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The Recognition of Microscopic Images of Ceramics Incorporating Blockchain Technology

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ABSTRACT

Having summarized the previous research on ceramic identification and anti-counterfeiting, the authors propose a ceramic identification system that combines computer vision algorithms with blockchain technology. The system uses irregular pores on microscopic images of ceramic surfaces as image features, and it applies the SIFT (scale-invariant feature transform) algorithm to extract feature. The images and feature vector sets are then stored by IPFS (inter-planetary file system). When a consumer needs to authenticate a ceramic product, it is only necessary to take a microscopic image of the specified location, and then the SIFT algorithm will compare the picture with the data stored in the IPFS network, previously obtained through the records on a blockchain network. The matching result then determines whether the photographed ceramic is one of those already recorded. Experimental results show that the matching results can be used as a strong basis for identifying the origin of ceramic products.

KEYWORDS

Blockchain, Ceramic Identification, Ceramic Products, Feature Extraction, Image Matching, IPFS Network, Microscopic Image, Sift Algorithm

INTRODUCTION

Research Background

Ceramics are used for a wide range of commodities, such as tableware, tea cups, vases and sculptural ornaments. In addition, there are a significant number of individual collectors of antique ceramics. However, as the pace of development increases, the limitations of the traditional method of visual identification of ancient ceramics become more apparent. It is more and more difficult to meet the needs of ceramic identification by relying solely on manual experience. Methods like chemical analysis (Yi, Feng, et al, 2017; Dogan, Tormo, et al, 2019) and thermoluminescence techniques (Wang, 2009; Trinkler, Christensen, et al, 1998) are often used for the identification of ceramics, but both of them are destructive to a certain extent. Li et al (Li, Guan, et al, 2019) has initiated a method for the identification of ceramics by extracting features from multi-band diffuse reflectance spectra of ultraviolet, visible and near-infrared light. Wu et al (Wu, Guan, et al, 2019) has advanced proposed a

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method for classifying and identifying ancient ceramics based on visible-near-infrared spectroscopy. These diffuse reflectance spectroscopy-based identification methods can effectively circumvent the damage to ceramics during the identification process, but they are inconvenient to data collecting and are susceptible to interference.

All the methods mentioned above have involved a number of computer techniques and algorithms to analyse the collected features, such as BP neural networks and k-NN algorithms. In fact, in recent years, computer technology, and in particular computer vision, has been increasingly applied to the identification of ceramics. For example, Mu et al (Mu, Wang, et al, 2019) has studied the artificial intelligence-assisted recognition of ancient ceramics in which three main ancient visual features of ceramics were converted into machine vision features: shape as object outline, decoration as image texture, and inscriptions as handwritten Chinese characters. Yang (Yang, 2014) has proposed an algorithm for feature extraction and classification of ceramic surface images based on artificial neural networks for extracting the shape feature of surface defects.

In the above methods of attempting to integrate computer vision techniques into ceramic identification, all the ceramic features, like shapes and patterns, are easy to collect but, as macroscopic features, are vulnerable to destruction and imitation. While the microscopic features, such as the pores formed on the surface of ceramics during the firing process, have a more stable form and cannot be imitated. Therefore, the computer vision algorithms combined with microscopic ceramic features have become a novel approach to ceramics identification in recent years. Chai et al (Chai, Feng, et al, 2020) proposed a ceramic microscopic fingerprint image generation method, which determines the identity of ceramics based on the microscopic features of a specific areas of ceramics. Due to the stability of micro features comparative rather than the macro features, this type of method tends to achieve better results in practice.

The story of Professor Kevin Ashton, who was inspired by the sale of a lipstick and then developed the concept of the IoT(Internet of Things) in 1999, is a well-told one; the development of IoT technology also provides another direction for the identification and traceability of ceramics: in addition to better defining the characteristics of ceramics, optimizing and improving the extraction methods of ceramic characteristics, and recording the relevant characteristics of ceramics in the network so that they can be accessed, and it is also a way to enhance the credibility of ceramic identification results. In other words, the cost of trust can be greatly reduced if consumers can obtain information about the identity of a ceramic directly from the ceramic itself.

In this process, the issue of what information should be recorded, where to store the information and how to determine the identity of a ceramic product from the recorded information is essential to be discussed. In the previous paragraphs, the question of what information is suitable as identification information for ceramics has already been discussed. The following paragraphs will focus on the latter two topics.

The current status of ceramic anti-counterfeiting traceability-related research is summarised as follows.

1. Identification methods based on chemical feature analysis and spectral feature analysis, although effective, are prone to damaging ceramics and are in need of a high level of expertise in terms of equipment and personnel; the use of computer vision methods allows the visual features of ceramics to be used as the object of identification, effectively circumventing these shortcomings.
2. In addition to better defining the characteristics of ceramics and optimizing the process of feature extraction, recording ceramic information in the network also makes it easier to trace back ceramics to the source of counterfeiting. Decentralised network storage, such as the blockchain, is trusted by consumers and favoured by researchers over traditional centralised network storage.
3. Having been combined with image feature matching algorithms, the microscopic features of ceramics can be used as a good identity marker for ceramics, facilitating identification without damaging the structure and artistic value of the ceramics themselves.