Application of GIS and VR Technologies in Chinese Civilization

Mao Feng Wu Yongxing

Abstract: Chinese civilization origin investigation needs not only collecting, sorting out and analyzing historical documents, but gathering, processing and explaining field archeological information as well. Based on GIS and VR technologies, digital archeology is a new method of scientific archeology which can realize the goals mentioned above. This paper introduces the theory of building unified historical and geographical frame by adapting GIS and VR technology; quests the technical route of the VGIS construction of Chinese civilization, comes up with the concept and method of temporal and spatial information mining in Chinese civilization origin search based on VGIS; it provides mathematical models of ruins, historical remains and relics that combined archeological stratigraphy, archeological typology and earth and space science; builds technology system of normalized information storage, process and data excavation that combines historical documents, archeological materials and special research to give comprehensive explanations; researches and develops VGIS system platform of Chinese civilization origin investigation and elaborates its function and application by taking Liang Zhu, Tao Si and Erlitou as examples. The research result of this paper is the technological means and methods for man-land relationship study, city and settlement archeology, comprehensive explanation of archeological materials, civilization analysis and origin and temporal and spatial analysis; it is a useful exploration on the application of spatial information technology in the project of Chinese civilization origin investigation.

Key Words:

1. Foreword

Chinese civilization is the only ancient civilization in the world that has lasted till the present time without interruption. The purpose of Chinese civilization origin investigation is to reveal the origination, formation and development of human being's early civilization in the territory of China and its periodic changing path, and inquire into the background, reason, development road, internal mechanism and characteristics of Chinese civilization's formation and development. The study of Chinese civilization origin investigation has both important theoretical meanings and realistic values not only on rebuilding Chinese nation's civilization history, but also on understanding the formation process of world civilization.

Focusing on archeological theory and based on excavated materials, Chinese civilization origin investigation carries out multi-disciplinary, multi-angle and

multi-level studies on Chinese civilization's connotation, origin and formation, and significant problems such as the process, background, characteristics, route and mechanism of its early development. This investigation not only needs collecting, sorting out and analyzing all the relevant historical documents, but also gathering, processing, storing and managing large amount of field archeological information. By combining all kinds of data and materials, this investigation conducts in-depth analysis and temporal and spatial excavation, obtains related evidences about Chinese civilization origin and enhances our understanding of Chinese civilization origin.

Geographical information system technology (GIS) is a comprehensive computer information processing technology which gathers, stores, inquires, analyzes and exhibits spatial data. It provides strong technical support for data collection, sorting out and analysis and information excavation in Chinese civilization origin investigation. Virtual reality technology (VR) is a computer technology which can create and experience a virtual world. It provides 3D virtual display for the results of civilization origin investigation, and makes immersed experience of ancient civilization scenes possible. Combining GIS and VR technologies, we can not only integrate and manage polygenetic and heterogeneous data effectively, but also have the technical method to display the analysis, excavation and results of relevant data.

Based on GIS technology and VR technology, this paper puts forward the theoretical frame, data model and software architecture of comprehensive geographical information system (VGIS) in Chinese civilization origin investigation, and conducts application study by taking the three typical ruins of Erlitou, Tao Si and Liang Zhu. The results prove that VGIS can organize polygenetic data for civilization origin investigation, conduct in-depth analysis, excavation and knowledge discovery to relevant data and provide technical support for Chinese civilization origin investigation.

2. Theoretical Frame of VGIS

Based on archeology, Chinese civilization origin investigation is a comprehensive and systematic study combining multiple disciplines. Besides

launching ancient ruins investigation, discovery and excavation nationwide, it is needed to build temporal and spatial frame for civilization origin study, bibliographic database, ruins of Chinese civilization origin investigation and remains temporal and spatial data source. It is also needed to combine all the relevant materials to conduct temporal and spatial analysis and data excavation of Chinese civilization's origin, formation and development. This paper puts forward the theoretical research frame of VGIS after analyzing the need of Chinese civilization origin investigation comprehensively. (Figure 1)

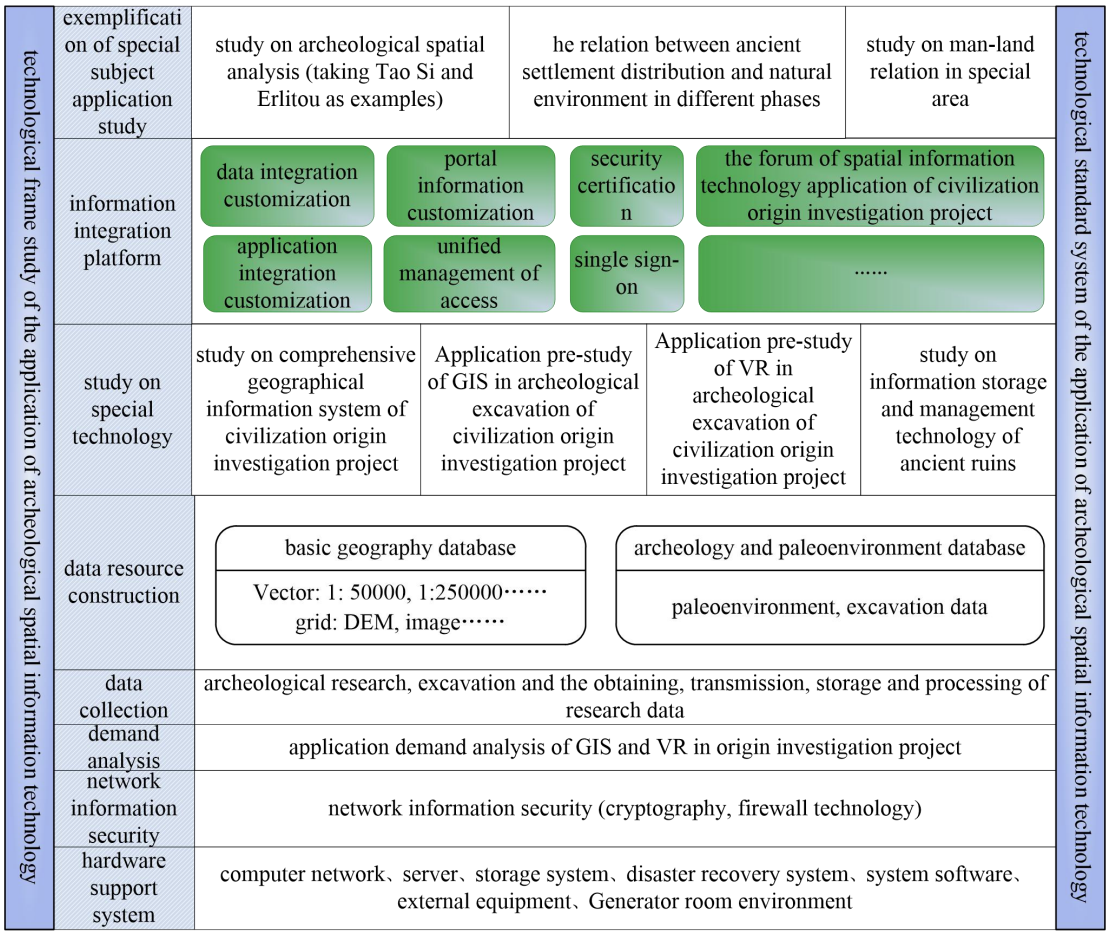


Figure 1 VGIS structural frame of Chinese civilization origin investigation

1) Temporal and Spatial Data Model

The main purpose of Chinese civilization origin research is to answer when and where Chinese ancestors extricated themselves from animal state and stepped into

civilized society, that is, the temporal and spatial problem of civilization's origination and formation. In order to build Chinese civilization's temporal and spatial frame, temporal and spatial mathematic model is needed to integrate archeological materials and historical documents and conduct temporal and spatial analysis. Add time axis into the traditional 3D GIS data model and form 4D temporal and spatial mathematic model, which can better meet this demand. Its concept is shown in the figure below,

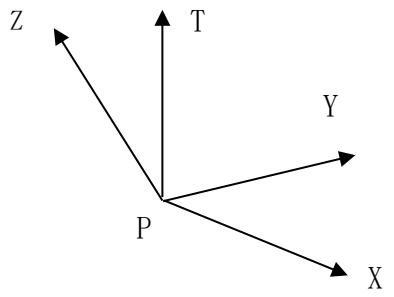


Figure 2 Conceptual graph of temporal and spatial mathematic model

In this figure, P (X, Y, Z) in location P is 3D space coordinate, P (T) in location P is time axis. Attribute description of the temporal and spatial data model for civilization origin investigation is shown in Table 1.

Table 1 Attribute description table of the temporal and spatial data model for civilization origin investigation

Time attribute（T）	Space attribute（X，Y，Z）
Archeological construction site phase	Nationwide, province, city (surface)
AD	Geographic area (surface)
Till now	Watershed (surface)
Heavenly stems and earthly branches	Cultural flora (surface)
Imperial calendar	Ruins scope (surface)
Dynastic calendar	Ruins domain (surface)
C_{14} age-dating	Relics (spot, line or surface)
	Remains (spot)
……	……

The attributes, such as form feature description, style feature description, technique feature description, can be corresponded and unified with spatial features by building attribute table of spatial features. The technological route for constructing temporal and spatial data model of Chinese civilization origin investigation is: first, on the basis of archeological stratigraphy and archeological topology, compile classification code of geographical attribute factors of civilization origin search (See attachment 1); then, use geographical information system (GIS) and exhibit temporal and spatial 3D information (X, Y, Z) of Chinese civilization origin investigation based on the geographical factor classification and the corresponding attributes; now match relevant temporal information (T) with the spatial information (X, Y, Z) of the attribute factors; finally, build temporal and spatial database of civilization origin investigation and GIS system platform, carry out Chinese civilization origin investigation, temporal and spatial information excavation, spatial cognition, temporal and spatial imitation and exhibition.

2) Information excavation of civilization origin investigation

One of the core contents of the study on Chinese civilization origin investigation is information excavation of all kinds of data and materials. It can be divided into two main aspects: text mining and temporal and spatial analysis. The specific process is shown in the figure below (figure 3):

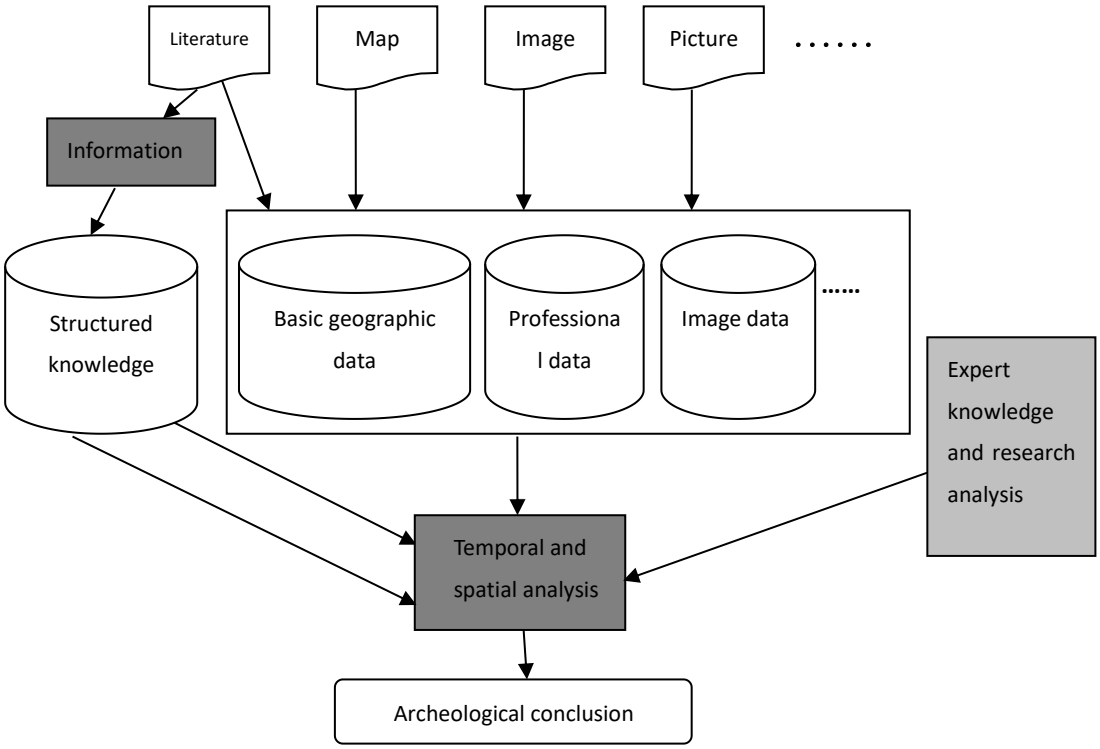


Figure 3 Information excavation process of the study on Chinese civilization origin investigation

3. System Design

The comprehensive geographical information system of Chinese civilization origin investigation should have the following functions: 1) basic functions of conducting data collection, edition, management, inquiry, statistics and charting output to relevant results of field archeology; 2) the function of conducting spatial analysis of spatial data, information extraction, and making archeological research report and excavation report; 3) the function of carrying out dynamic exhibition of civilization origin investigation data, 3D exhibition and analysis of key areas. During system process, the system is divided into 10 sub-systems. They are: graph exhibition, inquiry and statistics, temporal and spatial analysis, spatial analysis, data excavation, charting output, virtual reality, archeological report, data management and system

management. (Figure 1)

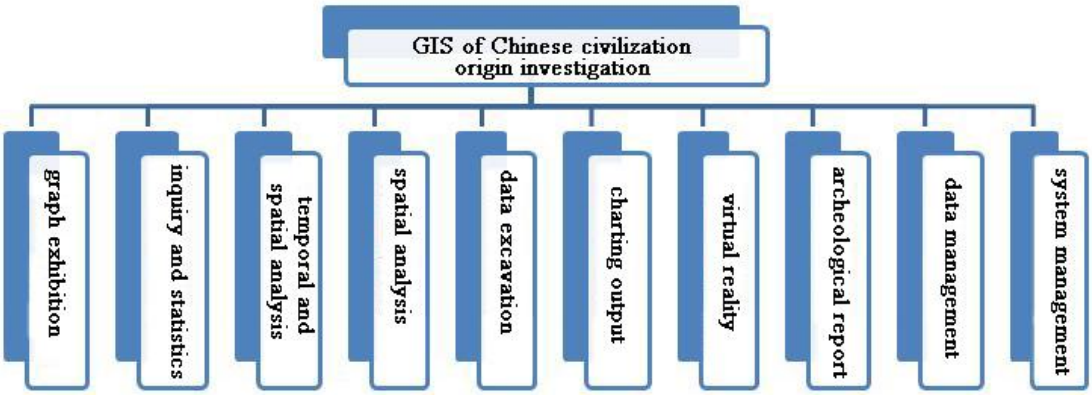


Figure 4 VGIS sub-system of Chinese civilization origin investigation

The sub-system of graph exhibition mainly satisfies users' need of viewing graphs by category; it provides operations such as stepless zooming. Graph exhibition mainly includes exhibiting by the category of archeological culture, exhibiting by the category of ruins, exhibiting by the category of topography and landscape, and exhibiting by the category of the connection between spatial location information and multimedia information such as charts, pictures, word descriptions and videos; graph operation function needs to provide operations such as graph zooming out, zooming in, panning and full screen display. The main functions of inquiry and statistics sub-system include inquiring spatial information by attribute, inquiring attribute information by space, customized inquiry and connection inquiry based on users' habit. The main functions of temporal and spatial analysis sub-system include temporal and spatial analysis of archeological culture, analysis of ruins change, environment change, climate change, temporal and spatial analysis of buildings and tombs. These functions are used to analyze the spatial distribution patterns and time changing features of different archeological factors. The main functions of spatial analysis sub-system include cluster analysis, route analysis, submerging analysis, multi-invisibility analysis and spatial measurement. The main function of virtual reality sub-system is to realize 3D display of archeological scenes. It includes roam browsing, scene editing, scene outputting and video recording.

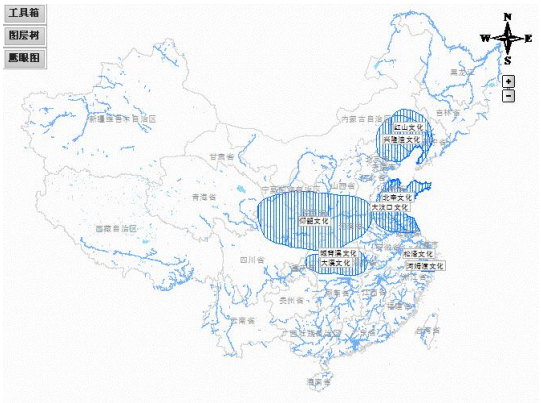
The main functions of charting output sub-system include charting editing and

outputting through different scopes. As for charting editing, it is required that the plate can provide the maximum flexibility to satisfy users' charting requirements by factors such as user customization, editing title, scale, compass and illustration. As for outputting by screen scope, it realizes outputting and printing the plate of the full screen scope; as for outputting by user-defined scope, it realizes outputting and printing the plate chosen by the user; as for outputting by rectangle scope, it realizes outputting and printing the plate drawn by the user as a rectangle.

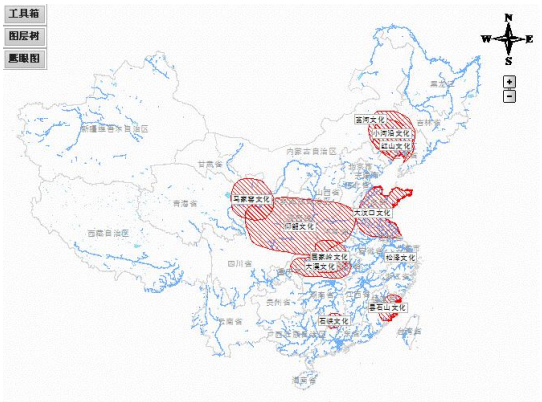
Figure 5 is a temporal and spatial exhibition of archeological culture. Using 1000 year as an interval, it exhibits the archeological cultures of a certain period from 9000 years ago to 4000 years ago with partition statistics method.

9000-8000 ago

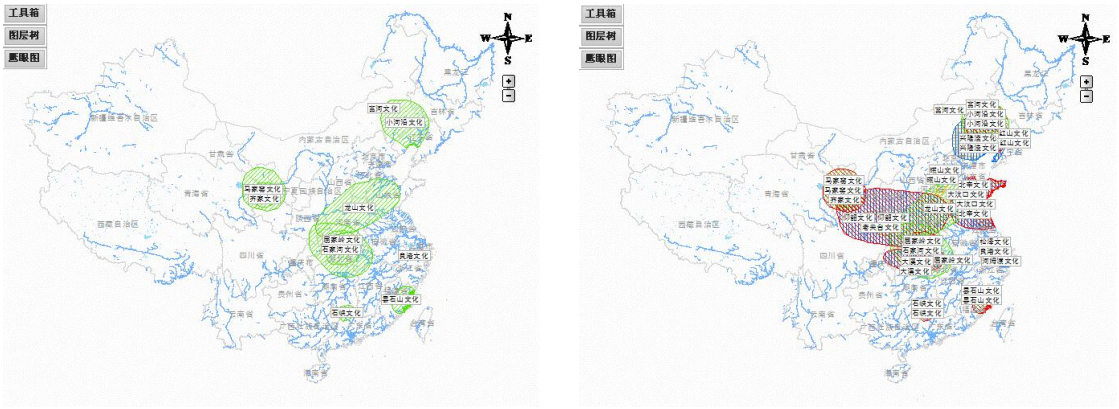
8000-7000 ago



7000-6000 ago



6000-5000 ago



5000-4000 ago 9000-4000 ago

Figure 5 Temporal and spatial exhibition of archeological culture

4. Conclusion

This paper introduces the theory of building unified historical and archeological frame based on GIS and VR technologies; it explores the technical route of the VGIS construction of Chinese civilization and comes up with the concept and method of temporal and spatial information mining in Chinese civilization origin search based on VGIS; it provides mathematical models of ruins, historical remains and relics that combined archeological stratigraphy, archeological typology and earth and space science; builds technology system of normalized information storage, process and data excavation that combines historical documents, archeological materials and special research to give comprehensive explanations; it researches and develops VGIS system platform of Chinese civilization origin investigation and elaborates its function and application by taking Liang Zhu, Tao Si and Erlitou as examples. The research results of this paper are the technological means and methods for man-land relationship study, city and settlement archeology, comprehensive explanation of archeological materials, civilization analysis and origin and temporal and spatial analysis; it is a useful exploration on the application of spatial information technology in the project of Chinese civilization origin investigation.

Till present, VGIS has only been applied in Liang Zhu, Tao Si and Erlitou, and the application depth and scope are both limited. In the future, more ruins need to be selected to carry out the experiment, further improve and perfect this system.

Reference

[1] Application and Prospect of GIS in Archaeology, Zhang Yinglan， Journal of NorthwestUniversity(Philosophy and Social Sciences Edition)， Nov. , 2006,Vol. 36,No. 6

[2] Research and Construction of GIS for Field Archaeology, L I An – bo，BI Shuo – ben，PEI An – ping，LV Guo – nian，Geography and Geo - Information Science，Vol. 20 No. 1，January 2004

[3] Method of 3D Reconstruct ion for A rchaeo log ical Strat igraphy, Kan Aike，Application Research of Computers，Vo.l 24, No.3 M arch 2007