Research on cultural landscape supported by digital technology

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Abstract. Cultural landscape is a combined work of both human and nature. The study of cultural landscape in a region is helpful to discover the historical changes and human factors in the region. With the development and maturity of digital technology, there are many kinds of research ways, such as UAV, satellite remote sensing, etc. Firstly, this paper collects and understands the domestic and foreign research examples, then analyzes the application advantages of UAV in cultural landscape research, and then takes Guling, Fujian Province as an example to carry out the landscape culture research using UAV technology, and finally summarizes that UAV technology can provide reliable data sources for Cultural Landscape Archaeology, solve the accessibility problem in Cultural Landscape Archaeology Research, and provide more perspectives for desktop work.

1. Introduction

Cultural landscape first appeared in geography, emphasizing the interaction between human and nature. It was considered that cultural landscape "contains the extremely rich connotation of the interaction between nature and human". Cultural landscape should include material and spiritual aspects, which can be simply understood as the landscape created by human and nature.

In the era of Internet and new media, the method of using digital technology to assist cultural landscape research is gradually mature, and the research of cultural landscape heritage assisted by digital technology has become a hot spot in recent years. Ekta Gup uses high-resolution true color satellite images from different years and seasons from Google Earth, high-resolution images from USGS 1967, and IRS-R2 (LISS IV) and the high-resolution multispectral image of World View-2 satellite is used for visual analysis and field exploration of a Buddhist site in sannati, India, to determine the potential location of the site and obtain ideal results [1]. Simone Mantellini uses remote sensing technology to obtain data; Through the combination of spatial data sets of different periods, targeted field surveys and interviews with local farmers, important information about the way and time of change was obtained to assess the extent of human change in the past 70 years and its impact on archaeological heritage in the taivilac area [2].

In recent years, the rise and development of UAV has added new research methods to this field. Nowadays, it is common to use UAV photography technology to obtain data, and then use modeling software to quickly model to obtain 3D model, and combine 3D and 2D map for research. Tesse D.
Stek uses both small UAVs and aviation technology to survey Lepiniele, Italy. Through the comparison of the results, it is confirmed that small UAVs provide a cost-effective and time-saving tool for the archaeology of recording and managing such scattered Mediterranean landscape [3]. UAVs can also combine different technologies or models for different research. Feng Maoping introduces the method in detail, and thinks that the technology can serve for urban planning, land survey, geographical situation monitoring, industrial and intelligent city construction and other fields, with profound and significant significance [4]; Wang Ce uses the UAV tilt photography technology to shoot from five angles respectively, builds and optimizes the 3DMAX model with Altizure, and then uses the 3D virtual roaming real scene modeling software to interact with the building and the environment [5]. Marco Dubbini uses the digital terrain model established by UAV photography combined with structure motion method and the digital terrain model established by kinematic global navigation satellite system survey. The result of verification provides the final vertical accuracy of about 10 cm [6]. Through the digital terrain model, it can provide important support for the important assumptions of landscape archaeologists about the ancient environment. Juan Antonio Pérez Álvarez can obtain the historical evolution information of the plot by using the digital recovery technology and modeling means through the flight photography of UAV on the historical track and comparing with the past photos [7].

Based on the application of UAV technology, this paper takes Guling modern summer resort located in Fuzhou City, Fujian Province, southeast coast of China as an example, and discusses the application of UAV technology in cultural landscape research and Landscape Archaeology from the aspects of data acquisition, model construction and the comparison of model and historical.

2. Application of UAV in cultural landscape archaeology

The cultural landscape is a large and changing heritage. Its research and protection are based on a large number of data collecting, sorting and dynamic monitoring. Traditional manpower survey and mapping can no longer meet the needs of digital protection in the new era. The introduction of new technologies and new viewpoints is an inevitable trend of cultural landscape research and protection.

2.1. Technical advantages of UAV

In the process of cultural landscape archaeology, digital technology can mainly provide help in the following aspects: (1) to quickly grasp the current situation of the site and save manpower and material costs. Take the DJI Mavic Air as an example. It can complete the high-definition image data collection of nearly 10 hectares of land in 1 hour, which is much more efficient than manual survey. (2) to improve accessibility. UAV's reconnaissance is not affected by roads, walls and other ground features. It has incomparable advantages for some areas that cannot be reached by human beings. (3) Providing efficient dynamic monitoring scheme. The monitoring of traditional cultural landscape is mostly completed. With the application of UAV technology, changes in landscape can be obtained by following the existing flight routes and conducting regular aerial surveys. (4) to quickly establish a three-dimensional model. Through the application of Context Capture, Altizure and other softwares, the collected results of UAV can quickly generate 3D models, which can replace inefficient manual modeling and provide a solid data basis for the work in the industry.

2.2. Carry out the historical prospect research in combination with geographic information system

After data collection is completed by unmanned aerial vehicle (UAV), the historical changes of cultural landscape can be studied by combining with WebGIS platform. The data content stored on WebGIS platform usually includes regional geographic information, heritage form information and description information. In data structure design, the data sets can be roughly divided into application and geographic information, and subdivided into multiple sub-items (table 1). Among them, landscape feature distribution map, remote sensing image, digital DEM and topographic map can be obtained from the data collected by UAV. If the UAV is combined with airborne laser equipment, the spectral information and spatial information of various ground objects can be analyzed and extracted in the
later stage. By comparing with the historical map, the changes of the historical cultural landscape can be examined.

Table 1. Data structure of digital recording platform of cultural landscape  
(source: self-drawing)

| The data set                      | The serial number | Content                                                                 | The data format                                                                 | If can be obtained by drone |
|----------------------------------|-------------------|-------------------------------------------------------------------------|--------------------------------------------------------------------------------|-----------------------------|
| Application data set             | 1                 | Non-material elements such as oral history, folklore, traditional singing, dancing, drama, faith and ritual activities | Image, video, audio, documents and other multimedia formats                     | No                          |
|                                 | 2                 | Heritage information of historical buildings, structures, ancient and famous trees and other material elements with coordinates or ranges | Point standard, polygon, point cloud and other spatial data                    | Yes                         |
|                                 | 3                 | Landscape feature distribution map                                       | Spatial data stored as polygons                                                  | Yes                         |
| Geographic information data set  | 4                 | Historical maps, topographic maps, and district maps                    | Coordinate calibrated static image, digital DEM or topographic map, remote sensing image and other 2d or 3d spatial data | No                          |
|                                 | 5                 | Ecological functional area, land use and other related drawings         |                                                                                  | No                          |
|                                 | 6                 | The distribution of vegetation, water and other natural features        |                                                                                  | Yes                         |
|                                 | 7                 | Remote sensing image, digital DEM, topographic map, etc                 |                                                                                  | Yes                         |

2.3. Examples of cultural landscape archaeology using drones

In recent years, the popularization of UAV rapid modeling technology has provided a new channel for the research and protection of cultural landscape. Liu Qianli and his team used close-range photogrammetry technology to obtain point cloud data and constructed a modeling method for landscape architecture based on point cloud technology [8]. Gu Liyuan and her team used UAV and photogrammetry technology to study the mapping of garden rockery, and pointed out that this method has brought epoch-making changes to the mapping of irregular garden elements [9]. The efficiency of spatial data collection and the quality of sampling are improved by using UAV to do tilt photogrammetry and automatically generate 3D model.

UAV has been widely used in many foreign cultural landscape archaeological studies. Throughout the cultural archaeology of Cyprus, drones have been recorded and monitored: high-resolution aerial imagery from UAVs also allows the rapid generation of 3D digital surface models for documentation and model reconstruction in a variety of applications. In the meantime, photogrammetry is also used to create 3D models of the site, which can also be printed using a digital printer [10]. With the new technological developments in UAVs, the implementation of active aerial remote sensing in landscape archaeological projects has become accessible, feasible, and efficient. The flexibility and ease of use
of the new generation of small UAVs or drones now allows detecting new archaeological features, as demonstrated for the Le Pianelle area, or the further exploration of known sites through aerial photography using UAVs [11].

3. Archaeological study of cultural landscape supported by UAV Technology: a case study of Guling

3.1. Basic information of Guling
Guling is a modern summer resort located in Fuzhou, Fujian. Most part of Guling is between 630-800m above sea level. The cool climate attracted many Westerners who could not bear the heat of Fuzhou in the late 19th century. From 1885 to 1937, through continuous construction, Guling gradually developed into an influential mountain summer resort in Southeast China. In the course of Guling's development, the overseas Chinese organized public welfare organizations, construction committees and other institutions, and successively mapped three numbered maps for the use of summer people and postmen. These data became an important support for the study of cultural landscape changes in Guling.

3.2. Application of GIS and GPS Technology
The basic idea of the study is to use GIS to register the coordinates of numbered historical maps, to compare the satellite remote sensing map and aerial survey map, to preliminarily screen out the distribution of historical buildings and suspected sites in Guling, and to investigate the conservation status of ancient trees simultaneously. On this basis, the site situation is rechecked by GPS handset to judge the coordinates and maps of the preliminary screened sites Paper correspondence. Through the comparison of the list and historical map of the summer villas in Guling in 1907, 1919 and 1933, 3 location maps were generated in the GIS system, showing the distribution of the summer villas in Guling in the Qing Dynasty and the Republic of China (Figure 1).

![Figure 1. The map of Guling summer villa in 1907 (drawn by the author)](image1)

![Figure 2. Aerial survey map of Guling ground objects collected by UAV (Taken by the Author)](image2)
3.3. Introduction of UAV Technology
In the process of historical map registration and preliminary determination of historical buildings and sites, the research team found that relying on satellite remote sensing images, topographic maps and historical maps is not enough to confirm the site conditions. There are three reasons: (1) limited by the technology at that time, the mapping of historical map is not accurate; (2) due to the behavior of road building and construction, some features have changed, which is difficult to confirm; (3) the resolution of satellite remote sensing image is insufficient, and there are many clouds in Guling area, and the number of available satellite images is not enough. Therefore, the introduction of UAV technology has become a reasonable choice.

In this study, three areas of Guling, QiTouding, LiangCuo and HouPulou were photographed by the Drone (a DJI Mavic Air). And the route and modeling software was Altizure and Context Capture. UAV mainly provides a perspective different from ground survey; HouPulou area is rarely visited for a long time, and some historical buildings have been buried in the weeds. The Drone provided an opportunity of viewing the site from low altitude and multi-angle; and finally the heritage map of the area is generated (Figure 2).

4. Conclusion
4.1. Drone technology provides a reliable data source for cultural landscape archaeology.
The investigation of the relationship between settlements and land patterns, natural resources and changes is the focus of cultural landscape archaeology. Compared to mapping topographic maps, Drones provide a three-dimensional perspective; compared to satellite remote sensing maps, Drones have higher resolution and more detailed information in low-altitude aerial photography. It also provides reliable data sources in many aspects: (1) Through basic aerial survey and oblique photography, it can obtain frontal and multi-sided images and latitude and longitude information of the architectural landscape; (2) Through LiDar, it can obtain High-precision point cloud data; (3) Through desktop software, high-precision aerial survey images and multi-spectral data can be formed.

4.2. UAV solves the problem of accessibility in cultural landscape archaeological research.
The traditional cultural landscape archaeological research relies heavily on field operations. Cultural landscape archaeology has a larger scale, and site surveys require a lot of time, manpower, and material resources. The production of site plants, changes in rivers, and topography may not only cause the loss of heritage information, but also hinder the exploration work of scientific researchers. The application of UAV technology provides great convenience for research: (1) UAV can quickly reach the site above the site, combined with geographic information system, which can prompt researchers to make timely decisions on whether to conduct human exploration; (2) Unmanned aerial vehicle provides the perspective of observing the site from the air, and can flexibly and efficiently collect the location, texture and other information of the feature.

4.3. UAV technology provides additional perspectives for desktop work
Traditional archaeological studies of cultural landscapes are often based on satellite remote sensing imagery and topographic mapping. The topographic map of the field survey is precise and accurate, combining with the remote sensing image, it can meet most of the needs. But the UAV technology provides more visual angles for desktop work: (1) The point cloud generated by oblique photography can not only reflect the terrain, but also show the buildings, plants and other objects; (2) The time-effectiveness of the UAV cannot be achieved by other acquisition methods. In the Guling case, the remote sensing images take at least six months to a year to be updated, while the changes in topography and construction conditions over a relatively short period of time, through regular aerial photography by unmanned aerial vehicles, can quickly reflect in the desktop environment.

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