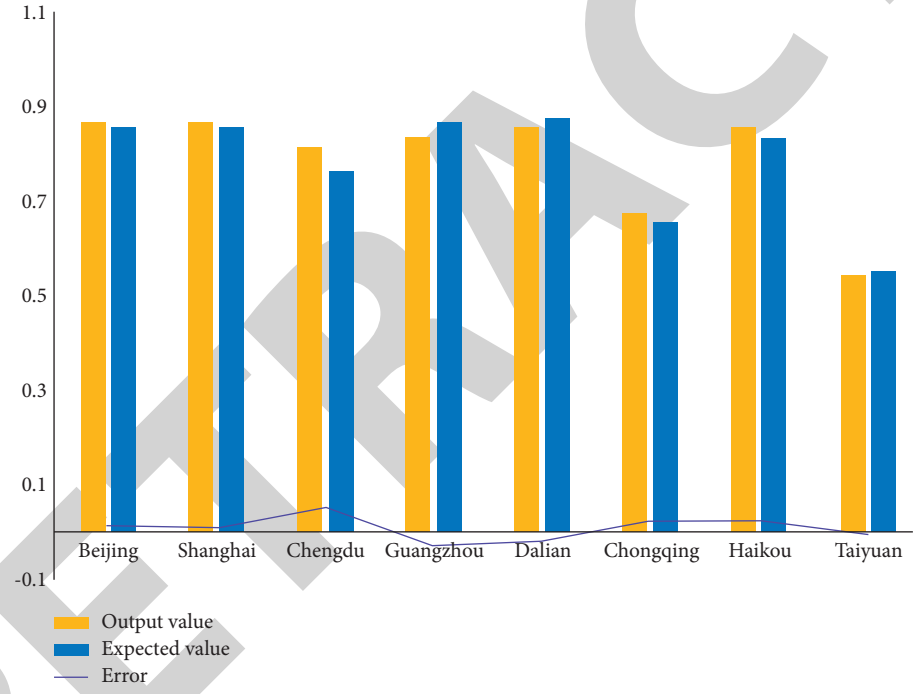

Figure 6: Evaluation error results.

data processing software MATLAB was used to create the ANN iterative structure. Consider eight representative tourism cities such as Beijing, Nanjing, and Guangzhou as examples. Figure 4 depicts an iteration curve of the evaluation model in MATLAB. Figure 5 depicts model evaluation results, and Figure 6 depicts an error graph resulting from the model evaluation mistake.

5. Conclusion

The characteristics of strong nonlinearity and fault tolerance of the artificial neural network model are used in this study to develop a tourism resource evaluation model based on artificial intelligence neural network model. The model is then used to evaluate tourism resources. Eight representative cities, including Beijing, have their tourism resources evaluated using an evaluation index system constructed from five primary indicators and twelve secondary indicators. The evaluation results are within the permissible range of error, allowing for the objective evaluation of tourism resources to be achieved.

5.1. Follow-Up Work. The current data did not use the method of data preprocessing; although it is said that the current evaluation model meets the current stage of engineering needs, it will be affected by outlier data or irrelevant

data, so in the follow-up work, we will add the method of data preprocessing in the experiment to improve the accuracy of the evaluation model.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Hindawi
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Retraction

Retracted: Research on the Design of Public Space in Urban Renewal Based on Multicriteria Cluster Decision-Making

Advances in Meteorology

Received 13 September 2023; Accepted 13 September 2023; Published 14 September 2023

This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope

(2) Discrepancies in the description of the research reported

(3) Discrepancies between the availability of data and the research described

(4) Inappropriate citations

(5) Incoherent, meaningless and/or irrelevant content included in the article

(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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[1] H. Bian and H. Su, "Research on the Design of Public Space in Urban Renewal Based on Multicriteria Cluster Decision-Making," *Advances in Meteorology*, vol. 2022, Article ID 7186946, 8 pages, 2022.

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Volume 2022, Article ID 7186946, 8 pages
https://doi.org/10.1155/2022/7186946

Research Article

Research on the Design of Public Space in Urban Renewal Based on Multicriteria Cluster Decision-Making

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Urban design is a critical technical tool for shaping and intervening in urban space, but it is also developing into a critical governance tool for guiding the orderly development of urban renewal, thereby contributing significantly to its effectiveness. This paper examines the design of public space in urban renewal through the lens of multicriteria group decision-making, introduces urban design governance theory, develops a theoretical framework for instrumentalizing urban design governance to respond to various levels of urban renewal, and investigates strategies for assisting urban renewal through the innovation of governance subjects and semiformal governance tools, in addition to the formal path of combining urban design and planning. Simultaneously, a multicriteria decision-making algorithm is proposed that combines theoretical concepts from the fields of computational intelligence and multicriteria decision-making, adopts a normalization fundamental model to standardize the attribution function, selects valid data information function values to combine into an aggregation function, and then establishes a multicriteria approach to deal with heterogeneous information based on the aggregation function. The experimental results demonstrate that the proposed algorithm is capable of coping with and representing the imprecision and uncertainty inherent in the input data.

1. Introduction

While urban design has always been an important technical instrument for shaping and intervening in urban space, during the course of the twentieth century and post-Fordism, it has progressively evolved into an important governance tool for guiding the orderly development of urban redevelopment. China's urban renewal work has long been hampered by difficulties in element coordination, a lack of policy supply, insufficient departmental coordination, implementation cost constraints, and a lack of social participation [1–5]. As a result, the country's urban renewal work has tended to be focused on elements such as development capacity, property rights, and functions, with insufficient attention and discussion given to how to play and ensure the beneficial role of urban design in urban renewal projects [1]. Urban regeneration is complicated by the fact that social, tenure, and capital interactions in historic spaces are difficult to coordinate through the use of a single bottom-line planning technique [6, 7]. New avenues for urban design to play a part in urban renewal are predicted to emerge as a result of the maturing and implementation of urban design governance theory, which will serve to complement formal planning.

Some academics argued for design-led urban regeneration during the end of the twentieth century, and the concept helped to establish the national practice of design-led urban regeneration in the United Kingdom in the early twenty-first century. Others have stressed the importance of urban design as a global leader in urban renewal, stating that the qualities of urban design are a precondition for urban renewal to develop and function effectively [8, 9]. Some researchers go on to say that the improvement in spatial quality brought about by urban design is a source of value

that helps to strike a balance between the costs and benefits of urban redevelopment when faced with severe restrictions [10–14].

Urban design and urban renewal should be part of a broader governance framework, according to increasing numbers of academics in recent years. This is necessary for truly effective urban design and urban renewal. Following this development, new studies have begun to expose the impact of urban design on urban renewal from many perspectives, as well as to investigate the requirement of integrating institutional structures between urban design and urban regeneration [15, 16]. In urban renewal, some academics propose that urban design can serve as a technical hub for optimizing the allocation of public spatial resources and connecting macrolevel planning with the implementation of urban spatial planning at the medium- and microscale levels. They also argue that future development of urban design in the stock will be focused on a collaborative governance model that integrates technical, policy, and social attributes [17, 18]. The use of urban design in urban renewal, according to some scholars, should shift from the creation of physical space environments to the management of urban space, which should include both planning and management. They also propose that formal and informal systems be integrated through the use of an urban design governance system [19].

Using the theory of urban design governance as a starting point, this paper develops a theoretical framework for the instrumentalization of urban design governance to respond to different target levels of urban renewal, and it investigates semiformal paths for urban renewal in addition to the formal path of combining urban design and statutory planning to achieve urban renewal objectives [20–24].

At the same time, we use the empirical object of the practical exploration carried out in Beijing in recent years to comprehensively evaluate the applicability and advantages of the new urban design governance path in order to meet the real challenges, and we make recommendations for the deep integration of urban renewal and urban design work in China [25, 26]. Also included is an investigation into the design of public space in urban renewal based on multicriteria group decision-making, as well as a proposal for a multicriteria decision-making algorithm that is capable of dealing with and representing the imprecision and uncertainty that is inherent in the input data [27].

2. Related Work

2.1. Characteristics of Traditional Urban Public Spaces and Human Behavior. In his research, sociologist Zimmer discovered that the link between people and the relationship between place and space are interrelated. It is the demands of people that govern the construction of public space, and the manner in which people interact with one another defines how space is represented. Throughout history, the shape of urban public space has been influenced by three factors: the breadth of social interaction, the form of engagement, and the substance of interaction at that particular point in time. It is the author's intention to evaluate and condense the fundamental characteristics of human social interaction behavior in traditional civilizations into three parts in order to gain a more complete understanding of the essence that lies behind the physical design of traditional urban public spaces.

(1) The inclination for people to congregate in order to communicate is referred to as gathering. The creation and growth of early towns and cities are inextricably linked to their ability to attract and gather people. A market square was the birthplace of early democracy during the ancient Greek period (800 BCE-146 BCE) when people assembled in large groups. Currently, such aggregation is more frequently exhibited in public space as a group activity that occurs in specific places or in response to specific occurrences, rather than as individual conduct.

(2) The instinctive desire to avoid damage as a result of human perception is referred to as avoidance. It is common for people's conduct to be restricted by instincts that have been programmed in advance, which allow them to assess whether they are comfortable in an area or whether they need to take measures against a specific place or object. People will always try to avoid or leave a physiologically and psychologically harmful environment as soon as they can and will seek out a more secure or more pleasant environment place.

(3) The term "experiential" refers to the property that humans obtain relevant information about their daily spatial surroundings through their bodies' perception of space. Space cognition is founded on the perception of one's own body, which serves as both the medium for receiving information and the most direct reference during the cognitive process. The ability to perceive and form impressions of the space and environment in which they are present is a fundamental characteristic of traditional space. People in traditional space are able to recognize and form perceptions of the space and surroundings they are in because they are physically present in the space and environment.

As a result of these characteristics of human behavior in traditional space, the public space of the city is forced to present a spatial representation that corresponds to them. The square became the focal point of traditional urban public life as a result of this congregating. This core type of public space was characterized primarily by a central enclosed form with clearly defined boundaries and obvious emphasis, which served to limit and influence crowd activities while also adapting to the behavioral characteristics of people who tend to obtain information through gathering and activities (i.e., information gathering). Piazza San Marco in Venice and Piazza del Campo in Siena, two famous examples of such public areas, date back to the Middle Ages (476-1492) and the Renaissance (14th–17th centuries).

People have a tendency to create single-purpose spaces in traditional cities, limiting the range of functions and activities that can be carried out while also making them exclusive and limited, such as designated areas for children's activities in cities or designated rest areas for people in traditional parks. Due to the experiential nature of people's behavior in traditional urban public space, a greater emphasis is placed on direct personal physical participation and sensory experience in order to perceive the meaning implied by the space, such as the large scale and symmetrical design of St. Peter's Square in the Vatican and the National Mall in Washington, DC, which have an impact on people's senses, leaving a lasting impression on those present and providing space carrier.

To summarize, whether it is the market square as a place for civic activities and deliberations in ancient Greece, the square with religious, municipal, and commercial functions in the Middle Ages, the open park and city square providing daily leisure and sports space for citizens in the twentieth century, or the "hybrid public space" supported by information and communication technology in the Internet era, all of them can demonstrate the direct influence of people's evolving social neoliberal values on public space.

2.2. Innovation Zones with a Focus on Spatial Design. Because we live in an era of knowledge-innovation economy, businesses are transitioning from internal innovation to open innovation, and people are transitioning from meeting basic needs to seeking richer experiences and more diverse lifestyles. As a result, the changing needs of users have prompted new requirements for the spatial design of innovative areas. With reference to the research on new-generation innovative areas and the study of the motivation mechanism, it can be concluded that there are five priorities of spatial design in urban areas, which are brand display, innovation concentration, spatial permeability, accessibility, and facility wisdom. These priorities are necessary to respond to the innovation development trend and realize the successful cultivation and sustainable development of urban areas, which can be summarized as IDEAS.

2.2.1. Brand Visibility. The desire for place quality expressed by the creative class indicates a reevaluation of the value of urban space in the context of global localization. Global localization is the result of local conditions feeding back into globalization, and the two processes of universalization and particularization are merging at the same time as they do in other areas of the world. This effect is achieved by integrating localized ecological, humanistic, and rural aspects into urban environments, which, when combined with internationalization and industrialization, brings forth the distinct value of the new ecological-humanistic economy. The number of urban regions that have developed a positive image through local natural or cultural branding, highlighting their special appeal and attracting innovative clusters, is in no short supply.

Los Angeles Silicon Beach, for example, is a typical exemplar of nature branding. Santa Monica, Venice, and Marianel Bay are three technology hubs with the highest concentration of innovative companies along the 7-kilometer long coastline, with 20 percent of all startups located within one kilometer of the beach. The coastline is famous for its sunny beaches, and three technology hubs with the highest concentration of innovative companies are adjacent to the beach, including Santa Monica, Venice, and Marianel Bay.

The London Knowledge District, for example, is a cultural brand. This region has an abundance of cultural resources, including more than seven universities, thirteen cultural institutes, and twenty-one museums and galleries. Following the establishment of the innovation platform, the University of the Arts London was the first institution to be invited to reside in the area, which is the source of further building cultural landmarks, attracting food festivals, music festivals, and commercial brands with a cultural image, such as Louis Vuitton, to reside in the area, preserving a large number of old industrial districts and historical buildings, and through renovation and transformation, implanting cultural and creative elements into the environment.

2.2.2. Innovation Concentration. According to the open innovation model of enterprises, the design of innovation areas must take into account the possibility of bringing together the greatest number of different types of enterprises, institutions, and facilities within a given spatial scope. The high concentration of multiple elements makes the networked connection among innovation subjects more convenient and solid, thereby inducing more open innovation behaviors.

Silicon Alley in New York City is a classic example of a highly concentrated innovation network in action. Originally, the term "Silicon Alley" refers to a concentration of Internet and mobile information technology companies centered around Fifth Avenue and the Ironman district in Manhattan, New York, where they were founded. As a result of the constant entry of technology and innovation firms, the spatial scope has increasingly grown to include the DUMBO district in Manhattan and Brooklyn, resulting in the formation of various inventive and active neighborhoods, such as the Ironman neighborhood. In part because of the high concentration of elements, the dense networking among Silicon Alley companies has prompted innovative companies to combine New York's traditional strengths in fashion and media with innovative technologies. These companies are tapping into new growth points on the Internet such as new media such as BuzzFeed and Tumblr; financial technology and e-commerce companies such as Betterment; and Internet life services and business services such as eHarmony and eHarmony International. For example, within a 0.5 km^2 radius of the ironmongery district, there are 1,737 professional services, 927 commercial services, 221 financial services, and 136 media services.

2.2.3. Spatial Permeability. Good spatial permeability is seen to contribute to the publicness of urban space; that is, a well permeable place might encourage more interpersonal

contact and a greater variety of uses, so producing more chances and conditions for communication and even urban development. Building overheads where closed and open spaces interpenetrate, third spaces where residential and workplace spaces interpenetrate, and mixed or flexible use areas where different purposes interpenetrate are examples of such spaces.

In 2015, Boston completed the construction of the world's first freestanding public innovation center. The building, which measures 1,100 square meters and includes a 250-seat dining area open to the public, as well as a gathering area with lounges and work tables and several telescoping spaces known as pods that can be configured to serve a variety of purposes such as pop-up retail stores, meeting rooms, classrooms, and showrooms, is a nonprofit project that anyone can utilize. It was the venue for the 2017 World Cup. In addition to hosting nearly 100,000 attendees at more than 1,000 events and meetups, the distinctive space has evolved into an open office space as well as a meeting, social, and business venue, helping to open up the region's innovation climate and increase the region's space for growth. It has also become a key facility in Boston's Innovation District.

2.2.4. Transportation Accessibility. The district's ability to attract the attention of the creative and development classes is also influenced by its ability to provide easy access to a variety of facilities. Highly dense road network neighborhoods and slow-moving friendly streets make it easy and comfortable to communicate between elements within a district, which can improve the use of facilities, increase the sense of access of creative people, consolidate the networked connections that stimulate innovation, and improve the development potential of the city, among other things.

Several open spaces in Kendall Square, a prominent innovation neighborhood near the Massachusetts Institute of Technology, were found to be the most frequently used by the innovation crowd, including Tech Square Lawn, Genzyme Square, the expansive Canal Walk, and the Marriott Hotel plaza and lobby, according to a study of the efficiency of space use in the neighborhood. Good access to these spaces is ensured by the linking of the plazas to one another to form a continuous two-way pedestrian flow, as well as by the orientation of the facility entrances to the connected public realm. This is considered an important factor in the efficient use of the plazas themselves and the facilities surrounding them, with sufficient traffic flow to make the spaces more dynamic and, as a result, encourage more frequent visits and access

2.2.5. Facility Intelligence. Because the pioneering and experimental nature of cutting-edge technology both highlights and fulfills the creative class's desire for novel experiences, smart infrastructure and governance platforms not only ensure the orderly operation of modern cities but also have the potential to trigger their sense of identification with the area. This is because the creative class's taste in where to live and their desire for novel experiences are both satiated by the pursuit of novel experiences.

Smart city construction has been widely implemented in cities around the world, including Helsinki, Finland, Copenhagen, Denmark, Amsterdam, the Netherlands, Eindhoven, the Netherlands, and Barcelona, Spain. In these cities, a model known as living labs has been widely implemented, where cities are used as testing grounds for technological advancements and smart technologies are more closely integrated with everyday life. In one example, a sports field with attractive playground facilities is set up to encourage residents to exercise and relax while monitoring equipment records data such as users' movement information and interactive use of facilities, allowing for a more accurate understanding of citizens' health status and usage requirements on the one hand and the product development of innovative companies in the sports equipment category on the other hand.

3. Method

As a result, we propose a multicriteria fuzzy information fusion decision-making algorithm (MCFIFDM) that combines concepts from computational intelligence domains with multicriteria decisions. The algorithm generates reference compliance graphs, where each pixel is represented by two values, the table index and the criterion value for each criterion decision, reference, and its respective rating value. MCFIFDM It is also possible to customize and alter the selected parameters to better illustrate the relative importance of standardization due to the adaptability of the system.

(1) The goal of the MCFIFDM algorithm is not simply to select alternatives but to effectively fuse information on the basis of the selection scheme

(2) MCFIFDM can fuse the target information in time k and does not include the spatial-temporal aggregation process of feedback

(3) MCFIFDM is not limited by the two phases of the previous dynamic model, data preparation at the beginning and decision evaluation at the end

(4) MCFIFDM can fuse the target information in time k and does not include the spatial

(5) The multicriteria decision-making framework incorporates the aggregation approach into the dynamic model, which will combine the hybrid operator and the weighting function to manipulate any type of information using qualitative and quantitative methods, including the processing of imprecise information

The ability to choose from a set of prospective solutions that are sufficient to satisfy one or more goals is achievable when dealing with multicriteria decision-making. Because of the uncertainty surrounding the standardization of findings or options, there will be certain issues during the decision-making process stage. When dealing with any type of information aggregation, aggregation operators will use

appropriate methods to select operators, and the most common selection methods are max–min methods, generalized mean methods, distance-based methods, pairwise comparison methods, and so on.

This paper focuses on the generalized hybrid operator, also known as the mean operator, which penalizes low normalized performance and rewards high normalized performance by using a weighting function, where instead of assigning individual values to weights, a function of normalized satisfaction is represented accordingly, and this aggregation method extends the weighted average to some extent, so the mathematical representation of the hybrid operator is as follows:

$$W_i(x_i) = \sum_{i=1}^{n} w_j(x) x_{ij}, \tag{1}$$

where W_i is the aggregated value of alternative, and x_{ij} and X_{ij} are the satisfaction values of the alternative x_{ij}.

$$W_j(x_i) = \frac{f_j(x_{ij})}{\sum_{j=1}^{n} f_j(x_{ij})}. \tag{2}$$

According to the results of the previous analysis, it is known that the operator is divided into two types: the first is a linear weight generating function, and the second is a quadratic weight generating function. As a result, the linear function that follows is as follows:

$$l(x) = \alpha \frac{\beta x + 1}{1 + \beta}, \quad 0 \le \alpha, \beta \le 1. \tag{3}$$

For a family of fuzzy functions $(\xi_i)_{i \in J}$ becomes a frame, if $A > 0, B < \infty$, then for f in space H, we have

$$A\|f\|^2 \le \sum_{i \in J} \left|\langle \xi_i, f \rangle\right|^2 \le B\|f\|^2, \tag{4}$$

where A, B are, respectively, subframes of the range of values and ξ_i of the dual-frame center $\widehat{\xi}_i$ is a series of frames in the space H. For all f in the space H, we have

$$\frac{1}{B}\|f\|^2 \le \sum_{i} \left|\langle \widehat{\xi}_i, f \rangle\right|^2 \le \frac{1}{A}\|f\|^2. \tag{5}$$

If $A = B$, then such a frame ξ_i can be called a dense frame, and in the dense frame, for all $f \in H$, we have

$$\sum_{i \in J} \left|\langle \widehat{\xi}_i, f \rangle\right|^2 = A\|f\|^2,$$

$$\widehat{\xi} = \frac{1}{A}\xi, \tag{6}$$

$$f = \frac{1}{A} \sum_{i} \langle \xi_i, f \rangle \xi_i.$$

Figure 1 depicts the fundamental framework structure of the proposed MCFIFDM, which serves as a starting point for further development.

This is seen in Figure 1, where the unpredictability of the step filtering is primarily used to demonstrate assignment

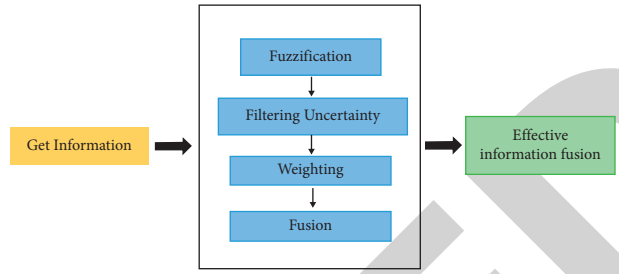

Figure 1: The structure of MCFIFDM.

normalization that is independent of relative priority. However, in MCFIFDM, it is necessary to perform the fusion of valid information using a weighting function of hybrid operators, primarily because it allows to reward or penalize the presence of hybrid operators that do not satisfy the normalization within the system by extending the normalization dagger operator to transition the uncertainty of the step filtering, as described above. As a result, the following description of the exact steps will be chosen to demonstrate that any other suitable aggregation operator can be selected and that the four steps of MCFIFDM are required in order to create a successful fusion of data. In this case, the four main steps of the proposed MCFIFDM algorithm are as follows:

(1) The normalization procedure, which is primarily concerned with the change of the fuzzy adventure mechanism in order to ensure the merging of numerical and similar information, is described in the following. It is required to do the normalizing process before fusing the information through the comparison of numerical functions when dealing with a heterogeneous matrix such as the risk mechanism's matrix.

When it comes to normalization, it will apply the fuzzy attribution function, which is also known as the normalizing procedure. Other benefits of the normalization method include the ability to express data using semantic concepts such as low slope or low variation, in addition to guaranteeing that data is uniform and comparable.

(2) Filtering uncertain input data from information containing inaccuracies is a common practice. Given the potential inherent uncertainty in the input information system, it is necessary to find an effective fusion of verbal information, and in any given alternative, it is necessary to adjust the normalization by the lack of confidence and inaccuracy in the corresponding input data. This requires the use of a double filtering function operation, which is required for this step. The first combines standardization to deal with both input value uncertainties and the decision-maker's attitude, and the second deals with both input value uncertainties and the decision-maker's attitude. Having a lack of trust in the decision-maker has an impact.

For all membership values entered, intervals of divergence from the initial values are produced on the left and right sides of the graph. Choosing this function for MCFIFDM was primarily motivated by the fact that it has the capability of adapting the attribution function to account for embedded input information uncertainty. According to the formal definitions of the accuracy and confidence parameters (a_{ij} and wc_j, resp.), the expression for altering the uncertainty of an attribution function value is as follows:

$$fu_{ij} = w_j\left(1 - \lambda \max_{x\in[a,b]}\left\{\left|\mu(x) - \mu\left(x_{ij}\right)\right|\right\}\right)\mu\left(x_{ij}\right), \quad (7)$$

where x_{ij} is the j-th normalized value of node, $\mu(x)$ is the affiliation measure in the fuzzy set, wc_j is the confidence level associated with the normalization, and $[a, b]$ is the inaccuracy interval and is defined as follows:

$$a = \begin{cases} \min(D), x_{ij} - a_{ij} \le \min(D), \\ x_{ij} - a_{ij}, x_{ij} - a_{ij} > \min(D), \end{cases}$$
$$b = \begin{cases} \max(D), x_{ij} + a_{ij} > \max(D), \\ x_{ij} + a_{ij}, x_{ij} + a_{ij} \le \max(D). \end{cases} \quad (8)$$

(3) Assign a relative priority to each standardization in relation to the weighting function, which will be based on how well the standardization meets or is suitable for the given option. MCFIFDM uses a linear weighting function to represent the standardized relative importance where the primary idea of the weighting function is to affect the predetermined relative importance by the satisfaction value of the standardization, as is the case in many other applications. It is proposed that the MCFIFDM algorithm be implemented using a modified linear function $L(fu_{ij})$ in order to increase computational efficiency and understanding.

$$L\left(fu_{ij}\right) = \alpha\frac{1 + \beta fu_{ij}}{1 + \beta}, \quad (9)$$

where $0 \le \alpha \le 1, 0 \le \beta \le 1$.

(4) To integrate all normalized pattern matrices into a single composite pattern matrix, the aggregation/fusion method (i.e., the aggregation operator) will be utilized in the fourth step. The emphasis in this step is on merging the changed input information from several sources into one cohesive whole. The hybrid role of operators serves as the foundation for the proposed operator fusion strategy. The general formula for the weighting function is denoted by the following symbol:

$$w\left(fu_{ij}\right) = \frac{L\left(fu_{ij}\right)}{\sum_{k-1}^{n} L\left(fu_{ij}\right)}. \quad (10)$$

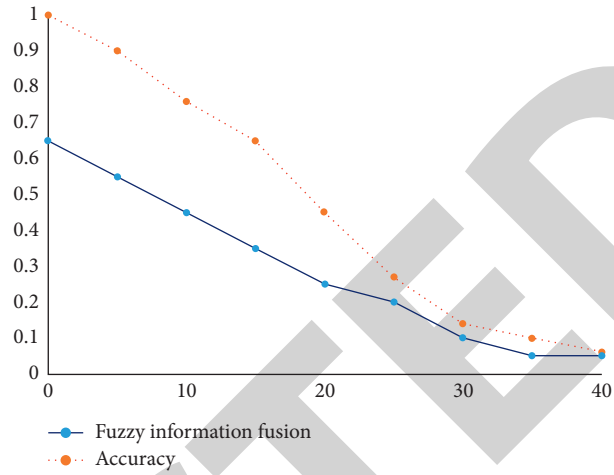

Figure 2: The curves of low texture with uncertainty.

4. Evaluation Result

From the perspective of the MCFIFDM algorithm, we have the following:

(1) MCFIFDM fuzzy rule-based approach (FRBM) is more adaptive because it does not require resetting the data information base, it is not affected by the before and after steps of the system during the application, and it is tested only by standardized evaluation.

(2) MCFIFDM fuzzy rule-based approach (FRBM) is more adaptive because it does not require resetting the data information base.

(3) It is not necessary to train the algorithm with a training set in order to fine-tune the algorithm. Furthermore, it is applicable to any environment and does not necessitate any special training. Apart from that, MCFIFDM is capable of dealing with unpredictability in the input data, whereas other approaches are typically unstable in rapidly changing contexts.

In addition, MCFIFDM is capable of dealing with and representing the imprecision and uncertainty inherent in the input data, in contrast to FRBM, which requires prior preconditioning. In addition, FRBM is not designed to support multiple normalization targets; hence, in these situations, some form of prior aggregation is required before normalization can take place. Because each type has its own advantages and they can work together to produce superior data outcomes, it is obvious from this comparison that hybrid approaches will almost surely contribute to the enhancement of information fusion.

The graphs of all of the values in the low-texture input matrix are depicted in Figures 2 and 3. Its topology is utilized to define the many attribution functions that are associated with it. Two separate fuzzy input matrix modes are represented by two different simulation plots, the first of which is the mode with an expertise fuzzy input matrix and the

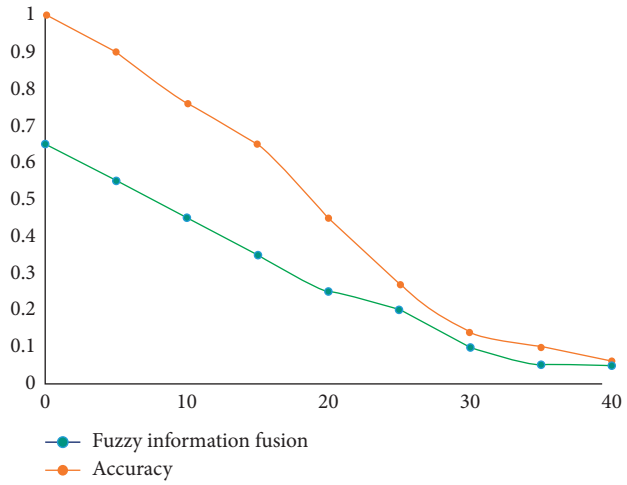

Figure 3: The smoothed curves of low texture with uncertainty.

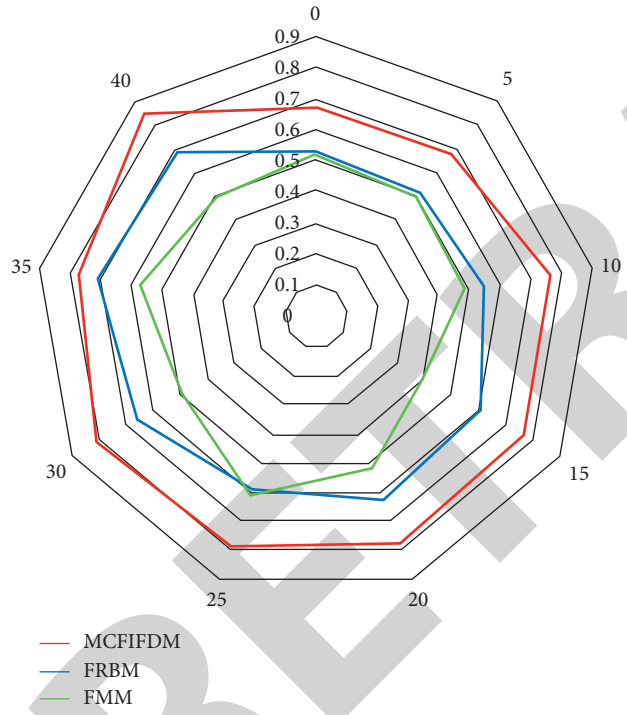

Figure 4: Comparison of different algorithms.

second of which is the mode with a suitable form of the fuzzy input matrix, both represented by curve plots.

Based on the results of the two previous figures, it can be observed that the optimal measure is obtained by employing the suitable attribution function. When using information fusion, the goal is to receive the outcomes of the combined measure value data for each choice without having to perform the decision job of selecting the best alternative.

To further illustrate the superiority of the MCFIFDM algorithm, we compare the MCFIFDM algorithm with the FRBM algorithm and FMM algorithm, which is as shown in Figure 4.

From Figures 3 and 4, we can see that our method performs well. Further, our method significantly outperforms FRBM and FMM.

5. Conclusion

The traditional practice of relying on the replacement of high-end functions for low-end functions to balance the cost of urban renewal is very likely to cause an imbalance in the urban functional structure. In the long run, improving the quality of public space design can bring sustainable returns to multiple subjects. A safe and convenient street environment, or a community plaza that promotes interaction, is undoubtedly an integral part of the land value. Based on multicriteria group decision-making, this paper studies public space design in urban renewal, introduces urban design governance theory, builds a theoretical framework for urban design governance to deal with different target levels of urban renewal, and explores urban renewal strategies. At the same time, a multicriteria-based decision-making algorithm is proposed to handle and represent the imprecision and uncertainty involved in the input data. In the future, we will enrich the multicriteria principle and try our best to consider multiple indicators.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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https://doi.org/10.1155/2023/9823485

Retraction

Retracted: A Personalized Recommendation Method for Short Drama Videos Based on External Index Features

Advances in Meteorology

Received 22 August 2023; Accepted 22 August 2023; Published 23 August 2023

This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope

(2) Discrepancies in the description of the research reported

(3) Discrepancies between the availability of data and the research described

(4) Inappropriate citations

(5) Incoherent, meaningless and/or irrelevant content included in the article

(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] X. Gong, "A Personalized Recommendation Method for Short Drama Videos Based on External Index Features," *Advances in Meteorology*, vol. 2022, Article ID 3601956, 10 pages, 2022.

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Research Article

A Personalized Recommendation Method for Short Drama Videos Based on External Index Features

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Dramatic short videos have quickly gained a huge number of user views in the current short video boom. The information presentation dimension of short videos is higher, and it is easier to be accepted and spread by people. At present, there are a large number of drama short video messages on the Internet. These short video messages have brought serious information overload to users and also brought great challenges to short video operators and video editors. Therefore, how to process short videos quickly has become a research hotspot. The traditional episode recommendation process often adopts collaborative filtering recommendation or content-based recommendation to users, but these methods have certain limitations. Short videos have fast dissemination speed, strong timeliness, and fast hot search speed. These have become the characteristics of short video dissemination. Traditional recommendation methods cannot recommend short videos with high attention and high popularity. To this end, this paper adds external index features to extract short video features and proposes a short video recommendation method based on index features. Using external features to classify and recommend TV series videos, this method can quickly and accurately make recommendations to target customers. Through the experimental analysis, it can be seen that the method in this paper has a good effect.

1. Introduction

With the rapid development of Internet communication technology and multimedia technology in China, the number of new media short videos in China is increasing day by day. By the end of 2019, the total number of video viewing videos of IQIYI and Tencent TIKTOK and short video was 100 million, and the number of monthly users was close to 300 million. The number of videos was up to 1 billion 500 million per day. Using data mining can make research and decision-making, help clarify the complexity of data interaction, understand the uncertainty caused by lack of data, and dig deep into the huge business value behind complex data. In the broad short video market, data mining runs through it, such as market analysis, segmentation, target selection, and finally making plans, which will be inseparable from data mining. It can be said that data mining has opened up a new path for the development of short video.

The prosperity and development of short video mainly depends on the continuous optimization of China's communication infrastructure development and application. The continuous improvement of network environment and the improvement of information transmission speed and stability also provide a strong technical guarantee for the development of short video [1–4]. The popularity of smart phones provides valuable soil for the accumulation of short video users, and the video production in the short video app is simple and easy to learn, the use threshold is low, the integration of production and production is realized, and the operation cost of users is reduced. In the field of visual imaging, the application of AR technology enhances the user's multidimensional experience. Based on the accurate push of data mining, it forms the user's unique personalized label and firmly locks the user.

UGC is the abbreviation of user original content. The positioning of short video platform is content sharing [5]. All users can upload and share their own life short videos.

There is almost no content restriction, which meets the personalized needs of users. Through the UGC content mode, the threshold of user production content is reduced and the number of users of the platform is expanded, so as to occupy the market.

Short video has the characteristics of brevity, rich content, and strong participation and interaction. At the cognitive level, users identify the external rich world through a large number of short videos [6]. At the psychological level, short video occupies most of the scattered time of users, and short video gives users an immersive experience through the three-dimensional form of text, sound, and image senses. At the action level, users' comments and forwarding have become a part of the short video experience, which has also improved and enhanced users' sense of participation.

In recent years, the rapid development of the Internet has increased the convenience of people's access to information. At the same time, thanks to the reduction of production costs of various electronic and digital devices and the progress of production technology, the number of users who use convenient smart phones to shoot and produce videos is growing exponentially [7–9]. A huge user group uploads the captured and produced videos to the Internet, forming a large amount of video data. According to the 38th statistical report on China's Internet development recently released by China Internet Network Information Center (CNIC), as of June 2016, the number of online video users in China had reached 514 million, an increase of 10 million over the end of 2015, and the utilization rate among Internet users was 72.4%. For users, video operators provide rich video data. According to the official data released by YouTube, the world's most famous video social networking website, YouTube has been viewed 2 billion times a day, and users spend an average of 15 minutes browsing YouTube every day. For domestic video operators, the field of Internet video has a sense of competition. Baidu video, Tencent video, LETV, Youku Tudou, Ku6, and other video aggregation and sharing platforms have emerged successively.

Personalized recommendation technology is to recommend content suitable for users' interests according to their previous behavior in huge data. The birth of this technology can well solve the problems of information overload and difficult search. What is more meaningful is that users do not need to go through specific settings. Personalized technology can recommend interest related content for users when users are not aware of their needs, improve user experience, and increase user loyalty. Personalized recommendation technology has become the focus of video website development, and our research in this direction is also of great significance.

The research contributions of the paper are as follows:

(1) In this paper, external index features are added to extract short video features, and a short video recommendation method based on index features is proposed.

(2) The paper uses external features to classify and recommend TV series videos, which can be quickly and accurately recommended to target customers. Through the experimental analysis, it can be seen that the method in this paper has a good effect.

2. Related Works

This paper mainly introduces the relevant theoretical knowledge and technology used in the paper, mainly including log data preprocessing method, short video log text model, and classification algorithm [10]. Firstly, this paper will preprocess the short video log and user behavior log. The processing methods include Chinese word segmentation and part of speech tagging. In addition, this paper also introduces the relevant knowledge of noise processing. Next, this paper introduces the models used to represent short video features in detail, mainly including the vector space model used in short video text and the LDA topic model for constructing short video topic features. Finally, the classification algorithm for short video recommendation in this paper is introduced, mainly including factor decomposition machine, gradient lifting decision tree, and logistic regression algorithm.

2.1. Data Preprocessing Technology. Detailed preprocessing work should be carried out before model representation of short video related logs, including Chinese word segmentation, removing stop words, and removing noise in data. Next, it briefly introduces the Chinese word segmentation technology and noise processing of the text.

2.1.1. Chinese Word Segmentation Technology. One of the most important processing links of text data is Chinese word segmentation. The result of word segmentation can determine the efficiency of follow-up research. The purpose of word segmentation is to select the basic units containing complete semantics from the given text. Compared with English words, they are generally segmented with spaces or punctuation marks, and Chinese is much more complex. The purpose of Chinese word segmentation algorithm is to cut the Chinese sentence sequence in the data into a series of words with basic semantics. At present, the main Chinese word segmentation methods include word segmentation based on string matching, word segmentation based on dictionary, and word segmentation based on statistics. The main idea of word segmentation method based on string matching is to use string matching algorithms, such as forward maximum matching method (FMM) [11]. The main idea of Chinese word segmentation method based on dictionary is to build a corresponding Chinese dictionary, compare and match the input Chinese text with the words in the dictionary, and cut the words if the matching is successful, but not anyway. The statistical method is to determine whether the word can be formed according to the frequency of the string in the corpus. If the frequency between adjacent words is high, a word can be formed.

It includes a variety of algorithms, Chinese word segmentation methods, and other Chinese tools, such as part of speech tagging, keyword extraction, and other functions. Boson is the most authoritative platform in the field of open Chinese semantic tools.

2.1.2. Denoising. Noise data refers to meaningless data in the data set. If the meaningless noise data in the data set is not removed, it will produce deviation and bad results for video description and analysis in the experiment. The noise in the dataset used in this paper mainly includes repeated text data, stop word processing, and semantic noise of short video data itself.

2.2. Short Video Model Representation

2.2.1. LDA Topic Model. The English full name of LDA is latent Dirichlet allocation, that is, implicit Dirichlet distribution. It is a topic model. The main idea is to give each document in the text set in the form of probability distribution. Using this idea, we mine their topic distribution from the text and then cluster or classify them according to the mined topics. LDA topic model needs to manually specify the number of topics K in the training process. At the same time, it is an unsupervised learning algorithm. When training LDA topic model, it does not need to manually label the training set.

LDA is a three-tier generative model, which contains words, documents, and topics. It represents a document as the probability distribution of a certain number of topics, and the topics are represented as the probability distribution of all different words in the document set. Suppose there is a set of documents, marked D. According to the idea of LDA, we believe that document set D is composed of M documents and different words, in which the number of K topics is given manually. The process of document generation by LDA can be represented by graphical model representation, as shown in Figure 1. Firstly, the parameters of LDA are β. The relationship between topic and word is extracted from the Dirichlet distribution$Q$. When LDA generates a document D, it randomly selects a k-dimensional vector from the Dirichlet distribution with parameter α to represent the topic distribution in document D. According to this distribution, for all words in document D, z_{dn} is randomly selected from the polynomial distribution with parameter θ_d to represent the topic selected by the current word. Finally, the word ω_{dn} is extracted from the polynomial distribution with parameter $\varphi_{z\,dn}$.

The box in Figure 1 refers to repeated sampling, where the sampling times are represented by the values of M, N, and K in the lower right corner. Among them, M, N, and K constants represent the number of documents, words, and topics, respectively, and the number of topics is manually set. The gray circle in the figure represents the observable variable, the hollow circle represents the potential variable, and the arrow represents the dependency between the two variables α, β which are the hyperparameters of Dirichlet distribution.

The process of generating a document by LDA is actually to extract the subject information in the document [12]. After obtaining the subject information, the corresponding hidden variables can be deduced by using the word information, so as to obtain the subject probability distribution θ of each document and then mine the potential semantic

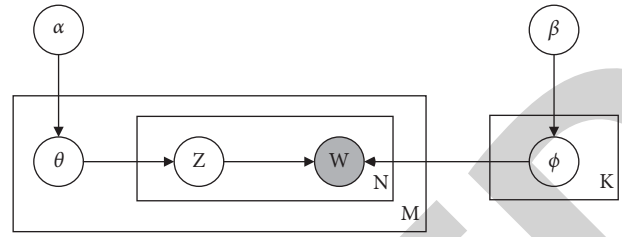

Figure 1: Working mechanisms of LDA.

knowledge in the text. In solving LDA topic model, this paper uses Gibbs sampling method to solve the parameters of LDA model and realize topic mining.

2.2.2. Vector Space Model. Vector space model was proposed by Salton et al. in the 1970s [13]. It is an algebraic model taking text content as space vector. Now it is widely used in the fields of information retrieval, data mining, and related sorting.

The vector space model first simplifies the text content into a vector, ignores the order and position of specific semantic units, and only considers their frequency in the text. Then, by taking the spatial similarity as the semantic similarity to measure the text similarity, the processing of text content is simplified into vector operation. The related concepts of vector space model are given below:

(1) Text: it is the content to be processed by the model, which is composed of one or more complete texts and sentences and usually has systematic meaning.

(2) Feature item: it mainly refers to the text, words, and phrases in the text content, which can be used as the basic language unit for model processing. They are the basic units of text model.

(3) Feature item weight: a weight value is used to indicate the importance of a feature item in a text. The higher the weight is, the more important the feature item is. The weighting functions include Boolean weight, word frequency weight, and TF-IDF.

TF-IDF is a statistical method to calculate the importance of a word in the whole text. It is often used in data search and data mining [14]. Term frequency (TF) refers to judging the contribution of a word to the text by counting the number of occurrences of feature items in the document. The higher the frequency, the greater the contribution. If only statistical methods are used, there will be limitations. For example, words that do not contribute to classification in statistical texts without screening, such as prepositions and conjunctions, will affect the accuracy of classification. In addition, for example, if the value of a word with a high statistical characteristic value of F is also high in other documents, the document to which it belongs cannot be judged. In addition, it is often used together with IDF for statistics because of the limitations of using it only. The idea of inverse document frequency (IDF) is to ignore the feature items that appear in multiple documents and retain the feature items that appear in a small number of documents as

a measure of the importance of a word. The IDF statistical method is to divide the total number of documents by the number of documents with feature items and then take the logarithm of the result.

2.3. Text Classification Algorithms. In this paper, our classification algorithms for short video features mainly include three kinds: factor decomposition machine, gradient decision tree algorithm, and logistic regression algorithm. These algorithms are introduced in this section.

2.3.1. Factor Decomposition Machine. Factorization machines (FM) [15] is a machine learning algorithm based on matrix decomposition proposed by Steffen Rendlel in 2012. The purpose of this algorithm is to solve the problem of feature combination under sparse matrix. The traditional machine learning problem only considers how to give weight to features without considering the interaction between features. The proposal of FM model solves this problem better.

The factor decomposition machine simulates the factor decomposition model through the eigenvector, can model the interaction between different types of variables, and can predict any real value vector. The factor decomposition machine model can give the prediction results according to the real value characteristics in the data. It uses factor parameter decomposition to build the model between the characteristic variables. Combined with the advantages of SVM, FM can deal the very sparse data well. Meanwhile, compared with SVM, FM has a better performance and its complexity is linear. Suppose x is the inputted feature vector and y is the target variable; we can predict the value of y by the following formula:

$$\widehat{y}(x) = \omega_0 + \sum_{i=1}^{n} \omega_i x_i + \sum_{i=1}^{n-1} \sum_{j=1i+1}^{n} v_i, v_j x_i x_j. \quad (1)$$

In this formula, n stands for the dimension of features, v_i, v_j is the interrelationship between the i-th and j-th variable and it can be calculated by $v_i, v_j = \sum_{f=1}^{k} v_{i,f} v_{j,f}$, k is a hyperparameter, and $\omega_0 \in \mathbb{R}$ is the parameter of the model.

Stochastic gradient descent (SGD) [16], alternating least squares (ALS), and Markov Monte Carlo (MCMC) are three machine learning methods commonly used to solve the parameters of factorization machine. When using the three methods for parameter calculation, it is necessary to select the specified loss function for optimization. The effect is achieved by minimizing the loss function on the specified observed data set. The definition of the loss function minimization optimization function is shown in the following formula:

$$OPT(S, \lambda) = \arg\min \sum_{x,y} loss(\widehat{y}(x|\theta),\ y). \quad (2)$$

According to the model parameters in practical problems θ to determine the optimization function $\widehat{y}(x|\theta)$, the value of $\widehat{y}(x|\theta)$ is determined. In order to make the optimization function meet the requirements better, we must use the appropriate loss function according to the actual problem. For the regression problem, the loss function takes the least square difference, as shown in the following formula:

$$loss(\widehat{y}, y) = (\widehat{y} - y)^2. \quad (3)$$

For the binary classification problem, we use the logistic regression function as our loss function, and it can be calculated by

$$loss(\widehat{y}, y) = -\ln\ \sigma(\widehat{y}y). \quad (4)$$

When we find the values of the model parameter θ, they may be overfitting since there are too many parameters. So, in practice, we must optimize the loss function. The commonly used optimization method is to use L_2 normalization, and the formula is

$$OPT(S, \lambda) = \arg\min \left\{ \sum_{x,y} loss(\widehat{y}(x|\theta), y) + \sum_{\theta \in \Theta} \lambda_\theta \theta^2 \right\}. \quad (5)$$

In this paper, the stochastic gradient descent algorithm is used to solve the calculation of the loss function of the factorizer. SGD algorithm uses each iteration to calculate the gradient and then updates the parameters of the required solution. SGD can effectively target large data sets, and its algorithm complexity is linear, so SGD has good performance. The updated calculation of parameters by SGD is shown in the following formula:

$$\theta \leftarrow \theta - \eta \left(\frac{\partial}{\partial \theta} loss(\widehat{y}(x), y) \right) + 2\lambda_\theta \theta. \quad (6)$$

2.3.2. Decision Tree Algorithm. Decision tree is to train certain sample data to learn decision rules and classify unknown data efficiently. In short, decision tree is a widely used classifier for exploratory knowledge discovery. Decision tree has two advantages: (1) it has good readability, which is helpful for manual analysis; (2) it has high efficiency and can be used many times without repeated construction. The maximum calculation times of each prediction cannot exceed the depth of the decision tree.

The core algorithm of the decision tree is to select the attributes of each node in the tree that are most conducive to the classification of instances. On the basis of ID3 algorithm, the concept of information gain is introduced to determine the attributes used for classification on different nodes at each level of the decision tree through the value of information gain.

Gradient boosting decision tree (GBDT) algorithm is a boosting machine learning idea based on decision tree proposed by Schapire et al. in 1990 [17]. Gradient boosting is an algorithm combination model in which multiple different classification algorithms can be used. Generally, boosting algorithm is an iterative process, and each training is to improve the last result. Each calculation is to reduce the last residual. Because there are many cases where the decision tree is used as the basic model, gradient boosting is often used as the decision tree of gradient promotion.

2.3.3. Logistic Regression Algorithm. Logistic regression is a binary classification model commonly used in machine learning. It is widely used in practice. For example, logistic regression is widely used in statistics and sociology. It is used to analyze the hit rate prediction problem. At present, logistic regression is widely used in the field of computing advertising.

In order to solve the binary classification problem, it is necessary to use logical regression to generate values in the range of 0 to 1. Therefore, sigmoid function is introduced into logistic regression for fitting. The mathematical form of sigmoid function is shown in the following formula:

$$g(x) = \frac{1}{1 + e^{-x}}. \tag{7}$$

The corresponding curve for sigmoid function is shown in Figure 2.

As can be seen from Figure 2, the sigmoid function is a S-shaped curve whose value is between [0, 1], and different input values will result in different output results. Far from 0, the value of the function will quickly approach 0/1, and conversely, near 0, the result will be closer to 0. This property allows us to interpret it in a probabilistic way. Therefore, using logistic regression to predict the hit rate of short videos can solve this problem well, and the parameters in the sigmoid function represent the weights of the features extracted in the short video hit rate prediction problem and their corresponding parameters. A common way to solve for parameters is to use maximum likelihood estimation, i.e., to find a set of parameters, the greater likelihood (probability) of our data under this set of parameters. In this paper, we use logistic regression to solve a binary classification problem. The formula of logical regression can be expressed as shown in

$$f(x) = \frac{1}{1 + e^{-g(x)}}. \tag{8}$$

In this formula, $g(x) = \beta_0 + \beta_1 x_1 + \ldots + \beta_n x_n$.

3. The Framework of Short Video Recommendation

This section focuses on the basic framework of short video personalized recommendation and mainly introduces the overall process of short video personalized recommendation, short video data processing module, and short-sighted recommendation module.

Short video is short video, which generally refers to the video transmission content with a duration of less than 5–20 minutes on new Internet media. Short video is different from long video. It has the characteristics of fast propagation speed, timeliness, and hot search. In view of the above outstanding characteristics of short video, this paper focuses on the extraction and analysis of short video features and proposes a short video feature construction method integrating external indexes. Short video recommendation is regarded as a classification problem. LDA topic model is used to construct features, and three different classification algorithms are used to compare, hoping to get more accurate recommendation results.

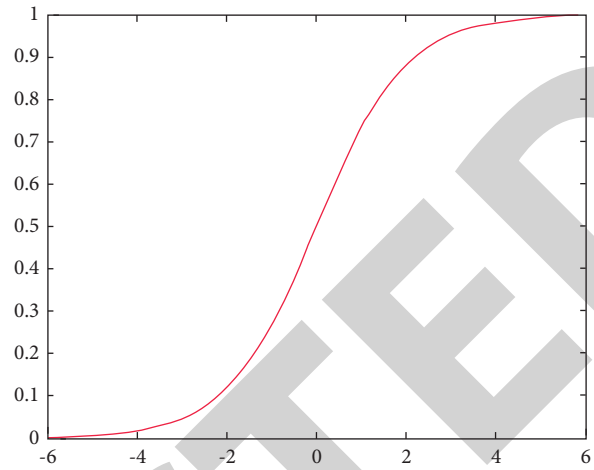

Figure 2: The plot of sigmoid function.

3.1. Overall Process of Network Short Video Recommendation. In this paper, short video recommendation is abstracted as a binary classification problem. In the binary classification problem, how to construct the features used in classification is a core work. At present, although the traditional LDA topic features can capture certain implicit semantic information, the topic features obtained by LDA model can not reflect the timeliness and hot search of short video. Therefore, this paper introduces the external index feature into the short video recommendation method and constructs an LDA topic model based on the integration of external index feature, so as to better recommend the network short video with high public attention to users. The overall framework of this work is shown in Figure 3.

As can be seen from Figure 3, the framework mainly includes the preprocessing of short video data sets, the analysis and extraction of short video features, the construction of classifiers, and short video recommendation methods. Among them, the analysis and extraction of short video features and the construction of feature model are the focus of this paper. This paper integrates the relevant features of external index on the basis of traditional topic-based features and applies it to the recommendation method of short video. This approach can effectively improve the shortcomings of short video recommended to users, which is lack of timeliness and hot search.

(1) In the preprocessing of short video data set, this paper uses the background log data of Baidu video, a well-known aggregated video in China. The log data includes the short video data of the aggregated video app and user behavior data. Firstly, the data are sorted and cleaned according to the technology and method of data preprocessing. Then use the open API provided by boson Chinese semantic tool to segment and label the data. Then cluster the divided words to get the different topics contained in the short video and user search words.

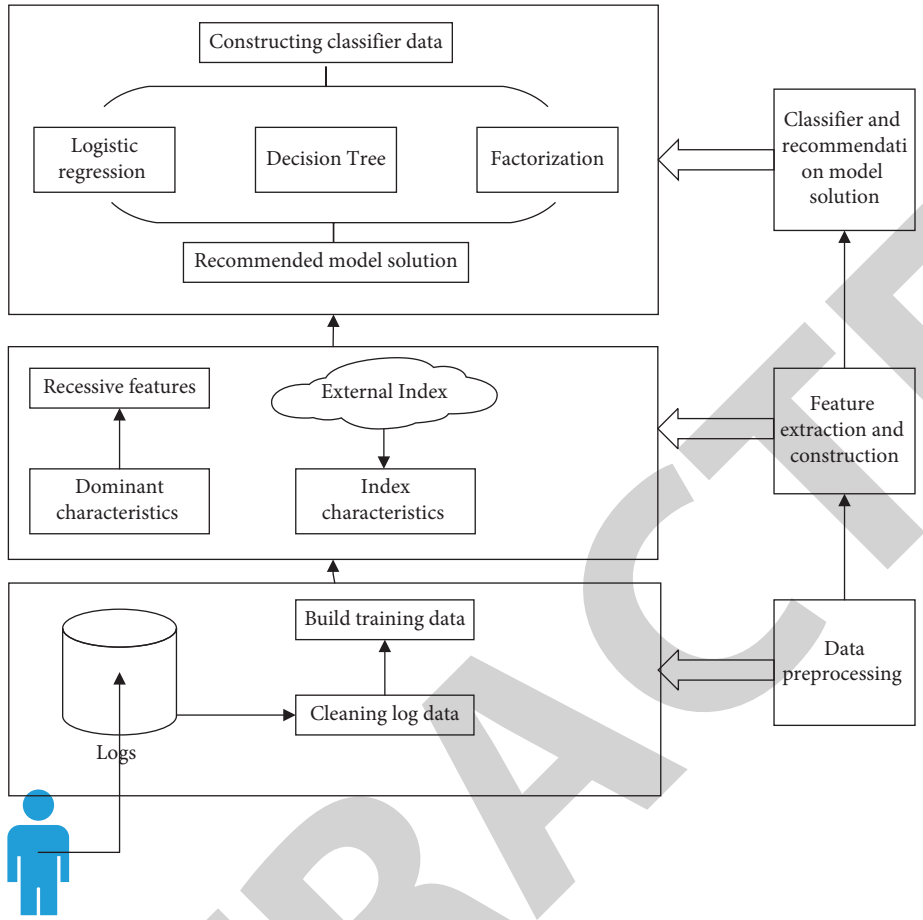

Figure 3: Short video recommendation flow chart.

(2) In the aspect of feature analysis and extraction, the features of short videos are divided into dominant features and recessive features, the two features are statistically analyzed, and the important features are extracted. In the aspect of constructing features, this paper combines the external index features on the basis of the traditional topic features and gives the construction method of constructing the LDA topic feature model which combines the external features.

(3) In terms of classifier construction and short video recommendation methods, in this paper, we abstract network short video recommendation into a binary classification problem. In the experiment, this paper mainly selects three different classification algorithms such as factor decomposition machine, gradient generation decision tree, and logical regression to realize short video recommendation and compares the performance of three different classification methods in short video recommendation.

3.2. Network Short Video Data Processing and Feature Extraction Module. Data preprocessing is an important part of constructing training set. There will be a lot of noise data in large data, such as zombie users and repeated and defective data. If these garbage data are not handled well, it will affect the construction of feature model. The data preprocessing in this paper includes the following aspects:

(1) The description text data of short video (positive title, subtitle, description, etc.) and the search words in the user's search log are fused

(2) Propose useless data in the data set

(3) word segmentation, de stop words, de symbols, part of speech tagging, etc. for the fused text data

(4) Filter high-quality users for the user's playback behavior log

The extraction of short video features in this paper comes from the playing log of short video and the user's behavior log. The original basic features of short video can be extracted from the log. This paper defines these features as dominant features. Based on the original features, the features mined by statistical analysis are defined as invisible features in this paper. In addition, this paper also innovatively introduces the characteristics of external indexes, including Tencent Rulan index (TBI), Sina Micro Index, and Baidu Index, three authoritative index platforms of Internet big data. Short video feature categories are shown in Figure 4.

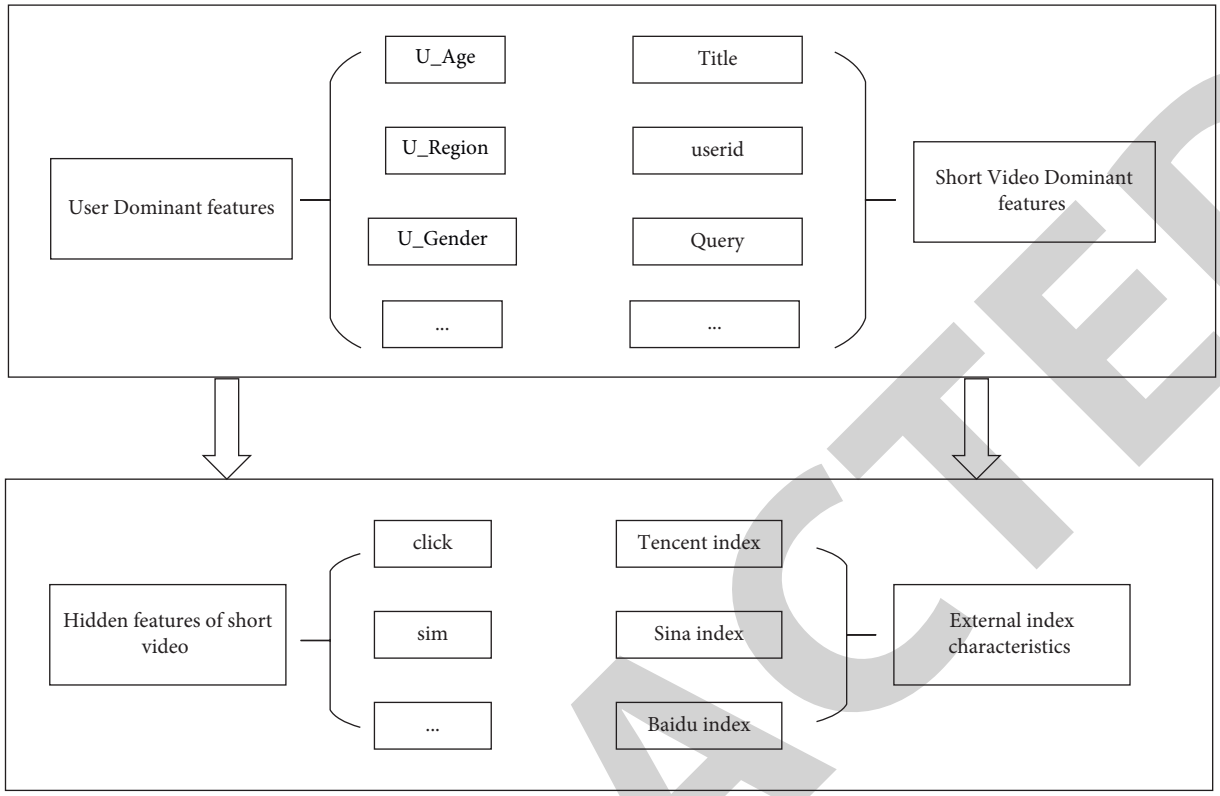

Figure 4: Short video features.

3.3. Short Video Recommendation Module. After obtaining the training set and extracting the corresponding features from the training set, this paper uses three different classification algorithms to establish the short video recommendation model, including factor decomposition machine, decision tree, and logistic regression. For the logistic regression algorithm, it belongs to the discriminant model. For the binary classification problem, it has a good effect. For the multicategory features extracted from short video, this paper can give faster results. However, the short video features extracted in this paper have the problem of too large feature space, which makes the performance of logistic regression poor. For the decision tree method, this paper uses the gradient iterative decision tree (GBDT) of boosting method. This paper uses this combination algorithm combined with short video features without detailed feature filtering. For the factorization machine, it can solve the sparsity of short video features. Therefore, these three classification algorithms are used as short video recommendation algorithms in this paper.

4. Experiment and Analysis

4.1. Experimental Corpus and Processing Methods. In terms of data selection, the experimental data used in this paper comes from Baidu video, a well-known aggregation video in China. The data includes the short video log data of Baidu video and the behavior log data of users using it. In terms of time dimension, this paper selects the log data from July to November 2016, a total of 1712460 users watching short videos and 50 g short video playback logs. In order to ensure the accuracy of the model recommendation results, this paper does not sample the sample data, but selects all the sample data. In this paper, the short video logs in July, August, September, and October 2016 are used as training data, and the short video data in November are used as test data.

In terms of data preprocessing, this paper uses the data preprocessing method proposed in Section 2 to clean the data. The main cleaning work includes deduplication of users, cleaning of duplicate data, screening of high-quality short video users, text segmentation, and part of speech tagging of short video playback logs and user behavior logs, etc.

When constructing topic features, this paper constructs topic features based on the topic model of LDA. In this experiment, we set the number of topics of short video data to 10, 20, 50, and 100, respectively, and finally determine the appropriate number of topics of the data set. At the same time, we select the first 20 subject words in descending order of probability value for the subject words extracted from each subject to prepare for the later integration of external index features. A specific example is shown in Figure 5.

When constructing the theme model integrating the characteristics of external indexes, this paper selects Tencent browsing index (TBI), Baidu Index, and Sina Micro Index, three data sharing platforms with massive data and users on the Internet. They can provide the heat impact index of relevant events in the corresponding time period based on the given keywords and time period. Therefore, this paper

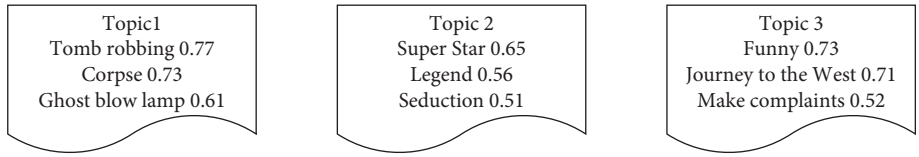

Figure 5: The topic of short video.

combines these external exponential features with short video topic model to construct feature model.

4.2. Evaluating Indicator. It is a very important work to evaluate the performance of the classifier. There are many indexes to evaluate the model algorithm, including accuracy (Accuracy), accuracy (Precision), recall (Recall) *l*, and F-measure (F-value). For two typical two-classification problems, it is very necessary to use AUC as the evaluation index of the classification model. In this paper, the receiver working characteristic curve (receiver operating characteristic, ROC) is used to describe the dynamic performance of the classifier, and ROC can be used to directly represent the performance of the classifier. For the binary classification problem, the classifier will produce a probabilistic prediction for the data, which ranges from 0 to 1. At this time, the classification performance can be seen intuitively by using the ROC curve. The longitudinal coordinate of the ROC curve is the true positive rate (TPR, true positive rate), and the Abscissa is the false positive rate (FPR, false positive rate). The ROC space is formed by TPR and FPR, and the curve is drawn. The larger the area under the curve, the higher the accuracy. Since there are many indicators to evaluate classifiers, why use ROC? This is because the ROC curve has a good characteristic: when the distribution of the positive and negative sample cloth in the test set changes, the ROC curve can remain the same. However, several kinds of uneven phenomena often occur in the actual data set; that is, the proportion of positive and negative samples is very uneven, the distribution of samples in different categories is also very uneven, and the use of ROC curve can solve this problem very well.

To understand the AUC evaluation indicators, you need to introduce the confusion matrix first. The following first gives the relevant knowledge of the confusion matrix: the confusion matrix is a visualization tool in the field of artificial intelligence, which is used to compare the classification results with the real information to get the result matrix. The rows in the result matrix represent the results of the classification, and the columns represent the actual information categories, as shown in Table 1.In the table, positive represents that the prediction instance is from a positive class, and negative represents that the prediction instance is from a negative class. True represents correct prediction and false represents wrong prediction. In the short video click prediction problem, the short video most likely to be clicked by the user is pushed to the user according to the predicted value of the click through rate. AUC is the area under the ROC curve, and its value is between 0.5 and 1.0. The larger its value, the more accurate the prediction of the click through rate of the short video.

Table 1: Confusion matrix.

Simplified representation of confusion matrix	Meaning
TP	True positive
TN	True negative
FP	False positive
FN	False negative

ROC index is most concerned with FPR index and TPR index in the confusion matrix. FPR represents the probability of accurate prediction of negative sample distribution, and TPR represents the probability of accurate prediction of positive sample distribution data, as shown in the following formula:

$$TPR = \frac{TP}{TP + FN}, \; FPR = \frac{FP}{FP + TN}. \tag{9}$$

In addition to using ROC as the evaluation index, this paper also uses the accuracy, precision, recall, and F value commonly used to evaluate the performance of classifiers as the evaluation index.

4.3. Experiment and Result Analysis of Network Short Video Recommendation Method. In order to verify the effectiveness of the proposed method, we conducted the following groups of experiments:

(1) The first group of experiments: we first verify the short video recommendation performance of the feature model constructed using the explicit and implicit features of short video under three different classification algorithms: factor decomposition machine, logistic regression algorithm, and decision tree. It can be seen from Table 2 that the classification results using factor decomposition machine are much better than logistic regression algorithm and decision tree. Next, this paper will use the factor decomposition machine to carry out the next experiment.

(2) The second group of experiments: in this group of experiments, we mainly verify the impact of the number of topics on the click through rate of short video in the process of algorithm based on LDA-FM. In this experiment, short video text information is tested according to the number of topics to determine the impact of the number of topics. In the process of experiment, we carry out the experiment on different sizes of training sets for the purpose of comparative experiment. The size of the training set is set to 100%, 80%, 60%, and 40%, respectively.

Table 2: Comparison of recommended performance of different classifier.

	FM		Logistic		GDBT	
Evaluating indicator	Accuracy rate (%)	F value (%)	Accuracy rate (%)	F value (%)	Accuracy rate (%)	F value (%)
Dominant feature	71.05	73.79	68.33	70.28	70.31	71.34
Dominant + invisibility	74.56	75.83	70.29	72.21	70.79	72.43

Table 3: Example of selected topic words and their external index values.

Subject words	Time	Tencent browsing index (average)	Sina Micro Index (average)	Baidu Index (average)	Composite index
Tomb robbing	2016.7	5647	5966	2878	4830
Zombie	2016.7	6380	7621	13604	9201
Ghost blow lamp	2016.7	17700	13035	26247	18994
Subject words	Time	Tencent browsing index	Sina Micro Index	Baidu Index	Composite index
Tomb robbing	2016.12	5088	3089	1473	3216
Zombie	2016.12	4766	5612	8743	6373
Ghost blow lamp	2016.12	7723	9102	13310	10045

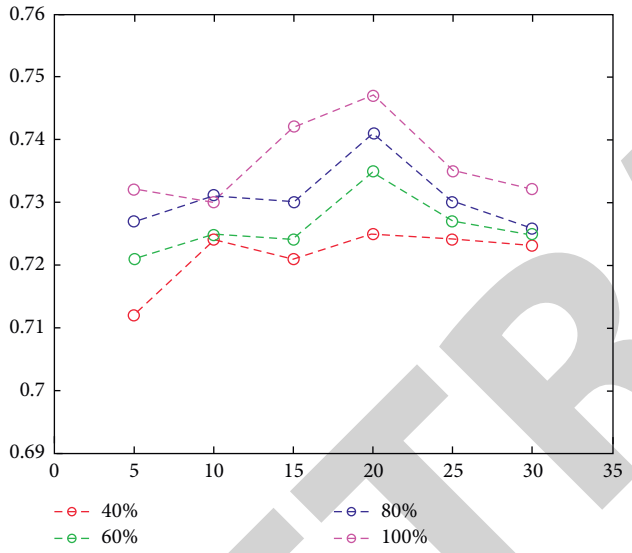

Figure 6: The influence of the number of different topics on the click through rate.

As can be seen from Figure 6, the clicks of short videos with different topics are completely different, and the value of AUC gradually increases with the increase of the number of topics. In increasing the number of topics from 10 to 20, the AUC improved significantly. When the number of subjects peaked at 20, the AUC value stabilized after 20. Therefore, the number of subjects selected for subsequent experiments is 20.

(3) The third group of experiments: the third group of experiments is mainly used to construct the topic characteristics of the fusion external index. This paper generates 20 topics based on the LDA topic model and selects the top 20 words with the largest probability value from each topic. Then input 20 words and corresponding dates into Tencent browsing index, Baidu Index, and Sina Micro Index, respectively, and some results after weighted average of the three index values will be obtained, as shown in Table 3. The index of zombie related words has a mean value in July and decreased significantly after November. It can be seen that the external index characteristics can reflect the change of theme heat.

5. Conclusion

This paper mainly focuses on short video recommendation methods and proposes a short video recommendation method based on topic model based on external exponential features. The main content of this paper includes the following parts.

(1) The recommendation framework of network short video is designed. The recommendation framework gives the overall recommendation process from short video log preprocessing to feature analysis and extraction and then to the establishment of recommendation model.

(2) The features of short video are analyzed, and the explicit and implicit features of short video are extracted. The feature construction method for short video recommendation is studied, and a short video topic feature construction method combining the features of short video itself with external exponential features is proposed.

(3) The short video recommendation method based on binary classification is studied. In this paper, short video recommendation is abstracted as a binary classification problem, and three different classification algorithms are used to realize short video recommendation: factor decomposition machine, gradient iterative decision tree, and logical regression. Firstly, this paper describes the short video recommendation methods of three different classification algorithms in detail and then verifies the performance of different classification algorithms in short video recommendation through experiments. The experimental data in this paper are from the log data of Baidu video, a well-known aggregate video in China. On this basis, experiments and comparative

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Retraction

Retracted: Study on Meteorological Disaster Monitoring of Field Fruit Industry by Remote Sensing Data

Advances in Meteorology

Received 22 August 2023; Accepted 22 August 2023; Published 23 August 2023

This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope

(2) Discrepancies in the description of the research reported

(3) Discrepancies between the availability of data and the research described

(4) Inappropriate citations

(5) Incoherent, meaningless and/or irrelevant content included in the article

(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] G. Bei, S. Zhang, Y. Guo, L. Yanli, N. Hu, and J. Liu, "Study on Meteorological Disaster Monitoring of Field Fruit Industry by Remote Sensing data," *Advances in Meteorology*, vol. 2022, Article ID 1659053, 9 pages, 2022.

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Research Article

Study on Meteorological Disaster Monitoring of Field Fruit Industry by Remote Sensing Data

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Meteorological disasters have brought a great negative impact on people's lives. With the rapid development of modern science and technology, the detection technology of meteorological disasters has been continuously improved. At present, satellite remote sensing detection technology has made gratifying achievements, and it has a good application in meteorological disaster prediction. In this paper, the application of satellite remote sensing technology in the process of meteorological disaster monitoring is discussed in depth. In traditional work, the accuracy and timeliness of meteorological disaster monitoring is the key and difficult point of meteorological disaster prevention. Using satellite telemetry to monitor meteorological disasters can effectively improve the accuracy and timeliness of meteorological disaster monitoring, provide reasonable solutions and decision-making basis for meteorological disaster prevention, and achieve the purpose of disaster prevention and mitigation. This paper introduces the basic principle, technical system, and important role of satellite remote sensing technology, expounds on the application of satellite remote sensing technology in the monitoring of agricultural meteorological disasters such as water, drought, freezing, and hail, and provides a scientific reference for farmers, agricultural sustainability, and agricultural decision-making. The continuous development of our country's modern social economy has put forward higher requirements for agricultural production. Traditional monitoring technology can no longer meet the needs of agricultural meteorological disaster monitoring. The scientific application of remote sensing monitoring technology has important value, which can effectively improve the detection level and make it have higher accuracy and real-time performance, thereby promoting modern agricultural production in China. Based on the analysis of the application value of remote sensing monitoring technology, this paper comprehensively discusses the specific conditions of different disasters monitored by remote sensing monitoring technology in agricultural production.

1. Introduction

Meteorological disasters refer to accidents and disasters caused directly by weather, climate, and other weather factors or indirectly. The current meteorological disaster influence on our daily life is very much. In many cases, with the development of the economy and the advancement of science and technology, meteorological disasters can be monitored. Reducing the impact of meteorological disasters on us before the accident and reducing the loss of national property are the main directions of research. We can predict and monitor the meteorological situation through advanced science and technology to prevent tragedies and avoid losses, which is also the embodiment of the development of science and technology and social progress. This paper explores the application and development of remote sensing technology in disaster prevention and disaster avoidance process through the introduction of the concept and characteristics of satellite remote sensing technology [1].

Meteorological remote sensing technology is a method to predict weather and climate disasters by calculating the physical parameters corresponding to ground, sea, weather, and climate conditions using certain calculation programs through radiometric measurement. Remote sensing technology has been fully verified in many large-scale meteorological disaster monitoring work and achieved good results. The specific implementation of meteorological remote sensing technology is to monitor atmospheric temperature and humidity, wind speed and direction, cloud movement, and other physical elements through various types of equipment equipped on the man-made Earth satellite for monitoring weather and climate physical parameters. Such artificial Earth satellite is usually called the weather satellite [2–5]. Equipped with a satellite remote sensing device, it can acquire and monitor the mainland and in the air can identify light and infrared rays; through conversion, equipment will catch the light, convert it to electrical signal data, and then forward it to the receiving station; the station will get the data information through the computer software for processing, weather map information, clouds, sea, ground figure, and so on. Then special software is used to process and finally form the meteorological data that people need.

Compared with other monitoring technologies, the meteorological remote sensing technology has the following characteristics: First, the detection area of remote sensing technology is very wide, which can realize real-time dynamic monitoring. As remote sensing technology is to measure data through radiation of the meteorological satellite, monitoring frequency is more frequent than other technologies [6]. Remote sensing technology can be used for daily weather forecast, ocean and river detection, atmospheric quality monitoring, and environmental detection, and China has a number of weather satellites. Second, the satellite has high observation efficiency and good detection data quality. Third, meteorological satellite monitoring has no space and regional obstacles and no requirements on air quality and environmental conditions. Accurate and timely detection can be carried out continuously [7–10].

Based on the electromagnetic wave theory, remote sensing shows that the content of biochemical components and canopy structure of crops change before and after the disaster, and the electromagnetic wave received by sensors also changes accordingly. Through comparative analysis of electromagnetic wave information before and after the disaster, the disaster situation of crops can be obtained [11]. At present, remote sensing disaster monitoring has been carried out, including flood disaster, drought, snow disaster, sandstorm, pests and diseases, and typhoon. Due to the physiological and biochemical effects of various disasters on different crops, such as the occurrence of floods, the core of the impact on plants is excessive liquid water. Plants grow in an oxygen-deficient environment, plant growth is small, leaves yellow, petioles grow obliquely, the root system is shallow and thin, and the hair is noticeably reduced. Then, it turns black, rots, and stinks, and soon the whole plant dies. Drought refers to the phenomenon of crop wilting due to the lack of soil moisture or low atmospheric relative humidity. Many crop diseases are characterized by wilting or withering. Freezing injury often causes the freezing of plant tissues, resulting in plant injury or even death [12]. The phenomena presented by different disasters of various crops are different, and they also have their own characteristics in the spectrum, so the remote sensing monitoring methods are different.

The paper is organized as follows: Section 1 introduces the domestic and foreign research situation of the full text, Section 2 introduces the related work, Section 3 introduces the construction of agrometeorological disaster indicators, Section 4 carries out simulation experiments, and Section 5 summarizes the paper.

2. Related Work

Meteorological conditions directly affect the development of agriculture, and good meteorological conditions are the key to the healthy development of agriculture. In China, meteorological disasters have a great impact on agricultural development. After the occurrence of meteorological disasters, monitoring and evaluation of the disaster situation by relevant departments is an important means of disaster relief. Accurate assessment can reduce disaster losses to a certain extent and provide an objective basis for the formulation of disaster prevention plans [13–16].

2.1. Principles of Agricultural Remote Sensing Disaster Monitoring

2.1.1. Remote Sensing Flood Disaster Monitoring. Relevant investigation shows that the purpose of multiband satellite data classification is to obtain water inundation information. At present, some new recognition methods appear in our country, such as manual recognition, computer image classification, and water discriminant function. However, remote sensing technology still has some shortcomings in flood disaster monitoring, so it needs to be studied pertinently.

2.1.2. Remote Sensing Drought Disaster Monitoring. Agricultural drought refers to the situation that crops lack the necessary water due to the lack of rainfall and late irrigation in the growth process of crops, resulting in production reduction. Soil water content and water demand are the key factors to reflect the degree of drought. Remote sensing technology can calculate soil water content through the change of soil temperature difference between day and night and realize the control of soil water content. Although this method has high accuracy, it is difficult to monitor water content in the seed germination and growth stage [17].

2.1.3. Sandstorm Monitoring by Remote Sensing. In the process of aeolian sand activities, the disaster factors have certain characteristics, that is, risk and vulnerability. In China, sandstorm mainly occurs in spring; once sandstorm

weather occurs, crops and grass will be affected. The thick sand covering the leaves of plants not only affects photosynthesis but also reduces crop yield [18].

2.1.4. Remote Sensing Monitoring of Pests and Diseases. When crops are affected by meteorological disasters, the different degrees of disasters can be shown in the bands of remote sensing satellites. Some related scholars have analyzed the remote sensing monitoring of pests and diseases of various crops, and at the same time, they have also established the vegetation index and the remote sensing recognition algorithm for pests and diseases monitoring [19].

2.2. Development Needs and Focus on Solving Problems

2.2.1. Rapid Response after Disaster Is the Key to Realize Agricultural Industrialization. The progress of science and technology promotes the rapid development of productive forces at the same time; it also creates a certain labor surplus. In order to pursue better living conditions, some people have poured into the city, which has led to the phenomenon that the number of rural arable lands is less and less, providing necessary conditions for the development of agricultural industrialization. At the same time, the reduction of the number of people will increase the amount of arable land and make it easy to form the scale of agriculture; the degree of dependence on science and technology will deepen accordingly [20–22]. Therefore, in order to improve agricultural productivity, advanced science and technology is particularly important.

2.2.2. Providing Certain Guarantee for Agricultural Insurance. China's agriculture is greatly affected by meteorological disasters, and the risk of agricultural operation is great, which requires agricultural insurance to share part of the risk and reduce part of the loss. Agriculture, rural areas, and farmers are important issues in agricultural development, and agricultural insurance can provide an important guarantee for agriculture, rural areas, and farmers. At present, the business scale of agricultural insurance in some areas of our country is not large, and the main reasons are as follows. The scale of farmers' operations is relatively small, and most of them are not enthusiastic about participating in agricultural insurance. Although they participated in agricultural insurance in time, it was still difficult to be investigated. Therefore, the establishment of meteorological disaster monitoring and assessment system will greatly contribute to the development and popularization of agricultural technology.

2.2.3. Deficiencies of Remote Sensing Monitoring of Agricultural Meteorological Disasters. Agricultural remote sensing research in China began in the 1980s, and this technology has been used in agricultural management and production in some regions of China. At present, China still has some shortcomings in this kind of technology, mainly for the following reasons: China's agricultural production is open. There are many factors influencing agricultural development, such as seed quality, cultivation and management measures, and ecological environment. Different kinds of crops have different degrees of disaster. Moreover, the same crops are affected differently at different stages of development. Related studies show that remote sensing monitoring of the same object with different spectrum and foreign body with the same spectrum phenomenon is relatively common. In the process of agricultural planting and management in the past, the loss after meteorological disasters was less than that in research. If remote sensing technology is used for disaster assessment, it is necessary to develop a comprehensive disaster monitoring and assessment system from various aspects. Agricultural remote sensing technology is based on spectral analysis. When agricultural disasters occur, if the weather conditions are not good, it will increase the difficulty of obtaining remote sensing information.

Meteorological disaster emergency management institutions and their constituent elements system can be theoretically summarized as the basic content shown in Figure 1.

Figure 1 introduces the basic elements of the meteorological disaster emergency management system and makes a clear analysis of the relationship between the various elements.

2.3. Application of Meteorological Satellite Remote Sensing Technology.

Meteorological satellites play an important role in weather and climate. Through light line recognition equipment equipped with satellites, different areas are monitored to form cloud images. Seawater is usually black in the cloud images, while continents are gray, and snow and ice-covered areas are white. Red diode equipment is used to detect the humidity and temperature changes in the air in different areas, combined with the cloud map to depict the distribution of water and rainfall in the atmosphere. "Haze" is a frequent weather phenomenon, which occurs when the visibility of urban roads is low, which is easy to cause traffic accidents and affect people's travel. Remote sensing technology can effectively detect the "haze," timely issue the "haze" warning, remind people to make preparations before timely mention, and prevent the occurrence of accidents. Satellites can express the degree of "haze" in the form of images and achieve real-time detection, which is convenient for us to intuitively monitor air quality [23].

Meteorological satellite remote sensing technology is mainly used to monitor sea ice and river ice flood. As many sea surfaces in China will freeze in the cold season, the scope and conditions of the freeze will affect the transportation of ships at sea, the acquisition of oil fields, the docking of ships at coastlines and ports, and so on. It is necessary to monitor the state of the freeze in real time and issue a warning to avoid the occurrence of harm. The detection of sea ice is also based on the difference between ice and water in spectral properties of discernible light and infrared light. Through the processing of data information, we can extract which areas have been frozen, which sea surface is still seawater, and the extent of the ice. In addition, during our expedition to the North and South Poles, we should also monitor the

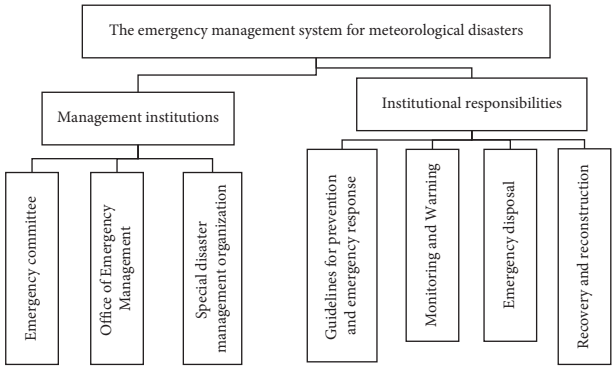

Figure 1: Basic elements of the meteorological disaster emergency management system.

state of sea ice, predict the state of the ice in advance, and make investigation plans to avoid accidents. Ice-melting flood means that the lower part of the river ice is on the surface, and the upper part is massive, forming a dam. Over time, the upstream water level continues to rise and eventually develops into a dyke burst, causing serious disasters and accidents. Satellite remote sensing technology can effectively monitor river ice conditions. After the ice in front of the dam does not reach the early warning, the relevant departments are notified to take immediate measures to avoid the occurrence of ice floods [24].

In China, drought, sandstorms, and other meteorological disasters occur from time to time. Meteorological satellites can monitor the moisture on the soil surface and the temperature of surface plants, judge the water content of the soil, and predict the occurrence of drought. The phenomena such as additional, sand, dust storms often occur in our country in the western region; satellite remote sensing technology can be used to identify infrared light of dust and the reflection rate of the ground and to identify the occurrence of dust storms. Using remote sensing technology to identify sand and dust storms has a high recognition rate, but this method is only suitable for monitoring during the day, and the reflectivity is insufficient at night, so it is difficult to identify.

Monitoring fire and typhoon satellite remote sensing technology and its application, there is radiant heat during fire, and the quality of ground meteorological satellites can be continuously monitored. Once a fire occurs and the temperature rises, the sensor can detect the wavelength change of radiant heat, which can identify the occurrence of fire and form. The image can intuitively reflect the area and extent of the fire. Remote sensing technology is mainly used in the monitoring of typhoon cloud map technology; in the cloud map, we can clearly see the center of the typhoon, change trend, moving speed, and so on, predict the impact of the typhoon in advance, and prevent the occurrence of disasters.

3. Construction of Agricultural Meteorological Disaster Indicators

Drought is the most common and the most serious natural disaster in agricultural meteorology. It is related not only to precipitation but also to temperature, humidity, evaporation, soil moisture, and other factors. Determining the drought index is an important basis and prerequisite for drought monitoring and early warning. Selecting appropriate monitoring and early warning index can provide a scientific basis for agricultural meteorological disaster prevention and reduction, which is also necessary for this system. In order to find the most scientific drought index and provide the best countermeasures for disaster prevention and reduction in Jiangsu Province, this system selects the following common drought indexes for comparative analysis.

The percentage of precipitation anomaly refers to the deviation degree of precipitation in a certain period of time from the average precipitation in the same period of the year. Most meteorological departments use the percentage of precipitation anomaly as the index to classify drought and flood in their daily operations.

$$M_i = \frac{R_i - \overline{R}}{\overline{R}} \times 100\%. \tag{1}$$

M_i is the percentage of precipitation anomaly in period I, I represents a certain period of time, R_i represents precipitation in this period, and R represents the average precipitation for many years in the same period.

Z index refers to local precipitation in a certain period of time, which does not follow the normal distribution. Now, it is assumed that monthly precipitation and seasonal precipitation follow the Pearson-M distribution, and its probability density is

$$P(X) = [\beta T(\gamma)]^{-1} \left[\frac{(X-a)}{\beta}\right]^{\gamma-1} e^{-((X-a)/\beta)}. \tag{2}$$

Precipitation X is normally processed; that is, the probability density function Pearson-III type distribution is converted to the standard normal distribution with Z as the variable, and the conversion formula is as follows:

$$Z_i = \frac{6}{C_s}\left[\frac{C_s}{2}\phi_i + 1\right]^{1/3} - \frac{6}{C_s} + \frac{C_s}{6}. \tag{3}$$

C_s is the skewness coefficient, and Bi is the standardized variable of precipitation, both of which can be calculated from precipitation data series. The calculation formula is

$$C_s = \frac{\sum_{i=1}^{n} (X_i - \overline{X})^2}{n\sigma^3}. \tag{4}$$

σ is the mean square error, X_i is the precipitation in a certain year, X is the average precipitation in N years, and n is the sample number.

Standardized precipitation index (SPI for short) refers to the following: assuming that the precipitation in a certain period is a random variable X, the probability density function of its R distribution is

$$g(x) = \frac{1}{\beta^{\alpha}\Gamma(\alpha)} x^{\alpha-1} e^{-x/\beta},$$
$$\Gamma(\alpha) = \int_0^{\infty} x^{\alpha-1} e^{-x} \mathrm{d}x. \tag{5}$$

X is the precipitation, β is the scale parameter, σ is the shape parameter, and $\Gamma(a)$ is the gamma function. The optimal estimation values of σ and β can be obtained by the maximum likelihood estimation method; that is,

$$\alpha = \frac{1 + \sqrt{1 + 4(A/3)}}{4A},$$
$$\beta = \frac{\overline{x}}{\alpha}, \tag{6}$$
$$A = \mathrm{In}(\overline{x}) - \frac{\sum \mathrm{In}(x)}{n}.$$

n is the length of the calculated sequence. For a given time scale, the cumulative probability is calculated as follows:

$$G(x) = \int_0^x g(x)\mathrm{d}x = \frac{1}{\beta^{\alpha}\Gamma(\alpha)} \int_0^x x^{\alpha-1} e^{-x/\beta-(x/\beta)}\mathrm{d}x. \tag{7}$$

Let $t = x/\beta$, and the above equation can be transformed into an incomplete gamma equation:

$$G(x) = \frac{1}{\Gamma(\alpha)} \int_0^x t^{\alpha-1} e^{-t}\mathrm{d}x. \tag{8}$$

Since the gamma equation does not include the case of $x = 0$ and the actual precipitation can be 0, the cumulative probability can be expressed as

$$H(x) = q + (1 - q)G(x). \tag{9}$$

q is the probability of 0 precipitation. If m represents the number of precipitation 0 in the precipitation time series, then $q = m/n$. The cumulative probability $H(x)$ can be converted to a standard normal distribution function by the following formula. And from that, we can figure out SPI.

$$SPI = -\left(t - \frac{c_0 + c_1 t + c_2 t^2}{1 + d_1 t + d_2 t^2 + d_3 t^3}\right). \tag{10}$$

Meteorological disaster drought composite index (CI for short) refers to the composite of standardized precipitation index and relative humidity index in the recent 30 days and the recent 90 days; namely,

$$CI = 0.4Z_{30} + 0.4Z_{90} + 0.8M_{30}. \tag{11}$$

$Z30$ and $Z90$ are SPI values in the recent 30 d and 90 d, respectively, and M30 is relative wettability index in the recent 30 d. The formula for calculating the relative wettability index is

$$M = \frac{P - ET_0}{ET_0}. \tag{12}$$

P is the precipitation in a certain period; ET_0 is the possible evapotranspiration of a certain period, which can be calculated by using the Penman–Monteith evapotranspiration formula recommended by FAO:

$$ET_0 = \frac{0.408\Delta(R_n - G) + \gamma(900/T + 273)U_2(e_s - e_a)}{\Delta + \gamma(1 + 0.34U_2)}. \tag{13}$$

ET_0 is the potential evapotranspiration; $\triangle$ is the slope of the relation curve between saturation vapor pressure and temperature.

The simple secondary development is limited by the programming language of GIS tools. Therefore, the integration of GIS software and visual development language has become the mainstream of GIS development. Component-based GIS development technology can not only make full use of GIS functions, but also make use of its object-oriented visual programming language and other characteristics of development due to its simple, powerful, and flexible GIS development functions, and no need to directly embed GIS development languages. Improve the development efficiency of the application system, and the developed program has a more powerful database function and a more beautiful system interface. Based on the above advantages, this study mainly adopts the component GIS development mode to develop the monitoring and early warning system of major agricultural meteorological disasters in Jiangsu Province based on RS and GIS, giving full play to the advantages of geographic information technology and meteorological data processing. The comprehensive development process is shown in Figure 2.

4. Experimental Results and Analysis

In this study, hyperspectral mechanism, whole-process identification and monitoring of rape freezing injury, regional monitoring of oilseed rape freezing injury, and remote sensing inversion of biophysical parameters related to rape freezing injury were studied. According to the purpose of the study, the experimental data involved included temperature data, indoor spectral data, physiological and biochemical parameters of rape leaves, canopy structure parameters, and satellite image data with different spatial resolutions. The following is an introduction to the instruments and methods used in data acquisition.

From 1980 to 2018, the average disaster rate of drought in Panjin city was 0.78%, and that of hail was 0.09%. From the disaster rate, the Panjin drought disaster rate is higher than the hail disaster rate. Drought and hail were 75.8% (1994) and 11.5% (1990), respectively. From 1980 to 2018, there was no drought or hail disaster in 22 years, and drought and hail disaster occurred in 2 years, accounting for 5.1%. During this period, the incidence of the drought was 20.5%, and there was about one drought in 4.8 years, but from 2015 to 2018, there was about one drought in 1.3 years. The incidence of hail disaster was 28.2%, and it happened once in about 3.5 years. From 2011 to 2018, hail disaster happened once in about 2 years, as shown in Figure 3. The incidence of hail is higher than that of drought.

Supercooling refers to the lowering of plant cell temperature below freezing point, but not immediately freezing, and it is a common mechanism for plants to avoid freezing injury. In order to determine the temperature of leaves in the state of undercooling, the leaf temperature curves of several rapeseed plants were measured under the condition of fixed freezer gear, and the freezing point temperature and

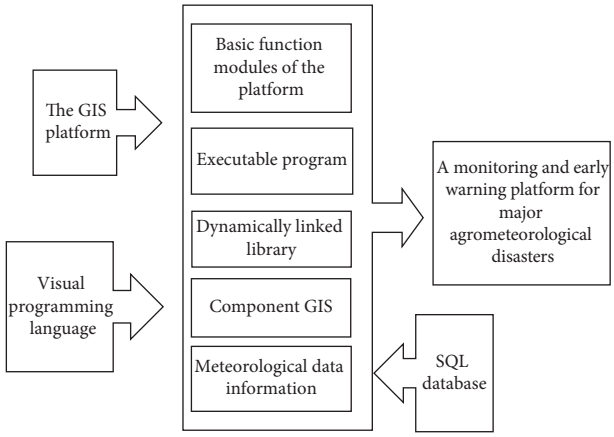

Figure 2: Development flowchart.

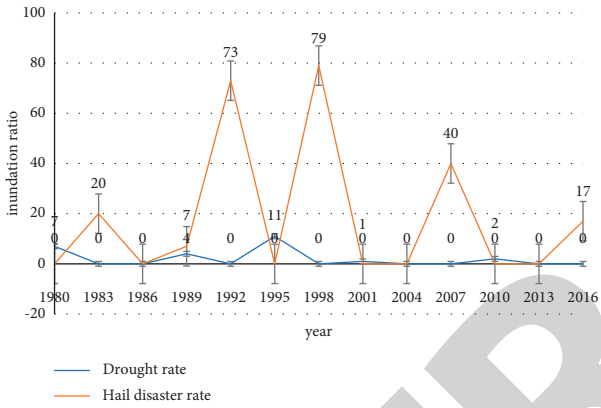

Figure 3: Disaster rates of drought and hail disasters from 1980 to 2018.

undercooling point temperature were recorded many times. According to several measurements of freezing point temperature and supercooling point temperature, it is concluded that the supercooling of rape leaf in this study refers to the state when the leaf temperature reaches. A typical rapeseed leaf temperature curve is shown in Figure 4.

Spectral observation experiment of rapeseed freezing injury process at different freezing times: the experiment was sown on October 20, 2014, and 100 rapeseed plants were planted in total. The effects of rapeseed varieties, tested soil, and rapeseed management on cell structure and water content of rapeseed leaves were consistent with those of freezing injury treatment. The main growth process of rape from sowing to the beginning of treatment is shown in Figure 5.

Statistics of water content in rape leaves under normal and frozen conditions are shown in Table 1. T-test of paired samples showed that there was no significant difference in water content between normal and frozen rapeseed leaves ($A = 0.05$; $B = 0.648$).

The changes of SPAD value in the whole process of rape leaf freezing injury are shown in Figure 6. On the whole, the value of SPAD decreased in the whole process of rape freezing injury. The SPAD value in the state of supercooling and icing for 1 hour decreased less than that in the normal

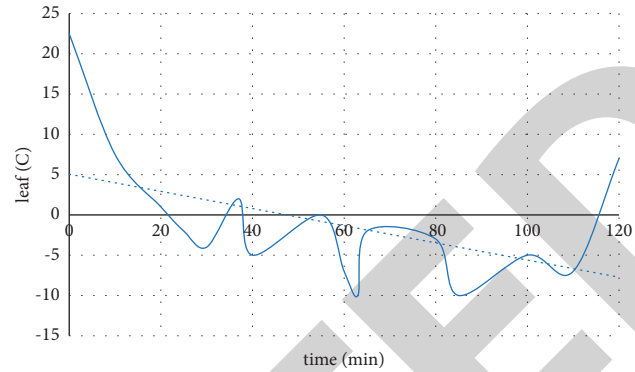

Figure 4: Change of rape leaf temperature during freezing injury treatment.

state. After 2 hours of thawing, the SPAD value decreased significantly compared with the normal SPAD. SPAD values were more variable 2 h after thawing, possibly due to uncertainty in the measurement of SPAD values. Finally, the rape leaves have turned yellow, close to death. The paired sample T-test was used to test the significance of the difference between the SPAD values under normal and 1-hour icing conditions, and the results showed that the difference was not significant ($a = 0.05$; $P = 0.056$).

Figure 7 shows the changes of cell structure in rapeseed leaves under normal and 1-hour icing conditions. Light microscopy can observe changes in cell microstructure, including changes in cell shape and volume as well as changes in larger organelles inside the cell such as chloroplasts and mitochondria. Figure 7(a) shows the microstructure of leaf cells in rapeseed under normal conditions. It can be seen that the cell structure is intact, the cells are closely arranged, the cells remain dilated, and the chloroplast surrounds the edge of the cell wall. When rapeseed leaves froze, due to the water potential difference caused by ice between cells, cells were dehydrated to varying degrees, leading to atrophy of cells and loss of original turgor, cell inclusions clustered to the middle, and the gap between cells became larger. In addition, the organelles, especially the chloroplasts, were damaged.

Compared with the optical microscope, the electron microscope has higher magnification and resolution and can observe the changes of cell submicroscopic structure, such as grana and starch grains in the chloroplast. Figure 7(c) is a radio-lens image of leaf cells in rape under normal conditions. You can see that the chloroplast structure is intact and is distributed around the cell wall. When rapeseed leaves froze, it could be seen that chloroplast stroma lamella was damaged, chloroplast membrane was damaged, and starch grains had been separated from the chloroplast. It can be concluded that icing destroys the photosynthesis of chloroplast in rape leaves.

Stomatal conductance (Gs) and transpiration rate (Tr) gradually decrease to close to zero. Intercellular carbon dioxide concentration (Ci) increases rapidly and then remains relatively stable. The combination is shown in Figure 7. The ice layer seriously damages the cell structure of rapeseed leaves, resulting in serious damage to the physiological function of rapeseed during the thawing process.

Figure 5: Main growth process of potted rape from sowing to freezing injury treatment.

Table 1: Statistics of water content in rapeseed leaves under normal and 1-hour icing conditions.

	Max	Min	Avg	The standard deviation	Coefficient of variation
Normal	0.922	0.753	0.868	0.042	20.456
Frozen	0.924	0.758	0.869	0.043	20.088

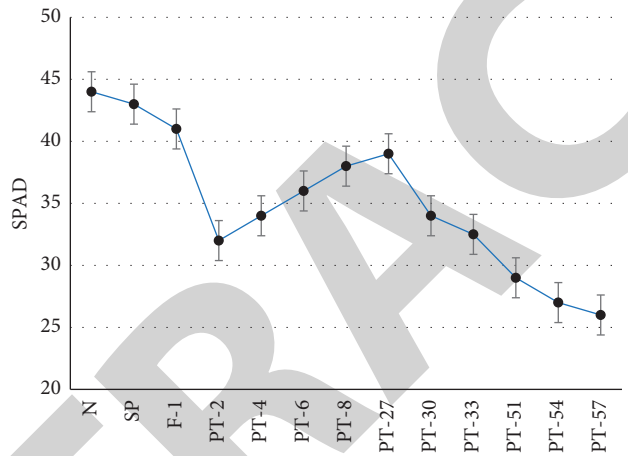

Figure 6: Changes of SPAD value in the whole process of rape freezing injury ($n = 26$).

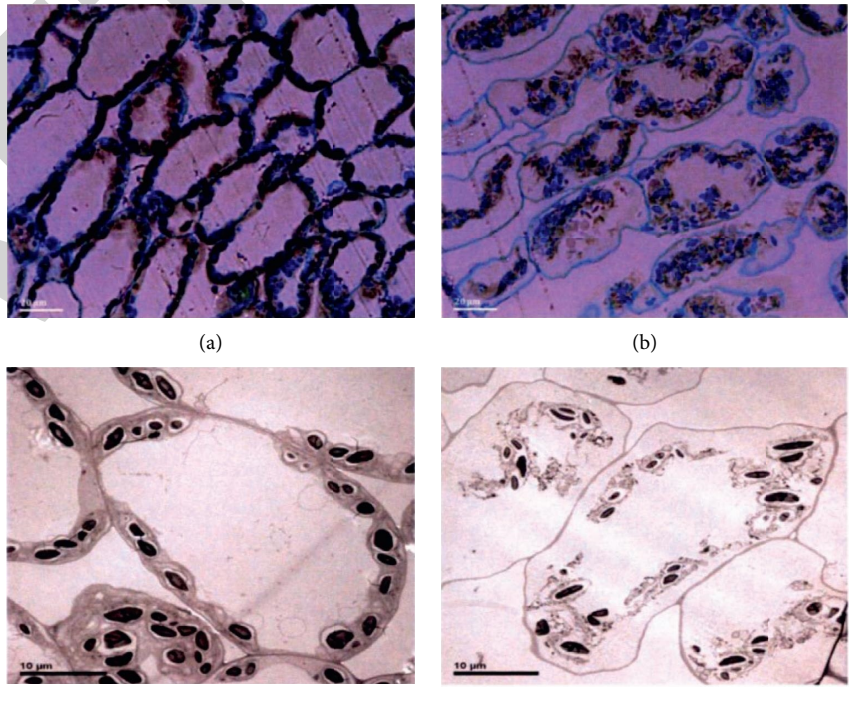

Figure 7: Microstructure and submicrostructure of rapeseed leaves under normal condition and 1-hour icing condition.

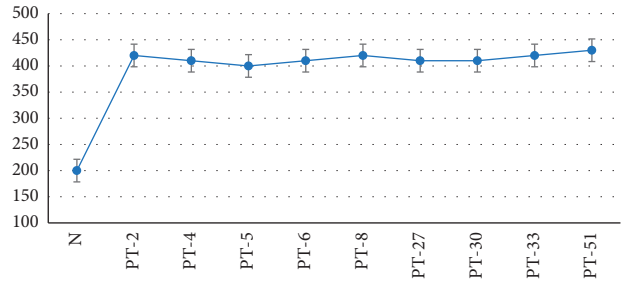

Figure 8: Changes of net photosynthetic rate.

The net photosynthetic rate, transpiration rate, and stomatal conductance decrease rapidly. The carbon dioxide concentration between cells is close to the environment. The blade is seriously injured, and the blade is dying. Photosynthetic parameters were not measured at 54 and 57 hours of thawing, mainly because leaves were dried and broken, and leaf chambers were difficult to clamp, which led to the decrease of measuring accuracy. Changes of net photosynthetic rate are shown in Figure 8.

Figure 8 shows the changes of photosynthetic parameters in the thawing process of rape leaves. As can be seen from the figure, the net photosynthetic rate (Pn) of rapeseed leaves decreased to near zero after 2 hours of thawing, indicating that photosynthetic organs of leaves were destroyed and photosynthetic rate and respiration rate were basically equal.

5. Conclusion

This paper proposes using satellite remote sensing to predict and analyze meteorological disasters. On the basis of systematic analysis and componentization of geographic information systems at home and abroad, based on theory and technology, a variety of agricultural meteorological disaster indicators are analyzed. On the basis of the monitoring and early warning system of major agro-meteorological disasters in Jiangsu Province, a variety of early warning indicators for agro-meteorological disasters such as RS and GIS are developed. Agricultural remote sensing is mainly based on spectral analysis. After agricultural disasters, basic information cannot be obtained in bad weather (cloudy). In addition, the acquisition of satellite data has a certain periodicity, which increases the difficulty of remote sensing monitoring. In order to improve the value of remote sensing technology in agricultural meteorological disaster monitoring, it is necessary to gradually carry out the research and application of UAV aerial photography and radar remote sensing monitoring technology. Fourth, the occurrence and development of agro-meteorological disasters are mainly affected by meteorological factors and have certain suddenness. Positioning observation can only obtain occasional data in a certain situation, and it takes a long time to obtain data compared with systematic data.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

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