Research on Disaster Acquisition Method Based on Point and Surface Combination of UAV Technology

Xuehua ZHANG, Duo DENG

National Earthquake Response Support Service, Beijing, China

E-mail: zhangxhua_nerss@163.com

Abstract. UAV (Unmanned Aerial Vehicle) remote sensing technology plays an increasingly important role in disaster acquisition. At present, after the disaster occurs, the orthophoto images of the UAV in the disaster area can be quickly obtained, but the bidimensionality of the orthophoto image limits the accuracy of disaster information extraction; it is required to improve the timeliness of the large-area 3D model established using the oblique photography technology in the disaster area. Combining the advantages of orthophoto and 3D models, this paper proposes a method for rapid acquisition of disasters based on point-surface combination. The Tibet Milin M6.9 earthquake is used as an example to analyze the advantages and disadvantages of this method in practical applications.

1. Introduction
After the disaster occurs, it is important to obtain disaster information quickly so that decision makers can reasonably dispatch rescue equipment and other forces according to the extent of damage and resources available in different areas, and minimize the damage and loss of people and property in the disaster area. In particular, the occurrence of major natural disasters often causes problems such as communication disruption and traffic damage in the disaster area, leading to a failure in timely conveying the situation of the disaster area, which brings certain difficulties to disaster assessment, command and rescue, and other work (Zheng, et al. 2010, Wang, et al. 2015). After years of development and practice, UAV remote sensing technology plays an important role in disaster information acquisition and monitoring, emergency rescue, disaster assessment, and post-disaster reconstruction in the face of major disasters such as earthquakes, geologic hazards, and freezing rains and snow (Shuai, et al. 2018, Liang, et al. 2013, He, et al. 2017, Lei, et al. 2011).

UAV remote sensing technology is used to obtain the spatial remote sensing information of ground features by carrying optical cameras, multispectral and other payloads on UAV flight platforms. UAV has been increasingly used in aerial photography, reconnaissance and monitoring because of its low cost, easy take-off and landing, and beyond-visual-range (BVR) autonomous flight. Meanwhile, when encountering interrupted communication and blocked traffic in the disaster, UAV can quickly cross mountains and rivers and penetrate deeply into the disaster area to obtain relevant information, providing accurate information for rescue and relief in a timely manner (Lu, et al. 2011).

At present, the main way of using UAV remote sensing technology to timely acquire disaster information is to obtain wide-range, high-resolution orthophoto remote sensing images of the disaster area using the fixed-wing UAV mounted optical cameras, so as to quickly grasp the overall disaster situation. However, as these data are 2D images, the amount of information is limited and cannot...
express the disaster information of the disaster-affected area in an all-round way, which cannot meet the needs of accurate disaster assessment and other aspects. The development of oblique photography by UAV has broken through the limitations in orthographic aerial survey by 2D images, namely to obtain multi-angle image information of vertical and inclined targets simultaneously by mounting multiple cameras in different angles on the same flying platform. A high-precision and omni-directional three-dimensional model can be established for targets through data processing of professional software. Combined with measuring tools, the length, width, area and volume of damages to the ground objects can be measured, so as to give an accurate assessment of the disaster situation from a quantitative perspective (Gerke, et al.2011). However, the current oblique photography data processing method has the disadvantages of immature algorithm, slow processing speed and long-time consumption. Even using medium- and high-end computer hardware equipment, it takes 80–100 h/km² to establish the 3D fine model of disaster areas, which is far from meeting the demand for rapid emergency response in large areas (Huang, et al.2017). Therefore, it is important to find a suitable method that can satisfy both demands for large-area disaster information acquisition and accurate disaster assessment.

Depending on the orthophoto aerial survey that can quickly acquire large area disaster information, and the oblique photography that can display disaster information in an all-round and quantitative manner, this paper proposes a rapid disaster information acquisition method based on point-surface combination, aiming to quickly and comprehensively display the situation in the disaster area and provide emergency rescue, disaster assessment, and other services.

2. Methodology
To meet the emergency demand for rapid response and the purpose of accurate disaster assessment, emergency aerial surveys by orthophoto were first carried out in key disaster-affected areas, UAV oblique photography technology was used to take oblique photography of the key and typical damage points found during the aerial survey and after data processing, and the orthophoto aerial survey data was quickly stitched and processed at the disaster site to obtain the Digital Orthophoto Map (DOM) of large disaster areas. Meanwhile, the 3D models with different degrees of refinement were processed and constructed taking into account the number of oblique shot points, the area, the processing equipment on site and other factors. The technology roadmap is described as follows:
The fixed-wing UAV or multi-rotor UAV is used to fly at high altitudes to quickly acquire orthophoto data of the disaster area. The UAV remote sensing system equipped with a digital image transmission system can perform a visual interpretation during the UAV flight and record the current flight path points of UAV to determine the location and orientation of key and typical damage points. The UAV remote sensing system without a digital transmission system can conduct the DOM fast stitching processing of remote sensing data after the UAV has landed, and then carry out the visual interpretation or automatic computer interpretation of DOM to determine the location of key and typical damage points.

After determining the location of the key and typical damage points, the multi-rotor UAV is used to acquire oblique photography data of the damage points. The analysis of the data post-processing process shows that the core task of data acquisition is to obtain all-round image information of the target, so in addition to using a professional multi-lens oblique photography system, a consumer-grade single-lens UAV can also be used to take low-altitude flight shots of the target point in accordance with the requirements of oblique photography technology (Gu, et al.2017, Li, et al. 2016).

In the data acquisition phase, “surface” refers to the orthophoto image of a large disaster area acquired using a fixed-wing or high-altitude multi-rotor UAV, while “point” refers to the oblique image of a key and typical damage point acquired using multi-rotor oblique photography technology. Through integrating the respective advantages of the fixed-wing UAV or high-altitude multi-rotor UAV orthophotography system and the multi-rotor oblique photography system, the acquisition of disaster image data based on the point-surface combination can not only obtain wide-range rough disaster information, but also show the details of small-scale disaster damage and help perform...
accurate measurement, thus achieving the complementation between the information of different levels and heights, providing wide-range disaster depictions, and characterizing the reproduction of small-range typical damage, so as to meet the demands for emergency rescue, disaster assessment and other work.

3. Data processing technology

3.1 Orthphoto aerial survey data processing
Automatic stitching of UAV data is the process of automatically stitching the image sequences with a certain degree of overlap into a ground panoramic image with a large field of view, which has been developed maturely in foreign countries and formed a relatively complete theory (Li, et al. 2012). At present, there is a lot of software for fast stitching orthophoto in the market, and most of the oblique image processing software has the function of fast stitching orthophoto, such as Photoscan, Pix4Dmapper, PixelGrid (an integrated mapping system for high-resolution remote sensing image data developed by Chinese Academy of Surveying & Mapping), MapMatrix and so on.

3.2 Oblique photography data processing
In terms of oblique image processing, apart from pre-processing such as geometric correction and image enhancement for the original image data, the main processing steps also include aerial triangulation, multi-view image dense matching and 3D modelling, and etc. The resulting remote sensing images not only provide a true and comprehensive picture of the ground conditions, but also accurate geographical information.

At present, there are mature image post-processing technologies and intelligent image processing software systems for oblique photography data. Common software includes Pictometry oblique image processing software, Smart3D (Bentley), Pixel Factory (Infoterra), LPS Workstation(Leica), DP-Modeler (TJH) and other oblique photography software (Yang, et al. 2016). The data post-processing software not only integrates the data processing functions of oblique photography technology, but also has spatial analysis and application functions, which can accurately determine the 3D spatial coordinates of each point on the image, measure the length and volume, etc., and then explore more real environmental information. It plays an increasingly important role in disaster emergency, recovery and reconstruction.

![Oblique images processing flow](Figure 2)
4. Applications analysis

As measured by the China Earthquake Networks Center, on November 18, 2017 at 06:34 Beijing time, a M6.9 earthquake occurred in Milin County, Nyingchi Prefecture, Tibet, with the epicenter located at 29.75°N, 95.02°E, a hypocentral depth of 10km and a maximum earthquake intensity of VIII (8 degrees). The epicenter was located in the uninhabited area of a high mountain valley. The village and town nearest to the epicenter location was Jiala Village, Pai Town, Milin County, with a distance of approximately 12 km, which was sparsely populated and had no casualties (Figure 3).

![Landscape map of Milin earthquake](image)

**Figure 3. Landscape map of Milin earthquake**

The author, as a member of the on-site team of the China Earthquake Administration, carried out an earthquake damage survey in Pai Town, Zhibai Village and Jiala Village in Milin County. It is found that there is no obvious damage to buildings in Pai Town on the UAV images, the houses and population in Jiala Village are less and concentrated. The earthquake damage survey was completed through visits. In Zhibai Village, the buildings are scattered and some buildings have serious damage. Therefore, this paper takes Zhibai Village as an example for illustration.

As Zhibai Village was approximately 16.5km away from the epicenter, the earthquake did not cause any obstruction to the roads to Zhibai Village, so the investigators were able to enter the village directly. During the survey of this village, orthophotography of the entire village area was conducted using the multi-rotor UAV with automatic route planning function. During the shooting, the real-time visual interpretation of the returned images revealed the presence of a rubble and stick pile under the eaves of a building located southeast of the take-off point, which was preliminarily concluded to be a vandalized structure (Figure 4). An investigation was then performed using another multi-rotor UAV, and oblique aerial photography was carried out to produce a refined 3D model on site, which was combined with ground survey data to make thematic maps for the command.
Figure 4. Orthphoto and aerial location map of Zhibai village

5. Conclusion
Combining the respective advantages of orthophoto and oblique image, the UAV damage survey method based on point-surface combination can achieve wide-range disaster depictions and small-area disaster reproduction, and fully take into account the wide range and processing speed of orthophoto and the detailed display characteristics of oblique image, thus providing a reliable basis for rapid and accurate assessment of the disaster. Due to the relatively minor damage caused by the Milin earthquake, the advantages of this method have not been well illustrated, but the usefulness of this method for accurate disaster assessment has been demonstrated. In subsequent potential disaster investigations, the author will continue to use the UAV disaster acquisition method based on point-surface combination to obtain disaster data to serve all levels of command.

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**Acknowledgments**
The authors would like to thank the anonymous reviewers. This work was supported by the National Key R&D program of China (2017YFB0504104).