Application of Oblique Photogrammetry in Intelligent Transportation System

Puheng Zhang, Yanping Xiao*1,a, Guangqiang Chen2, Jiming E2, Ting Li2, Shengwen He2

1Logistical Research Institute of Science and Technology, Beijing, China
2China International Engineering Consulting Corporation, Beijing, China
a hollyhamzhang@163.com, ypxiao0619@sina.com
*Corresponding author: Yanping Xiao, ypxiao0619@sina.com.

Abstract. Remote sensing is one of the most effective spatial management tools at home and abroad. Oblique photogrammetry technology, as one representative, can help quickly and accurately obtain the 3D model of the surface, roads and buildings, and provide a more intuitive database for transportation. This paper introduces the production procedure of map image and real-time 3D model, and takes the intelligent transportation system as an example to display the operation flow and application of oblique photogrammetry technology. Oblique photography images can be embedded into intelligent transportation system to comprehensively display traffic and environmental information in detail. Combined with real-time traffic monitoring data, the virtual scene can be more realistic, and user experience can be greatly promoted. Thus, traffic scheduling and control can be more effective and efficient.

1. Introduction

The sustainable development of cities requires modern infrastructure for transportation management. In the 21st century, it has become a consensus to coordinate economic development with environmental protection while maintaining balance between social and economic development, population, resources and environment. The establishment of a coordinated system that ensures integrated, fast, convenient, safe and economically efficient transportation serves as the prerequisite of transportation infrastructure, and the guarantee of sustainable development. The modern coordination system could optimize road traffic conditions and improve utilization of resources. It also coordinates urban road management with passenger and freight transportation, thus shortening the time that people spend on traffic, improving the utilization rate of vehicles, reducing energy consumption by traffic, and lowering the noises produced by vehicles.

The technology of Oblique Photogrammetry and real-time 3D has been widely applied in the design and construction of intelligent transportation system. The technology needs to integrate 3D software, database, fast loading of data, fast 3D scanning as well as the actual needs of all parties involved. Based on the shape and features of ground objects in DLG/DOM, the ground objects are screened and categorized according to their functions, their 3D images as well as the actual needs to produce the 3D model, which serves as the database of intelligent transportation system.

The remainder of this paper is organized as follows. Advantages of Oblique Photogrammetry are presented in Section II. The procedure and principle of data generation with oblique photogrammetry
are illustrated in Section III. Application and solution to intelligent transportation are introduced in Section IV. Section V concludes the paper.

2. Advantages of Oblique Photogrammetry

2.1. The principle of oblique photogrammetry
Oblique photogrammetry is a newly emerging high-tech in surveying and mapping. Unlike orthophoto images that can only be taken vertically, it allows image collection not only from the vertical but also form four oblique angles because it is often equipped with multiple sensors on the flight platform, as in Figure 1. In this way, users are presented with the real and intuitive world that is in accordance with human vision.

![Figure 1 Schematic Diagram of Oblique Photogrammetry](image)

Oblique aerial images can not only reflect the ground objects, but also greatly expand the application of remote sensing images by integrating advanced positioning technology, accurate geographic information, enriched images and better user experience.

Because oblique images provide users with more geographic information and more friendly user experience, it can be widely used in urban transportation, as well as resource management, homeland security, urban management, real estate taxation, emergency response and so on.

2.2. Application of oblique photogrammetry
In overseas market, devices and post-processing softwares of oblique photogrammetry have been developing for nearly 20 years. For example, the AOS system of Trimble in US, the RCD30 system of Leica in Germany and the A3 system of VisionMap in Israel often appeared in international photogrammetry exhibition and in the photographic instrument market. The corresponding 3D modelling software includes Pixel factory in French Infoterra company and Smart3D in Bentley company and GIS7C in SuperMap in China. The post-processing software provided by the Eastdawn and HuaZheng are leading companies in China in the engineering application of oblique technology. However, the two companies’ solutions also require support of LIDAR data. The simultaneous production of DOM, DEM, TDOM, DSM and real-time 3D product with oblique aerial photography, tailored for transportation, remains a challenge up to now. This paper aims to find possible approaches to innovate the oblique aerial photogrammetry.
3. Techniques Involved in Data Generation with Oblique Photogrammetry

3.1. Process of integrated oblique aerial photogrammetry production

To ensure the quality and efficiency, we must rely on the mature and advanced surveying and mapping technology that integrates the mapping system "PixelGrid" based on high-resolution remote sensing image data for data processing. With "PixelGrid" software, we can effectively obtained DEM / DSM under complex terrain conditions based on multiple matching features or grid points, and only a small amount of manual editing is needed. We also use cluster distributed parallel processing technology, automatic and efficient network adjustment and image matching to automatically generate DSM and DEM data. In the production of DEM, we mainly apply the aerial triangulation encryption results of PixelGrid, and then generate high-precision DSM by producing epipolar image, matching seed point line, automatic image matching, and then restore the surface of original survey area through PixelGrid, filter, mean interpolation and other tools in order to generate high-precision DEM. With DEM, we can do orthogonal rectifying for the original image, and then we can obtain standard framing DOM results by hue homogenization, segmentation cutting and contour handling. TDOM can be achieved by resampling the DSM, which means geometric correction of images. Because DSM retains elevation information of buildings, bridges and trees, the final generated image not only corrects terrain, but also corrects surface buildings and maintains the surface landscape with vertical angle. Then, preliminary TDOM can be generated using Photomesh. At last, it is necessary to ① do check and repair for image noise and incomplete shadow, ②splice single image sheets, check and correct the edges, ③adjust the overall color. The procedures go as in Figure 2.

Figure 2 Technical Flow Chart
Regulations on the collection of aerial imagery data:

- We should first set the outline, with which the zoning boundary ought to be consistent. The elevation difference in the subarea should be no more than one sixth of the photographic altitude. The span of the zoning should be as large as possible and the photography route should keep straight. In case of drastic elevation difference, significant differences in topographic features or special requirements, divided maps could be adopted.

- As for buildings, the acquisition sequence should start from the highest level to ensure the integrity of the upper layer, and then gradually expanded to the lower layer. The external contour of the house should be cut accurately.

- As for roads, highway should be collected in detail, including the guardrail on both sides of the road, and the isolation belt in the center of the road. When collecting roads with equal width, parallel lines should be used so as to keep both sides of the road at the same height.

Suppose there is an aerial photography zone in the shooting area as the red range shown in Figure 3. Considering the efficiency of actual flight, the shooting area can be expanded to the area as the yellow range shown in the Figure 3.

3.2. Monolithic modeling

Because it needs to distinguish specific buildings, streets, bridges and so on in traffic command and control, we adopt automatic monolithic modelling and use CityBuilder to process the buildings in the 3D model in real urban scene. The thematic data was imported, and the 3D model of real urban scene was automatically divided along with the creation of an optimized model with levels of details (LOD), thus generating a 3DML urban model, which has the characteristics of fast loading speed, large display range, lossless data compression, but optimized flow and full texture. The sample monolithic model is shown in Figure 4.

4. Integrated Solutions to Intelligent Transportation

An important role of oblique photography is to construct a more interactive and elaborate scene, compared with images of high-resolution satellites. It can help to assist decision-making
indoor when confronted with snowstorm, extremely cold weather et al. Below introduces relevant applications in the field of intelligent transportation.

4.1. Used in Integrated service system of transportation network
The integrated service system of transportation network with oblique photogrammetry provides unified, standardized and one-stop transportation service to industry authorities, enterprises, employees, and the public via an online platform, which improves efficiency and service satisfaction of industry authorities. The services include online government management, administrative information management, legality review, electronic supervision, information service and other functions. With the help of oblique
photography and 3D modelling technology, combined with real-time traffic monitoring data, the virtual scene can be more realistic. Figure 5 shows the system interface.

4.2. Used in Intelligent transportation dispatching system
The intelligent transportation dispatching system supported by oblique photogrammetry, as shown in Figure 6, is mainly responsible for ensuring the effective operation and safety of the public transportation system. The fundamental purpose is to ensure the effective deployment of operating vehicles from various companies, guarantee on-time, balanced and orderly operation of vehicles on each route, and provide travel services for the public. It also tracks violations of laws and regulations to ensure the safe operation of vehicles and deals with accidents in a timely and effective manner so as to attain the annual strategic goals of the enterprise. Oblique photogrammetry technology can provide digital line graph, urban road network, site POI and 3D city model for traffic intelligent dispatching system, and help truly realize scheduling and management based on holographic city model. Besides, it can enhance the utilization of limited traffic resources.

4.3. Used in Apps for bus services
Similar applications based on oblique photogrammetry can still be adopted and displayed in mobile apps such as bus service. That app can send the dynamic information of public transportation to mobile phone users, providing inquiry services to the public in the form of electronic map integrating sites, routes as well as real-time road conditions marked in different colors. Oblique photogrammetry technology can bring immersive user experience, and users can vividly and intuitively observe relevant information of urban road network with their mobile phones.

5. Conclusion
The oblique photogrammetry technology can quickly obtain high-precision real-life 3D models, and provide powerful data support for the information management of urban intelligent transportation design, construction and operation. This paper takes the intelligent transportation project of a sample city to introduce the integrated production process of oblique photogrammetry that plays a role in the construction of the public travel service system. This technology would benefit people in transportation. However, it is still in the initial stage of development in the urban intelligent transportation, which will be widely applied in the future.

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