Research on component content model of ancient glass products based on statistical analysis

Yiheng Lan 1, a

1 School of Architecture, Chengdu Jincheng College Chengdu, China

a lanyiheng@cdjcc.edu.com

Abstract. This paper mainly analyzes and identifies ancient glass products based on the surface characteristics and chemical composition content of ancient glass products, preprocesses the given data, establishes relevant statistical models, and uses SPSS, MATLAB, PyCharm and other software to perform statistical analysis on the surface of ancient glass. Weathering chemical composition law. To classify ancient glass types, we used the BP neural network classification prediction model to train, and the classification rules obtained depended on the difference of chemical composition content, and we tested the places where there was an accuracy dispute between the two. The classification of subclasses is based on the index evaluation using the method of hierarchy-entropy weight-coefficient of variation. The chemical components of potassium oxide and lead oxide are used to subclassify different ancient glass types. According to the evaluation results, it is proved that they are reasonable, and then the classification is made. Sensitivity analysis was performed on the results, and OAT was used to adjust its parameters to achieve the best subclassification effect.

Keywords: component; neural network models; subclassification; ancient glassware.

1. Introduction

The erosion of glass and the atmosphere is called weathering, and the glass is eroded when buried in the soil, also called weathering. Glass is a valuable material evidence of early trade exchanges. The ancient glass production process in my country is made from local materials, and its chemical composition is different from other countries. It has important Significance. It is a traditional research topic to study glass weathering from the direction of chemical action. Through mathematical modeling and computer simulation of the weathering process, the weathering process and weathering products of glass cultural relics can be thoroughly clarified in theory, helping scholars to draw conclusions faster. Explore the relationship between the surface weathering of glass cultural relics and their types, decorations and colors and the results of their correlation. In the case of different glass types, analyze the statistical laws of the chemical composition content on the surface with or without weathering, and combine regression equations and other methods to predict weathering chemical composition content before. Study the classification rules of high potassium glass and lead-barium glass, and then use a certain classification method to divide them into subclasses, and get the results, and then analyze the rationality and sensitivity of the classification results. Analyze the chemical composition of unknown glass cultural relics, classify them according to the established classification model, and conduct sensitivity analysis on the classification results. Discuss the correlation between the chemical compositions of different types of glass cultural relic samples, and compare the differences in the correlation of chemical compositions. Build a machine learning classification model, use a decision tree classification model with better classification prediction and visualization by neural network, and analyze the classification rules of two types of high-potassium glass and lead-barium glass by using different chemical composition contents. Select the appropriate chemical components to sub-classify each category, first perform cluster analysis on the chemical components to obtain a cluster model, explain the rationality of the model and adjust
the model parameters during the classification process. One method analyzes the resulting changes in model sensitivity.

2. Model establishment and solution

An artificial neural network with a forward structure that maps a set of input vectors to a set of output vectors. MLP can be viewed as a directed graph consisting of multiple layers of nodes, each of which is fully connected to the next layer. Except for the input nodes, each node is a neuron with a nonlinear activation function that is learned first, then stores the data with weights, and uses algorithms to adjust the weights and reduce bias during training. Multilayer perceptrons. Can implement nonlinear discriminants, which can approximate a nonlinear function of the input if used for regression. After analyzing the processed data set, high-potassium glass and lead-barium glass were classified, and 80% of the data set was selected as a training set to establish a glass classification model. Use the remaining samples to perform the learning and training of the test MLP of the model calculation results.

For the training process, it is to give a set of four features, and by adjusting the parameters in the function, the output of the function is the corresponding category, such as [1,0,0]. The batch size in this experiment is 1, that is, a set of data is used for training each time. Training all the data in the training set once is called an epoch. When the output is calculated by the adjusted parameters in the function, the error of the network output is reduced to an acceptable level, and the number of learning times is set in advance.

The number of hidden layers in this neural network model is 1, and the activation function used is hyperbolic tangent[1].

The function image is as follows:

![Image of the tanh function.](image)

The output layer is to classify the type of glass. The number of units is 2, 1 means high potassium glass and 2 means lead barium glass. The activation function used is the regression classification function Softmax function. In the adjacent two layers, the positive and negative connection weights are distinguished by color. The gray synapse weight is greater than 0, and the blue color indicates that the synapse weight is less than 0. The thickness of the connecting line indicates the absolute value of the weight.
3. Reasonable Analysis

Relevant chemical element importance ranking cumulative gain graph. The percentage on the horizontal axis represents the proportion of predicted cases, the gain on the vertical axis represents the proportion of correctly predicted samples in a certain category to all the correctly predicted samples in that category, and blue represents the type of high-potassium glass. The cumulative gain line of red indicates lead-barium glass, because the two lines start from left to right relatively steep, and the surrounding area under the graph line is larger, so the prediction and classification effect is better.

![Graph 1](image)

Figure 2. Reasonability test.

4. Sensitivity analysis

The blue and red curves represent different types of ROC curves. The coordinate \((0, 1)\) in the figure means that the sensitivity is the largest and the specificity is the smallest, that is to say, the classification effect is the best. The closer the ROC curve is to the upper left corner, the higher the sensitivity. High, the lower the false positive rate\([2]\), the better the performance of risk assessment. For quantitative analysis we introduce AUC, which refers to the area under the ROC curve, which is 1, which is very accurate.
The classification rule is to classify according to the number of important chemical components. By establishing a multilayer perceptron neural network model, we can obtain tin oxide, potassium oxide, silicon dioxide, calcium oxide, lead oxide, iron oxide, copper oxide, and barium oxide. The chemical elements most affect the classification of glass types.

5. Conclusion

Based on the Hierarchy-Entropy-Coefficient of Variation method, the first certain index after the evaluation of high potassium is potassium oxide. For all high potassium categories, the potassium oxide content is greater than 20, less than 20 but greater than 10, and less than 10, and the label is obtained. 16, 13, 04, 05 are the first gears; numbers 01, 04, 18, 06, 03 are the second gears; numbers 12, 10, 22, 09, 07, 21, 27 are the third gears.

After the evaluation of lead and barium, the first certain index is lead oxide. All the lead oxide content in all lead and barium categories is more than 50, less than 50 but more than 20, and less than 20. The labels are 40, 39, 43, 54, 51, 38, 02, 52, 34, 57, 43, 41, 50, 19, 36, 56, 51, 58, 30, 49, 55, 08, 25, 50, 26, 24, 08, 47, 11, 46, 49, 35, 42 are the first gear; the labels 32, 37, 28, 23, 31, 33, 45, 48, 53, 44, 29 are the second gears; the label 20 is the third gear.
The OAT sensitivity analysis method was used to change its coefficients many times to obtain the best classification effect.

6. Discuss

The ancient lead-barium glass in China has attracted the attention of many scholars with its unique composition and mysterious technology. It is extremely difficult to study the origin and development of this glass in the absence of definite historical data on the manufacture of lead-barium glass. In order to clarify the raw materials used in the glass manufacturing process, a series of simulation experiments were carried out to produce lead-barium glass under different mineral conditions. In this paper, the data are preprocessed and the interval value is determined to make the model more reliable. Multiple models are used to process and test a problem, avoiding the chance errors or data processing problems of a single model that affect the accuracy of the results.

In the course of modeling the compositional content of ancient glassware, Abe, Y. et al. used a portable X-ray fluorescence spectrometer to reveal the provenance of fragments of a relief glass bowl used for ancient rituals on the sacred Japanese island of Okino more than 1,000 years ago. The fragment was unearthed from a ritual site on the island in the 1950s and is now designated as a national treasure of Japan. Nondestructive and in-situ X-ray fluorescence analysis techniques were applied to the Hedge Island glass fragments to determine where and when they were originally manufactured based on their chemical composition[3]. The clear correspondence between the chemical composition of fragments and glass unearthed from Sassanid ruins in Mesopotamia indicates that the fragments came from a type of glass vessel, mainly produced in the glass workshops of the Sassanid Empire between the fifth and seventh centuries AD. This is the first scientific evidence that glass was imported from overseas thousands of kilometers away and then used exclusively for rituals on Okinoshima. Qin, Y. et. al According to the results of the experiments and comparative analysis of archaeological samples and natural mineral raw materials, such as barite and witherite, it is possible to come to the conclusion that ancient Chinese craftsmen could only use witherite as barium-containing material to make the lead-barium glass. Moreover, the existence of barium carbonate ore in China was the most fundamental internal factor of the origin of lead-barium glass from the viewpoint of mineral resources. A better understanding of raw material of this ancient glass and improved identification of the product of lead-barium glass in the Chinese ancient society will aid in the recovery and analysis of glass artifacts and further efforts to reconstruct this mysterious technology[4]. Gratuze, B In the Bronze Age, artificial glass as glass beads became the object of long-distance trade. Glass objects found at French Bronze and Iron Age archaeological sites have been used to indicate the relationship that exists between the chemical composition of objects, their age and the area of production of the raw materials, which can be used to model the distribution of glass. show that glass composition can also be used as a relative dating tool, which can help specify stratigraphic properties of objects. We then illustrate the importance of trace element determination to determine the origin of some of the raw materials used in glass workshops. The emergence of some very strange glass formulations is discussed: with the help of some complementary methods, such as lead isotope ratio analysis, it is shown how it is possible[5]. Gan. et. al Combined with external beam proton excited X-ray fluorescence analysis, X-ray diffraction, and laser Raman spectroscopy, 17 glass artifacts from the early to middle and late Warring States period unearthed in Hubei Province were analyzed without damage. The results show that these glasses belong to Na2O-CaO-SiO2, K2O-CaO-SiO2 and PbO-BaO-SiO2 systems, respectively. PbO-BaO-SiO2 glassy glaze layer was found on pottery for the first time. The coloring characteristics of these glassware, the chemical composition of the carcass and the core material, and the manufacturing technology were analyzed, and a
A general comparison was made with other glassware of the same period or earlier in other parts of the world. The possible origin and technical origin of the analyzed samples were initially discussed. Quantitative analysis of ancient glass and vitreous materials has important reference significance for the study of their production age and origin, source of raw materials and production technology. Compared with analysis methods such as electron probe (EPMA) and energy dispersive scanning-electron microscopy (EDX-SEM), LA-ICP-MS can quickly and accurately provide primary and secondary amount and trace element information of samples[6]. To study the influencing factors in the quantitative analysis of ancient glass elements by LA-ICP-MS, Hu et. al believed that the influence of the matrix difference between the glass standard NIST610 and Corning glass standard under the 193nm laser was small, while the glass standard NIST610 was used as the correction strategy of external standard combined with matrix normalization method to measure Corning standard results shows that this strategy can accurately reflect the composition of different types of ancient glass materials[7]. different research needs. The study analyzed the unearthed samples and provided data support for the origin research of the product. Fu et al. used multivariate statistical methods to analyze the chemical composition data of more than 100 ancient glass samples unearthed in Sichuan, Chongqing, Guizhou, Guangxi, and Guangdong. regions were analyzed and processed by multivariate statistical methods. The results show that the ancient glass products in southern and southwestern China are mainly composed of ancient glass products with Chinese characteristics. It is composed of lead-barium silicate glass and potassium silicate glass, which can be subdivided into five system categories: K₂O-CaO (~10wt%) SiO₂ system, K₂O-SiO₂ system, PbO-BaO-SiO₂ system, PbO (~25wt%)-BaO-SiO₂ system, CaO-PbO (~40wt%)-BaO-SiO₂ system. The local production of glass in the southern and southwestern regions of my country during the Han Dynasty was discussed by factor analysis, indicating that this region already had independent production of ancient glass in the Han Dynasty[8]. The experimental results and experimental data processing methods provide a new way to study the production and technical exchange of ancient glass on the ancient Silk Road.

References


