The Spatial Distribution and Transmission Path of Byzantine Gold Coins Unearthed in China Based on Big Data

Yao Zhang

zhangyao96@stu.scu.edu.cn

The College of Arts, Sichuan University, Sichuan, China

Abstract. In the 20th and 21st centuries, a large number of Byzantine gold coins have been unearthed in China, corroborating the history of frequent exchanges between the Byzantine Empire and China through the Silk Road. With archaeological discoveries, the number of Byzantine gold coins and their imitations unearthed in China has been on the rise year by year, and has attracted much attention in the subjects of archaeology, art and history. Taking into the background of artistic and cultural exchanges between the Byzantine Empire and China, this paper takes the Byzantine gold coins and their imitation coins unearthed in China as the research object, and explains the application method of big-data technology in cultural heritage protection and research. Through data statistics and analysis, the specific number of Byzantine gold coins and their imitation coins excavated in China is obtained. According to the geographical distribution data, the dissemination path is summarized, which is of great significance to the material culture exchange and spiritual civilization mutual appreciation between the East and the West.

Keywords: Big Data Technologies, Byzantine Gold Coins, Spatial Distribution, Dissemination Paths

1 Introduction

One of the most tangible sets of changes associated with the fall of the Western Roman Empire was that which affected the monetary system.[1] The Byzantine Empire had a total of twelve dynasties and ninety-three emperors. As the oldest monarchy in European history and once the economic and trade center of the Mediterranean Sea, Byzantine gold coins became the standard economic circulation medium of exchange throughout the world at that time. Gold coins were widely used for circulation, reserves, taxation, tribute, payment of officials' salaries and international trade. The gold coins were printed with rich and vivid imperial busts, religious symbols and inscriptions, which made them bear the functions of publicizing the authority of the emperor and practicing the indoctrination intention of the Christian Church. Justinian had invented a type for the portrayal of the emperor[2], so Byzantine gold coins united the classical cultures of ancient Rome and Greece, and circulated along the Silk Road from the Byzantine Empire to China, witnessing the economic, political, cultural and social exchanges and evolution of the ancient Eurasian continent.

Although a large number of Byzantine gold coins have been unearthed in China, academic research still faces some difficulties. For example, how to reasonably count the number ; how

PMBDA 2023, December 15-17, Nanjing, People's Republic of China

DOI 10.4108/eai.15-12-2023.2345305

to classify the gold coins according to their characteristics; how to analyze the temporal and spatial distribution characteristics; and how to re-draw the paths of the gold coins in circulation. The era of "Big Data + Cloud Computing" is coming, big data technology has been applied to the protection and research of art and cultural heritage, through the use of relevant algorithms to process and analyze the massive data, and fully explore the value of the data. They require specialized software, special preparation of their input files, large computing capabilities to run, and long model system run times.[3] Cloud computing technology is used to record the excavation and discovery of artistic and cultural heritage, summarize the transmission path and development direction, and provide comprehensive services in Science-technology Archaeology.

This paper focuses on quantitative statistics and data analysis by combining the research results of the previous researchers and the new archaeological data in China. Firstly, it elaborates the characteristics of Byzantine gold coins excavated in China and divides them into three categories. Secondly, the internet today is a vast and interconnected system of software applications and computing devices,[4] the computer big-data skill is used to assist the combing of archaeological materials, and the temporal and spatial distribution in China is summarized through reasonable investigation data analysis. Finally, the transmission path is concluded by Big-data.

2 Characteristics and Classification of Byzantine Gold Coins Unearthed in China Based on Big Data

2.1 Theories of big-data technology applied to science-technology archaeology

In the fast-developing information age, "Big Data" has become a core driving force. Big data and data science will no doubt bring important uses and benefits to people, commerce, government, and society.[5] The concept of "big data" was first proposed by McKinsey & Company, a famous consulting firm in the world, and refers to data technology that far exceeds previous database software in terms of collection, storage, interaction, and application. Big data technology is characterized by four main features: massive data scale, rapid data flow, diverse data types and value density.

Generally speaking, this technology has the following four typical characteristics, volume, variety, velocity and value, for an example see **Figure 1**. Big-data technology is a generalization and summary of the past and present, which itself does not have the characteristics of trend and direction, but the using of Big-data to understand the objective law of the development of things, understand human behavior, and can help us change the past way of thinking, establish a new data thinking model, so as to make predictions and speculations about the future.

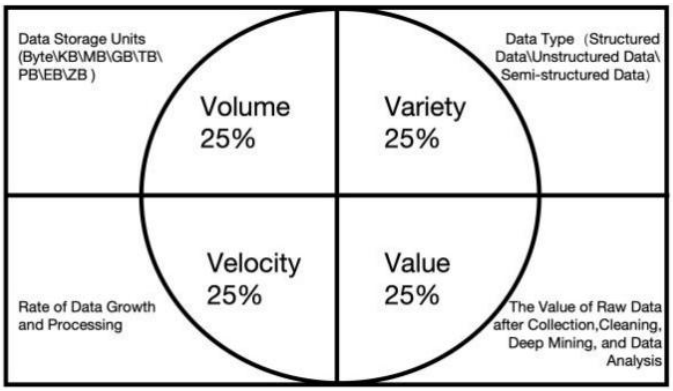

Fig. 1. Four typical features of Big-data

Using Big-data to the area of archaeology involves the storage and processing of large quantities of data, which is related to, among other things, hardware equipment (data storage), search software tools (archival systems), data search, partial archival excerpts, visualization (imaging systems, geographic information systems, 3D), and data processing (visualization of images, multidimensional data analysis, modeling), etc.

Research firm Gartner defines "big data" as an information asset that requires the collection of new data models, the use of big data cloud computing to optimize process capabilities, and the rational organization of the "exploding" information tide.These terms offer a shared, cross-disciplinary schema for describing the media technologies that store, transmit, and process human culture.[6] Big-data technology is used in the field of archaeology, which is gradually becoming a science that studies the social messages of the past for describing the intrinsic messages of artifacts and the extrinsic messages that record the veins of these relics and their relationships.

2.2 Key Points of Byzantine gold coins unearthed in China

The study under Big Data fully utilizes the interactive technology of "Internet + Cloud", relying on the data of archaeological databases, sorting out the huge archaeological unearthed information by virtue of powerful algorithms, and outputting the data organizing charts according to different input passwords, so as to come up with more objective and credible analyses.How to use Big Data in the organization of cultural heritage of archaeological discoveries and how to ensure the accuracy and adaptability of this technology are all problems that need to be faced by modern information network technology intervening in traditional humanities.

After many centuries of development, the number of Byzantine gold coins unearthed in China increases every year, but the phenomenon of data duplication may occur. Therefore, the data need to be rigorously checked and updated, and the possibility of data duplication should be ruled out according to the land of excavation, the grams of gold coins, the clarity of portrait patterns, and the chronology of inscriptions.

2.3 Classification of Byzantine gold coins unearthed in China

The Byzantine solids were made to strict standards and were full gold struck currency. The Byzantine emperors strictly forbade the neighboring barbarian kingdoms to make and issue gold coins, let alone allow them to print the king's name on their privately issued coins. However, from the 6th to 7th centuries onwards, barbarian states, including the Ostrogothic and Visigothic kingdoms, issued gold coins in the name of the Byzantine emperors, which resulted in the imitation coins that are now found in China.

Based on the size, clarity of the pattern, clarity of the inscription, and the number of decorative surfaces, Byzantine gold coins and their imitations unearthed in China can be roughly categorized into three groups using big data analysis, for an example see **Table 1**.

Table 1. Three types of Byzantine gold coins and their imitation coins unearthed in China

	Byzantine real gold coin stamped from Constantinople	Byzantine imitation coins	coin-shaped gold or gold plaque
Clarity of Inscription	70%-90%	30%-50%	0%-20%
Clarity of Pattern	70%-90%	30%-50%	0%-20%
Weight（grams）	4.4-4.54	≦4.4	≦2
Stamping（sides）	2	2	1

3 Research and Experiments on Byzantine Gold Coins Unearthed in China Based on Big Data

3.1 Reason for experiment

The earliest archaeological report of Byzantine gold coins and their imitation coins unearthed in China can be dated back to the 1950s, when Xia Nai, a Chinese archaeologist, opened the prelude to the study. Byzantine gold coins and their imitations are diversified and regionalized, and they have been unearthed in Xinjiang, Ningxia, Gansu, Shaanxi, Inner Mongolia and other provinces of China in different quantities, so it is necessary to establish a large database based on archaeological data from different regions and analyze the data experimentally.

3.2 Data sources

Before 1986, the archaeological data in the large database came from the Encyclopedia of China (Archaeology Volume), which counted the number of 21 pieces. While the archaeological data in the large database from 1991 to 2004 came from the CNKI database, which analyzed the specific data from the archaeological reports of Byzantine gold coins and their replica coins unearthed in China, combined with the tools such as VOSviewer and Citespace to quantify and visualize the literature, as shown in **Figure 2**. In recent years, there are controversies over the gold coins unearthed in many places in China, and there is no

resolution of the doubts about the imitation coins or the gold pieces, because the unearthed reports of 2004 and before are not controversial, and the data are more detailed, so in order to pursue the data objectification, the data of this experiment is up to 2004.

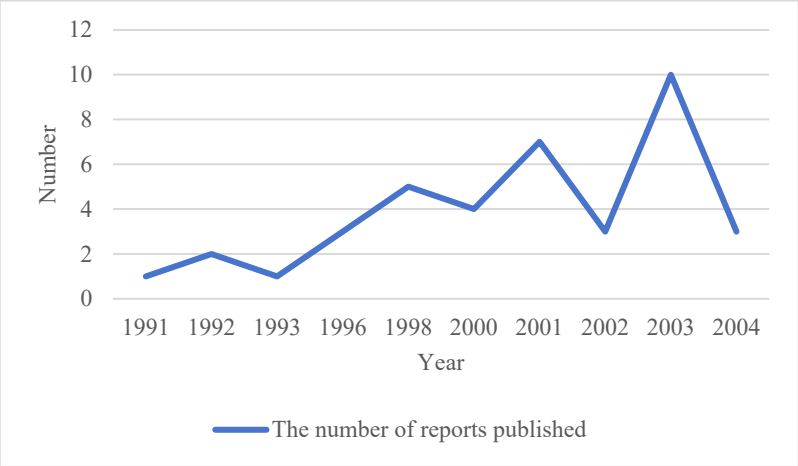

Fig. 2. The number of archaeological reports about Byzantine gold coins unearthed in China (1991-2004)

3.3 Experimental Steps

Step 1: Data Entry. Basic information on Byzantine gold coins was extracted from the archaeological material documentation, including weight, clarity of inscriptions and portraits.

Step 2: Data Extraction. The image sequence formed based on the labeled factor elements extracted to classify the Byzantine gold coins.

Step 3: Data Labeling. Re-label the image sequence with provenance information to form the observation object, including provenance land, age, etc., to form the expression sequence. Bata mining searches select individuals for scrutiny by analyzing large data sets for suspicious data linkages and patterns.[7]

Step 4: Quantitative Ranking. Based on the weights of the factors, the order of execution is quantitatively ranked.

Step 5: Statistical Analysis. Comprehensive statistical information on the land, combined with the geographic distribution of China, to derive the spatial distribution pattern and dissemination path.

The experimental steps consisted of five steps, as shown in **Figure 3**. It seems thus entirely appropriate to adopt it here as well, when referring to digital engagement with archaeology as a discipline.[8]

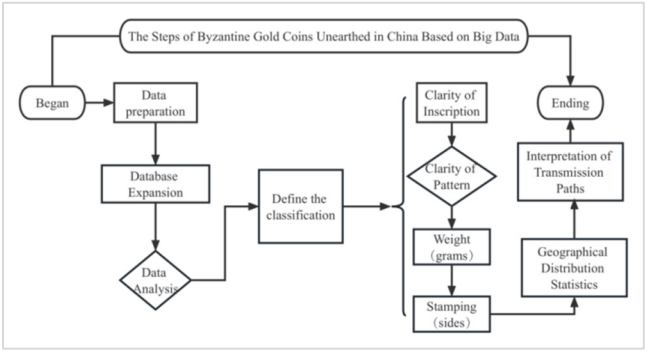

Fig. 3. The steps of this study

4 Analysis of the Experimental Results of Byzantine Gold Coins Unearthed in China Based on Big Data

4.1 Geographical scope and number statistics

The relationship between provinces and quantity in **Figure 4** is obtained through the quantification of Big-data statistics. Big-data is now an indisputable fact.[9] We can conclude that three provinces in northwest China, Xinjiang, Ningxia, and Inner Mongolia, have the highest number of Byzantine gold coins and their imitations unearthed. **Fig. 4** also reflects that the southern provinces of China have the lowest number of excavated Byzantine gold coins and their imitations, with the smallest percentage weight. Not only can digital technologies improve efficiency and reduce operational costs, they also can enable new energy ecosystems, create new business models, and accelerate the energy transition.[10]

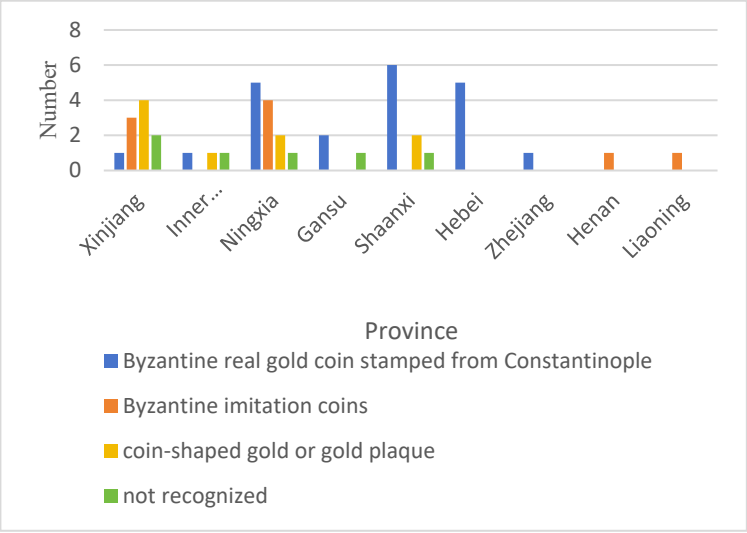

Fig. 4. Number statistics by Province（Up to 2004）

4.2 Integration of geographic transmission pathways

Combined with maps and statistics on the number of Byzantine gold coins and their imitation coins unearthed in various provinces within China, because data, information and knowledge are usually considered to be parts of the same continuum.[11] It is summarized that the routes of Byzantine gold coins flowing into China are roughly divided into three paths, as illustrated in **Figure 5**.

One is the north road, the road from the northern steppe connected by the Black Sea and Caspian Sea from the Western Turkic Khanate to the Byzantine Empire.

The second is the middle road, the eastward transmission through the way of commerce and trade exchanges of the Central Asian peoples.

The third is the south road, which is the sea road, and it is the eastward transmission from the port of the Red Sea or the Persian Gulf by means of the activities of the maritime trade exchanges of the Byzantines, Persians, Arabs, and Indians, and so on.

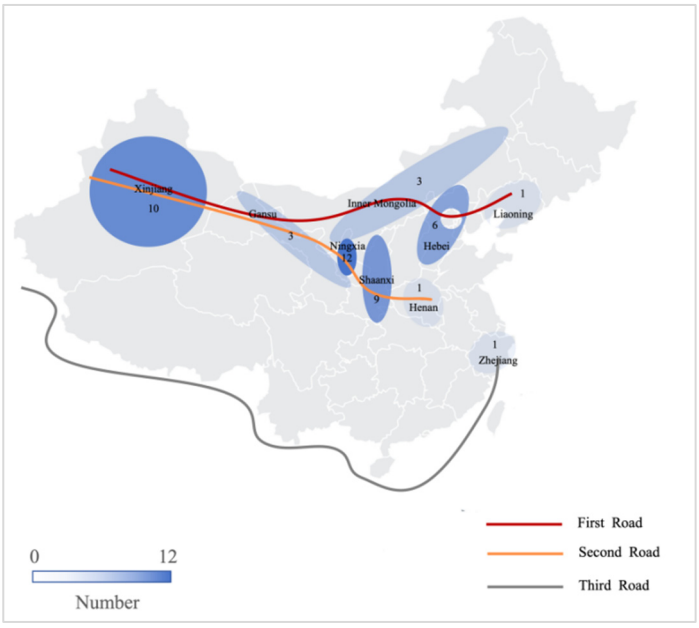

Fig. 5. Three geographic transmission pathways

5 Conclusions

By using Big Data and Cloud Computing technology, the article counted the number of Byzantine gold coins unearthed in China and confirmed the basic information of 46 gold coins (as of 2004). By sorting out the unearthed gold coins and Silk Road maps and documents, and through multi-disciplinary knowledge such as geography, history, philology, archaeology, numismatics, religion, etc., we strive to restore the Middle Ages from the perspective of the Silk Road Circulation routes.The multidisciplinary integration of cross-cultural art research

and the observation method from an international perspective opened up the global context for this study and provided an important cross-cultural framework idea. By crossing the long distance of the ancient Silk Road, Byzantine coins circulated across the Eurasian continent. This study follows the two latitudes of time and region, based on archaeological data, and focuses on the two aspects of "spatial and temporal distribution" and "propagation path". This theme breaks through the boundaries of monetary history, ethnic history, religious history, political history, art history and other disciplines, and comprehensively studies the emergence, development and decline of Byzantine gold coins in China.

After comprehensive information such as weight, fineness, inscription and decoration clarity of gold coins, gold coins are divided into three categories: Byzantine gold coins, imitation coins and gold flakes. Statistics on the geographical scope of where they were unearthed revealed that central and western China is the main unearthed area for Byzantine gold coins. In addition, coupled with map descriptions, we can derive three routes for Byzantine gold coins to be introduced into China: the first is the road through the northern grasslands; the second is the road for trade among Central Asian peoples; and the third is the road for maritime trade.

References

[1] Naismith, Rory: Gold Coinage and Its Use in the Post-Roman West. Speculum, Vol. 89, No. 2 , pp. 273-306 (2014).

[2] Raymond, Bellinger Alfred: THE GOLD COINS OF JUSTINIAN II. Archaeology, Vol. 3, No. 2 , pp. 107-111 (1950).

[1] Hammadi, Ayad A., and Eric J. Miller: An Agent-Based Transportation Impact Sketch Planning (TISP) Model System. Journal of Transport and Land Use, vol. 14, no. 1, pp. 219–53 (2021).

[1] Greenstein, Shane. “The Basic Economics of Internet Infrastructure.” The Journal of Economic Perspectives, vol. 34, no. 2, pp. 192–214 (2020).

[1] Landon-Murray, Michael :Big Data and Intelligence: Applications, Human Capital, and Education. Journal of Strategic Security , Vol. 9, No. 2, pp. 92-121 (2016).

[6] Trettien, Whitney. “Substrate, Platform, Interface, Format.” Textual Cultures, vol. 16, no. 1, pp. 286–312 (2023).

[7] Ira S. Rubinstein, Ronald D. Lee and Paul M. Schwartz:Data Mining and Internet Profiling: Emerging Regulatory and Technological Approaches. The University of Chicago Law Review ,Vol. 75, No. 1, pp. 261-285 (2008).

[8] Bonacchi, Chiara: Key Concepts in Public Archaeology. UCL Press, pp. 60-72 (2017).

[9] Buzzetti, Dino: Towards an Operational Approach to Computational Text Analysis. On Making in the Digital Humanities: The Scholarship of Digital Humanities Development in Honour of John Bradley, edited by Julianne Nyhan et al., UCL Press, pp. 179–212 (2023).

[10] Fuentes, Rolando: The Implications of Digitalization on Future Electricity Market Design. Oxford Institute for Energy Studies, 2023.

[11] Hu, Yao-Su:The impact of increasing returns on knowledge and big data: from Adam Smith and Allyn Young to the age of machine learning and digital platforms. Prometheus , Vol. 36, No. 1 , pp. 10-29 9 (2020).