A RECTANGULAR ARRAY FOR MOTION INDUCED SYNTHETIC APERTURE RADIOMETER

Hyuk Park, Sung-Hyun Kim, Ho-Jin Lee, Nam-Won Moon, and Yong-Hoon Kim

Department of Mechatronics, Gwangju Institute of Science and Technology (GIST)
261 Cheomdan-gwagiro, Buk-gu, Gwangju 500-712, Korea, email: yhkim@gist.ac.kr

1. INTRODUCTION

Aperture synthesis has been used to improve poor angular resolution of a microwave radiometer. The resolution of a single large aperture antenna is achieved by an interfermetric technique using an array of antennas arranged in a particular configuration, for example, linear array for ESTAR [1], "Y" array of MIRAS [2]. We can call this type of radiometer "Position Induced Synthetic Aperture Radiometer" because the platform is assumed to be static in imaging process. Meanwhile, there have been studies of aperture synthesis with platform motion, which is considered to be capable of reducing the number of elementary antennas [3]–[6]. Despite various nomenclatures, we can commonly call this type of radiometer "Motion Induced Synthetic Aperture Radiometer".

As the most recent study, the Doppler-radiometer has presented a two-dimensional imaging with an analysis of the impulse response and the spatial resolution [5],[6]. Unfortunately, the impulse response was damaged by speckle-like grating lobe due to the antenna configuration: only three antennas with very long baseline. This paper proposes the efficient rectangular array configuration to overcome this problem.

2. METHODS AND RESULTS

The observation scenario for the proposed system is very similar to that of the Doppler-Radiometer except the antenna configuration. The proposed rectangular array is configured with more antennas as shown in Fig. 1: an example of rectangular array of which maximum baseline is given by 20 times of the wavelength (20λ). Along the diagonal with angle of α , eight elementary antennas are deployed with proper distances from the origin antenna AO: 1, 2, 3.5, 5, 7, 10, 14, and 20 times of wavelength. Along the x and y axis, antennas are deployed at the projection point on each axis. From the array configuration, we can obtain the four directions of baselines: x, y, α , and $-\alpha$.

The image reconstruction is also similar to that of Doppler-Radiometer: pixel by pixel matched filtering. The difference is the way to synthesize the output of each baseline. The Doppler-Radiometer uses the geometric mean of outputs of two baselines, and the proposed system uses the arithmetic mean of the outputs of many baselines.

The advantages of the rectangular array can be revealed on the instantaneous spatial frequency domain what is called 'uv plane'. Fig. 2 demonstrates the frequency coverage of the rectangular array in Fig. 1 with $\alpha = 55^\circ$. It covers the designated domain uniformly and homogeneously, to some extent. On the other hand, the existing methods cannot cover the uv plane uniformly; especially they cannot cover the low frequency region because of the long baseline commonly used in [3]–[6]. The lack of low frequency samples results in speckle-like grating lobe of the impulse response. The proposed rectangular array consequently outperforms the previous system in imaging performance such as sidelobe.

A resultant impulse response of the rectangular array in Fig.1 is shown in Fig. 3. The following parameters have been used: platform height 800 km, center frequency 1.4 GHz, antenna look angle 45°, antenna half power beamwidth 20° in x and 30° in y axis, and source position (0,800 km). The sidelobes decrease below the value of 0.3, and the spatial resolution (width of contour level 0.5) is observed to be 72 km along x and 130 km along y. Overall, it shows a balanced feature as a two dimensional point spread function (or array factor) for imaging.

In the study, we proposed the sparse rectangular array for the motion induced synthetic aperture radiometer. We conclude that the proposed array can provide improved imaging compared with existing system while keeping the advantage of the motion induced synthetic aperture radiometer: smaller number of antennas compared with position induced synthetic aperture radiometer.

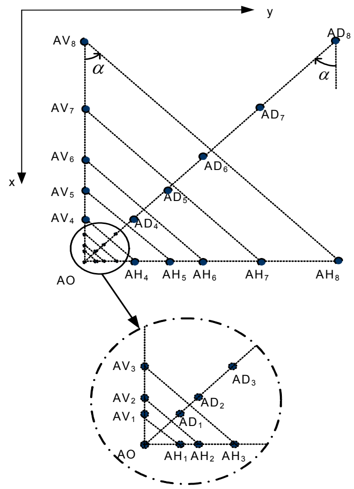

Fig. 1. Rectangular array configuration

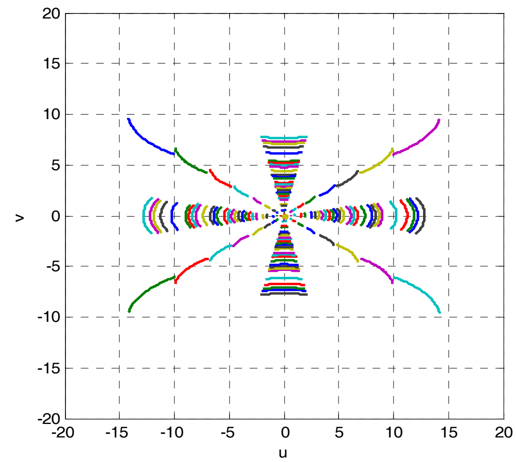

Fig. 2. Spatial frequency coverage of the rectangular array

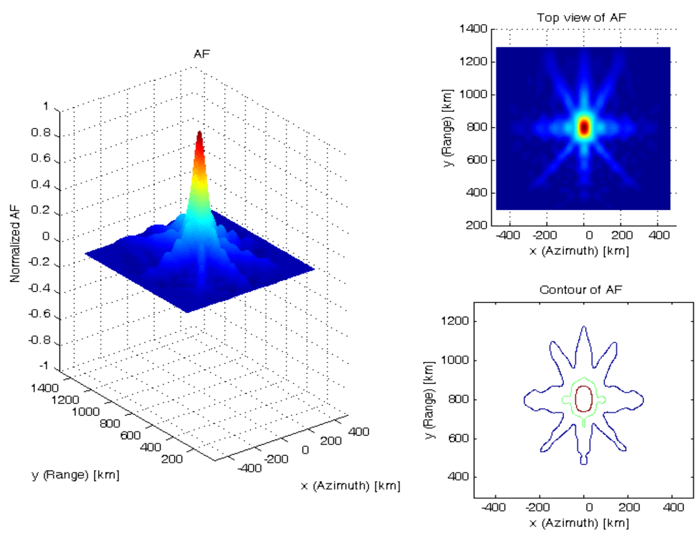

Fig. 3. Impulse response of the rectangular array; Contour level: 0.5, 0.3, and 0.1.

3. REFERENCES

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