PRELIMINARY STUDY ON EARTHQUAKE SURFACE RUPTURE EXTRACTION FROM UAV IMAGES

Yuan Xiaoxiang, Wang Xiaoqing Ding Xiang, Wu Xiaoyong, Dou Aixia, Wang Shumin
Institute of Earthquake Forecasting, China Earthquake Administration, Beijing, China;42585936@qq.com

ABSTRACT

Because of the advantages of low-cost, lightweight and photography under the cloud, UAVs have been widely used in the field of seismic geomorphology research in recent years. Earthquake surface rupture is a typical seismic tectonic geomorphology that reflects the dynamic and kinematic characteristics of crustal movement. The quick identification of earthquake surface rupture is of great significance for understanding the mechanism of earthquake occurrence, disasters distribution and scale. Using integrated differential UAV platform, series images were acquired with accuracy POS around the former urban area (Qushan town) of Beichuan County as the area stricken seriously by the 2008 Wenchuan Ms8.0 earthquake. Based on the multi-view 3D reconstruction technique, the high resolution DSM and DOM are obtained from differential UAV images. Through the shade-relief map and aspect map derived from DSM, the earthquake surface rupture is extracted and analyzed. The results show that the surface rupture can still be identified by using the UAV images although the time of earthquake elapse is longer, whose middle segment is characterized by vertical movement caused by compression deformation from fault planes.

1.INTRODUCTION

After the devastating earthquake, the intense tectonic movement often results in the surface rupture on a certain scale. The location and spatial distribution of earthquake surface rupture plays an important role in estimating the seismogenic mechanism, tectonic activity and disaster distribution of the earthquake. In the past, earthquake surface rupture was investigated by artificial ground surveys, satellite and aerial image interpretation methods (Xu X. et al, 2008; Fu B. et al, 2008; Ran Y. et al, 2010).

In recent years, with the further development of UAV platform and image processing method base on computer vision, it has become the focus for many scholars to use the high overlap degree of UAV images to reconstruct 3D scenes and use high-precision digital elevation model to study the active tectonics（Bemis S. P. et al. 2014;Wei Z. et al. 2015;Gao S. et al. 2017;)

this paper uses the recent acquisition of UAV images with differential POS data and uses the multi-vision 3D reconstruction technology to obtain the high accuracy of surface terrain information of rupture for extraction research.

2.MULTI-VIEW 3D RECONSTRUCTION METHOD

The specific process of The multi-view 3D reconstruction method includes the structure from motion (SfM) and multi-view Stereo (MVS) (Snavely N. et al, 2008; James M.R. et al, 2012)(Figure 1). The SfM method first identifies the feature points for each image. Then matches the pixels of the same name point with overlapping images. After that the camera parameters of each image are restore to obtain the sparse three-dimensional position of the target (Snavely N. et al, 2010). In this paper, based on SfM and MVS method, we get the dense point clouds of the study area, and then build the terrain 3D model to generate the digital surface model (DSM) (Figure 4a).

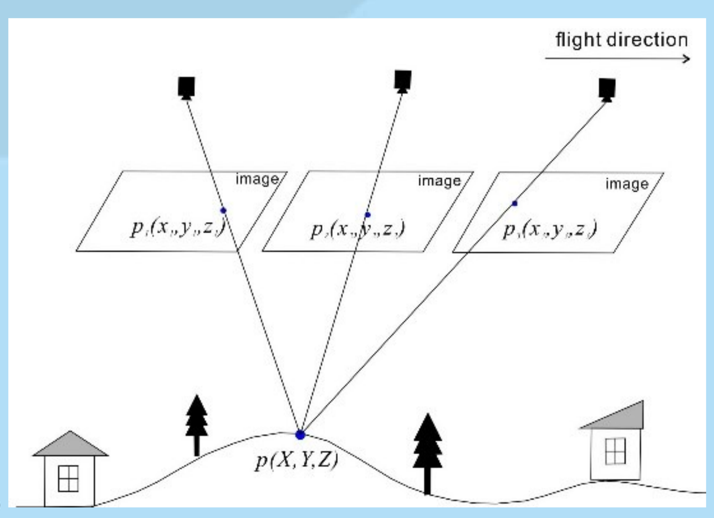

Figure1. Multi-view 3D reconstruction strategy

3.UAV DATA ACQUISITION AND EARTHQUAKE SURFACE RUPTURE IDENTIFICATION

The study area is located in former urban area of Beichuan County and its surrounding area (Figure 2). Using vertical take-off and landing UAV produced by JOUAV Company, a series of UAV images were obtained, whose degree of heading overlap is 80% and the lateral overlap is 70%. The relative flight height is about 700m. The single image size is 7360 × 4912 pixels. The differential GPS is used to obtain the POS data of the flight. The mean of the horizontal distance deviation of POS between the difference and non-difference is about 192.7cm, and the mean of the vertical distance deviation is about 44.1m.

Finally, the average resolution of the generated DOM (Figure 2) is about 0.1m and DSM (Figure 4a) about 0.2m.

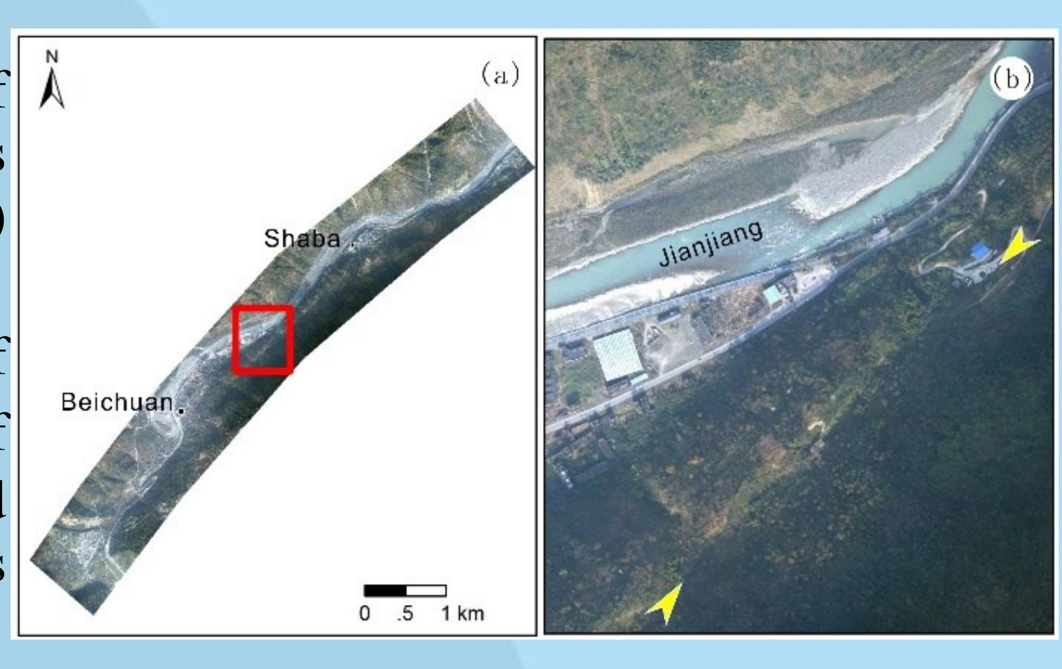

Figure 2. Mosaic image in study area.

Based on shaded-relief map ，through the experiments of different light direction angles and height angles, when the azimuth is 135 degrees and the height angle is 45 degrees, a clear strip shape tonal abnormality is obviously showed between the Shaba village and the former Beichuan County, and the trend is North East (Figure 4b). Based on visual interpretation of linear and terrain features, exact position of the earthquake surface rupture is obtained (Figure 4a, b). Through calculating the aspect image, it shows that the middle segment of main fault faces southeast and east (Figure 4c). It has obvious vertical movement. However, aspects of north segment and south segment are not obvious orientation because of smaller vertical movement. The result is in accordance with previous field survey results (Xu X. et al, 2008; 2009; Tan X. et al, 2010; Ran Y. et al, 2010).

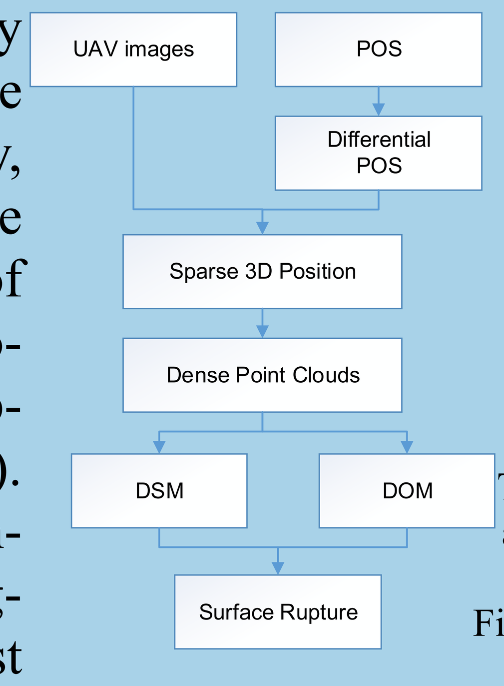

Image ID	△X（cm）	△Y（cm）	△Z（m）
DSC_0003	136.82	148.95	-44.02
DSC_0004	155.85	149.97	-44.19
DSC_0005	103.54	134.82	-44.33
DSC_0006	135.58	185.21	-44.18
DSC_0007	93.55	182.42	-44.26
DSC_0008	129.45	151.44	-44.22
DSC_0009	117.34	172.11	-44.17
DSC_0010	120.21	158.80	-44.24

Table1. Deviation between pre and post differential POS data

Figure 3. UAV images processing Flow

By measuring the cross-section of the fault, the obvious topographic mutation can be seen as shown by the arrows in Figure 4d. Due to the compression movement between the fault planes, the north-western side increased, resulting in the formation of the fault scarp, which changed the original topography characteristics of low in the northwest and high in the southeast, and formed the obvious terrain anomaly mark.

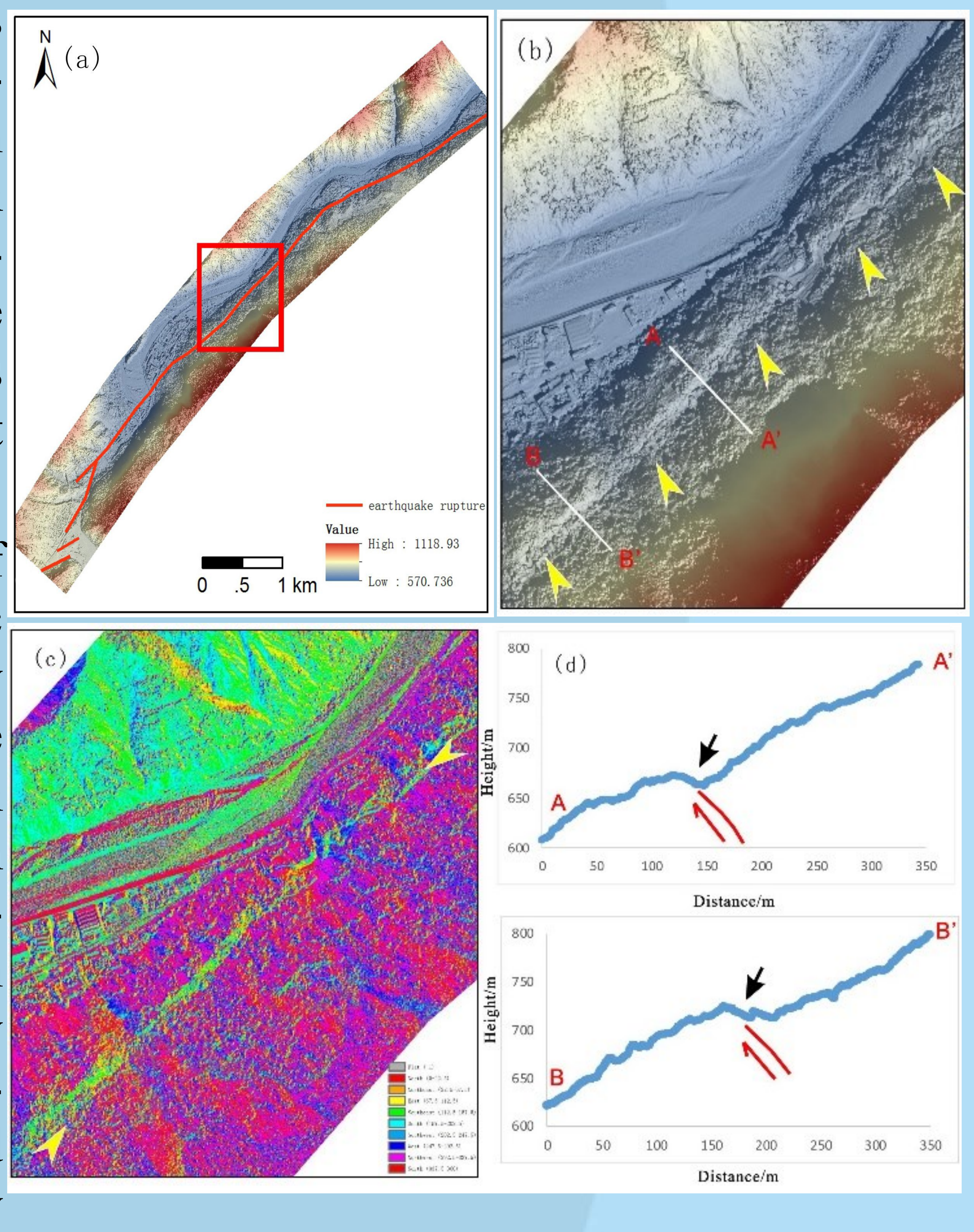

Figure 4. Beichuan topographic map and seismic surface rupture

4.CONCLUSION AND DISCUSSION

The results of this study show that although the study area has a thick vegetation cover, higher accuracy DSM can be produced using the UAV image with differential POS data compared to non-differential POS data. According to the terrain analysis of DSM such as shade-relief and aspect, it can be found that the earthquake surface rupture caused some features of topographic change like fault scarp, trough valley et al., which cause obviously linear tone distribution due to movement in vertical and horizontal direction. However, due to the effect of thick vegetation cover on the earthquake-ruptured surface, the horizontal motion characteristics of the earthquake rupture need further study.

ACKNOWLEDGEMENTS

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