A Method for Estimating Layover Areas for Spaceborne SAR

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***Abstract*—We propose a method for estimating layover areas occurring in the course of earth surface observation by a spaceborne SAR. Specifically, a graph treating the distance from the satellite to a sample point on the earth is created and used to evaluate the existence of a span of the same length. If such a span exists, it is extracted as a layover area. The usefulness of the proposed method is confirmed over virtual terrain with known geometry and an actual satellite flight path of ALOS-2, operated by the JAXA.**

***Index Terms*—DEM, layover, remote sensing, spaceborne SAR**

I. Introduction

A synthetic aperture radar onboard a satellite (spaceborne SAR) is an active sensor that irradiates observation microwave (OM) pulses at fixed time intervals and records received signals in arrival order [1]. As Fig. 1 shows, this observational setup causes two irregularities to arise: radar shadow areas and layover areas. Signals from multiple locations arrive simultaneously at these two areas [2]. We propose a method to extract the layover areas using satellite flight path data and digital elevation model (DEM) data. The proposed method improves the accuracy of spaceborne SAR data analysis by excluding extracted layover areas from the analysis target.

II. Outline of the Proposed Method

A. Basic ideas

The ground surface is constructed by using DEM5A data [3]. OM is emitted perpendicular to the satellite flight direction at an extremely small time interval. Then, an OM irradiated from a satellite can be assumed to form a plane called the OM irradiation plane (OMIP). Sampling rays cast from a satellite to the earth's surface for the extraction of layover areas are generated on the crossing line (orange line in Fig. 2(a), hereafter sampling line), formed between a virtual ground surface of uniform elevation and the OMIP. Layover occurs over any span over which successive measures of the distance from the satellite to the ground surface overlap. Therefore, we construct a graph that expresses the relationship between the distance and the location on the sampling line, allowing detection of the layover area.

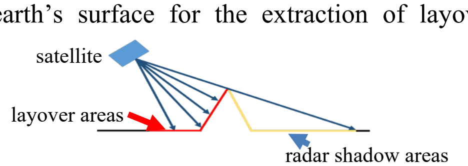
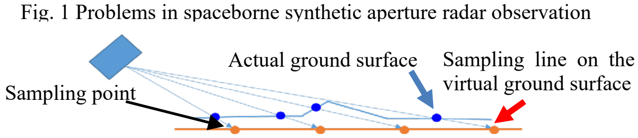
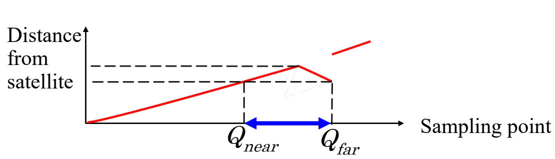


Fig. 1 Problems in spaceborne synthetic aperture radar observation



(a) Relationship between sampling ray and sampling point generated on the sampling line on the virtual ground



(b) Distance graph

Fig. 2 Determination of layover areas

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B. Process flow outline

The process flow can be described as follows:
(1) Sampling points to generate the sampling ray are created on the sampling line. (2) For each sampling ray, the nearest intersection and its distance from the satellite are calculated. (3) A graph is constructed with the location of the sampling line as the horizontal axis and the distance from the satellite as the vertical axis. (4) Layover occurrences are evaluated according to the graph. In the example shown in Fig. 2, the red line in Fig. 2(b) is drawn according to the distance graph in Fig. 2(a). In this case, successive distance measures overlap over a span between Q_{near} and Q_{far}, so the layover is identified as occurring over this span.

III. Examples and Discussion

The proposed method was implemented and applied to a virtual terrain (with known geometry) and actual flight data of ALOS-2, operated by the JAXA. Fig. 3(a) shows the virtual terrain. In Fig. 3 (b) and (c), black pixels show the layover areas; red and blue arrows show the flight and OM directions, respectively.

IV. Conclusion

We proposed a method to extract locations where layover occurs under spaceborne SAR observation and confirmed the method's usefulness. Future work will focus on investigating strategies for the acceleration of the workflow.

Acknowledgment

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References

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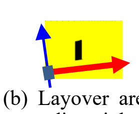
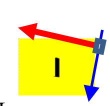
[2] M. Ide, T. Samura, K. Tadamura, Development of Database of Radar-shadow Cast by a SAR Satellite Using High Resolution DEM Data, Proc. of IWAIT2020, pp.115152Z-1-6, 2020.

[3] Geospatial Information Authority of Japan, download service, https://fgd.gsi.go.jp/download/menu.php, (Accessed 2023.8.10).

(a) Virtual terrain with known geometry



(b) Layover area for ascending-right observation



(c) Layover area for descending-right observation

Fig. 3 Application examples