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Original Paper

Exploration of Three-dimensional Modeling by Unmanned Aerial Vehicles for Application in Practical Engineering

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Abstract

Citing actual engineering cases, this paper aims to enhance the application of the model in actual engineering by describing the experience gained in the process of generating 3D stereo models generated by UAV aerial surveys, as well as the characteristics of the aerial photography and model generation process.

Keywords

UAV aerial survey, 3D stereo modeling, elevation survey, topographic mapping

1. Background of the Study

With the rapid development of technology, the rapid advancement of UAV technology has revolutionized the field of aerial surveying. With its advantages of mobility, flexibility, easy operation and low cost, UAVs have become an ideal platform for aerial survey data collection. By carrying advanced equipment such as high-resolution cameras and multi-spectral sensors, UAVs can efficiently and accurately acquire large-area surface image data. These data provide rich raw materials for the generation of three-dimensional stereo models and greatly promote the development of three-dimensional modeling technology.

At the same time, the continuous progress of photogrammetry technology and computer vision technology also provides solid technical support for UAV aerial survey to generate three-dimensional stereo models. The 3D model constructed by UAV tilt photography has the advantages of being realistic, not limited by the shape of the model and the topography of the terrain, and fast generation speed (Xu, Wang, Zhang, et al., 2023). By applying these technologies, image data obtained from drone aerial photography can be accurately processed and analyzed to efficiently handle the removal of trees and a small number of houses, as well as the reconstruction of lake vacancies, thus generating three-dimensional models with realistic textures and precise coordinates.

2. Overview of Unmanned Aerial Surveys

Compared with traditional measurement methods, UAV aerial surveying simplifies the measurement process and significantly improves work efficiency. The small size and light weight of the UAV make it flexible to operate in various terrain conditions, especially suitable for complex environments such as mountains, hills and forests (Yang, Wang, Zhao, et al., 2024). In the specific measurement area required for the project, professional technicians set up drone routes through the drone to efficiently perform comprehensive raw image data acquisition of the project measurement area. In this process, all collected photographs and coordinate data are stored on a pre-prepared SD card to ensure data integrity and ease of subsequent processing.

Before data collection can officially begin, assembling the drone is a top priority. This step requires the operator to strictly follow the Assembly Procedure to ensure that the wings are properly and securely deployed to avoid accidents during flight. It was also essential to ensure that the SD card was functioning correctly so that data could be written.

After the drone is assembled, perform a power-on self-test procedure. Ensure that the UAV equipment is in proper condition, including but not limited to battery power, sensor sensitivity, and the functionality of the communication module. The communication link between the drone and the remote control must also be rigorously tested to ensure that a stable communication link is maintained throughout the flight.

For the project Not only do they need to carefully observe the terrain and landscape, but they also need to consider many factors such as flight safety, data collection efficiency and model construction quality. On this basis, the operational staff will flexibly adjust key parameters such as heading overlap rate, flight altitude, photo interval and shooting angle to ensure flight safety while further improving the accuracy and details of the model construction.

Figure 1. Drone Route Planning

Once the drone is assembled and the flight path is properly planned, the drone will take off smoothly according to the preset path and start to perform the data acquisition task. In this process, the UAV will take all-round shots of the project survey area from multiple angles (including five-way or three-way tilt and overhead view) to capture richer, three-dimensional image information. At the same time, the specific GPS positioning information of each group of photographs taken will also be accurately recorded and saved in the form of dwg files. These detailed data will provide solid information support for subsequent engineering analysis, design and construction.

3. Drone-generated 3D Stereo Models

With the rapid development of urbanisation, there is an increasing demand for accurate and detailed 3D models of cities (Hu & Hu, 2024). Using DJI Zhitu software for 3D reconstruction, 3D models and point clouds are generated. After eliminating overhanging points and fixing smooth surface holes, OSGB, OBJ, PLY and other formats can be generated for model local modification, web uploading and modelling repair.

OSGB format for local use:

OSGB (OpenSceneGraph Binary) format is a binary file format specially designed for the OpenSceneGraph (OSG) graphics engine. It can effectively store geometric information, textures, materials and animations in the 3D sceneries, etc. The DOM class library can parse the metadata files of the OGSB model, automatically obtain the spatial reference system and origin coordinates of the model, and parametrically model the 3D live model using the ArcGIS Pro ModelBuilder Model Builder, realizing the automatic conversion of the format (Shao, Gou, Li, et al., 2024). Since OSGB is tightly combined with OSG, it provides excellent performance when rendering, interacting, and dynamically simulating 3D models locally. This makes it an extremely important file format for 3D visualization and virtual reality.

OBJ format is used for mould repair:

OBJ format is a simple and widely used 3D model file format, which mainly contains vertex, texture coordinate and face information of the model. Because of its clear structure and easy parsing, OBJ format has become one of the standard input and output formats supported by many 3D modeling software (e.g. Blender, 3ds Max, Maya, etc.). In the process of model revision, the OBJ format can be used to easily import the model into various 3D modeling software for geometric adjustments, material replacement, texture mapping, etc. At the same time, the modified model can also be imported into various 3D modeling software for texture mapping. Meanwhile, the modified model can also be directly exported to OBJ format for data exchange and collaborative innovation between different software.

PLY format is used for web presentation:

The PLY (Polygon File Format) format is a file format for storing polygon mesh data. It supports a variety of attribute information including faces, vertices, colors, normals, etc. and is either in ASCII text format or binary format. For web presentation, the PLY format is favoured for its simplicity and compatibility. Many web 3D display frameworks and libraries (e.g. Three.js, Babylon.js, etc.) support loading PLY format model files directly. By embedding these model files into HTML pages and combining them with WebGL technology, we can achieve dynamic rendering, interaction, and animation effects of 3D models on web pages, providing users with an immersive 3D experience.

Figure 2. Model Display

4. Model Format Conversion and Data Export

In the process of 3D model construction, it is crucial to generate point cloud files synchronously. As a collection of discrete points in 3D space, the point cloud contains rich geometric and attribute information, which provides a solid foundation for modelling, elevation data reading and actual measurement. Through professional software, elevation points can be accurately extracted from the point cloud, which contain elevation values and are related to the actual geographic location, which is crucial for terrain analysis, earthwork calculation and planning design.

The elevation point data in the table visualises the terrain and geomorphological features, which provides accurate reference for the fine adjustment of the model. In the modelling process, the point cloud elevation information is used to optimise the model structure and ensure realism and accuracy. At the same time, the point cloud data helps the real-life measurement, compares with the actual measurement data, verifies the model accuracy, accelerates the measurement process, and guarantees the rapid progress of the project.

In conclusion, the point cloud files generated simultaneously during the model generation not only enhance the work efficiency, but also ensure the accuracy of the data, which provides a reliable basis for the subsequent modelling, elevation analysis and actual measurement, and is an indispensable and critical step for 3D modelling.

Table 1. Selected Elevation Point Data

546685. 25	4020624. 8	91. 722923
546700. 25	4020624. 8	95. 037857
546715. 25	4020624. 8	97. 829857
546730. 25	4020624. 8	96. 711281
546745. 25	4020624. 8	94. 415932
546760. 25	4020624. 8	92. 883308
546775. 25	4020624. 8	92. 738449
546790. 25	4020624. 8	95. 551361
546805. 25	4020624. 8	95. 686874
546670. 25	4020609. 8	91. 738701
546685. 25	4020609. 8	91. 800629

Although high-tech and equipment such as laser 3D scanning and inclined photogrammetry are developing rapidly, and the degree of intelligence and automation of in-house data processing software has increased dramatically, large-scale digital mapping based on total station and RTK still has irreplaceable roles in the fields of updating national basic scale topographic maps, and mapping of hidden areas (Luo, Zhang, Zhou, et al., 2019). Using CASS software, we can re-import the elevation point data into the 3D model to generate an accurate triangulation network. In this process, CASS software can intelligently identify houses, trees and some other features. Based on these recognition results, CASS will automatically remove the triangular mesh portion of these features, thus ensuring the clarity and accuracy of the topographic map and providing a solid foundation for the subsequent application of the topographic map.

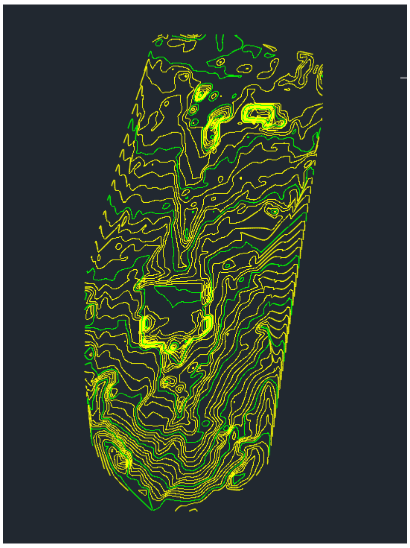

Figure 3. Contour Model

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