Frame Rate Analysis of Video Synthetic Aperture Radar (ViSAR)

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Abstract **– Video Synthetic Aperture Radar (ViSAR) is the new application of SAR technique. Through reasonable system parameter design, ViSAR system can obtain the SAR image at a faster image rates (also referred to herein as frame rate) which permit the detection of dynamic changes that are occurring in the target scene. Therefore, frame rate as one of the core parameters of ViSAR system should be carefully studied.**

Index Terms **— spotlight-mode SAR, ViSAR, frame rate.**

1. Introduction

ViSAR system works in the conventional spotlight-mode. The radar echoes of spotlight-mode are processed into SAR images. Customarily, a single synthetic aperture data set is used to form a single image. Then, SAR image sequence can be obtained from a sequence of respectively corresponding synthetic apertures. Based on the sequence of continuous SAR images, a video of the interested area can be formed. That is the reason for the name of ViSAR system.

2. Frame rate analysis

Since the spotlight-mode is used, the azimuth resolution of ViSAR system can be expressed by [1]-[3]

$$\rho_a = \frac{\lambda}{2 \cdot \alpha} \cdot k \tag{1}$$

where λ denotes the wavelength of the transmitted signal, α represents the angle through which the target is viewed during the coherent processing aperture, k is set to 1.2 based on experience.

According to the geometrical relationships of ViSAR, the synthetic aperture length can be denoted by $R \cdot \alpha$, where R is the operating range of ViSAR. Then, the synthetic aperture time can be written as [4]

$$T = \frac{R \cdot \alpha}{V} \tag{2}$$

where V represents the velocity of the platform. Therefore, the image rate or the frame rate can be given by

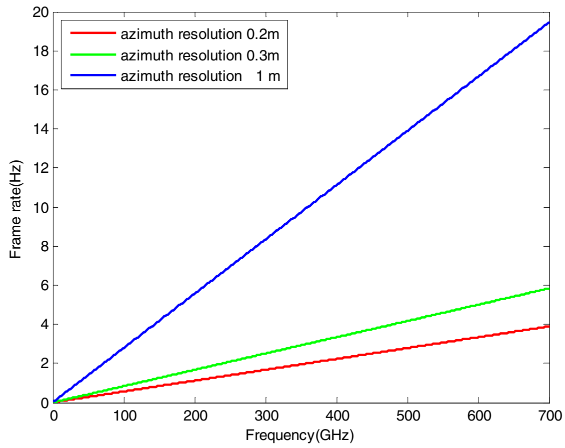
$$F = \frac{V}{R \cdot \alpha} \tag{3}$$

From equation (1) and (3), the frame rate can be further expressed by

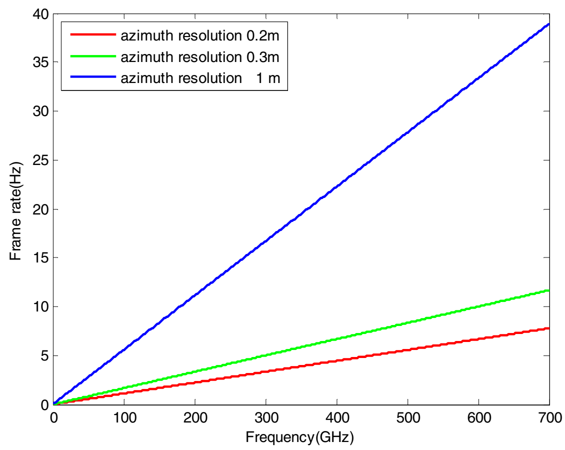
$$F = \frac{2 \cdot \rho_a \cdot V}{R \cdot k \cdot \lambda} = \frac{2 \cdot \rho_a \cdot V \cdot f}{k \cdot R \cdot c} \tag{4}$$

where c is the velocity of light, f is the carrier frequency.

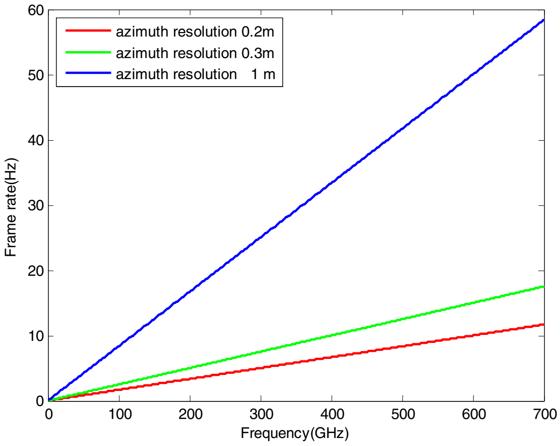
It is well known that the frame rate should be no less than 5Hz to make a video seem continuous, therefore we calculate the frame rate of ViSAR system with the practical system parameters. Suppose the operating range of ViSAR is 10km, and the platform velocity is set to 50m/s, 100m/s, 150m/s respectively. Then the curves of frame rate changes as a function of carrier frequency and azimuth resolution (see Fig.1).



(a) Platform velocity=50m/s



(b) Platform velocity=100m/s



(c) Platform velocity=150m/s

Fig. 1.The changing curves of frame rate.

Conclusion: From Fig.1, it can be seen that the frame rate is in direct proportion to the azimuth resolution, platform velocity and carrier frequency. That is, to achieve the frame rate of 5Hz, the carrier frequency should be set to 600GHz with platform velocity of 50m/s, 300GHz with platform velocity of 100m/s and 200GHz with platform velocity of 150m/s.

3. Overlap processing

According to the aforementioned analysis, the frame rate of ViSAR system put forward a high request for the system carrier frequency, which is difficult to realize at the current conditions. However, this problem can be solved through overlap processing in azimuth direction [5]-[8] (see Fig.2).

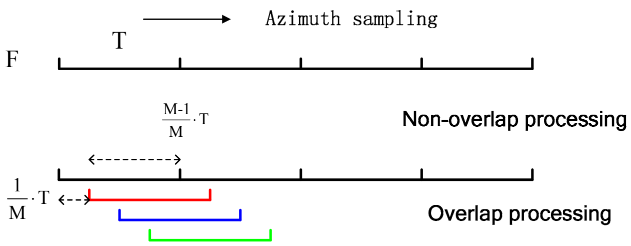


Fig.2. Non-overlap and overlap processing in azimuth sampling

In Fig.2, T is the synthetic aperture time and the frame rate is F for the non-overlap processing system. In overlap processing, the overlapping part is $\frac{M-1}{M} \cdot T$, where M is a positive integer. Then, it can be calculated that the frame rate is increased to $M \cdot F$ for overlap processing. For example, if M is set to 5, the carrier frequency of a non-overlap processing ViSAR system should reach 300GHz to let the frame rate greater than 5Hz. However, in the same condition, the carrier frequency is 60GHz for an overlap processing system which greatly reduces the difficulty for real ViSAR system realization.

4. Conclusion

In this paper, the mathematical expression of the frame rate in ViSAR system is derived. Besides, overlap processing is proposed to solve the requirement of a high carrier frequency. Other problem in system design, such as the maximum detection range and the diameter of maximum scene size, will be analyzed in the future.

Acknowledgment

This work reported herein was jointly supported by the Natural Science Fund Project in Jiangsu Province under Grant BK20150759 and the National Natural Science Foundation of China under Grant 61501231.

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