International Journal of Antennas and Propagation

Deep Reconfigurable Backscatter Communication Technologies for Wireless Adhoc Networks

Lead Guest Editor: Tao Cui
Guest Editors: Kai Chen and Xinjie Wang

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Retraction

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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] Q. Luo, "Development of Urban Waste Recycling Industry from the Perspective of Ecology," *International Journal of Antennas and Propagation*, vol. 2022, Article ID 9087177, 10 pages, 2022.

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Research Article

Navigation Control Method of Indoor Mobile Robot Based on Visual Servo

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In order to improve the navigation control effect of indoor mobile robot, this paper studies the navigation control method of indoor mobile robot combined with visual servo technology. For the problem that the target may be out of the camera's field of view during the servo process, a control algorithm with field-of-view constraints is proposed, which assigns a certain weight to the image feature error at each moment. Moreover, this paper realizes the servo process that the image features are always located in the field of view by setting the variable values involved in the weight value calculation method. Through the simulation test, it is verified that the indoor mobile robot navigation control method based on visual servo has certain effects.

1. Introduction

Visual navigation and positioning technology have emerged in recent years, and are also the further development of computer image processing technology in the field of intelligent control. This technology utilizes the industrial camera installed on the moving carrier to continuously collect the pose information in the navigation pattern in the driving path, and input it to the controller of the driving system after processing and calculating using the internal processor to realize the navigation [1]. Generally speaking, if a QR code image is laid on the preset driving path, the processing calculation is to parse out the relevant position information through special analysis software; and calculate the pose of the motion carrier according to the geometric relationship of these positions, if the preset driving path is paved with images containing several target objects. The internal processor first uses the target detection algorithm to identify and locate the area of each small target and then uses the corner detection algorithm to extract several corners of the target area. The geometric relationship of the corner points is calculated to obtain the pose of the motion vector [2]. Comparing the two navigation patterns, the QR code-type navigation pattern is complex in design and difficult to lay on the industrial road, while the navigation image with the target object type has a simple design and is more convenient to lay on the industrial road. In addition, the target detection algorithm containing the target object-type navigation pattern has been continuously researched and improved on the basis of the fusion of deep learning algorithms in recent years, which is a key step for the motion carrier to use this kind of navigation pattern for visual navigation and positioning [3].

RFID is a wireless communication technology that can identify the target only through radio signals without establishing direct contact with the target, and can exchange data with the target. Generally speaking, RFID devices can be divided into four frequency bands: low frequency, high frequency, ultrahigh frequency, and microwave according to the different frequency bands of the radiofrequency carrier [4]. Among them, ultrahigh frequency (UHF) RFID has the advantages of long reading distance and high reading speed compared with other frequency-band RFID and has been widely used in the field of warehousing environment and logistics and transportation [5].

A typical RFID system is mainly composed of: reader, antenna, tag, and a background server. Among them, the main function of the reader is to generate radiofrequency signals and transmit them through the antenna so as to communicate with the tags and to filter and demodulate the received radiofrequency signals to obtain the information [6]. The antenna is the bridge between the RFID reader and the tag in the communication process. It can be used to transmit the radiofrequency signal generated by the reader and receive the radiofrequency signal reflected by the tag and transmit it to the reader for processing. The main function of the background server is to control the reader and manage the signals read by the reader. Tags can be divided into active tags (Activetag), semiactive tags (Semiactivetag), and passive tags (Passivetag) according to whether they need additional power supply [7]. Since active tags need to be powered by batteries, although the reading distance is relatively long, the battery life is limited, and the batteries need to be replaced regularly and the cost is high. Passive tags do not need battery power, small size, low cost, and long life, so no source tags are widely used [8].

Detection means obtaining the effective information of the target from the video frame, which is the basis for the effective operation of the subsequent tracking module, which can be said to be the basic link of visual tracking. The detection methods studied so far mainly include the background difference method, frame difference method, and motion field estimation method [9]. The frame difference method is a commonly used method in the detection of moving objects. This method is to process the difference between the video frames accordingly to obtain the position information of the moving object. The effect is not good when the moving target is small; the background difference rule is to mathematically model the fixed background. Once a moving target appears in the background model, it is immediately recognized as a foreground target. Of course, accurate modeling is not easy, and if the focal length needs to be adjusted and the background depth of the field changes, then the modeling work will be extremely difficult [10]; the most common motion field estimation method is the optical flow method, which obtains the optical flow direction of the pixels of the moving target in a two-dimensional image. This method has a large amount of calculation and is sensitive to noise, and is also used as a basic link in the tracking process [11].

Matching tracking can be divided into four categories: model-based tracking, deformed template-based tracking, feature-based tracking, and region-based tracking. The idea based on the region matching method is to detect or extract the target template according to a certain method in the video sequence, find the best matching point based on the template matching algorithm in the following tracking, determine the target region, and update it regularly or irregularly in a template; feature-based tracking first extracts obvious features (centroids, corners, and boundaries) from the image and then matches the best similar target in the next video frame; this method can adapt to the tracking situation of partial occlusion, deformation-based. The template method hopes to perform matching by extracting the target contour or edge. Since the edge model is a vector model, it has good elastic adaptability and can be well adapted to complex backgrounds and occlusion situations, but it is troublesome to initialize contour extraction; model-based tracking is mainly by modeling the target (2D or 3D) to achieve the target body multipose tracking, and the accuracy is high but the real-time performance is poor [12].

Visual tracking based on filtering technology is also a very important technology in the field of visual tracking. This method is different from other methods that directly process images to obtain target information. Instead, it models the target and estimates its state to obtain target information. Obtain target tracking information [13]. Commonly used filtering methods are Kalman filter (KF), extended Kalman filter (EKF), unscented Kalman filter (UKF), particle filter (PF), and so on. Generally, the basic Kalman filter is only used for linear problems, and it is basically nonlinear in tracking problems, so it is rarely used [14]; EKF and UKF can transform nonlinear problems through linearization methods. Of course, too serious nonlinear problems, linearization, and non-Gaussian row problems cannot be completely solved; particle filtering does not require linear and Gaussian row assumptions for the problem, based on Bayesian theory and Monte Carlo methods, random discrete sampling of the target state of the system (extract particles), represent the system state probability density [15].

Fusion-based tracking is actually a combination of multiple tracking algorithms, but in fact, many tracking problems require fusion methods because each algorithm has its own strengths and weaknesses, so fusion use can learn from each other, and the tracking effect achieves our expectations. Requirements to improve tracking accuracy. Of course, the multimethods included in the fusion method can be a variety of different tracking algorithms or can be different aspects of the same algorithm, such as multifeature fusion and multimodel fusion, which is to select a variety of features and models under the same tracking algorithm. Improving the tracking algorithm can effectively improve the tracking accuracy and solve problems such as occlusion [16]. Of course, the more fusion methods, the more accurate the tracking, but this also increases the constraints on the target object, complicates the environment, and greatly affects the real-time performance. Therefore, how to fuse the tracking methods reasonably is also one of the research directions of the tracking algorithm.

This paper combines visual servo technology to study the navigation control method of indoor mobile robot to improve the navigation control effect of indoor mobile robot.

2. Visual Servo System Design

2.1. Design of Constrained and Delayed Controller. In the visual servo system, the image feature information is out of the field of view of the camera, which will lead to a failed visual servo. By adding certain constraints to the feature quantities in the image space, the control input that satisfies the visual field constraints can be obtained, and the failure phenomenon caused by the target not existing in the camera's visual field can be avoided. Since the sampling period of the vision sensor is inconsistent with the control

period of the manipulator, the time delay at each moment of the system is different. Moreover, performing certain feature estimates for each moment is expected to fundamentally compensate for the image delay problem.

The weight error is defined as assigning a certain weight value to each error amount on the basis of the task error specified by the system, which is expressed as

$$e_w = We_t. \tag{1}$$

Among them, W is the weight matrix of the characteristic error amount of the system image and is in the form of a diagonal matrix, which, respectively, corresponds to each error amount in the system.

For systems with multiple feature information, the specific form of the weight matrix is as follows:

$$W = \begin{bmatrix} W_1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \vdots & W_k \end{bmatrix}. \tag{2}$$

Among them, W_i is the weight value corresponding to the i-th feature error in the system, which depends on the image feature amount at the current moment.

Therefore, the above formula (1) can be specifically described as

$$\begin{bmatrix} e_{w_1} \\ e_{w_2} \\ \vdots \\ e_{w_l} \end{bmatrix} = \begin{bmatrix} W_1 & 0 & \cdots & 0 \\ 0 & W_2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & W_l \end{bmatrix} = \begin{bmatrix} e_{t_1} \\ e_{t_2} \\ \vdots \\ e_{t_l} \end{bmatrix}. \tag{3}$$

In the above formula, l represents the number of feature quantities, which is twice the number of corresponding feature points.

When the weight value of each error amount in the system is set to 1, that is, $W = I_{\text{txl}}$, at this point, $e_w = e_t$ is satisfied, and the system is in the traditional form of the control law. In order to constrain the field of view of the camera, the weight value is set according to the feature amount at this time for different feature error amounts to achieve the effect of constraint. The determination of the weight value will now be described.

2.1.1. Determine the Visual Field Constraint Range of the System. The visual servo control system takes the acquired image features as the amount of information, and the image features reflect the pixel coordinates of the target object in the camera image plane, so the resolution of the vision sensor limits the range of available feature amounts in the system. If the maximum resolution of the camera used is $u * vr$, the visual field constraint range of the system is the size value of the maximum resolution, corresponding to the range of feature quantities in the horizontal and vertical directions, respectively.

s_u and s_v represent the image feature values in the horizontal and vertical directions, respectively, s_{u^-} and s_{v^-} represent the lower limit values of the image feature quantities in the horizontal and vertical directions, and $s_{u^+} s_{v^+}$ represent the upper limit values of the image feature quantities in the horizontal and vertical directions. Then, the mathematical description of the constraint range in the horizontal direction and the constraint range in the vertical direction obtained by the vision sensor is as follows:

$$\begin{aligned} s_u &\in \left[s_{u^-}, s_{u^+}\right] = \left[0, u_l\right], \\ s_v &\in \left[s_{v^-}, s_{v^+}\right] = \left[0, v_l\right]. \end{aligned} \tag{4}$$

The constraint range determined by the resolution of the vision sensor itself in the above is called the physical constraint of the system field of view.

2.1.2. Define the Security Range of System Features. When the image feature value is closer to the edge, it is easier to leave the field of view. On the basis of the physical constraints of the field of view, by setting an adjustment parameter ρ, it is used to adjust the safety range space of the set feature quantity, which is defined as the safety limit of the field of view. The connection between the two constraint ranges is as follows:

$$\begin{cases} s^{\rho}_{u^-} = s_{u^-} + \rho\left(s_{u^+} - s_{u^-}\right), \\ s^{\rho}_{u^+} = s_{u^+} + \rho\left(s_{u^+} - s_{u^-}\right), \end{cases} \tag{5}$$

$$\begin{cases} s^{\rho}_{v^-} = s_{v^-} + \rho\left(s_{v^+} - s_{v^-}\right), \\ s^{\rho}_{v^+} = s_{v^+} + \rho\left(s_{v^+} - s_{v^-}\right). \end{cases} \tag{6}$$

In formulas (5) and (6), ρ satisfies $0 \le \rho \le 05$. When the parameter ρ is set to 0, the security constraints in the system are equivalent to physical constraints, and the coefficient ρ can be adjusted appropriately according to the size of the visual field constraints in the system.

The image plane for the restricted field of view is shown in Figure 1.

According to the prescribed visual field constraints and safety constraints, the calculation method of the weight value corresponding to the system image feature value is given, and the formula is as follows:

$$W_u = \begin{cases} e^{-\dfrac{\left(s^i_u - s^m_u\right)^{2n}}{\left(s^i_u - s^{\rho}_{u^-}\right)^m \left(s^{\rho}_u - s^i_u\right)^m}}, s^{\rho}_{u^-} < s^i_{u^-} < s^{\rho}_{u^+}, \\ 0, s_{u^-} \le s^i_u < s^{\rho}_{u^-} \,||\, s^{\rho}_{u^+} \le s^i_u < s_{u^+}, \end{cases}$$

$$W_v = \begin{cases} e^{-\dfrac{\left(s^i_v - s^m_v\right)^{2n}}{\left(s^i_v - s^{\rho}_{v^-}\right)^m \left(s^{\rho}_{v^+} - s^i_v\right)^m}}, s^{\rho}_{v^-} < s^i_{v^-} < s^{\rho}_{v^+}, \\ 0, s_{v^-} \le s^i_v < s^{\rho}_{v^-} \,||\, s^{\rho}_{v^+} \le s^i_v < s_{v^+}. \end{cases} \tag{7}$$

In the formula, s^m_u and s^m_v are the median value of the safety constraint range in the horizontal and vertical directions of the image, and n and m are the adjustment coefficients for weight calculation.

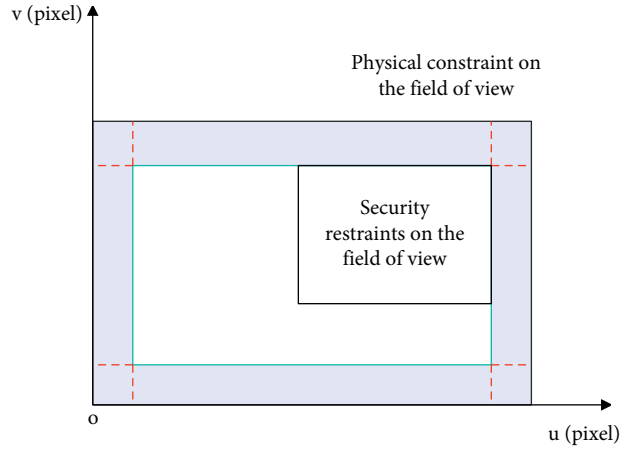

Figure 1: Image field-of-view constraint range diagram.

The median calculation formula is as follows:

$$s_u^m = \frac{s_{u^-}^\rho + s_{u^+}^\rho}{2}, \quad s_v^m = \frac{s_{v^-}^\rho + s_{v^+}^\rho}{2}. \tag{8}$$

The schematic diagram of the weight curve is given. In the case that the physical constraint range of the visual field is 610 ∗ 180, the adjustment coefficient of the safety range setting in the setting system is $p = 0.25$, and the values of n and m are shown in Figures 2(a) and 2(b)$n = m = 1$ is set, and the value of p is as marked in Figures 2(c) and 2(d).

According to the distance between the target feature set by the system and the current actual feature, the values of the parameters p and n, m can be adjusted appropriately so that the system can achieve the desired effect.

The system completes visual servoing, that is, when the task error in the system meets the set error value, it is considered that the system reaches the set desired image feature position. The system counts the number of features whose current error value is less than the set error value in real time. For the situation where four target position points are set in the system, there are eight image features. When the number of statistics ≥6, the weight of the feature in the system is reset to 1, which can improve the situation of inactivity within the safe range.

For the error for which the weight value is set, the task error vector e_t becomes the weight error vector e_w in the system. Then, the interaction matrix used in the system is also given the same weight value, that is, the basic interaction matrix J is changed to a weighted interaction matrix $J_w = WJ_I$ so as to form a new variable weight control law. The form is as follows:

$$\begin{aligned} v_c &= -\lambda (WJ_I(k))^+ (We_t(k)), \\ \dot{q}(k) &= -\lambda J_q(k)^+ \varsigma(T_e^c)(k)^+ (WJ_I(k))^+ (We_t(k)). \end{aligned} \tag{9}$$

The speed control quantity obtained by the weight control law is substituted into the discrete visual servo system model, and the joint incremental model of the system is obtained as

$$\begin{aligned} \Delta q(k+1) &= \alpha \Delta q(k) + \beta T_r \dot{q}(k) \\ &= \alpha \Delta q(k) - \lambda \beta T_r J_q(k)^+ \varsigma(T_e^c)(k)^+ (WJ_I(k))^+ (We_t(k)). \end{aligned} \tag{10}$$

Let $A \in \mathbb{C}^{n\times m}$, if matrix $X \in \mathbb{C}^{n\times m}$ satisfies some or all of the following relations:

$$\begin{aligned} AXA &= A, \\ XAX &= X, \\ (AX)^H &= AX, \\ (XA)^H &= XA. \end{aligned} \tag{11}$$

Then, X is called the generalized inverse of A.

Specifically, if X satisfies equation (i), then denote $X = A^{(i)}$, then the set of $A^{(i)}$ is $A\{i\}$, $A^{(1)}$ is denoted as A^-, and $A^{(1,\,2,\,3,\,4)}$ are recorded as A^+. The relevant theorems about the operational properties of generalized inverse matrices are as follows:

If we set $S \in C_m^{m\times m}$, $T \in C_n^{n\times n}$ and B= SAT, then:

$$(SAT)^+ = T^{-1} A^+ S^{-1}. \tag{12}$$

According to the above theorem, the expanded form of the interaction matrix with weights is considered. The weight matrix is a diagonal matrix of dimension 8×8, and the interaction matrix is a matrix of dimension 8×6. Moreover, it is considered that the matrix is always in the state of full rank, so the equation is simplified by adding the form of unit matrix to the model, and the calculation is further deduced. It is believed that the above equation (13) can be simplified into the following equation:

$$\begin{aligned} \Delta q_{k+1} &= \alpha \Delta q(k) - \lambda \beta T_r J_q(k)^+ \varsigma(T_e^c)(k)^+ J_I(k)^+ e_t(k) \\ &= \alpha \Delta q(k) - \lambda \beta T_r C(k)^+ e_t(k). \end{aligned} \tag{13}$$

Considering the delay problem caused by sampling, the above equation is further transformed into the following equation:

$$\Delta q_{k+1} = \alpha \Delta q(k) - \lambda \beta T_r C(k-d)^+ e_t(k-d). \tag{14}$$

Therefore, the application of the stable gain threshold analysis under the traditional exponential convergence algorithm to the visual field constraint of the weight design is still feasible.

2.2. Image Feature Estimation with Delay Compensation. In the robotic arm vision servo control system, the sampling rate of the used vision sensor is generally slower than the communication rate of the robotic arm. Moreover, the sampling period is longer than the control period of the robotic arm, which makes the image features used in the system have a time delay problem, which in turn affects the performance of the control system, and it is mainly reflected in the longer servo time to a certain extent. The relationship between the camera sampling rate, the control frequency of the robotic arm, and the related image feature sequence in the system is shown in Figure 3. Starting from the image

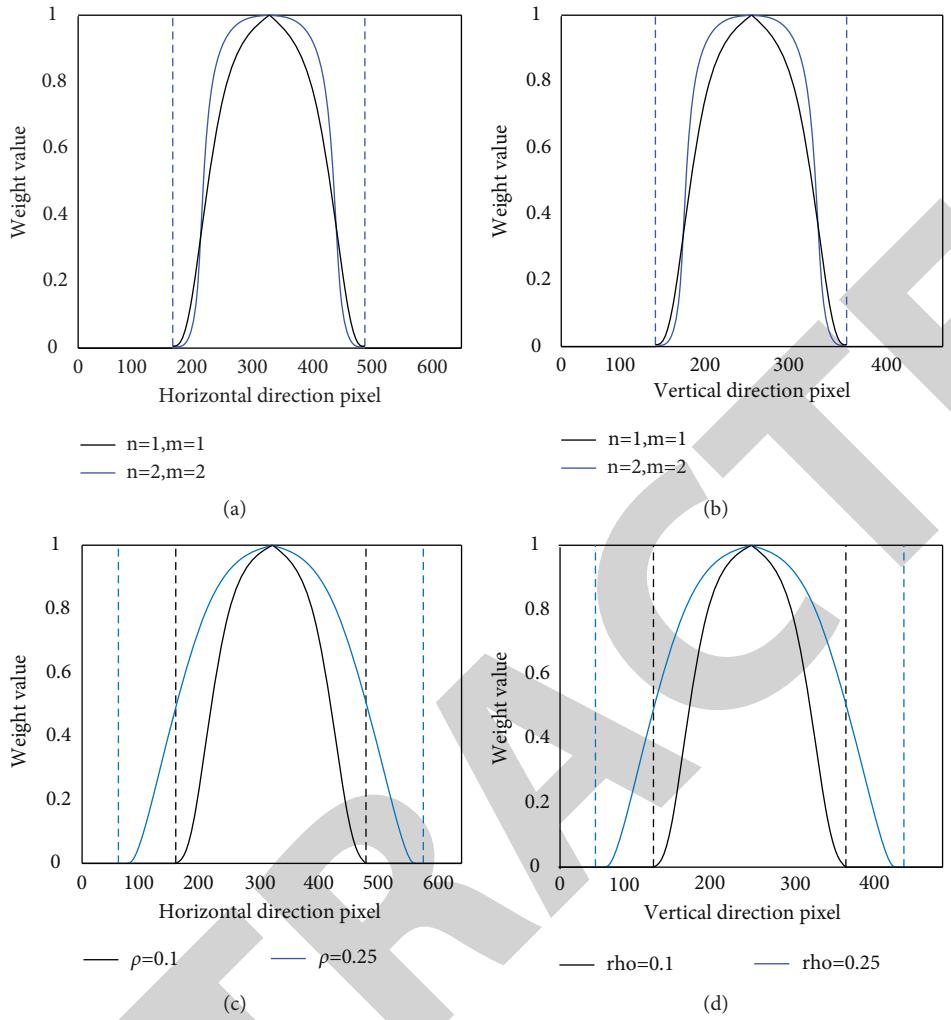

Figure 2: Curve diagrams of feature weights. (a) Horizontal direction weight curve diagram, n/m. (b) Vertical directional weight curve diagram, n/m. (c) Horizontal direction weight curve diagram, ρ. (d) Vertical directional weight curve diagram, ρ.

feature itself, the influence of time delay is reduced by real-time estimation and compensation of the image feature quantity at the current moment of the system.

The control period of the robotic arm is T, and the sampling period of the camera is T. The system can obtain hT in real time. However, the image feature information within the sampling interval cannot be obtained, so the actual value obtained is replaced by the estimated value for the image feature within the sampling interval of the vision sensor.

The image feature quantity obtained by the system at the current moment is represented as $s(k)$, and the image feature prediction value at the current moment is represented as $s(k)$. Finally, the estimated value of the current moment is applied to the system to realize servo control.

This paper mathematically expresses the motion of system image features:

$$\begin{cases} u(k+1) = u(k) + V_u(k)T_r, \\ v(k+1) = v(k) + V_v(k)T_r. \end{cases} \tag{15}$$

In the formula, $s_2(k)$ and $V_v(k)$ are the image feature velocities at the current moment, $u(k)$ and $v(k)$ are the image features at the current moment k.

The state variable $X(k)$ of the system is defined as the combination of image feature and image feature velocity, and the output vector $Y(k)$ is the image feature, as follows:

$$\begin{cases} X(k) = [\, s_1(k) \;\; s_2(k) \;\; s_3(k) \;\; s_4(k) \;\; V1(k) \;\; V2(k) \;\; V3(k) \;\; V4(k) \,]^T, \\ Y(k) = [\, s_1(k) \;\; s_2(k) \;\; s_3(k) \;\; s_4(k) \,]. \end{cases} \tag{16}$$

In the formula, $V = [\, V_u(k) \;\; V_v(k) \,]$ is the image feature velocity.

$s_i = [\, u_i(k) \;\; v_i(k) \,]$ is the image feature.

Combined with the mathematical formula (15) of the characteristic motion, the state description equation is obtained:

$$\begin{cases} X(k+1) = AX(k) + w(k), \\ Y(k) = CX(k) + v(k). \end{cases} \tag{17}$$

Among them,

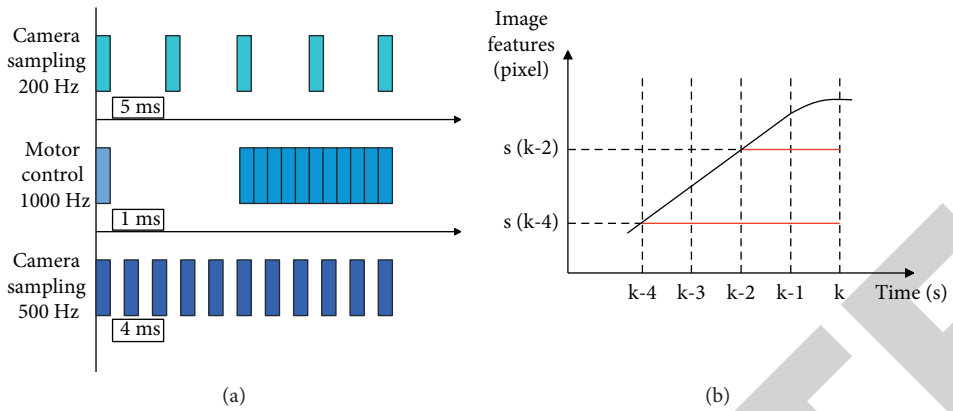

Figure 3: Feature time-series diagram of the visual servo control system. (a) Frequency difference chart and (b) feature timing diagram.

$$A = \begin{bmatrix} I_{8\times8} & T_r I_{8\times8} \\ 0_{8\times8} & I_{8\times8} \end{bmatrix}, \quad C = \begin{bmatrix} I_{8\times8} & 0_{8\times8} \end{bmatrix}. \tag{18}$$

In the formula, A is the system state transition matrix, $C$is the observation matrix of the system, w is the process noise matrix with mean 0 and variance Q, and v is the observation noise sequence for the system with mean 0 and variance R.

The Kalman filter algorithm is used to complete the calculation of the image feature estimator at the current moment through the state quantity of the system at the previous moment and the predicted quantity at the current moment. The model is as follows, divided into prediction and update parts.

2.2.1. Prediction Equation

$$\begin{cases} X1(k) = AX(k), \\ P1(k) = AP(k)A^T + Q(k). \end{cases} \tag{19}$$

In the formula, $X1(k)$ is the state predictor at the current moment, $P1(k)$ is the covariance matrix of $X1(k)$, and $Q(k)$ is the state transition covariance matrix.

2.2.2. Update Equation

$$\begin{cases} K(k) = P1(k)C^T\left(R(k) + CP1(k)C^T\right)^{-1}, \\ \widehat{X}(k) = X1(k) + K(k)(Y(k) - CX1(k)), \\ P(k) = (I - K(k)C)P1(k). \end{cases} \tag{20}$$

In the formula, $K(k)$ is the Kalman gain value, $\widehat{X}(k)$ is the best estimated value at the current moment, $P(k)$ is the modified covariance matrix, $R(k)$ is the observation noise covariance matrix, and $Y(k)$ is the current image feature quantity predicted by historical data at the current moment.

The image feature quantities of the first m moments of the system are, respectively, recorded as $s(1), s(2), \ldots, s(m)$. The known m sets of data fit a polynomial description equation to expect the estimation of the current image feature value through the polynomial.

The equation representation of the polynomial fit is as follows:

$$\widetilde{Y}(k+1) = k1X_1(k) + k2X_2(k). \tag{21}$$

In the formula, $X_1(k)$, $X2(k)$ is the image feature quantity in the state variable and the image feature velocity quantity, $\widetilde{Y}(k+1)$ is the estimated value of the feature quantity at the current moment to the feature quantity at the next moment, and $k1$, $k2$ is the coefficient value of the image feature amount and the image feature velocity amount. Fitting the coefficients of the polynomial through the acquired historical data makes the objective function f reach the minimum value, and the function is as follows:

$$f = \sum_{k=1}^{m-1}\sum_{i=1}^{4} b_k\Big[\left(s_{iu}(k+1) - \widetilde{Y}_{2i-1}(k+1)\right)^2 + \left(s_{iv}(k+1) - \widetilde{Y}_{2i}(k+1)\right)^2\Big]. \tag{22}$$

In the formula, s_{iu}, S_{iv} is the horizontal and vertical components of the image feature point at the current moment, $\widetilde{Y}_i$ is the i-th component of the predicted image feature quantity, b_k is the weight value of the k-th group of data in the objective function, and the sum is 1.

For the assumed content specified by this system, when the system is at time T_{r1}, its image feature value is the acquired image feature value, that is, the value at time T_{c1}. The image feature quantity at time T_{r1} is used as the image acquisition quantity at each time in the sampling interval, and when the system is at time T_{r2}, the image feature quantity is the calculated estimated value $\widehat{s}_{r2}$. The image feature quantity at time T_{r1} is taken as the feature quantity at the previous moment, and the current prediction quantity $\overline{s}_{r2}$ is calculated by the polynomial obtained from the historical data. After that, by combining the two data, the image features at the current time T_{r2} are estimated in one step, and the result value $\widehat{s}_{r2}$ is used as the feature quantity at the time T_{r2}. By analogy, the feature quantity at time T_{r_m} of the system is the quantity obtained at time T_{r1}, and the actual

usage quantity at time T_{r_m} at the current time is obtained after T_{r_m} – 1-step estimation through the prediction quantity of historical data. Alternatively, by estimating the number of delay periods for the acquisition amount at the current moment, the system will exhibit faster convergence.

3. Navigation Control Method of Indoor Mobile Robot Based on Visual Servo

For each RFID tag, there is a unique ID code inside, and the RFID tag is generally attached to the object to identify it. At the same time, the storage space inside the RFID tag can also be used to store some physical information about the posted object, which can be read and modified by the reader, as shown in Figure 4.

For the passive UHF RFID system, the RFID reader transmits radiofrequency signals to the tag through the antenna, and the backscattered signal returned by the tag is received by the RFID reader. The communication process is shown in Figure 5. At this time, the information that the reader can read is the ID, RSSI, and phase information of the tag.

During the process of the robot navigating to the target position, the position information of the target tag in the robot coordinate system is calculated through the target position estimation based on the acquired radiofrequency information. Then, the target position is used as the input information of the controller, and the servo controller of the robot is based on the input position information. After that, this paper combines the path planning algorithm to carry out servo control, and outputs the linear speed and rotation speed of the robot, so that the robot reaches the target label. The RFID servo method based on position information has a high dependence on the target position estimation model, and the navigation performance mainly depends on the positioning result. If the positioning fails or the positioning error is large, it is likely to cause the servo to fail, as shown in Figure 6.

Different from the RFID servo method based on position information, the robot does not need to calculate the position information of the target tag in the robot coordinate system in the process of navigating to the target position. It only relies on the characteristics of the RFID radiofrequency information fed back by the target tag to transform and process it. Then, the robot takes the characteristics as input information and then outputs the linear speed and rotation speed of the moving robot through the servo controller, and the robot can move toward the target label and keep approaching the target label. The RFID servo method based on radiofrequency information does not need reference tags, has a good navigation effect, and has a simple system and low cost. Compared with the RFID servo method based on position information, the RFID servo method based on radiofrequency information can directly control the navigation of the robot without calculating the relative pose relationship between the robot and tag. It has the advantages of low system requirements, small computational load, and no need to calibrate the relative pose relationship between the robot and antenna. In addition, it can also avoid the situation that the navigation fails due to a large error in the positioning process. The navigation of the mobile robot based on the RFID servo is shown in Figure 7.

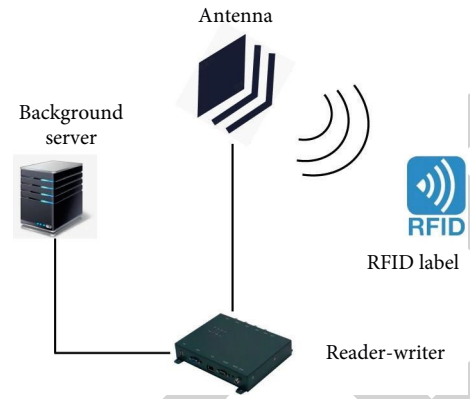

Figure 4: RFID system composition.

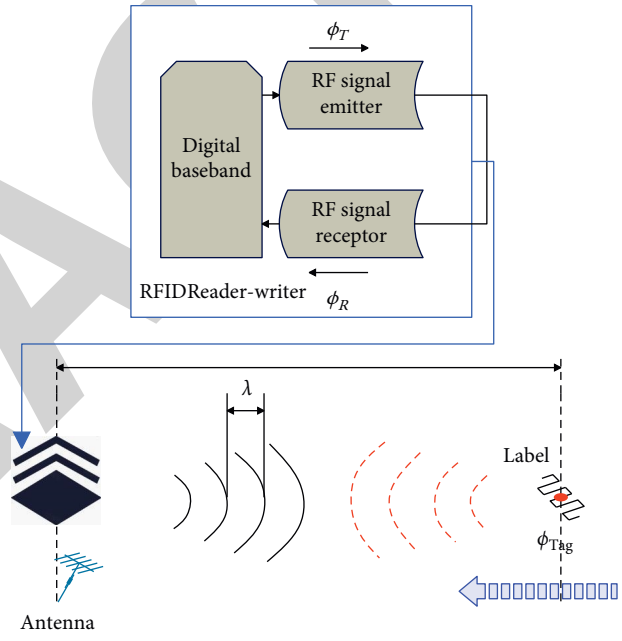

Figure 5: Tag backscatter communication model.

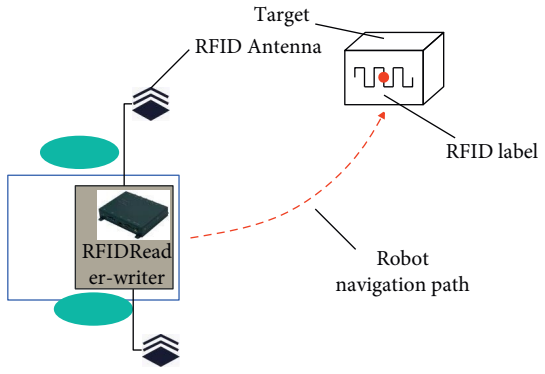

Figure 6: Navigation diagram of RFID servo robot.

During the movement of the mobile robot, the area in front of the mobile robot is divided into three orientations: front left, front right, and front right, as shown in Figure 8(a).

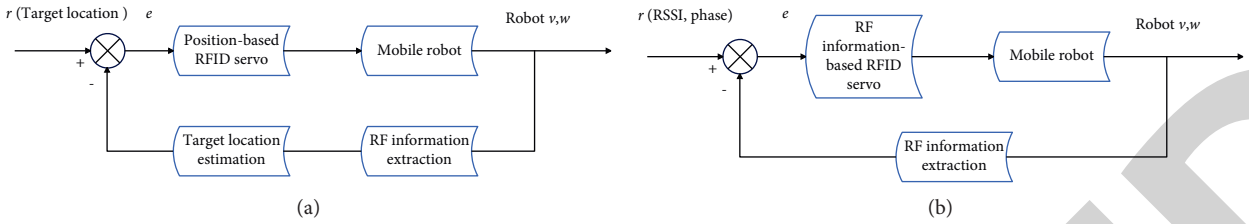

Figure 7: Mobile robot navigation based on RFID servo. (a) Position-based RFID servo. (b) RF information-based RFID servo.

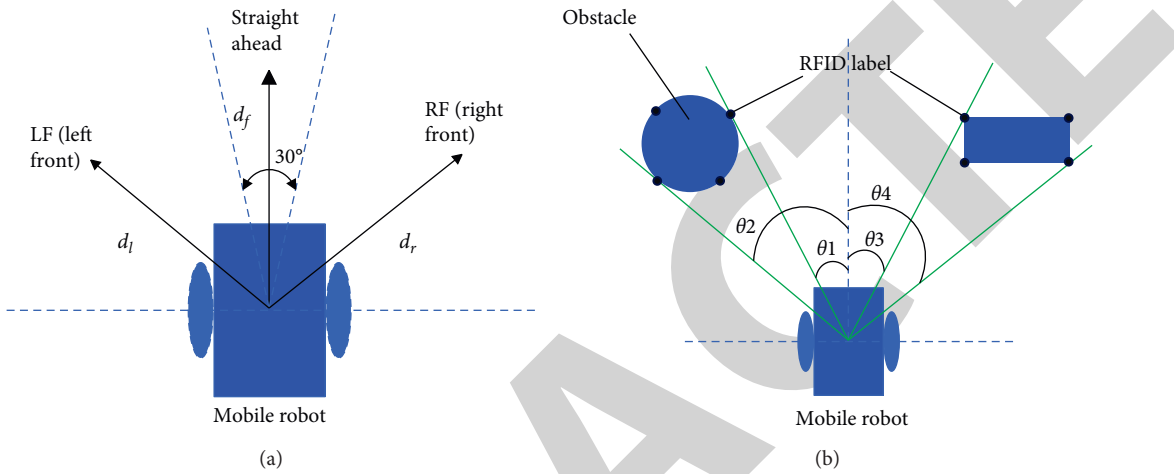

Figure 8: The division of the robot and the obstacle ahead. (a) The front orientation of the robot is divided. (b) Barrier orientation division.

The 30° range in front of the robot is defined as the front, the area on the left side of the front is defined as the front left, and the area on the right is defined as the front right.

To ensure that the robot can successfully perceive and avoid obstacles, an RFID tag is posted near each edge of the obstacle. The robot can read the RFID tag attached to the obstacle through the RFID reader, and estimate the angle formed by the currently read RFID tag to the center of the robot and the current direction of the robot. In this way, the angle formed by all readable labels on the obstacle and the current direction of the robot can be solved. According to the maximum angle θmax and the minimum angle θmin formed by the RFID tag on the obstacle and the robot center, the obstacle can be enveloped, as shown in Figure 8(b). Then, obstacles can be divided into corresponding azimuth areas.

In order to further increase the difficulty of robot obstacle avoidance, a number of different obstacles are set up in the environment at the same time, and the obstacle avoidance and servo performance of the robot are analyzed through simulation. In the same obstacle environment, there are four obstacles with different shapes and sizes and arbitrary positions in the environment, and two groups of experiments are set in which the robot has different initial poses relative to the target label and obstacles.

The initial position of the robot is set to (0, 0), the position of the target label is (300, 100), and the initial orientation of the robot is 0°. Then, we change the relative pose of the robot to the obstacle and target label, the target label position is (210, 150), and the initial orientation of the robot is 90°. The servo and obstacle avoidance processes of the robot are simulated in MobileSim, and the motion trajectories of the robot at different initial poses are obtained as shown in Figure 9. Moreover, this paper analyzes the motion trajectory of the robot in MATLAB. When there are many different obstacles in the environment, the robot can navigate to the target position by changing the different initial poses of the robot relative to the target label and obstacles, and the motion trajectory of the robot is relatively smooth. After that, the motion process of the robot is further analyzed, and the change in the heading angle of the robot is shown in Figure 10.

It can be seen from Figure 9 that the robot navigation system is verified through multiple sets of poses. Through the verification of multiple angles, it is found that the robot can effectively find the target point when navigating from multiple angles, and carry out reasonable path planning, which verifies the performance of the system algorithm in this paper, navigation effect and path decision effect.

It can be seen from Figure 10 that after setting different obstacles, the system model in this paper can still choose a reasonable obstacle avoidance route during the obstacle avoidance process, which can not only effectively avoid obstacles but also effectively improve movement efficiency, which verifies the algorithm model in this paper, effectiveness.

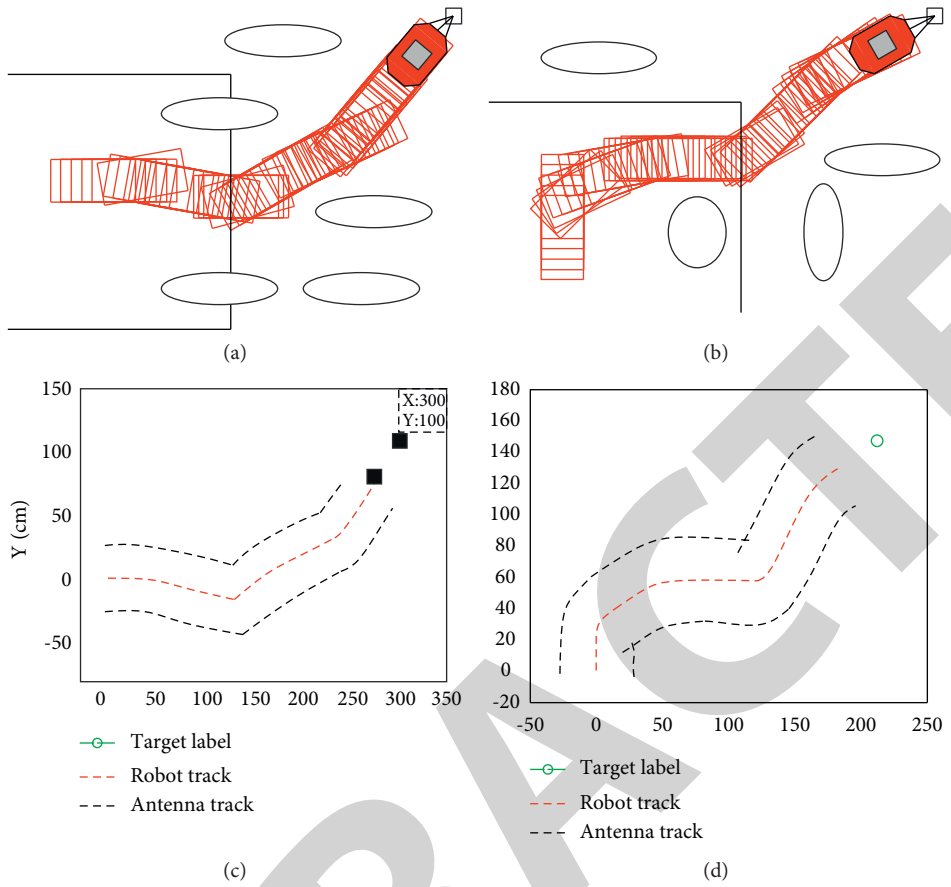

Figure 9: Obstacle avoidance trajectory in different poses. (a) Initial orientation angle of 0°, target location (300, 100). (b) Initial orientation angle of 90°, target location (210, 150). (c) Initial orientation angle of 0°, target location (300, 100). (d) Initial orientation angle of 90°, target location (210, 150).

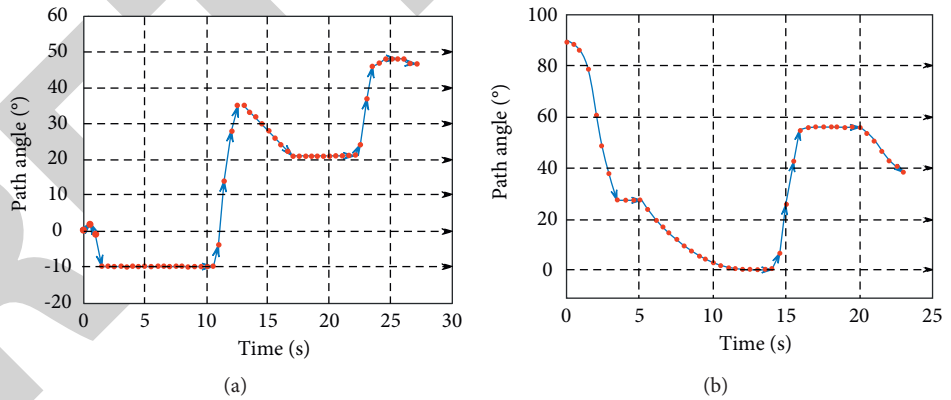

Figure 10: Changes in angle. (a) Initial orientation angle of 0°, target location (300, 100). (b) Initial orientation angle of 90°, target location (210, 150).

During the movement of the robot, the heading angle changes monotonically in an interval, and the change is slow in the monotonic interval. The robot runs smoothly and the trajectory is smooth most of the time. In the presence of multiple obstacles, the servo navigation algorithm and the obstacle avoidance algorithm also have strong robustness. Therefore, it is verified that the indoor mobile robot navigation control method based on visual servo has certain effects.

4. Conclusion

Aiming at the defects in the traditional RFID visual servo navigation method, an innovative navigation method is proposed: an autonomous navigation method for mobile robots based on RFID servo. By using the characteristics of RFID radiofrequency information, the robot can be directly controlled to navigate to the vicinity of the target position

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Retraction

Retracted: The Effect Model of College PE Teaching Reform Based on Moral Education

International Journal of Antennas and Propagation

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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] X. Zhao, T. Guan, and X. Chen, "The Effect Model of College PE Teaching Reform Based on Moral Education," *International Journal of Antennas and Propagation*, vol. 2022, Article ID 4040613, 10 pages, 2022.

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Research Article

The Effect Model of College PE Teaching Reform Based on Moral Education

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In order to further promote the integration of moral education and college PE teaching and improve the effect of college PE teaching reform in the new era, a research on the effect model of college PE teaching reform based on moral education is put forward. Based on the demand background of moral education, the personalized PE teaching reform path is proposed, and the factors that affect the improvement of college PE teaching reform are analyzed with the help of mathematical statistics from the five aspects: teaching, teachers, students, field equipment, and culture system. Through KMO and Bartlett sphere test analysis, it is found that the explanatory variance contribution of the five factors is 16.910%, 13.757%, 11.835%, 10.973%, and 10.065%, respectively, and the cumulative variance of the five influencing factors is 63.541%, meeting the minimum standard of 60%, which also confirms the feasibility and effectiveness of integrating moral education into physical education teaching reform.

1. Introduction

In recent years, China has been committed to comprehensively promoting the development of quality-oriented education. Under this background, moral education has always been placed in the forefront of school education. The educational structure's reform and teaching in the new era will also attach great importance to the cultivation of talents with both moral and physical competence. The integration of moral education and physical education requires that the purpose of physical education must be changed from the traditional physical fitness to the transformation and improvement of students' ideological will and moral character, which is also the important content of moral education and physical education reform in colleges and universities in the new era [1]. Integrating the content of moral education in college physical education is to further enrich the content of physical activities and integrate the factors of ideological and moral education on the basis of traditional physical education. In the physical education classroom teaching time, the continuous integration of discipline education, collectivism education, civilization education, and so on truly realize the moral, intellectual, and physical development of college students [2].

2. Literature Review

Some scholars point out that students in different types of schools in their country have a positive attitude towards sports. School sports are mainly in the form of clubs, and clubs have a strong effect on physical education [3]. According to the questionnaire survey, the willingness of middle school students to participate in physical exercise is higher than that of high school students, and the physical evaluation of middle school students is also positive, but there is a problem that the higher the grade is, the less attention is paid to physical education; the concept of people with physical education proposed by some scholars has been implemented in every link of physical education in primary and secondary schools, which reflects that students are always the main body of teaching and that students can well adapt to the society and stimulate their physical and mental

health. They advocate taking sports as fun so as to achieve a good physical education teaching effect; a study of 36 different secondary schools by scholars shows that most schools have policies and practices to support physical exercise, and schools must cooperate with community partners and officials to provide the best environment to support physical exercise. This shows that they attach great importance to the construction of physical education infrastructure, which is supported by the state and society; through the comparison of PE and health curriculum content (standard) of middle schools in different countries, the paper puts forward that school curriculum content can be divided into different fields from different levels of learning; in the content, the exercise, physical ability, and skill of students are very crucial; to realize the close combination of education and content, teaching and content complementary relationship; reinforce the idea that sport is a lifelong sport without losing touch with life [4]. The analysis of the internal and external factors of physical examination shows that the examination items are constantly improved, and the examination score is increasing year by year. In this article, the implementation of the physical education system of the middle school entrance examination and the improvement of the bonus point mechanism are actually the progress and improvement of the physical education level, and the level of teachers should be improved and innovative in order to better guide students. The consciousness of students participating in exercise and the sports they love can evaluate students' physical quality and health condition comprehensively and objectively. Alleviating the students' burden is an important part of PE examination; examination reform should seize the main information and key points, the reform of the examination reform mainly includes the following four points: the first is the change of the score, the change of the test project, the test standards, and electronic evaluation. As the midterm exam sports reform continuously, improving students' physical quality has positive influence and also has a positive effect to promote the development of school sports [5]. To sum up, the above literature is mainly studied from the continuous improvement of the development of the physical quality of students with educational functions, the improvement of students' cognitive ability to participate in physical exercise, and the development of students' physical quality through the reform of physical examination.

3. Research Process of College Individualized Physical Education Teaching

Students and teachers from six colleges and universities were selected from a certain place to design a questionnaire. The main content of the questionnaire is the reform and development of personalized college PE teaching and the results achieved. Among them, 15 questionnaires were sent out to teachers, and 15 were effective, with an effective recovery rate of 100%. 450 questionnaires were sent out to students, and 408 were returned, with an effective recovery rate of 90%, as shown in Table 1.

In order to ensure the quality of the questionnaire, the design of the questionnaire was modified by referring to the opinions of several experts, and relevant experts were invited to check the questionnaire before it was issued to ensure the validity of the questionnaire. The test results showed that the questionnaire was highly effective, as shown in Table 2.

At the same time, the valid questionnaires were digitally edited, and the obtained data were input into EXCEL software. Statistical software SPSS22.0 was used for statistical processing and graph analysis of the data, and factor analysis and explanation were made for the data obtained from the impact factor survey [6].

4. Analysis of Survey Results

4.1. The Situation of Curriculum Setting in the Pilot Universities of Individualized Teaching Reform of College Physician Education. It can be seen from Table 3 that at present, some of the pilot universities and pilot cultivation schools adopt the form of male and female class division. This is certainly a big improvement over the previous program, which was all-male and all-female. Teachers can teach students in a more unified way and prepare teaching content for gender differences in a more reasonable way [7].

As shown in Table 4, it can be seen that the application of stratified teaching in pilot universities is not ideal, which has many reasons. However, universities have gradually changed their original teaching methods, from no stratified teaching at the beginning to stratified teaching in part [8, 9].

In the experimental universities of teaching method reform, the traditional way of class classification is broken. Most of them choose two ways. One is to teach without any distinction and assign students with different technical foundations and physical qualities together. In teaching, after a period of grouping, the students with good foundation have basically the ability to instruct others to practice and have certain organizational management ability. The most important thing is that the technical level of these students has also been greatly improved. The other is the statistical grouping of students' skills and physical quality in the first class, and the specific technical requirements are determined by the teachers of the elective course [10, 11]. Physical fitness groups are divided into different grades according to physical fitness test results, and special skills are divided into basic group and promotion group according to teachers' assessment requirements. Teachers teach at different levels according to their different levels. The form of course opening is shown in Table 5:

It can be seen from Table 5 that the form of PE class is not limited to the form of class, and sports club has become another popular form of opening classes after PE option. Sports clubs and teams are another part of the physical education curriculum, which attracts college students with its unique characteristics [12, 13]. It is far from enough to carry out the individualized teaching reform of college physical education, and then the excellent role of sports clubs will be highlighted. It can be seen from Table 6 that each pilot university lays more emphasis on competition rules in the learning of sports theoretical knowledge. There

Table 1: Questionnaire statistical form.

Type	Recipients of the questionnaire	Number of questionnaires issued	Number of questionnaires returned	Questionnaire effectiveness (%)
Student questionnaire	Pilot college	450	408	90
Teacher questionnaire	Students pilot college teachers	15	15	100

Table 2: Validity test expert evaluation results (n= 6).

Content	Questionnaire	Very feasible	Relatively feasible	Feasible	Relatively not feasible	Not relatively feasible
Content validity	Student questionnaire	3	1	2		
	Percentage (%)	50%	16%	33%		
	Teacher questionnaire	4	1	1		
	Percentage (%)	66%	16%	16%		
Construct validity	Student questionnaire	3	2	1		
	Percentage (%)	50%	33%	16%		
	Teacher questionnaire	4	1	1		
	Percentage (%)	66%	16%	16%		

Table 3: The organization form of P.E. curriculum in experimental colleges and universities.

Fundamental state	Shanghai normal university	Donghua university	Shanghai institute of technology	Shanghai university	Shanghai business school
Organizational form	Some programs are divided into male and female classes	Some programs are divided into male and female classes	Some programs are divided into male and female classes	Some programs are divided into male and female classes	Some programs are divided into male and female classes

Table 4: The stratified teaching situation of PE course in pilot colleges and universities.

Fundamental state	Shanghai normal university	Donghua university	Shanghai institute of technology	Shanghai university	Shanghai business school
Stratified teaching	A few projects are taught at different levels	None	None	Some projects are taught at different levels	Yes

are many sports events, and each event has different rules. It is necessary to learn competition rules if you want to be more interested in a sport. Only when a sport has rules can it develop better. Therefore, rules always come first in the study of theoretical knowledge in various pilot universities.

It can be clearly seen from Figure 1 that contemporary college students' preference for physical education curriculum content mainly focuses on these aspects: novel and easy to master teaching content and moderate teaching content. Among them, easy to master in teaching occupies the largest proportion, which shows that the premise of students' liking of physical education curriculum content is to be able to learn it easily. In the teaching reform of major pilot universities, the content taught by special teachers mainly focuses on making it easier for students to learn [14, 15].

The reasons for college students' liking of physical education teaching content are shown in Figure 1.

The change of the PE evaluation method in colleges and universities is related to the degree of college students' liking for PE courses and also an indispensable part of the teaching process, as shown in Table 7.

It can be seen from Table 7 that the evaluation methods of PE courses in colleges and universities mainly include teacher evaluation, student mutual evaluation, student self-evaluation, and group evaluation, among which teacher evaluation occupies the largest proportion, indicating that teachers still play a major role in the evaluation methods of pilot colleges and universities, and teacher evaluation plays a crucial role for students. At the same time, we can also see that students' mutual evaluation and group evaluation also occupy a large proportion, which reflects that colleges and universities begin to attach importance to course evaluation, making the evaluation method more reasonable (Table 8).

Physical education teaching is a special technology. From the above table, we can clearly see that the pilot schools still put special techniques at the end of the teaching evaluation [16, 17].

Table 5: Open class form survey statistics (n= 15).

Form of the commencement of the course	Frequency	Percentage (%)
PE optional course	15	100
Sports club (association)	8	53.3
Sports team	4	26.6
Others	2	13.3

Table 6: Theoretical knowledge of individualized teaching of college physical education (n= 408).

	Theoretical content	Frequency	Percentage (%)
Theoretical knowledge of individualized teaching of college physical education	History and development	209	51.2
	Value and function	243	59.5
	Rules of a contest	408	100
	Sports injury and protection	197	48.3
	Judicial rules	212	51.9
	Organization and arrangement	75	18.3

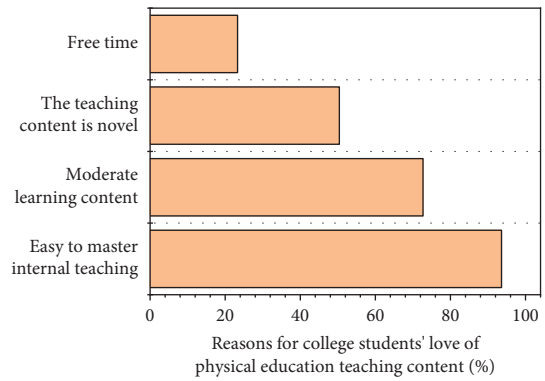

Figure 1: Reasons for college students' liking of physical education teaching content.

Table 7: Pilot the evaluation method of PE courses in colleges and universities (n= 15).

Evaluation method	Frequency	Percentage (%)
Teacher evaluation	15	100
Peer assessment	10	66
Self-evaluation of students	5	33
Group appraisal	9	60
Other evaluation	2	13

Table 8: The evaluation indexes adopted by teachers in the evaluation of physical education teaching in pilot colleges and universities.

Evaluation content	Specific technique	Basic physical fitness assessment	Daily performance
Sequence	First	Second	Third

4.2. The Teaching Mode of Colleges and Universities on the Pilot of Individualized Teaching Reform. Physical education teaching mode, as a unique teaching style, plays an important role in the teaching reform of experimental colleges and universities. The following is the centralized teaching mode in the major pilot universities, as shown in Table 9.

In the teaching process, teachers are the organizers and practitioners, while students are the main body. However, teachers play a leading role, especially physical education teachers. Compared with other teachers, physical education teachers need stronger organizational ability and field control ability, as shown in Table 10.

We can see from the above table that most of the PE teachers in the pilot universities believe that they should improve their technical and tactical level. This is related to the improvement of the special ability level of PE teachers in universities after the teaching reform, especially for today's many college students who themselves have relatively excellent professional skills [18, 19]. Secondly, we can see that teaching organization management and methods also occupy a large proportion of the teaching reform. This will mean that the physical education teachers in colleges and universities will update their previous teaching methods and methods by using a more effective way in order to better adapt to the personalized teaching reform of college physical education.

4.3. The Achievement of Individualized Teaching Reform. It can be seen from Table 11 that after the teaching reform, students' lung capacity has been most significantly improved. Meanwhile, they have also been significantly improved in 1000 m running, 800 m running, and pull-up [20, 21]. It shows that the endurance quality of students has been improved. The endurance quality is an indispensable part of human body quality, and it can improve students' ability to resist fatigue and effectively eliminate students' aversion. With the continuous improvement of students' physical test scores, students' physical qualities will be steadily improved, and college students' physique will be better and better. In the long run, this is conducive to the development of good exercise habits, makes it easier to maintain a healthy and happy attitude in the future, and can have a good ability to resist pressure when facing various difficulties, as shown in Table 11.

As can be seen from Table 12, the students in pilot colleges and universities who think their motor skills have been improved account for the highest proportion, which indicates that there has been a great improvement in the course content, teaching mode, evaluation method, and so on. Students become more interested in learning motor skills; changes in teachers' teaching methods will make the teaching of skills more attractive [22, 23]. After optional classes, students can also choose corresponding sports clubs according to their own needs. Under the influence of multiple factors, college students' motor skills have been significantly improved. At the same time, the interpersonal communication ability, cooperation, and competitive spirit

Table 9: Pilot the school teaching model.

	Shanghai normal university	Donghua university (pilot)	Shanghai university of technology (pilot)	Shanghai business school (cultivation)
Model of teaching	The teaching mode of elective course + sports club is adopted	Freshman year: physical education teacher basic teaching sophomore year: special teachers Junior year: teachers use the way of competition training and guidance	Classroom cooperative teaching mode: students are divided into groups according to their skill level in the class and cooperate to complete teaching tasks	Based on the teaching mode of three independent stratified elective courses, the first and second grades carry out the stratified teaching management mode, set up compulsory elective courses, divide them into basic and advanced classes, and formulate the corresponding teaching outline plan and teaching content

Table 10: Reform the ability of P.E. teachers in pilot colleges who think they need to improve (n= 15).

Ability to improve	Frequency	Percentage (100%)
Level of the tactics and skill	12	80.0
Teaching methods	4	26.6
Teaching organization management method	9	60.0
Theoretical knowledge	6	40.0
Academic research ability	7	46.6

Table 11: Improved physical test scores of college students after teaching reform (n= 408).

The cervix grades	Frequency	Percentage (%)
Lung's capacity	341 8	3.5
Sit and reach	138	33.8
Standing broad jump	96	23.5
Fifty meters	112	27.4
1000 meters	209	51.2
800 meters	215	52.6
Pull-up	54	13.2
Sit-up	267	65.4

Table 12: Improvement project for University students after teaching reform (n= 408).

Improve project	Frequency	Percentage (%)
Motor skill	405	99.2
Performance status	347	85.0
Interpersonal communication	192	47.1
Volitional quality	241	59.1
Spirit of cooperation and competition	287	70.3

have been improved, and all these demonstrate the correctness of college physical education reform.

As the epitome of college campus culture, college sports culture atmosphere can explain the current situation of college campus culture. It can be seen from Table 13 that only a small part of the sports equipment in colleges and universities has been improved in the teaching reform, which indicates that colleges and universities still need to increase efforts in the improvement of equipment. College PE teachers generally believe that the school PE atmosphere is becoming stronger and stronger after the personalized teaching reform of college PE. In order to promote the individualized development of students, college PE teachers have made great improvements in teaching, the altered teaching method makes it more in line with the characteristics of college students, and it can give full play to the independent character of students. In addition, the organizational form of the original classroom has been updated, from the former mixed class to the present part of the project's male and female classes, so that students can fully stretch in the learning of physical education courses and be more conducive to classroom teaching. The factors above make the atmosphere of sports culture in colleges and universities increasingly strong. In such a strong sports culture atmosphere, students have been imperceptibly changed and have begun to exercise more actively. Persisting in doing this not only promotes the students' form of sporting habits, but also the students will drive the campus sports atmosphere.

4.4. The Deficiency of Individualized Moral Education Teaching Reform in College Physical Education. From Figure 2, we can see that at the management level, there are mainly problems such as the incomplete personalized teaching management system, too few teachers participating in the personalized teaching reform group of schools,

Table 13: The results obtained at the school level in personalized teaching reform (n= 15).

Achieve a result	Frequency	Percentage (%)
Field block equipment improvement	2	13.3
The school sports atmosphere is getting stronger and stronger	15	100
The teaching staff has been improved	8	53.3
Schools pay more attention to sports	10	66.6

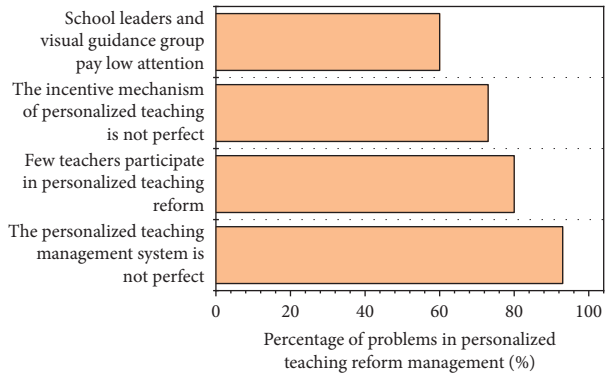

Figure 2: The proportion of problems existing in personalized teaching reform management.

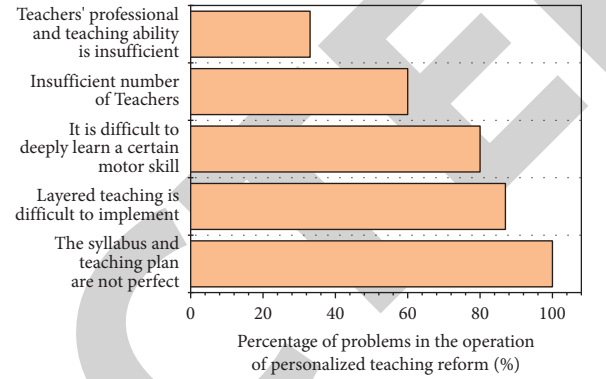

Figure 3: The proportion of problems existing in the operation of personalized teaching reform.

incomplete incentive mechanism of personalized sports teaching reform, and low attention level of school leaders and the visual guidance group [24].

It can be seen from Figure 3 that all the pilot schools at the present stage have the problem of imperfect PE individualized teaching syllabus and teaching plan, which indicates that there are still many deficiencies in the operation of personalized teaching reform of college PE.

5. Analysis on Influencing Factors of Individualized Moral Education Teaching Reform in College Physical Education

This study adopts exploratory factor analysis to conduct factor analysis on 22 influencing factors of personalized teaching reform of college physical education, as shown in Table 14.

It can be seen from the table that the KMO value is 0.761, and the concomitant probability value of the Bartlett sphere test statistic is 0.000, which is far less than 0.05, indicating that the scale is suitable for factor analysis. After passing the test, principal component extraction and orthogonal rotation were carried out by the principal component analysis method and maximum variance method, and the total variance of the obtained factors was shown in Table 15:

5.1. Extraction Method: Main Component Analysis. After analysis, the common factors greater than 1 were extracted, and a total of 5 factors were extracted. The variance contribution rate of the five factors is 16.910%, 13.757%, 11.835%, 10.973%, and 10.065%, and the cumulative variance contribution rate is 63.541%, indicating that 63.541% of the total information can be explained, reaching the minimum standard of 60%. The lithotripsy diagram of the extraction process is shown in Figure 4: It can be seen from the lithotripsy diagram that 5 of the 22 items selected in this paper are the most suitable principal components for extraction, and the results of principal component analysis are presented significantly again from the diagram.

Rotation of each item in their respective factors is shown in Table 16:

As can be seen from Table 16, component 1 contains five questions, teacher's skill level, teacher's participation, teacher's teaching attitude, teacher's teaching experience, and teacher structure, which are teacher factors; Component 2 includes students' physical fitness, students' interest level, students' learning attitude, students' free time, and students' physical education; Component 3 includes the quantity of gymnasium, the quantity of sports equipment, the quality of stadium equipment, and the perfection of indoor stadium, which is the venue equipment factor; Component 4 contains four items of organizational form, teaching content, teaching method, and teaching evaluation, which are teaching factors; Component 5 contains four questions, namely, the school's sports atmosphere, the school's sports culture, the organizational strength of sports competitions, and the importance attached by leaders, which are factors of the cultural system. According to these five components, the influencing factors of personalized teaching reform of college PHYSICAL education are obtained (see Figure 5).

5.2. Teaching Factor. Teaching factor consists of teaching content, method evaluation, and organizational form. Teaching is more important in the individualized teaching reform of college PHYSICAL education, so the teaching reform should be better developed. It is necessary to diversify organizational forms and teaching methods, the

Table 14: KMO and Bartlett sphere inspection.

Kaiser–Meyer–Olkin	Measure sampling appropriateness	761
Sphericity test of Bartlett	Approximately chi square df significance	3885.130 231.000

Table 15: Total variance of interpretation.

	The starting property value			Extract the sum of squares and load			Loop sum of squares loaded		
Component	Total	Mutated (%)	Accumulate (%)	Total	Mutated (%)	Accumulate (%)	Total	Mutated (%)	Accumulate (%)
1	3.803	17.285	17.285	3.803	17.285	17.285	3.72	16.91	16.91
2	3.045	13.843	31.128	3.045	13.843	31.128	3.027	13.757	30.667
3	2.703	12.287	43.415	2.703	12.287	43.415	2.604	11.835	42.503
4	2.319	10.539	53.954	2.319	10.539	53.954	2.414	10.973	53.475
5	2.109	9.586	63.541	2.109	9.586	63.541	2.214	10.065	63.541
6	0.952	4.328	67.869						
7	0.914	4.155	72.023						
8	0.828	3.765	75.789						
9	0.669	3.041	78.83						
10	0.568	2.582	81.412						
11	0.501	2.277	83.689						
12	0.487	2.216	85.905						
13	0.434	1.974	87.879						
14	0.409	1.859	89.737						
15	0.372	1.691	91.428						
16	0.344	1.563	92.991						
17	0.324	1.474	94.466						
18	0.308	1.401	95.867						
19	0.281	1.275	97.142						
20	0.248	1.125	98.267						
21	0.219	0.996	99.263						
22	0.162	0.737	100						

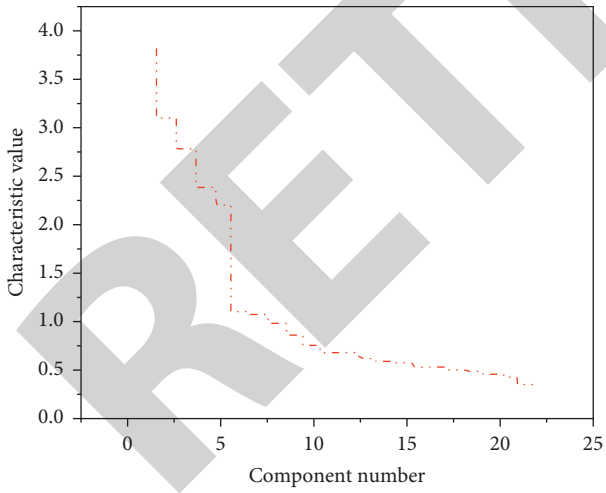

Figure 4: Scree plot.

teaching content is more abundant, and teaching evaluation is systematic. Through the analysis, most of the students in the pilot universities think that the teaching content is more substantial, but through the comparison, it can be obviously found that the teaching content is set according to the specific situation of their own colleges and universities. The teaching method has also changed due to the proposal of teaching reform. Because of the difficulty of comprehensive implementation of stratified teaching, the frequency of the mutual help method, cooperation method, and competition method began to rise gradually. This can not only increase students' interest but also better implement layered teaching and solve the situation of school facilities and resources shortage to a corresponding extent.

5.3. The Teacher Factor. The teacher factor includes five aspects: teacher's skill level, participation degree, teaching attitude, teaching experience, and teacher structure. Through analysis, it can be seen that the characteristic value of teacher's skill level is the largest. Whether the teacher can teach is on the one hand, and on the other hand is the degree of teacher participation. In the individualized teaching reform of college PHYSICAL education, the influence of the level of teachers' special skills on the teaching reform is more important, especially in the later period of students' learning of high and difficult technology, which highlights the skill level of physical education teachers. Therefore, it is essential to train PE teachers before and during their service. Whether the personalized teaching reform can go wider depends on the participation of teachers. The participation of teachers not only plays a great role in the later promotion but also enables each teacher to improve their understanding of the reform and teaching ability in the process of participation.

Table 16: Rotating component matrix.

	Element				
	1	2	3	4	5
The skill level of the teacher	92%	−0.041	0.006	−0.033	−0.049
Faculty structure	89%	−0.052	0.008	−0.008	−0.027
Teacher's teaching attitude	84%	0.029	0.018	−0.069	−0.015
Degree of teacher involvement	82%	−0.011	0.003	0.036	−0.055
Teacher's teaching experience	81%	0.019	−0.002	−,053	0.006
The physical quality of students	−2%	0.819	−0.021	−0.046	0.035
Student's interest level	−1%	0.818	0.029	0.015	0.135
Students' learning attitude	−7%	0.797	0.04	0.011	0.133
Students' free time	1%	0.775	0.059	0.021	−0.090
The sports foundation of students	1%	0.641	−0.021	−0.079	−0.114
Number of stadiums	−1%	0.045	0.851	0.036	−0.029
The amount of sports equipment	−0.004	0.006	0.837	0.049	0.007
The quality of the equipment	−0.015	−0.021	0.811	−0.036	0.023
Indoor stadium perfection	0.045	0.041	0.699	0.028	−0.016
Organizational form	0.014	−0.012	0.069	0.835	−0.012
Content of courses	−0.109	−0.012	0.026	0.831	−0.015
Teaching method	0.019	−0.112	0.054	0.739	0.13
Teaching evaluation	−0.031	0.042	−0.057	0.666	0.022
The sports atmosphere of the school	−0.065	0.002	0.022	0.009	0.826
The organization of sports competitions	0.043	−0.062	−0.006	−0.043	0.804
School sports culture	−0,012	−0.029	0.081	0.089	0.8
The importance of leadership	−0.053	0.095	−0.070	0.045	0.403

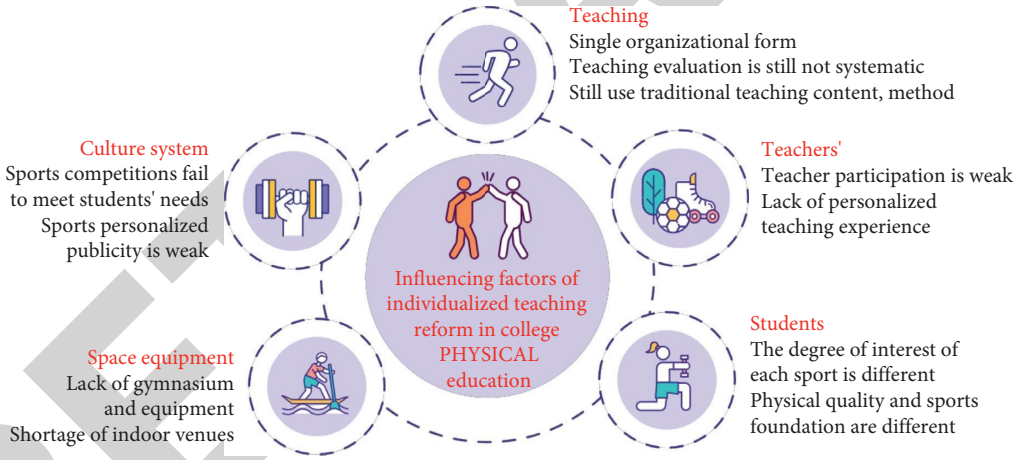

Figure 5: Factors influencing personalized teaching of college PHYSICAL education.

5.4. The Student Factor. The student factor includes five aspects: students' physical quality, interest level, study attitude, free time, and students' sports foundation. Through the analysis, male and female students have different interests in different sports, and most of them prefer the low-competitive sports such as aerobics, sports dance, and running. Most boys like basketball and football, but both boys and girls are more interested in new sports, such as rock climbing and roller skating.

5.5. Venue Equipment Factor. The equipment factor includes four aspects: the quantity of the stadium, the quantity of the sports equipment, the quality of the equipment, and the perfection of the indoor stadium. The problem of site equipment has always been an urgent problem for colleges and universities. For some colleges and universities, the problem of equipment may be easier to solve, but due to the geographical location of Shanghai, the land is relatively tight, so the site problem has been plaguing colleges and universities.

5.6. Cultural Institution Factor. Cultural system factors include four aspects: school sports atmosphere, sports culture sports, competition, organization strength, and leadership attention. The progress of personalized teaching reform of college PHYSICAL education is directly related to the attention of leaders. The higher the attention of school leaders, the more conducive to the development of teaching reform. According to the survey, most students expect to be tested in the form of competitions after they have made certain

achievements in sports learning, which can not only exercise students' spirit of cooperation but also greatly improve their actual combat ability.

6. College PE Teaching Reform Strategy Based on Moral Education

6.1. Carry Out Professional Ethics Education and Reform the way of Moral Education. Reforming the way of moral education is not rebuilding on the ruins, but in the moral education concept connotation and other aspects of innovation, in order to adapt to the social development of moral education, putting forward new requirements. In order to reform the cultivation of moral education, professional ethics education is the best choice. Classroom education is the primary link of professional ethics education. The links such as case analysis guided by theory, role playing, reasoning, and debate are helpful to the cultivation and development of college students' professional ethics consciousness, ethical choice, and ethical responsibility in terms of consciousness and behavior, so that they can show a high level of moral quality in the future professional activities.

At present, the courses of professional ethics education in domestic colleges and universities can be opened in two ways: one is to independently open relevant professional ethics courses in the middle and later stages of the whole professional education process. Students first master the basic professional knowledge and skills and then engage in some practical activities with the help of the platform of practice. After these three stages, they have basically acquired the ability of ethical selection and evaluation. At this time, the implementation of professional ethics education is beneficial to arouse their interest and thinking, and the effect is also remarkable.

Second, the ethical values and ethical responses to ethical dilemmas, ethical choices, and ethical crises should be taught systematically in the existing courses. For example, the content of professional ethics education should be added to the ideological and moral character, and the knowledge of ethical norms should be combined with the professional courses. Although this approach is not conducive to highlighting the importance of ethics in professional practice to some extent, and teachers lack relevant ethical theories and ethical practices, it is also a feasible method considering the large proportion of moral education courses in the whole curriculum system. This requires teachers to seriously study how to integrate the right moral and value content into the curriculum. Therefore, the teacher's professional ethics course is the core foundation in the educational process.

6.2. Strengthen the Cooperation with the Practice Unit and Establish the Practice Moral Education Environment inside and outside the School. The process in which schools carry out teaching activities with the help of workplace resources is the process in which schools and enterprises jointly organize teaching, as well as the process of consolidating and developing the effect of school moral education in workplace activities. Colleges and universities should break the traditional closed teaching mode and strengthen communication and cooperation with various industrial enterprises. For example, the teaching content of school teaching cases and scene simulation is in line with vocational activities. According to social needs, an open moral education environment that can be exchanged inside and outside the school is built. Schools and enterprises cooperate to establish teaching and scientific research practice bases of industry-university cooperation. The university provides customized education for enterprises. The university invites experienced in-service personnel from various industries as part-time teachers to the platform to teach moral education experience in vocational activities. It provides more opportunities for students to engage in professional work during their education. The ethics education of students is a combination of theory and practice. The prerequisite of school-enterprise cooperation is to ensure the consistency of students' perceptual and rational understanding of professional values and ethics. This kind of cooperation has great influence on students: it helps students experience and identify with professional ethical values and construct ethical thinking. It helps students know and understand ethical and value issues in practice, learn knowledge theories that cannot be learned in class, and narrow the gap between students' own ethical values and professional values. It helps students know themselves and gain preliminary understanding of the complexity of professional ethical issues for the future work psychological preparation. The ethical practice of students outside the classroom is still an educational trend, which aims at the realization of educational goals, can greatly improve students' practical ability and ideological understanding, and promote students to internalize ethical education into beliefs and behaviors so that students finally achieve the unity of knowledge and action.

7. Conclusion

This study proposes a personalized PE teaching reform path, and through KMO and Bartlett sphere test analyses, it can be found that the variance of interpretation of the five factors contributed 16.910%, 13.757%, 11.835%, 10.973%, and 10.065%, respectively, and the cumulative variance of the five influencing factors was 63.541%, meeting the minimum standard of 60%, which also verified the feasibility and effectiveness of integrating moral education into physical education teaching reform. At present, students' moral education consciousness is weak in the process of physical education teaching in colleges and universities, and there are many moral anomie behaviors, which cannot better integrate moral education into the physical education curriculum. At the same time, PE teachers cannot better grasp the opportunity to correct students' immoral behavior in time when they meet students' moral misconduct. Moreover, it is difficult for some teachers to set an example for students' moral education. In physical education teaching, some teachers deal with students' faults improperly, which damages students' self-esteem, leads to students' resentment, indifference, opposition, and other negative emotions, thus

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Retraction

Retracted: Development of Urban Waste Recycling Industry from the Perspective of Ecology

International Journal of Antennas and Propagation

Received 19 December 2023; Accepted 19 December 2023; Published 20 December 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) Manipulated or compromised peer review

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] Q. Luo, "Development of Urban Waste Recycling Industry from the Perspective of Ecology," *International Journal of Antennas and Propagation*, vol. 2022, Article ID 9087177, 10 pages, 2022.

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Research Article

Development of Urban Waste Recycling Industry from the Perspective of Ecology

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Urban garbage has become an important field affecting the healthy development of urban ecology, and urban ecological environment protection has naturally become a crucial part in the process of modern urban development. Deepening the relevant concepts of ecological and environmental protection also makes modern cities pay attention to the recycling and utilization of waste resources. This work is combined with the development status of urban waste recycling industry. Taking urban construction waste and domestic waste as examples, this paper focuses on the operation model and development path of urban waste recycling industry. For example, in the aspect of domestic waste treatment, the resource industrialization path of incineration fly ash is proposed, focusing on the water washing and dechlorination of incineration fly ash, the production of unburned ceramsite from water washed fly ash, and the separation and recovery of inorganic salts in fly ash water washing solution. The results show that the recoveries of NaCl, KCl, and $CaCl_2$ are 96.21%, 95.85%, and 94.72%. Through the analysis of social, environmental, and economic benefits, the government, scientific research institutions, and enterprises are encouraged to make joint efforts to develop the construction waste recycling industry, so as to fundamentally solve the current situation of "mountains of garbage and cities surrounded by garbage" in China.

1. Introduction

For a long time, the development of cities has always been the most favorable confirmation of the human social and cultural progress, scientific and technological development, and degree of civilization. At the same time, it is also a key link directly related to the healthy development of national social economy. On the other hand, the continuous increase of urban construction waste and living garbage has virtually increased the pressure on the urban environment, and the overall environmental pollution of the city is becoming more and more serious [1]. In the face of more and more urban domestic waste and construction waste, how to deal with and make good use of these wastes from the perspective of ecological and environmental protection has become an important issue to be considered for the green and healthy development of modern cities. From the perspective of ecology, gradually realizing the resource utilization, harmless treatment, and reduction development of urban construction waste and domestic waste is an effective means to solve urban waste scientifically and effectively [2]. Therefore, from the perspective of ecological and environmental protection, starting with the development status of modern urban waste recycling, this paper focuses on the operation model and development path of urban waste recycling industry. In terms of domestic waste treatment, the resource industrialization path of incineration fly ash is proposed, focusing on the research on the water washing and dechlorination of incineration fly ash, the preparation of unburned ceramsite from water washed fly ash, and the separation and recovery of inorganic salts in the water washing solution of fly ash, as shown in Figure 1 [3, 4].

2. Literature Review

There is an obvious gap between developing and developed countries in the research of garbage problem. In world organizations such as the joint program, developed

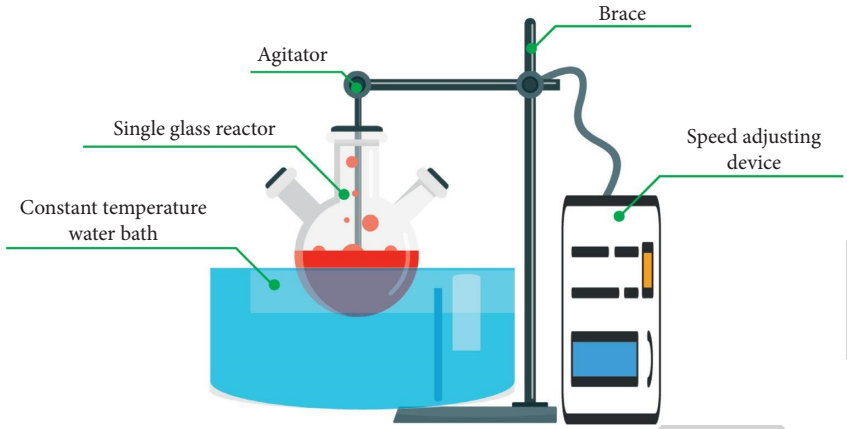

Figure 1: Water washing experimental system.

countries have detailed databases describing the characteristics of their municipal solid waste, including the amount, rate, and composition of municipal solid waste [5]. The research on municipal solid waste treatment includes the application of technology, such as quantitative analysis of resource utilization rate and determination of resource utilization quota under sustainable state, and construction of key ecological model for strategic management of municipal solid waste. Comprehensively considering the impact of ecology and economics and integrating the methods of multidimensional optimization selection of life cycle, many scholars have studied the relationship between various pollution and functional obstacles caused by municipal solid waste landfill and incineration and external costs, which provides effective support for the decision-making process. The material and cost of landfill are determined by the optimization model, and the decision-making scheme is optimized by the simulation model [6]. Developed countries have also carried out more extensive research on the impact of psychological and socioeconomic factors on human behavior. Psychological research aims to know residents' attitude toward municipal solid waste recycling through self-statement of personal behavior and comparison with actual behavior in the form of questionnaire. Consumption pattern, education level, gender, age, and income level are the main factors related to classified recycling in social economics.

Based on the current research, Li. and others found that the content of soluble chloride (NaCl, KCl, $CaCl_2$, etc.) in fly ash decreased rapidly after water washing [7]. Chen and others found that water washing can remove chlorine salt in fly ash, and Al, Si, Ca, and other substances will not be washed away, which provides the possibility for its subsequent use in making cement, ceramsite, and other materials [8]. Yang and others studied the removal rate of chlorine ions from fly ash under different water washing parameters. In order to further improve the removal efficiency of chlorine salt in fly ash, carbon dioxide can be introduced during water washing to increase the solubility of mixed solution [9]. Cao and others mixed fly ash with cement to make cement solidified-body and studied the effect of the amount of fly ash added in the solidified body on its performance [10]. He and others prepared belite cement with high strength and high corrosion resistance by low temperature calcination technology with fly ash and lime as main raw materials [11]. Xu and others used fly ash with low calcium content to prepare cement and studied the water consumption, fluidity, setting time, stability, and dry shrinkage of cement. The water consumption, setting time, and stability of cement also increase, and the dry shrinkage rate of cement decreases. At the same time, the addition of fly ash can reduce the strength of cement samples [12]. Studies by Li and others show that fly ash can be used as raw materials to prepare alinite ecological cement with high compressive strength, and metal ions and chloride ions in fly ash can improve the characteristics of cement, improve the flammability of cement raw meal, and promote the formation of cement [13]. Nadori and others discussed the feasibility of using waste incineration fly ash to make high-strength concrete by conventional process means, took the lead in successfully developing high-strength concrete meeting industrial application conditions in China, and confirmed that fly ash can be used to make concrete [14]. Cui and others used limestone and fly ash to replace cement to prepare concrete and made in-depth research on its working performance, mechanical properties, and microstructure. The results show that the concrete prepared with the mixture of 50% cement and 50% limestone powder and fly ash has small slump loss within 60 min and the compressive strength meets the requirements [15]. Jian and others studied the feasibility of replacing cement with fly ash mass in a ratio of 40~70% to produce mass concrete and analyzed its compressive strength and hydration characteristics [16].

3. Analysis of the Current Situation of Resource Utilization and Industrialization of Urban Construction Waste in China

3.1. Estimation of Urban Construction Waste Output. The annual growth rate of construction waste is about 10%. Especially after the financial crisis in 2008, the production of construction waste in China shows a rapid growth trend. The annual growth rates of construction waste in 2010 and 2011

are 13.06% and 14.05%, respectively. Its cumulative value is even more terrible, nearly 12×108 t in 2011. If China does not step up the rapid development of construction waste recycling, construction waste will become a major burden on China's development. According to statistics, the amount of construction waste generated by brick concrete and frame structures in urban areas is about 1.0~1.5 t/m^2; the output of other wooden and steel structures is about 0.5~1.0 t/m^2. According to the statistics of a Chinese housing company, about 1.35 t of construction waste is produced by 1 m^2 of housing [17, 18]. Therefore, considering the structural characteristics of the current demolished buildings, it is determined that the demolition of 1 m^2 of buildings will produce about 1.30 t construction waste.

3.2. Prediction of Construction Waste

3.2.1. Establishment of Grey Prediction Model GM (1,1). The so-called grey system refers to the system in which some information is clear and some information is unknown. The grey system theory is aimed at the system with incomplete information. It studies and predicts the unknown field through the known information, so as to understand the whole system. The grey prediction model GM (1,1) aims to reduce the influence of random factors by accumulating the original discrete data, so as to generate regular data. In this paper, the annual growth system of construction waste contains not only clear information, but also unknown and uncertain information. At the same time, through the estimation of the annual output of construction waste, the data has an obvious upward trend, and its prediction has high accuracy [19]. The specific steps are as follows.

First, nonnegative original data sequence is as follows:

$$X^{(0)} = \left\{x^{(0)}(1), x^{(0)}(2), \ldots, x^{(0)}(n)\right\}, \tag{1}$$

where

$$X^{(0)}(k) \geq 0, k = 1, 2, \ldots, n. \tag{2}$$

The generated sequence of one-time accumulation of the original data weakens the randomness and volatility of the original data and strengthens the regularity of the data, resulting in the following:

$$X^{(1)} = \left\{x^{(1)}(1), x^{(1)}(2), \ldots, x^{(1)}(n)\right\}, \tag{3}$$

where

$$X^{(1)}(k) = \sum_{i=1}^{k} x^{(0)}(i), k = 1, 2, \ldots, n. \tag{4}$$

The superscript "0" indicates the original sequence, and the superscript "1" indicates the cumulative production sequence at one time.

Let $Z^{(1)}$ be the nearest mean generation sequence of $X^{(1)}$:

$$Z^{(1)} = \left\{Z^{(1)}(2), Z^{(1)}(3), \ldots, Z^{(1)}(n)\right\}, \tag{5}$$

where

$$Z^{(1)}(k) = \frac{1}{2}\left(X^{(1)}(K) + x^{(1)}(K-1)\right), K = 2, 3, \ldots, n. \tag{6}$$

Then, the definition type of GM (1,1), that is, the grey differential equation model of GM (1,1) model, is as follows:

$$X^{(0)}(K) = Z^{(1)}(K) = b. \tag{7}$$

If (8) is a parameter column and satisfies the following formula:

$$\widehat{a} = (a, b)^T, \tag{8}$$

$$Y = \begin{bmatrix} x^{(0)}(2) \\ x^{(0)}(3) \\ \cdots \\ x^{(0)}(n) \end{bmatrix}, B = \begin{bmatrix} -z^{(1)}(2) & 1 \\ -z^{(1)}(3) & 1 \\ \cdots & \cdots \\ -z^{(1)}(n) & 1 \end{bmatrix}, \tag{9}$$

then the least squares estimation parameter column of GM (1,1) model $x^{(0)}(k) = z^{(1)}(k) = b$ satisfies the following:

$$\widehat{a} = \left(B^T B\right)^{-1} B^T Y. \tag{10}$$

Then, we have the following.

The whitening equation of GM (1,1) model is as follows:

$$\frac{\mathrm{d}x^{(1)}}{\mathrm{d}t} + ax^{(1)} = b. \tag{11}$$

The time response sequence of GM (1,1) grey differential equation is the GM (1,1) prediction model:

$$x^{(1)}(k+1) = \left(x^{(0)}(1) - \frac{b}{a}\right)e^{-a} + \frac{b}{a} \quad k = 1, 2, \ldots, n. \tag{12}$$

The restore value is as follows:

$$\widehat{x}^{(0)}(k+1) = \widehat{x}^{(1)}(k+1) - \widehat{x}^{(1)}(k), \quad k = 1, 2, \ldots, n. \tag{13}$$

The above three equations are the prediction equation.

3.2.2. Accuracy Test of GM (1,1) Model. The absolute residual sequence is as follows:

$$\begin{aligned} \Delta^{(0)} &= \left\{\Delta^{(0)}(k), k = 1, 2, \ldots, n\right\}, \\ \Delta^{(0)}(k) &= \left|x^{(0)}(k) - \widehat{x}^{(0)}(k)\right|. \end{aligned} \tag{14}$$

The sequence of relative residuals is as follows:

$$\varphi = \{\varphi_k, k = 1, 2, \ldots, n\}, \varphi_k = \frac{\Delta^{(0)}(k)}{x^{(0)}(k)}. \tag{15}$$

Calculate the average of the original sequence:

$$\overline{x}^{(0)} = \frac{1}{n}\sum_{k=1}^{n} x^{(0)}(k). \tag{16}$$

Calculate the mean square deviation of the original sequence:

$$S_1 = \left(\frac{\sum_{k=1}^{n} \left(x^{(0)}(k) - \overline{x}^{(0)} \right)^2}{n-1} \right)^{1/2}. \quad (17)$$

Calculate the mean of the residuals:

$$\overline{\Delta} = \frac{1}{n} \sum_{k=1}^{n} \Delta^{(0)}(k). \quad (18)$$

Calculate the mean square deviation of the residuals:

$$S_1 = \left(\frac{\sum_{k=1}^{n} \left(\Delta^{(0)}(k) - \overline{\Delta} \right)^2}{n-1} \right)^{1/2}. \quad (19)$$

Calculate variance ratio:

$$C = \frac{S_2}{S_1}. \quad (20)$$

Calculate small residual probability:

$$p = P\left(\left| \Delta^{(0)}(k) - \overline{\Delta} \right| < 0.6745 S_1 \right). \quad (21)$$

3.2.3. Prediction of Construction Waste. The prediction results of China's construction waste production in 2017 and 2020 are shown in Tables 1 and 2 and Figures 2and 3.

Comparing the original value of construction waste with the predicted value, we get the fitting curve between the original value of construction waste output and the predicted result shown in Figure 3.

Table 1 and Figure 3 show that the initial annual production cost of waste production in 2006–2016 was close to the estimated cost. The Gray Prediction GM (1,1) model has been shown to be accurate in estimating annual construction waste, and China's annual waste disposal volume will grow at an annual rate over the next four years. 15%. By 2020, China's annual garbage output is expected to exceed 21×108 tons, an increase of more than 70% over 2016, which is largely in line with the reality of China's urban development, commerce, and construction. If such a large amount of construction waste is not disposed of reasonably, it will not only occupy land resources and pollute the natural environment, but also destroy the living environment, affect the city appearance, and greatly hinder urban development [20, 21]. Therefore, the recycling of construction waste is required and forced by the situation and has become an industry in urgent need of development in China.

4. Water Washing of Municipal Solid Waste Incineration Fly Ash and Treatment Experiment of Water Washing Solution

4.1. Source of Experimental Fly Ash. The ash used in the experiment was obtained from a waste incinerator in Gaoantong, Beijing. The solid waste incineration plant has introduced SN grate technology from Tianxion, Japan, and is equipped with SNCR desulphurization and dehydration [22]. Part of the ash was dried in the oven at 105 C for 3 hours, drained, ground, filtered, and checked by an X-ray fluorescence spectrometer (XRF), as shown in Tables 2 and 3 and Figures 4–6.

Tables 2 and 3 and Figures 4 and 5 shows that the high content of chlorine salt will cause corrosion to building materials, so the original fly ash must be treated before it can be used for the subsequent production of unburned ceramsite [23]. The SO_3 content of the initial ash is up to 26.7% due to the reaction of SO_2 and heating during combustion [24]. Figure 6 shows that the variance of the incineration ash in general has a significant difference, with the highest particle size of up to 30 mm or about 65% being ash. Productivity during incineration is minimal. Total ash

Table 1: Output of urban construction waste in China from 2017 to 2020.

Particular year	2017	2018	2019	2020
Estimate	143266.9	164751.8	189458.7	217870.7

Table 2: XRF analysis results of original fly ash (1).

Component	Mass fraction (%)
SO_3	26.71
Na_2O	26.58
CaO	11.43
Cl	9.59
SiO_2	7.179
K_2O	5.208
Br	3.519
F	3.35
Al_2O_3	1.55
Fe_2O_3	1.108
ZnO	0.9022
SnO_2	0.8608
P_2O_5	0.857

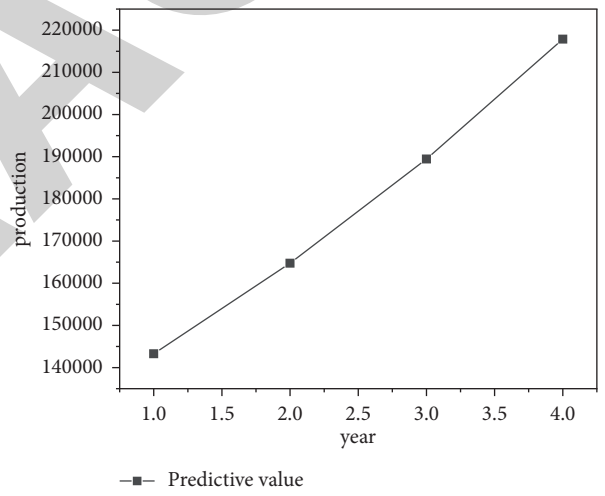

Figure 2: Output of urban construction waste in China from 2017 to 2020.

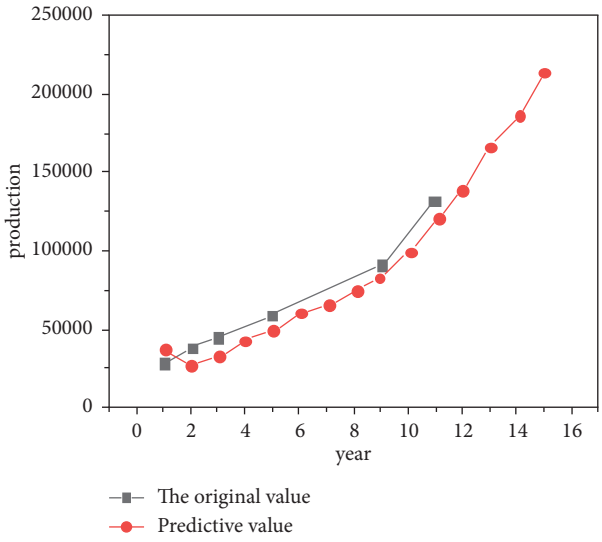

Figure 3: Fitting curve of annual output of construction waste in China.

Table 3: XRF analysis results of original fly ash (2).

Component	Mass fraction%
MgO	0.292
TiO_2	0.285
CuO	0.2038
PbO	0.189
BaO	0.069
Cr_2O_3	0.0503
Sb_2O_3	0.0325
CeO_2	0.025
ZrO_2	0.014
MnO	0.014
As_2O_3	0.0104
SrO	0.008

over 117 um is almost zero due to the fact that the ash grows

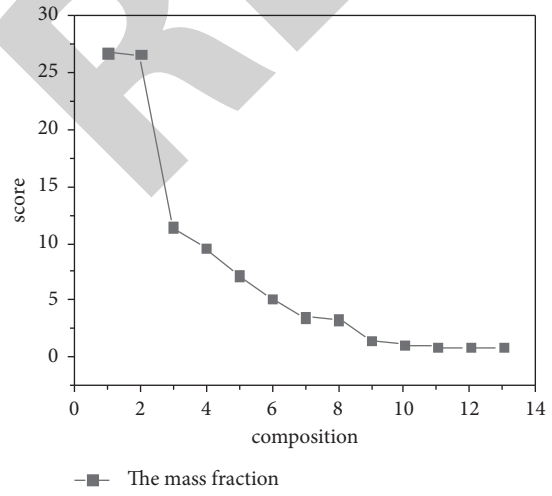

Figure 4: XRF analysis results of original fly ash (1).

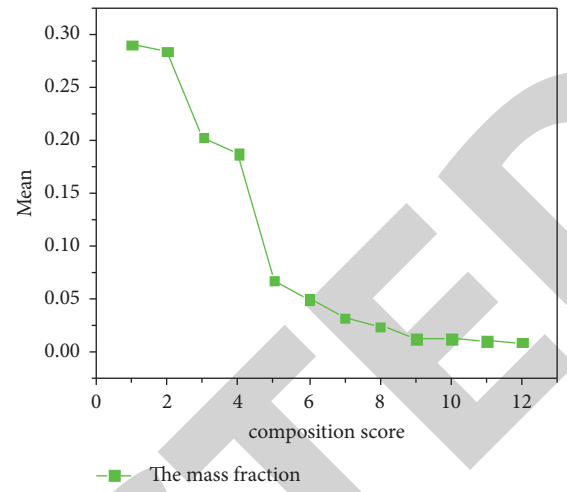

Figure 5: XRF analysis results of original fly ash (2).

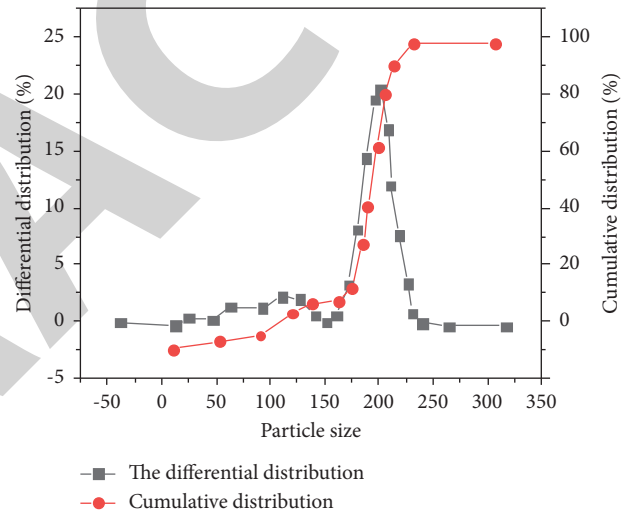

Figure 6: Particle size diagram of fly ash.

in the slag along with some incomplete material.

4.2. Experimental System and Method

4.2.1. System. Fly ash contains a large amount of soluble chlorine salt, which is directly dissolved in water after washing to form high chlorine salt wastewater. This wastewater will be directly discharged without treatment, which will cause the death of soil organisms and plants and seriously damage the ecological environment. This section mainly deals with the chlorine salt in the water washing solution. The process flow chart of the treatment experiment is shown in Figure 7. Firstly, take the fly ash water washing solution under the best experimental parameters of fly ash water washing treatment, and analyze its main components. The results are shown in Table 4.

In Table 4, the content of chloride ion is as high as 45418.7 mg/l, far more than 1%, belonging to the range of high salt wastewater. Take 100 ml fly ash water washing

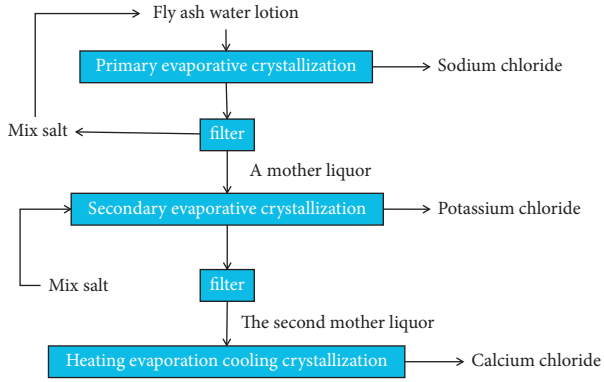

Figure 7: Experimental process flow of fly ash washing solution treatment.

Table 4: Main components of fly ash washing solution.

Material	Na^+	K^+	Ca^{2+}	Cl^-	Zn^{2+}
Concentration	14369.2	4341.4	768.78	45418.8	0.04

solution and place it on the heater for heating. By adjusting the temperature of the heater, controlling the evaporation temperature in the aqueous solution, and measuring the changes of M (NaCl)/M (KCl), *m* (KCl)/M (CaCl2), and *m* (NaCl)/M ($CaCl_2$) in the water washing solution, the separation temperature of NaCl, KCl, and $CaCl_2$ is obtained, so that the chloride salt in the water washing solution can be crystallized and separated, and finally NaCl, KCl, $CaCl_2$, and other products can be obtained.

4.2.2. Detection and Analysis Method. In order to detect the chemical water washing and analyze its element composition and the change of composition before and after treatment, the fly ash is detected by X-ray fluorescence spectrometer. The model and data are shown in Table 5.

(1) Sample preparation by crushing: dry the sample into powder, and grind it to 300 mesh–400 mesh.

(2) Samples: put the samples in X-ray fluorescence spectrometer sample cup for analysis.

In order to understand the mineral phase composition in the fly ash and the reason for the decrease of chloride content after water washing, X-ray diffractometer (XRD) is selected to detect the fly ash before and after water washing. The model and parameters of the instrument are shown in Table 6.

4.2.3. Detection of Heavy Metal Leaching Toxicity. The national standard leaching toxicity leaching method of solid waste—horizontal oscillation method (GB5086.2–1997)—was used to carry out the leaching toxicity experiment, and the leaching concentrations of heavy metals copper, zinc, lead, cadmium, and chromium in fly ash and unburned ceramsite were determined by inductively coupled atomic

Table 5: Main technical indexes of XRF instrument.

Project	Parameter
Model	S8 tiger
Maximum output power	4 kW
Excitation current	5–170 mA
Excitation voltage	20–60 kV
Ceramic light tube	75 μm ultrathin beryllium window rhodium target
Optical positioning goniometer	The positioning accuracy is better than ±0.001°, and the angle reproducibility is better than ±0.0001°

Table 6: Main technical indexes of XRD instrument.

Project	Parameter
Model	Smart lab 9 ∗
Maximum output power	3 kW
Closed X-ray tube	Cu target
Rated voltage	20–60 kV
Minimum focal spot size	0.4 ∗ 8 mm^2
Goniometer system	20 scanning range: −3°~160°
Maximum size of testable sample	250 mm (L) ∗ 250 mm (W)

emission spectrometry [25]. The specific test methods are as follows:

4.3. Test Results and Analysis of Fly Ash Washing

4.3.1. Effect of Liquid-Solid Ratio on Chloride Ion Removal. 100 g fly ash was taken from the experiment. The washing time was 15 min, and the washing temperature was 25°C. The mixed solution after water washing is vacuum-filtered through a Brinell funnel paved with two layers of qualitative filter paper. The liquid-solid comparison is shown in Figure 8. The concentration of chloride ions in the ash before and after washing with water under different conditions and the rate of emission of chloride ions are shown in Figure 8.

4.3.2. Influence of Washing Time on Chloride Ion Removal. Take 100 g fly ash, and set the washing temperature at 25°C, the liquid-solid ratio at 6 ml/g, and the stirring speed at 170 ± 10 r/min. Wash the fly ash for 5, 15, 25, 35, 45, and 55 min. Under different washing time conditions, the chloride ion content and chloride ion removal rate in fly ash before and after washing are shown in Figure 9.

As can be seen from the figure, the length of the cleaning time is less effective at removing chloride ions from the ash. But as the cleaning time increased, the chloride ion emission increased to 86.7%. This is because chloride salts, such as sodium chloride, potassium chloride, and calcium chloride, are soluble in water and dissolve rapidly in liquid phase. Thus, the rate of chloride ion removal has not improved much over time. In addition, the cleaning delay in the project will actually increase the operating costs of the entire

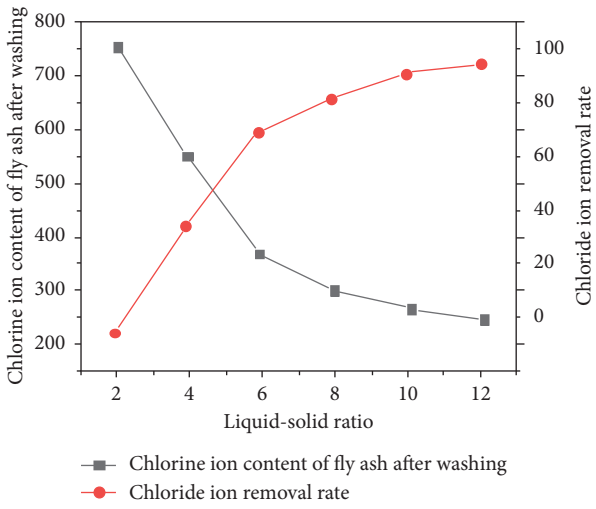

Figure 8: Effect of liquid-solid ratio on chloride ion removal in fly ash.

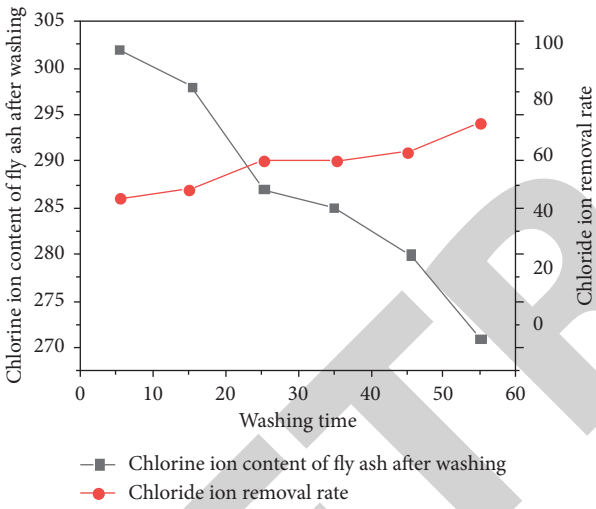

Figure 9: Effect of washing time on chloride ion removal from fly ash.

washing equipment. Therefore, the cleaning time is finally defined as 5 minutes, while the removal rate of chloride ions reaches 85.2%.

4.3.3. Influence of Water Washing Temperature on Chloride Ion Removal. Wash the fly ash at the washing temperatures of 25, 30, 40, 50, 60, 70, and 90 min. Under different water washing temperatures, the chloride ion removal rate of the chloride ion content meter in the fly ash before and after water washing is shown in Figure 10.

The amount of chloride ion release also gradually increases, as shown in Figure 10. When the washing water is hot, about 70°C, the rate of chloride ion removal remains almost unchanged. The rate of removal of chloride ions gradually increases with temperature, but the conversion rate is not very good. Therefore, hot wash water has an impact on the removal of chloride ions in the ash. As the

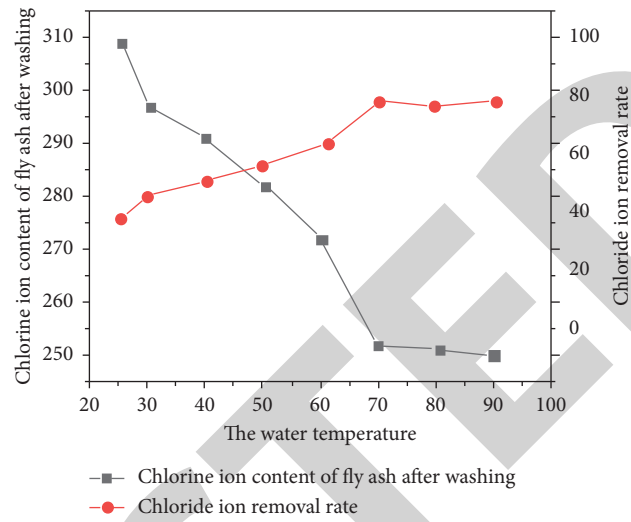

Figure 10: Effect of water washing temperature on chloride ion removal from fly ash.

solubility of chloride salts in the ash increases with increasing washing temperature, the rate of dissolved chloride ions also increases, and the effect of chloride ion removal increases with increasing temperature. As the temperature rises to 70°C, the effect of the chloride ion removal changes slightly as some of the soluble chemicals and solids in the ash dissolve.

4.4. Experimental Results and Analysis of Fly Ash Washing Solution Treatment

4.4.1. Primary Evaporation Crystallization Separation Temperature. According to the analysis results in the previous section, the crystallization separation temperature of NaCl and KCl is further analyzed to determine the primary evaporation crystallization separation temperature. Take a certain amount of water washing solution of fly ash, heat and crystallize it in the range of 112–116°C, and stop heating at different temperatures; after settling for 5 minutes, filter the bottom crystal while it is hot, and measure the change of mass fraction of NaCl and KCl in the solution with temperature, as shown in Figure 11.

4.4.2. Secondary Evaporation Crystallization Separation Temperature. The crystallization separation temperature of KCl and $CaCl_2$ was further analyzed to determine the secondary evaporation crystallization separation temperature. The solution after primary evaporation crystallization separation is heated and evaporated. The mass fraction of NaCl, KCl, and $CaCl_2$ in the solution changes with temperature, as shown in Figure 12.

The solution separated from NaCl and KCl was heated and evaporated. After heating to 135°C, the temperature was reduced and crystallized to obtain CaCl2 · 6H2O. According to the primary and secondary evaporative crystallization separation temperature determined above, the water washing solution is subjected to cyclic evaporation

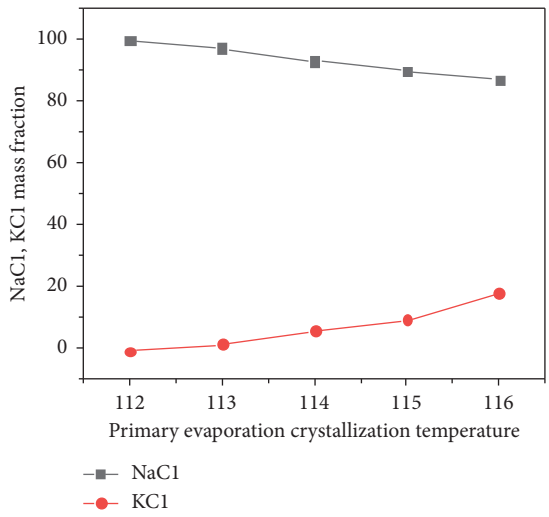

Figure 11: Effect of primary evaporation crystallization temperature on chloride content.

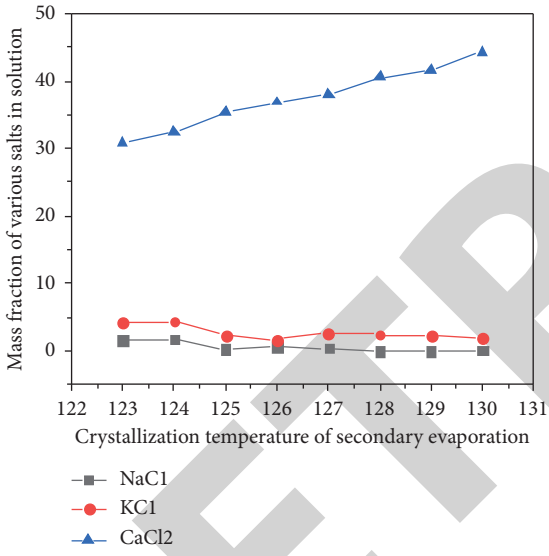

Figure 12: Effect of secondary evaporation temperature on chlorine salt in mother liquor.

treatment. Finally, the recoveries of NaCl, KCl, and $CaCl_2$ in the effluent washing solution are 96.21%, 95.85%, and 94.72%. Through the evaporation crystallization treatment of fly ash washing solution, not only are the chloride content in the washing solution and the harm of wastewater discharge reduced, but also the chloride can be recovered and reused.

4.5. Result Discussion. The chloride ion in fly ash was treated by water washing method. The filter solution after water washing of fly ash was treated by evaporation separation technology, and the suitable crystallization separation temperature of NaCl, KCl, and $CaCl_2$ in the water washing solution was analyzed. The main results are as follows:

(1) According to the results of the ash particle size analysis, the particle size is 16–117 mm, the particle size is less than 70 mm, about 98% of the total volume, and the total ash is less than 0.4 mm or more, more than 155 mm. The fact that it is almost zero indicates that the ash is very small.

(2) The maximum emission of chloride ions in ash is 88.72%. The ratio of liquids to products has the highest efficiency of chloride ion removal, while washing time and temperature have the least impact on chloride ion removal.

(3) The experimental results of evaporative crystallization of fly ash water washing solution show that the primary evaporative crystallization separation temperature of NaCl and KCl is 113°C, and the secondary evaporative crystallization separation temperature of KCl and $CaCl_2$ is 128°C. Through the cyclic evaporation treatment of fly ash water washing solution, the recoveries of NaCl, KCl, and $CaCl_2$ in effluent washing solution are 96.21%, 95.85%, and 94.72%.

(4) After washing the ash with water before and after testing with an electrometer, most of the ashes are gradually transformed into a spherical or oval shape. The crystalline solution that begins to adhere to the ash does not come to the surface of the wash ash, indicating that most of the chlorine salts in the ash are removed after rinsing with water.

(5) The XRD results showed that the mineral phase in the ash was chlorine salts (NaCl, KCl) and calcium salts (Ca (OH) 2, CaSO4), of which NaCl and KCl were chlorine salts. After washing with water, the chloride content in the ash is reduced, and CaSO4 • 2 (H_2O), SiO_2, $CaCO_3$, and other chemicals are formed, which guarantees the production of ash expanded clay as raw material.

5. Conclusion

The data were reported to study the theory of waste generation and recycling, to examine it for recycling, and to show that the development of waste in China has been increasing every year. In 2015, the city's annual waste was expected to exceed 21 × 108 tons, an increase of more than 70 percent over 2011. From 2001 to 2011, the growth rate of construction waste exceeded 10%, while from 2012 to 2015, the annual growth rate reached 15%. These data will provide basic data and theoretical basis for China's construction waste recycling management, policy, and technical decision-making and serve as the basic starting point for the research on China's construction waste recycling. The development of construction waste recycling is directly related to the social environment and the economic benefits of participating enterprises. This paper uses the method of economic mathematics to establish the economic benefit evaluation model of construction waste recycling. Case analysis shows that the economic benefits of urban construction waste recycling in China are considerable and attract more

enterprises and individuals to invest in the construction waste recycling industry. Through the analysis of social, environmental, and economic benefits, the government, scientific research institutions, and enterprises are encouraged to make joint efforts to develop the construction waste recycling industry, so as to fundamentally solve the current situation of "mountains of garbage and cities surrounded by garbage" in China. This study confirms that the production of unburned ceramsite with water washed fly ash, cement, and silica sol has good economic, environmental, and social benefits, but the experiment is still in the laboratory stage, and there are many uncertain factors in the actual industrial application process. It is suggested that its reliability is further verified in the industrial scale production of unburned ceramsite.

Data Availability

The labeled dataset used to support the findings of this study is available from the author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

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Retraction

Retracted: Marketing Model of Tourism Enterprises Based on New Media Environment

International Journal of Antennas and Propagation

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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] L. Wang, X. Wang, M. Song, and T. Niu, "Marketing Model of Tourism Enterprises Based on New Media Environment," *International Journal of Antennas and Propagation*, vol. 2022, Article ID 5273167, 13 pages, 2022.

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Research Article

Marketing Model of Tourism Enterprises Based on New Media Environment

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New media is a scientific and technological product under the background of the new era, and now new media technology has been widely used in all aspects of social development, and it has spawned the arrival of the new media era. In the new media environment, the survival and development environment faced by enterprises have undergone earth-shaking changes; if you still follow the traditional marketing methods, it will not only reduce the effectiveness of marketing but also because of the deviation from the development requirements of the times be eliminated, bringing threats to the survival and development of enterprises. The development of new media, represented by the Internet and mobile phones, has brought great changes to various industries in the world including tourism. The market size of the travel network is expanding, and online sales are soaring. At the same time, all kinds of tourism organizations often have blind optimism in the construction of tourism networks and lack of reasonable application means, so that tourism network marketing is far from exerting its potential in reality; on the one hand, it cannot provide transaction services that satisfy both supply and demand; on the other hand, it also affects the economic benefits of tourism organizations. Compared with the rapid development of the tourism media industry, the theoretical research related to the actual situation lags significantly. Although the number of related studies at home and abroad is increasing, most of them stay at the level of explanation and introduction, and the analysis of the tourism industry chain is not enough. The breadth and depth of the study are sorely lacking. The future letter needs to summarize the successes and failures of the development of the tourism media industry from a theoretical height and carry out theoretical improvement to guide practice, and it also needs to strengthen forward-looking research, summarize the laws and models, and put forward practical implementation plans to improve the overall development level of the tourism and media industry. Aiming at the problem of new media marketing strategy in shopping tourism scenic spots, this paper applies descriptive research, questionnaire survey, statistical processing, mathematical model, and other research methods to analyze the characteristics of new media such as prominence of personalization, increased audience selectivity, and diversified forms of expression presented by new media compared with traditional media, as well as the differences between the two in terms of communication status, dominant state, and audience state. 4I Marketing theory is applied to new media marketing, the changes in the marketing environment and marketing needs under the background of new media, and the extensive impact of these changes on the marketing mix strategy; the basic strategies and expected effects of new media marketing of tourism enterprises are studied from the aspects of product, price, channel, and promotion; the IPA model is constructed, and the empirical analysis of the shopping tourist attractions of Changshu Garment City in China is carried out. Through the research of this paper, in theory, the understanding of new media marketing is enriched, and in fact, it provides guidance for optimizing the new media marketing strategy of tourist attractions.

1. Introduction

New media is the use of digital technology, through wireless communication networks, satellites, and other channels, as well as computers, mobile phones, digital televisions, and other terminals, to provide information and services to users of the form of communication, and the types are mainly divided into electronic magazines, videos, and micro blogs [1]. New media is different from traditional old media, with real-time, large capacity, and interactivity. In the era of large-scale application of new media, tourism should be good at using new media, adopt appropriate marketing channels for different consumer groups, and actively innovate marketing strategies. With the advent of the new media era, the traditional marketing model has been unable to keep up with the speed of enterprise product reform and innovation and can not reflect the advantages in marketing promotion, which requires adapting to the new environment, introducing new media-centered marketing innovation strategies, using a variety of new media technology methods to do a good job in professional marketing publicity, as well as the use of online and offline combination of methods to improve the comprehensive efficiency of enterprises, improving the comprehensive quality of marketing. However, at present, there are fewer tourism enterprises using new media, most of them are in their infancy, and how to use new media to broaden marketing channels is the key issue for the development of tourism enterprises at present [2].

Tourism is a sunrise industry with strong comprehensiveness and strong industrial relevance, which can effectively promote the development of related industries. Based on a global perspective, tourism has gradually developed into a tertiary industry, playing an important role in the regional economy and national economy. From 1945 to 2016, the annual growth rate of foreign tourists exceeded 8%, far exceeding the growth rate of world GDP, and the overall global tourism revenue reached 896 billion US dollars in 2016, an increase of 450 times compared with 1945. According to relevant data, at this growth rate, by 2020, the number of global tourists will reach 1.62 billion, and the overall revenue of tourism will reach 990 billion US dollars. It is precisely because of such rapid development, huge economic benefits, and green environmental protection that various countries have begun to pay attention to the development of tourism, have concentrated various advantageous resources to vigorously develop tourism, and implemented the strategy of going out to compete for global tourism resources and tourism market share [3].

In the theoretical research, this paper is mainly to improve and supplement the marketing theory and strategy of shopping tourist attractions. In China, most of the tourism marketing theories are based on the concept of scenic spot image design, marketing themes, and cultural innovation, or through the combination of the above three aspects to study tourism marketing strategies and combination marketing methods. However, due to the rapid development of the Internet, the era of new media has quietly arrived, more and more marketing opportunities have begun to appear, and the traditional tourism marketing model has not been able to fully adapt to the development of the market economy and people's growing demand for diversification of the tourism market. Therefore, based on the tourism marketing of the new media era, it is necessary to conduct all-round and multifaceted analysis, strengthen innovation on the basis of previous research, and then build a new marketing system for tourist attractions in combination with the specific actual situation of the country. On the basis of the analysis of traditional marketing theory, this paper proposes the theory of new media marketing and analyzes the impact and effect of its marketing in shopping tourist attractions, so that it can realize the continuous optimization of marketing resources and guide the direction of marketing; at the same time, the tourism marketing theory under the new media has been further enriched and then combined with the current popular APP marketing model, such as Weibo marketing, WeChat marketing, to incorporate them all into the topic. The purpose is to study the theories that are relatively vacant in the current tourism marketing, so as to achieve the purpose of throwing bricks and stones and better serving tourism and marketing [4].

From the perspective of tourist attractions, through a series of empirical studies, this research scientifically analyzes the actual effect and actual impact of new media marketing strategies in specific tourist attractions, so as to promote tourism organizations or tourism enterprises to better implement their own marketing strategies as shown in Figure 1. Taking Changshu Clothing City as a case, based on new media marketing, through the practical application of specific marketing strategies, according to the actual marketing effect, the new media marketing strategy for shopping tourism scenic spots is scientifically and reasonably proposed. It is expected that, in the future marketing activities, with the help of new media, the social resources can be continuously optimized, the effective linkage between regions can be realized, and the marketing effect that cannot be achieved by traditional marketing methods can be achieved.

2. State of the Art

2.1. The Conceptual Connotation of New Media and New Media Marketing. In 1967, P. Goldmark pioneered the concept of "new media." The "new" of new media is relative, and new media is both a concept of time and a concept of development. At this stage, new media is a media with innovative forms based on digital information technology and characterized by interactive communication compared with traditional media such as newspapers and periodicals, radio, and television. Ohrens et al. summarized the emerging media groups as online media, mobile media, interactive TV media, building TV, car mobile TV, outdoor new media, etc. [5]. The new media in a large number of studies is "fourth media" and "fifth media," that is, online media and mobile media. In essence, new media marketing is the way, means, and process of marketing organizations to use information technology and new media characteristics to carry out marketing activities in order to achieve overall marketing goals. Compared with traditional media marketing, new media marketing pays more attention to experiential,

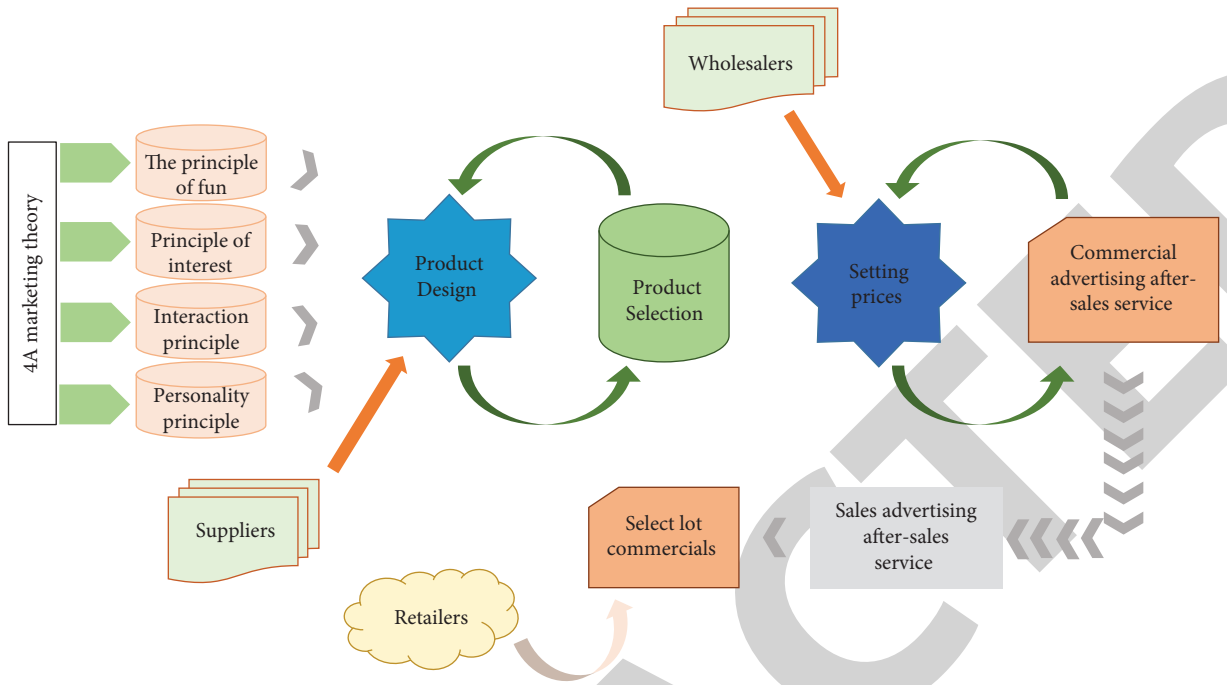

Figure 1: Marketing model of tourism enterprises based on 4A marketing theory.

communication, differentiation, and other aspects. New media are connected and differentiated from media forms such as digital media, self-media, social media, and online media. They are similar in terms of network and communication technology foundation, communication mode, etc., but digital media emphasizes binary forms, self-media focuses on individuals, social media focuses on sharing, and online media emphasizes platforms. It can be said that new media combines the advantages of digital media, self-media, social media, and online media.

2.2. Tourism Website Marketing. At the end of the 20th century, with the advent of the Internet, the tourism industry developed rapidly, and scholars began to study tourism websites and came up with some research results. For example, Li and Lu compared and analyzed Chinese and American tourism websites and then proposed a new "virtual distance measurement method" to predict the development mode of tourism websites [6]. Bertan established an intelligent evaluation index system and used fuzzy cluster analysis methods to evaluate 10 tourism websites in Shijiazhuang [7]. There are also scholars who study a certain branch of the tourism website, and the author searches for relevant literature and finds that the research on the tourism website of the scholars focuses on the official website of destination tourism and the website of scenic spots. Some scholars evaluated the official websites of 31 provincial and municipal tourism in China: Gao took marketing strategy, information services, transaction processing, technical support, and website operation as first-level indicators to evaluate the marketing functions of official tourism websites, while Koehn et al. proceeded from the perspective of tourist demand, according to information, interaction, transaction, and customs The evaluation system of 44 secondary indicators has been constructed at four levels and technical support [8, 9]. Szromek and Naramski collected the tourist evaluation of Guangxi tourism official website from four aspects, that is, information provision, information interaction, transaction realization, and relationship maintenance, and put forward the idea of building Guangxi tourism official website [10]. Regarding scenic spot websites, Buckley and Cooper compared 34 5A-level scenic sites from five interactive function modules and found that most of the interactive functions of the websites still need to be improved [11].

2.3. The Relationship between Tourism Marketing and New Media. With the application and development of new media technology, the academic community is still in the early stages of research on the relationship between tourism marketing and new media, and the foreign research time is not very long. Brown is mainly based on the analysis of travel websites in various countries in Europe and the United States, so as to summarize the current situation of online marketing in each link, which can also provide material for subsequent research. In addition, based on the interdisciplinary perspective, scholars have also conducted analysis, directly combining communication science with e-commerce to form a new research model [12]. Bowen, based on the Egyptian scope, conducted a study on the impact of information systems as a dependent variable on the tourism industry, and the results show that the use of market information systems can help tourism enterprises improve the quality of their services [13]. Ashaari analyzed the tourism marketing service model based on web2.0 when analyzing tourism enterprises. Singh took small- and medium-sized

tourism accommodation companies as the object of analysis and analyzed the impact of online distribution channels, and after a large number of studies, only the use of network marketing can occupy a certain advantage in the competition [14].

Regardless of the industry, marketing can help it gain stronger market competitiveness, and of course, the tourism industry is no exception. Therefore, relevant scholars began to study the marketing capabilities of tourism enterprises. Domestic new media marketing for tourism enterprises is mainly biased towards the analysis of necessity and importance, but it is lacking comprehensiveness. Diaz work is mainly a research on the brand marketing strategies of tourism enterprises. Diaz mainly analyze Weibo marketing and put forward a strategic position in marketing [15]. Millo and Kumar provides a new idea for the marketing of tourism enterprises, that is, from the perspective of planning tourism products, catering to personalized consumer demand, so as to customize tourism products in a targeted manner [16]. Chiang and Henry proposed that the new media spread fast, the scope of dissemination is wide, the user group shows a youthful trend, and it gradually changed the use habits and choices of Internet users, becoming a publicity platform favored by many enterprises [17]. Lee and Lee proposed that, in recent years, tourism enterprises have expanded their market share by using Weibo marketing, which has brought huge economic benefits to tourism enterprises [18]. Gonz ´lez Itziar and Carmen analyzed the advantages and limitations of tourism new media marketing and proposed the basic strategies to deal with it, starting from the credibility of new media use, the interactivity of participants, and the abandonment of traditional media marketing functions, to move new media marketing in the tourism market from the only way to the road of efficiency [19]. Xu Ding et al. based on the "4 Rs" marketing theory, conduct research on the WeChat marketing strategy of heritage tourism and put forward suggestions on the use of WeChat marketing in the relevant Imperial Tomb Scenic Spots in Guanzhong [20].

3. Methodology

3.1. The Impact of New Media on Marketing. Tourism marketing strategies in the new era should consider relying on modern scientific and technological means to achieve online and offline joint marketing, integrated marketing of new media, and traditional media communication methods, learn from each other's strengths, give full play to the advantages of each platform, carry out efficient marketing activities, and can also adopt the combination of point and surface and mobile electronic products such as mobile phones and the marketing of fixed products such as computers and televisions, so that consumers can pay attention to marketing products and marketing activities at any time, whether indoor or outdoor, and promote the development of tourism.

New media is involved in tourism marketing, and tourism individuals can display their own tourism needs and express their tourism needs through the network, and this demand information can be obtained by suppliers in real time. The real needs of tourists promote suppliers to adjust their product development and design direction in a timely manner. In the actual sales link, the traditional marketing method is mainly in the form of physical storefront marketing within the destination or in the exclusive location; in the marketing strategy of the new media environment, the traditional location marketing is virtualized, so that the virtual choice becomes the main body of the tourist's choice, and the tourism products that meet their own needs are obtained through the Internet, without being affected by regions, information, and products. Clear comparisons can be made through Tables 1 and 2.

From the background of marketing new media, the impact of new media on marketing in tourism industry marketing is elaborated in detail. In the Internet era, the gap between traditional media marketing strategies and new media marketing strategies is reflected in the whole process of marketing, and in the traditional marketing process, the roles between all suppliers, sales, and consumers are clearly positioned. However, in the new media environment, through the Internet, you can completely get rid of the original positioning and shackles between products, the marketing network in a broad sense has undergone major changes, and the changes between various roles are also intertwined, forming a borderless marketing network that is not affected by skin color, language, race, and country.

3.2. Analysis of Tourism Marketing Demand in the New Media Environment. The application and development of new media are becoming more and more diversified, and the marketing objects of various enterprises have also undergone tremendous changes. Even so, there are inherent characteristics in the marketing model and object of tourism enterprises. With the influence of new media technology, the most prominent performance of the marketing objects of tourism enterprises is that the grouping of marketing objects has gradually changed into the individualized development of the group, and the previous group marketing model has gradually changed into individual characteristic marketing. For example, in new media, the marketing carrier becomes a mobile APP, and the object also becomes a user of the mobile terminal and an Internet user. In the environment of new media, its audience can be the target of tourism enterprise marketing, and tourism enterprises can use one-to-one marketing model to develop customers, maintain customers, and achieve convenient, one-stop communication services. Therefore, in the Internet environment, the coverage area is increasing day by day, and the number of users is increasing.

Tourists have certain differences in tourism requirements and hobbies, so tourism enterprises can formulate corresponding tourism routes according to the tourist data provided by new media, stimulate tourists' interest in tourism, and ensure that tourists devote themselves to tourism with full emotions. In addition, tourists can plan tourism routes according to the tourism strategies provided by new media and local cultural customs, improve tourism pertinence, and enhance tourism experience.

In the first half of 2017, smartphones achieved almost complete coverage, and the efficiency increased effect of smartphone-based network penetration was significantly reduced, showing a state of slow growth. The Ministry of Industry and Information Technology released relevant data showing that, in 2013, the scale of netizens using mobile phones in China exceeded the scale of traditional netizens on the PC side for the first time. In 2014 and 2015, China's smart terminal shipments were 256 million and 298 million units, respectively, in 2016, China's smart phone shipments were 356 million units, and in the first quarter of 2017, 120 million smart phones were sold, an increase of 1.98% in the same period. From the perspective of growth trend, the market share tends to be saturated, showing a slow growth rate trend. By the end of 2017, the scale of mobile phone netizens in China reached 727 million, an increase of 2 percentage points over 2016. The widespread use of smart phones in the future with the need to grow the speed of netizens through mobile phones is almost impossible, and the future that will be in a long period of time will mainly rely on innovative mobile APP applications to meet the needs of customers, to meet the Internet demand of non-mobile phone netizens to drive growth.

According to the China National Tourism Administration, the overall tourism revenue in 2017 was 4,090 billion yuan, and the tourism penetration rate completed through the network was 11.7%. According to relevant experts, the penetration rate of the network will reach about 13% in 2018, as shown in Figure 2. With the increase in the penetration rate of intelligent terminal devices and the increase in the number of users, the marketing strategy of traditional tourism marketers has shifted from offline to online development, and various tourism companies have also invested in the specific tourism market in the cost of capital and labor costs, so that the growth rate of the online market is much higher than the growth rate of overall revenue.

3.3. Research on New Media Marketing Strategies of Tourism Enterprises. There are differences in the demand for products from people at the same consumption level, and the corresponding product strategies are also different, and targeted product strategies should be formulated to cope with market demand with obvious characteristics. This article is fully analyzed and integrated according to the collected literature, and the marketing characteristics of tourism enterprise products are fully compared, as shown in Table 3, and they are divided according to six different dimensions.

It can be understood from Table 3 that, for the above types of products, products with a high degree of digitalization can generally be sold directly to consumers in the network, while products and services with a low degree of digitalization can not often be sold through the Internet platform and can only be promoted simply by means of on-site promotional activities. For similar products, highly sensitive products tend to attract more consumers' attention, while highly rational products can usually be favored and supported by consumers faster. Products with a high degree of standardization: most consumers will not choose to inspect the goods opposite; that is to say, products or services with high standardization, high rationality, digitizability, and high sensitivity are more likely to meet the standards of Internet marketing.

Through the analysis in Table 3, it can be understood that traffic reservation is a kind of product that can be digitized and has high rationality and high sensitivity, which can be sold on the network platform, and from the perspective of market segmentation, the traffic reservation target market is generally broader and is easily favored by most consumers. However, some other tourism products have differences, although they are all highly perceptual attributes, but because of their low rationality and low degree of standardization, the feasibility of selling on the network platform is not very high, and the target consumers are usually scattered in the vicinity of the tourism enterprise. Based on this, tourism enterprises are to promote the mining of new media sales channels and traditional media compared with the very large advantages, but because of the further increase in online sales of traffic booking, but also to a certain extent, it has also transformed the traditional agency advantages they have and also relatively compressed the survival and development space of tourism enterprises, so that, in the current information age, the living environment of tourism enterprises has become more competitive. For tourism enterprises, in the new situation of new media, in the face of these new problems and challenges, we must persist in changing the past product marketing method from the root causes and accelerate the formulation of a more scientific product and service marketing strategy.

3.4. Marketing Channel Strategy Analysis. For the tourism industry, its industrial chain is very closely linked, and the marketing method of traditional tourism enterprises' products is generally distribution. Distributors hold a wealth of channel resources, which leads to tourism enterprises, and consumers can not really achieve direct communication, during which they are often separated by distributors; consumers put forward opinions, and feedback can not be very complete and rapid transmission to tourism enterprises; consumers can not have with tourism enterprises face-to-face communication. With the help of information transmission between distributors, there is also a phenomenon of secondary transmission, which has a large error between them, because distributors will inevitably consider their own profits and usually do not let consumers communicate directly with tourism companies. Under the new media marketing channels, tourism enterprises can rely on the Internet to achieve direct communication with consumers, further simplifying the marketing channels of tourism products, and according to the specific form of new media applications, its marketing channels can be divided as follows, generally including several types in Figure 3.

The most prominent feature of new media such as Weibo and WeChat is their interactivity and communication. Therefore, the tourism marketing strategy in the new era should also make full use of new media for interactive and

Table 1: Traditional marketing process of tourism enterprises.

Role division	Marketing process							
	Design a product	Select a product	Set the price	Select a lot	Information services	Commercial advertisements	Sales advertisements	After-sales service
Tourism supplier	✓		✓		✓	✓	✓	✓
Tourism wholesaler			✓				✓	
Tourism retailers		✓		✓	✓		✓	✓
Tourists		✓						

Table 2: New media marketing process of tourism enterprises.

Role division	Marketing process							
	Design a product	Select a product	Set the price	Select a lot	Information services	Commercial advertisements	Sales advertisements	After-sales service
Tourism supplier	✓		✓		✓	✓	✓	✓
Tourism wholesaler				✓	✓	✓	✓	✓
Tourism retailers					✓	✓	✓	
Tourists	✓	✓						

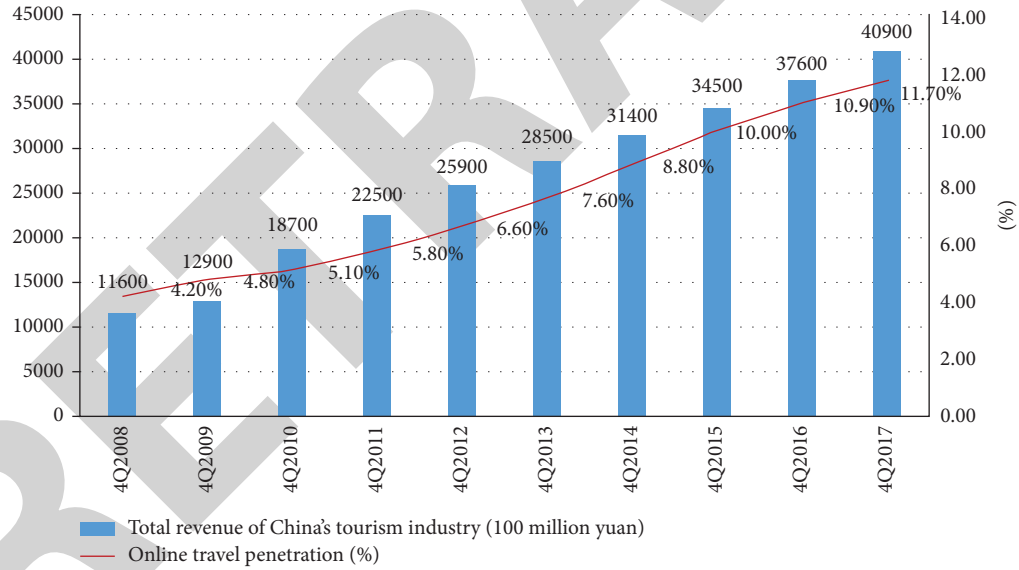

Figure 2: Total tourism revenue and online travel penetration rate in China from 2008 to 2017.

communicative marketing, so as to attract tourism targets to pay attention to marketing content and promote them to enter the marketing places. Figure 4 shows the number of active users of Weibo in the past three years. By December 2017, the number of domestic Weibo users had exceeded 400 million, an increase of 88 million compared with 2016, and the usage rate of netizens reached 40.2%, which was a large increase compared with the end of 2016. Among them, the mobile microblogging client users are about 300 million people, an increase of more than 8 million compared with 2016. After sustained high-speed growth from 2012 to 2017, Weibo has also become increasingly mature and began to show a momentum of centralized development, and some operators have also begun to slowly adjust their Weibo business. From the actual situation at this stage, the number of domestic Weibo users is increasing geometrically, and the information content in the Weibo platform is further deepening. First of all, the Weibo platform can provide more and more functions, and it began to transform into an individual, institutional, or media release platform and also gradually support other applications and software; secondly, from the Weibo platform information content, on the basis of pan-content and popular content, it began to produce more vertical and refined information, for users at different

Table 3: Comparison of marketing characteristics of tourism products.

Product name	Digitizable	Consumer psychological motivation	Degree of standardization	Technology content	Geographical coverage	The difficulty of new media marketing
Traffic reservation	True	High rationality and high sensitivity	High	High	Wide	Easy
Hotel	True	High rationality and high sensitivity	High	Not necessarily	Wide	Easy
Tourist route	True	Low rationality and high sensitivity	Low	Low	Narrow	Difficulty
Scenic spot ticket	True	Low rationality and high sensitivity	Low	Not necessarily	Not necessarily	Difficulty
Performance ticket	True	Low rationality and high sensitivity	Low	Not necessarily	Not necessarily	Not necessarily

levels that can meet their information needs; third, standing at the user level, Weibo platform users gradually "sink." From the newly established first- and second-tier city users as the core, it has begun to expand to fourth- and fifth-tier cities and the vast rural areas; finally, from the perspective of value application, the information content in Weibo is becoming more and more abundant, and it has made a lot of contributions in public opinion guidance, behavior prediction, and network marketing.

3.5. Establishment of Artificial Neural Network Model for Marketing Mix Strategy. Marketing combination means that, in the selected target market, after comprehensively considering the market environment, enterprise capability, market competition, and other conditions, the enterprise makes the best combination and application of the factors that can be controlled by the enterprise itself, in order to accomplish the purpose and task of the enterprise. Its essence is to give full play to the relative advantages of the enterprise and achieve "marketable market" in many ways to meet the overall needs of consumers, so as to improve the enterprise benefit and social benefit. This paper applies the artificial neural network to the determination of the marketing combination strategy of the enterprise and tries to provide the basis for the optimization of the marketing combination strategy of the enterprise by analyzing the various factors of the market and simulating the changes of the market.

Artificial neural network (ANN) is a widely parallel interconnected network composed of adaptive simple units (neurons). Its organization can simulate the interaction of biological nervous system to real-world objects. The basic model is shown in Figure 5.

Artificial neural network (ANN) has attracted the attention of scholars in many fields because of its self-learning, self-organization, good fault tolerance, and excellent nonlinear approximation ability. There are many kinds of models, but the most perfect and widely used model in theory is the error backpropagation (BP) model. In practical applications, 80% to 90% of the artificial neural network models adopt error backpropagation algorithms or their varying forms of network models (referred to as BP networks). The model designed in this paper is also based on BP neural network. The typical BP artificial neural network model is a multilayer network structurally, which is divided into input layer, hidden layer, and output layer. Each layer contains several neurons, and each layer is fully connected. The output of the units in the front layer can not be fed back to the previous layer, and there is no connection between the units in the same layer, as shown in Figure 6.

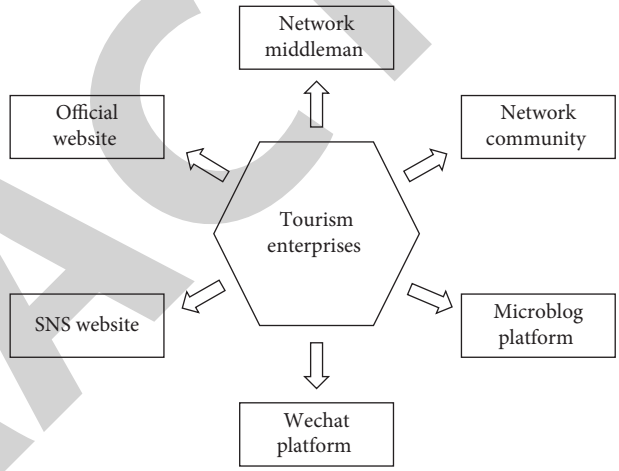

Figure 3: New media marketing channels of tourism enterprises.

BP neural network: output algorithm:

The output algorithm of each layer of neurons is

$$\delta(x) = \frac{1}{1+e^{-\partial x}} \ (\partial > 0),$$
$$\delta(x) = \sum_{i=1}^{n} w_{ij} t_i, \tag{1}$$

where ω_{ij} is the node weight from the input layer (or hidden layer) to the hidden layer (or output layer); n is the number of node input values, in this case from the input layer to the hidden layer $n = 10$. Weight correction ω_{ij}: the theoretical initial value can be a random number on [−1, 1], but if the weight does not meet the requirements, it must be corrected. From the output layer to the middle layer, the calculation formula is

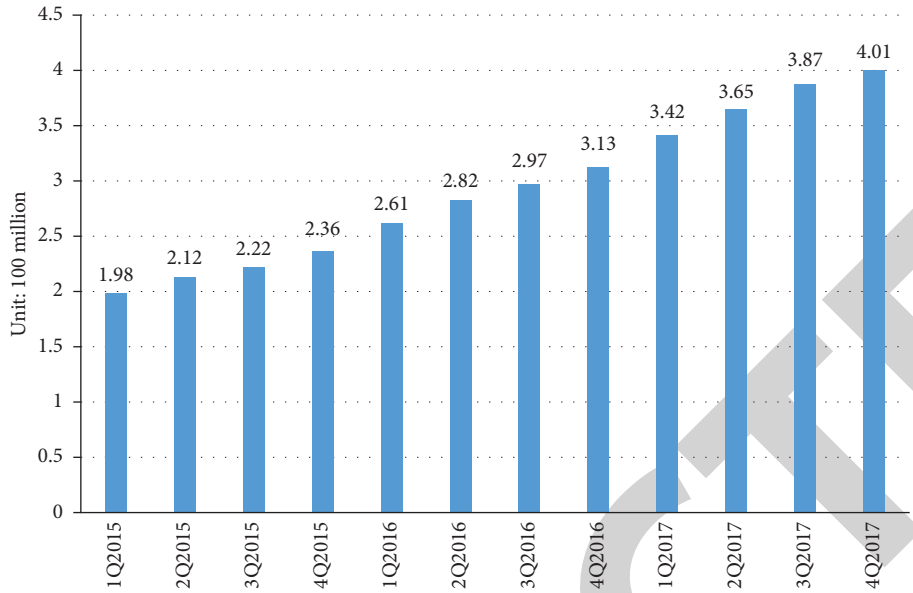

Figure 4: Number of active users of Weibo in the past three years.

$$w_{ij}(t+1) = w_{ij}(t) + \eta\delta_i M_i + \alpha\left[w_{ij}(t) - w_{ij}(t-1)\right]. \quad (2)$$

In the formula, $\omega_{ij}(t)$ is the connection weight from neuron j to the previous layer (input layer or hidden layer) at time t; η is the actual output of neuron j at time t; α is thenbsp;step size adjustment factor; take (0, 1); for the smoothing factor, take (0, 1); δ_i is the error weight adjustment factor.

For the output layer node, $\delta_i = x_j(1-x_j)(t_j - x_j)$ is the output target value; for the hidden layer node, $\sum_k \delta_k w_{kj}$ is the actual output value of the hidden layer node j.

Error analysis: select the network relative error function:

$$E_k = \frac{M_{k0} - M_k}{M_{k0}}, \quad (3)$$

where E_k is the network relative error function; M_{k0} is the actual value, and M_k is the predicted network output value. Usually, if the error E_k is not greater than the allowable value of the network error, it can be considered that there is no error in the calculation of the model. For the final output value x of the network, the inverse normalization transformation is performed using the following formula:

$$x = x\left(x\min_{\max} + x_{\min}\right), \quad (4)$$

where $x_{\min}, x_{\max}$ are the maximum and minimum values of the calculated output data, respectively; is the calculated output value. Calculate the actual output value of the neural network layer by layer.

$$y_j = f\left[\sum_{i=1}^{n} w_{ij}x_i - \theta_j\right],$$
$$z_k = f\left[\sum_{i=1}^{n} w_{ik}x_i - \theta_k\right]. \quad (5)$$

Starting from the output layer, the weights are adjusted in reverse, and the formula consensus is as follows:

$$W_{jk+1} = W_{jk} + \eta\delta_k V_j,$$
$$W_{ij+1} = W_{ij} + \eta\delta_j V_i, \quad (6)$$

where

$$\delta_k = (Z_k - Z_k)Z_k(1 - Z_k),$$
$$\delta_j = y_j\left(1 - y_j\right)\sum_{k=0}^{L-1}\delta_k W_{jk}. \quad (7)$$

Calculate the total error E; if $E \le \varepsilon$, then the learning stops; otherwise, recalculate. In the actual design of the network, if the step size is small, the learning speed will be slow, and if the step size η is too large, the network will oscillate. To solve this problem, a momentum α $(0 < \alpha < 1)$ can be added, namely,

$$w_{ij+1} = w_{jk} + \eta\delta_k y_j + \alpha\Delta W_{jk},$$
$$w_{ij+1} = w_{ij} + \eta\delta_j y_i + \alpha\Delta W_{ij}. \quad (8)$$

This is an iterative process, the dynamic parameter is selected as 0.001, and each value is adjusted once in each round, and so on, until the dynamic parameter is less than the set target. Such a good network training succeeded. Select appropriate network parameters and carry out a sufficient number of iterations, the final results of the network training, and the error between the simulation results and the actual results will fall within the allowable range.

4. Result Analysis and Discussion

Changshu Garment City has 7 state-owned markets, foreign trade clothing distribution centers, property companies, Fortis logistics, tourism service companies, and other directly subordinate units, in addition to more than 20 private markets to form an overall business model of clothing. At present, the average daily passenger flow of the garment city

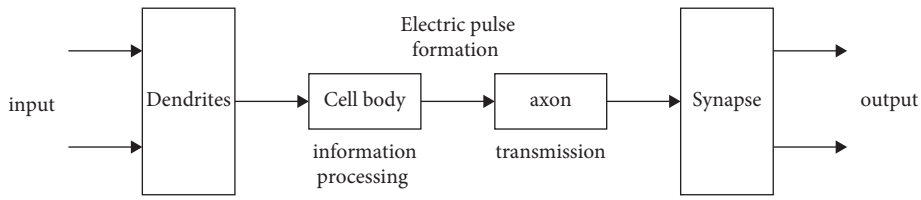

Figure 5: Single neuron structure model.

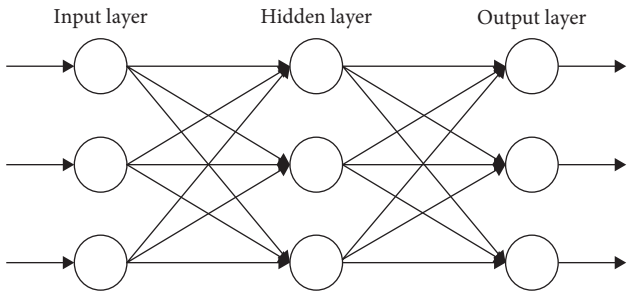

Figure 6: BP three-layer neural network structure diagram.

is 300,000 person-times, the daily capital flow is more than 2 billion yuan, and the overall annual turnover is increasing by 30%. For a long time, the garment city has gradually formed the status quo of national circulation with strong suction capacity and radiation capacity and gradually embarked on the road of specialization, marketization, standardization, and informatization. The brand is innovated, and the marketing department and brand area are gradually formed. Since 2015, Garment City has begun to realize the strategy of opening up and win-win inside and outside the industry on the basis of the existing basic business and gradually formed an open, inclusive, and integrated foreign trade market system. And it constantly innovates the construction of clothing trade platform and has formed a design, inspection, marketing, online consulting, and international trade and other 6 major public service platforms to provide customers with consulting, guarantee integrated services. At the same time, with its own brand, it has created the Garment City Expo, strengthening the way of enterprise leadership and industry-driven, realizing the combination of production and marketing, and creating the most influential garment city brand in China.

4.1. Analysis of Shopping Tourists. According to their permanent residence areas, the respondents were mainly from Jiangsu Province (48.2%) and Zhejiang Province (81.5%) and Anhui Province with 334 (8.3%), followed by Shandong Province with 277 (6.9%), Shanghai with 173 (4.3%), Fujian Province with 105 (2.6%), other provinces (including Taiwan, Hong Kong and Macao) with 310 (7.7%), and foreign tourists with 20 (0.5%). Among them, 1713 were males, accounting for 42.6%, and 2307 were females, accounting for 57.4%. The distribution of shopping tourists' habitual residences is shown in Figure 7.

According to the statistics of the 4020 questionnaire and the statistics of the same period of 2016 provided by the Clothing City Management Committee, the new media application of shopping tourists and the use of online equipment by shopping tourists are as shown in Table 4.

The market share is not only an important index to reflect the market synthesis and concentration, but also an important index to measure the competitiveness of an enterprise or a product. The scientific adjustment of marketing mix strategy is an important way for enterprises to increase their market share. To improve the market share of products, we can reduce the price, improve the quality of products and enterprises, improve the sales system, and so on. Now, take Fangtai Company as an example to illustrate the simulation results that it uses different marketing mix strategies to change its market share. The results are shown in Table 5.

4.2. Empirical Analysis of New Media Marketing in Changshu Clothing City Shopping Tourism Scenic Spots. The emergence of e-commerce has not had a substantial impact on the shipments, cash flow, and rental income of Changshu Garment City, and within the next five years, e-commerce will be replaced by new retail. New retail in the era of big data is an intelligent, personalized, and customized new commercial format that combines online, offline, and intelligent logistics. Changshu Garment City has integrated informatization and intelligence into all aspects of management in the development plan, created a flexible supply chain with the concept of supply-side structural reform, provided high-quality services and sufficient development space for enterprises and merchants in the park by means of informatization and intelligent services, and met consumer demand through management innovation and supply chain collaborative innovation, so as to achieve the sustainable development of China's Changshu Garment City.

Through the training of BP neural network model, the number of hidden layer nodes depends on subjective experience and repeated training of the network when the network reaches a certain stable state. We selected the number of hidden layer nodes as 7 and trained the network using MATLAB dynamic BP network training function trainbpx(), convergence accuracy is $5E-6$, get the model of each node weight and threshold model output market share of simulation value, neural network output accuracy is quite high, and the error rate of each product is below 5% (as shown in Table 5).

From the above analysis, it can be seen that there are many factors affecting product market share, but each factor

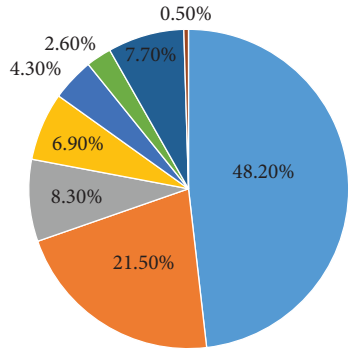

Figure 7: Distribution of shopping tourists' habitual residences.

in 4P and market share do not correspond to linear or other simple functions. How to combine 4P, with the limited resource investment to get the best income, so that the market position of enterprise products rises, improves the market competitiveness of enterprises; in the past, it was often difficult to carry out quantitative analysis. Here, we can use the market share neural network model for market simulation and put forward the marketing combination strategy for enterprise reference. There are many strategies to increase market share, such as price reduction, improving product quality and increasing advertising investment to improve visibility, and so on. We first list the schemes that enterprises may adopt, quantify them according to the input indicators of the neural network model, and simulate the model to calculate the predicted market share (as shown in Table 6).

The informatization and men's clothing index work of China Changshu Garment City are responsible for the Economic Development Bureau of the Changshu Garment City Management Committee, and the traditional media and new media advertising and the information collection of the "China Changshu Men's Clothing Index" are important tasks. Traditional media advertising includes television and radio advertising, periodicals and magazines, bus mobile TELEVISION, and outdoor (wall) advertising, with the slogan of "clothing ocean, shopping paradise, Jiangnan Blessed Land, Changshu," and this advertisement that has been broadcast in CCTV prime time for many years is the largest investment in advertising in recent years. In the information work, new media advertising mainly puts WeChat, tourism websites, microblogs, search engines, online videos, etc. The attention and practical application effect of WeChat public accounts show great potential with the increase of the number of global WeChat users, and it has been the best feedback effect in all media advertising. At present, the WeChat QR code matrix has been released on the official website of Changshu Garment City in China and traditional media advertisements (periodicals and magazines, bus mobile TV, outdoor wall advertising), realizing the effective combination of traditional media and new media. China Changshu Garment City WeChat QR code matrix includes Changshu Garment City, Changshu Men's Clothing Index, China Service e-commerce Park, Men's Wear Center, Tianhong Garment City, Festival Exhibition, Children's Wear Center, Small Commodity Market, Footwear Center, East China Textile Center, Changshu Garment Online, Garment City Tourism Service, Men's Wear Design Transaction, Laopin City, World Men's Wear Index, and intelligent mobile terminal users that can scan the code to pay attention to the relevant WeChat public accounts and obtain massive information services including commodity display, shopping navigation, catering and cuisine, hotel accommodation, surrounding scenic spots, and so on.

Table 4: New media applications for shoppers.

New media names	December 2016 (%)	December 2017 (%)
Wechat, QQ	92.3	97.4
Online shopping	88.5	92.3
Search engines	89.6	92.6
Online forums	48.2	52.5
Online group buying	35.9	39.2
Online payments	87.9	93.7
Online games	51.8	55.1
Blogs	45.2	48.6
Online videos	89.1	92.7
Strangers socializing	37.0	40.5
E-mail	58.5	55.6
Micro-blog	48.4	51.3

The official website of China Changshu Garment City is not only the official government service center website of Changshu Garment City, but also the website of shopping and tourism services, as well as the release platform of "China Changshu Men's Wear Index." "China Changshu Men's Wear Index" is a men's wear index that is compiled under the guidance of China Textile Industry Federation and compiled by China State Information Center, which has a strong leadership in new, representative, authoritative, and international market discourse. The "China Changshu Men's Wear Index" includes the men's export price index (composed of 7 subitems such as suit suits, cold suits, coats/windbreakers, jackets, shirts, knitwear, trousers, etc.), wholesale and retail men's domestic price index (composed of 8 subitems such as casual down jackets, cotton suits, suits, jackets, cotton casual shirts, trench coats, cotton trousers, T-shirts), and men's fashion index (composed of 4 subitems such as production prosperity index, e-commerce prosperity index, market prosperity index, and purchasing manager

Table 5: The weights and thresholds of each node of the product occupancy neural network model.

	Input node 1	Input node 2	Input node 3	Input node 4	Each hidden node threshold	Each hidden node to output node weight	Output node threshold
Hidden node 1	0.7715	−0.2137	−1095	−1.7885	1.2041	0.0678	
Hidden node 2	-0.6666	0.0937	−0.1753	5.3667	−2.1096	0.6960	
Hidden node 3	0.2009	−0.0400	0.2376	−6.6978	−0.8859	0.0064	
Hidden node 4	−0.1036	−0.1753	0.2347	−5.8509	−0.0489	−0.6284	0.359
Hidden node 5	0.8188	0.0815	−0.0997	−4.6836	−0.9967	0.3008	
Hidden node 6	0.5705	0.5903	0.5544	−3.8890	−1.2090	0.4865	
Hidden node 7	−0.1396	0.1820	0.2209	1.8453	0.3817	−0.8723	

Table 6: Marketing combination strategy and market share simulation value.

Scheme number	Product quality	Price (yuan)	Popularity	Distributor fee rate	Market share (%)
Original scheme	3	0.7	7	0.15	17
Scheme 1	6	1.4	7	0.15	23.00
Scheme 2	3.4	0.77	7	0.15	17.5
Scheme 3	3.3	0.7	7	0.15	15.9
Scheme 4	3	0.63	7	0.15	15.2
Scheme 5	3	0.7	8	0.12	11.3
Scheme 6	3	0.7	5	0.2	17.4
Scheme 7	4.5	1.4	9	0.2	39.4
Scheme 8	5	1.4	7	0.3	31.3
Scheme 9	3	0.7	7	0.2	27.1
Scheme 10	4	0.7	7	0.15	13
Scheme 11	3	0.8	7	0.18	25.6
Scheme 12	5	0.7	6	0.15	3.1
Scheme 13	5	1.0	7	0.2	21.6

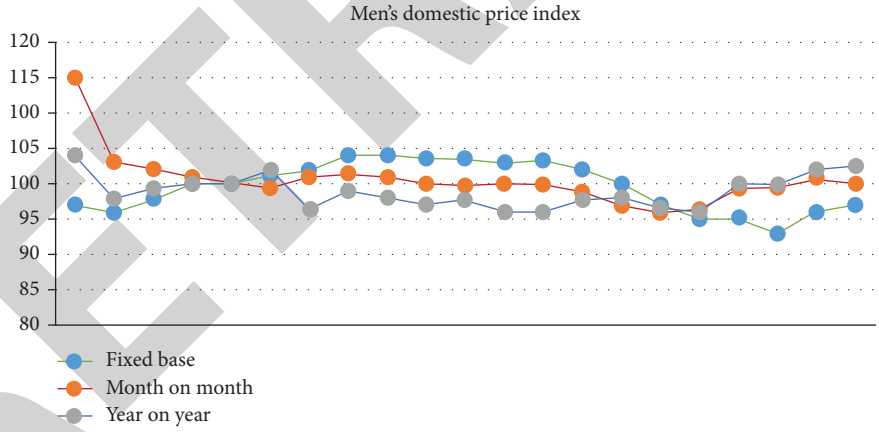

Figure 8: China Changshu men's wear index.

index), and every month, the data collected through 252 model companies and 552 model individual merchants in the middle and late years was uploaded to the China Changshu Men's Clothing Index Compilation Leading Group through computer terminals or mobile phone APPS and released after collation, as seen in Figure 8.

5. Conclusion

With the rapid development of the Internet, new media based on information technology have shown a strong momentum of development with continuous innovation, which in turn affects global technological innovation and economic development. At present, in the context of new media, marketing activities have also broken the traditional constraints, from simple single-phase communication to two-way immediacy communication and communication development, which makes the role of information communicators and audiences simpler and faster, and the interactivity of new media information dissemination is reflected. Based on this background, shopping tourist attractions have also undergone tremendous changes in marketing, which has brought certain challenges to marketing and also brought opportunities and conditions for the

sustainable development of scenic spots. Therefore, in order to maintain mutual integration with new media, shopping tourist attraction marketing needs to take into account the following aspects: first, compared with traditional media marketing, new media marketing pays more attention to the setting and free conversion of roles in the marketing process, and through a thorough analysis of the media communication mode, it is possible to make reasonable arrangements for the acquisition and dissemination of tourism information, which can also effectively control marketing costs. Second, the marketing of shopping tourism attractions based on new media can make marketing flexible and subtle, and at the same time, it can further broaden the coverage of marketing, so that it shows a trend of globalization, and the marketing model also shows a strong activity and two-way trend. Third, the new media marketing strategy of scenic spots is also gradually changing: in the future marketing, micro-marketing will definitely become the protagonist, that is, to carry out marketing activities through WeChat, Weibo, etc., and its biggest advantage lies in the Pang of the social circle Big nature, every WeChat friend, or a Weibo fan, which can become a disseminator of information, and marketing information is like a virus directly spread out; online video and network live broadcasting has replaced the fixed TV media advertising, becoming one of the most widely used marketing means; in the security of third-party payment to ensure the premise, online orders and online payment have become the new normal. These will bring unlimited possibilities to the marketing of scenic spots. Fourth, with the help of perfect hardware facilities and friendly soft environment in shopping tourism scenic spots, combined with new media marketing, we can cater to the consumption needs of the current mainstream consumer groups. In the promotion of products and the promotion of activities, new media have advantages that traditional media cannot have. Therefore, as long as we master the reform of marketing means, we can promote the transformation and upgrading of tourism marketing. The new media marketing strategy of the tourism industry in the new era should keep pace with the times, give full play to the role of new media, break through the inherent marketing concepts and outdated marketing ideas, expand joint marketing activities, give full play to the people-friendly, interactive, and communicative nature of new media, promote the exchange and interaction between the tourism industry and tourists, and, at the same time, establish a new tourism exchange platform to help spread the voice of "donkey friends" from the people, create a new type of new media marketing program, and establish a new type of new media marketing strategy.

Data Availability

The labeled data set used to support the findings of this study is 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: A DSP-Controlled Permanent Magnet Synchronous Motor Control System for Hybrid Vehicles

International Journal of Antennas and Propagation

Received 19 December 2023; Accepted 19 December 2023; Published 20 December 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) Manipulated or compromised peer review

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] Q. Fu, "A DSP-Controlled Permanent Magnet Synchronous Motor Control System for Hybrid Vehicles," *International Journal of Antennas and Propagation*, vol. 2022, Article ID 1996502, 9 pages, 2022.

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International Journal of Antennas and Propagation
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Research Article

A DSP-Controlled Permanent Magnet Synchronous Motor Control System for Hybrid Vehicles

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Compared with other motors, the permanent magnet synchronous motor (PMSM) is small and occupies less space. At the same time, its weight is relatively light, so it is more in line with the development trend of hybrid electric vehicle (EV) drive motor lightweight miniaturization and has been widely used. This article studies a DSP-controlled PMSM control system for hybrid vehicles. Firstly, the motor drive control system is mainly controlled by DSP2812 chip. Then, a maximum torque current ratio control method was proposed to optimize the energy efficiency of hybrid vehicles based on PMSM. The longitudinal dynamic model of the moving hybrid vehicle was obtained by force analysis. Combined with the basic equation of PMSM and the transmission system of the hybrid vehicle, the mathematical model of PMSM-EV was established. The experimental results show that the maximum torque current ratio control method applied to hybrid vehicles can effectively reduce the loss, improve the efficiency and dynamic performance, and solve the endurance problem of hybrid vehicles to a certain extent. This advantage is significant in the dynamic acceleration and deceleration of hybrid vehicles.

1. Introduction

As the most classical control technologies of PMSM, FOC and DTC are widely used at present [1]. However, FOC is too dependent on motor parameters and the steady-state torque pulsation of DTC is too large, which cannot meet the high precision control requirements of PMSM [2]. The dynamic performance of SMC is good, but the chattering problem cannot be solved effectively, resulting in mechanical loss of PMSM [3]. The future of predictive control and intelligent control is very promising. The advantages of PMSM are far from replacing other motors in the current competitive market environment [4].

For PMSM, its flux material is a permanent magnet. The magnetic flux direction represents axis d, and the axis perpendicular to the magnetic flux direction is axis q [5]. When the q-axis current can meet the requirements of the left-hand rule, the current belongs to the q-axis current [6]. Compared with the induction motor and the q-axis current, to ensure sufficient flux, there should also be a current in the d-axis direction, which belongs to the d-axis current. Therefore, the permanent magnet motor only needs less current to achieve the torque required for operation, effectively reducing operation loss [7]. More attention is paid to the motor drive system with higher operation efficiency in the research and development of electric vehicles. Based on the actual structure, the permanent magnet motor shows two characteristics. First, rotor permanent magnets can select built-in modes. Second, it can carry out multi-pole design [8]. The motor control system will inevitably develop toward smaller volume and lighter weight, and motor drive performance and operation performance will be further improved.

In this paper, a field weakening control strategy for electric vehicles with torque as the control target is proposed [9]. The maximum torque curve and strategy switching torque curve of the motor were obtained by off-line calculation. According to the feedback speed and target torque, the motor's weak magnetic working point is constantly updated to make it move in a certain area [10]. Thus, the

motor's torque response speed and operation efficiency are improved under complex operating conditions. The feasibility and performance advantage of the whole control strategy are verified by Matlab/Simulink simulation [11]. However, the Tmax and TP strategy switching curves used in this strategy are calculated by the actual motor parameters, so the motor parameters are not considered.

The maximum torque per ampere control method for hybrid vehicles was proposed [12]. The given value of motor drive current in this method is a nonlinear function of hybrid vehicle load, and the optimal given value of straight-axis current I_d and cross-axis current I_q can be obtained through the numerical solution. The proposed method is compared with the traditional other control methods under different external resistance and vehicle speed [13]. A maximum torque current ratio control method was proposed to aim at the energy efficiency optimization of hybrid vehicles based on PMSM. The longitudinal dynamic model of the hybrid vehicle was obtained by force analysis [14]. Combined with the basic equation of PMSM under *d-q* axis and the transmission system of the hybrid vehicle, the overall mathematical model of PMSM-EV was established [15]. But in this article, only the copper loss of the motor is optimized, without considering the influence of the motor iron loss, stray loss, reverse loss, transmission loss, and so on [16].

The mathematical model was first established and the maximum torque current ratio control was proposed at a low speed [17]. The current control strategy of full speed domain controlled by a weak magnetic field is adopted at medium and high speed, and the mathematical model of solving each control is analyzed [18]. Then, the mathematical model is discretized and the state space equation is obtained. Based on this, the speed controller of model predictive control and the current controller of beat-free predictive control are designed [19]. Predictive control is used to replace the traditional double-loop PI control. When the speed step is set, the speed response of the motor is fast and there is no overshoot. At the same time, the anti-load disturbance ability and recovery ability are better than the traditional double-ring PI controller. By limiting the torque increment, different acceleration modes can be realized to meet the different requirements of drivers for vehicle power and comfort.

Hybrid vehicles have broad development prospects. For the motor control system of hybrid vehicles, the current research and development are fundamental. In this article, DSP2812 chip is selected to build the PMSM control system. To improve the energy efficiency of PMSM hybrid vehicles, this article adopts the maximum torque current ratio control method for the motor control system. The longitudinal dynamic model of a hybrid vehicle was obtained by force analysis. Combined with the PMSM equation and the transmission system of the hybrid vehicle, the overall mathematical model of PMSM-EV was established. It is found that the new system can improve the accuracy of the control system when it is affected by parameter changes or external disturbances. At the same time, the ripple of flux and torque can be reduced and the accuracy of direct torque control can be enhanced. Comparing the improved system with the traditional motor control system, the feasibility and effectiveness of the control algorithm designed in this article are verified.

This article consists of four main parts: the first part is the introduction, the second part is the methodology, the third part is the result analysis and discussion, and the fourth part is the conclusion.

2. Methodology

2.1. System Hardware Circuit Design. The motor drive control system mainly uses DSP2812 chip to control each device. The driving part of power is driven by an IPM inverter so that the motor can work normally. Figure 1 shows the overall architecture of the motor control system.

The hardware architecture of the system is mainly divided into two parts. One part is the control hardware circuit and the other part is the power drive hardware circuit. In addition, the auxiliary circuit includes a power supply circuit and a signal detection circuit. Considering that the control circuit is susceptible to interference from the high voltage side of the power drive circuit during operation, the system architecture adds an optocoupler isolation circuit at the junction of the two parts of the circuit. The system controls the running state of the motor according to the command of signal acquisition. processor is added to the system, and TMS320F2812 is selected as the core control chip. For the application of the inverter, the internal power switch is the main control device. By adjusting the current amplitude and frequency, the current flow in the circuit is converted to a three-phase AC power supply, to drive the motor to work normally.

2.1.1. Main Power Circuit Design. This system uses MOSFET power tube IRF2807, which can get a faster switching speed, especially suitable for driving a small power motor. There is a reverse quick recovery diode integrated between the drain and source poles inside the motor, which can directly protect the MOS tube without an external connection. The bypass resistor R is used to measure the current on the DC bus of the motor. The current signal I is measured by the voltage drop of resistance R. The current signal can provide a feedback current signal for the current loop. At the same time, the current signal can be real-time monitoring current to prevent motor overcurrent failure. The overcurrent signal is input into the front driver chip and DSP processor of the power bridge, and the gate driver signal of the power field effect tube is blocked in time during overcurrent.

To improve the safety performance of system operation, this design scheme adds an inverter circuit to the system hardware architecture, PS21865 as the controller, design inverter circuit.

Because the PWM waveform generated by DSP has a high frequency (33 kHz), the switching time of the driving circuit will be longer with the general low-speed optocoupler, and the low-speed performance of the motor will be seriously affected at low speed and small load. Therefore, high-speed optocoupler 6N137 is selected in this article. The

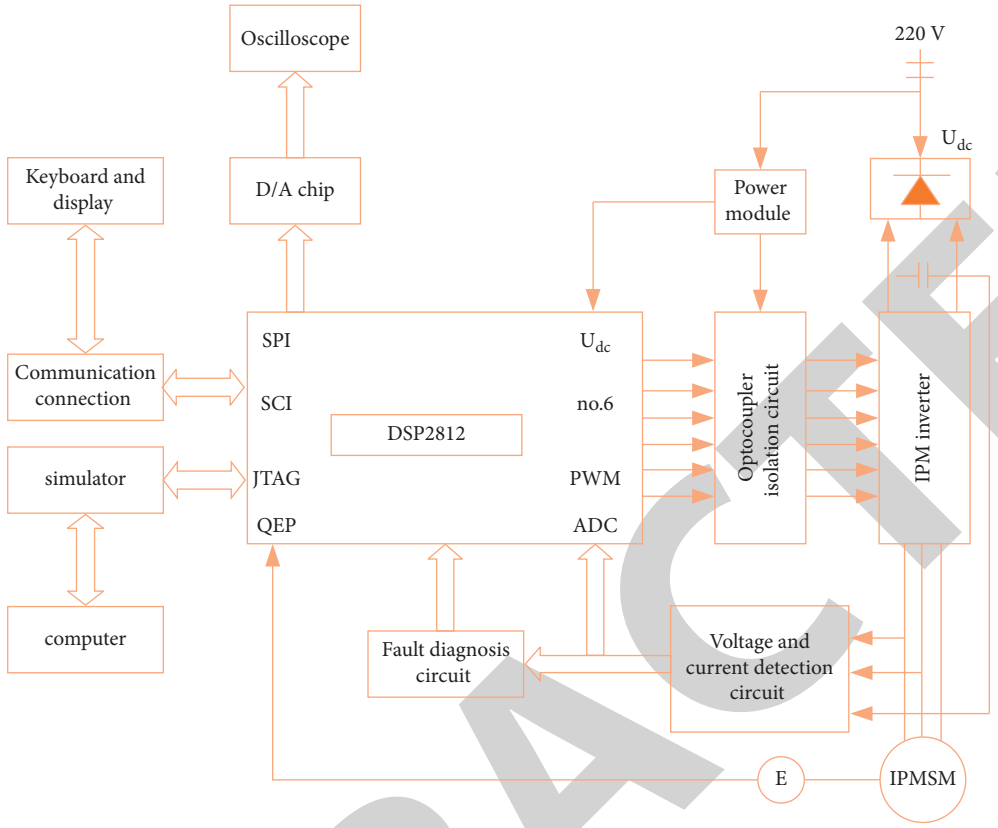

Figure 1: Overall architecture of motor control system.

maximum switching speed of the optocoupler is 10 MHz, which effectively improves the rapidity of the inverter.

2.1.2. Signal Detection Circuit Design. The three-phase stator voltage of the system, namely the U, W, and V phases, needs to be calculated according to the detection of DC bus voltage and the observation of the current inverter switch operation state. Considering that the voltage in the circuit is dc voltage, the system adopts the method of resistance voltage division to collect voltage information. The circuit sets the value of divider resistance in the limited range of DC bus voltage. The former is the power resistor and the latter is the patch resistor. To improve the impedance performance and isolation function of the circuit, a voltage follower is added after the voltage divider circuit, which works together with the analog photoelectric coupler to adjust the isolation signal in the circuit. The output signal of the circuit is an analog signal, after A/D conversion processing, the digital signal is generated, and TMS320F2812 calculates the signal data.

TMS320F2812 chip contains 12-bit unipolar A/D conversion module. The minimum conversion time is 60 ns, which can realize the three-phase voltage sampling of the motor without phase compensation. But because it is unipolar, we should add a lifting circuit when sampling AC, so that the voltage range of the AC signal is between 0 and 3 V. This system uses three A/D conversion inputs, two current detections, and one analog signal input sampling. Because of the balance between the three phases of the system, so as long as the detection of two currents, we can get the three-phase current. In the system, the hall current sensor is used to detect the motor stator current, and the input-output ratio is 200:1. The hall current sensor outputs weak current signals, which are converted into voltage signals, and then filtered and added. To prevent the voltage from being too high or too low, a limiting circuit composed of diodes is designed.

The current detection circuit is the biggest advantage of high precision measurement, good linearity, and can do no contact detection.

The protection circuit includes the overcurrent, overvoltage, and undervoltage of the main circuit as well as the fault signals such as overload and short circuit. To ensure the safe and reliable work of the power conversion circuit and motor drive circuit in the system, TMS320F2812 provides a PDPPINT input signal, which can be used to realize various protection functions of the control system conveniently.

Although IPM has a fully functional protection circuit, it still requires that the drive signal be removed in the event of power device failure. After IPM outputs four fault signals "or" to each other, they pass through the low-pass filter and serve as the protection signal of the DSP power device. At the same time, the guard signal controls the bus driver and immediately shuts down the drive signal sent to the rear stage when the fault signal is effective. With this dual protection design, the reliability of the system is further improved. The fault detection circuit is three fault output signals of the upper bridge arm of IPM, and the driving

power supply is isolated from each other. The three fault signals of the lower bridge arm are combined into one. Since there is no fault memory unit in IPM, the external control system needs to process its fault signal and take corresponding measures to completely block the IPM drive signal to ensure the safety of IPM. The fault detection module can complete the main circuit fault signal acquisition, and feedback to the control system, the control system according to the fault state to make a judgment and give the corresponding treatment scheme. The fault detection module collects the fault signal of the main loop and feeds back to the control system. Its function is to feedback fault signal in time, optimize the model, protect the circuit, and reduce the loss.

2.1.3. System Power Supply Circuit Design. First, the DC power supply is selected for the operation of each module in the system. To avoid mutual interference of power supply, the power supply of the system is isolated from each other. According to the rated voltage of the equipment, the power supply circuit is equipped, respectively. In this design, LM2576 is selected as the core chip of the circuit power supply, which supports 24 to 5 V power supply. Under the joint action of F2415S-2W equipment, the conversion between 24 V DC and 15 V DC is realized. Considering the power supply-demand of other equipment in the hardware circuit of the system, the WRA2412YMD-6W module is also added to the circuit, which provides ±12V power supply to each equipment with this model. Considering that some lines need partial voltage, this design scheme selects TMS320 F2812 as the control device, and the line supply voltage range is 1.9 and 3.3 V. The core chip of the control device is TPS767D301. Under the action of this chip, the power supply voltage is split into two channels, which are adjustable voltage (range 1.5~5.5 V) and fixed voltage 3.3 V, respectively. The line voltage is controlled by switching pin high/low level by adjusting the supply sequence.

2.2. Improved DTC Control Scheme

2.2.1. Establishment of Mathematical Model of PMSM. Since PMSM is not a linear system, the mathematical model of PMSM should be established if the control algorithm is used to achieve accurate control of PMSM. For PMSM, its flux material is a permanent magnet. The magnetic flux direction represents axis d, and the axis perpendicular to the magnetic flux direction is axis q. The relationship between coordinate systems of the mathematical model of PMSM is shown in Figure 2.

Formula (1) is the stator voltage equation of PMSM in a synchronous rotation coordinate system.

$$\begin{cases} u_d = Ri_d + \dfrac{\mathrm{d}}{\mathrm{d}t}\psi_d - \omega_e\psi_q, \\ u_q = Ri_q + \dfrac{\mathrm{d}}{\mathrm{d}t}\psi_q + \omega_e\psi_d. \end{cases} \tag{1}$$

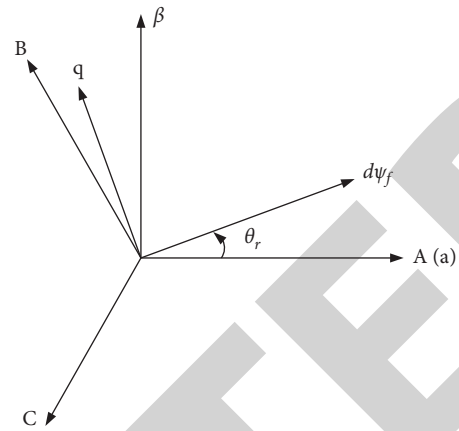

Figure 2: Relationship among coordinate systems.

Formula (2) is the stator flux equation.

$$\begin{cases} \psi_d = L_d i_d + \psi_f, \\ \psi_q = L_q i_q. \end{cases} \tag{2}$$

Formula (3) can be obtained by substituting the stator flux equation with the stator voltage equation.

$$\begin{cases} u_d = Ri_d + L_d\dfrac{\mathrm{d}}{\mathrm{d}t}i_d - \omega_e L_q i_q, \\ u_y = Ri_q + L_q\dfrac{\mathrm{d}}{\mathrm{d}t}i_q + \omega_e\left(L_d i_d + \psi_r\right). \end{cases} \tag{3}$$

When the mathematical model of PMSM is completely decoupled, the electromagnetic torque equation can be obtained.

$$T_e = \frac{3}{2}U_t i_q\left[i_d\left(L_d - L_q\right) + \psi_f\right], \tag{4}$$

where u_d and u_q are the stator voltages on axis d and q. Rs is the stator resistance. ω_e is electric angular velocity. i_d and i_q are the stator currents on axis d and q. ψ_d and ψ_q are the stator flux on axis d and q. ψ_f and U_t are permanent magnet flux and motor pole pairs. L_d and L_q are the inductance coefficients on axis d and q.

2.2.2. The Traditional DTC Control Scheme of PMSM. According to formula (4), DTC control further processes the electromagnetic torque formula to obtain the following formula:

$$T_e = \frac{3pn}{4L_d L_q}\left|\Psi_s\right|\left(2\psi_f L_q \sin\delta + \left|\psi_s\right|\left(L_d - L_q\right)\sin 2\delta\right), \tag{5}$$

where $|\Psi_s|$ is the amplitude of the stator flux. δ is the included angle between flux chains of the fixed rotor, also known as torque angle.

For the selected PMSM, the polar logarithm of the motor, the inductance coefficient of the d q axis, and the permanent magnet flux are constant values. According to formula (5), the only variables in the formula are torque angle and stator flux. When the control stator flux is

constant, that is, the circular magnetic field distribution, then the torque angle is the only variable, and the size of the electromagnetic torque depends on the change of the torque angle, which is the basic principle of the traditional DTC control of PMSM.

2.2.3. DTC Control Principle. The advantage of space pulse-width modulation is that it can synthesize the desired voltage vector at any position and improve the vibration caused by the finite voltage vector transformation in the table lookup method. Combining the advantages of space pulse width modulation with the simple control structure of DTC control technology to improve the flux and torque pulsation and slow response in traditional DTC control, this is the direct torque control principle of space voltage vector. The control system block diagram is shown in Figure 3.

The vector of voltage vector $\mathbf{U}_s$ in T_s is composed of the vector of non-zero voltage vector $\mathbf{U}_4$ in T_4 time and the vector of non-zero voltage vector $\mathbf{U}_6$ in T_6 time. The equivalence principle is shown in formula (6).

$$\begin{cases} T_s\mathbf{U}_s = T_4\mathbf{U}_4 + T_6\mathbf{U}_6, \\ T_s = T_4 + T_6 + T_0, \end{cases} \tag{6}$$

where T_0 represents the effective time of the zero voltage vector. T_s represents a control cycle.

The equivalence principle should be combined with the voltage vector synthesis method. The vector diagram of the voltage vector synthesis method is shown in Figure 4.

In space vector pulse width modulation direct torque control system, flux estimation module and torque estimation module remain unchanged. The expressions of reference voltage vectors U_α^* and U_β^* are shown in the following formula (7)

$$\begin{cases} U_\alpha^* = \dfrac{|\psi_s^*|\cos(\theta + \Delta\theta) - |\psi_s|\cos\theta}{T_s} + R_s i_\alpha, \\ U_\beta^* = \dfrac{|\psi_s^*|\sin(\theta + \Delta\theta) - |\psi_s|\sin\theta}{T_s} + R_s i_\beta. \end{cases} \tag{7}$$

2.2.4. The Influence of Stator Resistance Change on the Control System. In the PMSM control system, the calculation and measurement of stator flux value are troublesome and has low accuracy. One is the direct measurement method, which directly measures the stator flux value through the induction coil arranged inside the motor, but this measurement method is difficult to install, has low measurement accuracy, and has a high cost, so it is seldom used in engineering. The other is the observation model method, which uses a flux observer to obtain the stator flux value indirectly. Although this measurement method is simple and feasible, it needs to detect the change of motor parameter value in real-time. When the motor is at high speed, the flux can be estimated by the voltage model method. At this time, because the stator resistance partial pressure is much smaller than the stator voltage in the order of magnitude, it can be excluded. On the contrary, when the motor is in a low-speed state, the stator voltage change caused by the change of stator resistance value needs to be measured, otherwise, the stator flux measurement will have a large deviation. The flux equation of PMSM is shown in formula (8)

$$\psi_s^* = \int (u_s - R_S i_s)\mathrm{d}t. \tag{8}$$

According to formula (8), when the motor is at low speed, the value of stator resistance R_S affected by temperature changes, resulting in inaccurate flux measurement, thus affecting the normal operation of the motor and the overall control effect.

Theoretically, the stator resistance of the motor will not change, but in practice, when the motor runs at low speed, the increase of motor temperature will lead to the change of stator resistance and current. Assuming that their variations are, respectively, ΔR_S and $\Delta R i_S$, the actual stator flux and electromagnetic torque formula is shown in formula (9)

$$\begin{aligned} \Psi_s &= \int (u_s - (R_s + \Delta R_s)(i_s + \Delta i_s))dt, \\ T_e &= \frac{3}{2}U_t\left[\Psi_\alpha\left(i_\beta + \Delta i_\beta\right) - \Psi_\beta(i_\alpha + \Delta i_\alpha)\right]. \end{aligned} \tag{9}$$

Before the stator resistance changes, the formula of stator flux and electromagnetic torque is shown in formula (10)

$$\begin{aligned} \widehat{\Psi}_s &= \int [u_s - R_s(i_s + \Delta i_s)]dt, \\ \widehat{T}_e &= \frac{3}{2}U_t\left[\widehat{\Psi}_\alpha\left(i_\beta + \Delta i_\beta\right)(i_\alpha + \Delta i_\alpha)\right]. \end{aligned} \tag{10}$$

Thus, the error between stator flux and electromagnetic torque is shown in formula (11)

$$\begin{aligned} \Delta\Psi_s &= \Psi_s - \widehat{\Psi}_s = -\int \Delta R_s(i_s + \Delta i_s)dt, \\ \Delta T_e &= T_e - \widehat{T}_e = \frac{3}{2}U_t\left[\Delta\Psi_\alpha\left(i_\beta + \Delta i_\beta\right) - \Delta\Psi_\beta(i_\alpha + \Delta i_\alpha)\right]. \end{aligned} \tag{11}$$

The measurement error of stator resistance will bring a large deviation to the calculation of stator flux and electromagnetic torque measurement, which leads to large flux and torque pulse width of the whole control system, and seriously affects the accuracy and control performance of the whole control system.

2.3. Stator Resistance Tracker Design. The relationship between stator flux vector, stator current vector, and rotor flux vector in a synchronous rotation coordinate system is shown in Figure 5.

Suppose that ψ_1 and ψ_2 are the actual value and the observed value of stator flux, respectively. Is_1 and Is_2 are the expected current value and their actual value, respectively.

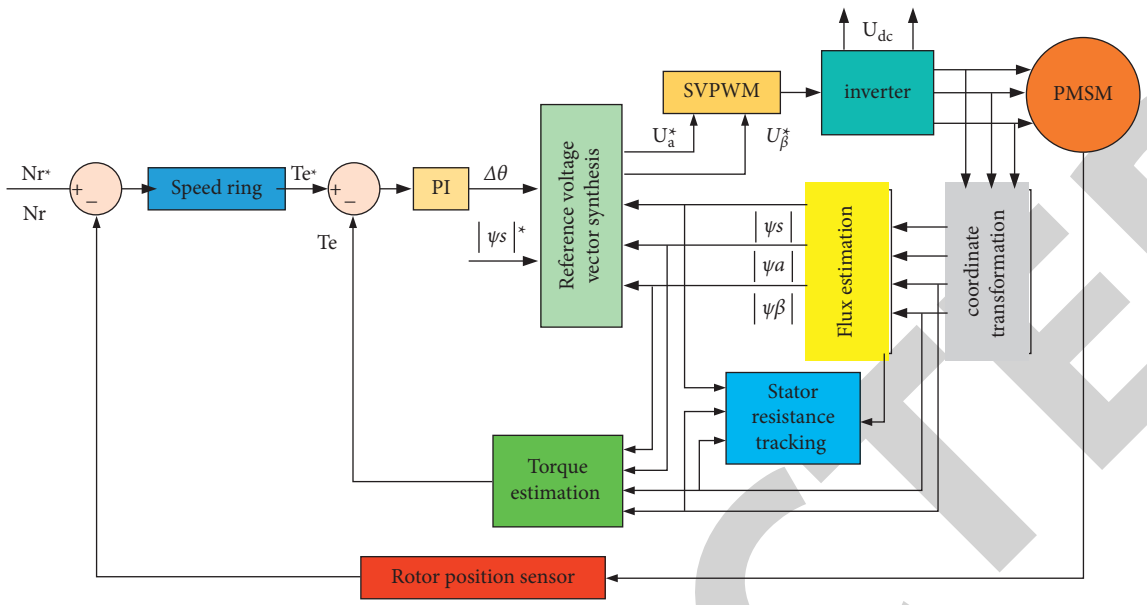

Figure 3: Block diagram of permanent magnet synchronous motor DTC control system with stator resistance tracking.

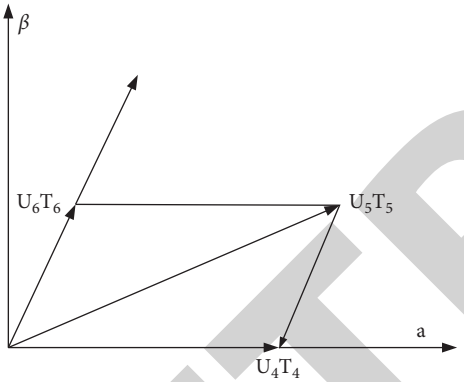

Figure 4: Voltage vector synthesis method.

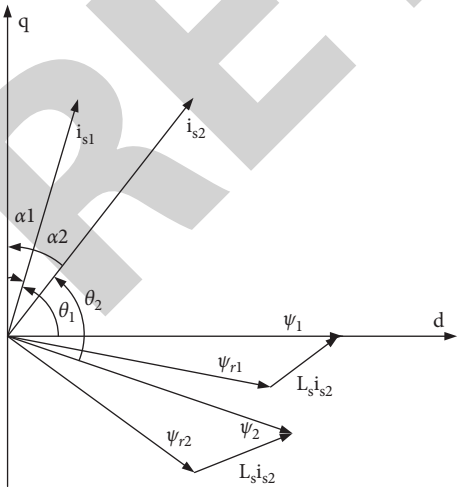

Figure 5: Schematic diagram of flux vector relations.

ψr_1 and ψr_2 are the actual value and the observed value of rotor flux, respectively. According to Figure 5, when the stator resistance value increases, the actual stator flux value should be ahead of the observed value, and the expected current value should be ahead of the actual value.

When the motor is running a steady-state, the flux is distributed according to the circular magnetic field, so the size of the flux is constant. Similarly, when the motor load does not change, the torque generated in the control system remains constant.

$$\begin{cases} |\psi_1| = |\psi_2|, \\ |\psi_1||i_{s1}|\cos\alpha_1 = |\psi_2||i_{s2}|\cos\alpha_2, \\ |\psi_{r1}| = |\psi_{t2}|. \end{cases} \tag{12}$$

Formula (13) can be obtained from trigonometric functions in Figure 5.

$$\begin{aligned} |\psi_{r1}|^2 &= |\psi_1|^2 + |L_s i_1|^2 - 2|\psi_1||L_s i_{,1}|\cos\theta_1, \\ |\psi_n|^2 &= |\psi_2|^2 + |L_s i_2|^2 - 2|\psi_2||L_s i_2|\cos\theta_2. \end{aligned} \tag{13}$$

Formula (14) can be obtained from formula (12) and formula (13).

$$2|\psi_2|\left(\cos\theta_2 - \frac{\cos\alpha 2}{\cos\alpha}\cos\theta_1\right) = |i_{s2}|\left(\frac{\cos\alpha_\alpha 2}{\cos\alpha_1} - 1\right)L_s. \tag{14}$$

Formula (14) is further simplified to formula (15)

$$\frac{|\psi_2|}{|i_{s2}|} = \frac{L_s}{2}\left(\frac{\cos 2_{\alpha 2} - \cos\alpha_{\alpha 1}}{\cos\alpha 1\left(\cos\theta_2\cos\alpha 1 - \cos\alpha_2\cos\theta_1\right)}\right). \tag{15}$$

Let $W = |\psi_2|/|i_{s2}|$, and take the partial derivative of α_2 with respect to W.

$$\frac{\partial W}{\partial \alpha_2} = \frac{L_s\cos\alpha_2}{\cos\alpha_1\cos\theta_1}. \tag{16}$$

According to $\cos\alpha_2 > 0$, W increases with the increase of $\cos\alpha_2 > 0$, resistance changes in the same direction as α_2, and

Table 1: Basic parameters of permanent magnet synchronous motor.

PMSM type	Non-salient pole type	A logarithmic	4
Stator resistance (Ω)	1.2	Dc bus voltage (V)	300
The stator inductance (/mH)	8.6	Rated power (kW)	1.8
Permanent magnet flux (Wb)	0.178	The rated torque (N·m)	6

Table 2: Control system simulation conditions setting.

Parameter	The numerical
Simulation step size and sampling time (t/s)	1e-6
Reference stator flux (Wb)	0.216
The given speed (Nr/(r·min^{-1}))	120
PWM switching frequency (f/Hz)	1000
The simulation time (t/s)	0.2

$\cos\alpha_2 > 0$ decreases with the increase of α_2, so the change direction of W is opposite to resistance. That is, the ratio between the observed value of stator flux and the actual current value is opposite to the direction of resistance change. Therefore, the actual stator resistance value can be measured by using an auxiliary variable flux observation value that changes in the opposite direction of the actual current value and the resistance. Then it passes through the low-pass filter and PI controller successively. Then the stator resistance's compensation amount can be obtained to measure the actual stator resistance value.

3. Result Analysis and Discussion

3.1. Experimental Parameters. In Matlab/Simulink simulation software, the simulation model of the traditional direct torque control system and space vector pulse width modulation DTC system with stator resistance tracking were established according to the above optimization control strategy. The simulation motor in the system adopts the implicit pole permanent magnet synchronous motor, and its basic motor parameters are shown in Table 1.

Simulation conditions are set as shown in Table 2.

3.2. Performance Comparison. The proposed algorithm and the other four control algorithms are compared.

3.2.1. Steady-State Energy Efficiency of Hybrid Vehicles under Different Driving Resistances at a Constant Speed of 28 km/h. Figures 6 and 7 show the simulationresults of the proposed algorithm and other control algorithms [20–23] for hybrid electric vehicles. Figure 6 shows the relationship between the lost power and road driving resistance moment (TR) of hybrid vehicles under the five controllers, and Figure 7 shows the relationship between system efficiency and road driving resistance moment (TR). When the speed is constant, with the increase of external resistance, the power loss of the hybrid vehicle increases gradually, and the system efficiency decreases gradually. When the external resistance is small, the loss of power of the five control methods is close to the system efficiency. With the increase of resistance, the

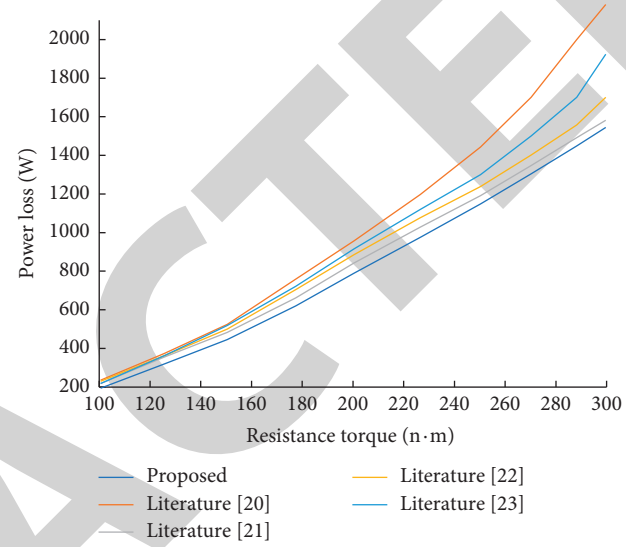

Figure 6: Relationship between lost power and resistance moment.

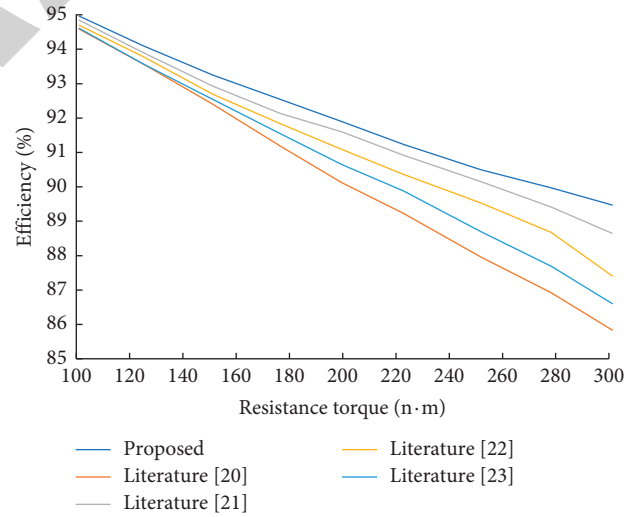

Figure 7: Relationship between system efficiency and resistance moment.

advantages of the proposed control method become more and more apparent. Compared with the other control method, the proposed control method can significantly reduce loss and improve efficiency.

3.2.2. The Steady State Energy Efficiency of Hybrid Vehicles at Different Driving Speeds When the Road Driving Resistance Moment Is Constant at 180 N m. Figures 8 and 9 show the

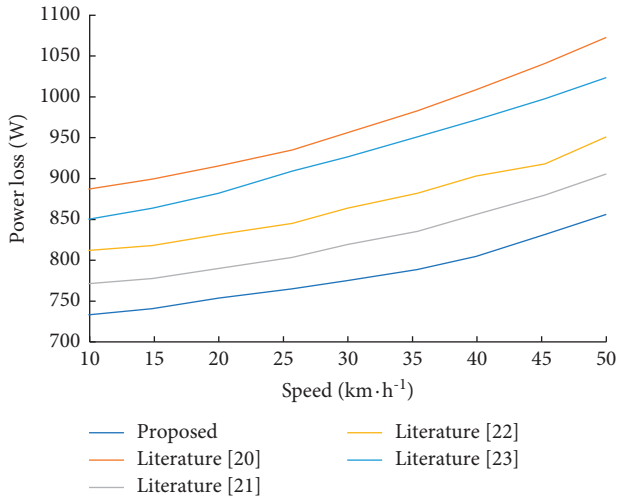

Figure 8: Relationship between lost power and driving speed.

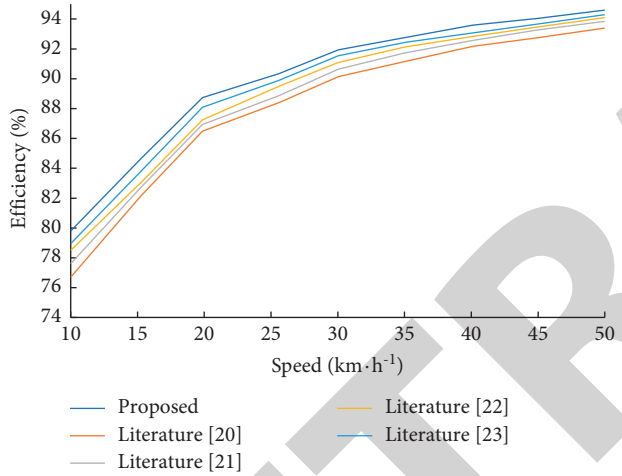

Figure 9: Relationship between system efficiency and driving speed.

simulation results of hybrid vehicles at different speeds. Figure 8 shows the relationship between lost power and driving speed of hybrid vehicles under the five controllers, and Figure 9 shows the relationship between system efficiency and driving speed. It can be seen that the proposed control method has lower loss and higher efficiency than the other control method at different speeds. With the increase in driving speed, the wind resistance gradually increases, and the power loss of the hybrid vehicle under the control of the five methods will rise slightly. However, the loss of power of the proposed method rises more slowly. Since the increase of useful work caused by the increase in speed is much higher than the increase of loss caused by the increase in wind resistance, the efficiency of hybrid vehicles increases gradually with the increase of speed. As the proportion of loss decreases gradually, the efficiency gap between the five methods decreases gradually.

As can be seen from (1) and (2), the performance of the proposed control method is superior to that of the other control method under different speeds and resistance moments. And with the decrease of velocity and the increase of resistance moment, its advantage becomes more and more obvious.

4. Conclusion

The system develops the main power circuit, signal detection circuit, and system power circuit, and reasonably selects the circuit control chip, and builds the hardware circuit for itself. The steady-state error, overshoot, and torque pulsation produced by the system are small. At the same time, the bus voltage output waveform of the system is relatively stable, which meets the requirements of system development. The principle of space voltage vector direct torque control (DTC) combines the advantages of space pulse width modulation (PWM) with the characteristics of the simple control structure of DTC control technology to improve the flux and torque pulsation and slow response speed in traditional DTC control.

This article proposes a maximum torque current ratio control method for energy efficiency optimization of hybrid vehicles based on a permanent magnet synchronous motor (PMSM). The longitudinal dynamic model of a hybrid vehicle was obtained by force analysis. The simulation results show that compared with the traditional zero-axis current control method, this control method can effectively reduce energy consumption and improve the efficiency and performance of the hybrid electric vehicle. This advantage is significant in the dynamic process of acceleration and deceleration of hybrid vehicles. The control strategy studied in this article can solve the endurance problem of hybrid vehicles to a certain extent. The proposed control method has lower loss and higher efficiency than the other control method at different speeds. With the increase of driving speed, wind resistance gradually increases, and the power loss of hybrid vehicles under the control of the two methods rises slightly, but the power loss of the proposed algorithm rises more slowly. The increase in useful work due to the increase in speed is much greater than the increase in loss due to the increase in wind resistance. Therefore, the efficiency of hybrid cars rises gradually with the increase in speed. As the proportion of loss decreases gradually, the efficiency gap between the two methods decreases gradually. The performance of the proposed control method is better than that of the other control method under different speeds and resistance moments, and its advantages become more and more obvious with the decrease in speed and the increase of resistance moments.

However, this article only optimizes the copper loss of the motor without considering the influence of iron loss, stray loss, reverse loss, and transmission loss. It is important research content in the future to integrate various losses on hybrid vehicles and optimize the overall losses.

Data Availability

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