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Bi-static forward looking using SAR imaging

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ABSTRACT: Conventional single-polarization radars have disadvantages compared to fully polar-metric radars for measurement of ocean wave characteristics. There is challenge in theoretical analysis of full polarization radar scattering. Prediction of classical composite model about cross-polarization component of normalized radar cross section is completely fails. SSA2 is new version of numerical implementation of small slope approximation. SSA2 correctly gives information about behavior of out of plane bi-static scattering. SSA2 shows opposite result of composite model for Bragg scattering of 2^{nd} order useful for modeling of cross-polarization scattering of rough surface.

KEYWORDS: SAR; Forward looking; back-projection; SSA2.

I.INTRODUCTION

One important application of the forward looking SAR imaging is aircraft landing system. Forward looking SAR system will helpful for pilot to land the aircraft securely in weather like dense fog etc. During this kind of weather visual ability of pilots is also significantly limited.

Disadvantages of Mono-static SAR

- Left/right ambiguity & low angular resolution.
- Principle of Doppler is used to locating symmetrically scatters in an illumined SAR that results small gradient of Doppler frequency in flight direction.
- In forward looking SAR system Doppler beam shaping mode used.
- For the antenna of the system must be specific aperture illumination function to maximize angular resolution.
- In this system two receiving antenna used on radar platform.

To remove this disadvantage of mono-static SAR Bi-static SAR is used for forward looking SAR imaging.

History of Forward Looking Imaging

In 1956 Texas Instruments began research on infrared technology that led to several line scanner contracts and, with the addition of a second scan mirror, the invention of the first forward looking infrared camera in 1963, with production beginning in 1966. In 1972 TI invented the Common Module concept, greatly reducing cost and allowing reuse of common components.

II.RELATED WORK

In [1] authors are modifying the LBF method and try to solve the instantaneous azimuth frequencies of transmitter and receiver directly. Then, we can obtain a bi-static point target reference spectrum (BPTRS), which is accurate enough for forward-looking configuration.

In [2]. Authors present analysis of the velocity resolution and the resolution of reconstructed reflectivity images. We analyze the error between the correct and reconstructed positions of targets due to errors in velocity estimation. Extensive numerical simulations demonstrate the performance of our method and validate the theoretical results.

III.SAR ALGORITHMS FOR BI-STATIC FORWARD LOOKING

Interpretation of back-projection as a linear & direct transformation process from radar echoes into complex SAR image. If g(t,Ʈ) is range compressed radar signal where,

t is azimuth time;

Ʈ is range time.

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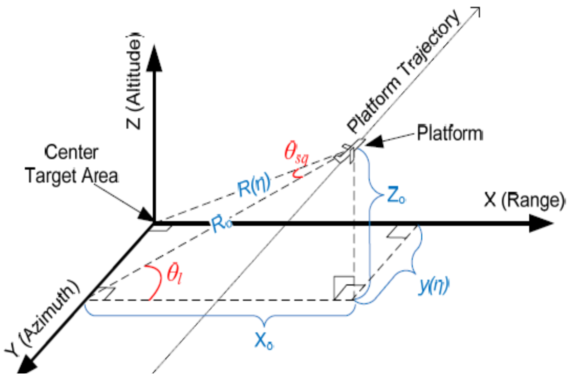

Fig-1 Three-Dimensional SAR Geometry

Then (x_m ,y_m) are sample of the SAR image in ground plane that reconstructed from superposition of back-projected radar echoes & represented as mathematically as follows.

$$h(\mathrm{xm}\,,\mathrm{ym}) = \int_{-t_i/2}^{+t_i/2} \frac{g(t,\ Rmn\,(t))}{2}\, dt \quad \ldots\ldots\ldots\ldots\ldots (1)$$

Where
C -velocity of light;
$R_{mn}(t)$ – bi-static range;
T_i –integration time.

$R_{mn}(t)$ is applied for all aperture position & all SAR image element. Radar echoes does not transform into SAR image directly first they intermediate into another form then interpolate SAR image, so that processing is time reduced. Let us consider a geometric shows fig-1 these geometrics are simulated with different parameter shown in table-1

Parameter	**Tx/Rx**	**Tx**
Frequency range	307-333MHz	307-333MHz
Platform speed	130 m/s	130 m/s
Flight altitude	600 m	600 m
PRF	1300 Hz	1300 Hz
Aperture step/length	0.1/600 m	0.1/600 m
Integration time *ti*	5 s	5 s
Minimum range *r*0	1000 m	1000 m
Antenna separation *d*	1.4 m	1.4 m

Table-1 simulation parameter of SAR imaging

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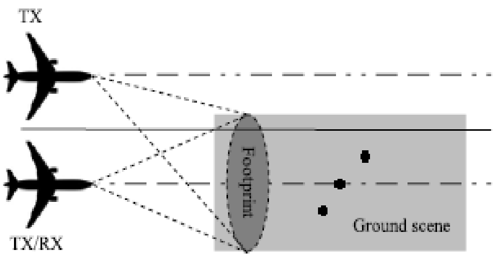

Fig-2 Bi-static geometries quasi-mono-static and azimuth invariant

IV.SIMULATION RESULTS

Quasi mono-static geometry

The arrangement of transmitter and receiver is like so that both are mounted on single platform and separated by distance of 3/2. GPS and navigation system is used in bi-static configuration for ground moving target indication. Narrow beam antenna is used & beam of antenna is illuminated the runway. Parameter shown in second column of table1 is used for simulation.

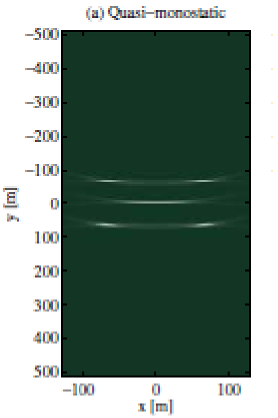

Fig-3 Forward looking bi-static SAR images of runway for quasi-mono-static.

The travelling distance of radar is approximated by two way travelling distance with respect to centre of transmitter & receiver. The result of simulation shows six targets but in actual there are only three targets this problem due to left/right ambiguity in forward looking & poor resolution in azimuth.Due to this problem two targets of centre merged together & not identify.

Azimuth Variant

In this case receiver & transmitter are mounted on separate platform & parallel to each other with same speed. Narrow beam antenna is used & beam of antenna is illuminated the runway. Parameters shown in second column are used for simulation of receiver & third column are used for simulation of transmitter. Time domain bi-static SAR algorithm used to reconstruction SAR image of same ground plane shown in figure-4 that shows exactly 3 targets. Simulation shows perfect result of targetthat targets are focused & located at correct coordinates.

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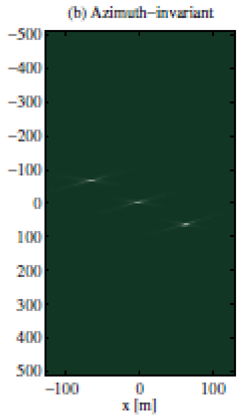

Fig-4 Forward-looking bi-static SAR images of runway for azimuth variant

Due to azimuth variant left/right ambiguity problem is solved & simulation shows only three target in SAR image. Due to azimuth variant model resolution in azimuth is improved than quasi-mono-static.

V.CONCLUSION AND FUTURE WORK

The Position of bi-static base line & antenna beam width are main reasons for left/right ambiguity problem in bi-static SAR imaging that valid for all geometries. Solutions for left/right ambiguity are follows:

1. Base line of bi-static forward looking SAR image is border for area of interest that is base line decide border of area.
2. Narrow beam antenna should be used.
3. Larger separation between receiving & transmitting antenna is required to avoid overlapping.

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