Implementation of X-band SAR Simulator for High-Resolution Surveillance

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***Abstract*—A synthetic aperture radar (SAR) is widely used for acquiring image regardless of the weather condition. Recently, as a demand for high-resolution image increases, many researchers focus on a higher center frequency. However, development of the SAR costs a tremendous amount, so the researchers need to a simulation tool for the SAR operation. Also, it is hard for student researcher to obtain and use the SAR simulator. In this paper, we analyze a geometry for the SAR operation and implement the SAR simulator using MATLAB. The SAR simulator shows a target allocation, a transmitted and a received signal, procedure of the signal processing, and a final image. We implement an entire procedure of the SAR operation and make an user interface to impress on student researchers. We expect that a student who studies beginning level references this SAR simulator.**

Keywords—SAR; SAR simulator; X-band; high-resolution image; geotetry

I. Introduction

A conventional SAR system has been adopted low center frequencies, such as L- (1-2 GHz), S- (2-4 GHz), C-band (4-8 GHz). As the low center frequencies are used, it has advantages that wide area observation and relatively high penetrability [1, 2].

Recently, however, as a demand for high-resolution image such as military purpose increases, higher center frequency is used for design the SAR system. Meanwhile, as a demand for the SAR increases, the SAR simulation also has emerged as an important field of research. Because of an enormous cost for the development of satellite on-board SAR, it is mandatory for researcher to simulate the SAR operation [3]. The SAR simulation tool supports virtual SAR experiment and simulates various environment. According to the development purpose, we can change a satellite altitude, center frequency, bandwidth, etc.

In this paper, we describe a geometry for satellite on-board SAR and use the geometry to develop high-resolution SAR simulator. The satellite parameters are adopted by operating satellites in the world. Also, because the simulator is needed to practical, core variable of SAR parameters are referenced from X-band SAR.

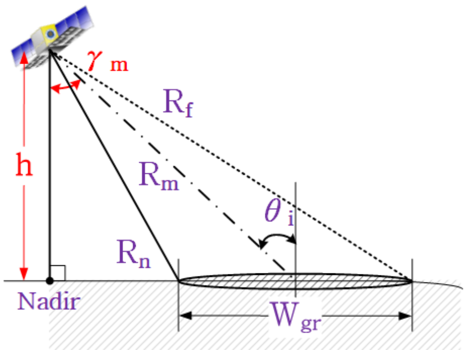

Fig. 1. Example of the SAR geometry parameters

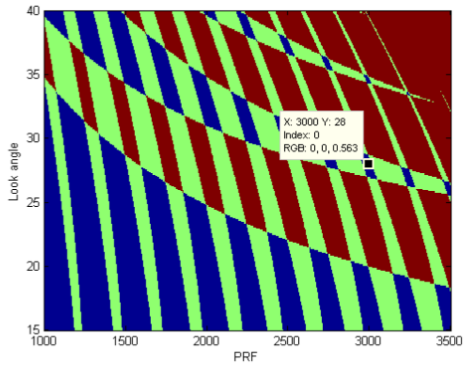

Fig. 2. Geometry analysis for PRF selection

II. Geometry Analysis for Satellite on-board SAR

Fig. 1. shows an example of the SAR geometry parameters. Representatively, distance between the SAR and the observation area varies with the altitude and the look angle. Round trip time of the signal, data sampling window are also changed in accordance with previous values. There are many other satellite parameters in space and we implement all this procedure in the SAR simulator. Especially, the SAR simulator is specialized in X-band (8-12 GHz) and is consistently upgraded to apply various environments.

Fig. 2. aids a selection for pulse repetition frequency (PRF) [3]. x-axis means PRF and y-axis means look angle in Fig. 2. As the SAR uses pulse signal, the pulses can be overlapped with

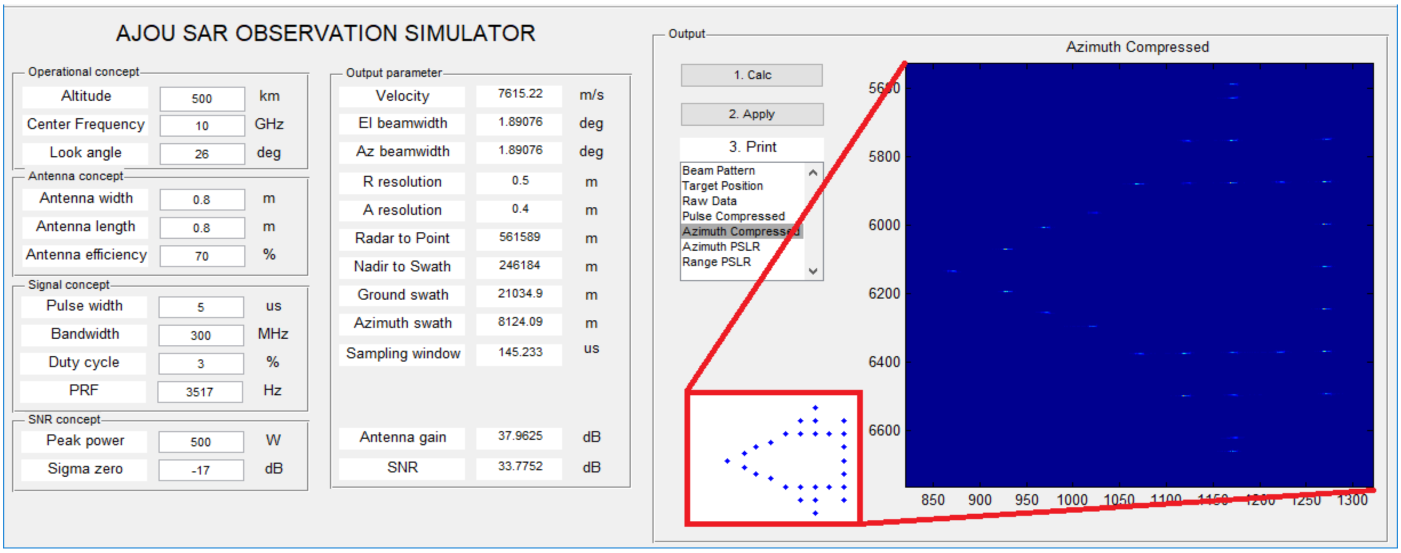

Fig. 3. The SAR observation simulator

previous or next pulse according to the timing. Furthermore, because the signal is emitted omnidirectional, we have to avoid nadir return signal that comes from the bottom. The PRF selection tool presents a guide to select the usable PRF.

III. SAR Observation Simulator

The SAR is operated as the mission. The missions are classified into the Earth observation, disaster monitoring, enemy surveillance, etc. In case of the Earth observation and disaster monitoring, the SAR system has a rough resolution (10m, 20m, etc.). However, in case of enemy surveillance, the SAR is needed to high degree of precision. For example, X-band (10 GHz) SAR using 300 MHz bandwidth has a 0.5 m of resolution in theory. We have made the SAR simulator to acquire high-resolution images.

Fig. 3. shows the developed SAR simulator. First, user can input twelve SAR parameters into the simulator. The input parameters are divided into four groups. An operational concept, which has the most affects to a satellite flight, has the altitude, the center frequency and the look angle. An antenna concept is consist of the antenna size and the antenna efficiency. The antenna parameters decide the beamwidth and the azimuth resolution. Parameters about the signal are included a signal concept. The signal affects the range resolution and an ambiguity, which is an error or making blur images, according to the transmission timing. A SNR (Signal to Noise Ratio) concept is an important parameter, which is related to final image quality. The SNR also means the system sensitivity. This requirement is that how much the system can tolerate the noise within the received signal. Second, user presses ‘Calc’ then the simulator displays twelve output parameters. ‘Apply’ carries out start to SAR observation. We have coded the satellite geometry and image processing algorithm so the simulator 1) calculates a distance between SAR and the target, 2) transmits a signal, 3) receives the signal, 4) processes data to image, and 5) displays final SAR image.

As shown in Fig. 3, we have arranged the targets as an airplane shape. We assume that the SAR simulator observes the targets during the flight path. A range-Doppler algorithm is used for signal processing of the transmission signal and the reception signal.

IV. Conclusions

In this paper, we have implemented X-band SAR simulator following the world demand. The developed SAR simulator is aimed at satellite on-board SAR. Therefore, we have analyze the satellite geometry to program the SAR simulator.

The SAR parameters can be clissified by several groups. We have divided the parameters to the characteristic of the parameters. We hope that the SAR beginner references this paper to understand SAR geometry.

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