Research on Digitization and Visualization Technique of Archaeological Sites Excavation based on Multiple Tempo-spatial Data

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Abstract: In this paper, a digitization and visualization technique of archaeological sites excavation based on multiple tempo-spatial mode is proposed. Firstly, a digital method for whole archaeological sites excavation process based on integration of multiple measurements is proposed. And unified catalog excavated data in a unified time and space reference. Secondly, design processing strategy and data model of multi-source spatial and temporal data from the archaeological sites excavation, and study visualization solution of multi-source, multi-resolution, multi-temporal and spatial data from the archaeological sites excavation based on three-dimensional geographic information platform. Finally, as an example to digital recording and visual expression for whole excavation process of Yejiashan archaeological sites in SuiZhou, achieve the target of 10 types, more than 1TB of multiple tempo-spatial data processing, management and visualization. The results show that the method can be better realized the digital recording and visual expression of the whole archaeological sites excavation process, has a strong practical and realistic significance model is used to perform the MTF compensation for WFI images. The results show that the restored image seemed clearer and contained more detailed information.

Key words: Archaeological sites excavation, integration, tempo-spatial data, Visualization

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1 INTRODUCTION

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The way of manual record which is mainly based on character information and images is usually adopted by traditional archaeological sites excavation process. However, collection of these character information and images is mostly accomplished by single surveying and mapping, taking pictures, recording videos, artificial filling in and so on which could not unify the information of archaeological sites excavation both in time and in space comprehensively and detailedly and this condition is not beneficial to later archaeological sites researches and digital management and visualization display of sites. In the ancient Pompeii excavation project of University of Cincinnati, iPad was used by researchers to record the electronic information, so that the information of archaeological excavation could be added into the database immediately to be edited, and at the same time, existing research results can also be made better use in the excavation process. Richard et al. from University of Applied Sciences in Hamburg used digital photogrammetric method to take the three-dimensional reconstruction of the ancient castle in northern Germany (Kersten T, et al., 2004). Paul et al. from the University of California, Berkeley, used few pictures to realize the three-dimensional reconstruction of the large-scale building (Paul E, et al., 1996). However, image distortion and blind angle exist in photogrammetry. Through the combination of "photography of virtual caverns" and "total-station surveying of caverns" adopted by Mellon International Dunhuang Files charged by Mellon Fund of America, three dimensional caverns information was obtained by computer generation of images and surveying data of caverns. However, these methods are still confronted with the problem of how to extract features matching with objects surveyed by the total station from the cave photographic images quickly. In the Longmen Grottoes digitization project of Peking University, three-dimensional data was obtained by the laser scanner to establish the three-dimensional model. And then the three-dimensional model was projected onto the two-dimensional image space to draw the digital line graphic according to the image and to be used in defect repairment of the cultural relics combining with digital technology. Therefore, shortages of data acquisition method with single source in some aspects could be solved by the effective integration of varied digital data collection methods like low-altitude unmanned remote sensing, three-dimensional laser scan of the ground, GPS-RTK and so on. And it is the developing trends of archaeological excavation digitization to realize overall surveying of the archaeological process by the merging processing of space-ground integration surveying data which could increase the integrity, precision and scalability of data.

A digitization and visualization method of archaeological sites excavation based on multi-source spatial-temporal data is proposed by this paper. In the method, techniques of low-altitude unmanned remote sensing, three-dimensional laser scan of the ground, GPS-RTK, the electronic form of archaeological field excavation and so on are used to realize full digitized record of archaeological sites and archaeological sites excavation data are unified in cataloging by the unified time and space reference; the visualization solution of multi-source, multi-resolution, multi-temporal and spatial data from the archaeological sites excavation based on three-dimensional geographic information platform is studied and multiple tempo-spatial data processing, management and visualization of whole excavation process of Yejiashan archaeological sites in SuiZhou which achieve the target of 10 types, more than 1TB is realized. The results show that digitization recording and visualization express of the whole archaeological sites excavation process could be realized by this method which also has strong practicability.

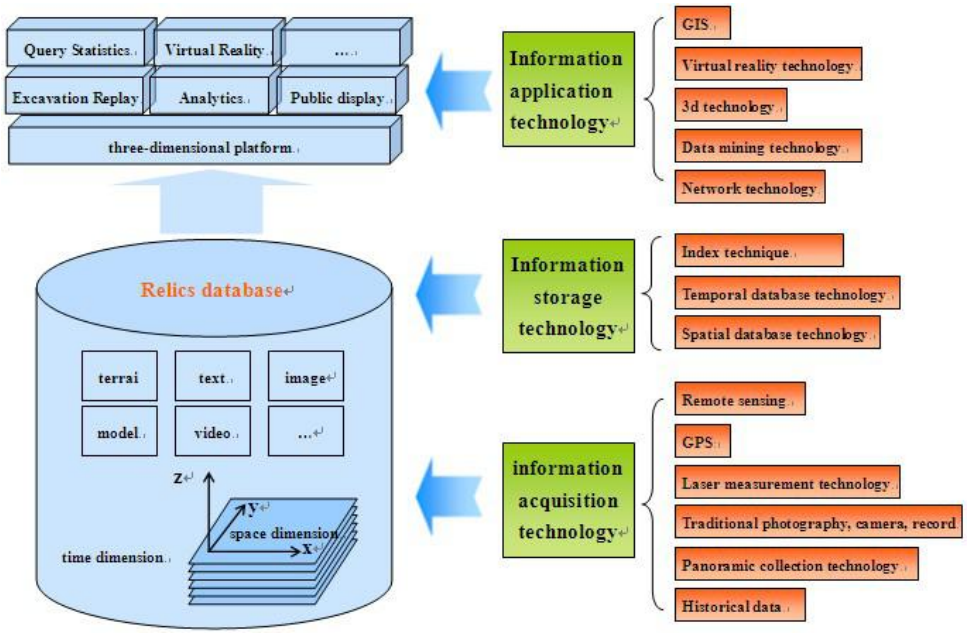
2 METHODOLOGY

The material acquired during the archaeological site excavation has space attributes. Spatial data could be used to show the location and extent of an archaeological site and three-dimensional coordinates could be used to show the spatial position of the relics, the phenomenon, even a utensils or pottery in the archaeological site accurately.

The full digitized excavation method of archaeological sites based on multi-source spatial-temporal data just starts from spatial attributes of archaeological sites or phenomenon, follows the space-time data and creates databases and image libraries in which multiple sets of spatial information and attribute information coexist. Consequently, it is convenient to record, display, query and simulate all the data information and to recover archaeological sites easily. And then, visualization and authorized share of information resources in the whole archaeological sites excavation process is realized.

2.1 Archaeological site digital excavation technology based on multiple space-time data

Surveying, mapping and remote sensing technology, spatial and temporal data management technology, information applications display technology are applied to the investigation, excavation, management and other aspects of archaeological sites by archaeological site digital excavation based on multi-source spatial and temporal data. Effectively, easily and regularly recording and storing of information in every link are realized, the space-time database of the whole archaeological sites excavation process is created and cataloging and sharing are carried on in unified time and space reference. And all the above techniques could serve in every links of investigation, exploration, study, management and display of archaeological sites. The technical system is shown in Figure 1.



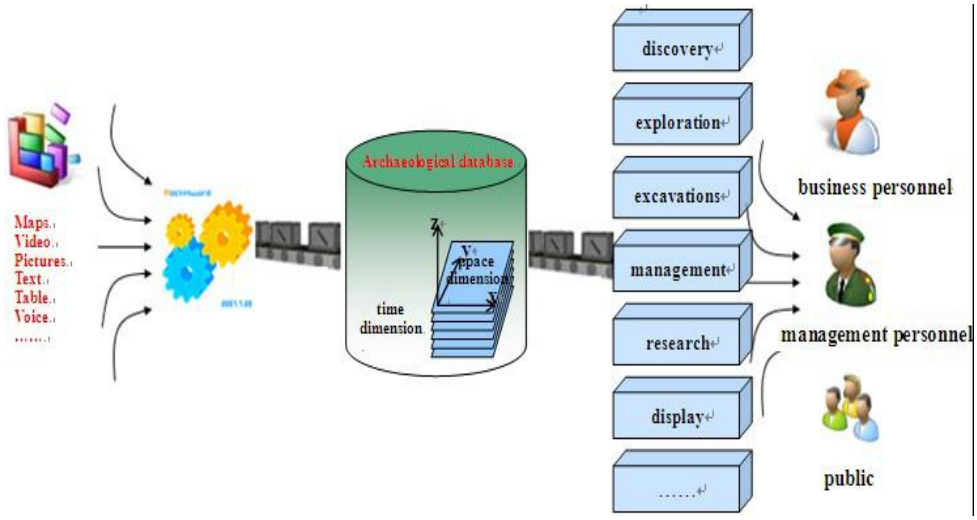


Fig. 1 archaeological site digital excavation technology

2.2 Acquisition method of archaeological site multiple space-time data

Spatial data, attribute data and links between them are included in the data of archaeological sites excavation process. Space data refers to the spatial position of various historical remains. Attribute data refers to the content and descriptions of the historical remains. Because of the complexity of archaeological sites excavation process as well as the microrelief features of archaeological sites, it is difficult to directly apply traditional single cartographic recording methods to the spatial information acquisition of archaeological sites. The space-time data acquisition method of the whole archaeological sites excavation process combining GPS-RTK, three-dimensional laser scanner and low-altitude unmanned remote sensing platform is proposed by this paper. In this method, multiple space-time data is recorded into database of archaeological sites excavation directly and indirectly with the spatial coordinates of archaeological sites as the basis in order to provide data source to management and visualization of excavation data.

Firstly, GPS-RTK technology is used to construct the archaeological sites reference control network which is the acquisition basis of archaeological sites excavation spatio-temporal data. Further, the whole process of field archaeological excavation which includes fine drawing, photography, heritage registration and excavation logging record to the archaeological sites field can be acquired and recorded based on the GPS-RTK platform, basic camera, and temperature and humidity sensor combining the field archaeological information recording function. In this process, large number of fragmented excavation records, drawings and image materials can be acquired and digitized in integration, and the mobile integrated input of spatial data and attribute data of the archaeological relics can be achieved, as the figure 2 shows.

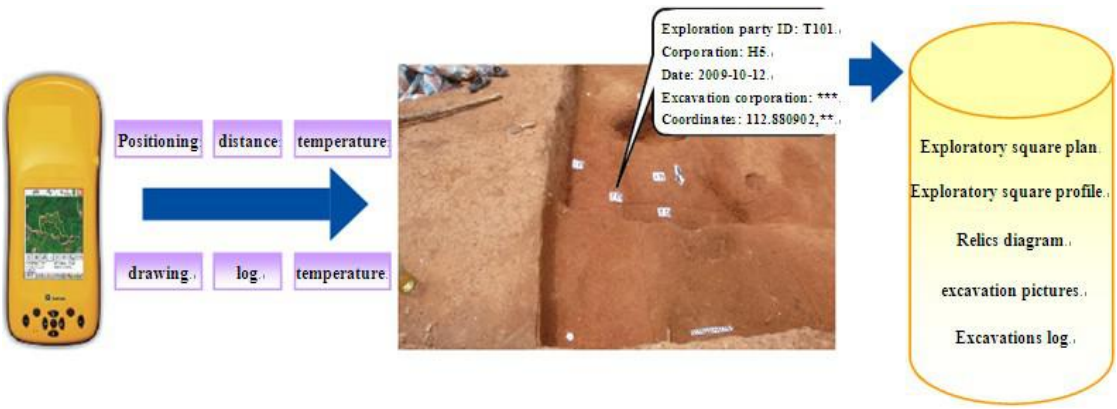


Fig. 2 GPS-RTK archaeological recorder

Secondly, according to the process of archaeological sites excavation, the remote sensing images of archaeological sites in different phase can be obtained by low-altitude unmanned remote sensing aircraft. The low-altitude unmanned remote sensing platform is consisted of UAV (Unmanned Aerial Vehicle), flight control, digital aerial photo and data processing. UAV is selected from fixed wing UAV, small four-rotor unmanned helicopter and aero model according to different fight mission and its flight is controlled by GPS or Wi-Fi. The images in surveyed area are obtained by the equipped high-definition camera which photos along the schedule route, then the large-scale and full-view mosaic images, orthophoto map, three-dimensional dense point cloud and topographic maps in series scale can be obtained after some software process, as the figure 3 shows.

Fig. 3 Digital acquisition of archaeological sites with low-altitude unmanned remote sensing

Finally, the portable scanner and ground three-dimensional laser scanner whose resolution can reach 2mm can be used to obtain the high-resolution 3D point cloud to meet the demand of archaeological sites relics' fine acquisition, then based on these data, some digital results such as vertical view map, sectional view map and cutaway view map can be generated quickly, which provide abundant data to archaeological research.

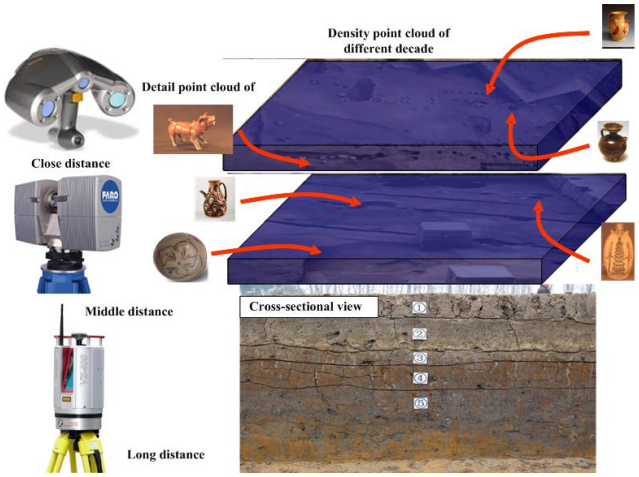


Fig. 4 Digital acquisition of archaeological sites with three-dimensional laser scanning

2.3 Management Model of Archaeological Sites Based on Multiple Tempo-spatial Data

Archaeological sites excavation data possess different features such as multi-source, multi-temporal, multi-scale and so on, besides, they have three typical features. First, all the archaeological sites excavation multi-source data have space characteristics. Point cloud, DOM, DEM and metella model all have their own space reference. Second, the sites excavation multi-source data have an attribute of GIS's layer, so the data can be classified as vector data, grid data, elevation data and 3D model data by the GIS data model. Thirdly, the sites excavation multi-source data are scheduling, therefore, these data can be managed in accordance with both the time dimension and space dimension. In this paper, the multiple spatio-temporal data are managed hierarchically according to the uniform space reference based on the temporal dimension, and different data models and the corresponding visualization methods are used to different types of data. The specific data organization and management model is shown in

figure 5.

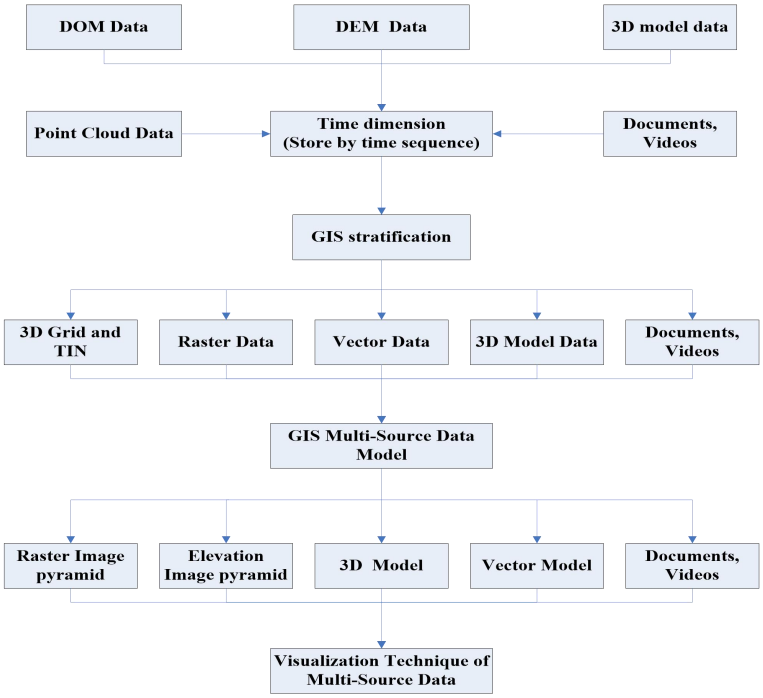


Fig. 5 The management of archaeological sites excavation multiple spatio-temporal data

As shown in figure 5, firstly, all the multiple spatio-temporal data obtained during the archaeological sites excavation process such as point cloud data, DOM data, DEM data, 3D model data, documents and videos about sites excavation are divided into different layers to store according to the time dimension. Then for each layer, they can be divided into six layers, which include 3D grid & TIN, raster layer, vector layer, 3D model data and documents & videos according to GIS in the space dimension. After that, different data models can be set up respectively according to different data layers. And finally, the visualization for different data models can be achieved through different methods.

2.4 Visualization of Archaeological Sites Excavation based on Multiple Tempo-spatial Data

The visualization management of different type archaeological sites excavation spatial data is based on ESRI ArcEngine 2D GIS platform and Skyline 3D platform. 3D terrain can be structured based on UAV remote sensing images and 3D laser point cloud elevation data, and can be used for the establishment of geographic information platform. What's more, 2D geographic information platform can be constructed through integrating different kinds of vertical view map, cutaway view map and excavation record of archaeological sites using the interface provided by 2D engine, and the consistency of 2D and 3D platform data visualization and spatial analysis can be achieved through the linkage mechanism.

3 EXPERIMENT AND DISCUSSION

Yejiashan Metella Relics is located in 8th Group of Jiangzhai village, Xihe town, Suizhou Economic Zone, Hubei Province, 1.5 kilometers south of West Garden and Miaotaizi (Neolithic age to Shang and Zhou Dynasties) Relics, which is consisted of 10 large-scale tombs (4m long, 3m wide), 5 medium-sized tombs (3m long, 2.5m wide), 50 small-scale tombs. The visualized management platform for Yejiashan Relics is established by 2D and

3D GIS platform with 10 different categories and more than 1TB in volume of spatio-temporal data obtained during the overall excavation process using the approach proposed in this paper with GPS-RTK, 3D LiDAR, and low-altitude unmanned remote sensing platform as data collection source. The system is shown in Fig 6.

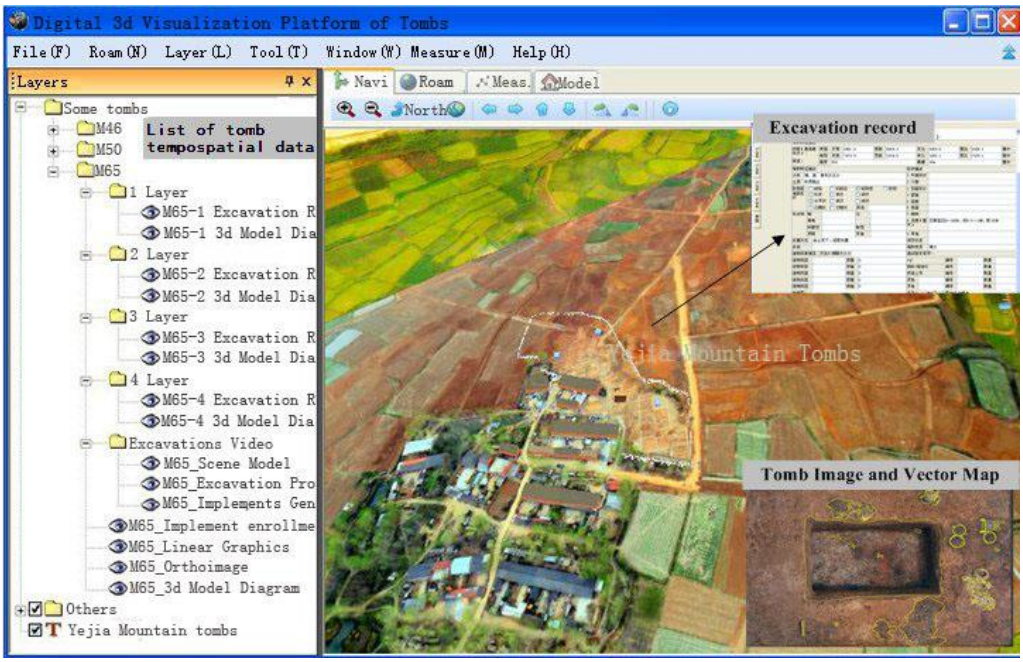


Fig. 6 The prototype of visualizing metella sites tempo-spatial data management

4 CONCLUSION

As the important part of cultural heritage, archaeological sites also provide extremely important entity information for the study of Chinese ancient history, culture, art and science and technology development. The data record collected during the whole process of archaeological sites excavation is the foundation of archaeological research work, and also the foundation of archaeological sites digital management, digital display and digital communication.

A digital visualization approach for the overall process of archaeological relics excavation based on multi-source spatio-temporal data is proposed in this paper. The organization and management of multisource spatio-temporal data including high-definition remote sensing images, DSM, 3D laser point cloud data, excavation blueprint, video and literal information etc. are realized using the utility of low altitude unmanned remote sensing, terrestrial 3D laser scanning, GPS-RTK, digital spreadsheet for archaeological field excavation and other approaches while the whole operation is archaeological relics excavation oriented. Based on the approach proposed above, an experimental operation is carried out for the processing, management, and visualization of the spatio-temporal data gathered during the excavation of Yejiashan Metella Relics which are composed of 10 different categories of data with the data volume of more than 1TB. The practicability of this approach is proved strong through the experiment.

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