Active downlink method for image quality enhancement in spaceborne SAR

Jong Soo Baik[1], Jung-Hwa Kang[1], Kyeongrok Kim[2], Hyuk Park[3] and Jae-Hyun Kim[2]

[1]*Department of Artificial Intelligence Convergence Network, Ajou University, 206, World cup-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do, 16499, Republic of Korea, and {whdtn9376, kjh990220}@ajou.ac.kr*

[2]*Department of Electrical and Computer Engineering, Ajou University, 206, World cup-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do, 16499, Republic of Korea, and {nowhere1104, jkim}@ajou.ac.kr*

[3]*CommSensLab-UPC, UPC-BarcelonaTech, Barcelona, 08034, Spain, park.hyuk@upc.edu*

Abstract - With the development of space technologies, satellite industry changes to the small satellites constellation which can supplement unserved area. In addition, satellites have become smaller and arranged at low Earth orbit (LEO). Since the LEO satellites have relatively short transmission time, the data, e.g. communication or observation, is transmitted via downlink within limited link time (below 10 minutes). Unlike conventional terrestrial networks, the LEO satellites can select service area, which satisfies service provider or user requirements, using steerable beam at satellite antenna. Meanwhile, terminals on the ground have various environments according to the performance of each terminal and the location. Thus, there is inefficient data distribution, in case of equally downlink using earth moving beam. In this paper, we propose active beamforming at LEO synthetic aperture radar (SAR) for the efficient downlink considering the computing performance (CP) of ground stations. In satellite image processing, SAR is widely used as it can acquire wide-range and high-resolution images. As SAR uses microwaves, it can observe the object and the area regardless of the time and the weather. We assume that each satellite SAR receives CP information in advance via inter satellite link. Therefore, ground stations guarantee maximum service quality because the data is allocated according to CP.

Reference scenario in this paper considers the earth moving beam of technical report (TR) 38.821. In addition, active beamforming was adapted to increase the efficiency of downlink and data processing. The ground base stations are located in Dongcheng of China, Lushunkou of China and Gangnam of Korea. CP ratio is assumed to be 31:25:44 referred by laboratory PC. Each base station uses macro suburban, macro rural and macro urban in the international telecommunication union radiocommunication (ITU-R) M.2292 report. LEO SAR downlinks data for 120 seconds during the flight path from Dongcheng to Gangnam. Then, the ground station processes the received SAR data for two scenarios (earth moving beam and active beam). In this process, image quality is compared using different image processing methods depending on scenario and CP. To compare SAR image quality, peak signal to noise ratio (PSNR) and structural similarity index metric (SSIM) are used as the indicators. PSNR compares the maximum signal power to the noise power. SSIM analyzes similarity using luminance, contrast, and structural parameters. In earth moving beam simulation, the image quality which is used same processing method shows that PSNR and SSIM are 29.89 dB and 0.96, respectively. The processing time is 264 seconds in Dongcheng, 271 seconds in Lushunkou, and 71 seconds in Gangnam. There is residual time because CP of Gangnam is better than others. The proposed method uses various of the processing methods according to the amount of data. Moreover, Gangnam which has higher CP processes more data and higher quality. As a result, we have 33.38 dB of PSNR and 0.98 of SSIM during maximum 154 seconds. The proposed method shows the enhancement of image quality and processing time.