A Study on Urban Change Detection Using Stereo Satellite Data

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ABSTRACT: Satellite images show high potential to detect geographic changes for wide range regions. The change detection methods using satellite images can be classified into single image and stereo image approaches. The single image approach shows limitation to detect building level changes because of the occlusion and relief displacement due to the acquisition angle differences at two different times. However, the stereo images can generate DSMs (Digital Surface Model) that include relief-corrected objects information. Therefore, we carried out the change detection over an urban area to investigate its performance. In this study, the RPC correction was performed using stereo images of two different times for two DSMs generation via stereo image matchings, followed by D-DSM (Differential DSM) computation. We investigated the topographic change detection performance by applying height thresholds to D-DSM.

1. INTRODUCTION

Aerial and drone photogrammetry as well as LiDAR (Light Detection And Ranging) have become useful in small area monitoring as D-DSM (Differential Digital Surface Model) was generated using aerial images to detect urban changes (Kwon et al., 2011) and LIDAR data were used to detect changes in urban areas (Choi and Lee, 2008). Satellite images show high potential to detect geographic changes for wide range regions. The change detection methods using satellite images can be classified into single image images (Kang et al., 2003) and stereo image approaches (Lee et al, 2017). The single image approach shows limitation to detect building level changes because of the occlusion and relief displacement due to the acquisition angle differences at two different times. In this study, we carried out an experiment to investigate the performance of change detection using stereo satellite data acquired at two different times. First the RPC (Rational Polynomial Coefficients) correction was carried out to ensure the geometric consistency between the data. Then the dense stereo matching was conducted for two DSMs generation after the epipolar image resampling. Second D-DSM was obtained by differentiating the DSMs. Applying height thresholds to D-DSM, the performance of the change detection was investigated.

2. EXPERIMENT

The stereo satellite images of two periods were obtained for the target area, Yangsan-si, Korea, as shown in Figure 1. Stereo images of 2006 IKONOS satellite and stereo images of 2013 KOMSAT-3A were used with intervals of 7 years.
RPC correction ensures the geometric accuracy of satellite images of two periods. To this end, we used GCPs for the bias-compensation (Oh and Lee, 2018). 10 GCPs were used for IKONOS and 6 GCPs were used for KOMSAT-3A. The horizontal accuracy of IKONOS satellite images in 2006 was about 0.8m and the vertical accuracy was about 1m. And KOMPSAT-3A's horizontal accuracy was about 1.4m and the vertical accuracy was about 1.8m.
Dense stereo matching of the stereo data produced two DSMs with GSD 2m as shown in Table 1. Blue color means 120m above sea level and red means 220m above sea level.

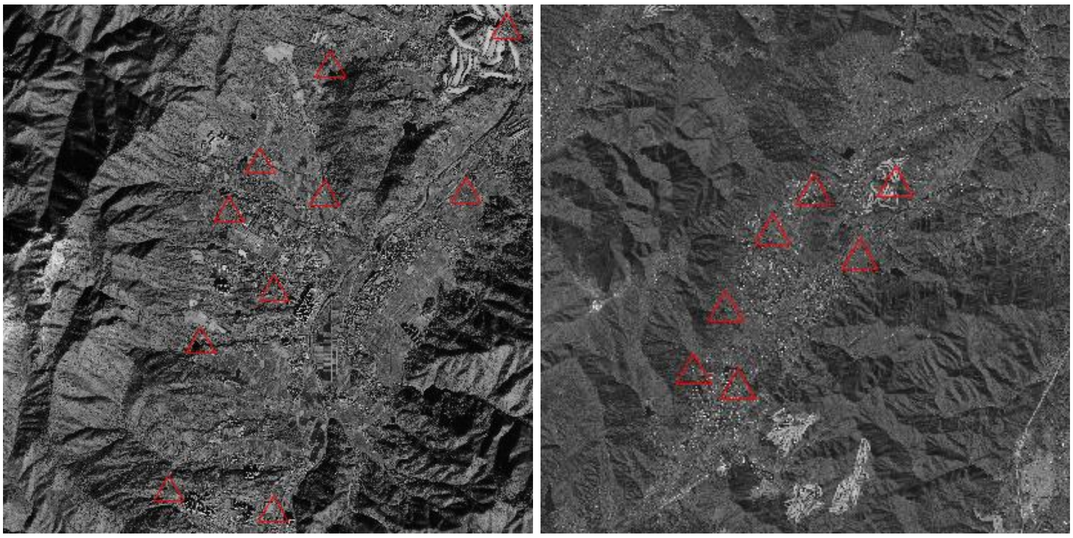
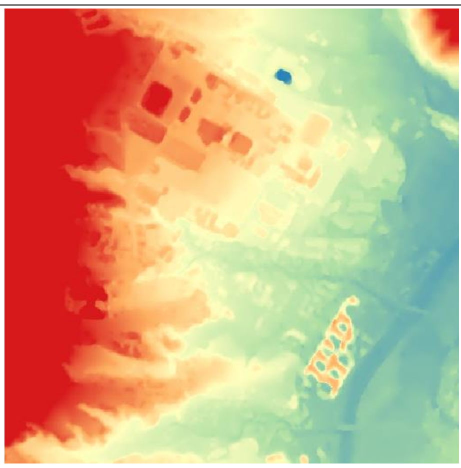
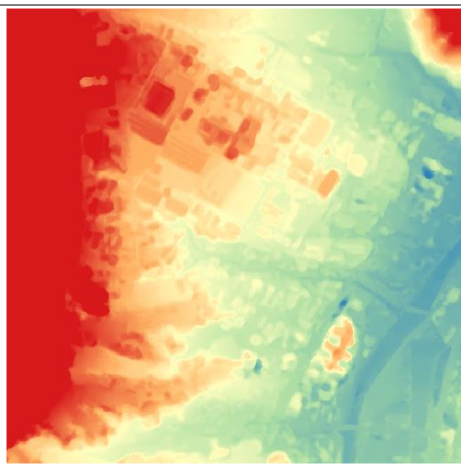


Figure 1. 2006 IKONOS (left), 2013 K3A (right)

Table 1. RMSE and DSM of each satellite image

	2006 IKONOS	2013 KOMSAT-3A
RMSE X (m)	0.77	1.77
RMSE Y (m)	0.79	1.09
RMSE Z (m)	1.09	1.83
DSM		
GSD	2m	

We checked the elevation accuracy of the DSMs as shown in the Table 2. The difference between the actual height of buildings and the DSM elevation was about 2 ~ 2.5m in both periods. Also, the elevation difference between 2006 and 2013 for the unchanged site was found to be less than 2m. Therefore we used 2m as a threshold for the elevation change detection.

Table 2. DSM vertical accuracy

	T1 - H	T2 - H	T2 - T1
Mean (m)	-1.08	-1.05	-1.02
RMSE (m)	2.44	2.20	1.95

After creating the DSMs, D-DSM was generated by subtracting 2006 DSM from 2013 DSM as shown in Figure 2. The significant elevation changes are highlighted in red on the D-DSM. In other words, changed areas are shown in red, and the blue area means no change.

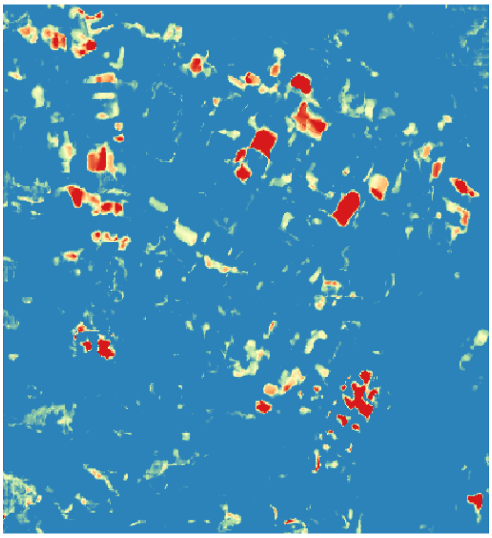


Figure 2. D-DSM

As shown in Figure 3, it can be seen that the building was built in the plain in 2006. These changes can be seen in D-DSM. Also, the orange or yellow colors can be observed depending on the elevation changes.

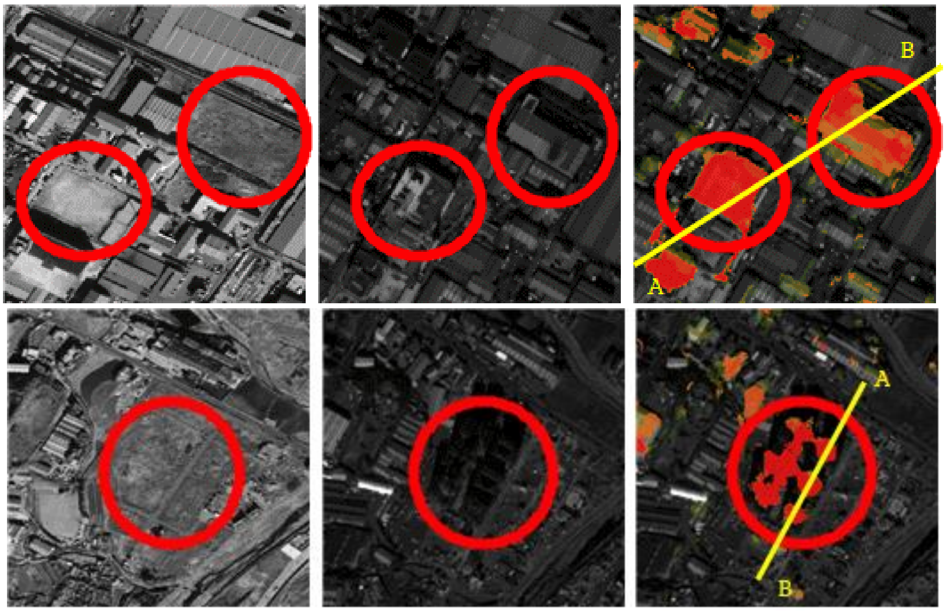


Figure 3. Samples of detected changes (left 2006, center 2013, right D-DSM)

3. CONCLUSION

In this study, the urban change detection was carried out using stereo satellite images. RPC compensation improved the vertical and horizontal accuracy for the DSM generation through the dense stereo image matching. The height accuracy of DSM at each time was estimated about 2.5m and the difference in height accuracy between the two periods was about 2m, which was the basis for the threshold for the changes in D-DSM. From the D-DSM, it was possible to identify the changes in various regions such as newly constructed buildings but the object level detection of apartment complexes of dense high-rise buildings was limited because of the stereo matching errors.

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