ABSTRACTS (MASTER THESIS)

Study on the accuracy improvement of 3D shape estimation of space debris

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Up to 2016, 20,000 debris have been found in the orbit around the earth. The number of space debris is still growing year by year. Since space debris threaten space infrastructures such as satellites and space stations, identifying their orbits and locations is very important in the meanings of avoiding collisions and removing them. It is necessary to expand the observation network for detecting debris and improve the accuracy of debris observation. We utilized an atmospheric radar to know the existence of debris to be removed in the present research. Atmospheric radars have the advantage that the global network has be already established. The atmospheric radar we used is the MU radar (Middle and Upper atmosphere radar) held by RISH, Kyoto University. Debris on low orbits can be sufficiently observed by lengthening the pulse and enlarging the transmission power of the MU radar. In the present thesis, we focused on studying the improvement of the accuracy of 3D shape estimation of space debris. In previous research, by combining the RCS (Radar Cross Section) method and the SRDI (Single-Range Doppler Interferometry) method, 3D shape estimation of space debris was roughly enabled. However, in this combined method, only one certain cross-section was estimated along an observation direction. This point should be improved to make estimation accuracy higher. To address this issue, we attempted to observe space debris by using multi-directional radar beams. The results showed the estimation of overall debris' size is close to the real size. On the other hand, we also examined the accuracy of the RCS values. Shape estimation errors come from the errors in calculating RCS values from radar echoes. We examined the limit in the precision of the RCS values by observing the small satellite called DIWATA-2b, which is 50 cm square satellite. We confirmed the echo signal from it. Calculated RCS value from it is 1 m^2. This calculated value is 50 times larger than expected value. Therefore, we think that RCS value is not correct for less than 1 m^2 . Moreover, with FDTD method, we performed computer simulations on the time variation of the RCS value to evaluate the observation results.

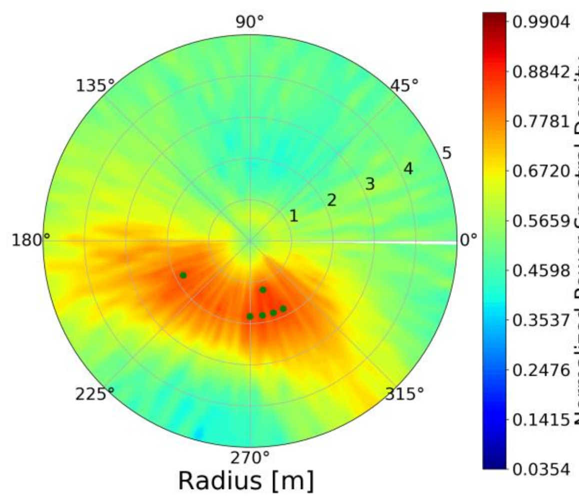

Figure 1. Estimated shape of the space debris (SL16RB) based on the MU radar echoes.