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Development and Implementation of The System Parameter Analysis Simulator for L-Band Synthetic Aperture Radar

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Feature of synthetic aperture radar

- **Supports high resolution image using relatively small antenna**
  - Synthesize the larger virtual antenna during the flight path
- **Use active sensor using microwave**
  - Transmits microwave signal and receives back-scattered signal from target
  - Acquires the images regardless of the weather/light conditions
- **Side-looking radar**
  - To avoid range ambiguities [5], [6]

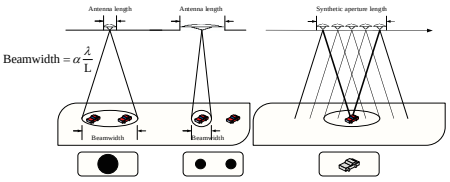

Fig. 2 Conventional Radar (left) vs. Synthetic aperture radar (right)

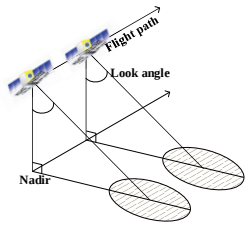

Fig. 3 The general side-looking SAR mechanism

[5] K. Tomiyasu, "Tutorial review of synthetic-aperture radar (SAR) with applications to imaging of the ocean surface," in *Proc. IEEE*, vol. 66, pp. 563-583, 1978.
[6] A. Moreira, P. Prats-Iraola, M. Younis, G. Krieger, I. Hajnsek, and K. P. Papathanassiou, "A tutorial on synthetic aperture radar," Geoscience and Remote Sensing Magazine, vol. 1, pp. 6-43, 2013.

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- ❖ Conclusion

SAR System Parameter Design

- **Requirements analysis**
  - Maximum range, altitude, minimum SNR, and etc.
- **Analysis on operation concept**
  - Platform velocity, operational frequency, and etc.
- **Calculation the system parameters**
  - Range and swath width, incidence angle, beam width, sampling window length, and etc.
- **Output parameters**
  - Antenna gain, resolution, SNR, and etc.

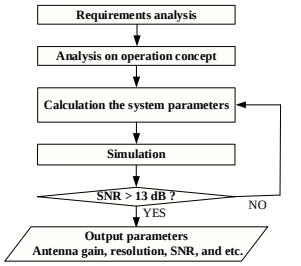


Fig. 4 Flow chart of the SAR system parameter calculation

SNR : Signal to noise ratio

Introduction

- **Synthetic aperture radar**
  - Radar which operates on the moving platform
  - National defense, disaster monitoring, resource exploration, and etc [1-3].
  - Especially L-band (1.27 GHz) SAR is used for the Earth observation

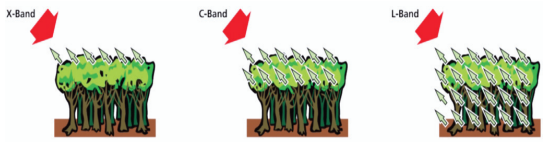


Fig. 1 Comparison of the penetration depth in X, C, and L-band[4]

[1] H. I. Yang, J. H. An, H. W. Jung, and J. H. Kim, "Circular Polarization Implementation on Synthetic Aperture Radar," in Proc. ICTC 2014, Busan, Korea, 22-24. Oct. 2014.
[2] A. Moreira, P. Prats-Iraola, M. Younis, G. Krieger, I. Hajnsek, and K. P. Papathanassiou, "A tutorial on synthetic aperture radar," Geoscience and Remote Sensing Magazine, vol. 1, pp. 6-43, 2013.
[3] J. Amini and J. T. S. Sumantyo, "Employing a method on SAR and optical images for forest biomass estimation," Geoscience and Remote Sensing, IEEE Trans. On, vol. 27, pp. 4020-4026, 2009.
[4] http://www.dlr.de/hr/en/desktopdefault.aspx/tabid-8113/14171_read-35852/

SAR System Parameter Design

Tab. 1 Calculated SAR system parameter

List	Item	Value
Operational concept	Altitude	600 km
	Platform velocity	7564 m/s
	Operational frequency	1.27 GHz (L-band)
	Look angle	32 °
Antenna concept	Antenna size	5 m (L) × 2.6 m (W)
	Antenna gain	32 dBi
Swath parameter	Range swath	70.87 km
	Azimuth swath	15.87 km
Range concept	Middle range	721 km
	Nadir to swath	382 km
Output parameter	Resolution	10 m (R) × 2.5 m (Az)
	SNR	27.05 dB

System Parameter Verification

❑ Antenna beam pattern analysis

➢ To verify the designed system parameters

- ✓ Output range direction antenna beam pattern
- ✓ Confirm the SNR requirement in printed area

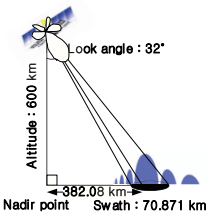


Fig. 5 Geometry concept of simulation

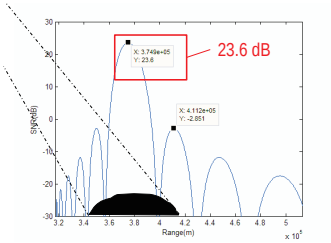


Fig. 6 Antenna beam pattern

System Parameter Verification

❑ Point target simulation

A. Set the point targets to observe using SAR

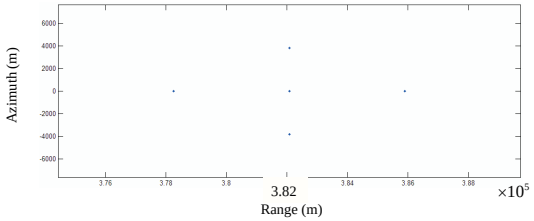


Fig. 9 Five point target

System Parameter Verification

❑ Point target simulation

➢ To verify the designed system parameters

- ✓ Targets are arranged in cross shape in printed area
- ✓ Raw data is generated by observation simulation and chirp signal generation
- ✓ Image processing using Range-Doppler algorithm
- ✓ Confirm the restored point targets

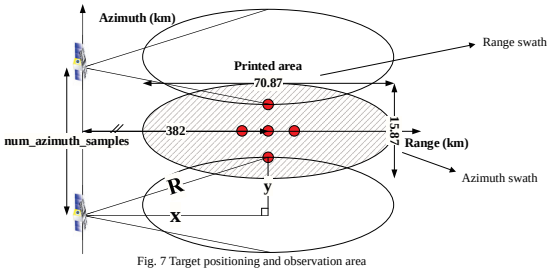


Fig. 7 Target positioning and observation area

System Parameter Verification

❑ Point target simulation

B. Obtained raw data by observation simulation

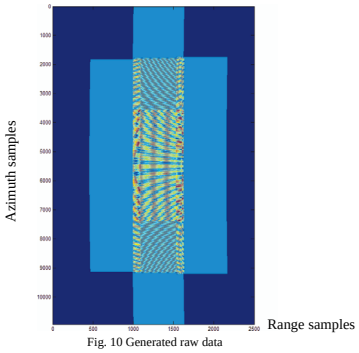


Fig. 10 Generated raw data

System Parameter Verification

❑ Point target simulation

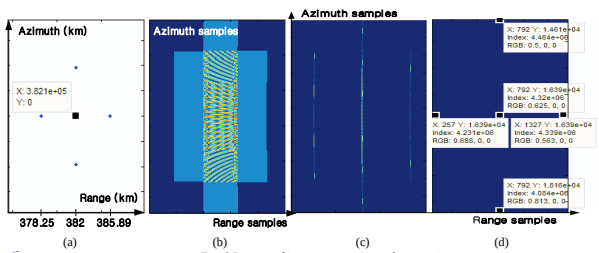
➢ To verify the designed system parameters

(a) The point targets

(b) Raw data

(c) Pulse compressed image

(d) Restored point targets after azimuth compression



(a) (b) (c) (d)

Fig. 8 Process of image processing and restoration

System Parameter Verification

❑ Point target simulation

C. Get the pulse compressed image using RDA algorithm

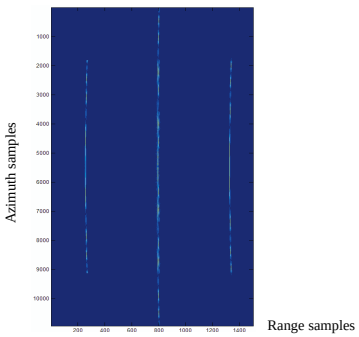


Fig. 11 Pulse compressed image

System Parameter Verification

- **Point target simulation**

D. Restored point targets after azimuth compression

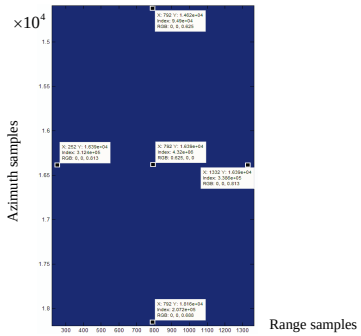


Fig. 12 Azimuth compressed image

Reference

[1] H. I. Yang, J. H. An, H. W. Jung, and J. H. Kim, "Circular Polarization Implementation on Synthetic Aperture Radar," in Proc. ICTC 2014, Busan, Korea, 22-24. Oct. 2014.

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[3] J. Amini and J. T. S. Sumantyo, "Employing a method on SAR and optical images for forest biomass estimation," Geoscience and Remote Sensing, IEEE Trans. On, vol. 27, pp. 4020-4026, 2009.

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[5] K. Tomiyasu, "Tutorial review of synthetic-aperture radar (SAR) with applications to imaging of the ocean surface," in *Proc. IEEE*, vol. 66, pp. 563-583, 1978.

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System Parameter Verification

- **Additional Image Processing**
  - To enhance resolution of the point target

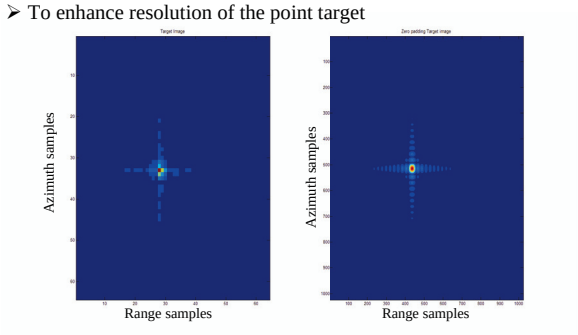

Fig. 13 Target image (left) vs. Zero padding target image (right)

Thank you

Conclusion

- **L-band SAR system parameter for earth observation has been designed and verified by simulation**
- **SNR has been calculated by antenna beam pattern analysis and is satisfied over 13 dB**
- **Point target analysis has been simulated and the simulation can be restored point target**
- **Planning to specify the parameter design and improving of MATLAB code to enhance resolution and to apply real satellite**