The possibility of applying layover simulation to change detection caused of natural disasters using multi-temporal SAR images

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1. Introduction

Change detection from multi-temporal Synthetic Aperture Radar (SAR) enables the rapid detection of severely damaged areas in the case of natural disasters. Especially, the emergence of meter scale SAR image has opened up the new possibility of detecting damages in a building unit scale. Unfortunately, despite of its outstanding resolution, distortion effects, such as layover and shadow, derived from the side-looking geometry have apparently hampered practical applications of damage detection. Notably, as far as geospatial characteristics of the Washington State is concerned, the presence of tall trees would be an obstacle of analyzing SAR image. In order to overcome this problem, we propose an application of RaySAR based change detection using pre-event LiDAR data to the damaged building detection. RaySAR is a software developed by Technical University of Munich and German Aerospace Center[1) 2)]. As shown in Figure 1, this software computes visible areas of building using LiDAR data, and then, the position of pixels that store backscattering from the building is estimated considering layover effets.

2. Experiments of Layover Simulation Using RaySAR

In this section, the extent of layover was evaluated in several conditions using RaySAR. In this experimental analyses, two virtual cuboids, including Object-A $(30 \times 20 \times 20)$ and Object-B $(25 \times 10 \times 20)$, were manually defined instead of importing LiDAR data. The cross section of the objects is shown in Figure 2. The local incidence angle of radar was set to 45°. Firstly, backscattering only from the Object-A and the floor was simulated. Secondly, backscattering only from the Object-B and the floor was simulated. Finally, the layover area derived from Object-A was detected considering both of the objects and floor. Simulation results are summarized in Figure3. It is obvious from the figure that the layover area of Object-A is decreased by the shadow area of Object-B. As we discussed in this section, extracting detailed backscattering from each building requires RaySAR analysis.

3. Perspectives for Collaboration

RaySAR has been successfully applied to some benchmark problems, such as monitoring city development[3)]. However, its possibility to contribute disaster damage assessment has not been sufficiently examined because of the lack of knowledge about disaster management and the limited accessibility to LiDAR data. During the workshop, we aim to discuss how RaySAR can support change detection of future disasters, and seek the possibility to conduct experiments of this method focusing on the Washington State, whose topography has been surveyed through several forest preservation projects.

References

1) Auer, S., Hinz, S., & Bamler, R. (2010). Ray-tracing simulation techniques for understanding high-resolution SAR images. *IEEE Transactions on Geoscience and Remote Sensing*, *48*(3), 1445-1456.
2) Tao, J., Auer, S., Palubinskas, G., Reinartz, P., & Bamler, R. (2014). Automatic SAR simulation technique for object identification in complex urban scenarios. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, *7*(3), 994-1003.

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3) Tao, J., & Auer, S. (2016). Simulation-based building change detection from multiangle SAR images and digital surface models. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, *9*(8), 3777-3791.

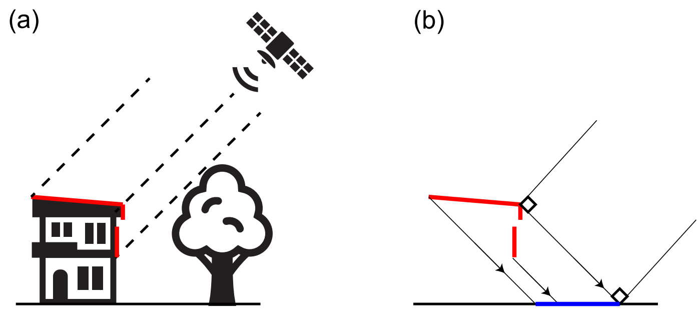

Fig.1 Schematic representation of RaySAR processing steps. The visible area (red line) from sensor is computed considering parameters of image acquisition, as shown in (a). Subsequently, the layover (blue line) derived from this area is detected, as shown in (b).

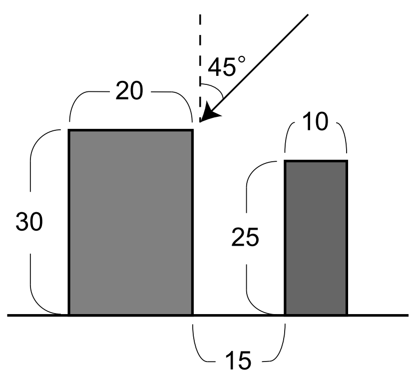

Fig.2 Cross section of target scene defined in POV-Ray. The left object is Object-A, and the right object is Object-B. The depth of them is set to 20.

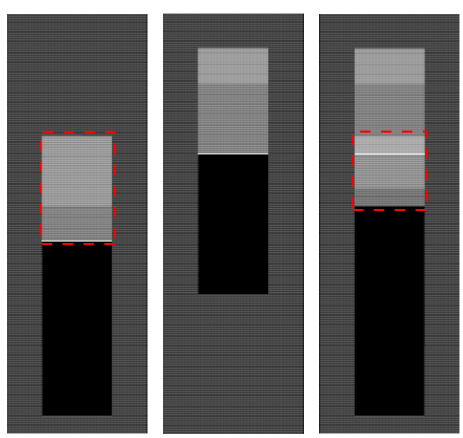

Fig.3 Summary of simulation results. Range coordinate is top-down. The red squares represent layover area derived from Object-A in each condition. (Left: Backscattering only from the Object-A and the floor is simulated. Middle: backscattering only from the Object-B and the floor is simulated. Right: backscattering from all of components is simulated)