A NEW CALCULATION METHOD OF NUSAR FOR TRANSLATIONAL VARIANT BISTATIC SAR

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1. INTRODUCTION

Processing bistatic SAR data all through numerical calculating is the concept of NuSAR, which is firstly proposed by Bamler[1]. NuSAR concept can cope with those SAR configurations whose range equations are complicate and whose analytical expressions in frequency domain are difficult to find. But the NuSAR proposed by Bamler needs to truncate the SAR echo in translational variant case and needs to allocate an extra memory equaling to the SAR echo. This paper improves the NuSAR block scheme for the translational variant bistatic SAR and provides a new calculation method for NuSAR. The new calculation method can save half of the memory compared with Bamler's method and runs efficiently. Besides, the new calculation method can analysis lots of properties about the raw signal before imaging, which helps to choose the right imaging method.

2. NUSAR FOR TRANSLATIONAL VARIANT BISTATIC SAR

The block scheme of NuSAR for translational variant bistatic SAR is shown in Fig.1. Here the main transfer functions include:

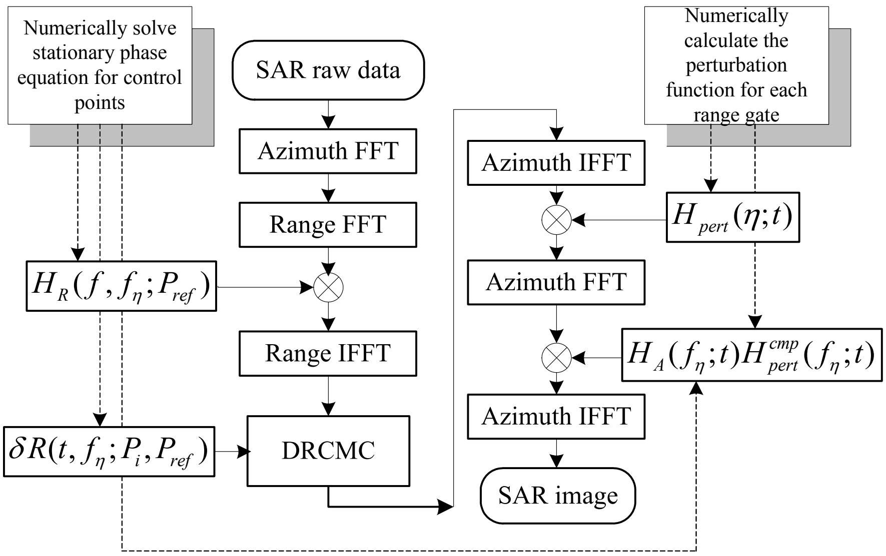

Fig.1 Block Scheme of NuSAR for translational variant bistatic SAR

1) the range processing function $H_R(f, f_\eta; P_{ref})$, which do the range compression, RCMC, SRC and all the higher order range phase compensation for the reference point P_{ref};
2) the differential range cell migration correction (RCMC) function $\delta R(t, f_\eta; P_i, P_{ref})$, which completes the RCMC for targets away from the reference point;
3) the azimuth perturbation function $H_{pert}(\eta;t)$ and the perturbation compensation function $H_{pert}^{cmp}(f_\eta;t)$ which is used to identify the Doppler FM rate within the same range gate and to minimize the perturbation phase error respectively;
4) the azimuth compressing function $H_A(f_\eta;t)$ which fulfills the azimuth compression for each range gate.

In translational variant bistatic SAR configuration, the Doppler FM rate changes not only in range direction but also in the azimuth direction. So the azimuth perturbation and compensation function is added to the flow to identify the Doppler FM rate in azimuth direction, so that each range gate can be processed by a unique matched filter.

3. NEW CALCULATION METHOD FOR NUSAR

The calculation proposed by Bamler begins from calculating the echo signal for a reference point in the time domain. The range processing function $H_R(f, f_\eta; P_{ref})$ is then obtained by 2D-FFT to the reference echo signal and conjugating the spectrum. This means an extra memory equaling to the SAR raw data size should be allocated. Here we use a different calculating method.

- Firstly, we calculate $H_R(f, f_\eta; P_{ref})$ by numerically solving the phase stationary equation below[2]

$$\frac{V_{Tx}(X_T + V_{Tx}\eta - x) + V_{Ty}(Y_T + V_{Ty}\eta - y) + V_{Tz}(h_T + V_{Tz}\eta)}{R_T(\eta; x, y)}\Big|_{\eta=\eta_c} + \frac{V_{Ry}(Y_R + V_{Ry}\eta - y) + V_{Rz}(h_R + V_{Rz}\eta)}{R_R(\eta; x, y)}\Big|_{\eta=\eta_c} = -\xi \quad \text{where } \xi = \frac{cf_\eta}{f_0 + f}$$

From the equation, it can be seen that, for a selected target (x, y) the stationary phase point η_c only depends on ξ. So once the curve of $\eta_c(\xi; x_{ref}, y_{ref})$ is obtained for the reference target, $H_R(f, f_\eta; P_{ref})$ at each (f, f_η), which corresponding to a unique ξ, can then be found by substituting $\eta_c(\xi; x_{ref}, y_{ref})$ to the phase term. This means only a curve of $\eta_c(\xi; x_{ref}, y_{ref})$ needs to be saved in the memory, so it's memory saving.

- Secondly, the differential RCMC function can be calculated by range-frequency curves through $f_\eta = -\frac{1}{\lambda}\frac{dR_{bi}(\eta; x, y)}{d\eta}$ (where $\lambda = c / f_0$) for some control targets and the reference targets. Then linear or quadratic polynomial interpolation is used to get the differential RCM in each range gate.
- Thirdly, azimuth compression function can also be calculated from the range-frequency curves for each range gate.
- Finally, the calculations of the azimuth perturbation and compensation function are described in the authors' former work [3].

If a 16 points sinc interpolation is used in DRCMC and quadratic polynomial interpolation is used in RCM and $\eta_c(\xi; x_{ref}, y_{ref})$ calculation, the complex multiplication times here without azimuth perturbation is $44N_A N_R$, while in Bamler's method it is $60N_A N_R$, when $N_A = N_R = 16k$. So the calculation method here is also efficient.

4. SIMULATIONS

The simulation results using the NuSAR provided above for a spaceborne-airborne bistatic SAR configuration are shown in Fig.2 and Table I. The width of the scenario in range direction is *16 km* while in azimuth is only *1.2 km,* which is limited by the co-working time of the satellite and the airplane. All targets are well focused. It verifies the correctness of the NuSAR proposed here.

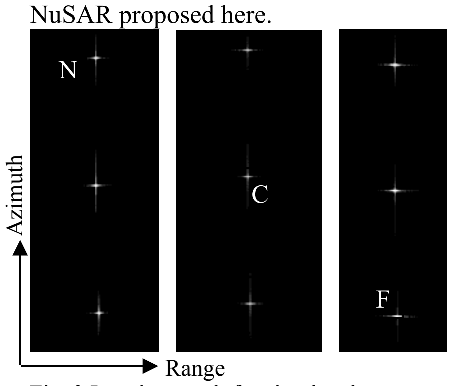

Fig. 2 Imaging result for simulated targets.

Table I Imaging quality for simulated targets

	Range direction				Azimuth direction			
tar.	Res. (m)	widen	PSLR (dB)	ISLR (dB)	Res. (m)	widen	PSLR (dB)	ISLR (dB)
N	1.521	1.035	-23.178	-17.520	5.295	0.980	-20.669	-15.057
C	1.448	1.035	-23.155	-17.505	5.299	0.981	-20.679	-15.081
F	1.401	1.033	-23.153	-17.505	5.299	0.981	-20.621	-15.068

5. CONCLUSION

This paper presents a NuSAR with azimuth perturbation, which can handle the translational variant case. And, it gives a new calculating method for this NuSAR with is memory saving and efficient. Simulations are exhibited to test the NuSAR method.

6. REFERENCES

[1] R. Bamler and E. Boerner, "On the use of numerically computed transfer functions for processing of data from bistatic SARs and high squint orbital SARs," in Proc. IGARSS, Jul. 2005, vol. 2, pp. 1051–1055.
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