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Feature Recognition and Classification of Shanxi Cave Dwellings Based on Deep Learning

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Abstract
Cave dwelling architecture is a unique style of architecture, and it is also the embodiment of Chinese traditional culture in China. It is widely used in the life of working people in ancient China. According to studies, a significant number of people still live in above-ground underground houses and cave dwellings in Australia, Spain, China, Turkey, and Tunisia, and over 40 million people do so in China. However, with the continuous development of society, cave dwellings are gradually unable to meet the needs of more and more people for comparison and work, and tend to be weak. Shanxi cave dwellings have been greatly challenged. Against this background, the aim of this research is to renew and develop cave dwellings better. The research methodology is quantitative method and exploratory research approach. Based on the premise of deep learning to identify and classify the architectural features of Shanxi cave dwellings. In this study, 200 questionnaires were used to measure the residents' requirements for cave dwellings. Through detailed investigation and research on specific examples in Shanxi, the results are as follows: (1) We identify and classify the architectural features of Shanxi cave dwellings based on deep learning algorithm so that we can better understand and explore Shanxi cave dwellings. (2) By analyzing the present situation of examples, it is concluded that most villagers affirm the living comfort and regional adaptability of cave buildings, and the identification and classification of cave building features in Shanxi based on deep learning can provide effective reference, in order to better complete the renovation and development of cave buildings in Shanxi.
Keywords: Deep Learning Algorithm, Shanxi Cave Dwelling Architecture, Feature Recognition, Classification

Introduction

Cave culture is an important part of Chinese traditional culture. Through the research on the architectural form of Qikou Cave, this paper aims to analyze the positive role of Qikou Cave architecture in promoting the development and utilization of modern resources and cultural communication. On the basis of consulting a large number of documents, taking Qikou Karst Cave as an example, this paper studies the architectural morphological characteristics of karst caves. It is hoped that through further excavation of cave culture, Chinese traditional culture will be promoted, and the development of modern construction industry and resource saving will be promoted(Bedard et al., 2021).By means of literature review and field investigation, this paper investigates, analyzes and summarizes the formation background, basic types, architectural layout, courtyard layout and decorative art of cave dwellings, and explores the artistic characteristics and existing significance of traditional earth architecture. As an important architectural form in Loess Plateau, cave dwelling contains local folk customs and residents' feelings for their homes.

However, with the development of economy, because of its own disadvantages, cave dwelling buildings are gradually replaced by commercial buildings. Through on-the-spot investigation in Jingsheng Village, Shanxi Province, the classification, types and application characteristics of furniture are summarized from the combination of caves, folk furniture and indoor layout. By drawing the common layout plans of a cave dwelling, the characteristics of each layout plan are analyzed. With the analysis of functional bubble diagram, three characteristics of cave dwelling layout are summarized (Lu & Kong, 2003).

In-depth study of folk culture, deep learning (DL) is a high-dimensional data reduction technology, which is used to construct high-dimensional predictors in input-output models. This research is a form of deep learning, which uses hierarchical analysis with characteristics. We reviewed the latest technologies of deep learning from the perspective of modeling and algorithm. We provide a list of successful applications in artificial intelligence (AI), image processing, robotics, and automation. Deep learning is predictive in nature, not inferential, and can be regarded as a black box method for high-dimensional function estimation(Wang & Liu, 2002).

In view of the fact that cave dwelling is a kind of ubiquitous dwellings, this paper analyzes and studies the moisture-proof and safety aspects of cave dwelling ecological buildings, discusses them, and puts forward some practical measures. Referring to the shape, structure and volume of an ancient cave stage in Chaoshan Temple, Shanxi Province, five traditional drama stage models are built. The calculation space is 15.46 m × 16.21 m × 6.12 m. Considering ancient wall materials, the model boundary consists of rigid boundary and perfectly matched layer (PML) absorbing boundary conditions. The finite-difference time-domain (FDTD) and spectral analysis of the impulse response of the receiving point under five models are performed by Matlab software. By comparing various simulation results with experimental data, the sound field distribution law and its influencing factors in different frequency bands under several typical structures are analyzed and discussed. It provides reference for actual performance. At the same time, some problems are pointed out. The research shows that the traditional cave dwelling stage can enhance the sound clarity, fullness and reverberation, and can achieve a certain frequency sound reinforcement effect(Ke & Sun, 2015).Deep Depth Neural Network (DNN) model allows feature mapping to evolve from simple feature mapping to complete feature mapping. In the ILVSRC competition, the deep DNN model obtains better top 1 accuracy. We discuss the general neural network layer functions. It includes convolution layer, activation layer, pool layer, batch normalization, packet loss and full connection layer. For deep learning, the layer output is transmitted to the next layer input, which affects the data distribution of covariance offset and has a causal relationship with the prediction accuracy. The full connection layer is used for object classification. It can be regarded as a convolution layer without redistribution, which can be reused for calculation. The development of deep learning needs a reconfigurable network to meet different model requirements. Deep learning hardware uses floating-point algorithm for training and reasoning(Huang & Ning, 2016).These works are based on traditional methods and techniques, which are rarely used to solve complex problems, such as large-scale data processing, large-scale sample analysis and historical investigation analysis, etc., instead of being directly applied to practical problems as in the previous millennium. This paper mainly discusses the deep network structure and related algorithms. These works can be divided into two parts: "input layer-output layer and middle layer-neuron model", while the latter involves many basic problems. Especially about the way of learning.

I will introduce my research from a brand-new perspective. It refers to how to use a lot of learning related knowledge in people's minds. This paper introduces some important concepts and theories. This paper analyzes the ecological characteristics of caves in Hougou Village of Yuci from the perspective of green buildings, This paper summarizes the advantages and disadvantages of cave dwelling on the basis of low carbon and energy saving, and puts forward some reconstruction methods such as adding sun room, high window on the north wall and adding lighting and ventilation shaft, and compares and analyzes the internal thermal environment of cave dwelling by using simulation software, aiming at providing suggestions for green building(Zhao et al., 2014).Some advanced concepts in deep learning are discussed. It focuses on extracting various models of complex visual patterns. One of the main improvements introduced by Deep Learning (DL) is a new layer to help build special types of models. These models can handle specific types of unstructured data, such as images or text. It will introduce how DL provides special layers and network architecture to help image analysis. These types of networks are specialized neural networks called convolutional neural networks (CNNs). CNNs have been widely accepted as the best model for analyzing images and extracting knowledge from them. This chapter also considers useful techniques that data scientists often use to solve problems. Using enhancement techniques, you can create more data to train the model (Ramseyer, 2014). The medieval Mediterranean population moved to cave villages because cave life provided many advantages, including natural climate control, access to water resources and easy construction. In addition, medieval Neanderthals developed sophisticated techniques to excavate and shape their cave environments and build well-designed hydraulic and defense systems. Therefore, the construction of cave settlements is a wise response to the Mediterranean climate, environment and geomorphological conditions, and it is also a reasonable economic and architectural choice for the Mediterranean population (Liu et al., 2021).

This is a new communication scheduling scheme. It can schedule multi-channel communication, i.e. a TDMA-like scheme in which multiple frequencies or DSSS codes are combined to coordinate rendezvous times. Scheduling is performed dynamically in a local, distributed manner and responsive to changing radio conditions, node joining and leaving, and traffic rates. The two main challenges are how to allocate channels and exchange states efficiently. The latter problem becomes more difficult because ordinary listening is not possible in a multi-channel system. The proposed algorithm only needs to keep a small number of soft states. We give the analysis results and simulation results of the new algorithm respectively. We also provide simple extensions to perform traffic-based adaptation and achieve fairness for each node. Suggestions on strengthening the cracks of arch culvert and inner cave dwelling are put forward, which can meet people's living needs on the premise of continuing cave dwelling culture (Piorkowski et al., 2018).

Early researchers believed that artificial neural network was just a simulation tool; They don't care what it can do at all. However, with the in-depth understanding of this problem, researchers gradually found that neural networks can not only solve complex problems, but also be used to predict future events. Therefore, artificial neural network has been paid more and more attention by scholars. It was not until the mid-1970s that artificial neural networks began to appear. After nearly 20 years of development, there have been a lot of research work based on deep learning, and now people begin to pay attention to how to integrate these new technologies into the existing deep learning model. As one of the most important machine learning algorithms in chemical informatics, deep neural network has developed rapidly in recent years. The application of deep neural network in quantitative structure-activity relationship, virtual screening and protein structure prediction is emphatically expounded, especially in the fields of quantum chemistry, material design and property prediction. Therefore, this paper mainly studies the application of deep learning algorithm in computational chemistry. In this paper, the differences and connections between deep neural networks and non-neural networks are summarized. Therefore, this paper hopes that deep learning algorithms can play a valuable role in computational chemistry(Guo & Tong, 2011).There are many factors causing the gradual decline of loess caves in the Loess Plateau of central and western China, According to the present situation of loess cave dwelling, This paper makes an in-depth analysis from the aspects of natural environment, traditional customs, social ethics and architectural technology, This paper tries to find out the root of the decline of loess cave dwellings, and discusses how to protect and develop loess cave dwellings in the future and adopt various remediation measures. At the same time, combined with regional economic development and rural social problems, this paper discusses the sustainable development of loess cave dwellings (Mian, 2021).

Deep learning mode network has been successfully applied in unsupervised feature learning in single mode such as text, image or audio. In this work, we propose a new application of deep network learning features in multiple modes. We propose a series of tasks for multimodal learning, and show how to train the deep network of learning features to solve these tasks. In particular, we demonstrate cross-modal feature learning, in which if multiple modes (such as audio, video, etc.) appear in the feature learning process, we can learn a better feature of one mode (such as video, etc.). In addition, this paper also demonstrates the method of sharing representation among learning patterns. The results show that the visual speech classification published in AVLetterss audio-visual speech classification has the best effect and has an efficient sharing representation learning effect (Porporato et al., 2022).

There are still a large number of dangerous loess caves in Shanxi Province. Due to soil conditions and disrepair, a large number of loess caves have diseases. According to the characteristics of loess cave dwellings and the local actual situation, Shilou County has developed the block reinforcement method, which has achieved good results and is worth popularizing and applying. Aiming at the problem of poor stability of traditional cave dwelling, this paper puts forward the suggestion of strengthening cave dwelling with loess, and makes a test check. Through the test, it is proved that the loess reinforcement can improve the strength and deformation of soil and cave dwelling structure, and its measures are scientific, reasonable, feasible and high in application value, which can be popularized and used in the future (Deltshev, 2011).

Deep learning is often used in hierarchical architecture, trying to use multi-layer information processing modules to automatically learn data representation methods. This paper introduces several typical mechanical fault diagnosis methods based on deep neural technology. Compared with traditional CNN, standard neural network (NN) has the following characteristics: its architecture consists of convolution layer, sub-sampling layer and pool layer. DBNs belongs to generative NNs. DBNs is superimposed with several restricted Boltzmann machines, which can be trained greedily, hierarchically and unsupervised, and then further fine adjustment of its relative training data labels is realized by adding the top softmax layer. RNN uses an adaptive network structure with global attention mechanism. In this paper, the principles, advantages and disadvantages of various models are discussed, and the future research directions are prospected. Finally, some experimental results are given. Like DBNs, RNNs can be trained to back-propagate in time to perform supervisory tasks with orderly input data and output targets(Zhao et al., 2014).We first briefly introduce the development history of artificial intelligence, and then introduce gradient descent method and its variants, such as random gradient descent method and natural gradient descent method. Then, the artificial neural network and its building blocks are reviewed. Time Back Propagation (TBP) and Time Back Propagation (TBP) are proposed for supervised training of feedforward neural networks (FNN) and recurrent neural networks (RNN), respectively. In the training process, the initialization and regularization are discussed. The architecture of deep neural network is proposed, including feedforward network (such as convolution neural network) and recursive network (such as long-term memory, short-term memory and gated recursive unit). On the basis of reviewing Hebbian learning as a basic unsupervised learning method, Gibbs sampling is introduced. Then Boltzmann machine and its variants, such as restricted Boltzmann machine, deep Boltzmann machine and deep confidence network, are introduced (Sharmila & Subramani, 2014).

Classification and recognition of basic forms of caves in Shanxi Province

The cave dwelling is generally consistent with the mountain-shaped trend, and the loess soil on the mountain is quite hard and thick, and it is tall and straight. For cave dwelling construction, Try not to choose too humid a location when selecting a site, The soil quality of cave dwellings needs to be kept as dry as possible, When choosing a location, try to choose a location with a slightly higher geographical location, and the lower location is slightly less safe, so as to avoid floods to a certain extent. When choosing the orientation, you should avoid dark locations and choose a location with sufficient sunshine, so that the lighting performance of caves can be improved. In addition, it is necessary to comprehensively consider local climatic conditions and other factors, and choose sunny construction as much as possible. To sum up, in order to build a safe, practical, beautiful and comfortable building environment, we should think comprehensively from the above aspects. There are many ways to build caves, such as adobe masonry, brick building and masonry wall building. In addition, there are some methods used under special circumstances, such as digging holes or digging kilns. There are many forms of cave dwellings, which are generally divided into three types: sinking type, cliff type and freestanding type. Among these three forms, sinking type is the majority, and cliff type and freestanding type appear in the future, which are also the most common, as shown in Figure 1.

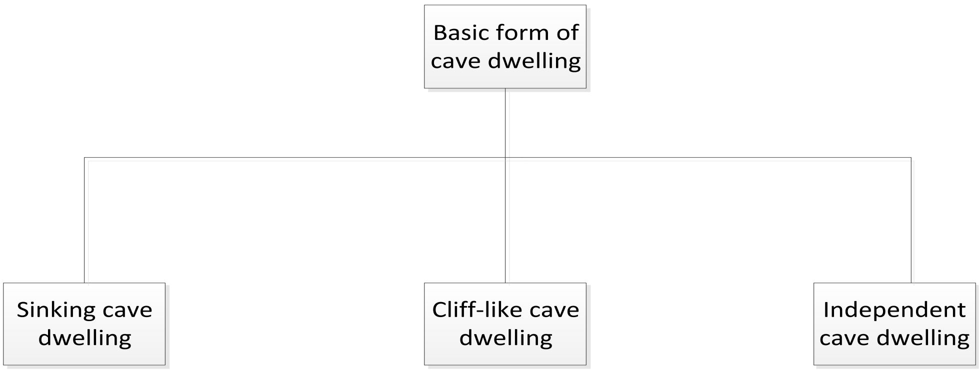


Fig. 1 Three forms of cave dwelling

Sinking Cave Dwelling

In essence, sunken cave dwelling is one of the most primitive information styles for understanding cave dwelling form in people's minds, it is mainly arranged in the rich area of loess source, and there is no hillside geology and gully wall geology available for utilization. It is widely distributed in the west of Henan Province. The local people call the sunken cave "ground scenting courtyard" or "pit courtyard", which is listed as a national key project because of its uniqueness. It is characterized by: opening a rectangular hole on the ground and opening a rectangular hole parallel to it on the hole wall; Each hole is surrounded by soil to form an indoor and passageway; In addition, all openings can be closed according to different needs, so that people have a closed effect. There are many kinds of caves. Then make the upper part of the cave wall into a step-like structure (Figure 1), and finally form a layer of soil wall (see Figure 2). The height of the soil wall is generally within 5 meters; the thickness is about 10 ~ 20 cm. There is no gap between the soil walls. The depth and width of the soil wall vary with the conditions. Usually, functional bodies with different shapes surrounded by fences can be seen in rooms, kitchens, warehouses and scents to protect the stratum from damage, that is, traditional cave quadrangles in China. Compared with the courtyard, the cave dwelling has its own unique features, which are mainly manifested as flexible site selection, small ups and downs of topography and compact and reasonable construction arrangement.

Cliff-like Cave Dwelling

Cliff-like caves are more common in mountainous or hilly areas, which are formed in Longdong Loess Plateau because of solid soil layer, good uprightness and low groundwater level. The utility model has the advantages of simple structure, convenient construction and low cost; However, its thermal insulation performance is poor, and freezing damage will occur in the low temperature environment of about 10-15 ℃; Therefore, it is widely used in cold areas. The utilization rate of cave dwellings is very high. This kind of cave dwelling is most common in hilly and gully regions in central and southern Gansu, Weibei arid tableland and Yellow River valley, and is more prominent in Pingliang area. Because most of these kilns are built in high mountains and dense forests, they have the outstanding advantages of good ventilation and light transmission, good heat preservation performance and ideal lighting and heat insulation effect. It is especially suitable for living in cold season in northern China. Therefore, it is deeply loved by the broad masses of the people. It has the following characteristics: simple structure, low cost, convenient construction and easy relocation. It is an economical and applicable form of traditional dwellings; Cave dwelling buildings are generally built on steep cliffs or soil slopes, which are characterized by steep slopes, thick loess layers as the top, and step-shaped caves. Under the condition of suitable mountain height, several terraced caves can also be set up, which is similar to the form of buildings. The bottom roof can be used as the courtyard of superstructure. Many modern mountain buildings learn from this form and indirectly develop the special modeling form of mountain buildings.

Independent Cave Dwelling

Independent cave dwelling is also called "hoop kiln". This cave dwelling form is not a cave dwelling on the soil layer in the true sense, but a house form built by hoop cave dwelling in masonry imitation cave dwelling form in plain area. It is a unique residential type in the Loess Hilly and Gully region of northern China, which has a long history and profound cultural heritage. Detached houses have the characteristics of warm in winter and cool in summer and good ventilation, but they are greatly influenced by terrain and natural conditions, so their architectural forms are quite different. While the terrain is flat, its cultural customs are similar to those of its surrounding areas. Its regional characteristics, ecological needs and local residents' basic needs for living conditions all provide substantial supporting conditions for the kiln residence form of local traditional dwellings, and thus produce local unique living value and folk cultural connotation.

Inner Space form of Loess Cave Dwelling

Cave dwellings are usually drilled in loess stone walls, and then the inner walls are reinforced with yellow mud and smoothed with chalk soil. Some cave dwellings are reinforced with stones or bricks to build kiln surface walls. The size of cave dwelling can be adjusted according to the needs of residents, and the outer space of some cave dwellings can also be increased, either large or small. Cave dwellings are divided into indoor type (that is, used by the elderly) and outdoor type (that is, used by children). Indoor type can be subdivided into: 1. Ordinary cave dwelling; 2. Special types of caves. The following is a brief introduction to these two. The internal space of the cave is generally about 4 meters high, the entrance is about 3 meters wide and 10 meters deep, and the front part is the main cave, which is slightly higher than other caves, with good lighting and other functions, and is generally for elders to live in. Doors and windows made of stones are rough in structure, but it can also play a certain role, such as opening a small hole in the hole for people to enter and exit, or opening a small hole in the whole wall for people to enter and exit, thus forming a closed space, which is usually called a doorway. People are used to using it to express different times of the day, so it is also called a door and a window type

Deep Learning Algorithm

Random Gradient Descent Algorithm

The classical momentum algorithm adds momentum term to SGD and considers the change of historical parameters to accelerate the process. In the update calculation formula in SGD, Cause $\Delta\theta_t = \theta_{t+1} - \theta_t$, There is $\Delta\theta_t = -\alpha_t \nabla f_{i_t}(\theta_t)$, The parameter update formula for CM is:

$$\Delta\theta_t = -\alpha_t \nabla f_{i_t}(\theta_t) + \rho\Delta\theta_{t-1} \quad (1)$$

Among them $\rho \in (0,1)$ Is the momentum coefficient (generally 0.9).As to whether it is effective to add momentum term, some scholars put forward that gradient can be regarded as the force acting on particles, Put $v_t = -\Delta\theta_t$ is regarded as speed, and force is used to change the speed and change its position. The joint formula (1) has:

$$v_t = \alpha_t \nabla f_{i_t}(\theta_t) + \rho v_{t-1} \quad (2)$$

The update formula of the algorithm can also be written as a formula:

$$\theta_{t+1} = \theta_t - v_t \quad (3)$$

Multi-peak is an improvement of the traditional method, but this method needs many iterations to achieve faster convergence rate. Therefore, an improved adaptive particle swarm optimization (APSO) algorithm is proposed. Firstly, random sampling and crossover operation are used to generate the initial population. Then mutation operator is used to improve individual diversity. Finally, a hybrid evolutionary strategy based on inertia weight and Gaussian-Newton formula is used to speed up the search. Add a correction factor to it and update the parameters. The formula is as follows:

$$v_t = \alpha_t \nabla f_{i_t}(\theta_t - \rho v_{t-1}) + \rho v_{t-1} \quad (4)$$

$$\theta_{t+1} = \theta_t - v_t \text{ v} \quad (5)$$

Random gradient descent algorithm for variance reduction

Then the variance reduction gradient algorithm establishes a general framework of variance θ reduction algorithm, and most of the variance reduction algorithms that appear one after another are rewritten in this version. Let θ be a parameter, and when θ retains a "snapshot" for itself every time it is updated, it is denoted as θ. Just like, if the initialization θ_0 parameter is updated by S and then variance reduction gradient algorithm for a certain number of times to get θ_s, then $\theta = \theta_s$ (determined as $s = n$ or $s = 2n$) is made.

The formula for calculating the average gradient of all samples at θ is:

$$\mu = \frac{1}{n}\sum_{t=1}^{n} \nabla f_i(\theta) \quad (6)$$

$$E[\nabla f_i(\theta) - \mu] = 0 \quad (7)$$

$\nabla_t = \nabla f_{i_t}(\theta_t) - \nabla f_{i_t}(\theta) + \mu$ as the approximate quantity of gradient in the t-round iteration, we can know that the parameter update formula of SVRG is:

$$\theta_{t+1} = \theta_t - \alpha_t \nabla_t \quad (8)$$

We prove that the variance generated by SVRG decreases with the increase of iteration times, which is smaller than that of SGD, that is,

$$E[\left\|\nabla_t - \frac{1}{n}\sum_{t=1}^{n}\nabla f_i(\theta_t)\right\|_2^2] < E[\left\|\nabla f_{i_t}(\theta_t) - \frac{1}{n}\sum_{t=1}^{n}\nabla f_i(\theta_t)\right\|_2^2] \quad (9)$$

In addition, SVRG algorithm generally adopts decreasing learning rate, and SVRG algorithm can still get fast convergence when the learning rate is fixed.

Although SVRG can accelerate convergence, it is only effective for smoothing objective function. In practical application, there are often local minimums, which make it impossible to get the global optimal solution; however, the convexity of the objective function is not taken into account when the traditional gradient method is used to solve the problem, which leads to the inaccuracy of the calculation results. Nonsmooth regular terms will increase the subgradient and substitution gradient in the objective function, and then affect the convergence rate. SVRG optimization problem is a convex quadratic programming problem, which will produce large errors in the process of solving. By considering a regularized version of the model, it has:

$$\min_{\theta \in R^d} J(\theta) = \frac{1}{n}\sum_{t=1}^{n} f_t(\theta) + h(\theta) \quad (10)$$

The formula for updating the target parameters of the random variance reduction gradient algorithm is as follows:

$$\theta_{t+1} = prox_{\alpha_t}^{h}(\theta_t - \alpha_t \nabla_t) \quad (11)$$

In this formula, $prox_{\alpha_t}^{h}$ is the projection algorithm of function H about the near end of hyperparameter α_t in the formula, and its formula is:

$$prox_{\alpha_t}^{h}(y) = \arg\min_{\theta \in R^d} h(\theta) + \frac{1}{2\alpha_t}\|\theta - y\|_2^2 \quad (12)$$

Random gradient descent algorithm of incremental gradient

Random average gradient algorithm (SAG) is proposed from IAG random version. The application of this algorithm in solving linear constrained optimization problems is discussed, and its performance is compared and verified by experiments. Experimental results show that the proposed algorithm has good performance and robustness. The initial weights are improved to make it more suitable for particle swarm optimization. The effectiveness of this strategy is verified by simulation analysis. For each example, gradient descent method or other methods are used when n initialization parameters $\theta_1, \ldots, \theta_n$ are generated. Newly created polymerization gradient $d_n = \sum_{i=1}^{n}\nabla f_i(\theta_i)$. When the iteration number $t > n$, the parameter update formula of the random average gradient algorithm is:

$$\theta_{t+1} = \theta_t - \frac{\alpha_t}{n} d_t \quad (13)$$

$$d_{t+1} = d_t - \nabla f_{i_t}(\theta_t) + \nabla f_{i_t}(\theta_{t+1}) \quad (14)$$

The updating process of stochastic average gradient algorithm is to replace the new gradient with the old gradient of a sample on the aggregation gradient, and then update the target parameter d_t / n by using the global gradient estimator. SAG and SGD are similar in iteration cost, but similar in convergence speed to FGD.

The stochastic average gradient algorithm firstly uses a simple gradient descent method or other methods to generate a new parameter θ_0; Then the intermediate variable ψ^i is introduced, and $\psi_o^i = \theta_0$, $i = 1,\ldots,n$ are made. The update formula of random average gradient algorithm is as follows:

$$\psi_{t+1}^{i_t} = \theta_t \quad (15)$$

$$w_{t+1} = \theta_t - \alpha_t(\nabla f_{t_i}(\psi_{t+1}^{i_t}) - \nabla f_{t_i}(\psi_t^{i_t}) + \frac{1}{n}\sum_{i=1}^{n}\nabla f_{t_i}(\psi_t^i) \quad (16)$$

$$\theta_{t+1} = prox_{\alpha_t}^h(w_{t+1}) \quad (17)$$

These are all objective functions with nonsmooth regular terms, and the new objective parameters can be updated according to the projection operator obtained by calculating w_{t+1} in equation (10).

This method not only ensures the accuracy, but also effectively improves the calculation speed. Because the approximate optimal solution is used as the initial search direction, the quadratic optimization of the original problem is avoided, and the whole solution process has good convergence and stability. The algorithm does not update the target parameters according to the gradient estimation, but only completes the new parameter update by constructing a special projection algorithm. It makes the i sample retain gradient g^i, and resets $g_o^i - \nabla f_i(\theta_0)$ and $i = 1,\ldots,n$. The Point-SAGA parameter update formula is:

$$z_t^{i_t} = \theta_t + \alpha_t(g_t^{i_t} - \frac{1}{n}\sum_{i=1}^{n} g_t^i) \quad (18)$$

$$\theta_{t+1} = prox_{\alpha_t}^{f_{i_t}}(z_t^{i_t}) \quad (19)$$

$$g_t^{i_t} = \begin{Bmatrix} (z_t^{i_t} - \theta_{t+1})/\alpha_t, i = i_t \\ g_t^i, i \neq i_t \end{Bmatrix} \quad (20)$$

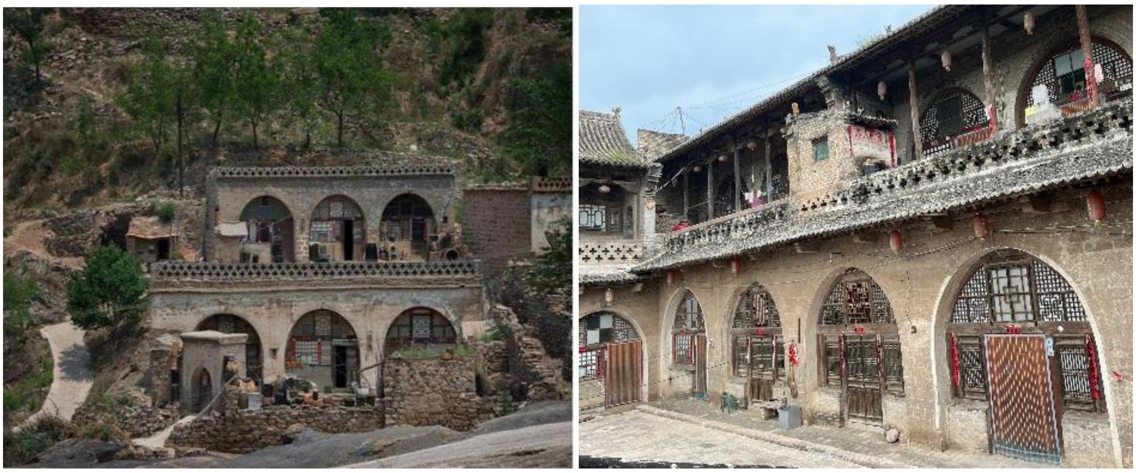
Where $z_t^{i_t}$ is the intermediate variable. $\theta_{t+1} = z_t^{i_t} - \alpha_t \nabla f_{i_t}(\theta_{t+1})$ is known from equation (19), which is an implicit equation about θ_{t+1}.

Experimental analysis and analysis investigation

Performance analysis experiment of Shanxi cave building under deep learning algorithm

Based on the basic theory of deep learning, a sparse self-coding deep learning network is designed, which can effectively learn primitive features for image reconstruction. Through the sparse combination of these primitive features, the redundant abstraction of useful information of the original image can be realized, and the abstraction result can better improve the performance of image feature recognition. Through experiments on handwritten digital images, the characteristics of sparse reconstruction of original images by depth network are verified. Through the control variable method, the related factors affecting the feature recognition effect of depth network image are studied. Experiments show that factors such as the number of network layers and the number of neurons in the layer show the bell curve characteristic that "too much or too little setting will reduce the accuracy of image feature recognition".

In this experiment, three recognition performance algorithms are used: deep learning algorithm, data mining algorithm and artificial intelligence algorithm to recognize and analyze Shanxi cave architecture drawing in Figure 2 below.



(a) (b)

Figure 2. Architectural drawing of Shanxi cave dwelling. (a) Cliff-like cave dwelling; (b) Independent cave dwelling.

The experimental results of image feature analysis using three algorithms for fig. 2 are shown in fig. 3

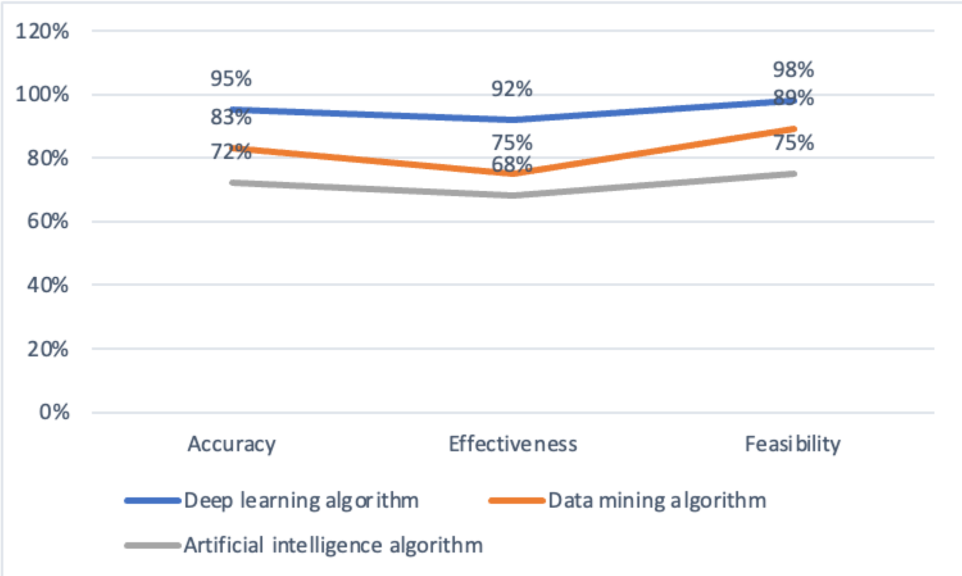


Figure 3. Cave image performance test under different algorithms

It can be seen from Fig. 3 that the accuracy, effectiveness and feasibility of cave building images under deep learning algorithm are 95%, 92% and 98%, 83%, 75% and 89% under data mining algorithm, and 72%, 68% and 75% under artificial intelligence algorithm.

By comparing the three algorithms, it can be seen that the recognition effect of Shanxi cave building performance test using deep learning algorithm is higher than the other two algorithms.

Classification according to the lithology of the existing strata of excavated caves

Fully understand the basis of cave type investigation, In order to investigate the characteristics of cave dwellings and classify them, the cave dwellings in the study area are divided into five medium-sized ones, namely Malan Loess Upper Cave, Malan Loess and Lishi

Loess Upper Cave, Lishi Loess and Mudstone Upper Cave, based on the statistical analysis of the results and the lithology of the local excavated cave dwellings. As shown in Figure 4

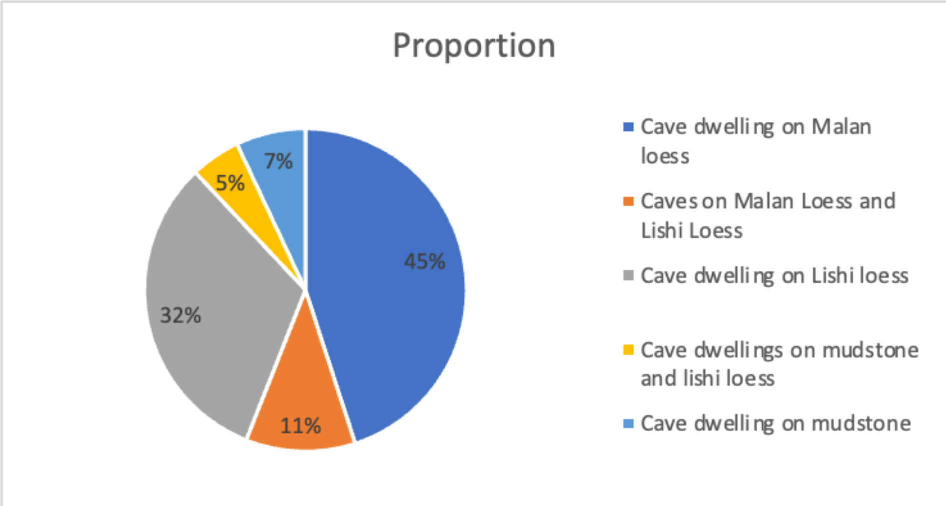


Figure 3. Division diagram by stratum occurrence environment of excavated cave dwelling

Distribution characteristics of cave dwelling types

Distribution characteristics of gullies

The cave dwellings in the study area are mostly located in the Yellow River tableland on the north bank of Jinghe River, loess slope zone, terrace and slope foot (valley) area.

These areas have complex topography and poor geological conditions, and are one of the areas with serious soil erosion in the Loess Plateau. Six gullies in the study area (Majiazhuang gully, Dujiagou, Qifuzhuang gully, Qifucun gully, Erfuzhuang gully and Xiliujiagou in Shanxi) were counted.

A total of 270 caves were investigated, including 16 caves dug in Majiazhuang Ditch, occupying 16 caves under investigation, 108 caves dug in Dujiagou, accounting for 67 holes under investigation, 26 holes excavated in Erfuzhuang Ditch and 25 holes under investigation, as shown in Figure 5.

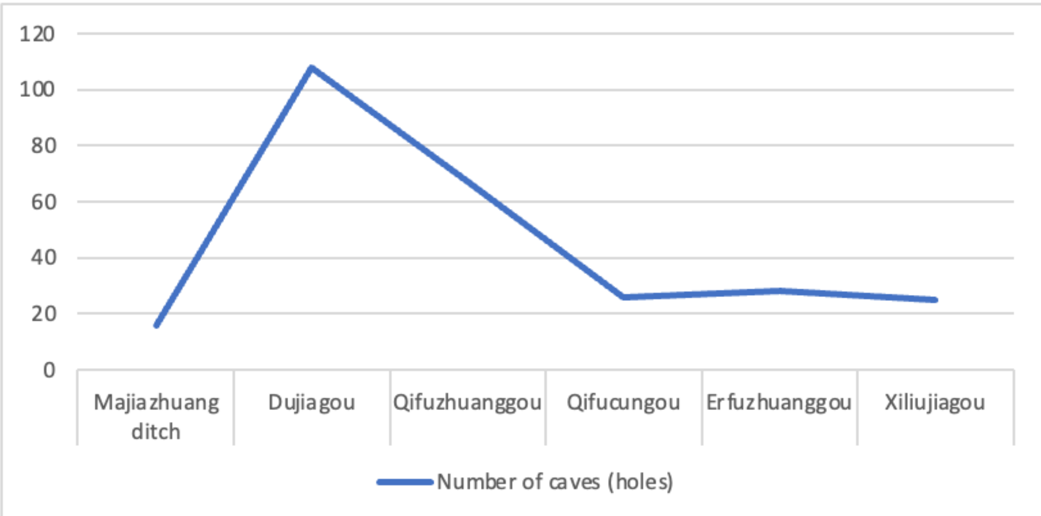


Figure 5. Distribution line diagram of cave dwellings in different gullies

Distribution Characteristics of Lithology

In the six gullies investigated in the study area, the stratum lithology of excavated cave dwellings from top to bottom are Malanshi Loess of Upper Quaternary, Lishi Loess of Middle Quaternary and Neogene mudstone. Among these four gullies, the gully landform types less affected by Holocene neotectonic movement are the most, followed by two erosion gully accumulation forms formed since Quaternary; through the comprehensive analysis of paleogeographic background and topographic conditions, it is considered that kiln pits are closely related to these geomorphic units. And reveals the position and spatial distribution law of each excavation section from a macro perspective; the corresponding engineering geological characteristics are summarized. In addition, various gullies in different times and periods of development are compared and analyzed, as shown in Figure 6.

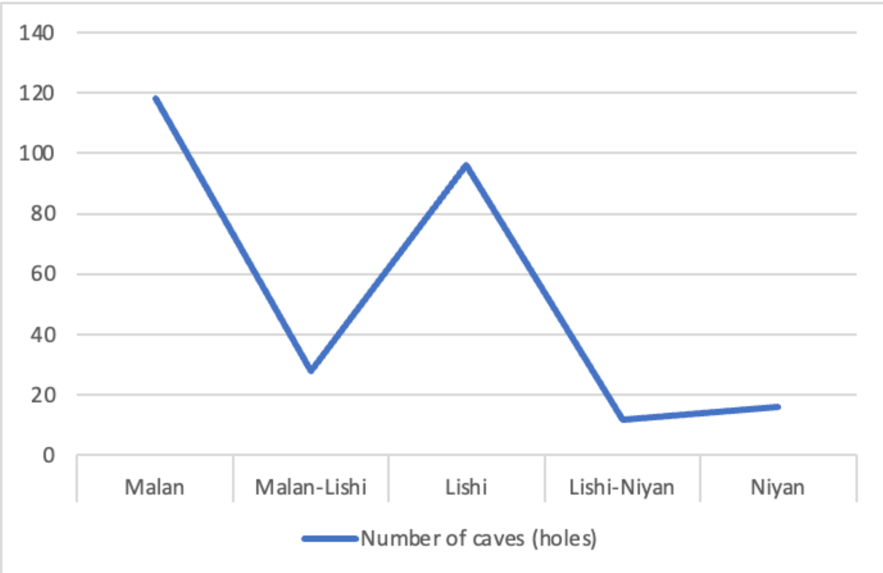


Figure 6. Distribution line diagram of cave dwelling in different lithology

As can be seen from the above figure, The lithology of cave excavation stratum is mostly loess, A total of 242 holes belong to loess caves, Occupy the number of cases investigated, However, a total of 214 caves excavated in a single stratum account for the number of loess caves, which shows that the caves in the investigated area are mainly excavated in a single lithology, which is related to the factors such as dense loess coverage, easy use of local materials, easy excavation of loess caves and more stable excavation of caves in a single stratum than two sets of lithology excavation of caves in the investigated area.

Investigation and analysis of the present situation of cave dwelling buildings

Shanxi caves have a long history and a large distribution area, so it is not convenient to check the specific number of caves in Shanxi today. However, according to the investigation and statistics, there were still people living in caves in Gongyi before 1990, and the current population living in caves is only about one person.

With the changes of the times and the progress of society, the traditional way of life has been gradually replaced by the modern mode of production. People have gradually lost interest in this ancient architectural form of cave dwelling. At the same time, due to the deterioration of the natural environment. In the development process of cave dwelling, it can be said that it stagnated and even began to retreat.

In this study, 200 questionnaires were distributed and collected from cave dwellings in Shanxi for 5 months, among which the respondents were residents aged between 16 and 97 years old; Through the analysis of these questionnaires, we can see that: 1. There are some differences in demographic characteristics among different age groups; 2. With the passage of time, people's requirements for building structure and environment gradually increase. A total of 187 valid questionnaires were obtained, and 160 people were randomly selected from the questionnaires and divided into four age stages for data statistics.

The questionnaire consists of four parts

1. The living conditions of the surveyor's cave dwelling

Table 1 the living conditions of cave dwellings are distributed in a straight line with the age groups, and the living time of cave dwellings of age groups is mostly in caves. Old people of different ages have different needs for living environment: with the increase of age, people have higher and higher requirements for living conditions in caves; with the improvement of education level, people's requirements for housing quality are also increasing. The older they are, the more they like living in caves. The 26 elderly people who are over 80 years old still live in caves. As shown in Figure 7.

Table 1
Questionnaire on Living Conditions of Cave Dwellings

Problem	Content of the question	Under 30 years old 42		30-55years old 44		56-79years old 48		80years old 26		Total number 160	
		Number of people	Proportion	Number of people	Proportion	Number of people	Proportion	Number of people	Proportion		
I still live in caves today		10	24%	21	48%	39	81%	26	100%	70	44%
Have lived in caves	5-10years old	9	21%	5	11%	0	0%	0	0%	14	8%
	10-20years old	21	50%	6	14%	4	8%	0	0%	31	20%
	20-30years old	12	29%	13	30%	7	15%	0	0%	32	20%
	Over 30 years	0	0%	20	45%	37	77%	26	100%	83	51%

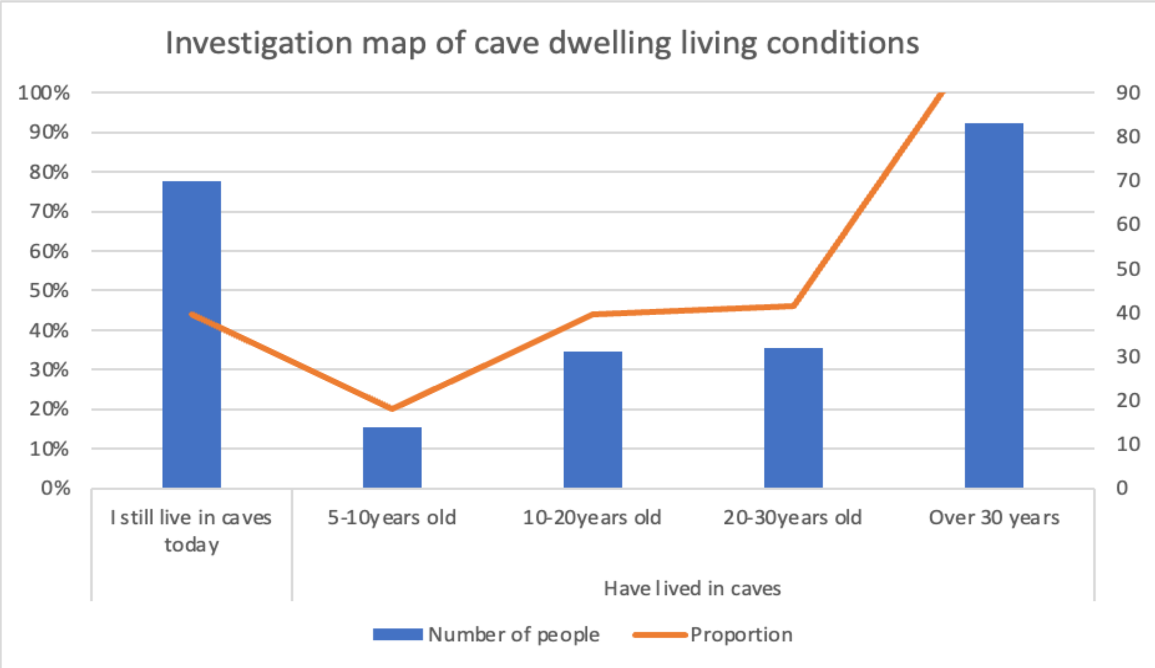


Figure 7. Living conditions in caves

The basic information of the investigator

The results show that most residents living in cave dwellings are in good health, and cave dwellings are an example of ecological dwellings, which have a good impact on the physical and mental health of residents and are suitable for life. Table 2 is as follows

Table 2

Health and Work Questionnaire

Problem	Content of the question	Under 30 years old 42		30-55years old 44		56-79years old 48		80years old 26		Total number 160	
		Number of people	Proportion	Number of people	Proportion	Number of people	Proportion	Number of people	Proportion		
Health status	Health	36	86%	39	89%	38	79%	22	85%	135	83%
	General	4	10%	4	9%	6	13%	3	12%	17	10%
	Infirm and sickly	2	5%	1	2%	4	8%	2	8%	9	5%
Working condition	Stable operation	20	48%	26	59%	5	10%	0	0%	51	32%
	Unstable operation	8	19%	15	34%	7	15%	0	0%	30	19%
	No job	14	33%	3	7%	36	75%	26	100%	79	49%

It is found that working conditions have a significant impact on the development of cave dwellings and the change of people's lifestyle. In the course of investigation, we know: At present, there are still a large number of farmers in rural areas who choose to use caves as their residences; although with the development of social economy and the improvement of scientific and technological level, caves have been gradually eliminated. Most people who still live in caves rely on agriculture to make a living or retire, and most young people leave villages to work in cities and towns. The change of working places is an important factor for abandoning caves, as shown in Figure 8.

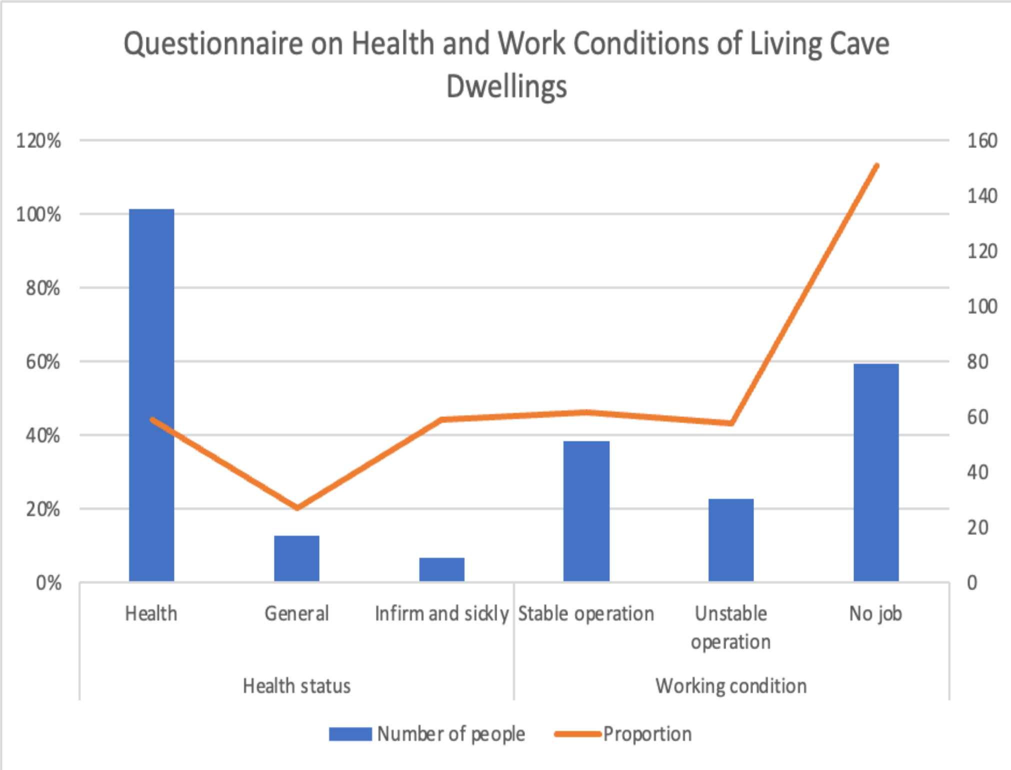


Figure 8. Personnel Health and Work Questionnaire

Views on "Abandoning Kilns to Build Houses"

Table 3 In the concept of abandoning kilns to build houses, most middle-aged and elderly people over 55 years old hold a negative attitude towards completely abandoning caves. They think that caves do have disadvantages such as poor lighting and ventilation and humidity, but they are comfortable to live in. In addition, some residents over the age of 50 are also in favor of abandoning kilns to build houses; most 60-70-year-olds still insist on abandoning kilns to build houses, but they doubt their reasons. About half of people aged 30-55 are in favor of abandoning kilns to build houses, while the other half still choose to keep caves. The main reasons for choosing to abandon kilns to build houses are inconvenient transportation for work and living and poor infrastructure of caves. Abandon kilns to build houses. This is determined by the following reasons: First, with the economic development and social progress, people have higher and higher requirements for living conditions. Secondly, the flow of rural population to cities is accelerating. Young people around 30 years old live in caves for a short time, and most people choose to abandon kilns to build houses. This is mainly because besides the inconvenience of life, they also regard living in caves as a backward performance, as shown in Figure 9.

Table 3
Investigation table on the recognition degree of the phenomenon of "abandoning kiln to build a house"

Problem	Content of the question	Under 30 years old		30-55years old		56-79years old		80years old		Total number	
		42		44		48		26		160	
		Number of people	Proportion	Number of people	Proportion	Number of people	Proportion	Number of people	Proportion		
Views on building houses by abandoning kilns	Want to build a house in a waste kiln	33	79%	24	55%	7	15%	0	0%	64	40%
	Build houses but keep caves	8	19%	12	27%	15	31%	5	19%	40	25%
	Hold on to the cave	1	2%	8	18%	2	54%	21	81%	56	35%
Reasons for building houses by abandoning kilns (multiple choices are allowed)	Inconvenient work and life	29	69%	25	57%	15	31%	0	0%	69	43%
	Poor infrastructure	25	60%	16	36%	12	25%	0	0%	53	33%
	Cave dwelling is a manifestation of backwardness	35	83%	18	41%	14	29%	0	0%	67	42%
	Others	2	5%	1	2%	0	0%	0	0%	3	2%

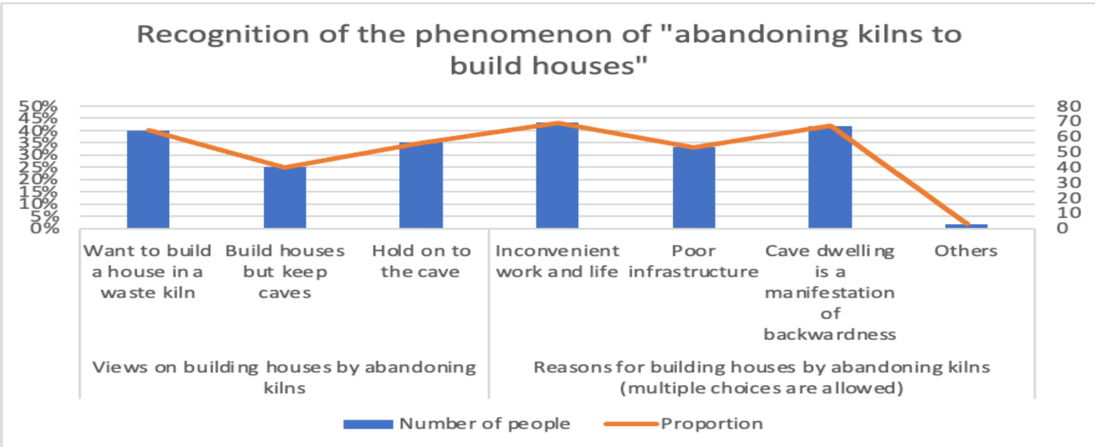


Figure 9. Investigation chart of the recognition degree of the phenomenon of "abandoning kiln to build a house"

Renewal intention of cave dwelling

Table 4

Investigation table of cave renewal intention

Problem	Content of the question	Under 30 years old		30-55years old		56-79years old		80years old		Total number	
		42		44		48		26		160	
		Number of people	Proportion	Number of people	Proportion	Number of people	Proportion	Number of people	Proportion		
Measures to be taken for the development of cave dwellings (multiple choices)	Rational planning by the government	35	83%	42	95%	40	83%	24	92%	141	88%
	Infrastructure construction	38	90%	40	91%	37	77%	15	58%	130	81%
	Tourism Economic Development of Opening Cave Dwellings	39	93%	38	86%	42	88%	20	77%	139	87%
	Protect the cave dwelling and its surrounding environment	7	17%	5	11%	10	21%	5	19%	27	17%
	Others	3	7%	4	9%	3	6%	0	0%	10	6%

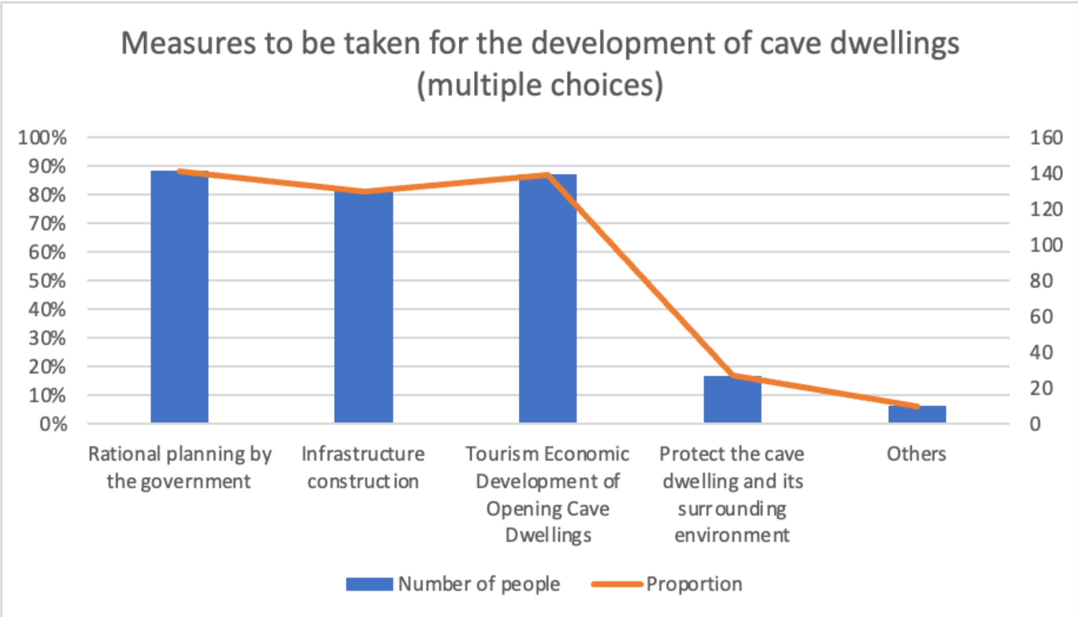


Figure 10. Investigation table of cave renewal intention

It can be seen from Table 4 that in the cave development suggestions, the villagers think that the government should rationally plan the cave area, strengthen infrastructure construction, develop tourism and develop economy. Questionnaire analysis shows that more than 90% of the respondents said they like caves; more than 70% of people want to have one or several nests of their own at home and live with their families. Most villagers hold a positive attitude towards the living comfort and regional adaptability of cave dwellings, while nearly many residents think that they are willing to continue to live in caves if the cave dwellings are ideally improved, as shown in Figure 10.

Conclusion

Based on deep learning, this paper studies the recognition and classification of cave architectural features in Shanxi. Combining with the knowledge of various disciplines, Through theoretical analysis, By means of field investigation and questionnaire survey, this paper makes a detailed investigation on the characteristics and present situation of cave dwellings in Shanxi traditional dwellings, This paper deeply studies and discusses the characteristics, existing problems and development trends of Shanxi cave dwelling architecture, takes specific cave dwelling villages as the research objects, expounds the commonness of Shanxi cave dwelling architecture, and obtains its common problems and development trends, in order to play a reference and help role in the development of Shanxi cave dwelling architecture. Through investigation, it is found that all villages and towns in Shanxi Province are facing the negative influence and threat brought by cave dwelling buildings to varying degrees. Cave dwelling contains rich cultural value, which should have the characteristics from whole to part. In the geographical and historical regional environment, on the basis of comprehensive investigation and theoretical research, protecting and renewing Shanxi cave dwelling architecture can better find the cultural characteristics and essence of cave dwelling architecture. It is necessary to better grasp the macro-control policies of the government and strengthen the cooperation between the government and designers, so as to promote the renewal and development of cave dwellings.

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