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Retraction

Retracted: Life Prediction Model of Wooden Structure Based on Artificial Intelligence Algorithm

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1].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] N. Cao, "Life Prediction Model of Wooden Structure Based on Artificial Intelligence Algorithm," *Mobile Information Systems*, vol. 2022, Article ID 3591967, 10 pages, 2022.

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Research Article

Life Prediction Model of Wooden Structure Based on Artificial Intelligence Algorithm

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The ancient wooden structure in China is a precious architectural cultural heritage in history, which has high cultural and artistic value. However, due to the influence of its own material structure and the long-term preservation and maintenance process, due to long-term loads, earthquakes, fires, man-made damage, etc., ancient buildings have suffered more or less damage, which may cause sudden failure of the structure, which seriously affects the safety of the building structure. Therefore, the research on the prediction of the life of ancient wooden structures has guiding significance for sustainable development. This paper studies the life prediction of ancient buildings and introduces artificial intelligence algorithms. By comparing the old and new of the ancient building with the damage of the various structures of the ancient building, and using a variety of methods to find a more accurate method to predict the life of the ancient building, through various aspects of research and comparison, we have discovered the variation of wooden columns and beams. The coefficients are 22.97% and 22.54%, which affect the service life of wooden members. The residual strength ratios of the compressive design strength and flexural design strength of the new material and the old material are 60.42% and 26.67%, respectively.

1. Introduction

Ancient Chinese wooden structure has a very important position in the history of Chinese cultural development and architecture. It is a vivid teaching material for people's education patriotism, socialism, national tradition, and revolutionary tradition. In particular, some ancient buildings have become symbols of cities and culture. The ancient wooden structure to a large extent shows the development characteristics of architectural culture, art, and technology. At present, many ancient wooden structures are an important part of China's outstanding and valuable cultural heritage, which not only has high academic value but also is closely related to the people's growing spiritual and cultural needs. Architecture reflects the technological and scientific level of an era, it faithfully reflects people's past lives, and is a nonrenewable resource, so it has a high social and cultural value. If these precious cultural heritages are not protected as soon as possible, they may suffer devastating damage. Preventing and eliminating the damage to ancient buildings and delaying the progress of damage in a targeted manner are important issues that need to be solved urgently. Robots are the crystallization of artificial intelligence, but their applications in the prediction of the life of ancient wooden structures are few and far between. For the management of major wooden structures, it is a very important and meaningful work to scientifically and effectively predict the service life of wooden ancient buildings. This paper uses artificial intelligence algorithm to study the service life of wooden structures, which has a certain innovation. The research of this paper can be widely applied to the monitoring and prediction of settlement of ancient buildings, the prediction of changes in physical properties of wooden structures of ancient buildings, and other related archaeological problems.

Many people have studied ancient architecture. Zhang research found that Huizhou architecture is one of the four ancient architectural schools in China, with wood as its core. Accurately predicting the timber life of Huizhou buildings is of great significance for protecting ancient buildings. At present, there is little research on Huizhou architecture. Elman neural network is a typical multilayer dynamic recurrent neural network, which has the function of mapping dynamic characteristics by storing internal states, so that the network has the ability to adapt to time. Variation characteristics can be used to predict complex nonlinear time-varying systems. The basic Elman neural network is slow to train and tends to reach a local minimum. Therefore, a particle swarm optimization algorithm using an adaptive mutation operator is used to improve the basic Herman neural network. The algorithm optimizes the weight of each layer. By improving the network, training values can be fitted more accurately and test values can be effectively predicted. Simulation results show that the network structure can be applied to life well. Span prediction of Huizhou buildings [1]. FX shows its abstraction through the research of artificial intelligence. Unlike in the past, current buildings are denser, resulting in reduced horizontal ventilation. However, high-density environments still offer opportunities to control solar radiation by providing shadows on-site and within the building. Traditional buildings use climate as a morphological modifier. Social and cultural aspects influence architecture, and as a result, local materials have evolved as part of modern architecture in urban areas. With surviving buildings in the largest cities, this study provides new vitality to the environmental changes in Surabaya as a lowland region and Malang as a highland region. A field study was conducted to identify and evaluate the actual condition of the building envelope surface through daily measurements. Infrared thermometers are used for on-site measurement of surface temperature. In addition, hygrometers are used to check the moisture content of materials, and solar power meters are used to check the surrounding solar radiation. The results of this study show that lowland houses have better material performance in climate control by reducing extreme conditions than highland performance. Overhangs and terraces as transition spaces can significantly reduce the amount of daily radiation, exceeding $1500\,W/m^2$. Generally, the problem of tropical houses is not only due to the frequency of receiving solar radiation penetration but also due to insufficient shielding of building materials [2]. Levin research found that AI-centric transhumanism and the large-scale data collection and surveillance pursued by commercial and government entities share core characteristics. That is, knowledge is informational in nature, technology is value-neutral, and ethical challenges can be technical procedural terms. In this article, I mainly focus on the manifestation of these characteristics of the latter in the whole society. Here, the critical uses that lead to technology-process change in data practice are limited because they create the illusion of basic progress, while retaining questionable assumptions about knowledge and value intact. Because the closest things are the hardest to collect, if we see them operating in a completely different and surprising environment, we might be able to more easily discern these assumptions. Ancient rhetoric embodies our version of three factors. Plato's critique of rhetoric and his philosophical methodological aspects can help us understand why we should refute the increasingly popular view of knowledge and values—but otherwise. [3]

In this paper, through the investigation and study of ancient wooden buildings, through a comparative study of all aspects of the building and the introduction of multiple methods of artificial intelligence, the structural reliability assessment and remaining life prediction of the wooden ancient buildings are conducted. Preservation has a positive effect. It can not only repair and renovate ancient wooden structures in a timely manner but also reduce the occurrence of hidden safety hazards and leave valuable cultural heritage for future generations [4]. Therefore, how to better protect ancient buildings is of great significance.

2. Proposed Method

2.1. Prediction Method of Remaining Life of Structure. The current methods for predicting the remaining life of structures generally only consider a few key factors among the various influencing factors, and the prediction methods will involve multiple disciplines. The factors affecting the service life of ancient wooden buildings mainly include physical, chemical, and biological aspects. Due to various factors, it is difficult to quantify the remaining service life of ancient wooden structures, so the prediction process is relatively complicated. For the prediction method of the remaining life of the structure, experts and scholars at home and abroad have proposed the following aspects [5, 6].

(1) Empirical prediction method: This method is mainly related to the researcher's experience, knowledge level, and prediction results. It is based on the results obtained by a large number of sites and laboratories and related experience and knowledge accumulation. Life is semi-quantitative to reason about predictions. Therefore, it is highly subjective.

(2) Residual life prediction method considering economic risk optimization: Considering the costs of detection, reconstruction, or expansion in the whole life cycle of the structure, conditional reliability and failure rate functions of existing structures, combined with optimization theory, are used to predict the remaining life of the structure [7].

(3) Theoretical prediction method of structural reliability: This prediction method is based on the principle of structural resistance gradually declining with time, and based on the non-stationary random process of the structural cross section, the relationship between structural reliability and time is established to calculate the structure reliability, the remaining life of the structure is the bearing capacity life of the structure minus the useful life of the structure, which is the remaining life of the structure. This method for predicting the service life of a structure is more reasonable.

(4) Structural durability prediction method: This prediction method uses the gray correlation as the standard, and divides the durability of the structure into two indicators: the degree of deterioration indicator and the rate of deterioration indicator. The

structure is evaluated at multiple levels and changes over time. The relationship of the structure deteriorates, and the remaining life of the structure is obtained [8, 9].

There are few algorithms for predicting the life of wooden ancient buildings, mostly focusing on the cumulative damage model of wooden structure, finite element analysis model, and BP neural network. In recent years, some experts and researchers have adopted intelligent methods such as neural network method, fuzzy method, and dynamic analysis method to predict the remaining life of the structure, and have achieved some important results, but further research is needed.

2.2. PLSS Measurement Method. In practical applications, because the relationship between the dependent variable and the independent variable is usually not linear, there is a complex nonlinear relationship between them. Traditional PLS is only suitable for linear models, which will cause large deviations in practical applications. The PLSS algorithm is a spline transform added to the PLS algorithm. The spline function is constructed using the idea of piecewise fitting. Its advantage is that it can be cut as needed to adapt to the continuous change of any curve. Spline functions are smooth and continuous [10, 11].

Collect independent and dependent variables [A, Y], and perform spline transformation on independent variable A to transform nonlinear problems into quasi-linear problems in high-dimensional space. The model uses a cubic B-spline function as the basis for the transformation.

$$\Omega_3\left(\frac{A_j - \xi_{j,l-1}}{h_j}\right) = \frac{1}{3!h_j^3}\sum_{k=0}^{4}(-1)^k \begin{pmatrix} 4 \\ k \end{pmatrix}\left(a_j - \xi_{j,l-1+k}\right)^3. \quad (1)$$

Among them, $\xi_{j,l-i}$ are the added insertion points for partitioning variable x_j; h_j is the segment length for partitioning variable A_j.

The minimum observation value of the variable x_j is min (A_j), and the maximum observation value is max (x_j).

$$\begin{gathered} \xi_{j,l-1} = \min\left(a_j\right) + (l-1)h_j, \\ h_j = \frac{\max\left(a_j\right) - \min\left(a_j\right)}{M_j}, \\ \left(l = 0, 1, \ldots, M_j + 2\right). \end{gathered} \quad (2)$$

Among them, M_j is the number of segments divided for the variable A_j. The nonlinear function relationship between all independent variables and dependent variables is

$$y = \beta_0 + \sum_{j=1}^{p}\sum_{l=0}^{M_j+2}\beta_{j,l}\Omega_3\left(\frac{a_j - \xi_{j,l-1}}{h_j}\right) + \varepsilon. \quad (3)$$

Among them, y has a linear relationship with $\Omega_3(x_j - \xi_{j,l-1}/h_j)$, which can be transformed into a quasi-linear regression model. Each dimension x_j is subjected to three B-spline transformations $x_j \longrightarrow Z_j$, and the original variable space (A, Y) is transformed into (Z, Y).

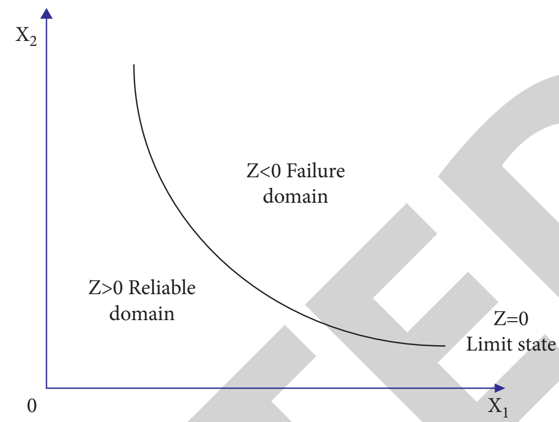

Figure 1: Working status corresponding to function.

Use the new independent variable and dependent variable (Z, Y) to predict the PLS algorithm and find $\hat{y}$.

2.3. Building Limit State. The limit state of a structure refers to a state in which the structure cannot be used normally, which mainly means that the overall structure or a part of the structure exceeds its prescribed bearing capacity [12]. The factors that affect the reliability of the structure include material strength, calculation mode, and load effect. These factors can be expressed as random variables. If $X_1, X_2, \ldots, X_n$ represents the basic random variable of the structure, the function of the structure is used to describe the function of the structure's working state, which is expressed as:

$$Z = g\left(X_1, X_2, \ldots, X_n\right)\begin{cases} < 0, \text{Failurestate}, \\ = 0, \text{Limitstate}, \\ > 0, \text{Reliablestatus}. \end{cases} \quad (4)$$

$Z = g(X_1, X_2, \ldots, X_n)$ is called the limit state equation of the structure [13, 14]. Figure 1 shows the working state of the structure in a rectangular coordinate system:

From the perspective of structural reliability, the factors affecting structural reliability can be divided into two random variables: structural resistance R (the ability to deform the structure or the ability to resist damage) and load effect S (the deformation caused by the load effect, internal force, etc.) At this time, the structure function can be expressed as:

$$Z = R - S\begin{cases} < 0, \text{Failurestate}, \\ = 0, \text{Limitstate}, \\ > 0, \text{Reliablestatus}. \end{cases} \quad (5)$$

2.4. Wooden Frame Structures of Ancient Buildings. One of the most remarkable features of the ancient Chinese wooden structure is the tenon-and-mortise connection between the beams and columns. The ingenious tenon-and-mortise connection method does not require a nail or an iron, and is unique in that it shows strong semirigid connection joint characteristics. It has a history of thousands of years in China. The tenon is usually inserted into the column about half the diameter of the column. The tenon connection can withstand a considerable bending moment. The wooden tenon that was common in ancient building repairs breaks along the vertical plane [15, 16]. On the other hand, the tenon-and-tenon joint weakened the cross section of the wooden members, which reduced the bearing capacity at the nodes. However, the material tolerance in the ancient building structure was extremely large, so the flexibility of semirigid joints was fully utilized. The drop connection not only changed the characteristics of the structure but also absorbed part of the energy from the deformation during the earthquake, reducing the seismic response of the structure [17, 18].

The tenon-and-mortise structure has many forms. From the perspective of mechanical properties, it is divided into straight and dovetail. Dovetails are usually used at the top of the tower, and straight tenons are usually used in the tower.

The dovetail structure can withstand both tensile and compressive forces. The beam with a straight tenon structure can withstand the pressure under the limit load, but because it is only inserted into the rectangular hole in the middle of the cylinder, it can withstand only a tenon. Maximum friction is there between the column and the pores of the column. When the tensile force exceeds the maximum friction force, the tenon will be pulled out [19]. Due to the pullout, there is a large relative movement between the structural members. This movement changes the integrity of the structure on the one hand and the internal force distribution of the structure on the other. Another ideal aspect of this structure is that under the action of dynamic loads such as earthquakes, the resulting structural looseness and friction between components will absorb a large amount of energy, which can improve the seismic resistance of the structure [20, 21].

The combination of the tenon of the beam and the cymbal of the column can not only withstand large pressure and small tensile force but also withstand a certain bending moment, and the bending moment will generate a certain secondary stress. This secondary stress will include both bending moment stress and shear stress that are stored simultaneously. In general, the bending moment stress is mainly considered [22, 23]. In addition, secondary stress also includes axial stress. This axial secondary stress is very small compared to the initial stress and can be ignored during calculations. The reason for the secondary stress is that when the tenons are combined, the tenons have a certain length when they are embedded in the tenons. This restricts the beam from rotating around the cylinder, which creates bending moments. Therefore, the node can be simplified into a variable stiffness element with certain stiffness in the calculation and added to the finite element program for calculation [24, 25].

When the wooden structure is not subjected to horizontal forces, the beams of the lower frame are unstressed, and the vertical load is borne by the columns. In the initial phase of the horizontal load, the tenon begins to engage and the structure shows a small amount of slip. At this stage, the

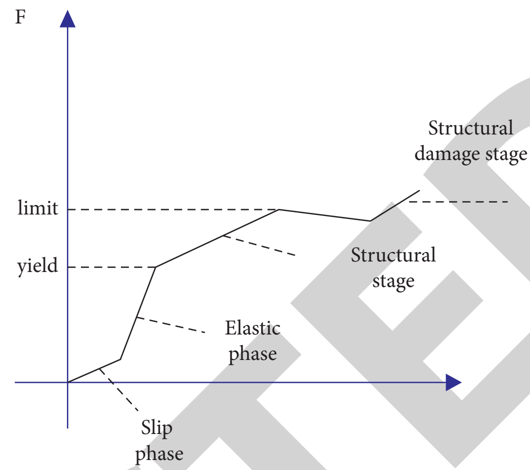

Figure 2: Structure F-δ curve.

tenon can be regarded as articulated. Continue to load, the mortise begins to be affected by shear and bending moments, and the structural strength increases until the yield load and the mortise is firmly connected. Continue loading to the limit load. The two ends of the column are connected to the tenon head, that is, the column and the foundation stone, and the top of the column and the bucket arch are pulled up or even detached. At this time, although the beam-column joint tenon is misaligned, it does not come out. Therefore, according to the working condition of the hoe under the horizontal load, the load-displacement curve of the wooden structure can be obtained as shown in Figure 2.

Structural damage is mainly caused by the insecure connection between the two ends of the column, disengagement, and weakened structural integrity. Therefore, as long as the two ends of the cylinder are strengthened, certain measures should be taken at the same time so that the hoes connected by the beam and column will not fall under the most unfavorable conditions. Strengthen the connection between various components, improve the structural rigidity, and give full play to the mechanical properties of the material, and then improve the bearing capacity of the structure, as shown by the dashed line in Figure 2. Eventually, the destruction of the structural material is destroyed.

The connection between the straight tenon and the column is mostly a semirigid connection. When the tenon is deformed, the axial deformation caused by the axial force of the tenon is nonlinear. It can be considered that elasticity is not a decrease in material properties. Except for the maximum static friction, the internal force of the beam formed by pulling out the tenon and the displacement of the beam including both ends of the tenon are similar to the ideal elastoplastic yield curve due to geometrical reasons. This relationship means that the relationship between the axial force of the beam and the relative deformation of the mortise is nonlinear, as shown in Figure 3.

2.5. Calculation Methods for Different Wooden Beam Characteristics. For ancient wooden beams, the above-mentioned constructor function method is only a macro

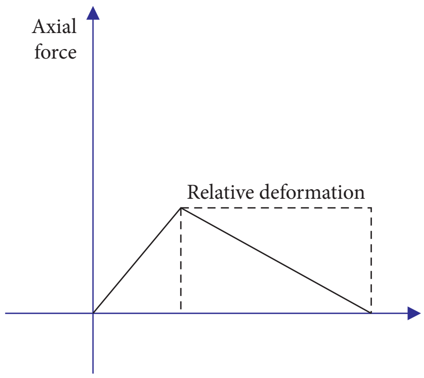

Figure 3: Relationship between beam axial force and relative deformation of camphor.

concept, and the following factors have not been considered specifically. First of all, the boundary conditions are different: wood structure beams and columns are connected by mortise and tenon, and the two ends of the wooden beams are semirigid bearings. The boundary conditions are between simple supported beams and fixed beams. Partial settlement at the beam support is prone to increase the deflection value; the third material is different: due to the existence of wood knots and other defects, the ancient process retains the irregularity of the log beam section; the fourth constraint is different: the wooden beam belonging to a single-span beam, the maximum deflection in the span has become a concern. In the following, the influence of the above four factors on the method of deriving the deflection of a wooden beam based on strain is studied.

In theory, simply supported beams have no bending moment under external force, but there are bending moments at both ends of non-simple supported beams. The existence of such bending moments causes the structure's strain distribution to change at the beam section, changing the deflection value. However, the tenon joint between the beam and the column in the traditional wooden structure belongs to the semirigid support of the nonrigid beam, so the bending moment of the support must have a certain effect on the deflection. From the perspective of mechanics, considering the semirigid bearings, the applicability of the combination of strain measurement and construction function method to the measurement of deflection of wooden beams is studied. Semirigid bearings are a kind of beam between simple support and fixed connection, so it is difficult to quantitatively determine the deflection equation theoretically. Therefore, the total strain of the beam can be divided into the strain due to the load and the strain due to the equivalent additional bending moment of the semirigid bearing, as shown below.

$$\Delta\varepsilon = \Delta\varepsilon_v + \Delta\varepsilon_F, \tag{6}$$

where $\Delta\varepsilon$ is the total strain, $\Delta\varepsilon_v$ is the strain generated by the equivalent additional bending moment of the semirigid bearing, and $\Delta\varepsilon_F$ is the strain generated by the load.

For simple supported beams, the settlement of the support will not cause the internal force of the beam to change. For members with semirigid supports at both ends, the beam's ends will generate additional bending moments, which will cause strain. However, according to the above, the additional strain of the beam body caused by the additional bending moment of the bearing may be included in the additional strain generated at the bearing, that is,

$$\Delta\varepsilon_F = \Delta\varepsilon_{\text{Load}} + \Delta\varepsilon_{\text{settlement}}. \tag{7}$$

The superimposed strains of bearings and loads are superimposed according to the same function form, and the calculation of the transformation of strain into deflection can be realized. However, the deflection value caused by the settlement of the support not only includes the strain but also the displacement. The algorithm only considers the deflection value caused by the strain, that is,

$$\omega(x) = \omega(x)_\varepsilon + \omega(x)_\Delta, \tag{8}$$

where $\omega(x)_\varepsilon$ represents the deflection due to strain, and $\omega(x)_\Delta$ represents the deflection due to settlement displacement.

In order to make the coefficients of the constructor function available through the strain solution, it is necessary to ensure that the unknown coefficients after the derivative do not disappear.

$$\omega(x) = A(x)\sum_{i=1}^{k} X_i g_i(x). \tag{9}$$

Equation (9) only represents the deflection ω_ε caused by the strain, and on this basis, ω_Δ can be linearly superimposed according to the proportional relationship between the settlement values Δ_l, Δ_r of the bearings at the left and right ends, that is,

$$\omega(x)_\Delta = \frac{l_2 - x}{l_2 - l_1}\Delta_1 + \frac{l_1 - x}{l_1 - l_2}\Delta_r. \tag{10}$$

Finally, the form of the deflection structure is obtained as follows:

$$\omega(x) = A(x)\sum_{i=1}^{k} X_i g_i(x) + \frac{l_2 - x}{l_2 - l_1}\Delta_1 + \frac{l_1 - x}{l_1 - l_2}\Delta_r, \tag{11}$$

where l_1 and l_2 are the lengths from the beam boundary (when l_1 is 0, l_2 is the beam length).

2.6. Deformation of Compression Members

2.6.1. Deformation of Pillars. In ancient Chinese architecture with wooden frames as the main body, wooden columns were the main load-bearing members. Depending on the position of the pillar, its load varies greatly. For example, the inner gold pillars and the middle pillars have larger loads than the eaves pillars, but the load on the various pillars is grain pressure. From the perspective of the damage of the pillar, it can be divided into several types of damage: the stigma, the root, and the entire shaft.

Stigma under pressure: the long-pressed wood pillar often splits into several petals along the grain at the stigma. What is more, the cracked part rises beyond the diameter of the column. In this case, the gold column in the top layer of the Yingxian wooden tower is the case where the cracked part appears under pressure.

Roots are rotten: the roots of ancient buildings easily rot due to prolonged humidity or rain. The wooden pillars are wrapped on the wall, and the roots of the wooden pillars are more susceptible to decay. The wooden pillars are corroded into jujube nuclei, and the surroundings of the wooden pillars become powdery substances. Both the eaves and the center pillar of Jingqingmen are this phenomenon. The root of the Jingqingmen pillar rotted, causing the pillar to sink. Another type of looming pillar that was not enclosed on the wall was eroded by wind and air temperature and corroded into grooves along the wood grain. This phenomenon also appeared on the outer eaves of the second-level flat tower of Yingxian wooden tower. It even erodes a stump to make it thin, but it is relatively rare that the stump is compressed and split.

Pillar splitting: early wooden buildings did not use ground rods, and all wooden components were exposed. Affected by various factors in nature for a long time, the cylinder will be split to different degrees. Some extend from the stigma at the stigma to some stumps, and some extend upward from the stumps. The fissures sometimes crack at multiple locations on the pillar and reach one centimeter, approximately the diameter of the pillar. The occurrence of cracks will inevitably affect the bearing capacity of wooden columns. The destruction of the wooden pillars was mainly due to compression along the grain.

2.6.2. Deformation Bucket of Bucket Arch Member. The function of the arch is to transmit the load of the tile roof and the beam frame to the column, so it is a group of complex members with complex forces. It is composed of a number of arches, hangs, warps, and buckets, which transfers the load to the stigma. In the process of force transmission, it is often cracked or broken at the intersection of arch and warp. The most common is the phenomenon of large buckets or interactive buckets splitting under pressure. The stigma and corner bucket arch are also easy to split due to the concentrated force, but the damage of the arch is mostly caused by the compression of the horizontal stripes.

2.6.3. Deformation of the Beam. Girder deflection: beams and hangs in ancient buildings are upper load-bearing members. Due to long-term load, beam bending is a common deformation in ancient buildings. This is the case in the Sanqing Hall of Yongle Palace, and the main hall of Chongfu Temple and Nanchan Temple in Shuoxian County has beam bending.

Beam splitting: cracks also occur in the beams of ancient buildings. One case is cracks around ill knots and turbines. Second, the internal stress of the beam is complicated. Under long-term stress, the strength of the wood gradually decreases, and these parts are also prone to damage.

Splitting of components such as beam: rafter, and crossbeam, which has a small cross section, has been subjected to long-term cleavage or bending deformation, which is more common in ancient buildings. Crossbeam is a member that is both compressed and tensioned. Crossbeam is a compression member that bears the load transmitted by the tween arch. Rafter acts as a ring beam at the intersection of the stigma and is also subject to a certain amount of tension. In another case, due to the long-term compression, the fracturing phenomenon along the wood grains in the middle or end of the poppet poplar, or the diagonal cracks occurred, which indicates that the compressive strength of the transverse grains was reduced and the damage occurred.

3. Experiments

3.1. Test Object. China's ancient architecture has been passed down for more than 7,000 years. It has always maintained an independent structural principle and has been recognized by future generations. It is an important cultural heritage protected by China's Cultural Relics Bureau. A proud treasure, but after many years of preservation, the ancient wooden structures that have gone through vicissitudes are destroyed by humans and natural forces to varying degrees. For example, the famous Mogao Grottoes in Dunhuang at home and abroad is a good representative. Due to the influence of natural environment and engineering geology, and the rapid development of industry and tourism in recent years, environmental pollution has caused many impacts. This article compares the old and new structures of ancient buildings with the damage of various structures of ancient buildings, and uses a variety of methods to find more accurate methods to predict the life of ancient buildings, and have better prevention and correction of ancient buildings.

3.2. Design and Implementation of Experiments. This article compares new and old materials through experiments, finds the difference between old and new wood through comparison, and predicts the life of wood and buildings through the time of wood. And through different prediction methods, it finds a more accurate prediction method, and by using artificial intelligence makes predictions more accurate and accurate. This article also conducts experimental comparisons of various parts of ancient buildings, and finds the useful life of different parts through comparison to make the prediction and research of ancient buildings more specific and accurate. It is hoped that the research and investigation of this article can promote the protection of ancient buildings in China and make them better protected.

4. Discussion

4.1. Comparison of Compressive Strength and Flexural Strength of Old and New Wood. The statistical results of the experimental data of the compressive strength and flexural strength of the old and new materials are shown in Figure 4. Through comparison, it can be found that the average values of the compressive strength and flexural strength of the old materials are significantly lower than those of the new materials, indicating that the after about 350 years of service, the material properties of ancient wooden components have deteriorated severely. The coefficient of variation of the

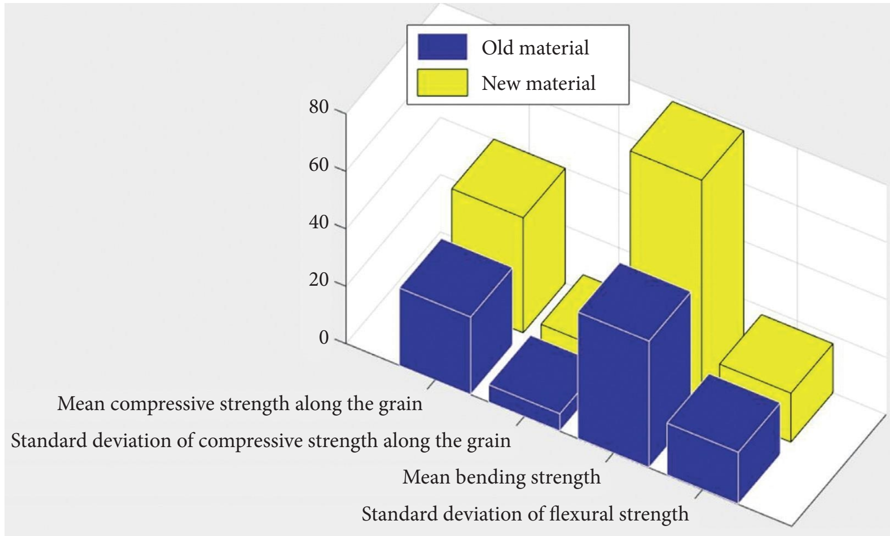

Figure 4: Comparison of old and new wood.

Table 1: Design strength of new and old materials.

Index	Design value of compressive strength along the grain (MPa)	Design value of flexural strength (MPa)
Old material	14.5	8
New material	24	30
Residual strength ratio (%)	60.42	26.67

index of compressive and flexural strength of the old wood is obviously lower than that of the new wood, indicating that in the long service history of the component, the wood in different parts is in different environments, and the degree of material strength degradation is different, and the influencing factors. Uncertainty leads to an increase in the dispersion of the test intensity index.

Due to the large variability of the test results, in order to ensure the reliability and safety of the analysis results in the evaluation of the bearing capacity of wooden members, various mechanical performance indicators of wood need to be converted according to a certain guarantee rate. The design strengths of the tested old and new materials are shown in Table 1. Compared to the new materials and old materials, the residual strength ratios of the compressive design strength and flexural design strength of the new material are 60.42% and 26.67%, respectively.

Figure 5: Statistical indicators of service life.

4.2. Comparison of Wooden Columns and Beams. The statistical indicators of the service life of wooden columns and beams are shown in Figure 5. The corresponding average values of the columns and beams are 370 and 355 years, respectively, and the coefficients of variation are 22.97% and 22.54%, respectively. Uncertainty leads to greater uncertainty in the service life of wooden members.

Table 2 gives the service life of the wooden columns and beams when the reliability indicators are 1.0, 2.0, and 3.0, respectively. It can be seen that the longer the predicted service life, the higher the probability of failure of the component, and its reliability and the lower the degree.

Table 2: Correspondence between service life and reliability index.

Reliability index	Service life of wooden pillars (years)	Service life of wooden beams (years)
1.0	285	282
2.0	230	233
3.0	195	190

4.3. Comparison of Different Prediction Methods. Table 3 shows that the PLSS method based on missing data estimation given in this paper has higher prediction accuracy. The prediction accuracy of the PLSS model based on missing

Table 3: Comparison of prediction results of different prediction methods.

Model	RPE
PLSS completion data	0.11
BP neural network	0.31
PLSS delete column	0.35
PLSS complement 0	0.16

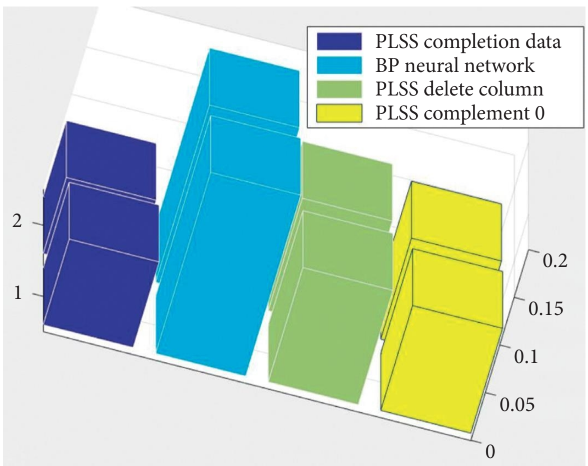

Figure 6: Comparison of prediction accuracy of actual collected data.

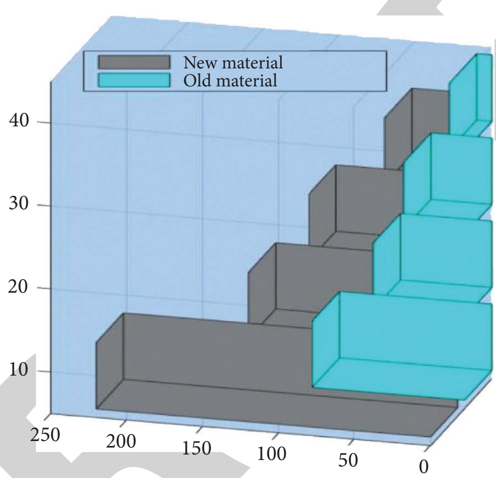

Figure 7: Effect of material properties on vertical bearing capacity of joints.

data estimation is higher, and the prediction result is closer to the original data result. It can be seen from Figure 6 that under the actual data collection prediction method, the estimated value of the PLSS ancient wooden structure based on the missing data is more consistent with the actual life value than other algorithms. It shows that the PLSS regression model has better prediction effect than other models.

4.4. Bearing Capacity of New and Old Timber Nodes. As shown in Figure 7, it can be seen that the change in the bearing capacity of the new material and the old material with the increase of the angle is similar, but the bearing capacity of the old material node is significantly lower than that of the new material node, and the bearing capacity of the new material is significantly lower. Therefore, accurately obtaining the mechanical properties of ancient wood is very important to scientifically and reasonably evaluate the bearing performance of nodes.

5. Conclusions

Based on the available data, this article mainly affects the life of ancient wooden structures: load factors of wooden structures, environmental factors, and characteristics of wood structure materials. The life prediction methods of ancient wooden structures are summarized, and fault diagnosis methods based on data feature extraction are introduced into the life prediction and anomaly detection of ancient wooden structures. This paper analyzes several main factors that affect the life of ancient wooden structures, and gives a systematic overview of the reliability theory and remaining life prediction methods of ancient wooden structures. Chinese ancient architecture is an important part of Chinese culture. It not only integrates architectural functions, literature, and art, and has a profound content. It shines brilliantly in the forest of world architecture, and has important artistic, historical, and scientific value. The structural reliability theory and the basic knowledge of remaining service life are introduced. At the same time, the commonly used reliability calculation methods and remaining service life methods of existing structures are summarized, laying a theoretical foundation for future research. It is an important responsibility of our scientific researchers to learn from the good mechanical properties of ancient buildings and apply them to modern buildings. This article uses artificial intelligence to predict the life of buildings, which is more efficient and more predictive, implying complex nonlinear relationships.

This article studies the main factors that affect the service life of ancient wooden structures, the lack of further experimental research and analysis of data collected by sensors for ancient wooden structures, and the impact of other non-main factors cannot be ignored. The assessment did not take into account the non-primary factors. At the same time, there are limitations in data sampling. Partial data can reflect part of the overall structure of the building and cannot fully reflect the actual overall state of the structure. The results have certain limitations. Fire, earthquake, and man-made situations may occur randomly in the actual environment of the wooden ancient buildings in service. This paper mainly monitors the long-term use, and does not consider the short-term transient conditions, and further research is needed. Due to the large number of wooden structural components and the extreme conditions shown by each component, health monitoring of each component is impossible. In order to effectively monitor the state of the structure and determine the impact of component reliability on the overall structure reliability, this method is also worthy of further research. In the finite element modeling process, due to the limitations of the analysis software functions, some of them are not very accurate when selecting the element properties and yield criteria, which have a certain degree of impact on the analysis results. Due to the large number of bucket arches and tenons used in ancient wooden structures, and their mechanical properties are very complicated, they show different characteristics under different stress states. How to correctly simulate in the finite element model, how to correctly judge, and how to correctly reflect the real situation need further analysis. In the modified cumulative damage model, some parameters need to be measured by sampling and statistically calibrated. However, no such data is currently available, and experiments are urgently needed. In the evaluation of the cumulative damage model under the action of bending moment, due to the lack of data and theoretical analysis, it is assumed that the ultimate bending strength is unchanged, which is biased relative to the actual situation, and details need to be studied in detail. Therefore, in the cumulative damage assessment of wooden structures, more experimental research is needed to verify.

All in all, this thesis introduces some methods of fault diagnosis into the life prediction and anomaly detection of ancient wooden structures, and provides a scientific, effective, and real-time method for the long-term maintenance and repair of ancient wooden structures. The application of these methods can more scientifically and accurately adjust the environment of ancient wooden structures, determine the repair or replacement time of wooden components, better perform conditional maintenance, and extend the life of ancient wooden structures. Through the experimental part, it can be seen that the bearing capacity of new materials and old materials is similar with the increase of angle, but the bearing capacity of old material joints is significantly lower than that of new material joints, while the bearing capacity of new materials is significantly lower. It is hoped that the research in this article can better provide decision-making basis for the conditional maintenance of ancient wooden structures.

However, the above research conclusions are obtained, but there are still some deficiencies in this paper, which need to be paid attention to in the future research. The research methods of this paper need to be further improved. The combination of various research methods is not strong. We will continue to study in the future to improve the life prediction model of wood structure.

Data Availability

No data were used to support this study.

Conflicts of Interest

The authors declare that there are no potential conflicts of interest in this study.

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References

[1] G. Zhang and R. Zhang, "Life span prediction of Huizhou architecture based on improved Elman neural network[J]," *Journal of University of Science and Technology of China*, vol. 47, no. 10, pp. 817–822, 2017.

[2] F. T. Badai Samodra, I. Irvansyah, and C. Erwindi, "Reinvigorating local building envelope for translated modern building and changed environment," *IOP Conference Series: Earth and Environmental Science*, vol. 213, no. 1, Article ID 012019, 2018.

[3] S. B. Levin, "The future of knowing and values: information technologies and plato's critique of rhetoric," *Philosophy and Rhetoric*, vol. 50, no. 2, pp. 153–177, 2017.

[4] L. Xu, J. Peng, and Y. Shao, "Prediction of expressway traffic flow on holidays based on improved GA-BP algorithm," *Journal of Computational and Theoretical Nanoscience*, vol. 13, no. 5, pp. 3290–3294, 2016.

[5] M. Li, H. Zhang, B. Chen, Y. Wu, and L. Guan, "Prediction of pKa values for neutral and basic drugs based on hybrid artificial intelligence methods," *Scientific Reports*, vol. 8, no. 1, p. 3991, 2018.

[6] E. Spitoni, F. Vincenzo, and F. Matteucci, "Are ancient dwarf satellites the building blocks of the Galactic halo?[J]," *Monthly Notices of the Royal Astronomical Society*, vol. 458, no. 3, p. stw519, 2016.

[7] K. Aziz, M. M. Haque, and A. Rahman, "Flood estimation in ungauged catchments: application of artificial intelligence based methods for Eastern Australia[J]," *Stochastic Environmental Research and Risk Assessment*, vol. 31, no. 6, pp. 1–16, 2016.

[8] J. Ma, J. Yu, G. Hao et al., "Assessment of triglyceride and cholesterol in overweight people based on multiple linear regression and artificial intelligence model," *Lipids in Health and Disease*, vol. 16, no. 1, p. 42, 2017.

[9] A. S. Peiman, U. Alp, and H. Takci, "Performance evaluation of different customer segmentation approaches based on RFM and demographics analysis[J]," *Kybernetes*, vol. 45, no. 7, pp. 1129–1157, 2016.

[10] K. Hu, Z. Zhou, and L. Weng, "An optimization strategy for weighted extreme learning machine based on PSO[J]," *International Journal of Pattern Recognition and Artificial Intelligence*, vol. 31, no. 1, Article ID 1751001, 2016.

[11] S. Pešić, M. Tošić, and O. Iković, "BLEMAT: data analytics and machine learning for smart building occupancy detection and prediction[J]," *The International Journal on Artificial Intelligence Tools*, vol. 28, no. 6, Article ID 1960005, 2019.

[12] N. Dudhwala, K. Jadhav, and P. Gabda, "Prediction of stock market using data mining and artificial intelligence[J]," *International Journal of Computers and Applications*, vol. 134, no. 12, pp. 9–11, 2016.

[13] S. T. Rasmana, Y. K. Suprapto, and I. Ketut Eddy Purnama, "Texture detection for letter carving segmentation of ancient copper inscriptions[J]," *International Journal of Pattern Recognition and Artificial Intelligence*, vol. 31, no. 01, pp. 1995–1998, 2016.

[14] Y. Bourek, N. M'Ziou, and H. Benguesmia, "Prediction of flashover voltage of high-voltage polluted insulator using artificial intelligence," *Transactions on Electrical and Electronic Materials*, vol. 19, no. 1, pp. 59–68, 2018.

[15] T. Sammour, L. Cohen, A. I. Karunatillake et al., "Validation of an online risk calculator for the prediction of anastomotic leak after colon cancer surgery and preliminary exploration of

artificial intelligence-based analytics," *Techniques in Coloproctology*, vol. 21, no. 3, pp. 869–877, 2017.

[16] B. Vahidi and H. Zeinoddini-Meymand, "Techno-economical lifetime assessment of power transformers rated over 50 MVA using artificial intelligence models:[J]," *IET Generation, Transmission & Distribution*, vol. 10, no. 15, pp. 3885–3892, 2016.

[17] W. Hu, T. Ding, and D. Liu, "Building shelf-life prediction models of postharvest strawberry[J]," *Journal of Chinese Institute of Food Science and Technology*, vol. 17, no. 3, pp. 186–193, 2017.

[18] E. Possan, J. J. D. Oliveira Andrade, and D. C. C. Dal Molin, "A conceptual framework for service life prediction of reinforced concrete structures[J]," *Journal of Building Pathology & Rehabilitation*, vol. 3, no. 1, p. 2, 2017.

[19] R. Guo, C. Ning, and J.-Y. Zhao, "Life prediction and test period optimization research based on small sample reliability test of hydraulic pumps[J]," *High Technology Letters*, vol. 23, no. 1, pp. 63–70, 2017.

[20] A. Atmaca, "Sustainable life span prediction of shelters constructed in refugee camps in Turkey," *Energy, Ecology and Environment*, vol. 3, no. 1, pp. 5–12, 2017.

[21] K. Wang, X. Xie, and Y. Li, "Prediction method of the dwell-fatigue life for titanium AlloysTi-6Al-4V at room temperature [J]," *Ship Building of China*, vol. 59, no. 2, pp. 123–128, 2018.

[22] Y. Zhang, R. Xiong, and H. He, "Lithium-ion battery remaining useful life prediction with box–cox transformation and Monte Carlo simulation[J]," *IEEE Transactions on Industrial Electronics*, vol. 66, no. 2, pp. 1585–1597, 2018.

[23] L. Ben, "Feringa. The art of building small[J]," *Scientific American*, vol. 38, no. 5, pp. 2–7, 2016.

[24] M. Korkanç, "Characterization of building stones from the ancient Tyana aqueducts, Central Anatolia, Turkey: implications on the factors of deterioration processes[J]," *Bulletin of Engineering Geology and the Environment*, vol. 77, no. 1, pp. 237–252, 2018.

[25] Q. Cheng, Q. Zhang, and Y. Cheng, "Short-term photovoltaic power prediction model based on hierarchical clustering of density peaks algorithm[J]," *High Voltage Engineering*, vol. 43, no. 4, pp. 1214–1222, 2017.