Modeling and Simulation of Rotating Targets Imaging in SAR

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In many cases, a target or a structure on the target may have micro-motions, such as rotations or vibrations. The source of rotations or vibrations might be a rotating antenna on a ship, mechanical oscillations in a bridge or a building, or other causes. In my research, rotating targets' imaging characters in SAR(Synthetic Aperture Radar) have been studied. The rotation might induce a frequency modulation on the returned signal that generates sidebands about the target's Doppler frequency shift. The echo of a rotating target can be modeled as the product of one specific cosinusoidal phase modulated signal and the echo of the rotating center, based on the analysis of the imaging geometrical scene(Fig. 1). Also the frequency spectrum of the cosinusoidal phase modulated signal have been obtained and analyzed by using Bessel function. Its effective frequency point number is depended on the rotating radius r_0 and frequency interval is depended on the rotating speed ω_r(Fig. 2). The imaging simulation of a rotating point target in SAR with different combinations
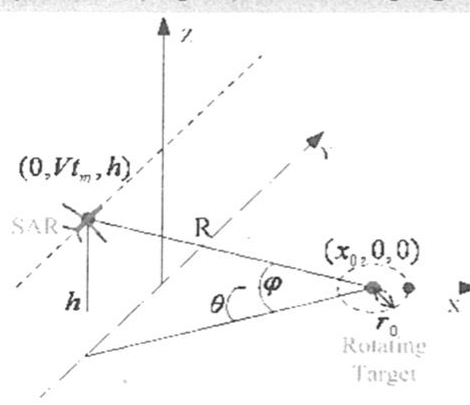
Echo of the rotating center

$$S(t,\omega)$$

Echo of the rotating target

$$S(t,\omega)\cdot e^{j\Delta\varphi(t_m)}$$

$$\Delta\varphi(t_m) = -4\pi\frac{r_0\cos\varphi}{\lambda}\cos[(\omega_r+\frac{V}{x_0})t_m]$$

Figure 1. The SAR imaging scene of the rotating target.

Where: $S(t,\omega)$ is the echo of the rotating center, $S(t,\omega)e^{j\Delta\varphi(t_m)}$ is the echo of the rotating target, $\Delta\varphi(t_m)$ is the cosinusoidal phase, ω_r is the

Frequency Spectrum of cosinusoidal phase modulated signal

$$S_{PM}(\omega) = \pi\sum_{n=-\infty}^{+\infty} J_n(4\pi\frac{r_0\cos\varphi}{\lambda})\left[e^{-jn\frac{\pi}{2}}\delta[\omega+n(\omega_r+\frac{V}{x_0})]+e^{jn\frac{\pi}{2}}\delta[\omega-n(\omega_r+\frac{V}{x_0})]\right]$$
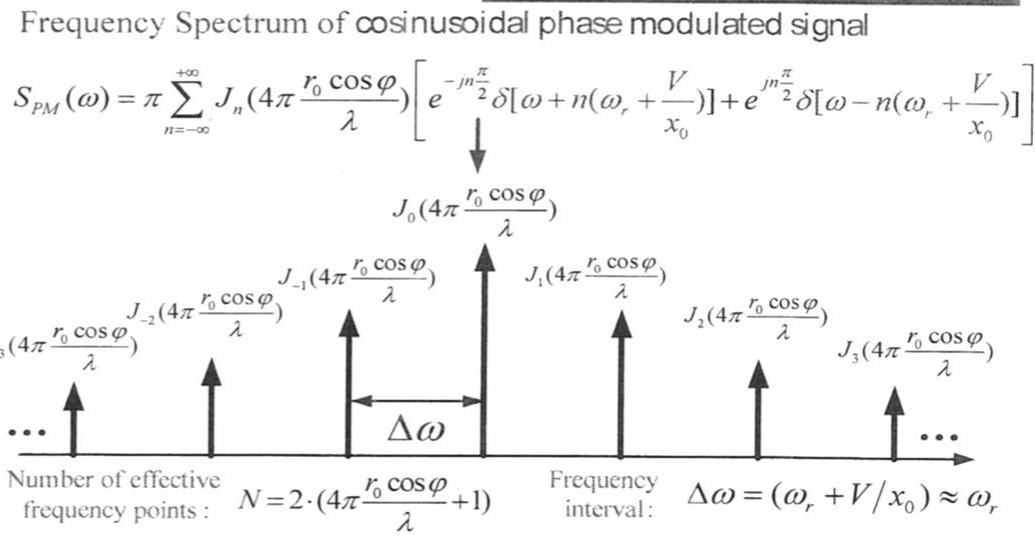
Figure 2. Analysis the frequency spectrum of the cosinusoidal phase modulated signal with Bessel function.

Where $J_n(\cdot)$ is the n-order

Number of effective frequency points : $N=2\cdot(4\pi\frac{r_0\cos\varphi}{\lambda}+1)$

Frequency interval : $\Delta\omega = (\omega_r+V/x_0)\approx\omega_r$
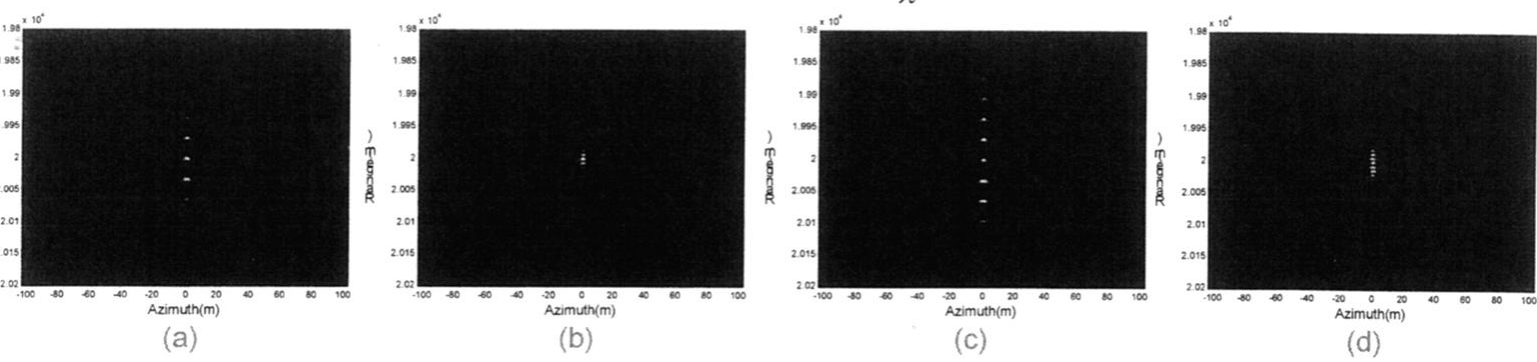

(a)　　　　(b)　　　　(c)　　　　(d)

Figure 3. The imaging simulation of a rotating point target in SAR with RD algorithm. Where N is

5 for figure (a) and (b), 9 for (c) and (d); $\Delta\omega$ is about 33(m) for figure (a) and (c), 3.3(m) for (b) and (d).