

Fuzzy Logic in Power Quality Management for Telecommunication Systems

Lead Guest Editor: P Karuppanan

Guest Editors: Marco Mussetta, Michele De Santis, and Shahid Hussain





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International Transactions on Electrical Energy Systems

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Retraction

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- (1) Discrepancies in scope
- (2) Discrepancies in the description of the research reported
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We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

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

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Research Article

A New Method for Fault Detection and Location in a Low-Resistance Grounded Power Distribution Network Using Voltage Phasor of D-PMUs Data

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Electric power grids are always affected by numerous unexpected faults. Occurrence of these faults will have a negative impact on network availability and reliability indices of the network. But the indicators of reliability and quality of electrical energy in the network can be augmented by locating the fault in the shortest time. Special features of distribution networks such as load and network imbalance, existence of different types of load with different connections, existence of multiphase branches, effects related to different conductors, capacitive effects of distribution lines, and limited numbers of measuring devices complicate the process of fault localization in distribution networks. On the other hand, increasing penetration of distributed generation units has caused conventional methods of fault localization. Therefore, it is mandatory to introduce new methods of fault locating by considering the mentioned features. Hence, in the current study, nonlinear methods are presented for identifying the location of ground faults in the power distribution network with the help of voltage phasor measurement at different network buses by the D-PMU phased distribution unit. In the first technique, the genetic optimization algorithms and particle swarm optimization for nonlinear modeling of fault position along the distribution line have been utilized for different single-phase, two-phase, and three-phase faults, and in the second technique, neural fuzzy network training has been proposed by different phasor measurement devices. In this case, it is enough to access the phase information of the network bus voltage. In order to show the effectiveness of the proposed algorithms, a 9-bus system is defined by MATLAB software and also defining different line lengths and line characteristics in different buses. Moreover, after applying single-phase, two-phase, and three-phase faults, as well as presenting the results, fault localization is detected in the shortest time.

1. Introduction

Nowadays, distribution and super-distribution networks have the highest number of different faults. Thus, the expansion of these networks and also the high volume of recorded information make these systems more complex. Consequently, it is imperative to implement a system in order to perform fault detection at the lowest possible time and with high reliability in distribution networks [1, 2]. The transmission line is an important component of the electrical power system and its protection is essential to ensure the stability of the system and reduce the damage done to the equipment due to a short connection in transmission lines

[3–5]. Transmission line relays have three important functions: detecting, classifying, and locating transmission line faults. Fast detection of a transmission line fault facilitates the fast separation of the faulted line from service; hence, it protects the system from harmful effects of the fault [6, 7]. Fault classification is the identification of the type of fault, and this information is essential for locating the fault and assessing the extent of repairs [8]. High accuracy of fault location is essential to facilitate rapid repair and separation of faulty line, improve reliability, and access to power source [9]. Various fault location (FL) schemes have been used in real systems, including phasor-based fault location (PHFL) techniques, which are still the most common [10]. These

solutions require estimation of the basic phases of voltage and current which are used as inputs to the FL formulae. Backup protection may be local, remote, or both [11, 12]. To realize the support of remote sensing protection, the use of phasor measurement units (PMU) has been subject to university and industry attention in several years.

Short circuit faults are common in transmission lines and are the worst type of faults that cause many hazards in lines such as reduced component life, increased power and heat loss of cables, and damage to insulation [13, 14]. Various types of short circuit faults occur during daily work and are mainly classified into two symmetric and asymmetric faults. Symmetric or balanced faults, which keep the system balanced, include three-line ground (LLLG) and triple-line (LLL) lines and are unlikely to occur, but they are the most severe type of short circuit faults, which include large destruction effects and damage to system equipment [15, 16]. Asymmetric or unbalanced faults that unbalance the power system during a fault include two-line ground (LLG), ground-to-line (LG), and line-to-line (LL) lines. Although their intensity is lower compared to balanced rivals, they are of great importance because one-to-ground faults are more than 80% likely to occur [17]. In this work, ground connection faults have been worked on.

In [18–20], smart meters (SMs) are placed in several system buses so that they do not synchronize prefault and fault voltage measurements. From the voltage drop vector, the flow distribution vector is calculated. The substation and all buses of DG have to be equipped with digital fault recorders (DFR). The amount of fault current is obtained through the sum of the currents injected by each DG and the source of the post. Knowing the system impedance matrix and fault current, different voltage drops are calculated for all buses with DG. Since the actual voltage sag is recorded on each bus with DG, the voltage drop calculated with the lowest fault, compared to the actual voltage drop, related to the fault location can be used [21, 22]. Therefore, such a method is based on classical analysis and does not require complicated mathematical techniques and load data; the fault occurrence position can be calculated with the help of voltage drop information at the beginning and end of the transmission line.

In the current study, a new method for locating faults in the distribution network using voltage phase information is introduced. Finding fault location in four stages is accomplished: first, the voltage before and during the fault is received by the phasor measurement equipment installed at the network buses. In the next step, utilizing the values of voltage drop in various phases of the power system, the types of single-phase, two-phase, and three-phase faults are calculated and estimated in proportion to each of these received voltage drops, and the segments with potential for fault are calculated according to the number of buses. In the third stage, using two nonlinear modeling methods using phasor measurement methods in each fault line, fault location for each of the fault types is extracted, and finally, due to the proposed techniques of genetic algorithm and swarm optimization of PSO particles and ANFIS neural fuzzy, the fault event location is achieved relative to the potential bus. In

addition, the algorithm utilizes an optimization of the coefficients of the third-order nonlinear model to investigate the range of faults estimated by minimizing the objective function to a detailed model to determine the fault location based on phasor measurement voltages of buses. The proposed method uses intelligent measuring equipment and D-PMU phase-measuring equipment to obtain voltage drooping. Distributed generation and loads were modeled as fixed impedance and then studied in the network. The proposed method is implemented in the IEEE 9 bus test distribution network as well as in the MATLAB simulator environment.

In this work, an endeavor is made to implement fault position detection in distribution networks using neural fuzzy network and optimization algorithms. Due to high volume of information in distribution networks, information monitoring is often encountered problems. Therefore, here, it has been tried to use voltage-phasor measurement information in buses. So, there is no longer the need for complicated mathematical calculations in other methods of fault detection such as impedance methods. Therefore, the phase voltage information is applied directly as input to the estimator system and with nonlinear modeling and according to fixed network information such as length and characteristics of network lines and types of single-phase, two-phase, and three-phase fault positions in the network, fault positions are tracked in the shortest possible time.

The contents of this paper are as follows. In Section 2, the study of the work carried out in the field of detection and positioning of events and faults is discussed in the power distribution network. Section 3 deals with background studies and provides basic concepts. Section 4 describes the proposed algorithms and techniques for accurate positioning and fault type. In Section 4, the 9-bus system studied under the MATLAB simulator and the results of the proposed techniques are discussed, and in the end, the performance evaluation of the method is presented according to the intended scenarios. Eventually, Section 5 summarizes the results of the study.

2. Literature Review

In [23], a model-free scheme is introduced which is capable of identifying the topology changes in distribution networks using the data of phase measurement units at the distribution level (DPMU). In this work, algebraic tools of behavioral system theory are utilized to progress easy-to-implement algorithms and the inherent problems associated with the D-PMU measurement and their proposed solution are discussed as an additional challenge to implement the proposed algorithms.

Frequency disturbance events (FDEs) occur due to various events such as generator trip (GT), blackout line (LO), and load interruption (LD) that affect the stability of power systems. Depending on the intensity of the disorder, small properties strongly affect the performance of the integrated system. Accurate and rapid recognition of the event and its location in monitoring the adequacy of resources and

preventing the economic loss and extinction is very imperative. The article [24], by concentrating on an advanced online hierarchical process, first recognizes the event and then identifies its classification. Finally, the exact location of FDE is found based on PMUs data. Compared with other articles, which are focused only on the classification or location of events, both goals are generated using the proposed new hierarchical framework. This study utilizes the deep learning (DL) progress for developing a recurrent neural network (RNN) model and a long short-term memory (LSTM) model for detection and localization of FDE with considerable precision. In this research, only a few time series frequency change rates (ROCOF) received from a limited number of PMUs are used as input to the DL algorithm. This hierarchical method has been tested on New England 39-bus, IEEE 14 bus systems, and the modified IEEE 118-bus system. The assessment results indicate the potential application of the proposed models for the detection and classification of FDEs compared to conventional algorithms and the frequency-based DL model. The proposed models have accomplished significant classification accuracy [25].

An imperative subject for fault classification in power distribution systems is the restriction of fault data for training classifiers to recognize types of power outages for repair. Measuring data from power systems are generally not labeled without specific types of faults, and labeled data with very limited types of faults are very limited and challenge educational classifiers with sufficient accuracy. Present fault classification methods for dealing with labeled small samples ascertain the underlying structures between labeled and unlabeled data. However, this line of methods has incorrect assumptions about nonlabel and labeled data and suffers from loss of accuracy when dealing with limited data that have a tag. The paper [26] suggests a novel latent structure learning under a multitask learning framework to supplement the information and address the challenges of limited-tagged data for fault organization. The proposed process not only uses the underlying structure of unlabeled data that is not used effectually but also eliminates the boundaries of learning the underlying structure by avoiding classifiers from being equipped with unlabeled data.

Rapid and accurate localization of electrical faults along power grids increases the reliability and continuity of the source, the rapid recovery of the power supply, and the consequent reduction of downtime. The paper [27] presents a method of locating network fault through multidata source information fusion. The compressed sensing algorithm is used to reconstruct the electrical signal twice and the rough fault amplitude and the degree of fault are achieved, respectively. Then, to attain the degree of switching fault of each element in the anomalous fault range, the Bayesian network is used. Finally, the DS evidence theory combines these two degrees of fault to obtain the result of spatial location. In [28], a new technique for online fault location tracking in distribution networks based on existing systems measurement using phasor units (PMUs) and iterative support detection (ISD) is presented. Through the fault event and by default, voltages are measured by PMUs that are optimally located along the

network. From the voltage change vector and the system impedance matrix, the flow change vector contains a nonzero element with the faulty part. Since PMUs are not located in all crossings, the system equation has already been determined. Hence, to solve a flow vector that has a rare nature, ISD method is utilized. The paper [29] considers the fault location algorithm suitable for medium unbalanced overhead distribution systems with or without distribution generation (DG). It should be noted that the proposed algorithm uses only simultaneous voltage measurement from two measurement points within the distribution system. Utilizing the basic fault analysis based on the bus matrix and the base impedance, objective algorithm estimates the fault position for each type of accurate short circuit fault. Fault resistance is considered in the algorithm, but it is not explicitly used in the transmission line impedance matrix.

To improve the sensitivity and reliability of system protection, detection, identification, and location are fundamental. This allows power systems to preserve stable performance. However, it is challenging in large-scale multidevice power systems. The authors in [30] present three new models of classification and deep learning regression (DL) based on deep neural networks (DNNs) for fault area identification (FRI), fault type classification (FTC), and fault location prediction (FLP). These new models ascertain transient data from pre- and postfault cycles for reliable decision making, while current and voltage signals are measured by phasor measurement units (PMU) at different terminals and are used as input features in DNN models. Here, sequential deep learning (SDL), through long short-term memory (LSTM) and high-dimensional multivariate features are utilized to model spatiotemporal series to accomplish accurate classification and prediction results.

Among the methods of fault localization, the most common of these methods is based on fundamental phase-based methods, whose approximation tends to converge with the stable state structure prior to opening the circuit breaker. Thus, conventional troubleshooters typically consider phase estimates obtained from shield relays or class P phase-measuring units, which show the time of filter delay less than the phasor measurement units of the class M. However, it is usually assumed that phasor measurement samples of M class are not suitable for fault location applications due to inherent filtering delays; studies on the possibility of using class M data-based fault locating programs are still scarcely found in literature [31]. The paper [32] was introduced to investigate whether the phasor measurement units of class M could be used in real location fault localization schemes using previously used measurement systems. In order to do so, the real fault events on the Brazilian electricity network are investigated and the performance of four different phasor measurement algorithms is assessed when phasor measurement models are used in a traditional protection relay algorithm and from the phasor measurement units of class M. As opposed to initial expectations, the obtained results indicate that the M-class phase measurements can be used in fault location applications because in the phase-based fault localization methods, faults are expected at the expected levels.

The authors in [33] present an approach that enables the fault location across the system using a small set of phase measurements. The proposed algorithm combines the prediction of voltage after fault and the scatter estimation. The obtained method allows for practical use of the scattering formula using Prony analysis to predict stable state voltages after faults at those buses equipped with phasor measurement units. A short transient recording is required for prediction only, which is usually accessible before the protective relays are activated. After the prediction stage, recognizing the location of the fault is essential from the least-angle scatter regression-based scattering estimation algorithm. However, for certain circumstances that are usually associated with small fault currents, the scattered estimate algorithm may not be able to accurately diagnose the location of the fault. To lessen this problem, ordinary least squares are used to increase the strength of the proposed method.

It is worthy to note that local protective elements such as fuses and relays are the first protection mechanism to overcome the fault and separation of the damaged portion of the power network. Although the capability of choice, speed, and sensitivity of these initial protective devices are relatively high and they cannot be considered flawless, there is small percentage of events for which the relays experience a fault occurrence. For these scenarios, a redundant arrangement can be made through backup protection. In [34], a centralized remote protection method based on two techniques, the Delta algorithm, and the least squares technique have been proposed. The proposed method identifies the transmission line, fault type, and distance to fault. Moreover, the phasor measurement unit data is utilized and is nonreproducible. According to phase measurement units, the network is divided into a number of subregions in order to accurately determine the location of the fault location. In the first stage, the affected area is located and then a deep search in the fault zone is carried out to determine the fault line. Ultimately, the fault distance is determined according to the distributed model of the transmission line.

In [35], a new high-voltage transmission line fault location scheme based on the use of support vector regression (SVR) has been proposed. The proposed scheme will only use the amplitude of the fault voltage wave amplitudes, measured at one end of the line. The various types of faults are investigated in different locations with different default impedance and types of fault initiation angles in the voltage transmission line of 400 kv and 300 km. Fault voltages are attained from the signals of the 1/8 cycle after the fault and also the removal of noise using a low-pass filter. The amplitude of the fault voltage signals is used as features for the SVR training. Subsequently, the SVR is used in the precise location of the fault on the transmission line. Compared to other fault locating schemes, the proposed scheme for estimating fault locations requires no information and a smaller data window. However, the proposed scheme gives more accurate estimates, regardless of fault types, fault initiation angles, and default impedance.

The paper [36] proposes a real-time fault detection technique and fault line detection capability obtained by calculating synchronous phase-based estimators. Each state estimator is characterized by different and reinforced topology in order to contain a floating fault bus. It should be

noted that the choice of state estimator that affords the correct solution is made by a criterion that calculates the sum of the weighted residues. The proposed process design is validated using a real-time simulation platform in which an active flow distribution network with a PMU-based monitoring system is simulated. It is postulated that the proposed process for active and passive networks, with neutral ground connection and without neutral ground connection, is appropriate for low and high impedance faults of any kind (symmetric and asymmetric) that occur in different places.

The authors in [37] present an innovative method for fault localization in distribution networks based on the analysis of classical circuits. Two synchronized and few nonsynchronized pre- and during-fault voltages are required in few buses beside the impedance matrix. A new impedance matrix manipulation method is suggested to survey the distribution system in partitions under multiple subsystems. This method allows the fault localization process to be solved by solving the equations of equations that are determined and this method is technically available. This fault is determined by analyzing the voltage drop across the terminal-bus of each subsystem separately.

Owing to the presence of different branches in the electric distribution network and the only accessible information on voltage and current at the beginning of the line and the unavailability of information at the end of the network, the detection of fault section in the distribution network is very essential. Smart meters are now used to measure voltage and flow of network lines, but due to limitations of installation sites, it is not possible to use these devices in all network lines. In [38], two techniques have been used to ascertain the fault section and the fault occurrence location in the network to estimate the fault distance at the beginning of the line with the current estimation at the end of each network line. Therefore, in this project, by installing smart meters in the main branch of the network, as well as information obtained from the current in the normal state of the network, we have tried to practically estimate the voltage and current at the beginning and end of each distribution. The network line in this method uses more power flow to compute the voltage drop and voltage estimation of the voltage and current at the end of the network lines to determine the fault area.

3. Conception

In power distribution networks, for accurate positioning of fault, different network states must be considered in fault estimation. In this section, we try to define concepts that are addressed and devoted to this article. First, the types of faults studied in this work are modeled and investigated for two fault detection systems in the network with no distributed generation sources and the impact of fault on the network will be discussed.

3.1. Types of Faults (Considered in This Study). Basically, the faults that may occur in a distribution feeder are single-phase to ground faults with ground resistance R_f and two-phase faults to ground with R_{arc} arc resistance and ground resistors R_f in different phases, and three-phase connection faults to ground. Before presenting the fault locating

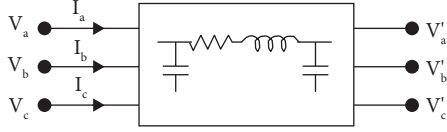


FIGURE 1: The circuit model of the branch division between the two buses.

algorithm, these three types of short circuit faults are modeled as shown in Figure 1.

3.1.1. Single-Phase to Ground-Fault Modeling. A single-phase short-to-ground fault with ground resistance R_f at distance d in terms of prionite from the node at the beginning of the fault section is shown in Figure 2. According to the figure, the relationship between the voltage at the beginning of the section and the location of the fault can be written as follows:

$$V_a = d \cdot (z_{11} \cdot I_a + z_{12} \cdot I_b + z_{13} \cdot I_c) + V_{fa}. \quad (1)$$

On the other hand, it can be written as follows:

$$V_{fa} = R_f \cdot (I_a - I'_a). \quad (2)$$

The value of the current phasor, I'_a , is obtained by implementing the load distribution algorithm presented in [39] in the downstream distribution feeder of point f holding the V_{fa} voltage phasor. However, since the location of point f , i.e., distance d , is unknown, so with a good approximation, the downstream distribution feeder of point S can be loaded

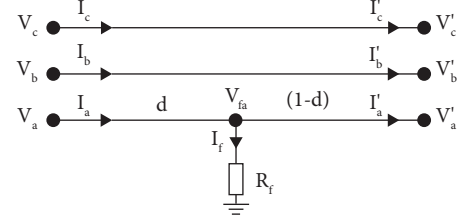


FIGURE 2: Single-phase fault circuit model.

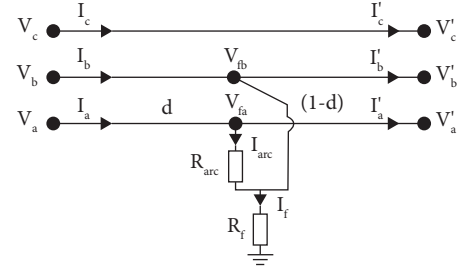


FIGURE 3: The circuit model of two-phase fault to each other and to ground.

without considering the fault with the existing voltage phase of V_a and the calculated current I_a instead of the current value I'_a used.

By substituting (2) in (1) and decomposing the result into two real and imaginary components, the values of R_f and d can be obtained; the value of d is given in the following relation:

$$d = \frac{\text{Im}[(\text{Re}(V_a) - j \cdot \text{Im}(V_a)) * (\text{Re}(I_a - I'_a) + j \cdot \text{Im}(I_a - I'_a))]}{\text{Im}[(\text{Re}(z_{11} I_a + z_{12} I_b + z_{13} I_c) - j \cdot \text{Im}(z_{11} I_a + z_{12} I_b + z_{13} I_c)) * (\text{Re}(I_a - I'_a) + j \cdot \text{Im}(I_a - I'_a))]} \quad (3)$$

3.1.2. Modeling Two-Phase Fault to Each Other and to Ground. In this case, a two-phase fault to each other and to ground occurred at a distance d from the beginning of the fault section with R_{arc} arc resistance and ground resistance R_f which is shown in Figure 3. As in the previous case, based on equation (1), the voltage of the faulty phases at the beginning of the desired section and the fault location can be written as the following equations:

$$\begin{aligned} V_a &= d \cdot (z_{11} \cdot I_a + z_{12} \cdot I_b + z_{13} \cdot I_c) + V_{fa}, \\ V_b &= d \cdot (z_{21} \cdot I_a + z_{22} \cdot I_b + z_{23} \cdot I_c) + V_{fb}. \end{aligned} \quad (4)$$

Regarding the aforementioned relations, the following relations are presented:

$$\begin{aligned} V_a - V_b &= d [(z_{11} - z_{21}) I_a + (z_{12} - z_{22}) I_b \\ &\quad + (z_{13} - z_{23}) I_c] + (V_{fa} - V_{fb}). \end{aligned} \quad (5)$$

On the other hand, it can be written according to Figure 3:

$$V_{fa} - V_{fb} = R_{arc} \cdot (I_a - I'_a). \quad (6)$$

By substituting (6) in (5), the values of R_f and d can be obtained as in the single-phase ground mode, with the fault distance d :

$$d = \frac{\text{Im}[(\text{Re}(V_a - V_b) - j \cdot \text{Im}(V_a - V_b)) * (\text{Re}(I_a - I'_a) + j \cdot \text{Im}(I_a - I'_a))]}{\text{Im}[(\text{Re}((z_{11} - z_{21}) I_a + (z_{12} - z_{22}) I_b + (z_{13} - z_{23}) I_c) - j \cdot \text{Im}((z_{11} - z_{21}) I_a + (z_{12} - z_{22}) I_b + (z_{13} - z_{23}) I_c)) * (\text{Re}(I_a - I'_a) + j \cdot \text{Im}(I_a - I'_a))]} \quad (7)$$

3.2. Fault Locating in the Distribution Network. In the first part, the fault location in the distribution network can be discussed without the presence of production sources and in the second part of the fault location in the distribution network with the presence of distributed generation sources. The fault of connecting three phases to ground is described here.

3.2.1. Fault Finding without the Presence of Distributed Generation Sources. The distribution network consists of all different branches. Branch is a part of the distribution network between two successive buses and there is only one line between which there is no other element. The single-line view of each section is shown in Figure 4(a). In this part, the π line model has been used for accurate modeling of each part. Therefore, the circuit model of each section can be extracted as shown in Figure 4(b).

To determine the fault distance according to the π model, the voltage line of point n at distance l from equation (8) is calculated [35].

$$\begin{bmatrix} V_{Rabcn} \\ I_{Rabcn} \end{bmatrix} = \begin{bmatrix} a_l & -b_l \\ -c_l & d_l \end{bmatrix} \begin{bmatrix} V_{Sabcn} \\ I_{Sabcn} \end{bmatrix}. \quad (8)$$

The coefficients a , b , c , and d are calculated from the following equations [21]:

$$\begin{aligned} a_l &= d_l = I + 0.5 \times Z_{ABC} \times Y_{ABC} \times I^2, \\ b_l &= Z_{ABC} \times I, \\ c_l &= Y_{ABC} \times I + 0.25 \times Y_{ABC} \times Z_{ABC} \times Y_{ABC} \times I^3, \end{aligned} \quad (9)$$

V_{Sabc} : voltage at the beginning of the line

I_{Sabc} : the current at the beginning of the line

Z_{ABC} : line impedance matrix

Y_{ABC} : the admittance matrix or capacitance of the line

V_{Rabc} : voltage at the end of the line

I_{Rabc} : the current at the end of a line

I : identity matrix

$$V_{Rabcn} = a_1 \times V_{Sabcn} - b_1 \times I_{Sabcn}, \quad (10)$$

$$I_{Rabcn} = -c_1 \times V_{Sabcn} + d_1 \times I_{Sabcn}. \quad (11)$$

Figures 5(a) and 5(b) show the single-line view and circuit model of a part of the distribution network when a fault occurs.

According to Figure 5(a), if fault occurs at location F , it can be observed. Hence, this can be created in the model line block π , before the fault point and after the fault point. When fault occurs at location F , the fault point voltage at distance x from the beginning of the branch is calculated with the following relation:

$$V_F = d_x \times V_S - b_x \times I_S. \quad (12)$$

Figure 6 shows the general model of the fault.

According to Figure 6, the fault-point voltage matrix is defined as follows:

$$\begin{bmatrix} V_{Fa} \\ V_{Fb} \\ V_{Fc} \end{bmatrix} = \begin{bmatrix} Z_{Fa} + Z_{Fg} & Z_{Fb} & Z_{Fc} \\ Z_{Fa} & Z_{Fb} + Z_{Fg} & Z_{Fc} \\ Z_{Fa} & Z_{Fb} & Z_{Fc} - Z_{Fg} \end{bmatrix} \begin{bmatrix} I_{Fa} \\ I_{Fb} \\ I_{Fc} \end{bmatrix}. \quad (13)$$

The fault phase has an opposite current of zero, so equation (13) in phase k is given equal to equation (12) and (14) results.

$$Z_{FK} \cdot I_{FK} + Z_{Fg} \cdot I_{Fg} = V_{SK} + x^2 \cdot 0.5 \cdot M_K - x \cdot N_K, \quad (14)$$

where I_F includes the sum of the fault currents in all phases.

$$\begin{bmatrix} M_a \\ M_b \\ M_c \end{bmatrix} = \begin{bmatrix} Z_{aa} & Z_{ab} & Z_{ac} \\ Z_{ba} & Z_{bb} & Z_{bc} \\ Z_{ca} & Z_{cb} & Z_{cc} \end{bmatrix} \begin{bmatrix} Y_{aa} & Y_{ab} & Y_{ac} \\ Y_{ba} & Y_{bb} & Y_{bc} \\ Y_{ca} & Y_{cb} & Y_{cc} \end{bmatrix} \begin{bmatrix} V_{Sa} \\ V_{Sb} \\ V_{Sc} \end{bmatrix}, \begin{bmatrix} N_a \\ N_b \\ N_c \end{bmatrix} = \begin{bmatrix} Z_{aa} & Z_{ab} & Z_{ac} \\ Z_{ba} & Z_{bb} & Z_{bc} \\ Z_{ca} & Z_{cb} & Z_{cc} \end{bmatrix} \begin{bmatrix} I_{Sa} \\ I_{Sb} \\ I_{Sc} \end{bmatrix}. \quad (15)$$

It should be noted that the results are from n equations where n represents the total number of fault phases. By dividing relation (14) into two parts, real and imaginary, and considering the pure resistance of Z_{Fa} , Z_{Fg} and Z_{Fc} , Z_{Fb} , respectively, the results are obtained:

$$\begin{aligned} R_{Fk} \cdot I_{Fkr} + R_{Fg} \cdot I_{Fkr} - x_{Fg} \cdot I_{Fki} \\ = V_{Sk} + x^2 \cdot 0.5 \times M_{kr} - N_{kr} = T_{kr}, \end{aligned} \quad (16)$$

$$\begin{aligned} R_{Fk} \cdot I_{Fki} + R_{Fg} \cdot I_{Fki} - x_{Fg} \cdot I_{Fki} \\ = V_{Sk} + x^2 \cdot 0.5 \times M_{ki} - N_{ki} = T_{ki}, \end{aligned} \quad (17)$$

where r represents the real part and i represents the imaginary part and is obtained by removing R_{Fk} from equations (16), (17), and (18). Im is the imaginary part and Re is the real part.

$$\begin{aligned} R_{Fg} \cdot \text{Im}[I_{Fk} \cdot I_F^*] - X_{Fg} \cdot \text{Re}[I_{Fk} \cdot I_F^*] \\ + [T_{kr} \cdot I_{Fki} - T_{ki} \cdot I_{Fkr}] = 0, \end{aligned} \quad (18)$$

$$\begin{aligned} R_{Fg} \cdot \text{Im}[I_F \cdot I_F^*] - X_{Fg} \cdot \text{Re}[I_F \cdot I_F^*] \\ + \sum_{k=\Omega k} [T_{kr} \cdot I_{Fki} - T_{ki} \cdot I_{Fkr}] = 0. \end{aligned} \quad (19)$$

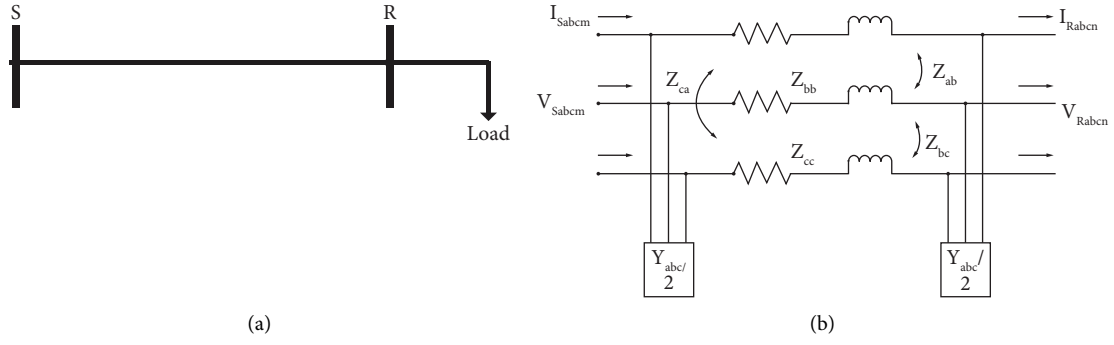


FIGURE 4: (a) Single line view of each part of the distribution network. (b) Circuit view of each part of the distribution network.

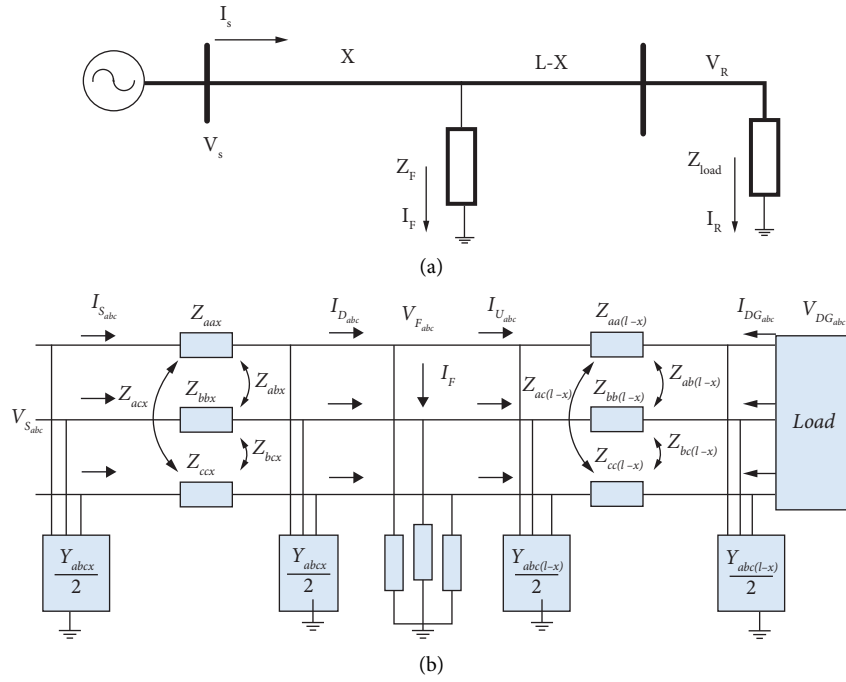


FIGURE 5: (a) Single line view of each part of the distribution network. (b) Circuit view of each part of the distribution network when fault occurs.

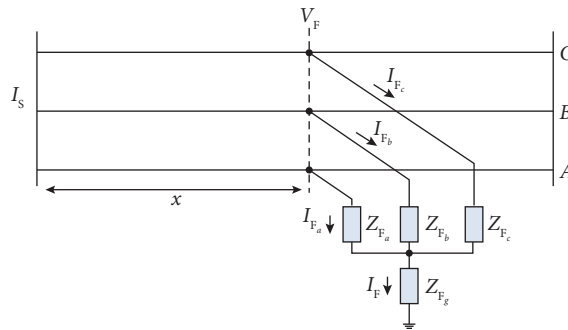


FIGURE 6: General view of resistance fault.

Given that the multiplication of two complex numbers in one's conjugate is equal to a real number and its imaginary part is zero, as well as the faults in the resistive power system, equation (14) has been rewritten from equations (11) and (12).

$$\begin{aligned} \text{Im}[I_F \cdot I_F^*] &= \text{Im}\{|I_F|^2\} = 0, \\ \sum_{k \in \Omega_k} [T_{kr} \cdot I_{Fki} - T_{ki} \cdot I_{Fkr}] &= 0, \end{aligned} \quad (20)$$

$$\begin{aligned} x^2 \left[0.5 \sum_{k \in \Omega_k} \text{Im}\{M_k \cdot I_{Fk}^*\} \right] - x \left[\sum_{k \in \Omega_k} \text{Im}\{N_k \cdot I_{Fk}^*\} \right] \\ + \left[\sum_{k \in \Omega_k} \text{Im}\{M_{sk} \cdot I_{Fk}^*\} \right] &= 0. \end{aligned} \quad (21)$$

In general, equation (21) can be rewritten according to

$$\begin{aligned} a_2 \times x^2 + a_1 \times x + a_0 &= 0, \\ \Delta &= a_1^2 - 4 \times a_2 \times a_0. \end{aligned} \quad (22)$$

So,

$$x_1 = \frac{(-a_1 \pm \sqrt{\Delta})}{2 \times a_2}. \quad (23)$$

3.2.2. Fault Location in the Distribution Network with the Presence of Distributed Generation Sources. To determine the fault distance in this section, an algorithm is first implemented for one section and this algorithm is generalized to more sections. Having the voltage and current at the beginning of the feeder and the voltage and current at the end of the feeder, which is the same voltage and current towards the distributed sources, the fault distance π is determined using the impedance algorithm based on the π model. Figure 7 shows a single-line view and circuit model of a distribution feeder with the presence of distributed generation sources.

Now, suppose fault occurs in the system. Figure 8 shows the error in the system. Fault point voltage is displayed with V_f . The fault point voltage is obtained by using the source voltage and the line model matrix π line, or by using the distributed source voltage, or, in other words, the line end voltage and the line matrix π model. The fault point voltage is equal from the source side and from the distributed generation sources.

Assume that the fault point voltage is calculated according to equation (8) by the source at distance x from

$$V_{Fs} = V_S + 0.5 \times zz \times Y \times V_S \times x^2 - zz \times x \times I_S. \quad (24)$$

The voltage of the fault point is calculated from equation (25) from the distributed generation sources that is located at the $l - x$ distance.

$$\begin{aligned} V_{FDG} &= V_{SDG} + 0.5 \times zz \times Y \times V_{SDG} \\ &\times (l - x)^2 - zz \times (l - x) \times I_{SDG}. \end{aligned} \quad (25)$$

The fault voltage from the distributed generation sources is set equal to the fault voltage from the source. A quadratic equation gives the following results:

$$\begin{aligned} 0.5 \times zz \times Y \times (V_S - V_{DG}) \times x^2 + Y \times zz \times l \times V_{DG} \\ - zz \times l \times V_{DG} \\ - zz \times (I_S - I_{DG}) \times x + V_S - V_{DG} \\ - 0.5 \times l^2 \times zz \times l \times I_{DG} &= 0. \end{aligned} \quad (26)$$

In general, equation (26) can be rewritten according to

$$\begin{aligned} a_2 \times x^2 + a_1 \times x + a_0 &= 0, \\ \Delta &= a_1^2 - 4 \times a_2 \times a_0. \end{aligned} \quad (27)$$

So,

$$x_1 = \frac{(-a_1 \pm \sqrt{\Delta})}{2 \times a_2}. \quad (28)$$

3.3. Genetic Algorithm (GA). Genetic algorithm is a computational model that solves optimization problems by imitating genetic processes and evolution theory [40, 41]. Solutions of a population set are used to form a new population set. This is hoped that the new population will be better than the previous population. The solutions that make new solutions are chosen according to their fitness: the more appropriate they are, the more likely they are for reproduction. This is repeated until some conditions (e.g., a number of generations or improvement in the best solution) are met. In traditional GA, all variables of interest must first be encoded as binary digits (genes) of a string (chromosome). To minimize a function $f(x_1, x_2, \dots, x_k)$ using GA, each x_i is first encoded as a dual or floating string of length m . Thus,

$$\begin{aligned} X_1 &= [11110, \dots, 01011], \\ X_2 &= [00101, \dots, 11110], \\ X_k &= [10001, \dots, 01001], \end{aligned} \quad (29)$$

where $\{x_1, x_2, \dots, x_k\}$ is called a chromosome and x_i is a gene. Then, three standard genetic operations, namely, reproduction, crossover, and mutation, are accomplished to produce the new generation [42, 43]. Such procedures are repeated until the number of predetermined generations can be achieved or accurately required. The results are illustrated by chromosomes and the methods are known as the fitness function. The evolution of the GAs is shown in Figure 9, while the original methods are introduced with three main definitions.

Selection: the process in which solutions must be maintained or entitled to disappear or be selected (or authorized solutions). The best solution is selected and others are eliminated. Here, the fitness function and the optimization are quantitatively determined.

Crossover: a new solution is created from existing solutions after the selection process.

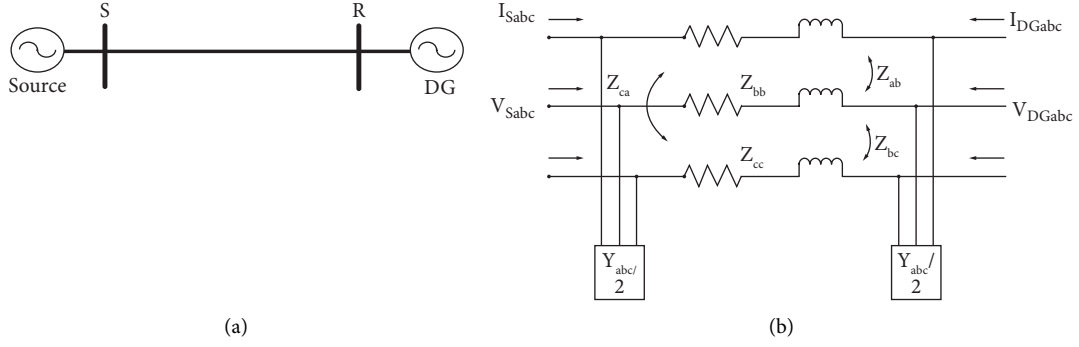


FIGURE 7: (a) Single-line view of a distribution feeder with distributed generation sources. (b) Circuit view of a distribution feeder with distributed generation sources.

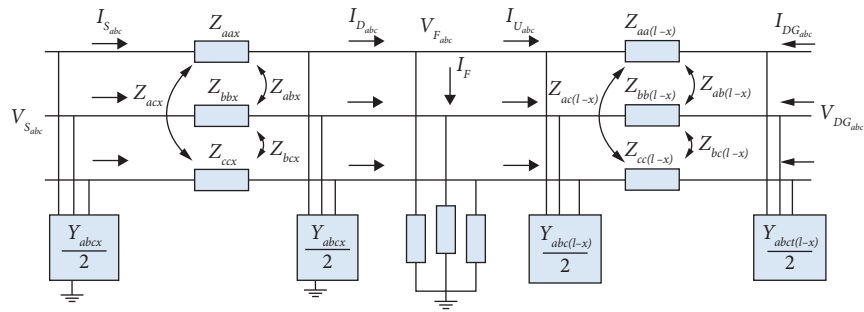


FIGURE 8: Incidence of errors in the distribution feeder with distributed generation sources.

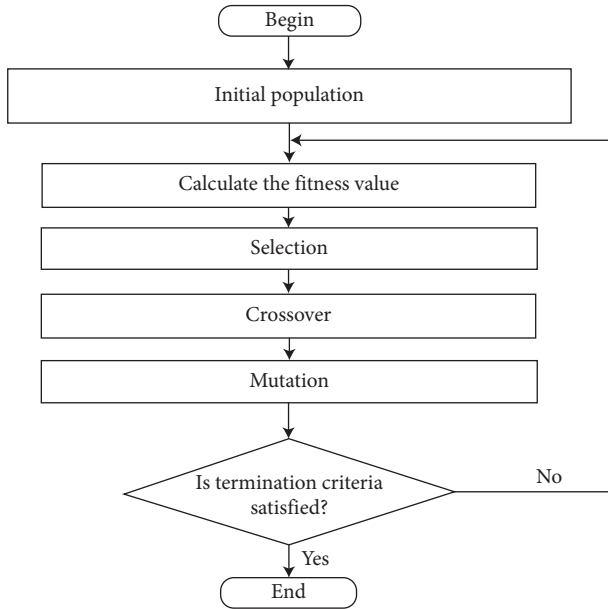


FIGURE 9: Flowchart of the standard genetic algorithm (GA) [41].

Mutation is the occasional introduction of new features into a solution string of the population. Mutation happens to preserve diversity within the population and prevent premature convergence.

3.4. Fuzzy Logic and Adaptive Neural-Fuzzy Inference System (ANFIS). Fuzzy logic is defined as a type of artificial methods used in the classification of fuzzy logic resource classification. Fuzzy logic theory is unclear in the scope of its activities or observations. In fact, fuzzy sets are developed, but it contains certain types of activities, such as “true-false” or numeric “1-0.” Fuzzy logic is known for its simplicity and ease in the design of the algorithm, but when increasing the complexity of the system, you have difficulty to determine the appropriate set of rules and functions. In general, fuzzy rules and membership function are based on the behavior of the method learned by the neural network using input and output data [44]. Figure 10 shows an example of the membership functions created by the fuzzy rule generator.

In this study, the use of ANFIS is introduced. ANFIS is the intersection of an artificial neural network (ANN) and a fuzzy logic inference system. An artificial neural network is designed to mimic features of the human brain and includes a set of artificial neural cells. An adaptive system is a multilayer system in which each node (neuron) plays the capacity of the input signals. You can read more about the structure of ANFIS in [45–47]. Figure 11 shows a general diagram of the structure of ANFIS. In this figure, fixed nodes with a circle and adaptive nodes with a square are shown. The ANFIS technique uses the Sugeno fuzzy model [49], in which the fuzzy rules (if-then) are formulated by

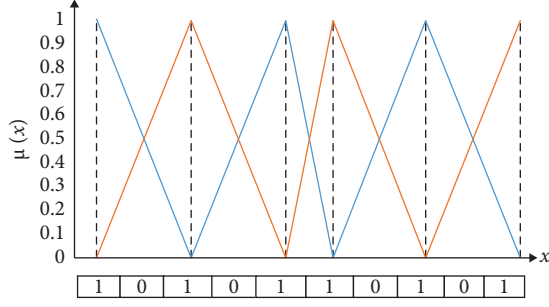


FIGURE 10: Membership function of fuzzy logic.

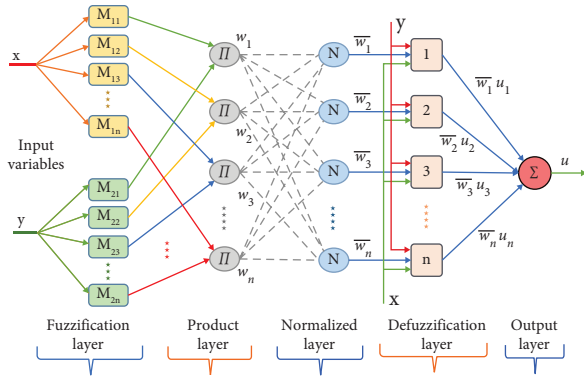


FIGURE 11: Schematic diagram of adaptive neuro-fuzzy inference system (ANFIS) architecture [48].

$$R_n \&9; = \text{if } M_{1i}(x) M_{2i}(y), \text{ then } f \quad (30)$$

$$\&9; = p_n x(t) + q_n y(t) + r_n,$$

where n represents the number of rules. Note that M_{1i} and M_{2i} represent fuzzy membership functions. p_n , q_n , and r_n represent the linear parts of the corresponding n law.

Note that the first layer of ANFIS contains the initial fuzzification in which the degree of membership functions is represented using the input variable. Typically, each node in the layer represents an adaptive function formulated by [50]

$$M_{1i} = \frac{1}{1 + [X - c_i/a_i]^{b_i}}, \quad (31)$$

where (a_i, b_i, c_i) represent the set of parameters. Note that layer 2 stands for the product inference layer in which each node called P is controlled by a specific fuzzy rule. Note that the w_i output of the layer is displayed as follows:

$$w_i = M_{1i}(e) \times M_{2i}(\Delta e). \quad (32)$$

In turn, the third layer shows a normalization layer, while the transfer power calculated from the previous layer is normalized:

$$\bar{w}_i = \frac{w_i}{\sum_i (w_i)}. \quad (33)$$

Layer 4 receives the normalized values from the third layer. Note that each node in this layer represents a defuzzification mode with the node function as follows [51, 52]:

$$\bar{w}_i u = \bar{w}_i (P_i e + q_i \Delta e + r_i), \quad (34)$$

where (p, q, r) , the result parameter, is set when u represents the control signal passed. Note that in the last layer, you have to calculate the sum of all the internal signals to collect the output of the rules [48]:

$$\sum_i (\bar{w}_i u) = \frac{\sum_i w_i u}{\sum_i w_i}. \quad (35)$$

4. The Proposed Method

Here, we describe our proposed process for detecting and locating faults in a default power distribution network. Regarding the studied faults, three models of single-phase, two-phase, and three-phase are studied, which can be generalized to other types of faults and only pay attention to ground connection faults. According to theoretical studies, as observed, the fault location estimation contains many complications and, on the other hand, the availability of branch flow or sections is critical and the problem of computation in different branches will require a series of computational complexity. This is while the voltage calculation at the feeder is independent of the path and the graph in the distribution network. Here, we focus our attention on the calculation of the error distance with the help of the voltage phasor measurement and not the calculation of the branch flow in the distribution network. In the proposed technique, we need only the amount of voltage phasor in the buses. Based on this, in a single network studied at a point of a unit D, PMU feeder is responsible for measuring the total voltages and is measured at any moment of time. The basis of our work in this paper is to calculate the voltage drop in each feeder when the error occurs when the fault occurs. It is also based on the proposed scheme to identify fault location after 0.1 s. Figure 12 shows the flowchart of the proposed scheme.

In this scheme, the phasor measurement voltage of each bus is checked regularly, and then the moment of the fault occurrence is detected by sudden voltage drop, which is determined in the next stage; according to the effective voltage drop in each phase, the type of ground connection fault of one, two, and three phases is determined and we enter the next stage. In this section, the difference between the voltage drop of each bus and the bus on the other side of each branch is calculated and aggregated for 0.1 seconds. Nodes with a more severe voltage drop are introduced, respectively, and any bus with a higher voltage drop is identified as a node subject to fault. Therefore, the fault must be calculated in the branches close to it. In the following, the calculated values of the difference in voltage drop of the branch are given to the fault positioning systems. In addition, information including line length and line length impedance according to model π is extracted for the fault event branch and this information is given to the fault location estimation system. In the last phase, the fault location estimation system analyzes these data factors and informs the operator the exact location of fault.

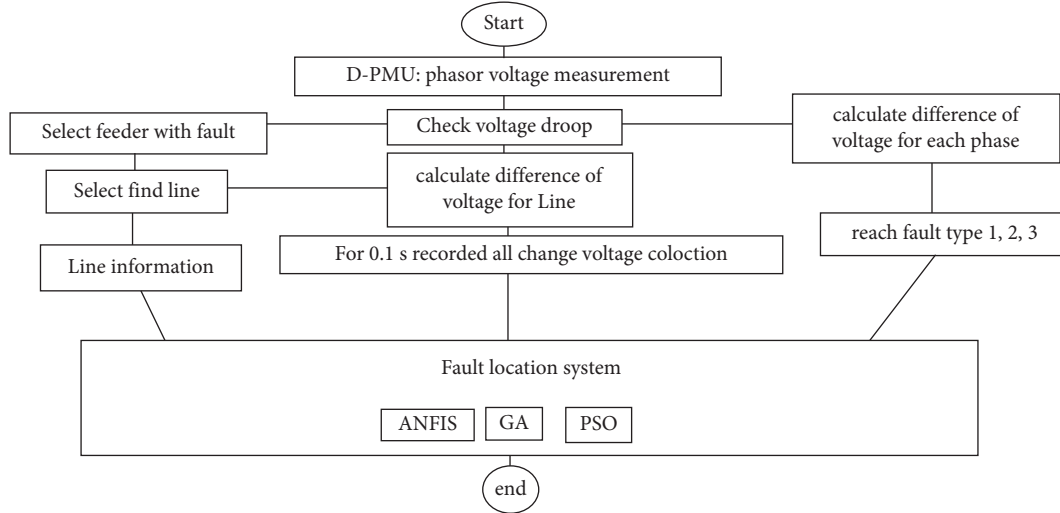


FIGURE 12: proposed flowchart.

4.1. Fault Location Estimation System along the Line. In this paper, we use three techniques to estimate the location of the fault along the line. The test data are extracted to investigate the faults and their information. Then, using a nonlinear model, we choose the location of the faults with the help of fuzzy neural methods, particle swarm optimization, and genetic algorithm. We have achieved an optimal model for estimating fault location in different types in the ANFIS method. In the following techniques, a nonlinear model of the third-order Taylor expansion is used, and we use the squares of the difference between the values of the nonlinear function and the real value as the objective function to determine the coefficients of the third-order nonlinear model, expressed in equation (36). With the help of the algorithms described above, these optimal coefficients are calculated:

$$\begin{aligned}
 \text{function } z &= \text{fitnessfunction}(x, y), \\
 z &= \text{sum}(\text{abs}((x(1) * y(: 1).\hat{3} \\
 &+ x(2) * y(: 1).\hat{2} + x(3) * y(: 1) \\
 &+ x(4).\hat{2} - y(: 2).\hat{2})); \text{end.}
 \end{aligned} \tag{36}$$

The target variables in this system are x_1, x_2, x_3 , and x_4 , which are defined as nonlinear models according to the input and output variables y_1 and y_2 .

5. Simulation Results

In this section, the performance results of the proposed design based on three methods of location estimation including fuzzy neural network and nonlinear model optimized with genetic algorithm and particle swarm algorithm are reviewed and compared. In this work, the 9 bus network studied is shown in Figure 13. Information about each line in the network is collected and uploaded under MATLAB software. In this case, when for a grid defined in terms of the length and connections and impedance of the lines, the proposed systems are trained for the next steps for detection

and test data, it works completely fast and in real time. The specifications of the computer used in this work are Intel Core i5 M480 @ 2.67 GHz.

Figure 14 illustrates the voltage drop for the error event in a branch between the 7 and 8 buses and displays the impact of this single phase error on the voltage drop at the different buses. The 25 km line has the highest voltage drop on the 7 and 8 bus. In Table 1, different fault cases have been investigated and selected, and for different fault lengths, it has been determined as the first option. According to Figure 14, the amount of voltage drop is different for different types of faults and the type of fault can be determined with a demarcation.

Figures 15–17 show the results of estimating the fault position with ANFIS, GA, and PSO methods, respectively, based on the comparison of actual and estimated results, and Table 2 shows the average fault percentage of the performance of all three methods. Based on the reviewed results, ANFIS method has provided more accurate results.

According to Table 1, for the types of faults taught to the estimator systems, in the first step, the location of the fault bus is identified, and in the second step, the exact position of the error is identified. First, the phasor voltage of each bus is regularly checked, and then the moment of the fault is detected by the sudden voltage drop. In this part, the amount of difference between the voltage drop of each bus and the bus on the other side of each branch is calculated, and according to the order of priority in the voltage drop that occurred in the buses, the locations of the buses with the most voltage drop are prioritized according to Table 1. In the next step, according to the effective voltage drop in each phase, the grounding fault type of one, two, and three phases is determined and we enter the next step. The first and second priority busses with the middle branch are prone to errors. Therefore, the error should be calculated in the branches close to it. In the following, the calculated values of the voltage drop difference of the branch are given to the fault location systems, along with that, the information including line length and line length impedance is extracted

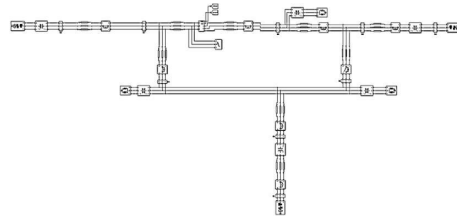
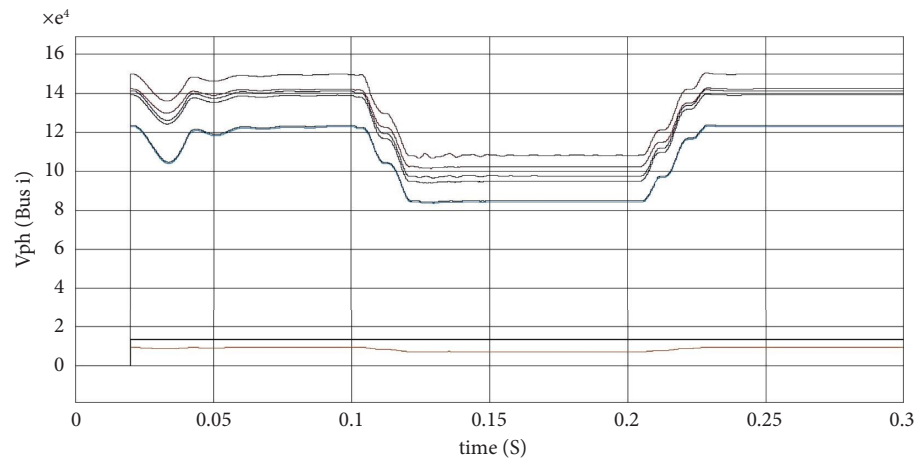
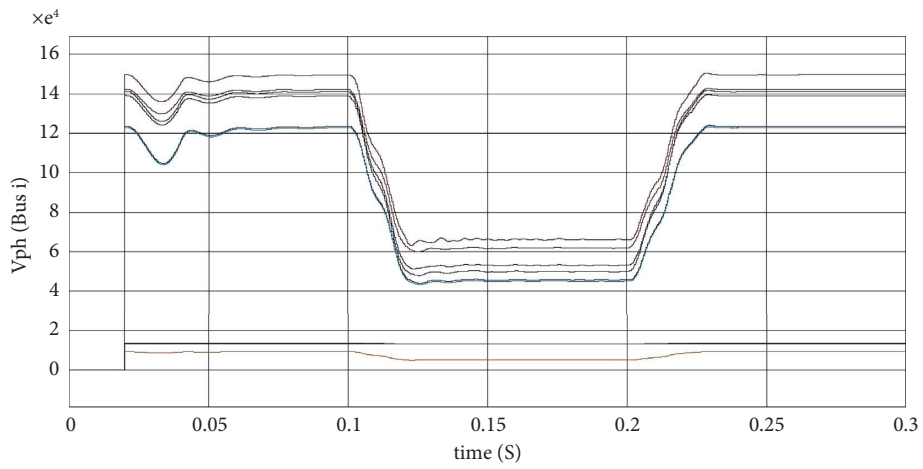


FIGURE 13: View the 9 bus distribution network under study.



(a)



(b)

FIGURE 14: Continued.

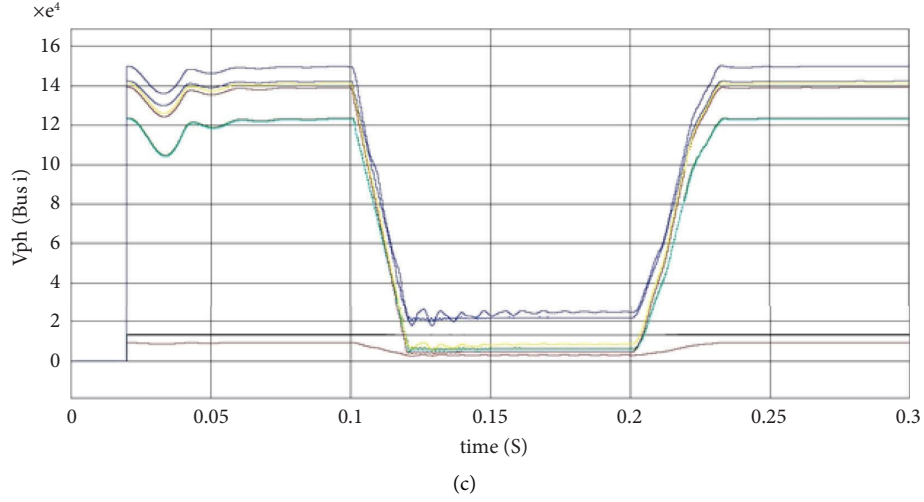


FIGURE 14: Display voltage drop for fault occurrence at a distance of 25 km. (a) Single-phase fault, (b) two-phase to ground, and (c) three-phase to ground.

TABLE 1: Display fault busses at different lengths.

Types of fault	1	1	2	2	3	3
Bus first priority	7	8	7	8	7	8
Bus second priority	8	9	8	9	8	9
Bus third priority	9	7	9	7	9	7
Distance	25	60	25	60	25	60

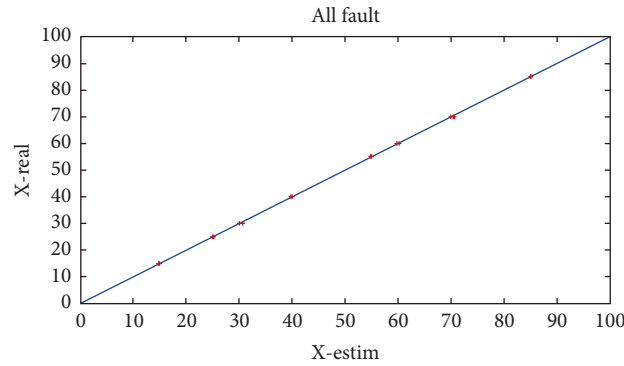


FIGURE 15: Adaptive neural fuzzy network fault length estimation system.

according to the π model for the same branch where the fault occurred, and this information is given to the fault location estimation system to be. In the last step, the fault location estimation system checks these information factors and informs the operator of the exact distance of the fault from the bus with the first priority. Table 2 shows the possible error in distance estimation for different proposed methods.

This means the estimated distance for grounding event with this amount of distance estimation tolerance.

According to Table 2, neural fuzzy methods and GA genetic algorithms and PSO particle swarm have been used as different and comparative techniques to estimate the location and distance of different errors. Among these, the ANFIS neural fuzzy method has been able to identify the

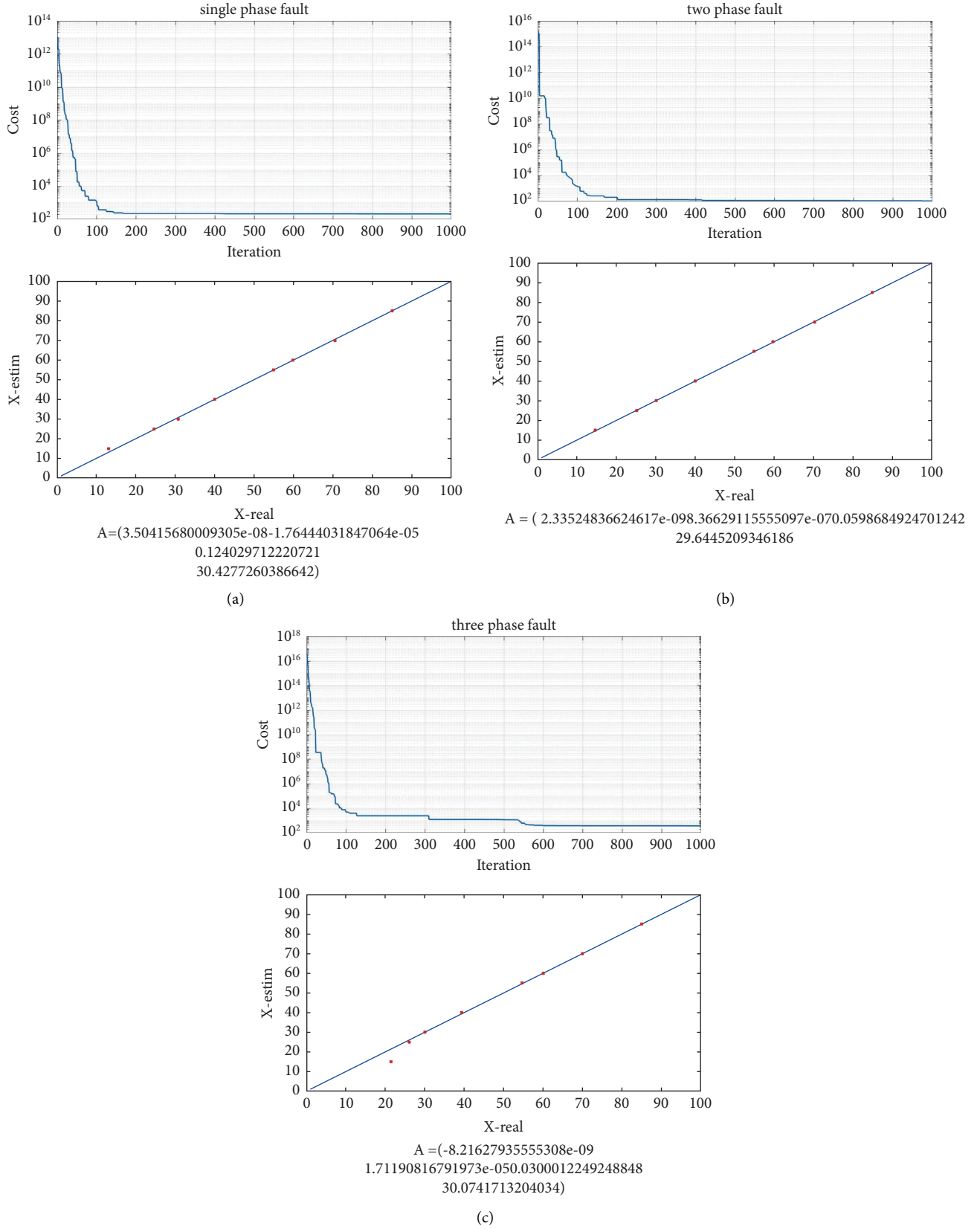


FIGURE 16: Nonlinear length estimation system optimized by genetic algorithm. (a) Single phase, (b) two-phase fault to ground, and (c) three-phase fault to ground.

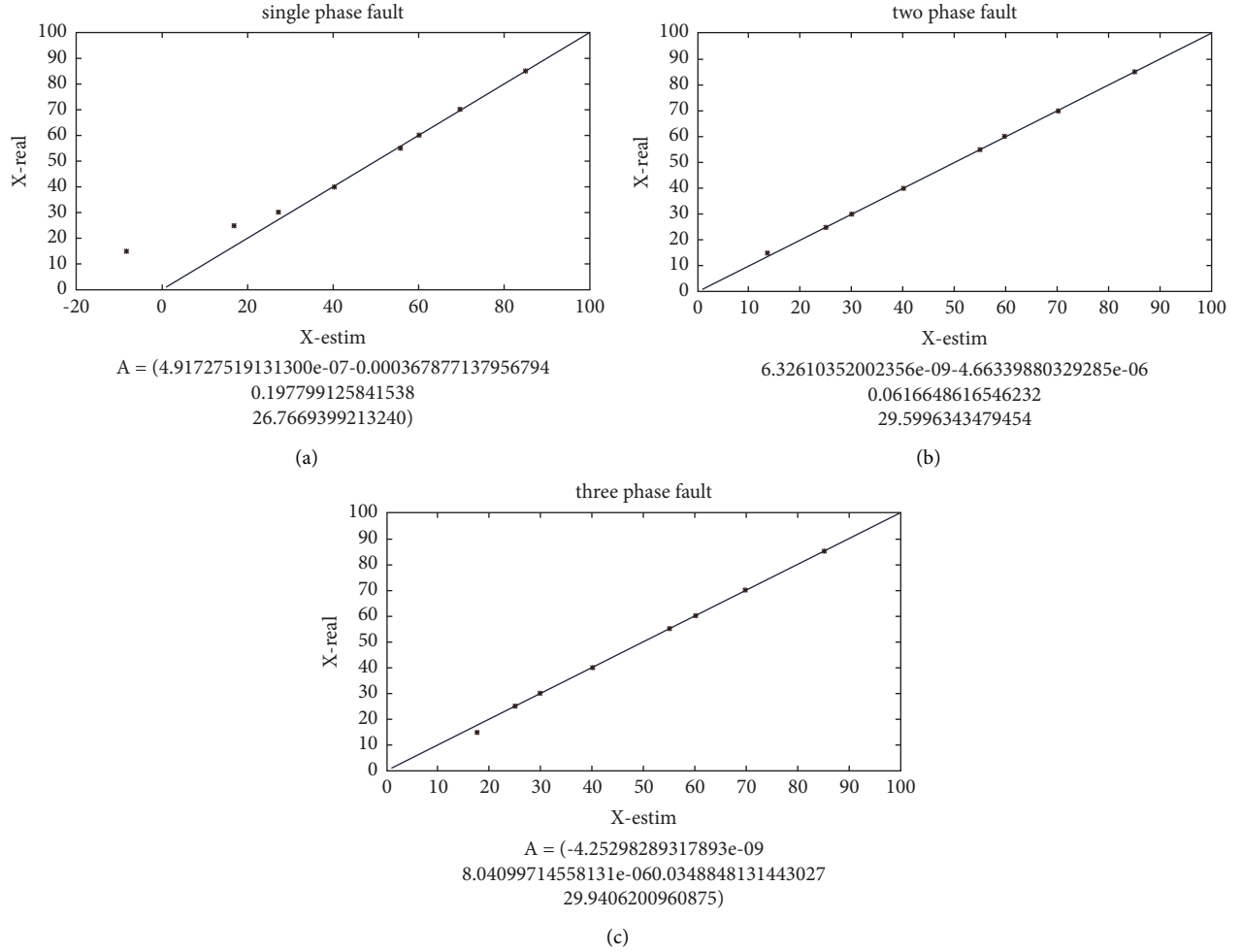


FIGURE 17: Nonlinear fault length estimation system optimized by particle swarm algorithm. (a) Single phase, (b) two-phase fault to ground, and (c) three-phase fault to ground.

TABLE 2: Comparison of the accuracy of the proposed estimating systems.

Proposed techniques	ANFIS	GA	PSO
Fault percentage for test samples (%)	0.34	2.54	6.3

exact location of the earth connection fault with the highest accuracy and lowest error tolerance.

6. Conclusion

Due to the increasing use of distributed generation sources in distribution networks, new proposed methods for finding fault in distribution network were provided by the presence of distributed generation sources to determine the fault location using the voltage information recorded at the beginning and end of the feeder and the distributed generation source. Due to the extent of distribution networks and the existence of multiple branches, fault locating in distribution networks is complicated into two parts: fault spacing in the distribution network without the presence of distributed generation sources and fault spacing in the distribution network with the presence of distributed generation sources.

In this paper, the fault location was performed using a nonlinear quadratic equation model optimized with GA and PSO algorithms and the ANFIS neural fuzzy intelligent model without the presence of distributed generation sources in the distribution network with the presence of distributed generation sources using circuit relationships. The proposed methods were placed in different conditions such as single-phase, two-phase, and three-phase ground connection faults in different locations in the 9-bus network, and the results show the high accuracy of the proposed methods. Among these, the ANFIS method has shown better performance for correct fault locating.

Data Availability

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

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Retraction

Retracted: Quality Control Strategy and Evaluation Algorithm for Noncontact Instrument Testing

International Transactions on Electrical Energy Systems

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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) 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.

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- [1] X. Jin and J. Tang, "Quality Control Strategy and Evaluation Algorithm for Noncontact Instrument Testing," *International Transactions on Electrical Energy Systems*, vol. 2023, Article ID 5080240, 10 pages, 2023.

Research Article

Quality Control Strategy and Evaluation Algorithm for Noncontact Instrument Testing

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The test quality of noncontact instruments is an important issue that has aroused social concern at present, which is also widely used in the power quality management of telecommunication systems. The fuzzy logic algorithm can be used in power quality testing to analyze the power quality of electrical equipment. Based on the advantage of the fuzzy logic algorithm, this paper studied the quality control strategy and evaluation algorithm of noncontact instrument testing and drew a conclusion. In terms of the investigation on the safety of power quality measurement, it was concluded that the method of noncontact instrument testing power quality improved the safety of voltage quality, current quality, power supply quality, and power consumption quality. In the investigation of the accuracy of the power quality measurement, it was concluded that the noncontact instrument was used to measure power quality, which greatly improved the accuracy of measurement. In terms of the investigation on the rapidity of the power quality measurement, it was concluded that the use of the noncontact instrument to test power quality could greatly improve the rapidity of current quality measurement and that the rapidity of the power quality measurement could be improved by more than 70%. In the aspect of economic investigation of the power quality measurement, it was concluded that the use of the noncontact instrument to test power quality could greatly improve the economic efficiency of the power quality measurement. In the aspect of fuzzy logic evaluation in power quality management, it was concluded that most of the power quality grades of the selected research objects were excellent. Therefore, the fuzzy logic method was very meaningful for power quality evaluation.

1. Introduction

The traditional power quality testing method usually uses a harmonic detection method. This detection method often injects a lot of harmonics into the power system because of the nonlinearity of the rectifier and frequency converter, which causes harmonic pollution, brings adverse effects to the environment, and causes panic among the masses. In order to avoid environmental pollution, improve the testing effect of power quality testing methods, and enhance the safety, rapidity, and convenience of testing, it is necessary to study the control strategy and evaluation algorithm of noncontact instrument testing power quality with a fuzzy logic method.

At present, there are many research studies on quality testing. Squara et al. introduced the main measurement quality standards and verification procedures for measuring instrument characteristics [1]. Grano et al. used the test cases of source code quality indicators for lightweight evaluation of effectiveness [2]. Bennert et al. studied the performance index of asphalt mixture determined by the indirect tensile test in the quality control test of New Jersey [3]. Manta et al. studied the statistical quality control method for the validation of the immunochromatographic rapid detection kit based on gold nanoparticles [4]. Yeh and Chen improved the test quality of integrated circuits to achieve the repeated test application of zero defect product requirements [5]. The research of quality testing mostly focuses on the methods

and strategies of quality control, and there is little research on noncontact instruments.

In recent years, the noncontact instrument has been widely concerned by scholars and has also been deeply studied. Lanza et al. analyzed the difference between the intraocular pressure assessment with contact and noncontact devices [6]. Goyal et al. studied the placement strategy of noncontact sensors for condition monitoring of rotating machine components [7]. Gulino et al. used gas-coupled laser acoustic testing for noncontact ultrasonic testing [8]. Pelivanov et al. used noncontact photoacoustics to identify the molecular fingerprints of nanoparticles in complex media [9]. Singhvi et al. studied a microwave-induced thermoacoustic imaging system with noncontact ultrasonic testing [10]. The research of noncontact instruments is mostly on ultrasonic testing, but there is little research on quality testing.

In order to improve the effect of power quality testing, this paper designed a method of noncontact instrument testing quality based on the fuzzy logic method and explained its control strategy and evaluation method. At the same time, this test method was compared with the traditional power quality test method. The safety, accuracy, rapidity, and economy of the power quality test were selected as the evaluation indicators, and finally, the feasibility conclusion was drawn. This paper provided a theoretical and practical basis for the analysis of control strategies and evaluation algorithms for the testing quality of noncontact instruments.

2. Noncontact Instrument Testing Technology

Noncontact measurement is a measurement technology based on photoelectric, electromagnetic, and ultrasonic technology. It can obtain the surface characteristic information of the object without the sensor of the instrument contacting the surface of the object being measured [11].

Typical noncontact measurement methods can be divided into optical and nonoptical ones, as shown in Figure 1.

Optical methods include structured light, laser triangulation, laser ranging, interferometry, and image analysis [12]. Nonoptical methods include acoustic measurement, magnetic measurement, X-ray scanning, and eddy current measurement. However, the research in this paper mainly focuses on the detection of power quality management in the telecommunication system, so the eddy current measurement method is mainly studied.

2.1. Eddy Current Method. According to the principle of electromagnetic induction, when the metal conductor is placed in the alternating magnetic field or the magnetic field where the magnetic field lines intersect, there would be eddy currents in the conductor, which are called eddy currents [13]. The eddy current sensor is based on the effect of the eddy current on the sensor. It has high reliability, high sensitivity, fast response time, and other characteristics. A typical device is a cable core device, and its structure is shown in Figure 2.

The basic principle is that the coil sensor uses alternating current to create a magnetic field, which induces current in the metal conductor. The magnetic field generated by the induced current weakens the magnetic field generated by the coil and affects the inductance of the coil. With the change in the induced current, the distance between the metal conductor and the coil changes and the inductance of the coil changes accordingly. The distance between the coil and the conductor can be measured by the change in inductance.

The vortex current measurement method is characterized by using a small eddy current sensor, which is very reliable in continuous operation and can measure displacement, velocity, voltage, thickness, surface temperature, material damage, etc. Typical sensors are speed sensors and eddy current thickness sensors. The disadvantage of eddy current measurement technology is that the measured object must be a metal conductor with a certain thickness and smooth surface, and other metal end faces cannot be used around the sensor coil.

2.2. Development Trend of Noncontact Instrument Testing Technology. At present, the development of noncontact instrument testing technology is moving towards the direction of high integration, high precision, high accuracy, and high intelligence, as shown in Figure 3.

2.2.1. Highly Integrated. The principle of noncontact measurement technology has been mature, but most of the measuring products at this stage have a single function and cannot achieve multifunction noncontact measuring instruments [14]. High integration is realized in the stereo vision room, such as integrated noncontact temperature measurement, displacement measurement, and vibration measurement, which greatly improves the practicability of the product. This would help reduce the purchase cost of measuring instruments for enterprises and accelerate the promotion and application of noncontact measurement technology.

2.2.2. High Precision and Accuracy. The current situation of noncontact measurement technology is not even as accurate as that of contact measurement technology. This requires the development of high-precision optical and electronic components as well as excellent analysis and processing software. Only in this way, the accuracy of measuring instruments in terms of shell cost can be improved, and finally, an all-round product higher than that of contact measurement technology can be realized.

2.2.3. Reduced Requirements for the Working Environment. Noncontact measurement technology is mainly based on optical elements. The harsh environment has a great impact on the working accuracy and accuracy of optical elements. In the bad working environment, optical measuring instruments cannot even work normally. This is a technical problem that needs to be solved urgently, and it is also the development direction of noncontact measurement technology.

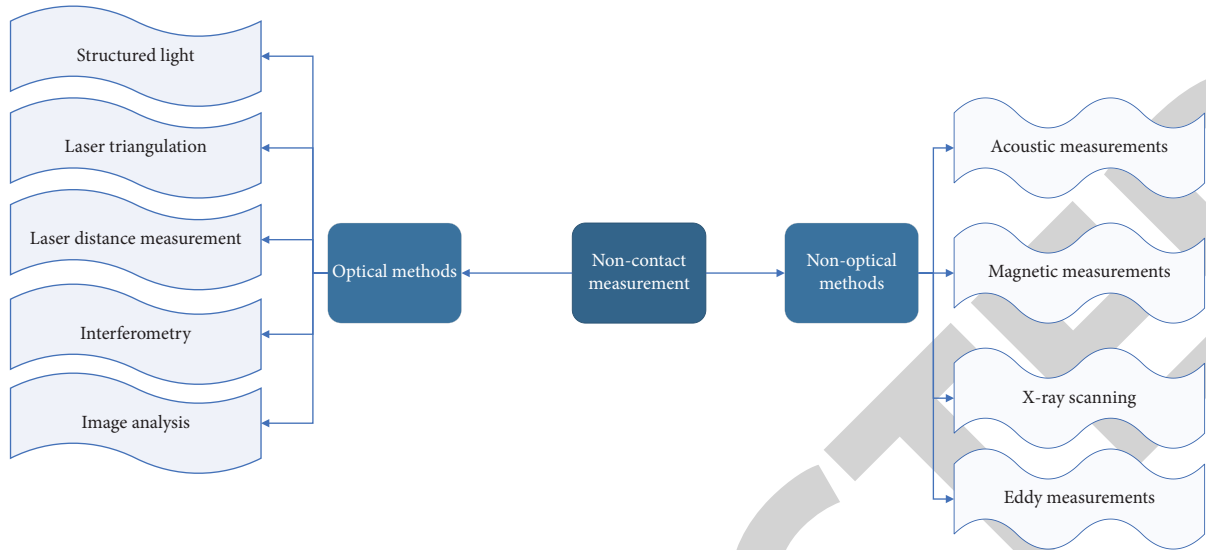


FIGURE 1: Noncontact measurement methods.

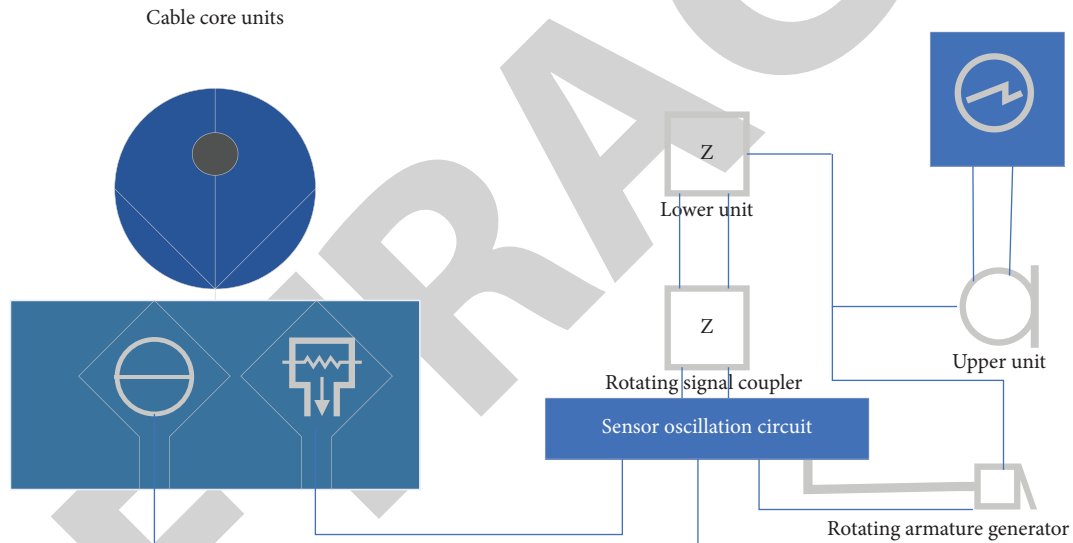


FIGURE 2: Structure of the cable core unit.

2.2.4. Highly Intelligent. With the rapid development of industrial technology, measuring instruments need to conduct highly intelligent analysis of the measured object, so it is necessary to develop noncontact measurement technology in the direction of intelligence. For example, the measured object can be intelligently analyzed, and the noncontact measuring instrument with the most appropriate measurement method can be automatically selected.

3. Quality Control Strategy for Noncontact Instrument Testing

In the noncontact instrument testing method, technicians conduct external inspection and then conduct thorough inspection with appropriate instruments. Instrumental testing usually involves the use of testing tools and other instruments to examine the structure of objects. The value

determined must conform to the standard manufacturing specification of the object. The use of the instrument must also take into account the classification of nondestructive testing technology, the practical application of leak detection, the nature and function of the object structure, the need to maintain the integrity of the object structure, and the need to prevent damage to the object structure. Non-destructive testing technology includes X-ray technology, ultrasonic technology, and electromagnetic induction technology. The difference between nondestructive testing and destructive testing is large, so standardized methods are usually used to study the structure of objects. After this basic activity, various pressure parts of the instrument can be tested and recorded to verify whether they meet the standard design and manufacturing specifications of the object. Once the information about power quality problems is identified and analyzed, effective management technology must be

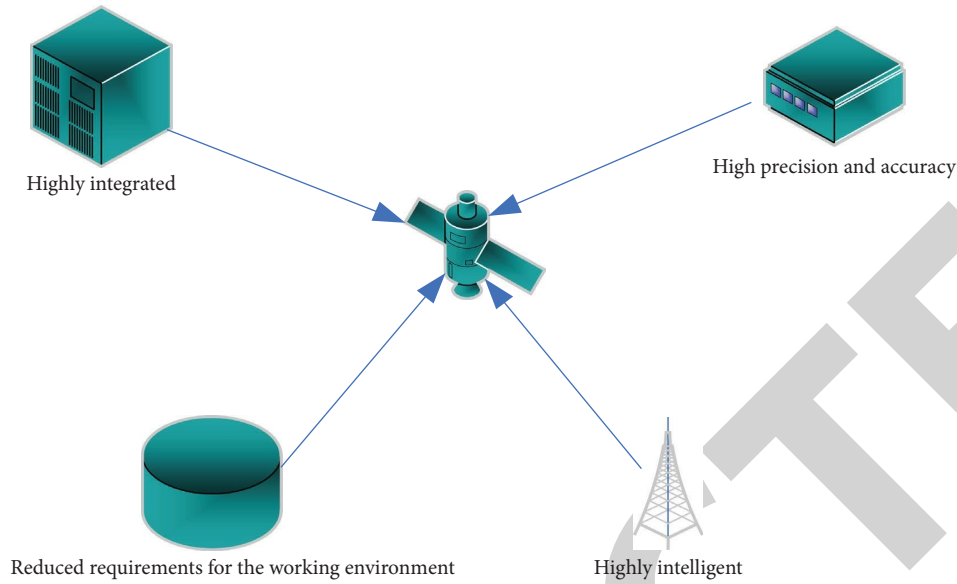


FIGURE 3: Trends in noncontact instrumentation test technology.

used to eliminate or suppress this information. The control method used is closely related to the type of power quality problems and control equipment.

Some constant voltage control devices, such as shunt capacitors, shunt inductors, and transformer tap changers, are traditionally mechanical. They have slow response to power quality problems, inaccurate adjustment, and limited control ability. The range of control strategies is very wide, which ranges from very simple open-loop control strategies to advanced control strategies, such as fuzzy control and intelligent control.

The power quality control device based on power electronics technology is connected to the power grid through the inverter [15]. At present, the most widely used control method is the inverter control technology, which can actively or passively control the four displays between the energy storage equipment and the power grid by adjusting the control angle and modulation pulse width. It can control the power exchange and reactive power and effectively suppress the harmonics on the alternating current side. At present, the power quality interference signal generated from this is being studied and applied to the most widely used control method to determine the final inverter starting signal.

The application of the fuzzy logic control method can improve this situation. When designing the controller according to the “frequency domain method” of classical control theory and the “time-domain method” of modern control theory, it is necessary to know the precise mathematical model of the controlled object [16, 17]. Although adaptive and self-tuning control greatly reduces the requirements for modeling accuracy, it requires a large number of prior data and online model identification with complex algorithms and high computational complexity, which limits its application. As an advanced control method, fuzzy control does not need an accurate system mathematical model. By using fuzzy description of system

characteristics, the cost of obtaining dynamic and static system characteristics can be greatly reduced. Fuzzy control is highly reliable and insensitive to external disturbances, process parameter changes, and nonlinearity. However, the characteristic of fuzzy control is a steady-state error, which is very sensitive to small fluctuations around the operating point. By combining other control technologies with fuzzy control, such as variable structure control and artificial neural network, the performance of fuzzy control can be improved.

4. Evaluation Algorithm for Testing Quality of Noncontact Instruments

4.1. Fuzzy Logic in Power Quality Management. The existing equipment for monitoring and collecting power quality data does not have enough detailed threshold parameters. Due to the limited capacity of this kind of equipment, the effective information about basic fault characteristics is easily submerged by the data of transient faults [18, 19]. In order to effectively and accurately classify the transient power quality interference, one of the main challenges is to develop a classifier that can accurately describe the relationship between the interference characteristics and interference types. The power quality disturbance signal itself is nonlinear and nonuniform, so artificial intelligence technologies such as fuzzy logic are widely used in the development of disturbance classifiers to flexibly describe the natural relationship between complex nonlinearity and disturbance types in power quality disturbances [20, 21]. However, fuzzy logic is a simulation of the human fuzzy thinking process, and it is difficult to generalize and learn the knowledge of fuzzy logic, so the process of parameter estimation of a fuzzy classifier is very complex; it is not easy to achieve optimal results. In addition, with the increase in error types and the improvement of intelligent optimization methods, the number of fuzzy variables, fuzzy rules, and classification

parameters required by the fuzzy classifier is also increasing. Although this provides a classification effect, it increases the size of the classifier and reduces classification efficiency. In order to solve these problems, fuzzy logic can be used to derive various power quality indicators [22, 23].

4.2. Quality Evaluation Algorithm. If q is the true correlation of detection quality, the number of each correlation mark follows the binomial distribution. The likelihood function is as follows:

$$y_1 = \prod_{l=0}^j (\pi_{ql}^{(k)}) n_{il}^{(k)}. \quad (1)$$

In the formula, $n_{il}^{(k)}$ represents the mass of the object.

The quality inspection of all objects is independent of each other. Therefore, when the condition of $T_{iq} = 1$ is known, the likelihood function of the number of correlation marks of the detection quality i is as follows:

$$y_2 = \prod_{K=0}^K \prod_{l=0}^j (\pi_{ql}^{(k)}) n_{il}^{(k)}. \quad (2)$$

The likelihood function under the condition that the restrictions of $T_{iq} = 1$ are unknown is

$$y_3 = \prod_{j=1}^J \left\{ P_j \prod_{k=1}^K \prod_{l=1}^j (\pi_{jl_{l=1}}^{(k)}) n_{il}^{(k)} \right\}^{T_{ij}}. \quad (3)$$

In the formula, p_j represents the probability of randomly selecting the correlation evaluation task whose true correlation is j .

Since all objects are independent of each other, the likelihood function of full data is as follows:

$$y_4 = \prod_{i=1}^I \prod_{j=1}^J \left\{ P_j \prod_{k=1}^K \prod_{l=1}^j (\pi_{jl_{l=1}}^{(k)}) n_{il}^{(k)} \right\}^{T_{ij}}. \quad (4)$$

If the values of $n_{il}^{(k)}$ and T_{ij} , p_j and possible probability values in formula (4) are known, the maximum likelihood estimation can be calculated to obtain the estimated value of each variable:

$$\pi_{jl}^{(k)} = \frac{\sum_i T_{ij} n_{il}^{(k)}}{\sum_i \sum_i T_{ij} n_{il}^{(k)}}. \quad (5)$$

When the probability value P_j ($j = 1, \dots, J$) is unknown, the value of P_j can be estimated:

$$P_j = \frac{\sum_i T_{ij}}{I}. \quad (6)$$

When the object quality error rate $\{\pi_{jl}^{(k)}\}$ and the edge probability $\{P_j\}$ are known and the true correlation of the evaluation task is unknown, Bayesian theory can be used to obtain the estimated value of the indicator variable T_{ij} ($j = 1, \dots, J$). The prior probability $P(T_{ij} = 1) = P_j$ is known. If the correlation result data of all evaluation tasks

are known, the following formula can be obtained according to Bayesian theory:

$$P(T_{ij} = 1 | \text{data}) = \frac{\prod_{k=1}^K \prod_{l=1}^j (\pi_{jl}^{(k)}) n_{il}^{(k)} P_j}{\sum_{q=1}^J \prod_{k=1}^K \prod_{l=1}^q (\pi_{jl}^{(k)}) n_{il}^{(k)} P_q}. \quad (7)$$

If the true correlation of each assessment task is not known in advance, that is, the correlation answer T_{ij} ($j = 1, \dots, J$) is unknown, the likelihood function of the whole data is as follows:

$$y_5 = \prod_{i=1}^I \left(\sum_{j=1}^J P_j \prod_{k=1}^K \prod_{l=1}^j (\pi_{jl_{l=1}}^{(k)}) n_{il}^{(k)} \right). \quad (8)$$

5. Evaluation of the Quality Evaluation Effect

The fuzzy logic in power quality management of the telecommunication system has great advantages in measuring the quality of noncontact instruments, so it can greatly improve the performance of quality testing. Based on this, this paper analyzes the measurement results of noncontact instruments from the perspective of safety, accuracy, rapidity, and economy. It is generally believed that power quality includes voltage quality, current quality, power supply quality, and power consumption quality, so this paper analyzes them from these four perspectives. The paper compares the noncontact instrument testing method with the traditional testing method. In order to investigate, the paper selects the residents' electrical equipment for investigation and records the results in Table 1.

The electrical equipment selected in this paper is common high-power electrical equipment in residents' homes, and its investigation has certain reference significance. The experimental data in this paper can provide a certain reference value for the safety of electricity consumption in residents' lives. The survey data in this paper are the average value of each electric equipment.

5.1. Safety of Power Quality Measurement. The risk of electricity use is a safety problem that residents are easy to encounter in life. In the process of the power quality measurement, unsafe events are more likely to occur to cause serious consequences. In order to avoid the occurrence of unsafe events, it is extremely necessary to investigate the safety of the power quality measurement [24]. This paper investigates the safety of the power quality measurement and records the results in Figure 4.

Compared with traditional testing methods, the non-contact instrument testing power quality method proposed in this paper improves the security of voltage quality, current quality, power supply quality, and power quality so as to promote the security of the power quality measurement. The safety of the voltage quality measurement is improved by 25.5%. The safety of the current quality measurement is improved by 26%. The security of the power supply quality measurement is improved by 26.1%. The safety of the electricity quality measurement is improved by 30.7%. The

TABLE 1: Electricity consumption equipment for residents.

Residents	Air conditioners	Electric water heaters	Induction cookers	Microwave ovens
Resident 1	4	1	2	2
Resident 2	3	1	3	1
Resident 3	1	1	1	1
Resident 4	2	1	2	2

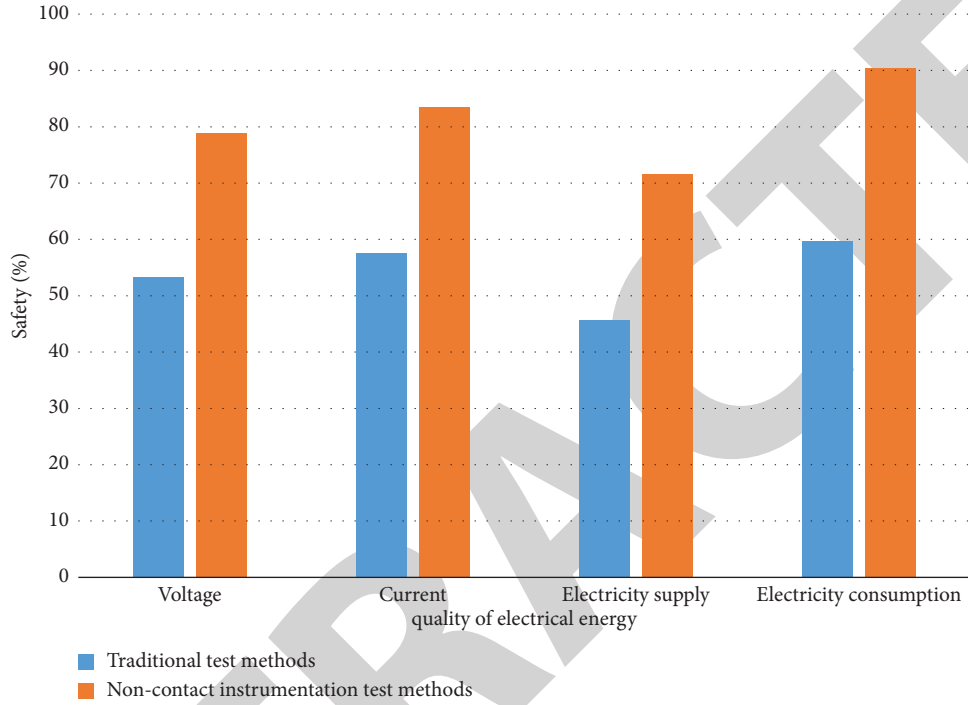


FIGURE 4: Safety of the power quality measurement.

safety improvement effect of the power quality measurement is the best, because the use of noncontact instruments avoids the interference of human factors, thus improving the reliability of power quality.

5.2. Accuracy of Power Quality Measurement. If the measurement of power quality is not accurate, it would lead to misjudgment, which would bring adverse effects to the measurement of power quality. Therefore, this paper selects the accuracy of the power quality measurement as the evaluation index of the power quality measurement and records the results in Figure 5.

The accuracy of the power quality measurement is related to whether the power can be reasonably judged and planned according to power quality so as to achieve good measurement results. Among them, the accuracy of the voltage quality measurement is improved from 59.5% of the traditional measurement method to 82.9% of the noncontact instrument method for measuring power quality, the accuracy of the current quality measurement is improved from 57.1% of the traditional measurement method to 78.4% of the noncontact instrument method for measuring power quality, the accuracy of the power supply quality measurement is improved from 62.4% of the traditional

measurement method to 89.2% of the noncontact instrument measurement method, and the accuracy of the power quality measurement is improved from 49.7% of the traditional measurement method to 71.6% of the noncontact instrument method. In general, the accuracy of the power quality measurement is greatly improved by using the noncontact instrument to measure power quality.

5.3. The Rapidity of Power Quality Measurement. If the power quality can be measured quickly, it would have a positive impact on the electricity measurement. The faster the measurement speed, the better it can meet the needs of current life. Based on this, this paper tests the rapidity of the power quality measurement and records the results in Figure 6.

The rapidity of the power quality measurement is kept below 70% when using traditional measurement methods, and it is more in the range of 50% to 60%. It shows that the traditional measurement method is not fast enough to measure power quality, which cannot meet the public's demand for the rapidity of the power quality measurement. However, when using the noncontact instrument to test power quality, the speed of the power quality measurement is improved by more than 70%. Among them, the rapidity of

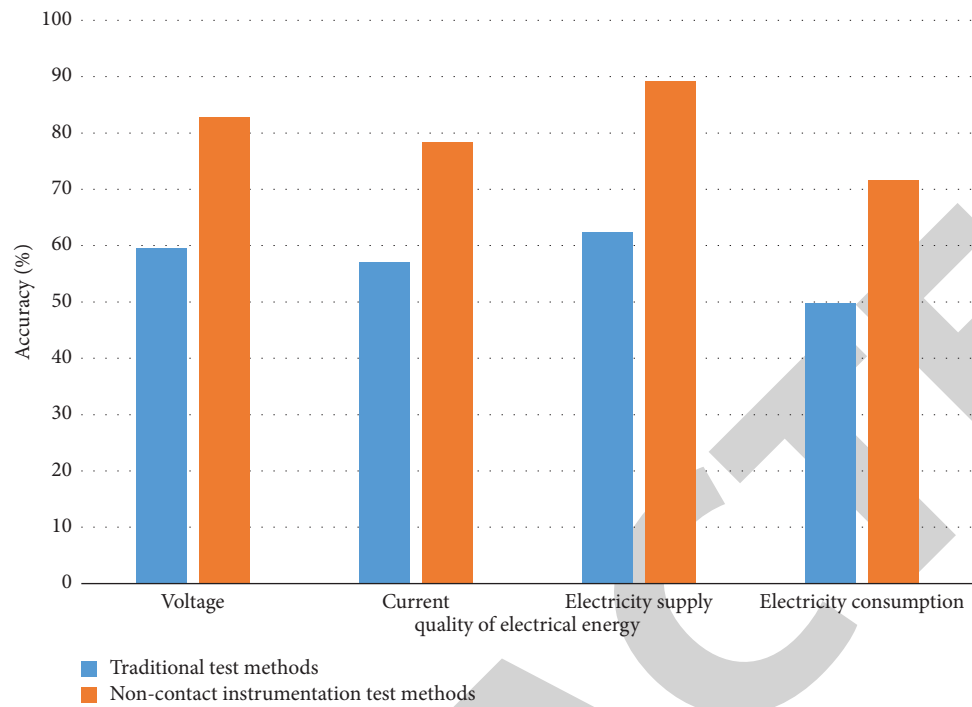


FIGURE 5: Accuracy of power quality measurement.

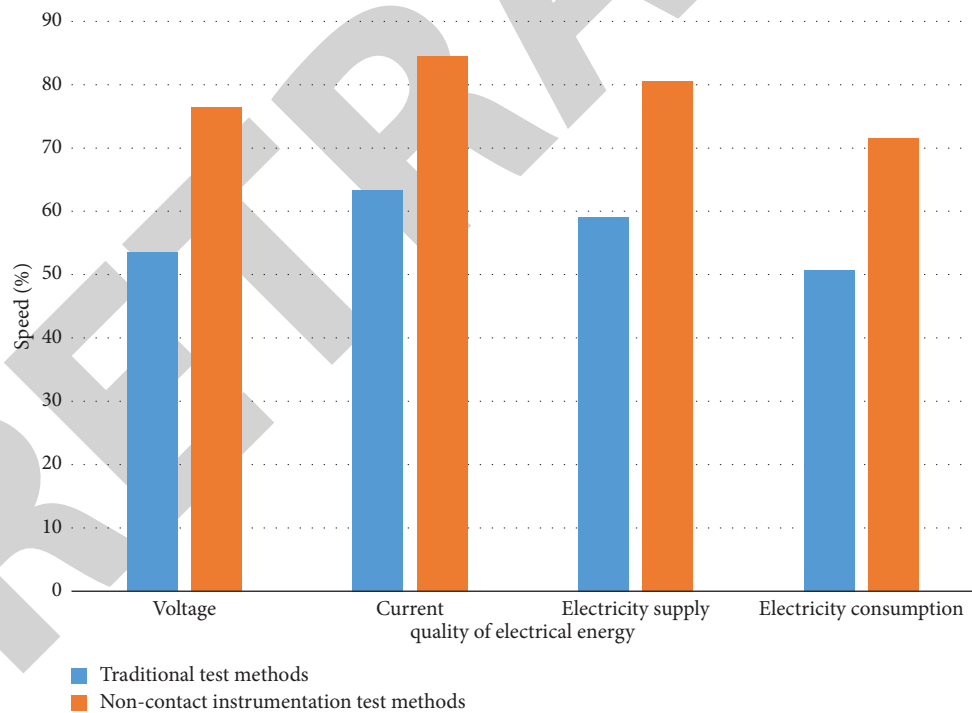


FIGURE 6: Speed of measurement of power quality.

the current quality measurement is increased by 21.1%, and the improvement effect is the best. Therefore, the use of the noncontact instrument to measure power quality can greatly improve the rapidity of the current quality measurement.

5.4. Economy of Power Quality Measurement. Economy refers to the lowest resource consumption when obtaining certain quantity and quality of products, services, and other achievements in the process of organizing business activities. The higher the economy, the better the measurement

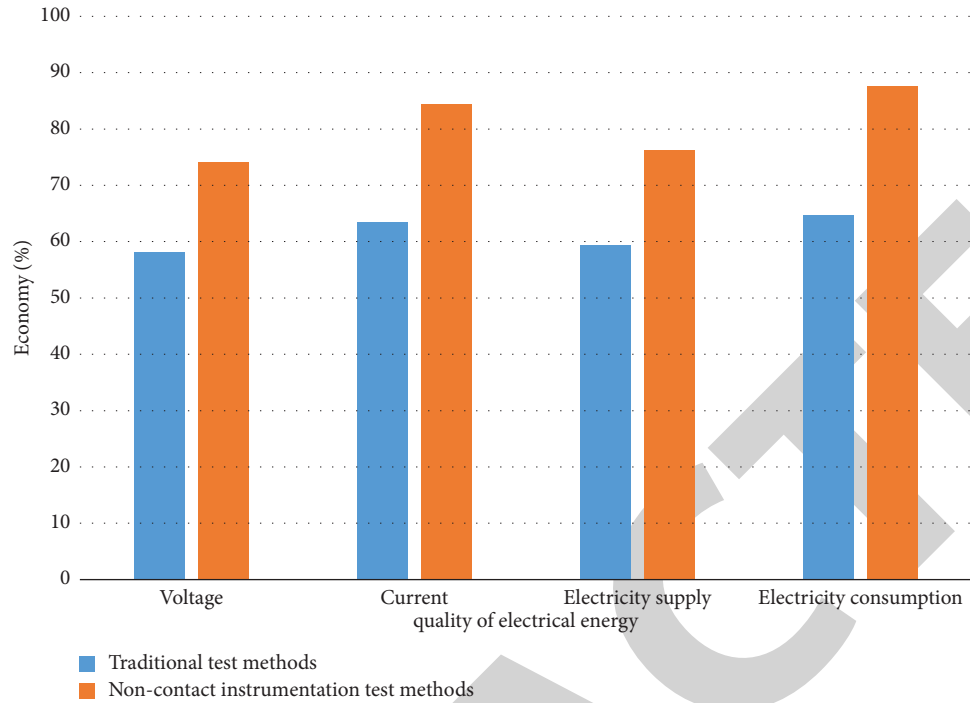


FIGURE 7: Economy of power quality measurement.

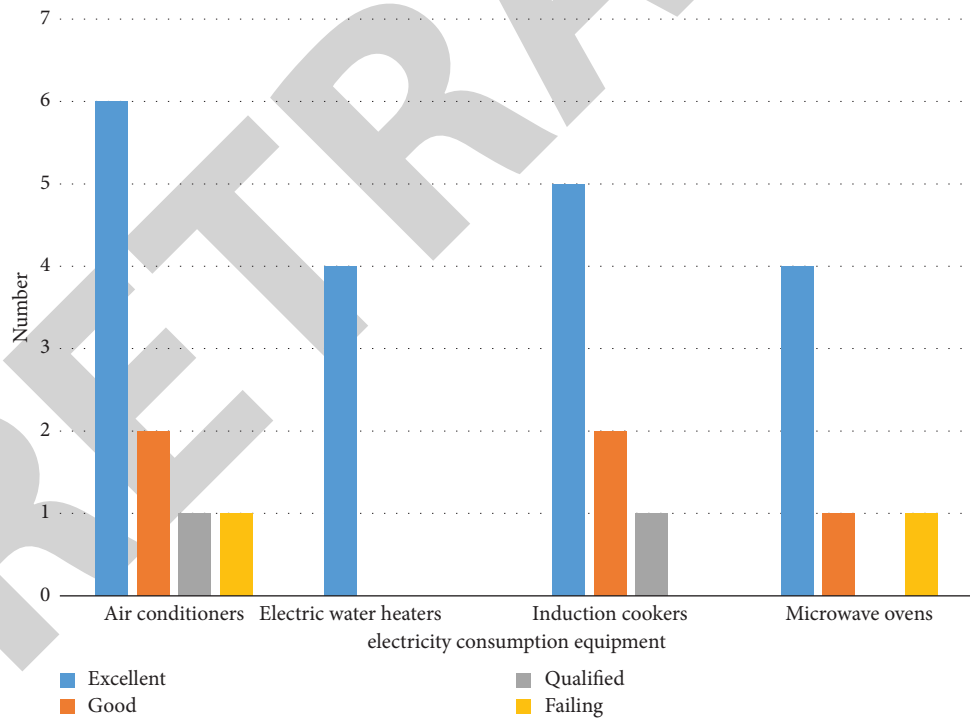


FIGURE 8: Fuzzy logic evaluation in power quality management.

method can meet the needs of the public, and the results are recorded in Figure 7.

The traditional power quality measurement method is not economical. The test economy of voltage, current, power supply, and power quality is not high, which is below 70%. However, the economy of power quality testing is greatly

improved when using the noncontact instrument to test power quality. Among them, the economy of the voltage quality measurement is improved from 58.2% of traditional measurement methods to 74.2% of the noncontact instrument measurement of power quality, the economy of the current quality measurement is improved from 63.5% of the

traditional measurement method to 84.5% of the noncontact instrument measurement method of power quality, the economy of the power supply quality measurement is improved from 59.3% of the traditional measurement method to 76.2% of the noncontact instrument measurement method, and the economy of the power quality measurement is improved from 64.7% of the traditional measurement method to 87.6% of the noncontact instrument method. In conclusion, the use of the noncontact instrument to test power quality can greatly improve the economy of the power quality measurement.

5.5. Fuzzy Logic Evaluation in Power Quality Management.

The fuzzy logic method can be used to evaluate power quality. The electrical equipment can be classified into air conditioners, electric water heaters, induction cookers, and microwave ovens. They are classified according to the level of excellent, good, qualified, and unqualified, and the results are recorded in Figure 8.

The fuzzy logic algorithm is used to evaluate the air conditioner, electric water heater, induction cooker, and microwave oven. It is found that, among the ten air conditioners, the power quality of six air conditioners is excellent, the power quality of two air conditioners is of good grade, the power quality of one air conditioner is qualified, and the power quality level of only one air conditioner is unqualified. The power quality of the four electric water heaters is excellent. In the survey of induction cookers, the power quality of five induction cookers is excellent, the power quality of two induction cookers is of good grade, the power quality of one induction cooker is qualified, and there is no induction cooker with unqualified power quality. In the survey of microwave ovens, there are four microwave ovens with excellent power quality, the power quality of one microwave oven is qualified, and the power quality of one microwave oven is unqualified. To sum up, the power quality level of the research object selected in this paper is mostly excellent, and only the power quality of two pieces of electrical equipment is unqualified.

6. Conclusions

In order to improve the quality of power measurement, this paper first introduced the basic method of the noncontact instrument measurement and then proposed a noncontact instrument measurement method of power quality. The quality control strategy and the evaluation algorithm of noncontact instrument testing were explained and applied to the measurement of power quality. They were also compared with those of the traditional power quality measurement method, and the final conclusion was drawn. Compared with the traditional power quality measurement methods, the noncontact instrument method proposed in this paper could greatly improve the safety, accuracy, rapidity, and economy of the power quality measurement. In the evaluation and analysis of the electrical equipment by the fuzzy logic algorithm, it was concluded that only two pieces of electrical equipment were at the unqualified level. In general,

the use of the fuzzy logic algorithm makes the measurement of power quality by using noncontact instruments more convenient and fast.

Data Availability

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

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Retraction

Retracted: Application of Wireless Sensor Network Computer Technology in Financial Management System

International Transactions on Electrical Energy Systems

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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) 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.

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- [1] J. Wei, "Application of Wireless Sensor Network Computer Technology in Financial Management System," *International Transactions on Electrical Energy Systems*, vol. 2023, Article ID 7304590, 9 pages, 2023.

Research Article

Application of Wireless Sensor Network Computer Technology in Financial Management System

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In the current enterprise competition, the core of the management information system is the financial management information system. Building a more comprehensive and efficient financial management information system can effectively establish a more efficient innovative enterprise and promote the transformation and development of the enterprise. This paper first designs a set of financial management system templates, including general ledger, accounts receivable, and accounts payable. Second, according to the characteristics of wireless sensor network technology, this paper proposes a financial management system based on the wireless sensor network and designs a load balancing topology control algorithm (LHTCA algorithm), which balances the energy consumption of network nodes and helps to improve the network life cycle. Finally, the management system is tested and validated. The test results show that the financial management system can realize the electronicization of financial data and paperless vouchers, improve the efficiency of financial work, and promote the sharing and integration of resources.

1. Introduction

With the advent of the digital information age, digital transformation of enterprises is an inevitable choice to adapt to the development of the times, and information technology is an important means to help enterprises achieve digital transformation. Enterprise development requires an information platform that can support enterprise development, strengthen centralized financial management, complete more online audit work, and reduce operational risks. In the economic and social development plan proposed by my country, it is emphasized that the digital economy innovation leads the development plan and completes the new infrastructure construction. Therefore, enterprises should pay attention to the huge advantages brought by the financial management information system to the enterprise and build a more complete financial management. Information system promotes the development and progress of enterprises. Digital management can not only realize the integration of enterprise management information but also help enterprises to achieve a qualitative leap in their management level.

The information construction of enterprise financial management can promote the improvement of the economic benefit level of the enterprise, which is mainly reflected in the improvement of the business performance of the enterprise, the reduction of transaction costs within the enterprise, the improvement of the overall work efficiency of the enterprise, the reduction of material waste, save costs, reduce the workload of corporate financial staff, and reduce work intensity [1, 2]. At the same time, the valuable experience of many successful enterprises in my country also proves that the information construction of enterprise financial management has indeed played a huge role in promoting the economic benefits and management level of enterprises. In addition, in the past, the financial management information system could not meet the current situation [3–8]. Therefore, to build a more complete financial management information system, enterprises must pay attention to avoid problems with enterprise information and affect the operation of the enterprise.

The wireless sensor network is an intelligent and comprehensive information system that integrates information collection, information transmission, and information

processing [9–13]. This is not only the most active research field but also has broad application prospects. Because the system integrates the following four technologies, it can perceive, monitor, and collect various types (regions) information in real time: one is embedded computer computing; the other is sensors; the third is distributed information; the fourth is communication technology [14, 15]. It has the ability to obtain and process information and finally send the information to the user. Based on wireless sensors, humans can obtain all kinds of useful information anytime, anywhere. In short, no matter from which aspect, it has a strong application prospect and has very considerable practical value and scientific research value, especially in various fields such as antiterrorism, industry and agriculture, rescue and disaster relief, environmental monitoring, military, and national defense, increasingly important role [16]. It is precisely because of this that it has been called the most influential technology in this century and has attracted great attention from all walks of life in all countries and fields.

From the analysis of research level, the wireless sensor network is undoubtedly a brand-new scientific research [17]. Relevant workers are required to deeply study the basic theory and verify the analysis in actual construction. Network management is a crucial part of it. What is network management? As the name implies, it effectively monitors the communication equipment and transmission system of the network and performs related operations such as control and diagnostic testing, and through these measures, the network performance is greatly improved. Network management is one of the important factors to ensure the stable, safe, reliable, and efficient operation of sensor networks. The effective solution to the problems of system heterogeneity, shared resources, network autonomy, and similarity is the sensor network, that is, to achieve unified management and maintenance of system resources, resource configuration, communication, performance, and faults, to ensure that the network system is efficient and reliable operation [18, 19]. Overview of the research status in this field, combined with the existing typical network management system, on this basis, the wireless sensor network management system is designed, and the monitoring and management are realized to make it play the best performance.

The world's first wireless sensor network management framework MANNA was proposed by Ruiz et al. It is a network management system based on policy integration. It dynamically collects management information and maps it to the design model. On this basis, it executes related services and management functions [20, 21]. The model maintains the entire network state. Network management can be implemented based on specific operating conditions. Related management functions. It integrates the following three levels of wireless sensor network management: one is the management function, the other is the logical management layer, and the third is the wireless sensor network. Based on the design goals of self-organization, self-healing, self-diagnosis, and self-management, MANNA's design philosophy separates network applications from network applications. The functional system, information system,

and physical system constitute the MANNA management structure.

WinMSI is a sensor network management system, which is formed based on policies and can fully improve network performance due to its self-management function advantages. It can realize unattended and still manage network nodes efficiently. WinMS can be reconfigured in combination with the current network characteristics, including data in the data aggregation tree, MAC protocol, and powerful management functions such as collection and distribution. It can self-govern a single node according to the neighbor network status. At the same time, using the network management mode, it can perform management; centralized network management mode performs effective prevention, correction, and other management functions according to the global information of the wireless sensor network. On the basis of the above, WinMS proposes the management function of transmission system resources, that is, sending network resources for other parts. WinMS activity is dependent on the specific sensor network model.

MARWIS is a heterogeneous wireless sensor network management architecture, which was proposed by Wagenknecht et al. In a heterogeneous wireless sensor network environment, MARWIS common management tasks are update program code, monitoring, and configuration. At the same time, the backbone network of the system is a mesh structure, which allows the heterogeneous sensor network environment to operate. It belongs to the gateway of each heterogeneous subnet. The subnet contains all kinds of the same sensor nodes. The mesh gateway is a prerequisite for subnet communication.

2. Related Work

At present, the sensor network has designed a research model with reference to the Open System Interconnection (OSI) reference model of the existing network [22], as shown in Figure 1, which can be divided into the following layers: one is the physical layer; the other is the data link layer; the third is the network layer; the fourth is the transport layer; the fifth is the application layer.

With the in-depth research, the sensor network system is further refined, as shown in Figure 2, which is the wireless sensor network architecture. The new architecture is still composed of network protocol stack and management platform, but two parts of positioning and clock synchronization are added to the protocol part, and topology, QoS, and network management platform are added to the management platform, making the system more in line with wireless sensor networks.

From the analysis of the location level, the clock and positioning synchronization sublayers are in a special position in the protocol stack. They run through the communication protocol (three layers) and rely on data to cooperate with the transmission channel, that is, to synchronize the clock and positioning. On the other hand, it can be a network protocol. Necessary synchronization information and location at all levels in the system should be

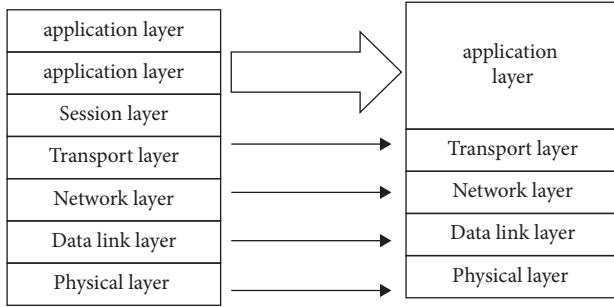


FIGURE 1: Research network model of the wireless sensor network.

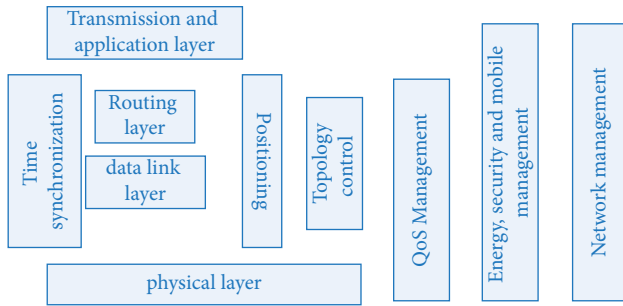


FIGURE 2: Wireless sensor network architecture.

provided. Each protocol layer should be assisted to realize functions more effectively.

The newly added QoS management subplatform is responsible for tasks such as queue management, bandwidth allocation, and service priority configuration in each protocol layer, and the topology control and management subplatform is responsible for the network topology, providing the necessary topology for the physical layer, MAC layer, and network layer [23]. Information, a good network topology will effectively improve the efficiency of the protocol. The construction of network topology depends on the effective operation of physical layer, MAC layer, and network layer protocols. The network management subplatform regularly collects the operating status and traffic information of the protocol, is responsible for the information interfaces embedded in each layer of the protocol, and also undertakes the task of coordinating the operation of each protocol component of the network.

As a two-way wireless communication technology, Zigbee technology mainly has the advantages and characteristics of low cost, low power consumption, simplicity, and short distance [24]. It is widely used in the field of remote control and automatic control and is formulated to meet the wireless network of small and cheap equipment. Zigbee technology is based on the IEEE802.15.4 standard and has developed an application protocol that can be shared among different manufacturers. In the working state of Zigbee technology, the amount of data that can be transmitted is small and the transmission rate is low, so the time for sending and receiving signals is short. On the contrary, in the nonworking state, Zigbee is in a dormant state. Zigbee has the advantages of low transmission power consumption, high data reliability, and low cost. The characteristics of

Zigbee technology make it show great advantages in some aspects. Its starting point is to build a low-cost wireless network that is easy to deploy. The main application fields are industrial control, medical equipment control, military, agriculture, and other fields.

3. Financial Management System Template Design

3.1. General Ledger Section. The general ledger section is the core of the accounting module. Basic elements such as accounting subjects, accounting periods, currency, and book sets in the system are set in the general ledger section [25]. Each submodule will transfer the generated accounting entries to the general ledger block during business processing, generate journals, and update account balances to generate subsidiary ledgers, general ledgers, and various financial statements. Since the financial information of the enterprise will be automatically posted to the general ledger section through the system and other submodules will also share data with the general ledger section, the general ledger section should be the best platform for querying company information, as shown in Figure 3.

3.2. Accounts Receivable Segment. The accounts receivable section is mainly used to manage the customer's current business and business collection and settlement business, including managing and saving customer data and information, issuing sales invoices integrated with the BOSS system, and managing customer accounts receivable and payment collection information, record receipt vouchers, and control the aging of customer arrears [26, 27]. At the same time, the accounts receivable section can automatically import the data of the business daily report interface provided by the BOSS system into the business accounts receivable invoice and import the bank receipt information into the accounts receivable section through this interface and then batch verification of invoices received. The core functions and business processes of the accounts receivable segment are shown in Figure 4.

3.3. Accounts Payable Segment. The payables section is used to manage business transactions with suppliers. The section contains basic information about suppliers such as supplier locations, contacts, and bank accounts. For the invoice management of the business transactions of the enterprise, the invoice needs to be paid after a strict approval process. The payment method can choose single payment or batch payment. The core functions and business processes of the accounts payable segment are shown in Figure 5.

4. Construction of Financial Management System

In order to facilitate the administrator to better manage the network and ensure the safe, reliable, and normal operation of the network, especially in the case of a harsh environment,

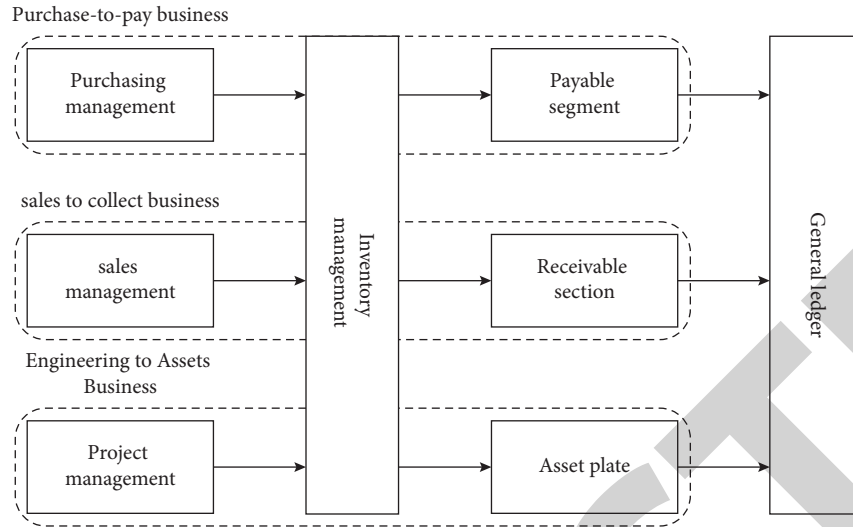


FIGURE 3: Wireless sensor network architecture.

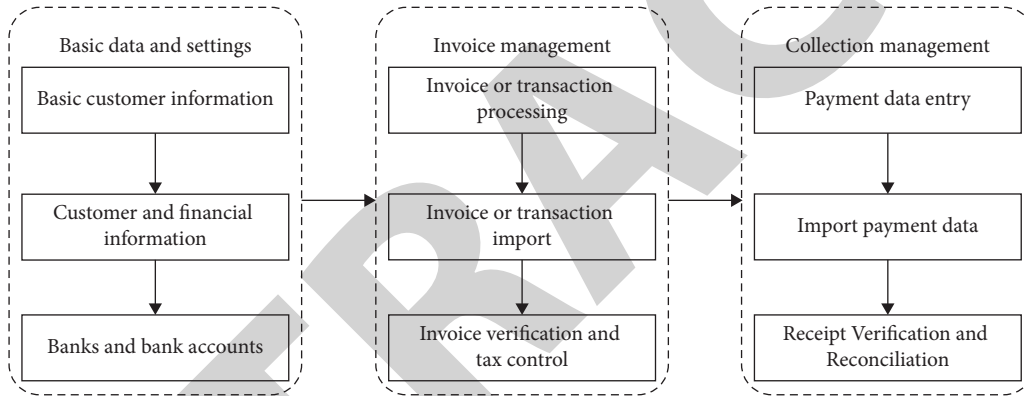


FIGURE 4: Core functions and business flowchart of accounts receivable segment.

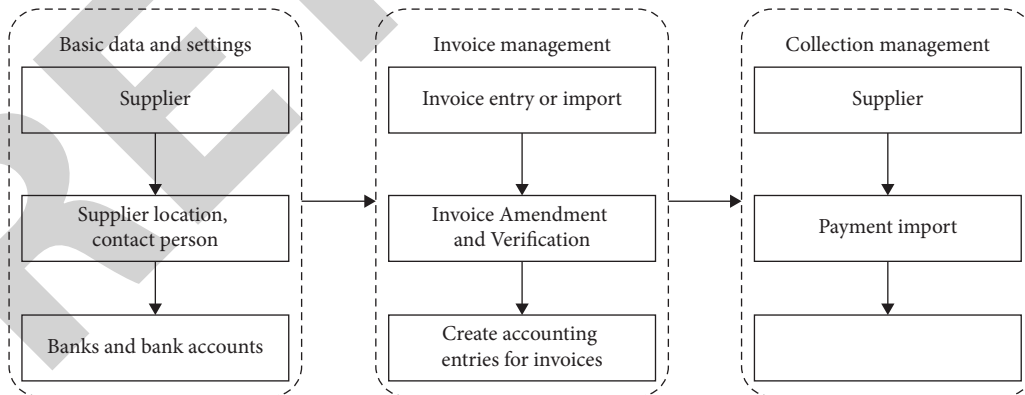


FIGURE 5: Core functions and business flowchart of accounts receivable segment.

it is very special to develop a reliable and safe network management software, importantly,

- (1) Configuration function: this function can mainly complete the setting of the network topology and can modify the relevant network parameters, restart the network and other functions, improve the

management of the network, and ensure that the network is in a good state.

- (2) Topology display function: this function can mainly display the current network topology in time.
- (3) Data storage function: real-time storage of network node data to provide a favorable basis for future

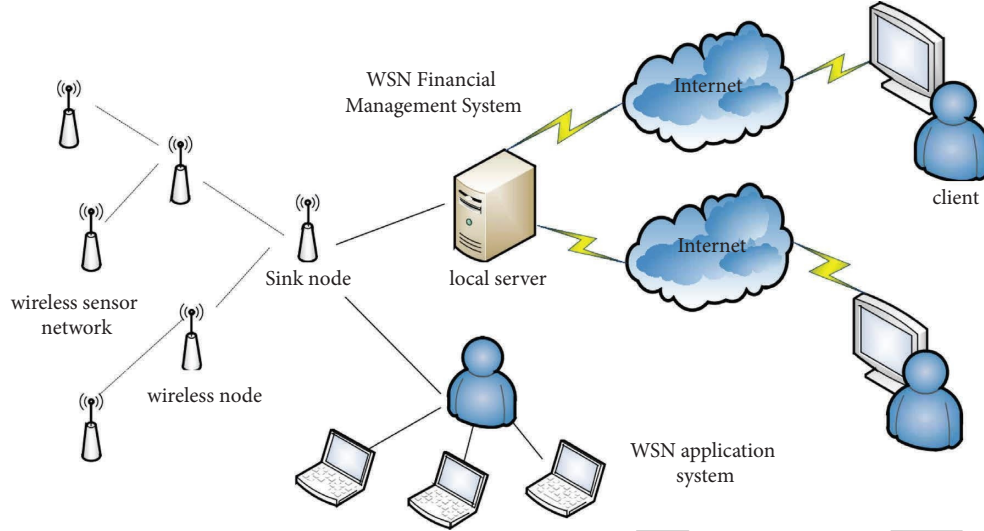


FIGURE 6: Core functions and business flowchart of accounts receivable segment.

network analysis. This function is able to store not only information related to node data but also status information.

- (4) Troubleshooting function: this function can have a real-time fault alarm function and can set a fault valve area. If there is an abnormality during the network operation, such as when the node in the network is disconnected, the data packet is lost, the node energy is exhausted, and so on, the software can make corresponding processing according to different faults and notify the relevant management personnel in time or deal with it according to the previously set method.
- (5) Query function: provide users with a variety of query interfaces, and users can easily grasp the actual situation of the network operation through the software.

To sum up, the wireless sensor network management software has the responsibility of maintaining and managing the entire network. In other words, it can supervise the entire network to ensure that the entire network can be in a normal operation state at all times, and at the same time, it can collect abnormal information in the network. The following describes the functions of the sensor network management software and other situations.

The geographic location of the WSN management software in the entire network is shown in Figure 6. The client can directly interact with user information and has the function of displaying and configuring tasks; the server is responsible for collecting and processing data in the network management software. The network management software will not affect the actual application of WSN; it can be completely independent of the application system, but directly read the required data from the base station.

4.1. REDM Model. The REDM model sets d as the distance between the receiving and transmitting nodes. First of all, it

is necessary to assume the threshold value d_0 . The energy consumption of the node to send k bit data packets is

$$E_{TX}(k, d) = E_{elec} \times k + \xi_{amp} \times k \times d^r. \quad (1)$$

The energy consumption of receiving k bit data packets is

$$E_{RX}(k) = E_{elec} \times k. \quad (2)$$

The energy consumption of data fusion is

$$E_{DA}(k, n) = E_{da} \times k \times n. \quad (3)$$

Among them, $E_{elec} = 50nJ/bit$ is used to describe the energy consumption required to transmit or receive 1 bit.

$\xi_{amp} = 100pJ/bit/m^2$ can be used to describe the consumption of the signal amplifier in sending 1 bit data to the unit area.

4.2. Cluster Establishment Stage. The selection of cluster heads at this stage should clearly affect the three factors that affect the selection of cluster heads: the first is the remaining energy of the node, the second is the distance of the cluster center, and the third is the current actual communication radius, and the node capability function $F_{omdbilt}$ should be fully considered:

$$F_{capability} = E_{resident} \times r_1 + \left(\frac{1}{D}\right) \times r_2 + R \times r_3 \quad (r_1 + r_2 + r_3, r_1 > r_2 > r_3), \quad (4)$$

where D is the distance, which is used to describe the distance between the cluster center and the node. Here, it is assumed that the location of the network node has been determined by the positioning algorithm; E is used to describe the remaining energy of the node; R is the radius of the node's current communication, that is, the node under the current transmitting power. The distance of transmission information, r_1 , r_2 , and r_3 are used to refer to the proportion of each part, and the sum of the three is exactly equal to 1. It

is worth mentioning that each proportion needs to be set in advance.

4.3. Data Communication Phase. The algorithm was first proposed by Chandrakasan et al. It is adaptable to the clustering topology algorithm and has the characteristics of low power consumption and periodicity [28]. The idea of this algorithm is to organize nodes into clusters, and each cluster has a cluster head. The other nodes are ordinary nodes; all ordinary nodes can only communicate with the cluster head node of their own cluster, and at the same time, it can collect a large amount of node data. After fusing the data, it is aggregated to a sink node.

LEACH proposes the concept of “round,” which includes the following two stages.

The specific algorithm of cluster head election is as follows: each node randomly generates a number in the $[0, 1]$ interval; if the number is less than the preset threshold $T_{(m)}$, the node will declare itself as the cluster head node.

$$T_{(n)} = \frac{p}{1 - p \times [r \bmod (1/p)]}, \quad n \in G. \quad (5)$$

Among them, p is the probability of becoming a cluster head in a node, r is the current number of rounds, $r \bmod (1/p)$ refers to the number of selected cluster head nodes in this round, and G refers to the collection of nodes that have not been selected in each cycle. Its probability can generally be represented by $T_{(m)}$, and $T_{(m)}$ will increase with the increase of the number of rounds; assuming that the node has been elected as the cluster head, the remaining rounds of $T_{(m)}$ can be set to be equal to zero. In other words, for a node that has not yet been elected as a cluster head, it means that after the next round, it has a better chance of becoming a cluster head, and all nodes will eventually have the opportunity to be elected as a cluster head.

4.4. Data Communication Phase. The above analysis needs to involve a problem, how to judge the load capacity of the cluster head node. This calculation shows the introduction of the load evaluation function method:

$$F_{\text{load}} = E_{\text{resident}} \times t_1 + \left(\frac{1}{D}\right) \times t_2 \quad (t_1 + t_2 = 1, t_1 > t_2). \quad (6)$$

Among them, D represents the distance between the node and the center of the cluster, and E_{resident} represents the remaining energy of the node; F_{load} has a load threshold $F_{\text{load}0}$, t_1 , t_2 , which needs to be set in advance according to the actual situation. After calculating the load F_{load} of the cluster head according to the formula, $F_{\text{load}} < F_{\text{load}0}$ judges the load.

Because the wireless sensor network is easily susceptible to external environment interference and other characteristics, due to the problem of instability, it means that the node has a low load capacity and has the characteristics of suddenness and short-lived [29–32]. Based on this, considering the need to avoid mistakes, it is assumed that when the node load $od < oan$, the number of errors is determined,

and the final judgment result is less than the load capacity, the cluster head can be ready to be abandoned.

By comparing the capabilities, the cluster head is formed, which means that the cluster head point formed will have all the capability information of other nodes. Assuming that the load capacity of the cluster head node is too low, it is necessary to combine the information list to determine the replacement cluster. The first node, that is, the excellent node within the selection range. At the same time, in order to prevent the abovementioned problems of the newly selected cluster head node, that is, the problem of too low load capacity, it is necessary to evaluate the load capacity of the replacement cluster head, and this work needs to be carried out before it officially becomes a cluster node. Only by passing the test and verifying that the load capacity of the replacement cluster head meets the requirements, can it become a real cluster head. At this time, the original cluster head node needs to send the information of other nodes in the cluster in the form of a list to the new cluster head node, and the cluster continues to enter the stable data communication stage; otherwise, the original cluster structure needs to be explained first, that is recombination, that is, re-determining all nodes of the cluster by random integers, and thus re-entering a new round of cluster establishment [25, 26].

5. Simulation Results and Analysis

This paper sets the area of $100 \text{ M} * 100 \text{ M}$ wireless sensor network model and distributes 100 nodes in the area, and these nodes are randomly generated. In order to make the results more realistic, the experiments in this paper were repeated 400 times. Finally, all the collected results are averaged to obtain the final data. After analysis and comparison, corresponding conclusions are drawn. The simulation parameters are set as given in Table 1.

The simulation scene of this paper is in a square area with base station coordinates (50, 175), the size of the area is $100 \text{ M} * 100 \text{ M}$, 100 nodes are randomly distributed, and the initial energy of each node is 2 J.

5.1. Cluster Head Selection. First, according to the process of cluster head selection, this paper uses Marble software to simulate the LEACH algorithm and the LHTCA algorithm. The simulation results are shown in Figure 7. o represents noncluster head ordinary node; $*$ represents the selected cluster head node. Figure 7(a) is the cluster head selection diagram of the LEACH algorithm. We can see that its cluster head selection is unevenly distributed. In some areas, the distribution of cluster heads is concentrated, but there are no cluster heads in some areas and some common nodes. It is far away from the cluster head, and the result is that too much energy is consumed in the process of data transmission, and there are too many ordinary nodes in the area where the cluster head is located, which will lead to the accelerated death or failure of the cluster head node, which will eventually lead to network load distribution, seriously out of balance. Figure 7(b) shows the cluster head selection

TABLE 1: Setting of simulation parameters.

Parameter name	Set parameter value
Number of nodes	100
Area size of the wireless sensor network	100 M * 100 M
Power consumption of transmission amplifier	10 Pj/bit/m ²
Packet size	200 B
Data processing energy consumption	5 nj/bit
Energy consumption of sending and receiving data	50 nj/bit

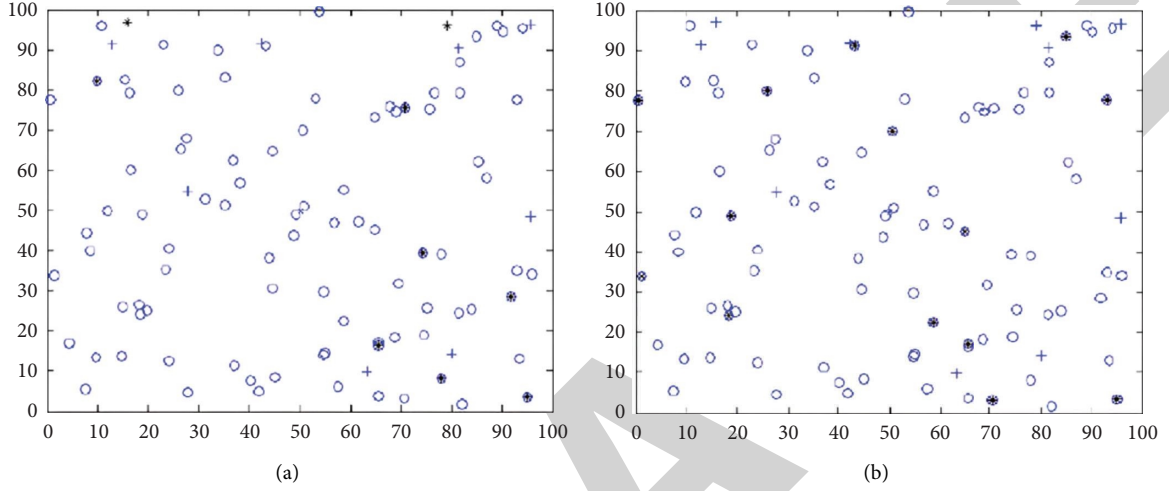


FIGURE 7: Cluster head election process of LEACH and LHTCA algorithms. (a) LEACH cluster head selection process. (b) LHTCA cluster head selection process.

process of the LHTCA algorithm. By comparing the above two sets of figures, we can see that the cluster head distribution of the LHTCA algorithm is more balanced, the probability of node death or failure is greatly reduced, and the network load is balanced. Sex is naturally high.

5.2. Lifecycle. From Figure 8, we find that when a takes different values, the life cycle of the LHTCA algorithm is much higher than that of the LEACH algorithm.

5.3. Energy Consumed by the Network. From Figure 9, we can see that in the first 25 seconds of network operation, the network energy consumption of the three algorithms is not very different, but from 25 seconds to 300 seconds, the curve changes between the LHTCA algorithm and the LEACH algorithm and the HEED algorithm. It tends to be more stable, and the network energy consumption of the LHTCA algorithm is much smaller than that of the other two algorithms. The resource utilization of the network system is improved, which indicates that the LHTCA algorithm has higher performance.

Through comparative analysis, it can be seen that the improved LHTCA algorithm has many advantages, such as good performance and load balancing, and at the same time, it helps to prolong the network life cycle, reduce network energy consumption, and improve the utilization of network system resources, in line with the purpose of the expected improvement in this paper.

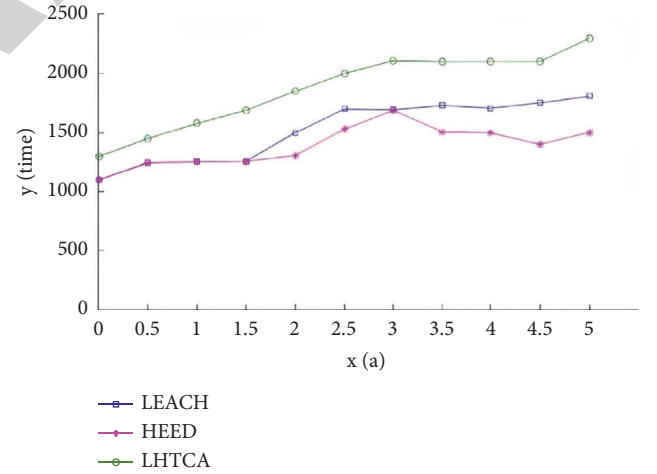


FIGURE 8: Life cycle comparison chart.

5.4. Performance Management Testing. Performance management is embodied in statistics and collection of performance management information, such as information related to sending and receiving data, delay, packet loss rate, and so on. At the same time, considering the actual situation of statistics, that is, it takes time, so it is usually necessary to design a certain time interval, and this article is suitable for 5 minutes. Through design, statistical analysis of all node performance information of network nodes is performed. Figure 10 shows the packet loss rate of a specific node.

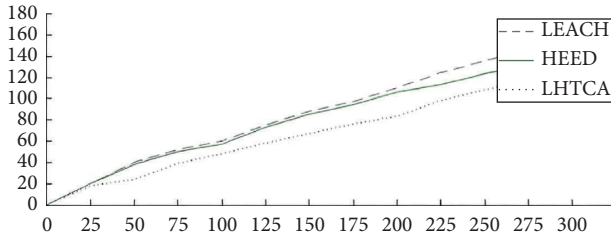


FIGURE 9: Total energy consumption of WSN.

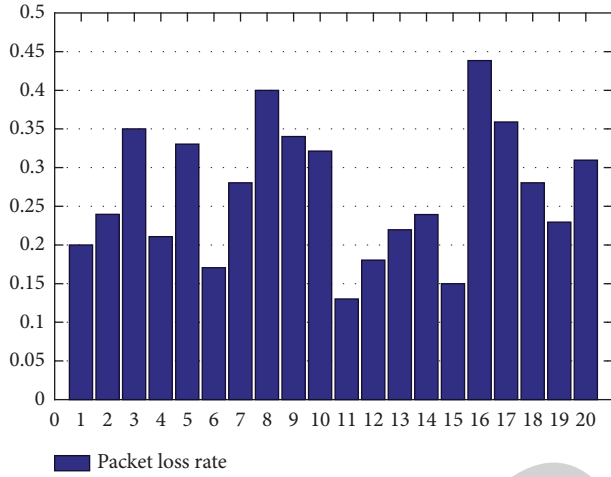


FIGURE 10: Histogram of node packet loss rate collected.

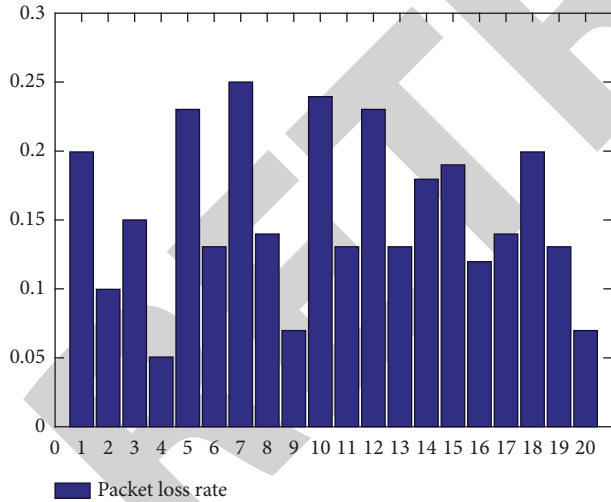


FIGURE 11: Average delay of nodes.

The statistical calculation results show that the average private contract rate of 20 nodes reaches 26.9%, of which the highest and lowest are 44% and 13%, respectively. The average delay of each node is shown in Figure 11.

As shown in the figure above, the average delay of 20 nodes within 5 minutes reaches 0.97 seconds, of which the highest and lowest delays are 1.8 seconds and 0.26 seconds, respectively. In addition, it is found through the graph that the node 20 is closest to the gateway, which fully shows that the node delay is related to the gateway distance.

6. Conclusion

With the rapid development of the economy, the financial management work of enterprises is increasing day by day, so the efficiency of financial management is becoming increasingly prominent. Enterprise development requires an information platform that can support enterprise development, strengthen centralized financial management, complete more online audit work, and reduce operational risks. This paper first designs a set of financial management system templates and optimizes the general ledger section, accounts receivable section, and accounts payable section. These optimizations can effectively reduce the workload of financial personnel and business personnel who use the system. Next, this paper designs a load balancing topology control algorithm (LHTCA algorithm) and proposes a financial management system based on wireless sensor networks. Finally, the management system is tested and validated. The test results show that the financial management system can improve the management efficiency, improve the economic situation, ensure the safe use of funds, reduce the workload of financial personnel, make financial analysis and decision-making more scientific, and improve the efficiency of resource use.

Data Availability

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

Conflicts of Interest

The author declares that there are no conflicts of interest.

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Retraction

Retracted: Application of Sports Clustering Deconstruction Based on Neural Network

International Transactions on Electrical Energy Systems

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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. Ma, "Application of Sports Clustering Deconstruction Based on Neural Network," *International Transactions on Electrical Energy Systems*, vol. 2022, Article ID 8203143, 9 pages, 2022.

Research Article

Application of Sports Clustering Deconstruction Based on Neural Network

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Sports cluster analysis can mainly provide more teaching ideas for physical education. Teachers can make scientific and reasonable arrangements for the teaching plan according to the analyzed data results, so as to achieve better teaching purposes. However, due to various factors such as exercise time and course time conflict, this method cannot be widely used. The neural network had a good memory function, and it can be used to integrate physical education resources in sports. Then, a knowledge framework was formed by simulating a large number of human brain neuron structures, which can solve the problems existing in the motion cluster analysis to a certain extent. In this paper, the sports based on neural network is used to improve the problems existing in the practical teaching application of sports clustering analysis. A teaching system model based on motion recognition was established to improve motion cluster analysis and promote the implementation of data-based education. According to the experimental data obtained from the experimental test, people can know that the detection rate of the sports cluster analysis model is about 89.5%, and the average missed detection probability is about 5.5%.

1. Introduction

The implementation of quality education can further solve the shortcomings of the traditional education model, which is always centered on achievement. At the same time, this not only means to improve the teaching level and teaching quality of key schools, but also to provide more comprehensive quality talents for national development. Physical education is an indispensable subject in quality education. The types of sports are complex and diverse, and different intensities of sports have different requirements for physical fitness. Not every sport is suitable for students of every age. The application of sports cluster analysis in sports is mainly about the degree of application of sports in physical education, whether students are interested in the training programs carried out, and the improvement of students' comprehensive physical quality. Neural network technology is a distributed algorithm model based on animal neural network framework, which is designed to process data through computation. Its working principle is that by adjusting the weight between neurons, the value of the

transfer function can be adjusted to control the weight threshold, so as to achieve the required accuracy. Neural network technology has developed rapidly in recent years because of its powerful data processing function, and its application range is also quite extensive. The application of neural network technology to sports teaching can better integrate physical education resources, make course teaching more interesting and vivid, and stimulate students' interest in sports. Also, it can help physical education teachers to choose sports that are more suitable for students' teaching.

Physical activity is indispensable for people's health in daily life, and the cluster analysis of sports has long been studied by international scholars. Kong used the model to identify and learn to analyze the TV golf course program and used the model to sense the teaching presence and learning effect of courses in different paths [1]. Kim studied the motivation of volunteers in sports events by cluster analysis and carried out a subdivision of the work of different volunteers in different events [2]. Kubo mainly discussed the conflict between school physical education and sports

commercialization and used the method of cluster analysis to study the content of high school physical education from media platforms and journals [3]. Thornton used a cluster analysis method to study the influence of individual characteristics and background factors on training load and game performance in adult men's semi-professional basketball [4]. Behravan used a cluster analysis method to cluster the performance data of players in different games to find the role of players in football [5]. Most of the above studies lack the support of experimental data, and traditional clustering algorithms have inaccurate data identification to a certain extent and are not applied in combination with new technologies.

Neural network is a new technology and has been optimized and improved in a short period of time, so it is also a research hotspot of scholars. Goh used neural networks to model the feasibility of complex relationships between seismic and soil parameters and liquefaction potential [6]. Perna proposed a strategy for choosing the hidden layer size in a feedforward neural network model [7]. Segler proposed a model that can count computer language. The model mainly used neural network as a research method and drew the conclusion that the language characteristics obtained in computer language processing were related to the characteristics of the model that trained it [8]. Kohl proposed an interstellar object formation route that is not convincing in current astrochemical models and proposed an evolutionary neural network for strategic decision problems [9]. Holden proposed a real-time character control mechanism using a novel neural network architecture called phase function neural network [10]. He proposed a desired state estimator for guaranteed-uncertain-delay neural networks, mainly studying the robust state estimation problem of uncertain neural networks with time-varying delays [11]. Zhao discussed stochastic neural networks with time delays by constructing a suitable convergence theorem to ensure almost certain exponential stability of the network [12]. The above experiments have a lot of in-depth research on neural networks, but there is no related research on the clustering algorithm of sports, so such research is very necessary.

This paper mainly studies the physical cluster analysis of neural network technology in physical education. A cluster analysis technology system suitable for sports teaching is obtained by constructing a model, which mainly enhances the function of cluster analysis technology in processing data timeliness and accuracy.

2. Construction Method of Sports Clustering Deconstruction Model Based on Neural Network

2.1. Sports Clustering Deconstruction Model. Cluster analysis is a clustering method that divides data into given requirements or rules according to a specific property [13]. In the cluster analysis, the label number of each object is

unknown, and the data objects with high similarity are divided into clusters. The final result of the division is that the similarity between different clusters is the smallest, and the similarity within the same cluster is the highest. The application of cluster analysis in sports is mainly in the integration of physical education resources, and the clustering results are obtained by identifying body movements and extracting and analyzing the characteristics of the data. For example, in sprinting, striding and arm swing are two core movements in sprinting, and the speed of sprinting also depends to a large extent on these two core movements. The sports clustering analysis can extract and analyze the sprinters' arm movements and leg movements and then obtain a teaching model through clustering. Its schematic figure is shown in Figure 1.

The extraction and classification of data is to extract the sprinting action information in the underlying data, then use the classifier to mark the attributes of different information, and finally identify each action [14]. A sports cluster analysis model suitable for physical education teaching is constructed and can be classified to a certain extent. Among them, the determinant of the accuracy of the results obtained by the algorithm lies in the feature expression, and the most important part in the algorithm calculation and recognition is the feature extraction stage [15]. This stage is the most time-consuming stage, so the determinant of whether the action of sports is accurate or not lies in the process of feature extraction. This step is to decompose a complex nonlinear problem into multiple unit layers to form several learning units with independent weight functions and connection weight matrices. By learning the input signal and output signal and the corresponding parameters in the process of processing, the relationship between neurons and the relationship and interaction between them are determined, thus forming a complete sports cluster analysis model. Its structure figure is shown in Figure 2.

2.2. Clustering Deconstruction Algorithm. The data structures in cluster analysis are mainly data matrix and difference degree matrix [16]. The rows and columns in the data matrix represent "object-attribute," as shown in the following formula:

$$S = \begin{bmatrix} Y_{1,1} & Y_{1,2} & \cdots & Y_{1,Q} \\ Y_{2,1} & Y_{2,2} & \cdots & Y_{2,Q} \\ \cdots & \cdots & \cdots & \cdots \\ Y_{Z,1} & Y_{Z,2} & \cdots & Y_{Z,Q} \end{bmatrix}. \quad (1)$$

The rows and columns of the dissimilarity matrix represent the same entity, which is an "object-object" structure. A certain calculation method is used to calculate the value of the feature difference degree between objects and store it in the form of a matrix:



FIGURE 1: Schematic figure of sprinting cluster analysis.

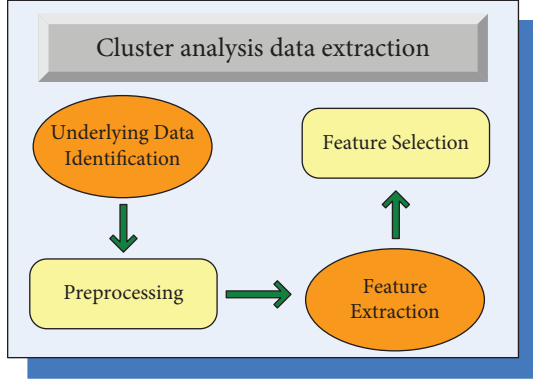


FIGURE 2: Schematic figure of cluster analysis model structure.

$$S = \begin{bmatrix} 0 & & & \\ f_{(2,1)} & 0 & & \\ f_{(3,1)} & f_{(2,1)} & 0 & \\ \dots & \dots & \dots & \dots \\ f_{(M,1)} & f_{(M,2)} & f_{(M,3)} & \dots & 0 \end{bmatrix}. \quad (2)$$

An interval-scaled variable is a unit of measure that represents a continuous variable [17]. The choice of

$$\left\{ f_{(i,j)} = \sqrt{|Y_{i,1} - Y_{j,1}|^2 + |Y_{i,2} - Y_{j,2}|^2 + \dots + |Y_{i,Q} - Y_{j,Q}|^2} \quad i = (Y_{i,1}, Y_{i,2}, \dots, Y_{i,Q}) \quad j = (Y_{j,1}, Y_{j,2}, \dots, Y_{j,Q}). \quad (5)$$

(2) The Manhattan distance is expressed as

$$f_{i,j} = |Y_{i,1} - Y_{j,1}| + |Y_{i,2} - Y_{j,2}| + \dots + |Y_{i,Q} - Y_{j,Q}|. \quad (6)$$

(3) The Minkowski distance is shown in the following formula:

$$f_{i,j} = \sqrt[n]{(|Y_{i,1} - Y_{j,1}|^n + |Y_{i,2} - Y_{j,2}|^n + \dots + |Y_{i,Q} - Y_{j,Q}|^n)}. \quad (7)$$

For binary variables, the correlation coefficient between variables is calculated by correlation analysis [18]. The binary variable data are shown in Table 1:

TABLE 1: Binary variable data.

		Object j		
		1	2	Sum
Object i	1	x	y	$x + y$
	0	m	n	$m + n$
Sum		$x + m$	$y + n$	Q

measurement unit determines the quality of the clustering results, so it is necessary to standardize the measurement values. The mean absolute deviation of $Z \times Q$ -matrix normalization calculation is

$$S_Q = \frac{1}{Z} (|Y_{1,Q} - n_Q| + |Y_{2,Q} - n_Q| + \dots + |Y_{Z,Q} - n_Q|). \quad (3)$$

The standardized metric value is calculated as

$$X_{iQ} = \frac{Y_{iQ} - n_Q}{S_Q}. \quad (4)$$

Distance calculation is to obtain the similarity by calculating the gap between two data objects. There are three main methods:

(1) The Euclidean distance is expressed as

When two variables have the same weight, it is called a symmetric binary variable, which can be used to evaluate the dissimilarity, as shown in formula (8):

$$f_{(i,j)} = \frac{y + m}{x + y + m + n}. \quad (8)$$

When the weight values of two variables are different, it is called an asymmetric binary variable, which can be used to evaluate the dissimilarity, as shown in formula (9):

$$f_{(i,j)} = \frac{y + m}{x + y + m}. \quad (9)$$

Standard variables are the generalization of binary variables:

$$f_{(i,j)} = \frac{Q-n}{Q}. \quad (10)$$

2.3. Sports Clustering Deconstruction Model Based on Neural Network. The neural network is actually a computational model through the processing of data information [19]. Its structure is similar to the human brain neuron network and a simple calculation model is built on the basis of this structure. Neuron is the most basic unit of a neural network. Its receiver is responsible for receiving information, and its output is responsible for transmitting information. Its structure is shown in Figure 3.

The output corresponding to the input value of the neuron is

$$S_{V,b}(y) = f\left(\sum_{i=1}^3 V_i y_i + b\right). \quad (11)$$

The connection between each two neurons in the neural network represents the weight of the signal through this connection, that is, the network memory is formed, and each neuron represents a specific function called activation function or excitation function [20]. In order to enhance the expression of the neural network, a continuous nonlinear activation function is generally used because the continuous nonlinear activation function can be derived and can be solved by optimization.

The sigmoid function is shown in the following formula:

$$\sigma(y) = \frac{1}{1 + \exp(-y)}. \quad (12)$$

The Tanh function is shown in the following formula:

$$\text{Tanh}(y) = \frac{e^y - e^{-y}}{e^y + e^{-y}}. \quad (13)$$

The two function figures are shown in Figure 4.

The neural network structure is the connection method of the network by each neuron, and its structure is the same as the neural network structure of the human brain [21]. It can also be divided into three layers: input layer, hidden layer, and output layer. These three correspond to the human brain neural network. The input layer corresponds to the receptive part, the hidden layer corresponds to the conduction part, and the output layer corresponds to the effect part. The neurons between layers and layers are connected to each other, and each connection will have a corresponding weight value. Its structure is shown in Figure 5.

The neural network adjusts the value of the transfer function by changing the weight relationship between neurons to control the threshold of the weight, so as to meet the required accuracy requirements [22]. After the neural network has performed the corresponding sample practice, if the input data and the training sample are the same data, regardless of whether the results are complete or accurate, the neural network can quickly obtain accurate judgment results through the data of the training samples.

Given an input vector $Q_k = (c_{1,k}, c_{2,k}, \dots, c_{m,k})$ and an output vector $T_k = (h_{1,k}, h_{2,k}, \dots, h_{m,k})$. According to the input vector and the initialized weight V_{ij} , the calculation of the transfer process can be obtained:

$$\begin{aligned} h_j &= \sum_{i=1}^m V_{ij} c_i - \theta_j, \quad j = 1, 2, \dots, q, \\ b_j &= f(h_j), \quad j = 1, 2, \dots, q. \end{aligned} \quad (14)$$

The output b_j weight of the hidden layer function is passed through the transfer function to obtain the result of the output layer, and the reflection is shown in the following formula:

$$\begin{cases} R_t = \sum_{j=1}^q W_{jt} b_j - \gamma_t, & t = 1, 2, \dots, p, \\ A_t = f(R_t), & t = 1, 2, \dots, p. \end{cases} \quad (15)$$

Then, through the output vector and reflection, the calculation error is

$$g_{tk} = (h_{tk} - A_t) * A_t * (1 - A_t), \quad t = 1, 2, \dots, p. \quad (16)$$

According to the hidden layer output value b_j , weight W_{jt} , and output layer error g_{tk} , to calculate the back-propagation of the error, the error between the basic units is expressed as

$$u_{jk} = \left[\sum_{t=1}^p g_{tk} * W_{jt} \right] * b_j * (1 - b_j), \quad j = 1, 2, \dots, q, t = 1, 2, \dots, p. \quad (17)$$

When the output value does not satisfy the error, return to formula (14) to recalculate until the basic unit error between samples meets the conditions. At this time, each layer performs the update and adjustment calculation of the weights and thresholds according to the output and error, as shown in the following formula:

$$\begin{cases} W_{jt}(m+1) = W_{jt}(m) + c * g_{tk} * b_j, \\ \gamma_t(m+1) = \gamma_t(m) + c * g_{tk}. \end{cases} \quad (18)$$

The weight threshold is updated and adjusted according to the error between the input vector and the basic neuron unit, as shown in the following formula:

$$\begin{cases} W_{ij}(m+1) = W_{ij}(m) + \beta * u_{jk} * c_{jk}, \\ \theta_j(m+1) = \theta_j(m) + \beta * u_{jk}. \end{cases} \quad (19)$$

In order to test the influence of the weight value on the experimental accuracy, the training data are selected to test the recognition accuracy of the model. The learning rate is the size of the update amplitude each time the value is updated, and the learning rate will affect the convergence speed of the parameters. The specific experimental conditions and parameters are shown in Table 2.

The learning rate is set to 0.001 according to the amount of experimental data in the actual experiment. According to the actual situation of the experimental hardware equipment and the size of the dataset, the attribute value is set to 32. In

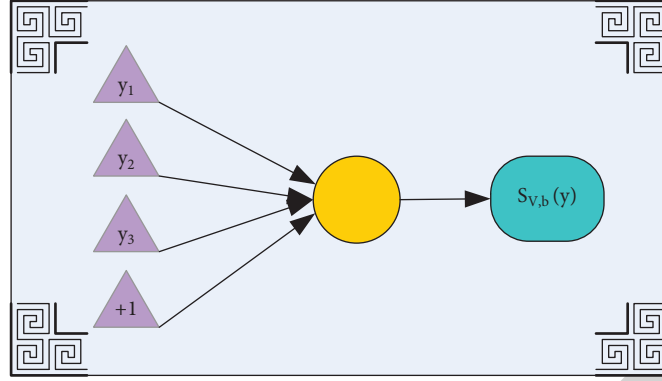


FIGURE 3: Schematic figure of neuron structure.

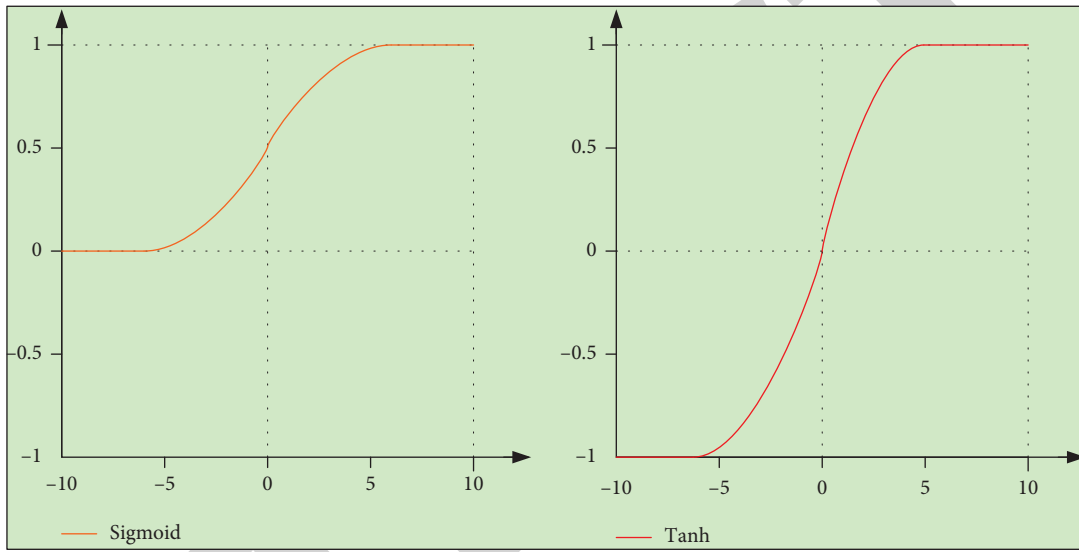


FIGURE 4: Figure of sigmoid and Tanh functions.

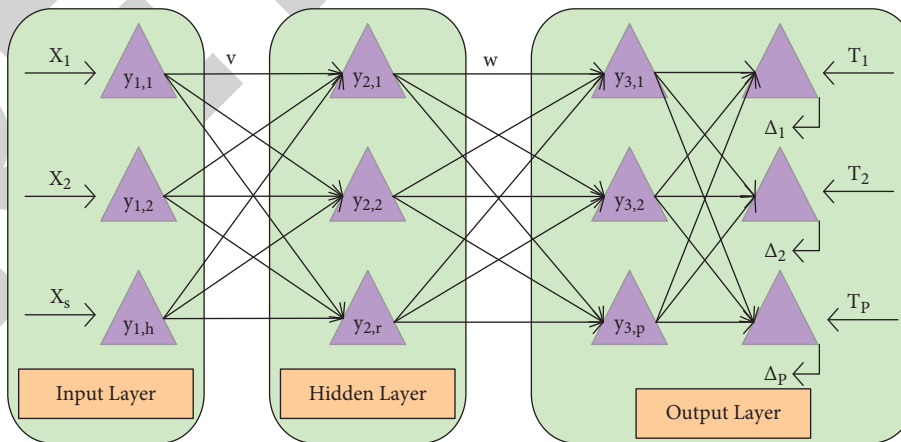


FIGURE 5: Schematic figure of neural network structure.

order to make the features more sparse and to a certain extent prevent the large amount of parameters generated by feature fusion from causing overfitting in network training, the output value is set to 0.1. The weights in the weighted

feature fusion formulas are tested on the dataset, and the value with the highest accuracy is selected as the accurate value of the weight. The specific experimental results are shown in Figure 6.

TABLE 2: Experimental condition data.

Parameter	Numerical value
Learning rate	0.001
Attribute value	52
Output value	0.1

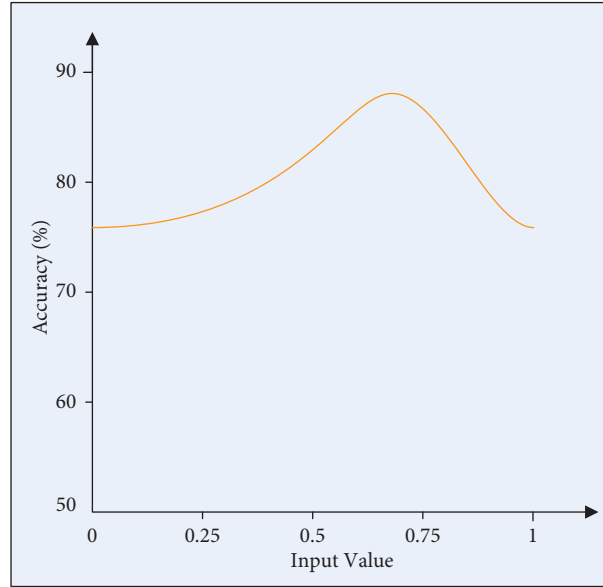


FIGURE 6: Line figure of weight value accuracy under different input values.

It can be seen from the analysis of the weight experiment results that when the weight of the input value is 0.7, the accuracy of the network algorithm is the highest, so the weight value is 0.7 in the next experiment. When the weights of the feature vectors are the same, the two features complement each other to reach a balanced state.

3. Experiment of Sports Clustering Deconstruction Model Based on Neural Network

To evaluate the model, conduct experiments on experimental samples of 5 kinds of sports teaching resources. Different numbers of experimental samples are taken for each sport, which are 50, 100, 150, and 200. The attribute values of each sample are 5, 10, 15, and 20. The specific experimental dataset is shown in Table 3.

In order to test the recognition performance of the model, the above experimental dataset is tested, and the functionality of the model is reflected by testing its sample detection rate and missed detection rate. The experimental results are shown in Figure 7.

The experimental results show that the detection rate of the model is about 89.5%, and the average missed detection probability is about 5.5%, which can achieve better functions. When the attribute values are different, the detection rate and missed detection rate of the model for different exercise types are also different. This is because the input values are different when the attribute values are different,

TABLE 3: Experimental dataset of sports teaching resources.

Type of sport	Attribute value	Number of training
Basketball	15	50
Sprint	10	150
Football	5	100
Badminton	20	200
Long jump	20	200

and the detection of samples with more attribute values is more complicated. According to the experimental results of various sports types, the three sports types of sprint, badminton, and long jump have higher missed detection rates. This is because the attribute values of these 3 sports are higher, and the detection rate of the model decreases when the number of tests is larger.

In order to further test the clustering effect of the model on sports, the accuracy of the clustering effect of different numbers of five sports is tested, and the attribute values of these five sports are controlled to be equal. The specific experimental data are shown in Figure 8.

It can be seen from the experimental data that when the number of samples gradually increases and when the number of samples is 100, the accuracy of the model with the highest accuracy rate decreases, and when the sample dataset doubles, the accuracy of the model decreases linearly. When the number reaches about 800, the accuracy of the model almost reaches its peak and remains at about 76.5%. This also

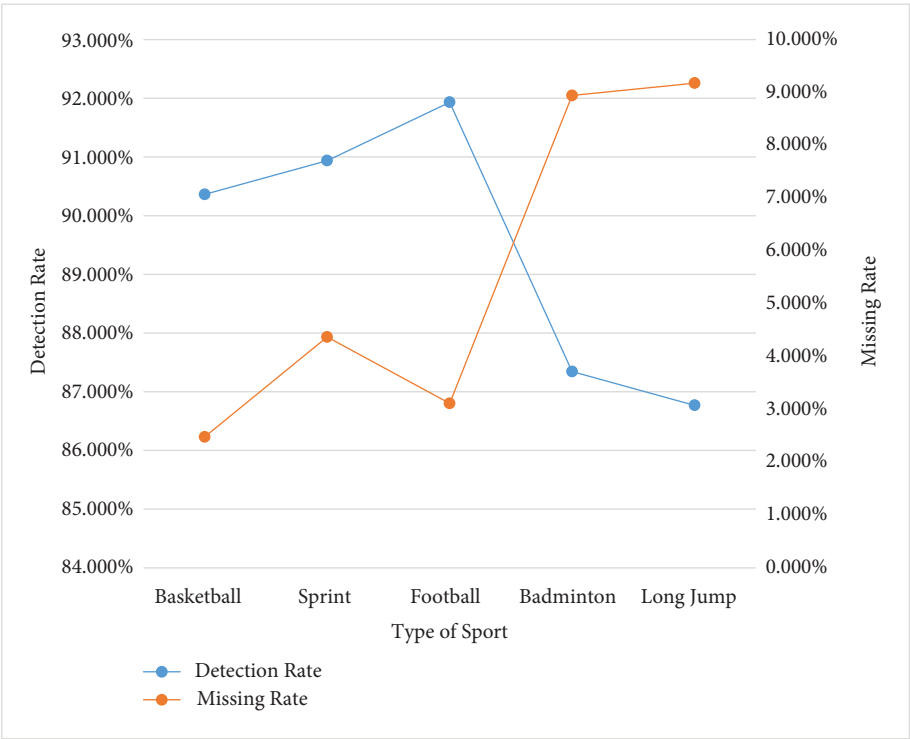


FIGURE 7: Line figure of detection rate and missed detection rate of different sports types.

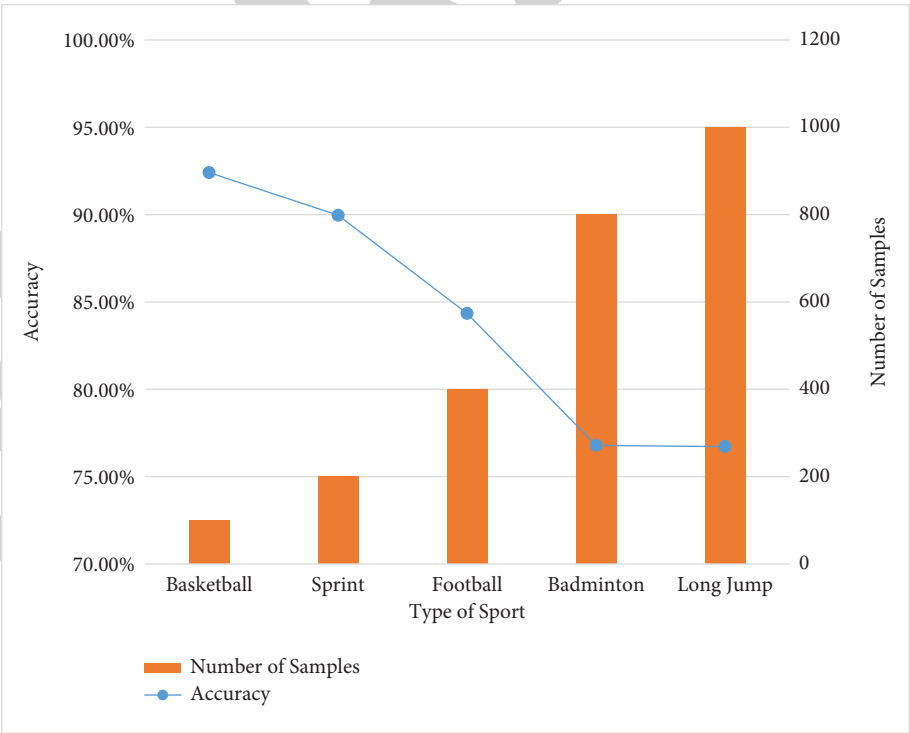


FIGURE 8: Accuracy of test results with different number of samples.

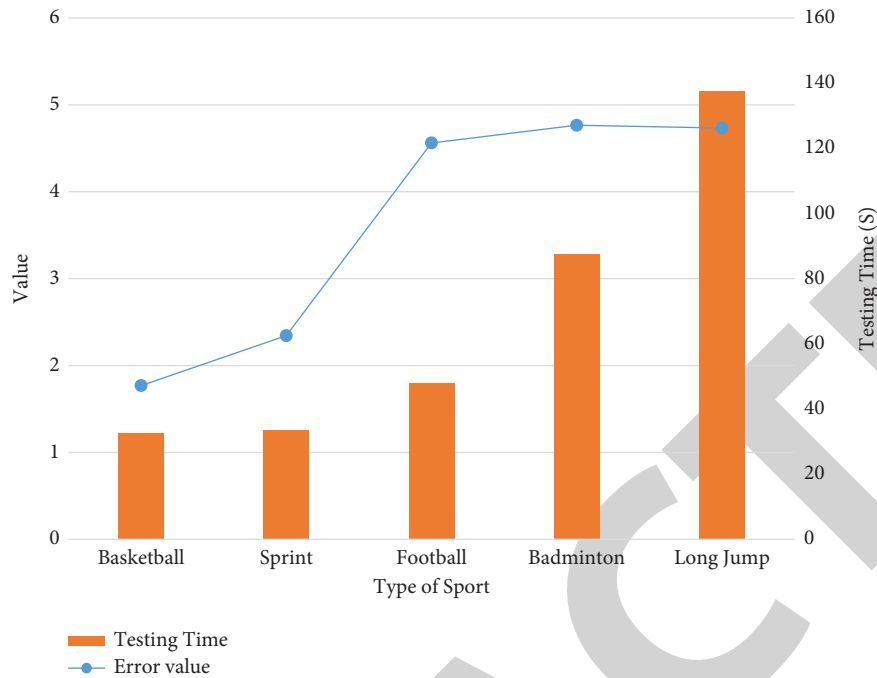


FIGURE 9: Comparison of error value and test time.

proves that the sample size affects the accuracy of the clustering effect of the model.

In order to further explore the influence of quantity on the accuracy of the model, the data statistics of the detection time and error value of the model for different data in the above experiments are carried out, and the results are shown in Figure 9.

It can be seen from the experimental results that when the number of experimental samples is low, the test time of the model is not much different, about 45 s or less. Experimental testing time increases with the number of samples, which shows that when the number of samples is large, the model needs to spend a lot of time to maintain the accuracy of the test. Moreover, when the number of test samples reaches a certain value, the error value of the test results of the model tends to be stable. When the number is about 400, the error of the model test is gradually stabilized, and the error is controlled at about 4.5.

4. Conclusions

The research content of this paper is the application of sports clustering analysis based on neural network. It mainly analyzes the clustering effect of sports and uses neural network to build a model. By building a model that can identify and accurately classify sports teaching resources, through the influence mechanism of the neural network and the influence of the weight value change on the model accuracy, the optimal experimental configuration is obtained to achieve a dynamic balance state. Then, use the model to test the detection rate, missed detection rate, error, and test time of sports test samples with different attributes and different numbers. Through the test results, it can be found that the detection rate of the model is about 89.5%, and the average

missed detection probability is about 5.5%. Also, the test time is positively correlated with the sample size, and the test time becomes longer as the number increases. This shows that when the number is large, the model needs to spend a lot of time to maintain the accuracy of the test and reduce the error value of the cluster. From the overall results of the experiment, the neural network technology designed in this paper has a good performance for the sports clustering analysis model. The optimization, reform, and upgrading of education is the only way for a country to become more permanent. It is said that physical health is the foundation of all achievements. Paying attention to physical education can not only make students have a better physique but also promote children's mental health and provide great help for children to complete their studies well.

Data Availability

No data were used to support this study.

Conflicts of Interest

The author declares that there are no conflicts of interest.

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Retraction

Retracted: A Machine Learning Algorithm for Supplier Credit Risk Assessment Based on Supply Chain Management

International Transactions on Electrical Energy Systems

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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) 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.

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- [1] Y. Wei, "A Machine Learning Algorithm for Supplier Credit Risk Assessment Based on Supply Chain Management," *International Transactions on Electrical Energy Systems*, vol. 2022, Article ID 4766597, 11 pages, 2022.

Research Article

A Machine Learning Algorithm for Supplier Credit Risk Assessment Based on Supply Chain Management

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In today's complex and ever-changing world, a distribution network in lending impact analysis is an evaluation of a client's procedures, rules, and financial well-being to evaluate as considerable risk and it provides to the contracting company. A creditor's capability to pay the current lender's obligations is considered while doing a lender's threat assessment. Traditionally, it refers to the concern that the borrower may not be able to collect the sequence and interest. The challenges in lenders' threat assessment are a lack of adequate data storage and retrieval, problematic delays caused by a lack of access to the relevant data at the right time, extended lead times that lead their shipments at risk, and demand for speedier deliveries. This paper introduces a machine learning-based linear regression algorithm (ML-LRA) for supplier credit risk (SCR) assessment based on supply chain management (SCM) in credit risk frameworks that depend significantly on modeling ML. Regression models are logistical constraints that can be used to simulate the impacts of multiple variables on a customer's creditworthiness. The chain of distribution forecasting tool assesses specific decisions based on assumptions in variability. As a result of the findings in this study, it can be assumed that ML-LR approaches have a significant role in a variety of business processes such as supplier selection, risk prediction along with the supply chain, and demand and sales estimation. Finally, the study's consequences for the most critical constraints and obstacles are examined to enhance the supply chain management system and ensure overall system sustainability.

1. Introduction

Presently, among small- and medium-sized businesses and their finance companies, supply chain management (SCM) has recently developed to replace decreasing credit availability. SCM differs from ordinary borrowed funds in that the company extends its financing to the business upstream or downstream [1]. Creditors have recently embraced it as a viable solution to SCR when it comes to funding small entrepreneurial firms with SCM. The ability to accurately forecast businesses' borrowers' delays is one of the concerns in budgeting. The enterprise of a company's logistic network includes everything from the time the starting materials are acquired until the completed stock is delivered to the customer. The terms "upstream" and "downstream" are frequently used to describe various parts of the supply chain. A company's supplies enter through its exploration and production. The term "supply procedures" refers to the processes in which the final product moves from the

organization to the client. Everything that goes into making a commodity into finished items is considered part of logistic network administration. If you want to optimize customer satisfaction and obtain an edge in the industry, you must actively streamline your supply-side processes.

On the other hand, traditional approaches to predicting credit risk fall short of these requirements [2]. Methods based on machine learning (ML) are highly regarded among scientists. To predict SCR's credit risk, consumers want to merge two popular ensemble ML approaches: random subspace and multiboosting [3]. It combines various services offered by providers and clients that cannot satisfy their current equity demands. Supply chain management uses a systematic structure to trade between SCR and their "credit risk" corporations, which are the most powerful companies in their supply chains [4]. Financial institutions, investment firms, insurance providers, and stockbroker companies are the most prevalent varieties of economic entities. Savings, lending, investing, and exchange rates are just a few of the

many services offered by these organizations to both individuals and businesses. Networks and equipment that work together to turn simple ingredients into completed, customer-ready goods constitute a distribution network. Interorganizational technology for managing these processes from start to finish is known as a supply chain management (SCM) system.

Consumer spending and acquiring behaviors have been transformed by the digitalization of marketing, which has resulted in disruption and discontinuous requests and pricing analysis. SCR organizations affected by these transformations must keep up in place to avert consumer unpredictability and financial risk and keep their profitability [5].

A linear regression (LR) model is required to detect supply chain management elements in the economic supply chain. Financial supply chain realities are combined with the standard ML method to produce a potential risk detection model based on LR in a real-world organization [6]. Supply chain finance has increased the modest and moderate business sector's interest rate businesses from an enterprise resource planning standpoint. Banking and investment firms have a crucial role in managing risk across the whole loan process, from preloan to postloan [7]. Risk in the distribution chain refers to the likelihood that vendors will face a corporate setting that could harm their commercial well-being. An incident of economic burden might happen as a result of the insolvency of a vendor, economic uncertainty, and many other factors. The stability and integrity of organizations are dependent on effective risk assessment. Institutions use this method to guarantee all threats connected with their operations are systematically evaluated and controlled in a timely and thorough manner by the bank's managers. They progressively depend on supply chain management to satisfy their financial demands, and this strategy depends largely on analyzing supplier credit risk assessment [8]. If the supplier credit risk of small- and medium-sized firms is widely dispersed, supply chain finance may become unpredictable and risky [9]. It has become increasingly difficult for banking institutions to create distribution network credit facilities because of the need to manage supply chain financial risk control [10]. As the supply chain desires to make a difference in the funding sources in the supply chain, they must keep an eye on their enterprise resource planning. This work uses LR preference relations to construct a risk analysis and assessment model that incorporates supply chain finance and safety theory research [11]. Supply chain financing is an expansion of payment plans offered to a client by a selling company. A harmonic distortion effect is created across the transaction network by delaying contracts in response to a client's cost overruns to transfer compensation; in the case of an agreement collapse, credit risk might be a viable option. For banking firms, the greatest danger is a default on customer debt. Contractual responsibilities are not met when lenders or suppliers default. An instance of this is when a borrower fails to pay back a loan's principal or interest. Stationary investments and bank cards are not the only sources of debt that might go under bankruptcy. The capacity to supply an

interconnected set of company software is referred to as enterprise resource planning (ERP). The ERP systems' shared information and process model covers final company operations, such as those in banking, HR, marketing, industry, service, and the distribution network. Detecting, analyzing, and managing associated economic concerns are also referred to as managing threats (SCRM). International logistic network administration systems have the potential to increase operating productivity and save costs, and customer satisfaction. Technology-based corporate and financial procedures, such as trade credit, can reduce costs, while increasing productivity for all involved parties. As provided, even as the buyer has a stronger credit rating than the seller, revenue management works well [12]. Designing a robust ML-LRA architecture that can handle increasing volumes of unchangeable financial data created from these records has been advocated in light of these problems and the potential for advanced analysis of these documents [13]. It is suggested that a strong database structure built on an ML be designed to meet the problems of storing and manipulating ever-increasing amounts of immutable transaction records in an LR network of multiple supply chain stakeholders. As production chain parties face increasing difficulties in maintaining and modifying the increasing numbers of the deterministic public ledger in a digital ledger, a robust LR architecture based on cloud infrastructure is proposed [14].

Classifying supply chain management with supplier credit risk and control issues and devising solutions to these problems is the focus of this paper. Consumers suspect risk leadership theories should be addressed at three levels: strategic, operational, and tactical. In contrast, variances, interruptions, and tragedies might appear in the supply route due to supply chain management. To increase production, the intelligence to provide systems is necessary for companies and distribution networks to increase production. These two sources of knowledge may be used to produce targeted potential buyers that boost revenues, allocate resources, and minimize costs. A more planned strategy for inventory distribution can be achieved through digital technologies. Digital computing's analytics can let businesses keep tabs on networks and prioritize delayed shipments. It is possible to automate some procedures and merge emotions more readily. A wide range of interruptions, including actual injury to manufacturing facilities, natural calamities, protests, and labor conflicts, capacities concerns, delays, inventory stock problems, and faulty forecasting, contribute to today's supply chain risk diversification [15].

First and foremost, production lines should be designed with constructed comfort levels so that when an unexpected event occurs, it can be contained. Both approaches need a thorough awareness of the production company's potential for unpleasant occurrences or the associated implications and impacts [16]. Using LR systems to reduce the distribution network investment burden is the topic of this paper, which examines the theoretical framework, technological route, and available work outcomes. Enhancing the use of financial MLLRA technology in supply chain economic risk management increases control over the economical possibility [17]. Accounting, marketing, supply chain, and

logistics are just a few areas where ML analytics has already been put to good service. Personal information analytics in the distribution network is becoming increasingly important due to significant advances in ML-LRA technology [18]. The term supply chain analytics refers to the process firms utilize to gain knowledge and generate income from the enormous amounts of material associated with the purchase, manufacturing, and the provision of commodities. Analysis of distribution network data is a critical aspect of the process (SCM). Using machine learning analytics is a completely new technique. For more in-depth, quicker, and complete data analysis, algorithms optimize the whole operation.

The main objective of this paper was as follows:

- (i) ML-LRA models in supply chain approaches can be used to analyze the effects of assorted variables on a customer's creditworthiness.
- (ii) Machine learning (ML) in supply chain management may be used to identify supplier system problems before they negatively impact the business. As the company has a well-developed distribution network forecasting system, it will be well prepared to deal with new issues and threats.

The remainder of the article is section 2, which indicates a literature review based on logistics, and to evaluate the lending threat of suppliers, section 3 denotes the machine learning in credit risk system, section 4 mentions results and discussion on creditor's financial health, and section 5 denotes experimental analysis of credit risk research and concludes this paper.

2. Literature Review

Li et al. (2022) introduced a supply chain management (SCM) with electronic information technology that is advanced and has become increasingly digital [19]. Financial institutions currently confront more efficiency and risk due to the abundance and complexity of audit information. As a result, commercial banks place a high value on credit risk assessment based on digital SCM. The capital adequacy of digitally SCM is evaluated using a hybrid extreme gradient boosting multilayer perceptron model to assess the credit risk of the digital SCM (DSCM) model.

Abbasi et al. (2019) proposed the framework of Cloud computing and IoT technology with an analysis of supply chain finance and its credit risk [20], and the unique functions of stock control in pledge funding strategy with supplier credit risk are all presented. The strategic sourcing market concept is then designed based on the Internet of Things to manage the supply chain. A financial stability measuring system is then developed using the support vector machine algorithm (SVMA) and the logistic regression approach, which takes into account a company's topic rating and its underlying debt rating.

Wang et al. (2019) proposed a logistic regression in support vector machine (LR-SVM) in supply chain management research. However, credit risk analysis dominates strategic sourcing economic threat research [21]. Research on online supply chain financing, particularly on systemic

concern, is limited; as a result, an in-depth investigation of the commercial supply chain in credit risk evaluation. The distribution network financing business used the nonlinear LS-SVM model for empirical analysis. It is related to the findings of the prediction model for the specialized SME method in the field of manufacturing. Furthermore, the developed indicator approach can accurately assess the risk associated with a given financial product or relationship.

Wong et al. (2022) introduced a partial least squares-based structural equation modeling (PLS-SEM) in artificial neural network (ANN) in supply chain finance businesses [22], which face a wide range of challenges in supplier credit risk. Commercial banks pay attention to supplier credit risk management if they intend to reduce and prevent threats. Traditional corporate governance is not ideal, and the ANN technique is reliable, increasing the likelihood of production network administration in this way. The educational system is well versed in studying distribution network economic borrowing ratings. Its assessment has been improved over time, starting with the formation of credit risk and continuing via prevention, indicator selection, and development.

Aboutorab et al. (2022) proposed a reinforcement learning approach for proactive risk identification (RL-PRI) for an efficient supply chain in supplier credit risk management, which is a must assignment [23]. To begin credit risk management, the supply chain manager must initially identify the risk events that are relevant for further research. To be proactive in managing supply chain risks, the controller must identify risk events promptly in the risk identification process. However, doing it and entering data is a time-consuming and difficult process. Finally, consumers demonstrate the RL-performance PRI's accuracy in recognizing the specific risk events of interest by comparing its output to the supplier risk events manually recognized by expert supply chain managers.

Yang et al. (2021) detailed a sustainable supply chain finance (SSCF) has increased the need for small- and medium-sized (SMEs) businesses to get supply chain financing (SCF) [24]. The rapid evolution of SCF has led to increasingly complicated economic concerns. SMEs have emerged as one of the most pressing concerns in the SCF world. Credit risk management is critical to achieving long-term sustainability in the financial sector SSCF. Because of this, it is essential to identify the major elements impacting the credit risk of SMEs and build a forecasting framework to improve SSCF, a current invention that combines supply chain management with finance. Finance-oriented and supply chain-oriented research on SCF now dominates the literature.

Dumitrascu et al. (2020) introduced a graphical user interface (GUI) based on artificial neural network (ANN) for the prediction accuracy and long-term viability was the primary consideration in organizing. Supply chain management for credit risk assessment and performance measurement system using their own set of key performance indicators (KPI) [25]. The challenges specific to each SCM system were identified using an observation research methodology. An assessment model for supply chain

management performance that relates particular problems to the most important KPIs for each subsystem is the primary purpose of this research. By utilizing this component, companies may assess the integrity of their supply chain management system as a whole and take a fresh approach to deal with the difficulties it faces.

Zhang (2019) detailed a K-nearest neighbor (KNN)-based supply chain financing development for credit risk is presented [26]. The k-nearest neighbor technique may be used to determine debt banking potential growth for logistic network financial enhancement. A look at industrial business market share and future mining capacity is also examined in this study. According to this study, the commodity system accounting projections depending on the k-nearest neighbor approach are more practical and accurate than conventional methods.

Zhao (2020) proposed a decision tree algorithm (DT) with systems that have grown into a substantial, competitive community of banking firms as a result of the growth of Internet finance [27]. Personal credit risk analysis is a pressing issue while developing Internet financial platforms and must be addressed. Using Internet technology, innovative methods for the administration of online financial platforms and data security are currently conceivable. This paper protects the most important principles for evaluating a person's personal credit in light of the present flaws in Internet financial credit evaluation. In this paper, the credit risk assessment method is designed, and unique supply chain evaluation technology is established using decision tree technology.

3. Proposed Methodology

Supply chain management (SCM), which has gained significant lender and institution certification programs available in the financial industry, has emerged as one of the most popular issues in logistics organizations. The convergence of logistics and business concerns is centered on the idea of SCM. Numerous businesses are experiencing liquidity issues and are in danger of experiencing a critical financial shortfall due to the effects of the global economic inflation and slump, particularly in the automobile and electronics manufacturing industries. Although buyers are extending their payment terms, suppliers are still attempting to get their clients to purchase a deposit. Supply chain marketing is the collaboration and marketing of supplier networks inside a company. At the same time, the operation strategy integrates and maintains (flow and storage) a group's goods (products). The transport and preservation of goods in a distribution chain are important to operations. Supply chain management (SCM) is broad, encompassing all of the collaboration among companies that have a function in this system, such as purchasing, processing, transportation, storage, and distributing.

When it comes to logistics management, transportation's primary goal is to raise the total value of each delivery, as measured by the happiness of the client. Reduced labor resources must thus be linked to a constant level of high-

quality customer care. SME and the enterprises they engage with impact the SCM processes of the community by marketing products and services, and their providers may improve financing terms and reduce operating investment costs, respectively. Financial institutions in SCM products need to examine the economic health of SME principal business comparable as well as its creditworthiness, which is often a founder firm with large size and stable income. As a result, the supply chain condition of the fund demander and its counterpart affects both SME and the major enterprise's financial health. It is essential for lenders to properly control risks by reviewing the money requester's extensive network of business associates and the massive scale of data they have at their disposal. Supply chain management systems provide the firm and its distribution network with the knowledge they need to make the most efficient use of their capabilities. These two types of data sources may be used to produce targeted sales opportunities that boost revenues, utilize resources, and minimize costs. It aids in determining the likelihood of proposed transaction risk. It aids in foresight in devising countermeasures in the event of a negative result. When used to build credit models, it is a powerful tool for gauging the risk linked to a specific loan decision.

Figure 1 expresses customers and suppliers unable to meet the financial risk management standards, which can utilize bank assistance as an innovative estimate solution for supply chain finance, selecting, and altering the loan duration as needed. The credit risk management techniques, such as avoidance, preservation, partnering, handing, and loss reduction and prevention, can be used in various aspects of an individual's life. They can pay off in the long term. Financial threat organizational processes were therefore impacted by the absence of acceptable borrowing surroundings, which was accompanied by difficulties in assessing and tracking credit appraisals, a lack of market risk analyses, strategic risk, and difficulties in conducting proper credit grants. Accounts receivable mode and purchase (accounts receivable in the future) mode are the basic loan modalities. A company can utilize a business finance platform to withdraw the credit principle and taxes from the organization mall's accounts receivable, or a retail shop may pay the enterprise's accounts receivable directly and set up a repayment plan for the business itself. Supply chain finance is a collection of digitally business and financial operations that reduces costs and enhances efficiency for the parties engaged in a business. Supply chain financing works effectively as long as the buyer has a stronger credit rating than the seller. Digitalization decomposes such boundaries and creates an interconnected economy that is transparent to all the parties involved from suppliers of raw materials, equipment, and parts manufacturers, through the carriers of completed items to the consumers who expect completion. Supplying network banking is a collection of technologically based commercial and funding operations that reduces expenses and improves productivity for the stakeholders of a transaction. Distribution network financing usually works whenever the purchaser has a stronger credit score than the supplier, allowing them to acquire cash at a lower cost.

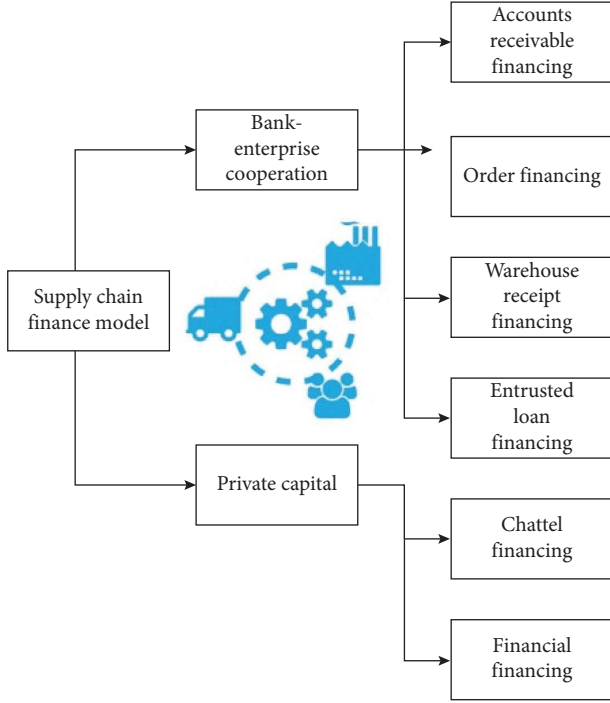


FIGURE 1: Supply chain finance development with machine learning model.

$$h_{\theta}(x) = [1 + (-\theta x)]. \quad (1)$$

The form of classification model strategy, termed logistic regression (LR), is commonly employed in the business world. It is possible to forecast a quantity using exponential function transfer and characteristic transfer. The probability of h_{θ} represents the value of the coefficient corresponding to the LR model, in which θ_x denotes the probabilistic prediction formula in logistics services. Assuming that x in perhaps every sampling in an information gathering is unrelated to the preceding samples. The purpose of the equation is to reduce the supplier credit risk assessment in supply chain management as follows in equation (1).

Figure 2 says the supply chain finance industry is split into three functional categories, as outlined here: banks, small lending firms, and similar lending institutions and their distribution network financing companies. Secondly, production chain economic businesses concentrate on giving services in the supply chain, particularly those upstream and downstream of the main company. It is a process through which a corporation transforms raw resources into goods that are ultimately sold to customers. The network of logistic consists of all the steps involved in obtaining a commodity from the producer to the final consumer. The third supply chain financial intermediation group includes investors and funds in the financial services sector. The Internet platforms for supply chain finance building, financial technology corporations providing digital banking services, logistics organizations providing cargo monitoring, and similar service providers are all examples of intermediate agencies.

$$c_y = (f_x - x_c) + \frac{X}{y} (N + Y), \quad (2)$$

where c_y denotes a metric for evaluating a platform's ability to save money in supply management, f_x is a partial dependence function with the differential equation in credit risk assessment, x_c represents a unique prediction model by comprising probability function, X is a support vectors multiverse in squares of learning algorithm with the logistic variable, y is the quantity of the identifier for each forecast, and N is a substantial number of practice formats in the commercial sectors. The partial dependence with the applied ML algorithm is a designated sequence with the entries corresponding to elements. The purpose of this equation is to enhance the supply management to better collaborate with suppliers and improve the quality control in business as follows in equation (2).

In Figure 3, credit and liquidity risk are the two most common types of financial risk. The operational risk is the threat of miscommunication, product defects, and administrative equipment malfunction, which increases credit and liquidity risk. Legal risk arises from a legislative system that is not designed to handle the kind of behavior, and it is supposed to be monitoring and controlling. In this study, it was shown that liquidity risk and credit risk had a positive correlation. A company's loan (asset) business is influenced adversely by a rise in credit quality (loans), resulting in higher financial distress. Credit risk occurs when a company or an independent lender fails to pay good on their loan commitments. Failure to collect principal and interest payments means that a lender is at risk of not being reimbursed for a loan. Systemic risk may be described as the likelihood of credit or financing disparities that might lead to a particular mistake by market participants in a banking market, and it can occur either collectively or independently from these other threats. It is the objective of asset categorization methods to determine a lender or operation's risks and grade the borrower or loan accordingly. Stochastic models are used to identify the unpredictable behavior of the credit quality or the parameters included in the computation of the credit risk. Portfolio risk models calculate the probability of a loss or the value of consumer loans; hence, they provide risk estimations. It is important to point out that the current study employs risk categorization models based on ML models for approving or rejecting loans.

$$y = 1, p(y = 1)x, \quad (3)$$

where y is the model's coefficients can be evaluated after the logistic regression model's expression has been obtained for the supply chain management, and p denotes a maximum likelihood estimation, which is the greatest popular tactic used in mathematics as follows in equation (3). To maximize the figure's probability x value under a given set of parameters, this approach first obtains a list of variables. The values of the log-likelihood function are stated in an analysis method in time series analysis. The purpose of the value is to achieve efficient fulfillment of demand and to enhance organizational responsiveness.

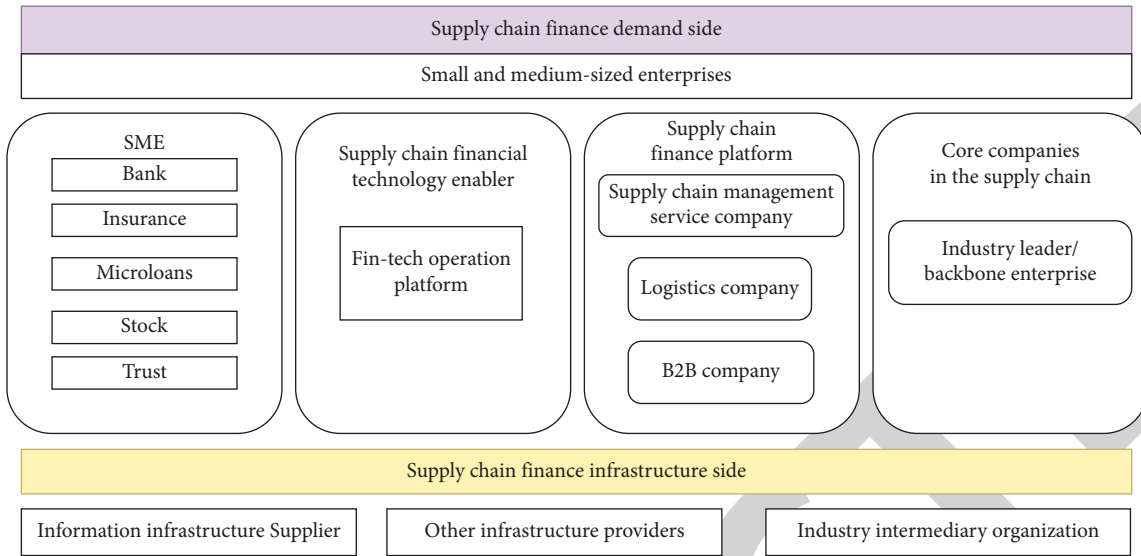


FIGURE 2: Supply chain finance participants organization model.

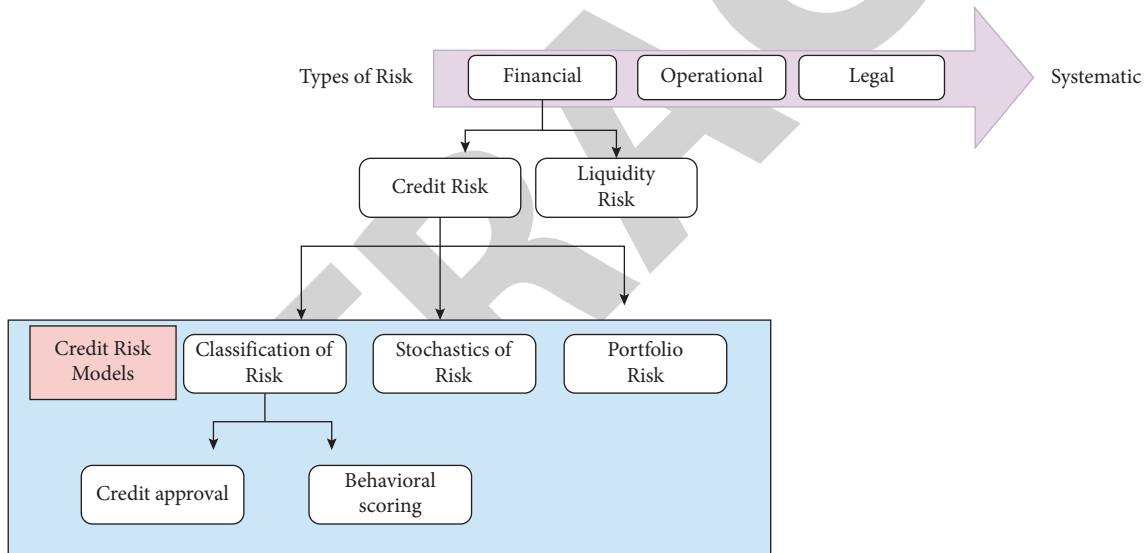


FIGURE 3: Classification of financial credit risk models.

Businesses and consumers are exposed to credit risk when they are unwilling or refuse to accept timely payments on their debts. Figure 4 shows the credit risk modeling in machine learning with interest owed to the creditor that provided the loan to the borrower would be unpaid. Since interest and fundamentals are the primary sources of revenue for creditors, this will lead to an uneven distribution in the cash flow. A higher amount of credit risk can harm the creditor by raising collection costs and interrupting working capital regularity. A bank uses a credit risk model to predict the probability of loan portfolios. Structural and reduced-form financial stability models may be classified into two primary categories. It is possible to estimate the likelihood of a company defaulting on its debt obligations using architectural modeling techniques. It is possible to determine the liquidity of a firm by reviewing its account of revenue

circulation and organization's ability to fulfill its hard debts. It could be utilized to anticipate the schedule, the quantity, and the uncertainty of future cash flows quickly and accurately. Clients unable to compensate it bring their firm in danger of going out of business. There are two types of credit risks: small accounts with bad credit or huge accounts with a heavy proportion that, if they go bankrupt, may spell the end of your firm. Lenders in participant lending want larger returns to compensate for the economic risk they undertake by making loans that are often uncollateralized, that is, without any physical security against them. It is also important that they make judgments under conditions of knowledge imbalance that benefit the lenders themselves. Loan decision makers seek a profit that more than balances whatever risks they take in making loans to implement reasonable choices.

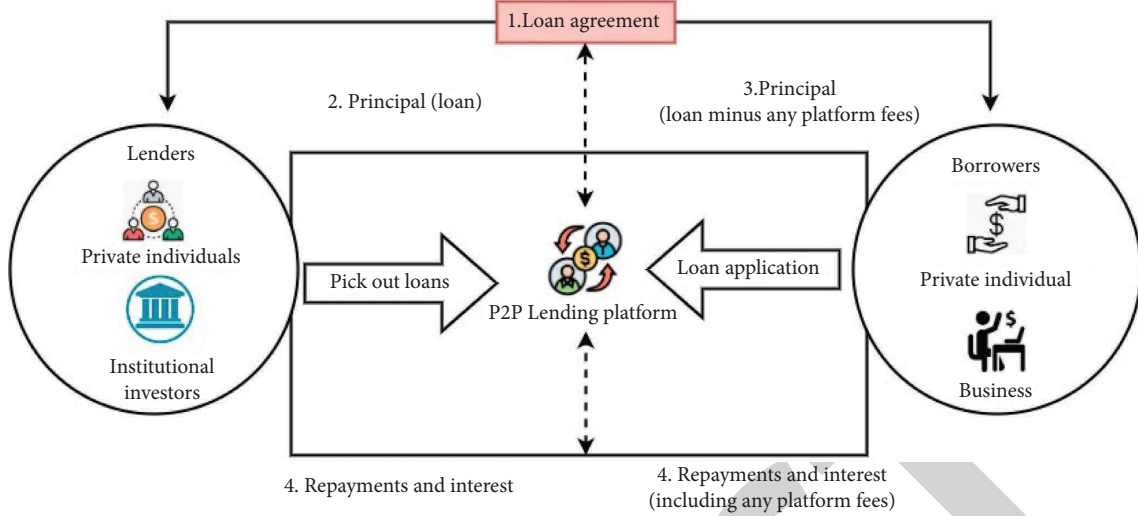


FIGURE 4: Credit risk modeling using machine learning approach.

$$y_i = (\omega^T x_i + b) H_1 H_2, \quad (4)$$

where y_i represented by a solid point and hollow point that has the classification line b is a different function, which divides each sample into two distinct classes, and the distance between the classification lines H_1 and H_2 in each class is known as the classification interval. The classification line equation may be expressed as $\omega^T x_i$ is the dimension of the feature space—the scalar parameter, b drives a high level of customer satisfaction. Make a linearly separable sample set by normalizing the data, and the sample space must have dimensions equal as follows in equation (4).

4. Results and Discussion

SCM can potentially expose smaller company's SME to both reputational probability from SCM competitors and quantitative bankruptcy costs. Supply chain disruptions harm global industrial production and commerce and have a favorable influence on inflation. Trying to figure out how much activity, trade, and pricing will be impacted by the above-mentioned distribution network shock and how much of a drag it will be on the recovery. These factors, with their supply and value chain long-term prospects and the market position, affect the ability to reduce loans to small businesses (SME). A company's economic situation (along with its profitability ratios and determination) needs to affect its ethical price volatility—its cooperation connections with major firms.

An SME credit risk is influenced by its organization's corporate accounting and financial operations, as its distribution network suppliers, the number of partnerships within that chain, and the progress made in that distribution network. The addition of third-party credit additionally complicates SCM credit risk assessment. Risk management is critical for small- and medium-sized firms since they often focus on expanding sales rather than being motivated to find their portfolios of loans. Delays in payments can negatively impact a company's financial capacity if managing reputation threats is neglected. Individuals within an

organization have traditionally dealt with third-party security in a compartmentalized approach, focusing on specific hazards, most often found in the distribution chain. The production process, which includes SMEs and their suppliers, must be considered by financial institutions when evaluating the liquidity prevalence of different SMEs. A database system for assessing investors' liability for SME is designed in this study by considering these elements [28].

4.1. Dataset Description. Commodities purchased online identification of the risk of project delays by predicting the quickest and most typical transport durations. E-commerce and goods/products delivery sectors will be able to identify the "risk of late delivery" and anticipate the fastest and most typical delivery time for their domestic and overseas buyers using the decision tree methodology we developed.

Customer information, such as sales figures, demographic information, and information about the company's financial performance (including net income and expenses), is all included in this dataset of DataCo Global's Supply Chains. Information on 180,520 consumers, spread across 53 columns, totaling 91 MB, is included in this data. It pertains to clothing, sports, and electronic supplies. <https://www.kaggle.com/code/sukanthen/e-commerce-multi-output-models-project-cse07>.

Figure 5 shows stock-market developments in the distribution chain by evaluating the paper's detection result with the credit risk in a traditional method. It is easy to see that the fast linear regression algorithm is significantly further to the appropriate analysis curve's value than the LR method. The financial risk to suppliers in the logistic network is the likelihood that they may run into a business scenario that jeopardizes their economic well-being. Supplier insolvency, market volatility, and additional can all cause a significant risk event. Businesses may make predictions and assess trends using linear regressions. The corporation may, for example, better predict sales by running a regression analysis on market data with monthly sales

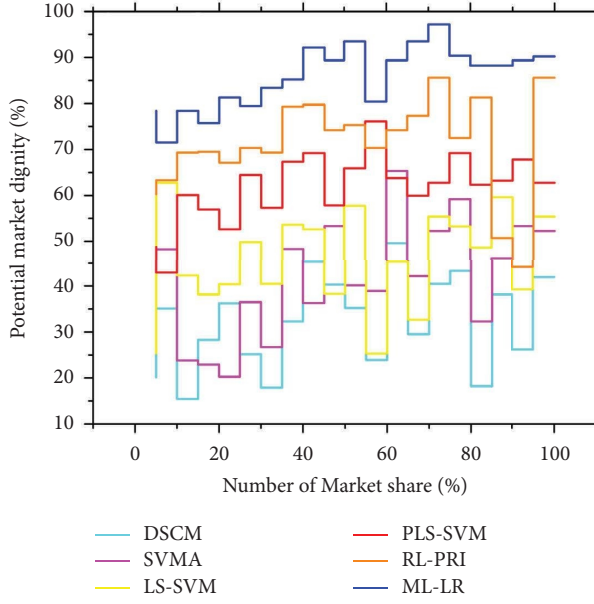


FIGURE 5: Analyzing credit risk with supply chain financial market development.

that have climbed gradually over the last five years. A currency industry framework driven by this approach has been proved to have greater coverage and precision in borrowing exposure managing than the current assessment, which is focused only on expert analysis. However, due to some data oscillations in the detection process, it is simple to cause a discrepancy in the recognition chart. Even yet, due to the extremely small percentage of unreliable evidence, it may go unnoticed during the detection process.

$$x_i = \frac{x_i - \min_i}{\max_i - \min_i}, \quad (5)$$

where x_i is to progress processing information for the enhancement of supply chain management, and \max_i is the first step to normalize the data. Statistics from cultural datasets on local business banking crises are the revised matrix product: \min_i is necessary to be utilized in this modified sequence as source geometry parameters for the SCM model, which indicates that long delayed and lending business brief contracts are not supported and not included in this figure. As a base classifier, specialists utilized several separate of the overall quantity of observations. Several training iterations were used to create support vectors and the SCM model build. The remaining one-third was used as a testing set for the LR model to transfer the things to customers through means of transportation as follows in equation (5). The logistic network accounting strategy is designed to account for the movement of products, knowledge, and funds concerning products, ranging from the sourcing of basic materials through the transit of the item to its final destination. This research method on supply chain management on DSCM, SVMA, LS-SVM, PLS-SVM, RL-PRI, and ML-LR with comparing to ML-LR has high efficiency in reducing the risk of supplier credit risk assessment shown in Figure 6.

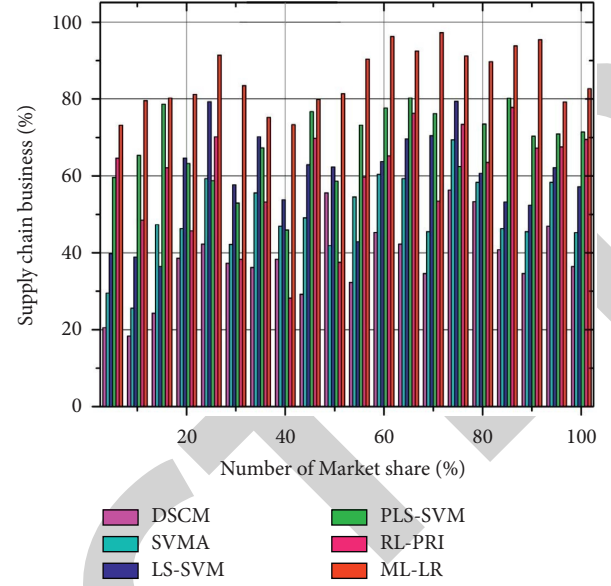


FIGURE 6: Commercial Bank's supply chain in credit risk assessment.

If a corporate institution's distribution network in big and minor cash flow fails to fulfill its debt commitments, it might lose a significant amount of money. Investment institutions' sovereign debt in the Internet distribution network is primarily attributable to the accompanying: unconstitutional legislation and operational inconsistencies. The digital supplier financing business has a wide variety of new products. The values of businesses mean that they are more prone to agreement faults, which raises several regulatory issues. Institutional investors' assets and objectives are jeopardized, while statutory hazards are not properly addressed, resulting in balance sheets. It is also important to verify the validity of the contract. Concerns about the entire chain of transactions are a major problem for commercial banks. The purpose of the variables with the financial institutions will be exposed to significant credit risks if supply chain participants conspire to falsify transaction contracts. The financial program's inefficiency is another issue for commercial banks. Certainly, this is a consequence of the country's nationalization. Due to bureaucracy, delays, and an inability to act quickly, banks have been unable to operate efficiently. The service or item may be tracked as it progresses through the production process, which keeps everyone informed. Companies may speed up delivery, enhance customer engagement, and reduce the supply chain cost by improving their supervision of these operations.

The above Table 1 shows that the production company's optimal benefit can be achieved if traditional methods are used to analyze and manage the detection of supplier credit risk in business mode, which is 10%–30% for industry sectors and 75% for the whole supply network. However, even if capital markets have grown, the profitability of sectors inside the logistics system is extremely low, which quickly leads to system structure changes and market volatility everywhere. Distributing network in stock market development with ML model analysis utilizing this paper's

TABLE 1: Detection of supplier credit risk in financial returns in supply chain.

Number of Business	DSCM	SVMA	LS-SVM	PLS-SVM	RL-PRI	ML-LR
1	26.5	19.8	41.5	36.5	57.5	60.2
2	29.2	19.2	31.5	49.5	32.4	50.4
3	16.6	25.6	39.1	57.6	50.5	70.5
4	19.8	17.8	29.3	39.1	56.3	68.2
5	35.9	29.9	36.2	55.9	68.5	78.7
6	39.6	19.6	37.2	49.5	67.6	85.2
7	30.5	32.5	42.8	59.4	70.3	76.4
8	15.7	29.7	39.5	58.3	79.3	90.4
9	52.2	62.2	55.4	69.7	85.6	97.2
10	55.2	49.2	39.2	67.2	72.5	89.4
11	42.3	34.3	58.6	62.3	81.3	93.2
12	38.3	44.4	67.6	59.4	72.6	95.5
13	53.3	46.3	53.2	67.4	86.5	97.3
14	30.2	42.5	59.4	67.5	79.2	95.2
15	15.8	26.5	48.5	64.6	59.6	72.2
16	26.9	17.6	39.9	65.3	42.5	89.6
17	22.3	39.3	26.4	58.7	73.1	86.3
18	35.5	46.3	59.6	68.2	39.7	90.2
19	45.7	53.3	68.3	51.8	78.2	89.4
20	59.2	48.2	68.7	52.9	60.3	97.5

quick linear regression technique guarantees that the banking system developer's health and stability are maintained substantially by optimizing intrinsic industry supply chain profit by 30 to 70 per cent. A machine learning system may analyze stock market-related media platform material comments. This information is then fed into a model, which is subsequently trained to make predictions about stock values under various conditions. It is the job of stock analysts to figure out exactly what will happen in the future with a product, industry, or market. Stock traders and investors make equity technical trading that informs purchase and sale decisions. By researching and evaluating past and present data, speculators and brokers can get an opportunity in the exchanges. The findings of this paper's assessment of the ML-LR provincial strategic sourcing growth accounting indications on an automated system and the standard evaluation technique of DSCM, SVMA, LS-SVM, PLS-SVM, RL-PRI, and ML-LR in supply chain financial development mode were found to be consistent.

The federal agency in digital financial innovation can be utilized to control the supply chain in financial risk. Although economic software was established, the distribution network in the business world has evolved quickly. The traditional improvement theory claims that banking advances boost factors of production effectiveness and institutions expansion by lowering transaction cost. One's financial situation shapes spending habits. As salaries rise for the average American, we may expect an increase in overall consumer expenditure. Industries will develop, poverty will be reduced, and the market will grow due to a rise in expenditure. However, a decline in consumer purchasing power is anticipated if earnings fall. Table 2 illustrates the supply chain in years with the value of supply chain financing in projected values has increased from 62.2 in 2003 to 94.2 in 2022 by applying the ML-LR model, which may improve the efficiency of business platforms. Developing

TABLE 2: Supply chain finance business in years.

Number of years	DSCM	SVMA	LS-SVM	PLS-SVM	RL-PRI	ML-LR
2003	29.8	18.8	38.5	51.5	47.5	62.2
2004	19.2	39.2	21.5	32.1	50.4	75.4
2005	21.6	26.6	18.1	30.6	59.5	73.5
2006	18.8	21.8	28.3	40.1	34.3	59.2
2007	25.9	39.9	46.2	36.9	57.5	62.7
2008	18.6	29.6	31.2	47.5	79.6	87.2
2009	22.5	30.5	39.8	59.4	69.3	75.4
2010	29.7	30.7	40.5	57.3	78.3	87.4
2011	52.2	32.2	45.4	62.7	85.6	97.2
2012	50.2	44.2	56.2	68.2	72.5	89.4
2013	39.3	49.3	60.6	61.3	81.3	92.2
2014	49.4	39.3	56.6	64.2	54.7	87.2
2015	46.3	50.3	65.3	43.8	64.2	89.4
2016	44.5	42.2	60.7	52.9	48.3	97.5
2017	21.5	15.8	29.3	42.1	69.3	75.4
2018	28.6	24.9	36.2	58.9	69.5	79.7
2019	19.3	29.3	39.4	58.7	62.1	86.3
2020	49.3	39.5	45.8	64.4	77.3	95.4
2021	56.3	29.7	39.5	59.3	79.3	89.4
2022	42.2	62.2	59.4	69.7	85.6	94.2

electronic banking systems at the federal level is perhaps the biggest important factor in developing this system. The federal level will be attained in terms of general planning and architecture, and top-level design for techniques like DSCM, SVMA, LS-SVM, RL-PRI, and ML-LR are the important technical developments and their applications. Analyses of financial business in accounting variables for ML-LR in province supply management using an organizational and managerial system and conventional evaluation techniques are presented in this research.

The distribution network is a specific aspect where the sequence of events and financial qualities may be used in

TABLE 3: Statistical data on the financial credit risk in supply chain finance companies.

Number of market share	DSCM	SVMA	LS-SVM	PLS-SVM	RL-PRI	ML-LR
1	28.3	40.3	69.8	54.2	77.6	98.6
2	42.2	58.7	52.9	42.3	92.5	98.4
3	21.8	29.3	39.1	59.3	71.8	82.2
4	21.9	30.2	51.9	67.5	53.9	81.3
5	15.3	36.4	58.7	40.1	70.5	81.4
6	32.5	42.8	59.4	70.3	58.6	89.6
7	21.7	35.5	57.3	72.1	85.5	90.2
8	42.3	58.6	62.3	81.3	72.3	84.3
9	19.3	42.6	37.2	57.7	78.3	89.6
10	53.3	65.3	53.8	44.2	93.6	97.2
11	41.2	56.7	47.9	67.3	86.5	98.6
12	37.9	29.3	30.1	65.3	67.8	89.6
13	57.3	69.3	41.8	49.2	72.6	85.3
14	48.2	58.7	59.9	46.3	87.5	94.5
15	22.2	45.4	62.7	88.6	68.4	91.2
16	55.2	53.2	69.2	72.5	79.6	96.7
17	40.3	54.6	62.3	88.3	72.3	93.4
18	46.3	59.6	68.2	56.7	81.3	97.1
19	56.3	61.3	59.8	50.2	72.6	96.3
20	59.2	55.4	66.7	87.6	79.4	94.2

combination with each other. Table 3 denotes the production network financing has commercial capital adequacy; in LR, technology trends to the analysis of the institutions surveyed, more than 30 percent used ML-LR for risk control, and 30 percent of firms used plotted methods. The use of linear regression technology is close to a third of the time, 27% of the time. According to the information supplied by the organizations questioned, credit risk management is frequently used in supply chain management. A study of fintech firms found that the sector has become stronger after surveying and interviewing them. According to the findings, financial institutions now involved in supply chain financial services ambitiously promote financial technology in supply chain business management. These include DSCM, SVMA, LS-SVM, PLS-SVM, RL-PRI, and ML-LR with the methods comparing ML-LR, which has high efficiency on supply chain management.

5. Conclusion

Supply chain finance presents a nonsystemic risk in the form of credit risk, which is also a fundamental threat. To analyze the detection rate and to construct a financial supply chain component in a linear regression model, this study applies machine learning methods guided by financial management theory and credit risk propagation theory. The supplier credit risk integration in the lending threat analysis methodology is also established in this research. The limitations of supply chain risks are the disruptions in the flow of goods, particularly raw materials and components, within the supply chain and a threat from outside the supply chain such as terrorism or social dissatisfaction. Future work on ML-LR techniques can assist procurement managers in reducing supplier risk. Supplier reliability and financial health may be predicted using machine learning models based on various inputs. The lack of enabling a complete administration of

compliance, actual insight into better consumer service, more efficient strategy, effective process inspectors in reducing costs, and forecast errors are the significant problems in supply chain management in ML-LR. The strength of this paper in ML-LR may help organizations to predict demand accurately, streamline logistics, cut down on paperwork, and automate human procedures. Final insight over the supply chain means that it will operate more smoothly, consume less energy, and be less prone to interruptions. Digitalization is the answer for supply chain enterprises because of today's dynamic and disruptive environment. The use of digital supply chain technology, combined with ML-LR technologies that enhance human decision making, is expected in the next three to five years. The proposed framework of ML-LR in this paper is tested using subjective and analytical methods in this study, which incorporate real-world data in business from the organization. The ML-LR model developed in this work has high accuracy in developing supply chain management, as evidenced by the information.

Data Availability

The data that support the findings of this study can be obtained from the author upon reasonable request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

Authors' Contributions

Yuqian Wei is from Hangzhou, Zhejiang province, China, 1994. She graduated from Zhejiang University of Media with a bachelor's degree. He is now studying at the School of Economics of Belarusian State University. His research interest covers supply chain management and enterprise management.

Retraction

Retracted: Evaluation of High-Quality Development of Shaanxi's Economy Based on Digital Economy Based on Machine Learning Algorithm

International Transactions on Electrical Energy Systems

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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] L. Wang, "Evaluation of High-Quality Development of Shaanxi's Economy Based on Digital Economy Based on Machine Learning Algorithm," *International Transactions on Electrical Energy Systems*, vol. 2022, Article ID 6327347, 9 pages, 2022.

Research Article

Evaluation of High-quality Development of Shaanxi's Economy Based on Digital Economy Based on Machine Learning Algorithm

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With the strong development of industrial transformation, the digital economy, as the most dynamic, innovative, and widely radiated economic form at present, has become an important force driving the development of the global economy. Shaanxi Province has accelerated the development of the digital economy, and the development of the province's digital economy has shown a good trend. However, the current digital economy development measurement is still unable to accurately observe the development law of the digital economy industry, which makes it difficult to measure the control standards for the digital economy industry. Therefore, this study has evaluated the development of digital economy in Shaanxi Province based on machine learning algorithms. This study first puts forward the dimensions of digital economy monitoring and evaluation and then combines the characteristics of digital economy development in Shaanxi Province to determine the quality evaluation indicators of digital economy development. Finally, according to the machine learning algorithm, a quality evaluation model of digital economy development was established, and through the evaluation results, suggestions were put forward for the development plan of digital economy in Shaanxi Province. The experimental results showed that, after re-planning the digital economy in Shaanxi Province according to the evaluation results, the development of the digital economy in Shaanxi Province has increased by 9.82%, indicating that the evaluation model plays a good reference role in the formulation of the digital economy development plan.

1. Introduction

Shaanxi Province has made great progress in the fields of digital economy such as online shopping, online entertainment, mobile communication, and online education, which has played the dual function of promoting epidemic prevention and control and economic and social development. In the process of promoting the scale of the digital economy, the main tasks of Shaanxi Province are as follows. The first is information infrastructure construction. Shaanxi has implemented communications' infrastructure construction actions for four consecutive years, which comprehensively enhances the supporting capacity of information infrastructure. The second is to innovate and promote the pilot demonstration of the digital economy, accelerating the implementation of special actions such as "Internet +" and "Intelligence +." The third is to implement

the "five major projects" for poverty alleviation through the Internet, and the e-commerce poverty alleviation and consumption poverty alleviation have achieved remarkable results. The fourth is to carry out international exchanges and cooperation in information infrastructure construction and digital economy development. However, there is currently no method to accurately assess the development level of the digital economy, which is an important issue that remains to be resolved.

Many scholars have conducted research on the digital economy. Han and Ding studied the impact of the digital economy on total factor carbon productivity [1]. In the context of COVID-19, Li and Liang examined the impact of the digital economy on the integration of China's cultural tourism industry [2]. Wang et al. discussed the role of the digital economy in green innovation and put forward relevant suggestions for improving geographic information

capabilities [3]. Chizhikov et al. considered a theoretical approach that made it possible to formulate rational choices for the construction of distributed systems and telecommunications in the digital economy under the influence of external special software and hardware [4]. On the basis of measuring the level of data economy at the city level, combined with pm2.5 data of haze pollution and related economic statistics, Huang discussed the relationship between the development level of digital economy and urban haze pollution from both theoretical and empirical levels [5]. Although there are many studies on the digital economy, further research is needed on the digital economy to promote the high-quality development of Shaanxi's economy.

Machine learning algorithms are widely used in evaluation. Frolov et al. used machine learning to assess changes in cerebral cortical synchrony under long-term cognitive load [6]. Beswick et al. evaluated the improvement of sinus computed tomography with CFTR modulator treatment by machine learning [7]. Hung used machine learning to evaluate the performance and predicted outcomes of robotic-assisted radical prostatectomy [8]. Guimaraes et al. evaluated whether the use of a machine learning software program can accurately define the use of a standardized reporting template and language for non-compliance with a human review performed by a machine learning software program [9]. Trentzsch and Schumann used a machine learning algorithm to identify gait parameters suitable for assessing subtle changes in gait in patients with multiple sclerosis [10]. Although machine learning algorithms are often used for evaluation, there is little research on machine learning algorithms in the evaluation of high-quality economic development.

This study first describes the dimensions of digital economy monitoring and evaluation, including six parts: digital infrastructure, data resource elements, digital technology innovation, digital industry development, digital industry application, and digital social governance. Then, based on these six dimensions, the quality evaluation index of digital economy development is proposed. Then, Support Vector Machine (SVM), K-Nearest Neighbor Algorithm (KNN), K-Means Clustering, and Gaussian Mixture Model are selected as models for evaluating the quality of digital economy development. Finally, according to the evaluation results, suggestions are put forward for the development of the digital economy in Shaanxi Province, and the digital development of Shaanxi Province is re-evaluated after adjustment according to the suggestions.

2. Evaluation Model of High-Quality Development of Digital Economy Based on Machine Learning Algorithm

2.1. Dimensions of Digital Economy Monitoring and Evaluation Based on High-Quality Development. The role of digital technology in the economy and society is mainly reflected in two aspects. One is the diffusion process of digital infrastructure, and the other is the integration

process of digital technology and social environment [11]. Based on the above framework, this study divides the evaluation dimension of the digital economy into two parts. The theoretical framework of digital economy monitoring is shown in Figure 1.

The base layer of the digital economy includes three parts: digital infrastructure, data resource elements, and digital technology innovation. The digital economy contribution layer includes three parts: digital industry development, digital industry application and digital social governance. The development and application of the digital industry reflect the economic benefits of the digital economy, and the governance of the digital society reflects the social benefits of the digital economy.

2.2. Selection of Quality Evaluation Indicators for Digital Economy Development. Combined with the construction goals and development characteristics of digital economy cities in Shaanxi Province, on the basis of six first-level dimensions, two-level dimensions and three-level indicators are determined [12]. The specific indicators are shown in Table 1.

2.3. Construction of the Evaluation Model. This research collected the analysis index data from 2015 to 2021 and selected K-Means clustering and Gaussian mixture model as the model to evaluate the quality of digital economy development.

2.3.1. Support Vector Machine Evaluation Model. In machine learning, SVM is a widely used supervised learning algorithm, which is commonly used for pattern recognition, classification, and regression analysis [13]. The SVM is shown in Figure 2.

SVM is used for classification in the research work of this study. The constraint of SVM is as follows:

$$x_i(w^T y_i + b) \geq 1. \quad (1)$$

When considering the problem of outliers, the constraints become formulas (2) and (3):

$$x_i(w^T y_i + b) \geq 1 - \xi_i, \quad (2)$$

$$\xi_i \geq 0. \quad (3)$$

If ξ_i satisfies formula (3), it is called a slack variable. Constraints are added so that the sum of ξ_i is minimized:

$$\min \frac{1}{2} w^2 + C \sum_{i=1}^n \xi_i, \quad (4)$$

where C is a parameter.

For nonlinear problems, a nonlinear SVM optimization problem can be obtained by constructing a Lagrangian function and solving the derivative in some way:

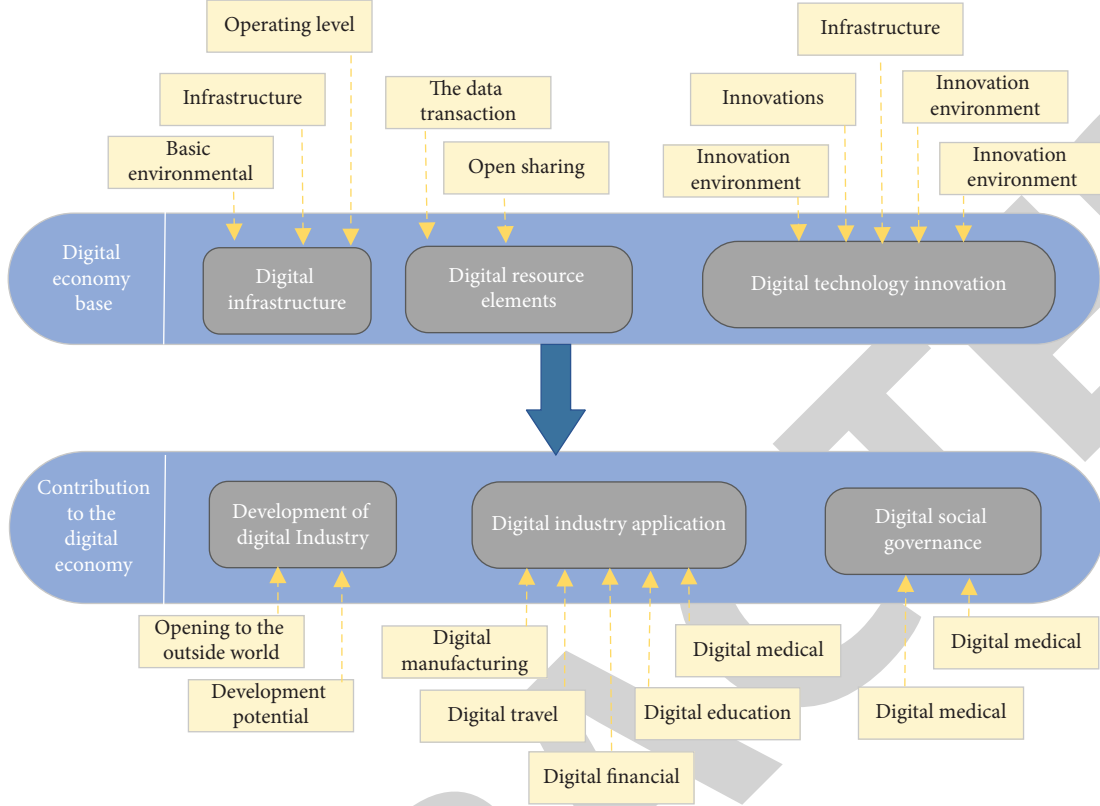


FIGURE 1: Theoretical framework of digital economy monitoring.

$$\min \frac{1}{2} \sum_{i=1}^N \sum_{j=1}^N \alpha_i \alpha_j \beta_i \beta_j H(y_i, y_j) - \sum_{i=1}^N \alpha_i, \quad (5)$$

$$\sum_{i=1}^N \alpha_i \beta_i = 0,$$

$$0 \leq \alpha_i \leq C.$$

When faced with data samples from low-level regions that cannot be divided, kernel functions can be used to map data samples from low-level regions to high-level regions to solve the problem. The commonly used kernel functions are as follows.

(a) Linear kernel function:

$$H(y_i, y_j) = y_i y_j. \quad (6)$$

Linear kernel function classification results are good. Therefore, when processing data, the first attempt is to use the linear kernel function to classify.

(b) Polynomial kernel function:

$$H(y_i, y_j) = ((y_i, y_j) + 1)^d. \quad (7)$$

The polynomial kernel function has many parameters. When the order is high, the computational complexity is too large to calculate.

(c) Gaussian radial basis kernel function:

$$H(y_i, y_j) = \exp(-\gamma y_i - y_j^2), \quad (8)$$

$$\gamma = \frac{1}{2\delta^2}.$$

The Gaussian radial basis function has better performance and less parameters.

(d) Sigmoid kernel function:

$$H(y_i, y_j) = \tanh(H(y_i, y_j) - \delta). \quad (9)$$

In this study, in order to select the best clustering result, the radial basis kernel function is used for training, and then, it is validated on the training dataset to find the best C and γ parameters. Finding better C and γ enables the classifier to correctly predict the test set data, while making the classification accuracy relatively high [14].

2.3.2. K-Nearest Neighbor Algorithm. The K-nearest neighbor algorithm is shown in Figure 3.

Figure 3 shows which group the test sample in the image, the yellow five-pointed star, should belong to. If the value of K is set to 3, which is the extent of the blue circle, then the yellow star is assigned to the green triangle group because there are two green triangles inside the circle and only one blue square. If the value of K is set to 5, which is the range of

TABLE 1: Digital economy development quality indicators.

First-level indicators	Two-level indicators	Three-level indicators
Digital infrastructure	Infrastructure	Number of 5 G base stations built
		The proportion of new infrastructure in the city
	Operational level	City's per capital computing power
		Number of mobile subscribers per 100 inhabitants
Data resource elements	Environmental basics	5 G end user penetration rate
		Gigabit broadband household penetration
	Open sharing	Ease of doing business
		Public data open index
Digital technology innovation	Data transaction	Big data transaction volume growth
	Innovation input	Research and development (R&D) investment intensity of digital economy enterprises
	Innovation environment	Global science and technology innovation center index
	Creativity	Growth rate and proportion of graduates majoring in digital economy
		The proportion of ICT employees in the city's employees
	Innovative achievements	R&D personnel account for the proportion of employees in the city
		Income and growth rate of enterprises in independent innovation demonstration zone
		The number of papers published in top journals in the field of computer science
		The number and proportion of digital economy invention patents authorized
Digital industry development	Scale structure	The added value of the core industries of the digital economy accounts for the proportion of the city
		The proportion of e-commerce transaction volume in the national e-commerce transaction volume
		The proportion of the top 100 digital economy benchmarking companies in the world by market capitalization
	Development potential	The number of digital economy unicorn companies accounts for the proportion of the world
		The scale of financing of digital economy public enterprises
	Open to the outside world	Digitizable trade in services
		The scale of investment in other countries in the digital economy
		The scale of capital utilization of other countries in the digital economy
Digital industry application	Digital manufacturing	Growth rate of total output value of digital manufacturing enterprises
		Technology contract turnover and growth rate of digital manufacturing enterprises
		Number of intelligent and connected roads built
	Digital mobility	Autonomous driving road miles
		Average daily service person-time of public transport mobile payment
		Dynamic data access rate of operating record parking lot
	Digital health	Monthly active users of key internet travel platforms
		Monthly active users of key internet medical platforms
	Digital education	The coverage rate of personal health records for each citizen, one code
		The number of people studying online on the internet education platform
Digital society governance	Digital finance	Growth rate of third-party mobile payment amount
		Operating income of key financial technology companies
		Online payment inter-bank clearing system business volume
		The rate of online handling of government service matters
	Digital government	The ratio of actual handling of government service matters
		Monthly active users of online government services
		Total applications of electronic business licenses
	Digital life	Digital life citizen satisfaction
		Intelligent rate of end systems of water, electricity, and gas systems

the red line circle, then the yellow five-pointed star is assigned to the blue square group.

In the field of pattern recognition technology, KNN algorithm is widely used for classification. In this study, the classification technique is mainly applied to the nearest neighbor algorithm.

When calculating the distance between objects in KNN, in order to avoid matching problems between objects, Euclidean distance or Manhattan distance is often used [15].

Euclidean distance:

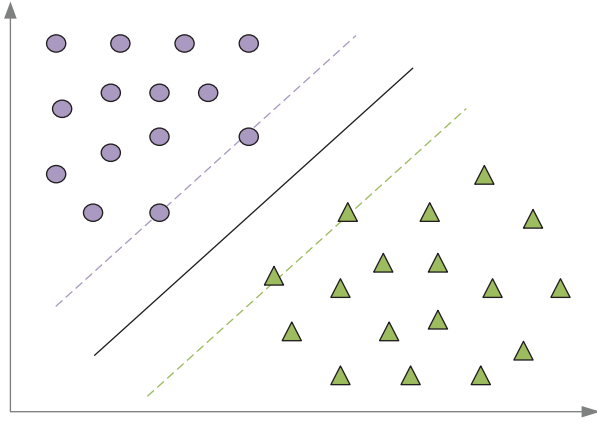


FIGURE 2: Support vector machine.

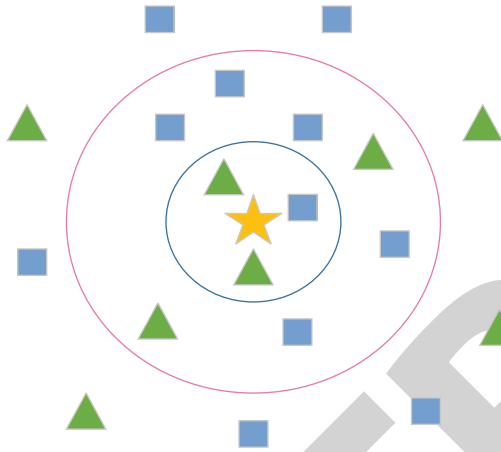


FIGURE 3: K-nearest neighbor algorithm.

$$d(x, y) = \sqrt{\sum_{k=1}^n (x_k - y_k)^2}. \quad (10)$$

Manhattan distance:

$$d(x, y) = \sum_{k=1}^n |x_k - y_k|. \quad (11)$$

In the nearest neighbor, the value of K affects the clustering results. If the K value is relatively small, overfitting easily occurs. If the K value is relatively large, it increases the training error, so the optimal K value can be selected by the method of cross-validation [16].

The training process of the K -nearest neighbor prediction model is as follows.

Input data: M is the dataset.

Training process: M is divided into two parts, training set and test set. New validation data are added to the training dataset circularly. The distance between the new data and each training sample is calculated. The K samples closest to the new data are found. The number of occurrences of each

class in the K samples is counted. The class with the highest frequency is selected as the class of the new data.

Output: it is the accuracy of the K -nearest neighbor prediction model on the test set.

2.3.3. K-Means Clustering. The K -Means has good measurement performance in a large number of samples and is widely used in many different fields [17].

Given a set of observations, $x = \{x, x_2, \dots, x_n\}$, the goal of K -Means is to obtain

$$\arg \min \sum_{i=1}^k \sum_{x \in s_i} x - \mu_i^2, \quad (12)$$

where μ_i is the mean of the midpoints of s_i .

The training process of the K -Means clustering prediction model is as follows [18].

Input data: The raw dataset $M\{X_1, X_2, \dots, X_n\}$ that is unlabeled is input.

Training process K cluster centroid points are randomly selected. The variance of the remaining data at the K centroids is calculated separately, and these data are input into the cluster with the smallest variance. The different centers of the K groups are recalculated based on the clustering results by taking the arithmetic mean of the different measurements of all elements in the group. All points in M are regrouped according to the new center. The fourth step is repeated until the clustering results no longer change.

Output: It is the prediction accuracy of the K -Means clustering model.

2.3.4. Gaussian Mixture Model. The Gaussian mixture model algorithm process is as follows [19].

The number M of Gaussian distributions in the Gaussian mixture model is set, and the parameter θ in the Gaussian mixture model is initialized.

θ is the set of mean function μ , covariance matrix Σ , and prior probability a_j for each model scale.

$P(j|x; \theta)$ is calculated:

$$P(j|x; \theta) = \frac{a_j N_j(x; \theta)}{\sum_{i=1}^M a_i N_i(x; \theta)}, \quad (13)$$

$$N_i(x) = \frac{1}{\sqrt{(2\pi)^d |\Sigma_i|}} \exp \left[-\frac{1}{2} (x - \mu_i)^t \sum_i^{-1} (x - \mu_i) \right].$$

The weights are updated:

$$a_j = \frac{\sum_i 1^n P_{ij}}{N}. \quad (14)$$

The mean is undated:

$$\mu = \frac{\sum_i 1^n P_{ij} x_j}{\sum_i 1^n P_{ij}}. \quad (15)$$

The covariance matrix is updated:

$$\sum_j = \frac{\sum_i = 1^n P_{ij} (x_i - \mu_j)(x_i - \mu_j)^T}{\sum_i = 1^n P_{ij}}. \quad (16)$$

The above steps are repeated until the convergence condition is satisfied [20].

The training process for a Gaussian mixture model is as follows.

Input data: the raw dataset 1 without labels is input.

Training process: for each Gaussian distribution, its mean and random variance are given. For each data sample, its probability in a Gaussian distribution is calculated. For each Gaussian distribution, the contribution of the Gaussian distribution for each data sample based on the probability is calculated [21, 22]. If the probability is large, the contribution is large, and if the probability is small, the contribution is small. Therefore, the contribution of the data samples to the Gaussian distribution is used as the weight to calculate the weighted mean and variance. The steps are repeated until both the mean and variance of the Gaussian distribution converge.

Output: it is the prediction accuracy of the Gaussian mixture model.

3. Experiment Results and Discussion of Digital Economy Assessment

The experiment collected data on digital economy indicators in Shaanxi Province from 2015 to 2021. The evaluation of digital economy development was carried out from six aspects: digital infrastructure, digital resource elements, digital technology innovation, digital industry development, digital industry application, and digital social governance [22, 23]. According to the evaluation results, suggestions have been put forward for the development plan of the digital economy in Shaanxi Province, and the development status of the digital economy in Shaanxi Province was re-evaluated according to the data after the plan [24].

3.1. Digital Infrastructure. The digital infrastructure index value of Shaanxi Province in 2015 is set to 100, and the evaluation results of digital infrastructure from 2015 to 2021 are shown in Figure 4.

The evaluation results of digital infrastructure in Shaanxi Province in 2016 and 2017 were relatively close to those in 2015, and the development of digital infrastructure in these two years has not changed much. Since 2018, Shaanxi Province has increased its investment in digital infrastructure, and the evaluation results of digital infrastructure have improved year by year. Especially in 2020 and 2021, the evaluation results of digital infrastructure have increased significantly. The evaluation result in 2019 was 117.83, which was raised to 132.58 in 2020 and 146.69 in 2021. It can be seen that the development of digital infrastructure in Shaanxi Province has made great progress in the past two years. In order to further improve the construction of digital infrastructure, it is necessary to integrate the network equipment of the four major operators, including Telecom,

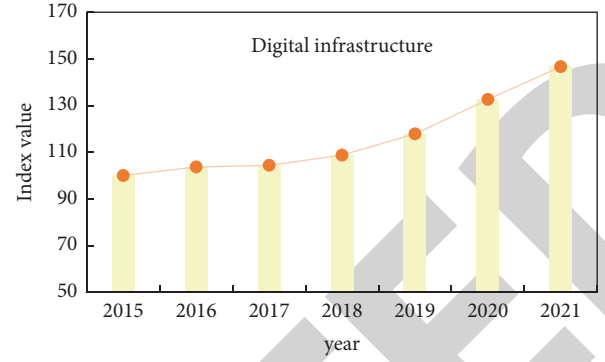


FIGURE 4: Digital infrastructure evaluation results.

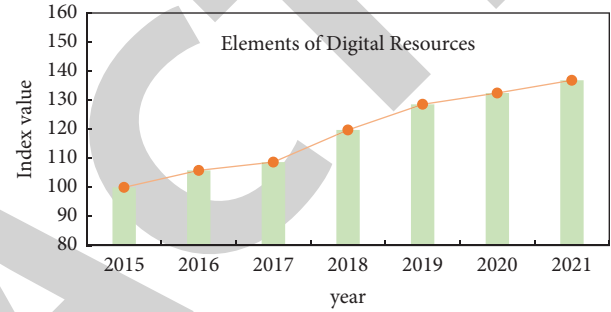


FIGURE 5: Evaluation results of digital resource elements.

China Mobile, China Unicom, and Radio and Television, increasing investment in various fields of “new infrastructure” and accelerating the pace of construction of new infrastructure such as data centers and 5G networks, to improve network equipment and implement speed-up and fee reduction.

3.2. Elements of Digital Resources. Setting the index value of digital resource elements in Shaanxi Province in 2015 to 100, the evaluation results of digital resource elements from 2015 to 2021 are shown in Figure 5.

The development of digital resource elements in Shaanxi Province was relatively slow in 2016 and 2017, but has been greatly improved in 2018. It increased from 108.69 in 2017 to 119.74 and then maintained a relatively fast growth rate year after year. In 2021, the evaluation result of digital resource elements was improved to 136.84. To further enhance the construction of digital resource elements, it is necessary to accelerate the construction of an intelligent society, with the interconnection of different operating systems as the main line, and to promote the co-construction, sharing of software and hardware facilities.

3.3. Digital Technology Innovation. The digital technology innovation index value of Shaanxi Province in 2015 was set to 100, and the evaluation results of digital technology innovation from 2015 to 2021 are shown in Figure 6.

The value of the digital technology innovation index in Shaanxi Province showed a gradually increasing trend, and its growth rate was the fastest in 2019 and 2020. The index

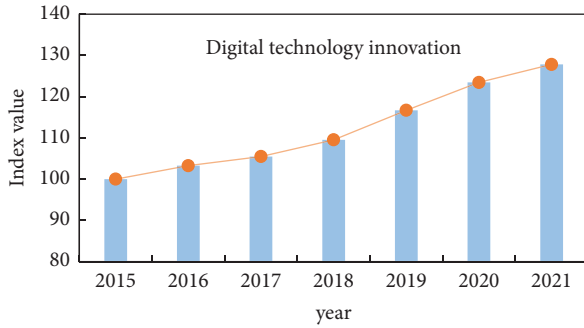


FIGURE 6: Digital technology innovation evaluation results.

value of digital technology innovation in 2019 was 116.69. The index value in 2020 was raised to 123.45, and it was 127.85 in 2021. To further enhance the construction of digital technology innovation, it is necessary to further increase the research and development investment intensity of digital economy enterprises and introduce digital economy professionals.

3.4. Development of Digital Industry. The digital industry development index value of Shaanxi Province in 2015 was set to 100, and the evaluation results of digital industry development from 2015 to 2021 are shown in Figure 7.

The development speed of the digital industry was relatively slow, showing a steady upward trend as a whole. In 2021, the development index value of the digital industry in Shaanxi Province was 157.36, and the development trend was good. To further enhance the construction of digital industry development, it is necessary to integrate good industries such as electronic information industry and software service industry to improve the effect of industrial integration. At the same time, relying on the existing industrial foundation and scientific and technological research and development advantages, the construction of digital industrial parks and bases needs to be continuously strengthened, and the radiation effect of the park should be enhanced.

3.5. Digital Industry Applications. The digital industry application index value of Shaanxi Province in 2015 was set to 100, and the evaluation results of digital industry application in 2015–2021 are shown in Figure 8.

In terms of digital industry applications, the development of digital industry applications was relatively slow from 2015 to 2018. It improved in 2019 and significantly improved in 2020 and 2021. The value of the digital industry application index in 2020 was 137.35, and the index value in 2021 was 174.93. To further enhance the construction of digital industry development, it is necessary to break industrial boundaries to promote industrial integration and industrial model innovation, forming a new economic growth point and industrial development model. It is also necessary to seize the opportunity that enterprises from all walks of life have realized the urgency and importance of digital transformation to guide the industry and encourage

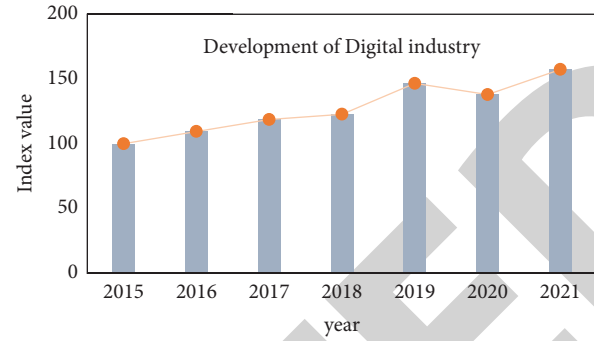


FIGURE 7: Digital industry development evaluation results.

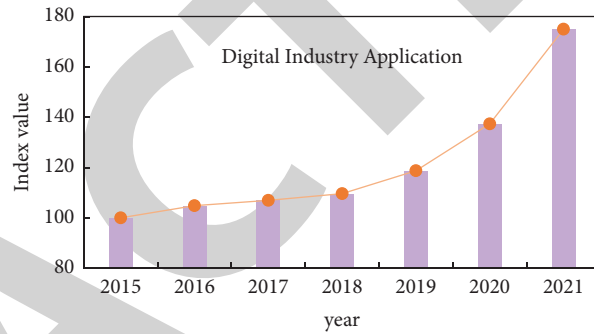


FIGURE 8: Digital industry application evaluation results.

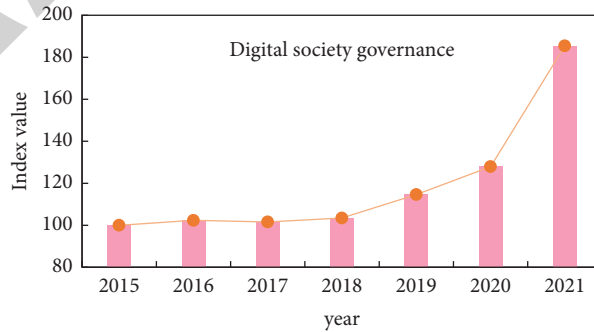


FIGURE 9: Digital society governance evaluation results.

enterprises, thereby flexibly implementing digital transformation strategies according to their own needs.

3.6. Digital Social Governance. The digital social governance index value of Shaanxi Province in 2015 was set to 100, and the evaluation results of digital social governance from 2015 to 2021 are shown in Figure 9.

The development of digital social governance in Shaanxi Province was relatively slow, and the index value did not change significantly from 2015 to 2018. In 2019 and 2020, the index value increased slightly, and in 2021, digital social governance developed rapidly. The digital social governance index value in 2020 was 127.93, and the index value in 2021 greatly increased to 185.44. To further enhance the

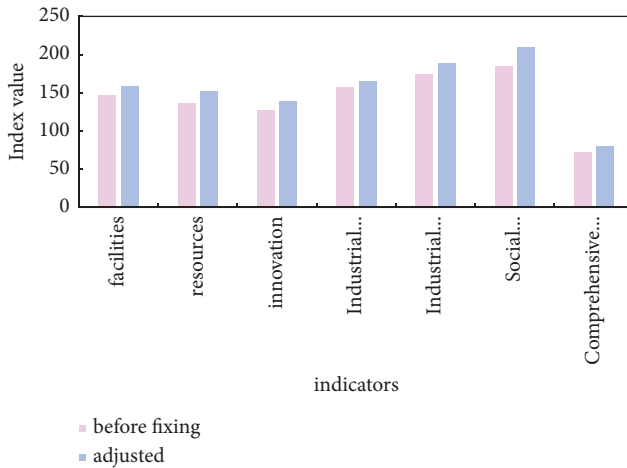


FIGURE 10: Digital economy development forecast.

construction of digital social governance, it is necessary to speed up the construction of digital government and improve the new system of data integration and sharing to vigorously develop e-government and facilitate the development and reuse of data value-added, which improve e-government-related laws and regulations and overall coordination mechanisms and improve the public data open system, thus ensuring the healthy development of e-government.

3.7. Development Forecast of Digital Economy. The digital economy development plan was adjusted according to the evaluation results of the digital economy development, and the development status of the digital economy in Shaanxi Province was evaluated according to the adjusted data, comparing it with the data in 2021. The results are shown in Figure 10.

After the adjustment, the index values of digital infrastructure, digital resource elements, digital technology innovation, digital industry development, digital industry application, and digital social governance have all improved. The comprehensive evaluation of the digital economy development in Shaanxi Province before the adjustment was 72.38, and the comprehensive evaluation after the adjustment was 79.49. The digital economy development in Shaanxi Province increased by 9.82%.

4. Conclusions

This study used machine learning algorithms to study the evaluation of the development of the digital economy, so as to grasp the law of the development of the digital economy for Shaanxi Province and build a digital economy monitoring and evaluation system according to local conditions, thereby effectively monitoring and evaluating the development of the digital economy and providing reference. This study first described the dimensions of digital economy monitoring and evaluation, including six parts: digital infrastructure, data resource elements, digital technology innovation, digital industry development, digital industry application, and digital social governance. Then, the digital

economy evaluation index was established, and then, the digital economy evaluation model was established. Based on the evaluation results of the digital economy, this study also puts forward suggestions on the digital economy planning of Shaanxi Province. According to the adjusted plan, the development of digital economy in Shaanxi Province was re-evaluated. The results showed that the evaluation model can grasp the development law of the digital economy and provide reference for the development of the digital economy.

Data Availability

No data were used to support this study.

Conflicts of Interest

The author declares that there are no conflicts of interest.

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