

## Research Article

# Collaborative Governance of Rural Relative Poverty under Blockchain and Back Propagation Neural Network

Xin-Jie Tian  and Zhi-Jun Ge 

*School of Agriculture, Ningxia University, Yinchuan; 750021, China*

Correspondence should be addressed to Xin-Jie Tian; [gzyjc@stu.nxu.edu.cn](mailto:gzyjc@stu.nxu.edu.cn)

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It aims at exploring the effect of coordinated relative poverty governance in rural areas based on blockchain and back propagation (BP) neural network, so that the living standard of rural areas can be significantly improved. In view of the shortcomings and defects existing in the rural relative poverty governance, artificial intelligence technologies such as blockchain and neural network are innovatively introduced to conduct intelligent storage and data visualization analysis on the rural relative poverty governance process. A visualized governance and mechanism innovation model of rural relative poverty data based on blockchain and BP neural network is constructed. Finally, its performance is analyzed through experiments. The results show that the accuracy of data visualization prediction of the proposed algorithm model reaches 94.31%. When the amount of data is 5.5 Mb, the calculation consumption of the proposed algorithm is 0.08 s, and the average leakage rate finally stabilizes below 10%. Therefore, the constructed poverty data visualization governance model can achieve good data transmission security performance while ensuring high classification accuracy. It can provide experimental basis and contribution for the intelligent development and mechanism innovation of rural relative poverty governance.

## 1. Introduction

The rapid development of computer science and technology, all walks of life are developing towards intelligence. Among them, poverty alleviation and relative poverty in rural areas is one of the difficult problems of social development. Due to the different forms, structures, and economic sources of rural poverty in different areas, it puts forward higher requirements for rural relative poverty governance. If data visualization technology is applied to relative rural poverty control, it can not only accurately reflect the current situation of relative rural poverty in different regions but also vividly show the factors leading to relative poverty [1, 2]. Therefore, under the current situation of artificial statistics of rural relative poverty information and poverty methods, the application of artificial intelligence technologies such as neural network [3] and blockchain to the rural relative pov-

erty data visualization governance and mechanism innovation has become the focus of relevant scholars.

Under the trend that Internet of Things, Big Data, artificial intelligence, and blockchain technology are widely used in all walks of life, it also brings inspiration to rural relative poverty governance and mechanism innovation. The core of relative poverty governance is the diversification, cooperation, and governance of public management participants. The core of relative poverty governance is to reduce management costs while improving people's economic level and promote the improvement of public service quality in rural areas [4, 5]. It requires the government to conduct open-source governance in the governance process, build a decentralized "multi governance and collaborative governance" model, clarify the governance needs, achieve accurate governance, improve the transparency of the relative poverty governance, and minimize the governance cost. In the process

of rural relative poverty governance, data visualization governance is very important to break the traditional data management model and mechanism. As a decentralized distributed ledger database, blockchain technology is a highly secure and tamper proof technology [6]. The distributed architecture of blockchain technology can store all rural poverty data at all nodes, so that the data can be distributed throughout the network and cannot be tampered with. In addition, when blockchain technology is applied to rural poverty data management, all nodes reach a consensus under the coordination of consensus algorithm, and the information transmission process of all nodes is recorded in the blockchain system. By using data hash conversion and asymmetric encryption algorithm, the data cannot be easily obtained through reverse calculation, so as to effectively protect data security [7, 8]. Therefore, blockchain technology is highly consistent with the current governance needs of decentralization of government relative poverty data governance, government data sharing, and ensuring government data security, which is of great significance to the mechanism innovation of rural relative poverty data visualization governance.

In summary, with the gradual maturity of the application of blockchain technology in the field of public services, it is of great practical value to take blockchain as a way of rural relative poverty data visualization governance and mechanism innovation. The innovation and contribution of this work lies in that, aiming at the shortcomings and defects existing in rural relative poverty governance, artificial intelligence technologies such as blockchain and neural network are introduced to intelligently store and analyze the data in the process of rural relative poverty governance. Combined with the analysis of the fit between blockchain technology and rural relative poverty data governance, a government data governance framework based on blockchain technology is put forward, and the metadata encrypted by Back Propagation (BP) neural network is used for analysis. Furthermore, a rural relative poverty governance and mechanism innovation model based on blockchain and BP neural network is constructed, and its performance is analyzed through experiments. It provides experimental reference for the intelligent development of rural relative poverty governance and data visualization governance and innovation in the later stage.

## 2. Related Works

**2.1. Research Status of Data Visualization Governance in Rural Relative Poverty.** As one of the current global problems, rural relative poverty governance has been studied by many scholars. Guohua et al. [9] establish a long-term mechanism for poverty governance. They also put forward the optimization strategy of rural residential areas based on relative poverty governance. The results show that revitalizing village industry, optimizing village spatial organization, strengthening village cultural identity, building green ecological village, promoting village multifunctional collaborative transformation, and promoting village sustainable development are all effective strategies in rural poverty gov-

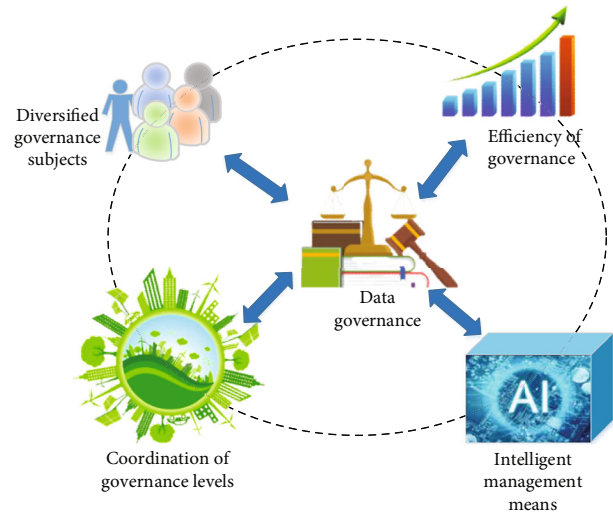


FIGURE 1: Schematic diagram of relative poverty data visualization governance characteristics.

ernance. Beauxis-Aussalet et al. [10] used data visualization technology to perform interactive analysis of artificial intelligence system, and finally found that data visualization technology is very important to the development of artificial intelligence. Qiao et al. [11] proposed to integrate the resource advantages of small watersheds into rural industrial development, and transform the economic and social benefits contained in the ecological environment into multiscale spatial benefits among farmers, villages, and regional rural areas of sustainable development. The results show that the proposed strategy is helpful to give full play to the comparative advantages of mountainous areas and promote endogenous sustainable development to a certain extent. Feenstra et al. [12] pointed out corresponding governance strategies for the problem of energy poverty in the Netherlands, and outlined the opportunity to formulate the energy poverty agenda in the national energy transformation policy as a part of multilevel energy governance.

**2.2. Research Status of Blockchain Applied to Visualization Governance.** In recent years, the use of blockchain has received attention in intervention and research in many fields. Blockchain technology can be used especially in the field of intelligent governance, which aims at ensuring more informed decision-making, openness, and collaborative participation of all relevant entities, and help minimize resource use, reduce consumption, and save costs. Liu et al. [13] innovated the data governance mode in the government based on the decentralized service computing paradigm of blockchain. Moreover, the data owner can define service rules/policies, where to store data and how to share data, and continuously manage the whole life cycle record of the actual use of data. Sifah et al. [14] presented a government decentralized employee evaluation system based on blockchain, which is based on Hyperledger Fabric as the blockchain platform and operation mechanism. The results indicate that the blockchain system can make effective decisions on employee performance. The system realizes trust, transparency,

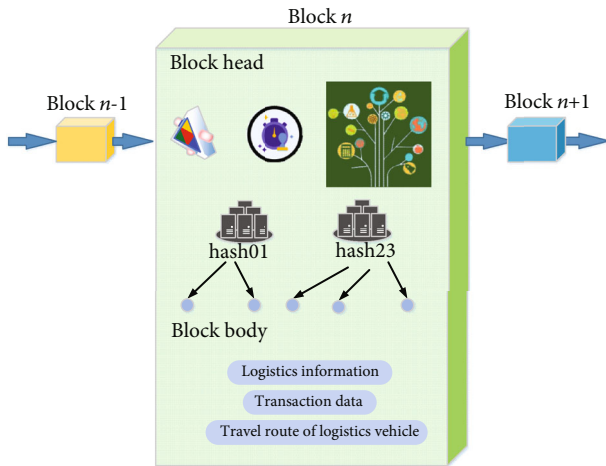


FIGURE 2: Blockchain structure.

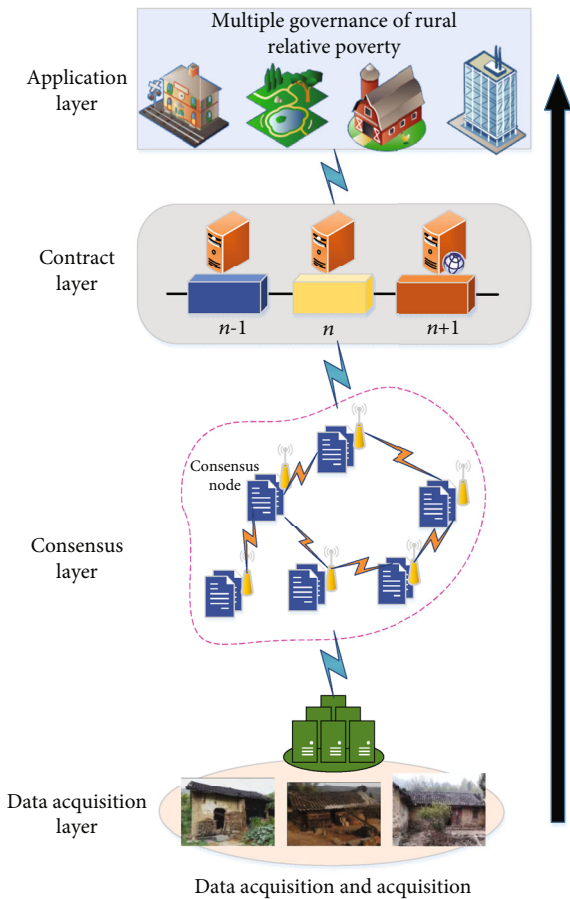


FIGURE 3: Schematic diagram of rural relative poverty data governance architecture based on blockchain technology.

security, and accountability among government staff in the smart city governance environment. Hassija et al. [15] used blockchain to provide a secure and transparent framework for government bidding, and created a transparent and secure Edge Computing infrastructure to implement government plans and policies by limiting human supervision to a

minimum. Kleinknecht [16] adopted blockchain technology to evaluate the relationship with the implementation of sustainability standards of Electronic Product Environmental Assessment Tool (EPEAT). It is found that some characteristics of blockchain provide greater support for specific standards, and the judgment of EPEAT environmental sustainability standards in terms of information transparency and traceability is more valuable.

Through the analysis of the research of the above scholars, it is found that the current rural relative poverty governance schemes are more diversified and tend to traditional governance, but there are no effective suggestions on how to effectively deal with the impact and challenges that economic development may bring to poverty governance. With the increasingly extensive application of blockchain technology in visualization governance, the application of blockchain and artificial neural network in data visualization governance of rural relative poverty is of great significance for the visualization and intelligent innovation and development of mechanism in the process of relative poverty governance.

### 3. Application of Blockchain and Neural Network Technology in Rural Relative Poverty Data Visualization and Collaborative Governance

*3.1. Intelligent and Visual Analysis of Relative Poverty Data Governance.* In the context of Big Data, data visualization governance is an important part of its intelligent development in the process of relative poverty governance. Data governance operates according to the preset governance framework, and defines the data governance subject, specific operation steps, specific application scenarios, and corresponding governance strategies and means. In relative poverty governance, data governance is the decision-making and action taken based on data management, formulating data management guidelines and use specifications, and organizing relevant data management activities to carry out correct data governance and decision-making, so as to ensure the maximum excavation and utilization of data value [17, 18]. In the process of relative poverty governance, data visualization governance includes not only the specific governance of the whole life cycle of data but also the active management of data stakeholders. Compared with traditional data management, management subjects are diversified, management approaches are diversified, management system is more perfect, and the breadth and depth of data mining are more systematic, so as to give more effective play to the data value in relative poverty governance [19]. In the process of relative poverty governance, the characteristics of data visualization governance are shown in Figure 1.

The characteristics of relative poverty data visualization governance mainly include the diversification of governance subjects, the coordination of governance levels, the intellectualization of governance means, and the high governance efficiency. The subject diversification is mainly to obtain

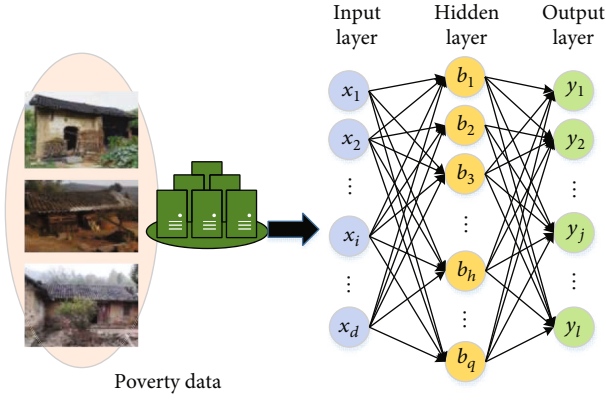


FIGURE 4: Schematic diagram of BP neural network classification of relative poverty data visualization governance.

diversified data through various portals and media platforms, so as to break the data acquisition restrictions of time, space, and region, so as to create more value for the development of people's livelihood and economy in the process of rural relative poverty governance. The coordination of governance levels is mainly reflected in the overall and systematic coordination among different governance levels such as government, state, and society. The intellectualization of governance means is to conduct data collection, storage, mining, and visual analysis by using technologies such as Big Data, artificial intelligence, and blockchain. The high governance efficiency is mainly reflected in the positive role between the government and nongovernmental subjects, mobilizing the collaborative governance among various subjects, so as to improve the overall governance efficiency [20].

**3.2. Application of Blockchain Technology in Relative Poverty Data Visualization Governance.** Blockchain technology has the characteristics of decentralization, openness, tamper proof, anonymity, and traceability. In the process of relative poverty digital governance, in order to promote the intelligent development of data governance, blockchain technology is introduced, which provides a new solution for mechanism innovation based on relative poverty governance. The blockchain structure is given in Figure 2.

The blockchain structure takes the time axis as the sorting basis, and ensures the tamper proof and unforgeability of block data through cryptographic algorithms. The blockchain data structure is used to summarize, process, and store data, and the distributed data nodes and consensus algorithm are used to ensure the generation, transmission, and storage of data. The specific rural relative poverty data governance architecture based on blockchain technology is illustrated in Figure 3.

The rural relative poverty governance metadata collected by the government show the characteristics of diversity, heterogeneity, and disorder, which makes part of the value of rural poverty data "swallowed". How to revitalize these government data resources, how to improve the value density of these government data and turn them into products and services that can be shared by the society have become the problems that the government should focus on in the pro-

cess of governance. In the process of relative poverty data governance using blockchain technology, it is encrypted through Paillier encryption scheme, which is an asymmetric algorithm based on public key cryptosystem. The scheme includes three steps as follows: Key Generation (KeyGen), Encryption (Enc), and Decryption (Dec) [21, 22].

- (1) KeyGen: two large prime numbers  $p$  and  $q$  are selected and the product of them is calculated.

$$n = p \times q. \quad (1)$$

A random nonzero integer  $g \in Z_{n^2}^*$  is selected, in which the set  $Z_{n^2}^*$  is composed of reversible elements in the set  $Z_{n^2}$ . The selection of  $g$  must satisfy that the order-number of  $g$  in  $Z_{n^2}^*$  is a multiple of  $n$  and satisfy Equation (2).

$$\gcd\left(L\left(g^\lambda \bmod n^2\right), n\right) = 1, \quad (2)$$

$$L(x) = (x - 1)/n. \quad (3)$$

$L(\cdot)$  is a function whose expression is shown in Equation (3).  $\lambda$  refers to the Carmichael function about  $n$ . The constructed public key is  $(n, g)$ , and the private key expression is as follows:

$$\lambda(n) = \text{lcm}(\varphi(p), \varphi(q)) = \text{lcm}(p-1, q-1). \quad (4)$$

According to the binomial theorem, the higher-order term can be reduced to obtain the following equation.

$$(1+n)^x = (1+nx \bmod n^2). \quad (5)$$

In practice,  $g$  is represented by.

$$g \equiv ((1+n)^t \cdot z^n \bmod n^2). \quad (6)$$

- (2) Enc: the plaintext  $m \in Z_n$  to be encrypted is input, and a nonzero integer  $r \in Z_{n^2}^*$  ( $\gcd(r, n)=1$ ) is randomly selected to calculate the ciphertext.

$$c = g^m r^n \bmod n^2. \quad (7)$$

- (3) Dec:  $L(g^\lambda \bmod n^2) = k$ , the inverse element of  $k$  in  $Z_n^*$  is calculated as

$$\mu \equiv k^{-1} \bmod n. \quad (8)$$

The plaintext is calculated as

$$m = L\left(g^\lambda \bmod n^2\right) \cdot \mu \bmod n. \quad (9)$$



In the data visualization governance of relative poverty in rural areas, in order to carry out more accurate poverty governance, it is essential to classify the poverty situation. BP neural network is introduced for classification (Figure 4).

When using BP neural network to classify the relative poverty governance data, first the training data set  $D = \{(x_1, y_1), (x_2, y_2), \dots, (x_m, y_m)\}$  is given,  $x_i \in R^d, y_i \in R^l$ , that is, the input example is described by  $d$  attributes, and the output is  $l$ -dimensional real value vector [23–25]. For the training example  $(x_k, y_k)$ , it is assumed that the output of the neural network is  $\hat{y}_k = (\hat{y}_1^k, \hat{y}_2^k, \dots, \hat{y}_l^k)$ , that is, there is the following equation.

$$\hat{y}_j^k = f(\beta_j - \theta_j). \quad (10)$$

$\beta_j$  refers to the input signal of the  $j$ th neuron in the output layer and  $\theta_j$  refers to the threshold of the  $j$ th neuron in the output layer.

The Mean Square Error  $E_k$  of neural network in  $(x_k, y_k)$  is expressed as

$$E_k = \frac{1}{2} \sum_{j=1}^l (\hat{y}_j^k - y_j^k)^2. \quad (11)$$

The cumulative error on the training set is as follows:

$$E = \frac{1}{m} \sum_{k=1}^m E_k. \quad (12)$$

BP neural network algorithm is an iterative learning algorithm. In each iteration process, the parameters need to be revised and updated. The method of updating parameters adopts the generalized perceptron learning rules.

$$v \leftarrow v + \Delta v. \quad (13)$$

The connection weight from the hidden layer to the output layer in the neural network is  $\omega_{hj}$ , and the learning rate  $\eta \in (0, 1)$  is given to control the update step size in each round of algorithm iteration. If the value is too large, it will easily lead to oscillation and miss the optimal update value, but too small will lead to low convergence speed. The update derivation process is as follows:

$$\Delta\omega_{hj} = -\eta \frac{\partial E_k}{\partial \omega_{hj}}. \quad (14)$$

The input value  $\beta_j$  of the  $j$ th neuron in the output layer is most directly affected by the weight  $\omega_{hj}$ , which then affects the output signal value  $\hat{y}_j^k$ , and the final error value  $E_k$  is also affected by it.

$$\frac{\partial E_k}{\partial \omega_{hj}} = \frac{\partial E_k}{\partial \hat{y}_j^k} \cdot \frac{\partial \hat{y}_j^k}{\partial \beta_j} \cdot \frac{\partial \beta_j}{\partial \omega_{hj}}. \quad (15)$$

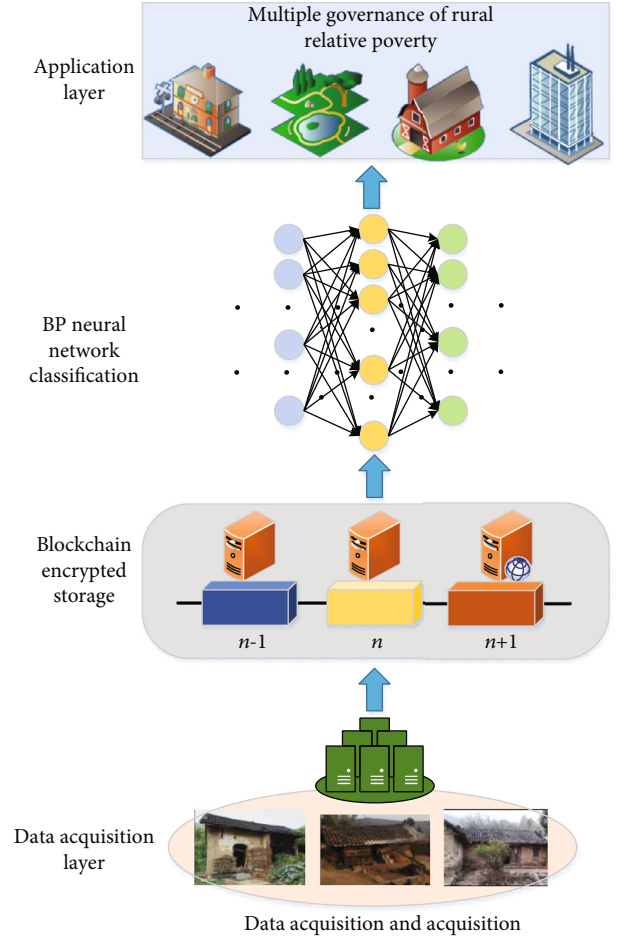


FIGURE 5: Schematic diagram of rural relative poverty collaborative governance of data visualization model based on blockchain combined with BP neural network.

According to the definition of  $\beta_j$ , there is the.

$$\frac{\partial \beta_j}{\partial \omega_{hj}} = b_h. \quad (16)$$

$b_h$  means the output of the  $h$ th neuron in the hidden layer. It is assumed that both hidden layer neurons and output layer neurons adopt Sigmoid function as excitation function, and the properties shown in Equation (17) exist in this function.

$$f'(x) = f(x)(1 - f(x)). \quad (17)$$

According to Equations (10) and (11), the following equation can be obtained.

$$\begin{aligned} g_i &= -\frac{\partial E_k}{\partial \hat{y}_j^k} \cdot \frac{\partial \hat{y}_j^k}{\partial \beta_j} = -(\hat{y}_j^k - y_j^k) f'(\beta_j - \theta_j) \\ &= \hat{y}_j^k (1 - \hat{y}_j^k) (y_j^k - \hat{y}_j^k). \end{aligned} \quad (18)$$

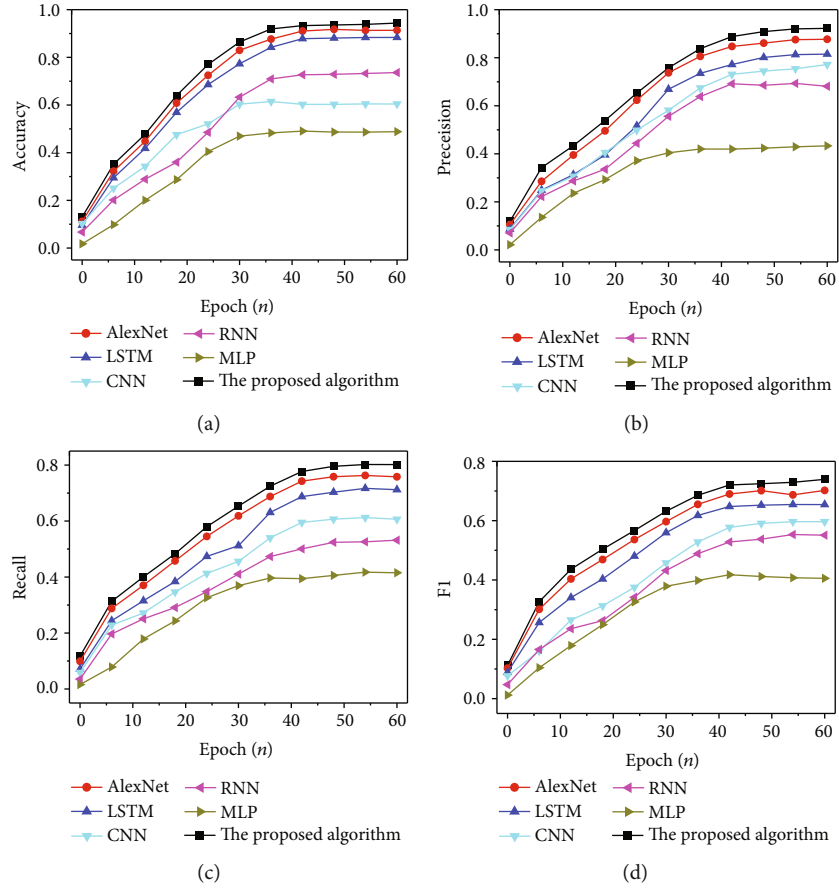


FIGURE 6: Influence curve of classification prediction accuracy with the increase of iteration times under different algorithms ((a) Accuracy; (b) Precision; (c) Recall; (d) F1 value).

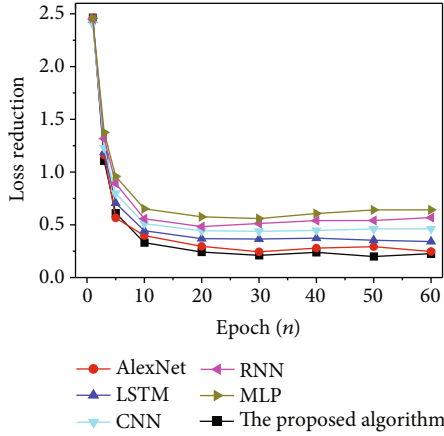


FIGURE 7: Curve of loss reduction with iteration times under different algorithms.

The updating process of the weight  $\omega_{hij}$  from the hidden layer to the output layer is as follows: Equations (16) and (18) are substituted into Equation (15), and then the results are further substituted into Equation (14) to obtain Equation (19).

$$\Delta\omega_{hij} = \eta g_i b_h. \quad (19)$$

Similarly, Equation (20)~Equation (22) can be obtained.

$$\Delta\theta_j = -\eta g_i, \quad (20)$$

$$\Delta v_{ih} = \eta e_h x_i, \quad (21)$$

$$\Delta\gamma_h = -\eta e_h. \quad (22)$$

$\gamma_h$  means the threshold of the  $h$ th neuron in the hidden layer;  $v_{ih}$  refers to the connection weight between the  $i$ th neuron in the input layer and the  $h$ th neuron in the hidden layer. The expression of  $e_h$  in Equations (21) and (22) are as follows:

$$\begin{aligned} e_h &= -\frac{\partial E_k}{\partial b_h} \cdot \frac{\partial b_h}{\partial \alpha_h} = -\sum_{j=1}^l \frac{\partial E_k}{\partial \beta_j} \cdot \frac{\partial \beta_j}{\partial b_h} f'(\alpha_h - \gamma_h) \\ &= \sum_{j=1}^l \omega_{hj} g_j f'(\alpha_h - \gamma_h) = b_h(1 - b_h) \sum_{j=1}^l \omega_{hj} g_j. \end{aligned} \quad (23)$$

$\alpha_h$  represents the input signal of the  $h$ th neuron in the hidden layer and  $\beta_j$  indicates the input signal of the  $j$ th

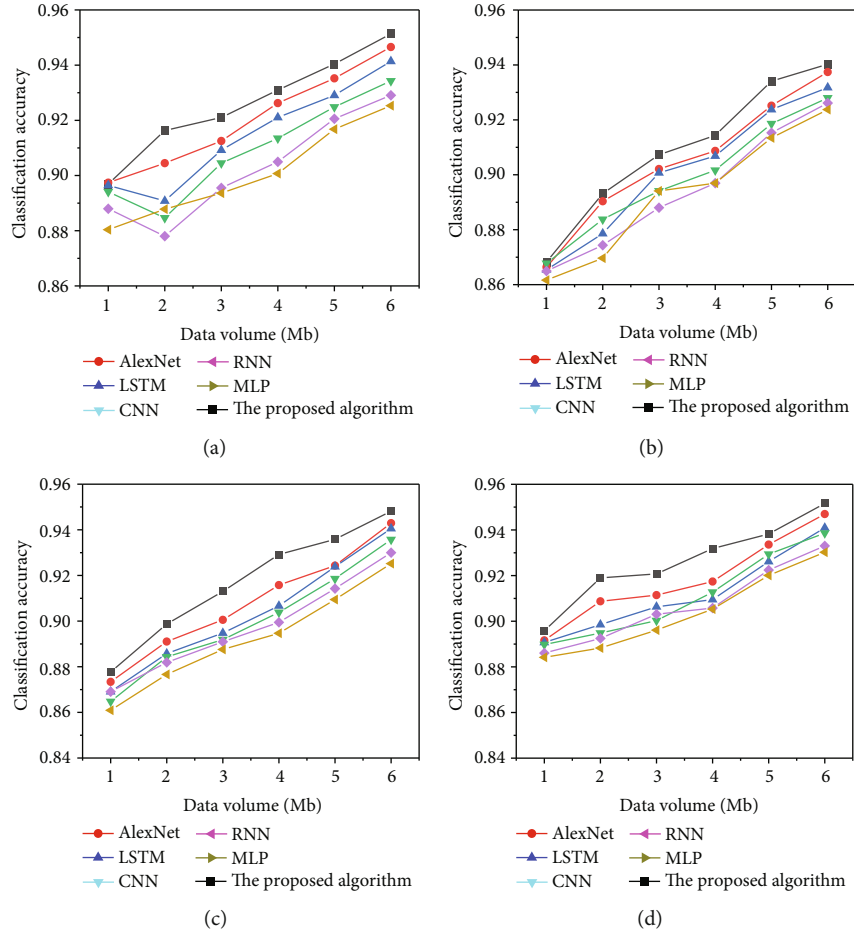


FIGURE 8: Classification accuracy change with the increase of the amount of data under different algorithms in each node ((a) node A; (b) node B; (c) node C; (d) node D).

neuron in the output layer. The expressions are as

$$\alpha_h = \sum_{i=1}^d v_{ih}x_i, \quad (24)$$

$$\beta_j = \sum_{h=1}^q \omega_{hj}b_h. \quad (25)$$

**3.3. Construction and Analysis of Visual Collaborative Governance Model of Rural Relative Poverty Data Based on Blockchain and BP Neural Network.** In view of the shortcomings and defects in rural relative poverty governance, artificial intelligence technologies such as blockchain and neural network are introduced to intelligently store and visually analyze the data in the process of rural relative poverty governance, so as to achieve the purpose of mechanism innovation. Combined with the analysis of the fit between blockchain technology and rural relative poverty data governance, the rural relative poverty data governance process is analyzed through the setting of rural relative poverty data governance module and the framework design of rural relative poverty data governance. A government data visualiza-

tion governance architecture based on blockchain technology is proposed to maximize the effective value of blockchain technology. In addition, the requested ciphertext data is retrained by BP neural network to obtain new classification accuracy. Two classification accuracy comparisons and currency transactions are carried out according to the provisions of the smart contract. If the accuracy is improved, the data owner can obtain high returns, so as to promote the upload and sharing of high-quality data on the alliance chain. The specific rural relative poverty collaborative governance of data visualization model based on blockchain and BP neural network is shown in Figure 5.

In this model, the collected metadata is constructed into a peer-to-peer network by using the blockchain architecture, so that each rural relative poverty data governance subject can carry out the collection, inspection, processing and analysis, exchange, and sharing of “linked government data”. A decentralized data self-organizing network is formed, and the real “multi center governance” is realized to promote the collaborative participation of multiple governance entities, and the equal rights of nongovernmental data visualization governance entities in the governance process is ensured. In the constructed blockchain architecture, the

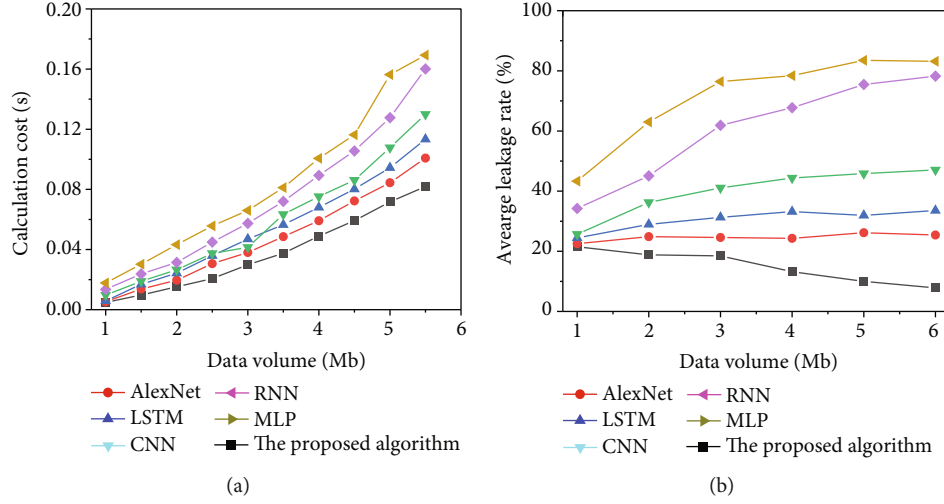


FIGURE 9: The influence curve of calculation consumption and average leakage rate with the increase of the amount of data under different algorithms ((a) calculation consumption; (b) average leakage rate).

Paillier encryption scheme applied therein is improved, and the inner product operation and maximum value operation are analyzed [26].

In the improvement of inner product operation, the plaintext vector  $x = \{x_1, x_2, \dots, x_n\}$  is given, the plaintext is encrypted with the public key  $pk = (n, g)$  to obtain the ciphertext vector.

$$E_{pk}[x] = \{E_{pk}[x_1], E_{pk}[x_2], \dots, E_{pk}[x_n]\}. \quad (26)$$

For another set of plaintext vector  $w = \{w_1, w_2, \dots, w_n\}$ , in the construction process, only the data owner  $S$  can obtain the specific information of  $x$ , while  $w$  can be obtained by both the data requester  $R$  and the data owner  $S$ .

Firstly, the data owner  $S$  is imnoised.  $S$  first performs imnoising processing on each element in the plaintext vector  $x = \{x_1, x_2, \dots, x_n\}$  to obtain the Equation (27).

$$x' = \{x_1 + r, x_2 + r, \dots, x_n + r\} \quad (27)$$

$r$  refers to the noise factor randomly generated by  $R$ , and  $r \in Z_n$ .

Then, the auxiliary inner product calculation is carried out for the data owner  $S$ .  $S$  performs inner product operation on the imnoised vector  $x'$  and plaintext  $w$ , and passes the operation result through the public key. After encryption of  $pk = (n, g)$ , the obtained ciphertext value  $E_{pk}[M]$  is sent to the data requester  $R$ .

Finally, the data requester  $R$  is denoised. In order to obtain  $E_{pk}[\langle w, x \rangle]$ ,  $R$  is needed to denoise  $E_{pk}[M]$ .

$$E_{pk}[\langle w, x \rangle] = E_{pk}[M] \times E_{pk} \left[ -r \sum_{i=1}^n w_i \right]. \quad (28)$$

$\langle \rangle$  indicates the inner product operation.

In the analysis of maximum operation, two plaintexts  $x_1$  and  $x_2$  are given,  $x_1$  and  $x_2$  are encrypted with the public key  $pk = (n, g)$  to obtain the ciphertext values  $E_{pk}[x_1]$  and  $E_{pk}[x_2]$ . In the construction process, only  $S$  can obtain the specific information of  $x_1$  and  $x_2$ , and  $R$  cannot obtain the comparison results.

Firstly, the  $S$  data of the data owner is imnoised.  $r(x_1 - x_2) - r'$  is obtained through imnoising the given two plaintexts  $x_1$  and  $x_2$  by  $S$ , and  $r, r' \in Z_n, r' \ll r$ .

Secondly, the data owner  $S$  assists the internal comparison calculation.  $S$  performs comparison calculation of imnoised  $r(x_1 - x_2) - r'$  with 0, then the result is encrypted with public key  $pk$  to obtain  $E_{pk}[i]$ , which is sent to  $R$ . The expression of  $E_{pk}[i]$  is as follows:

$$E_{pk}[i] = \begin{cases} E_{pk}[1], r(x_1 - x_2) - r' > 0, \\ E_{pk}[0], r(x_1 - x_2) - r' \leq 0. \end{cases} \quad (29)$$

Finally, the data requester  $R$  completes the processing of taking the maximum value.  $R$  uses the ciphertext comparison result  $E_{pk}[i]$  sent by  $S$  to complete the operation taking the maximum value of  $E_{pk}[x_1]$  and  $E_{pk}[x_2]$ .

$$\begin{aligned} \text{Max}(E_{pk}[x_1], E_{pk}[x_2]) &= E_{pk}[\max(x_1, x_2)] \\ &= E_{pk}[i(x_1 - x_2) + x_2] \\ &= \begin{cases} E_{pk}[x_1], i = 1 \\ E_{pk}[x_2], i = 0 \end{cases} \end{aligned} \quad (30)$$

$\text{Max}()$  refers to the operation of the maximum value.

After improving the Paillier encryption scheme, the rural relative poverty metadata is classified and calculated. The ciphertext is calculated as follows:



Firstly, the ciphertext of the input layer is calculated. During the operation of the input layer data on the ciphertext domain, the Paillier encryption scheme is used to encrypt the input plaintext data, so as to calculate a new ciphertext data [27, 28]. The output calculation of the input layer is actually the calculation of multiplication and addition in the ciphertext domain, which can be calculated by using the multiplication and addition in the original Paillier scheme.

Secondly, the hidden layer ciphertext operation is carried out. The input is the ciphertext output by the input layer, and the ciphertext calculation of this layer still uses multiplication and addition operations.

Finally, the output layer ciphertext is calculated. The input value is the ciphertext result output by the hidden layer. The ciphertext calculation of this layer also uses the constructed multiplication operation and the addition operation under the original Paillier scheme. From the original BP neural network, it can be found that each layer involves vector inner product operation. The improved inner product operation can be used to process the ciphertext calculation. For example, the ciphertext calculation of weight  $\omega$  and relative poverty governance metadata  $x$  is shown in

$$E_{pk}[y] = E_{pk}[\langle \omega, x \rangle] = \langle \omega, E_{pk}[x] \rangle. \quad (31)$$

In each layer, the ciphertext calculation involving the excitation function can use the constructed method for ciphertext operation. The specific operation method depends on the excitation function used. If the ReLU excitation function is used, the maximum operation can be adopted. If there is an input of ciphertext, when processed by ReLU excitation function, the output of ciphertext will be obtained.

$$E_{pk}[\Phi_t] = \text{Max}(E_{pk}[x_t], E_{pk}[0]). \quad (32)$$

**3.4. Experimental Analysis.** In order to verify the performance of the rural relative poverty collaborative governance of data visualization model based on blockchain and BP neural network, the experiment was carried out in the Ubuntu 16.04 system, and the alliance nodes were generated and the alliance chain was created based on Ethereum geth. A, B, C, and D nodes could act as data requester and data owner. The proposed BP neural network algorithm was based on python3.7. The specific parameters are set as follows: the neural network was set as double-layer, the input layer and hidden layer alternately used Sigmoid function and Relu function as activation function, the learning rate was set as 0.0002, the number of iterations (Epoch) is 60, and the amount of data is 1 Mb~6 Mb. The data set used the handwritten numeral set Mnist built in torch package in python, and 10 epoch training were done for each training sets to generate the model.

In the classification accuracy analysis of the algorithm model, it was compared with the algorithms applied by other scholars in related fields. LSTM [29], CNN [30], RNN [31], AlexNet [32], and Multilayer Perceptron (MLP) [33] were

selected for comparative analysis from Accuracy, Precision, Recall, and F1 values, as well as classification accuracy and encryption performance of different nodes and other evaluation indexes.

## 4. Results and Discussion

**4.1. Comparative Analysis of Accuracy of Algorithm Models.** In order to explore the performance of the rural relative poverty collaborative governance of data visualization model based on blockchain combined with BP neural network, the blockchain combined with BP neural network algorithm and LSTM, CNN, RNN, AlexNet, and MLP proposed by scholars in other related fields are analyzed from the perspectives of Accuracy, Precision, Recall, F1 value, and different nodes, The results are shown in Figures 6 and 7.

Comparing the system model with other neural network algorithms from the perspectives of Accuracy, Precision, Recall, and F1, it can be found that the classification prediction accuracy of the algorithm model reaches 94.31%, which is at least 3.23% higher than that of the algorithm models proposed by other scholars. Further from the perspective of Precision, Recall, and F1, it is found that the Precision, Recall, and F1 of the algorithm model are 92.19%, 80.18%, and 73.95%, respectively. Compared with other algorithms, it is obvious that the Precision, Recall, and F1 values of the algorithm model are higher, at least 3.62% higher than other algorithms. Thus, compared with the algorithm model proposed by other scholars in related fields, the rural relative poverty collaborative governance of data visualization model based on blockchain and BP neural network have better classification and prediction accuracy for rural relative poverty governance metadata.

Figure 7 shows the variation of loss reduction degree with the number of iterations under different algorithms. After the data requester  $R$  obtains the encrypted data set and encryption scheme of the data owner  $S$ , it uses the encryption scheme to process the local data plaintext with the same encryption algorithm to generate the ciphertext, and combines the encrypted data of  $S$  to obtain the loss reduction value by the phased classification model training. It is found that after many iterations, the loss reduction value of the algorithm model finally stabilized at about 0.22, while the loss reduction values of other algorithms are significantly greater than 0.22. Therefore, from the perspective of the loss reduction degree of the model, it is obvious that in the rural relative poverty collaborative governance of data visualization based on blockchain combined with BP neural network, the data loss reduction value is smaller and the reliability is higher.

When node A is the data requester, the classification accuracy of each algorithm shows an increasing trend with the increase of the amount of data. The classification accuracy of the algorithm model is basically stable at 95.13% when the amount of data is 6 Mb, which is significantly better than other algorithm models (Figure 8(a)). When node B is the data requester, the classification accuracy of each algorithm shows an increasing trend with the increase of the amount of data. The classification accuracy of the algorithm

model is basically stable at 94.02% when the amount of data is 6 Mb, which is significantly better than other algorithm models (Figure 8(b)). When node C is the data requester, the classification accuracy of each algorithm shows an increasing trend with the increase of the amount of data. The classification accuracy of the algorithm model is basically stable at 94.82% when the amount of data is 6 Mb, which is significantly better than other algorithm models (Figure 8(c)). When node D is the data requester, the classification accuracy of each algorithm shows an increasing trend with the increase of the amount of data. The classification accuracy of the algorithm model is basically stable at 95.16% when the amount of data is 6 Mb, which is significantly better than other algorithm models (Figure 8(d)). From the above experiments, the classification accuracy shows a stable upward trend after each node fuses the ciphertext data, and the order of the encrypted data shared by nodes A, B, C, and D is  $A > D > C > B$ .

**4.2. Analysis of Data Encryption Performance of Models under Different Algorithms.** The calculation consumption and leakage rate under each algorithm are further analyzed (Figure 9).

By analyzing the calculation consumption of each algorithm, it can be found that the calculation consumption increases with the increase of the amount of data. When the amount of data is 5.5 Mb, the calculation consumption of the algorithm model is 0.08 s, while the calculation consumption of the algorithm proposed by scholars in other related fields is significantly higher than 0.10 s (Figure 9(a)). Further from the analysis of the average leakage rate, it is found that the average data leakage rate basically has no significant change in the process of metadata transmission, and the data message leakage rate is no more than 10%, while the average data transmission leakage rate of other algorithm models is higher than 20% (Figure 9(b)). Therefore, from the perspective of different data volume, the algorithm model is obviously characterized by the lowest calculation consumption and average leakage rate. The rural relative poverty collaborative governance of data visualization algorithm model based on blockchain and BP neural network has good encryption performance of rural relative poverty governance data visualization.

## 5. Conclusion

With the maturity of blockchain technology in the application of public services, its application in the field of data visualization governance will be the general trend, which plays an important role in building an efficient, intelligent, democratic, and trusted multiagent participation mechanism. In view of the shortcomings and defects in rural relative poverty governance, artificial intelligence technologies such as blockchain and neural network are introduced to intelligently store and visually analyze the data in the process of rural relative poverty collaborative governance. Finally, a collaborative governance of data visualization model of rural relative poverty based on blockchain and BP neural network is constructed. Finally, through the experimental analysis, it

is found that the rural relative poverty collaborative governance of data visualization model, on the premise of ensuring the performance of high classification prediction (94.31%), the average leakage rate is finally stable below 10%, and the confidentiality performance is better, which provides an experimental basis for the intelligent development of follow-up rural relative poverty governance. However, there are some shortcomings in this work. For example, there will inevitably be many errors in the data collection process of this experiment. Human factors and environmental influences will make the data inaccurate. In the next step, we will deeply discuss the application and advantages of intelligent algorithms, Big Data, Cloud Computing, and other emerging information technologies combined with government audit, and use artificial intelligence, a new information technology, to build an intelligent government and handle smart government affairs, so as to optimize rural relative poverty governance. Secondly, the model proposed in this work should be further improved and perfected, so that relevant data in the field of poverty governance can successfully protect data privacy without being encrypted, and a better classification model needs to be studied.

## 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 no conflicts of interest.

## Authors' Contributions

Conceptualization, Xinjie Tian and Zhijun Ge; methodology, Xinjie Tian and Zhijun Ge; software, Xinjie Tian; investigation, Xinjie Tian and Zhijun Ge; writing—original draft, Xinjie Tian; writing—review and editing, Xinjie Tian; supervision, Xinjie Tian; project administration, Zhijun Ge; and funding acquisition, Zhijun Ge. All authors have read and agreed to the published version of the manuscript.

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## References

- [1] B. Ansari, M. Barati, and E. G. Martin, "Enhancing the usability and usefulness of open government data: a comprehensive review of the state of open government data visualization research," *Government Information Quarterly*, vol. 39, no. 1, article 101657, 2022.

- [2] A. Strantz, "Using web standards to design accessible data visualizations in professional communication," *IEEE Transactions on Communications*, vol. 64, no. 3, pp. 288–301, 2021.
- [3] Z. Lyu, Y. Yu, B. Samali et al., "Back-propagation neural network optimized by K-fold cross-validation for prediction of torsional strength of reinforced concrete beam," *Materials*, vol. 15, no. 4, p. 1477, 2022.
- [4] P. Yadav, Y. Malakar, and P. J. Davies, "Multi-scalar energy transitions in rural households: distributed photovoltaics as a circuit breaker to the energy poverty cycle in India," *Energy Research and Social Science*, vol. 48, pp. 1–12, 2019.
- [5] P. Lehoux, F. Roncarolo, H. P. Silva, A. Boivin, J. L. Denis, and R. Hébert, "What health system challenges should responsible innovation in health address? Insights from an international scoping review," *International Journal of Health Policy and Management*, vol. 8, no. 2, p. 63, 2019.
- [6] J. D. Sachs, G. Schmidt-Traub, M. Mazzucato, D. Messner, N. Nakicenovic, and J. Rockström, "Six transformations to achieve the sustainable development goals," *Nature Sustainability*, vol. 2, no. 9, pp. 805–814, 2019.
- [7] A. I. Ozdemir, I. M. Ar, and I. Erol, "Assessment of blockchain applications in travel and tourism industry," *Quality & Quantity*, vol. 54, no. 5-6, pp. 1549–1563, 2020.
- [8] A. F. Aysan, F. Bergigui, and M. Disli, "Blockchain-based solutions in achieving SDGs after COVID-19," *Journal of Open Innovation: Technology, Market, and Complexity*, vol. 7, no. 2, p. 151, 2021.
- [9] Z. Guohua, Z. Rujiao, and H. Yanhua, "Optimization of rural settlements and the governance of rural relative poverty," *Progress in Geography*, vol. 39, no. 6, article 06000902, 2020.
- [10] E. Beauxis-Aussalet, M. Behrisch, R. Borgo et al., "The role of interactive visualization in fostering trust in AI," *IEEE Computer Graphics and Applications*, vol. 41, no. 6, pp. 7–12, 2021.
- [11] J. Qiao, M. Crang, L. Hong, and X. Li, "Exploring the benefits of small catchments on rural spatial governance in Wuling Mountain Area, China," *Sustainability*, vol. 13, no. 2, p. 760, 2021.
- [12] M. Feenstra, L. Middlemiss, M. Hesselman, K. Straver, and S. Tirado Herrero, "Humanising the energy transition: towards a national policy on energy poverty in the Netherlands," *Sustainable Cities and Society*, vol. 3, p. 31, 2021.
- [13] X. Liu, S. X. Sun, and G. Huang, "Decentralized services computing paradigm for blockchain-based data governance: programmability, interoperability, and intelligence," *IEEE Transactions on Services Computing*, vol. 13, no. 2, pp. 343–355, 2019.
- [14] E. B. Sifah, H. Xia, C. N. A. Cobblah, Q. Xia, J. Gao, and X. Du, "BEMPAS: a decentralized employee performance assessment system based on blockchain for smart city governance," *IEEE Access*, vol. 8, pp. 99528–99539, 2020.
- [15] V. Hassija, V. Chamola, D. Nanda, G. Krishna, and M. Guizani, "A blockchain and edge computing-based secure framework for government tender allocation," *IEEE Internet of Things Journal*, vol. 8, no. 4, pp. 2409–2418, 2020.
- [16] L. A. Kleinknecht, "Can blockchain capabilities contribute to sustainable supply chain governance," *IEEE Engineering Management Review*, vol. 49, no. 4, pp. 150–154, 2021.
- [17] A. G. Scherer and C. Voegtlin, "Corporate governance for responsible innovation: approaches to corporate governance and their implications for sustainable development," *Academy of Management Perspectives*, vol. 34, no. 2, pp. 182–208, 2020.
- [18] Y. Li, Q. Zhang, G. Wang, B. McLellan, X. F. Liu, and L. Wang, "A review of photovoltaic poverty alleviation projects in China: current status, challenge and policy recommendations," *Renewable and Sustainable Energy Reviews*, vol. 94, pp. 214–223, 2018.
- [19] L. Xue, L. Weng, and H. Yu, "Addressing policy challenges in implementing sustainable development goals through an adaptive governance approach: a view from transitional China," *Sustainable Development*, vol. 26, no. 2, pp. 150–158, 2018.
- [20] A. Morisson and M. Doussineau, "Regional innovation governance and place-based policies: design, implementation and implications," *Regional Studies, Regional Science*, vol. 6, no. 1, pp. 101–116, 2019.
- [21] P. Howson and A. de Vries, "Preying on the poor? Opportunities and challenges for tackling the social and environmental threats of cryptocurrencies for vulnerable and low-income communities," *Energy Research & Social Science*, vol. 84, article 102394, 2022.
- [22] V. Filimonau and E. Naumova, "The blockchain technology and the scope of its application in hospitality operations," *International Journal of Hospitality Management*, vol. 87, article 102383, 2020.
- [23] Y. Yu, C. Wang, X. Gu, and J. Li, "A novel deep learning-based method for damage identification of smart building structures," *Structural Health Monitoring*, vol. 18, no. 1, pp. 143–163, 2019.
- [24] T. N. Nguyen, Y. Yu, J. Li, N. Gowripalan, and V. Sirivivatnanon, "Elastic modulus of ASR-affected concrete: an evaluation using artificial neural network," *Computers and Concrete*, vol. 24, no. 6, pp. 541–553, 2019.
- [25] Y. Yu, Y. Li, and J. Li, "Nonparametric modeling of magnetorheological elastomer base isolator based on artificial neural network optimized by ant colony algorithm," *Journal of Intelligent Material Systems and Structures*, vol. 26, no. 14, pp. 1789–1798, 2015.
- [26] D. Oberhauser, "Blockchain for environmental governance: can smart contracts reinforce payments for ecosystem services in Namibia?," *Frontiers in Blockchain*, vol. 2, p. 21, 2019.
- [27] A. Razaque, B. Alotaibi, M. Alotaibi et al., "Blockchain-enabled deep recurrent neural network model for clickbait detection," *IEEE Access*, vol. 10, pp. 3144–3163, 2021.
- [28] A. Yazdinejad, H. HaddadPajouh, A. Dehghantanha, R. M. Parizi, G. Srivastava, and M. Y. Chen, "Cryptocurrency malware hunting: a deep recurrent neural network approach," *Applied Soft Computing*, vol. 96, article 106630, 2020.
- [29] Y. Song, Y. Fu, F. R. Yu, and L. Zhou, "Blockchain-enabled internet of vehicles with cooperative positioning: a deep neural network approach," *IEEE Internet of Things Journal*, vol. 7, no. 4, pp. 3485–3498, 2020.
- [30] Y. Yu, M. Rashidi, B. Samali, M. Mohammadi, T. N. Nguyen, and X. Zhou, "Crack detection of concrete structures using deep convolutional neural networks optimized by enhanced chicken swarm algorithm," *Structural Health Monitoring*, vol. 21, no. 5, pp. 2244–2263, 2022.
- [31] V. Hassija, V. Gupta, S. Garg, and V. Chamola, "Traffic jam probability estimation based on blockchain and deep neural networks," *IEEE Transactions on Intelligent Transportation Systems*, vol. 22, no. 7, pp. 3919–3928, 2020.

- [32] R. Sujatha, V. Mareeswari, J. M. Chatterjee, A. M. Abd Allah, and A. E. Hassanien, "A Bayesian regularized neural network for analyzing bitcoin trends," *IEEE Access*, vol. 9, pp. 37989–38000, 2021.
- [33] S. Tanwar, Q. Bhatia, P. Patel, A. Kumari, P. K. Singh, and W. C. Hong, "Machine learning adoption in blockchain-based smart applications: the challenges, and a way forward," *IEEE Access*, vol. 8, pp. 474–488, 2019.