RANGE AMBIGUITY DISTRIBUTION CHARACTERISTIC OF SPACEBORNE SAR AND ITS DESIGN CONSIDERATION

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Abstract A new approach is proposed which can satisfy the range ambiguity requirement while keep the antenna width not to be enlarged and get the high quality image also. Here the chirp slope of the transmitted linear frequency modulated pulses is reversed alternately. Therefore, during the range compression significant portion of the ambiguous return which is due to the mismatching with the signal reference function is suppressed. The suggested method provides significant improvement in range ambiguity ratio and can be utilized in attaining wider swath.

Key words SAR; Range ambiguity ratio (RAR); Incidence angle; PRF; Uniform distribution; Cosine weighting; Chirp

I. Introduction

The illuminated area on the ground of a spaceborne SAR antenna is generally much wider than desired. Therefore, the returns from the scatterers which are located outside the required area are also received. Such returns are unwanted as they produce ghost-image interference or image ambiguities (Fig. 1). This ambiguity which is caused by the time overlap of these unwanted returns from the different transmitted pulses is termed as range ambiguity, and has been discussed much in detail in literature [1-6].

![Fig.1 Geometric relationship of SAR signal and ambiguous returns](image)

From the view of physics, the range ambiguity essentially depends on antenna elevation pattern, required swath width and pulse repetition frequency (PRF). The requirement of keeping the range ambiguity as low as possible imposes severe constraints on system design and parameter optimization. As the range ambiguity increase with the swath and incidence
angle increase. Hence, the wider swath and better range ambiguity suppression requirement are not compatible with each other. Moreover, there is an increasing demand for SAR data at larger incidence angles as SAR images used extensively, the range ambiguity at these incidence angles becomes more severely, especially for the small SAR platform in which the size of antenna is constrained, or even the conventional spaceborne SAR can not effectively operate at these larger incidence angles.

A lower PRF can suppress the range ambiguity but the azimuth ambiguity requirement prohibits reducing PRF below a certain limit. The only feasible solution at these larger incidence angles is to enlarge the size of the antenna along the range direction and design the antenna with a complicated weighting. There are not only significantly increasing in volume, weight and complexity of the spaceborne SAR equipment, or even we can not use a mid-size platform for carrying such SAR system. Therefore, the demand for wider swath and larger incidence angle SAR data with minimum acceptable range ambiguity level while keep the antenna width not to be enlarged needs a new approach which is different from the conventional ones.

The suggested new method which suppresses the range ambiguity significantly by reversing the chirp slope of the transmitted pulse alternately and subsequently reducing the odd ambiguities by mismatching with signal reference function during the range compression, is presented in this paper. This method can relax the constraints on PRF greatly, and realize wider swath and get clear radar image at larger incidence angle also, while keep the antenna width not to be enlarged. In the following sections, firstly the definition of range ambiguity is given. Then, we will discuss and analyze the range ambiguity distribution characteristic within the swath and its related factors. Finally, the new method which improves the range ambiguity significantly is presented.

II. Range Ambiguity

Fig.1 shows a spaceborne SAR signal and ambiguous return geometry. The antenna elevation pattern is shown at the bottom. Let \( P_{-3}, P_{-2}, P_{-1}, P_0, P_{+1}, P_{+2}, P_{+3}, \cdots \) be a set of point targets spaced an IPP (interpulse period) apart. It is observed that the useful return from point \( P_0 \) within the swath by the \( n \)-th transmitted pulse is accompanied with the returns from point \( P_{-1} \) outside the swath by the \((n-1)\)-th transmitted pulse, point \( P_{-2} \) by the \((n-2)\)-th transmitted pulse, point \( P_{-3} \) by the \((n-3)\)-th transmitted pulse, and from points \( P_{+1}, P_{+2}, P_{+3}, \cdots \) due to the \((n+1)\)-th, \((n+2)\)-th, \((n+3)\)-th, \cdots transmitted pulses respectively. These returns arrive the receiver at the same time. Among these returns, the return from point \( P_0 \) within the swath due to the \( n \)-th transmitted pulse is the only useful signal which we want. The returns from \( \cdots, P_{-3}, P_{-2}, P_{-1}, P_{+1}, P_{+2}, P_{+3}, \cdots \) by the \((n-3)\)-th, \((n-2)\)-th, \((n-1)\)-th, and \((n+1)\)-th, \((n+2)\)-th, \((n+3)\)-th, \cdots transmitted pulses respectively are all the interference signals. These interference signals constitute the range ambiguity. In order to obtain high quality image, we must suppress these interference signals to a minimum level. To quantitatively analyze the image degradation due to the ambiguity, a parameter