Simulation of JERS-1 SAR Images with Map Information

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It is not easy to identify a ground control point (GCP) or even locate its vicinity from a SAR image. Although simulated SAR images may be useful to interpret mountain areas, they are not useful in flat areas because they do not show ground coverage or key features such as rivers, lakes and roads. In this study, we developed a method to simulate SAR images integrating geographical features to DEM to facilitate to locate ground control features from SAR images.

1. Introduction

SAR is capable of observing under any weather conditions and it is suitable to monitor global environment and disaster. However, it is not very easy to interpret SAR images, especially to locate or identify features in the images because of peculiar topographic distortions, its backscattering intensity dependence on many parameters and speckle noise [1].

We have been identifying GCPs such as corner reflectors or other ground features from JERS-1 SAR images [2,3]. Simulated SAR images may be helpful to interpret hilly areas roughly. However, they are not useful to locate point-like features in flat areas precisely because they cannot display the differences of ground coverage or key geographical features such as rivers, lakes and roads. In this study, we developed a method to simulate SAR images integrating geographical features to DEM to facilitate to locate ground control features from SAR images.

2. Data and Study Areas

We used Digital Map 50m Grid (Elevation) and Digital Map 25000 published by Geographical Survey Institute. The resolution of DEM is about 50m and its unit of height is 10 cm. Although both DEM and Map 25000 exactly correspond to the same area, the coordinates of DEM are described in ellipsoidal angles (Bessel) and those of Digital Map 25000 are the UTM projections of the same ellipsoid. DEM is divided into 200×200 pixels and the map is divided into 4549×3698 pixels. In this study, we did not apply an inverse UTM projection to Digital Map 25000 data to match DEM coordinates but simply re-sampled the map.

In Digital Map 25000, there are several color coded geographical features that are extracted easily: 1) roads, rail roads and buildings, 2) national high ways, 3) vegetated areas, 4) elevation contours and subways, 5) water lines, 6) water regions and 7) annotations. In this study, we integrated 2) and 6) as geographical map information.

Omaezaki area (Single look simulation)

Omaezaki, Shizuoka is a well-known port city on the shore of Pacific Ocean and located at about 100-km southwest of Mt. Fuji. The map code of the area is 513871 Omaezaki. The SAR data (©MITI/NASDA) to be compared was observed on May 16,1997 and was processed by an EVSARP processor of Atlantis Corporation.

Fuji-no-miya city and vicinity (Three look simulation)

Fuji-no-miya city is located on the south-west foot of Mt. Fuji. Here we combined two maps (Kamiide and Fuji-no-miya). Map codes for Kamiide is 523874 and that for Fujino-miya is 523864. The SAR image observed on April 23, 1992 was extracted from 3-look JERS-1 SAR image of Mt. Fuji area included in NASDA-0001 CD-ROM "SAR and Optical Data set".

3. Method

We simulated a single-look SAR image of Omaezaki area integrating some geographical features as follows:

1) Extraction of Map features. Although we are able to observe color-coded features separately on the viewing system of Digital Map 25000, features in this study are contaminated with annotations because those features were directly extracted from the original TIFF data using a commercial software. Only water regions (rivers, lakes and sea) and roads (national highways) were used in this study.

   Rivers, lakes and roads: We did not apply a further pre-processing to these features.

   Coastal lines: We extracted water bodies and removed small lakes and ponds or thin rivers to obtain a sea area. Then we inverted the sea area to create a land mask and eliminated areas smaller than 1000 pixels (such as annotations in the sea). Then we eroded the land mask and subtracted it from the original land mask to obtain a coastline mask.

2) Size Conversion. We expanded the size of DEM 5 times to match approximately the slant range pixel size of observed SAR image. The corresponding map was re-sampled to match the size of the expanded DEM. Fig.1 shows DEM image of Omaezaki area. In this image, a brighter area corresponds to a higher elevation area and a darker area corresponds to a lower area. Fig.2 shows the extracted geographical features from Map 25000. Here black areas correspond to water regions, gray areas correspond to coastal lines and light gray areas correspond to roads. We noted that eastern coastlines of Digital Map 25000 are extended to the east considerably.

3) Elevation of Map Features. We added elevation information on geographical features as follows:

   Water regions and roads: A water body mask or a road mask was multiplied by DEM to create DEMs of those features.

   Coastlines: The elevation of the coastal lines was set to 1m high. Then an eroded land mask was applied to the enlarged DEM to clear everything outside. Finally the coastline DEM and the eroded DEM are added together to have the enlarged DEM with modified coasts.

   Single-look JERS-1 SAR Simulation. Single-look JERS-1 SAR images were simulated from an ordinary DEM, a DEM with a modified coastlines, a DEM of rivers and lakes, and a DEM of roads separately using an Earth View system of Atlantis corporation and JERS-1 SAR parameters (see Tab.1).

4) Overlay of simulated Map Features. The simulated images of water regions and roads were then binarized and overlaid to the simulated image from the DEM with modified coastlines.

Fuji-no-miya area was simulated similarly but this area does not have coastal lines.

Fig.1: DEM image of Omaezaki Area

Fig.2: Some Map features of Omaezaki Area

Tab.1: JERS-1 SAR parameters that we assumed in simulation

Top-left_corner_ lat Top-left_corner_long	34° 35′ 9″ N 138° 7′ 27″ E
Inter-row_spacing Inter-column_spacing scale offset	0.3° 0.45° 0.1m/unit 0
tie_point_lat tie_point_long altitude heading minimum_look_angle simsar_azimuth_line_spacing simsar_range_sample_spacing	35° 8′ 0″ N 138° 45′ 0″ E 568000m 188° 35° 4.5m 8.8m

4 Result and Discussion

4.1 Omaezaki Area (Single-look Simulation)

Fig.3, Fig.4 and Fig.5 are the observed SAR image, a SAR image simulated from DEM, and a simulated SAR image with some geographical features, respectively. These images roughly correspond to the right bottom quarter part of Fig.1 and Fig.2.

Fig.4 appears as square tiles piled up and presents only terrain undulations and no cities, rivers and roads. Therefore it is difficult to correspond the observed SAR features to the simulated image.

Fig.5 shows a simulated SAR image integrating geographical features. There are rivers, lakes, roads and harbor features. Therefore we can more easily correspond the features in the simulated image to those in the observed image. Coastlines of this image are similar to those of the observed SAR image. Western coastal lines particularly well correspond to those of the observed image. However, there are still not enough geographical features in the simulated image to identify or locate GCPs or their vicinities in the observed image accurately.

Fig.3: Observed SAR image of Omaezaki area (roughly corresponds to a lower right quarter of Fig.1 and Fig.2.)

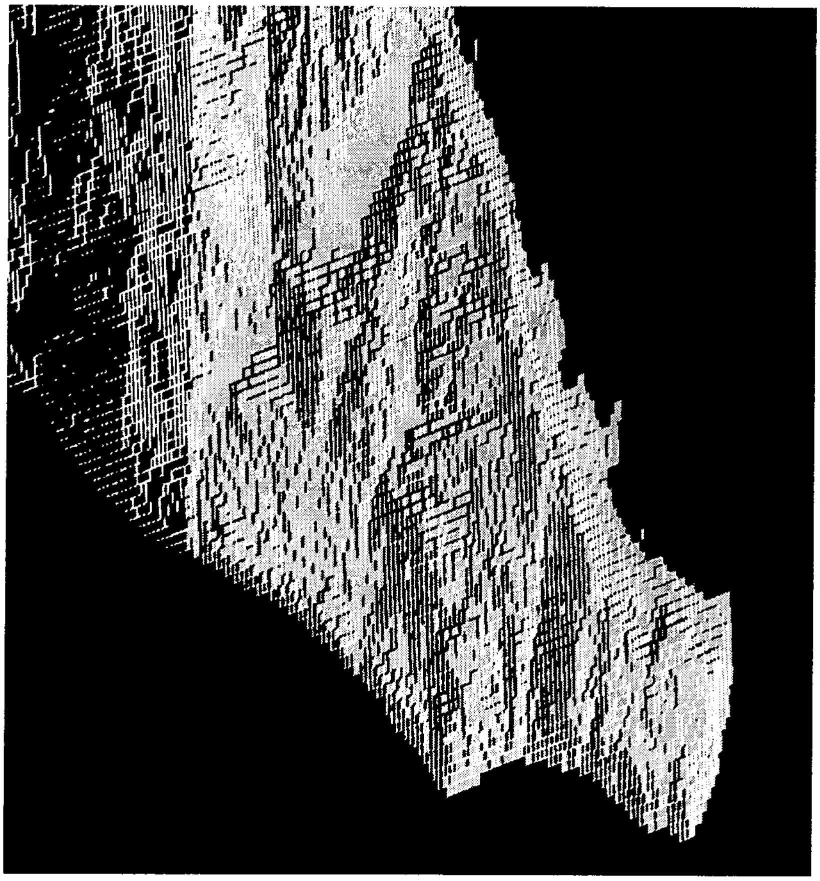

Fig.4: Simulated SAR image from ordinary DEM (roughly corresponds to a lower right quarter of Fig.1 and Fig.2.)

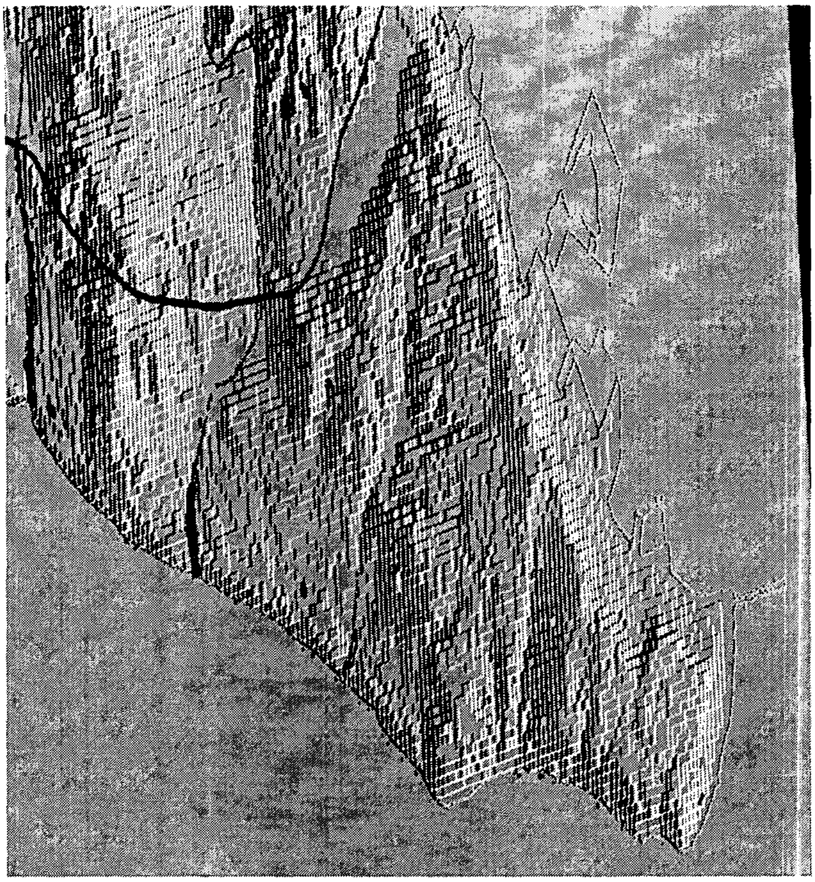

Fig.5: Simulated SAR image with geographical features (rivers, lakes, national highways and coastal lines (roughly corresponds to a lower right quarter of Fig.1 and Fig.2.)

4.2 Fuji-no-miya City and its Neighborhood (Three Look Simulation)

Fig.6 shows a simulated JERS-1 SAR image from DEM and Fig.7 shows an observed SAR image. It is possible to match two images in mountainous areas approximately, but not in flat areas.

Fig.8 and Fig.9 show simulated SAR images integrating rivers and national highways, respectively. Fig.7 roughly corresponds to an enclosed area in Fig.8 or 9.

5. Conclusion

We simulated SAR image with DEM adding geographical features. This is the first step to integrate geographical features to DEM to facilitates to locate ground control features. As a future study, we will integrate more roads and small streams to locate these features accurately.

6. Acknowledgment

We expressed grateful feeling to Array Corporation for processing single look JERS-1 SAR image.

7. Reference

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[3] T. Sakurai-Amano et al., "Detection of handy CR from SAR Imagery", Proc. RR Soc. of Japan, November, 1997, etc.

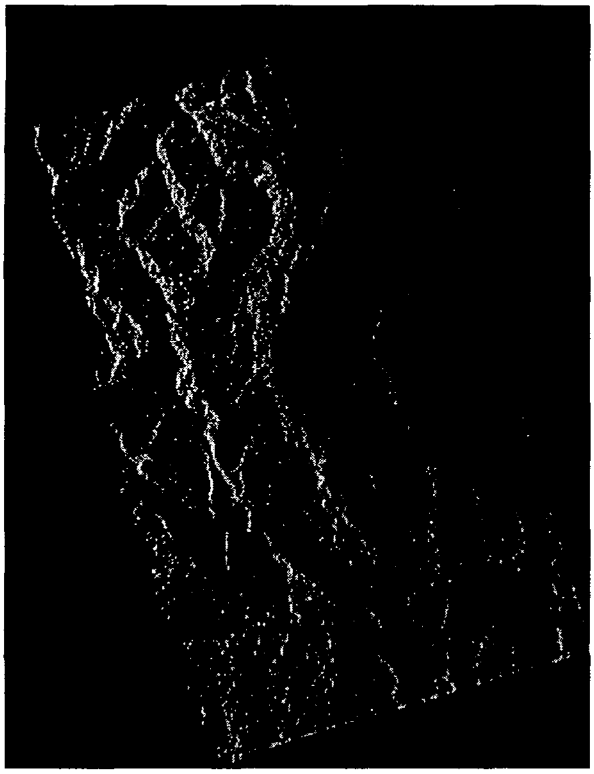

Fig.6: Simulated SAR image using only DEM

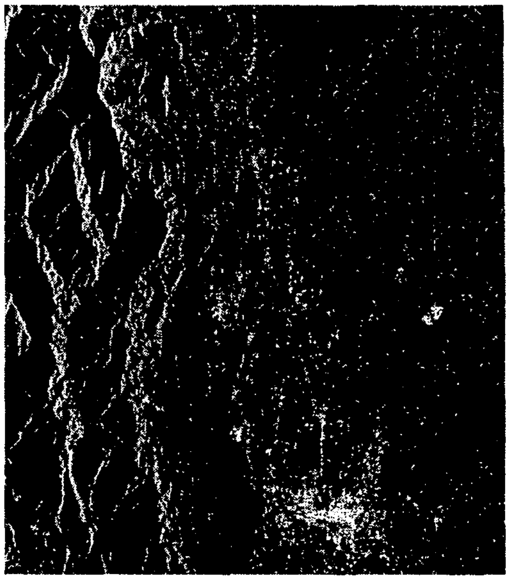

Fig.7:Observed 3-look Jers-1 SAR image of Fuji-nomiya city and its vicinity.

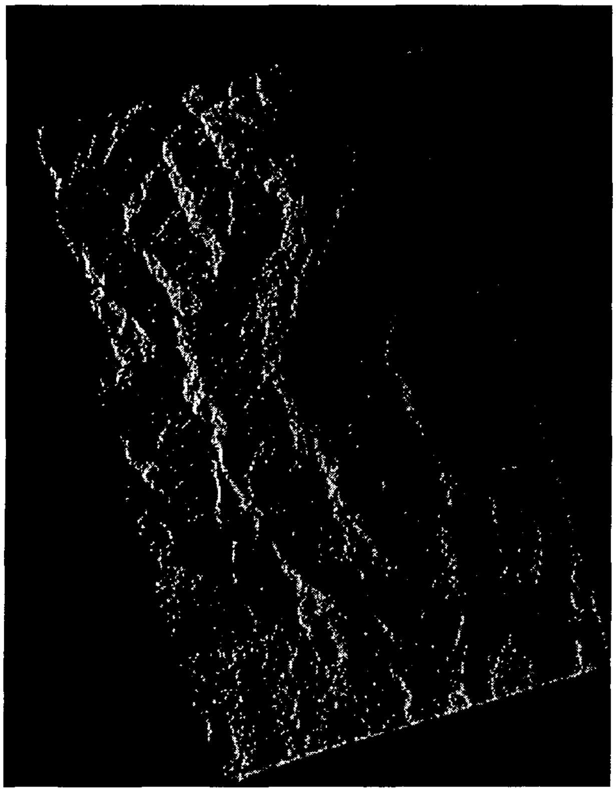

Fig.8: Simulated SAR image includig rivers.

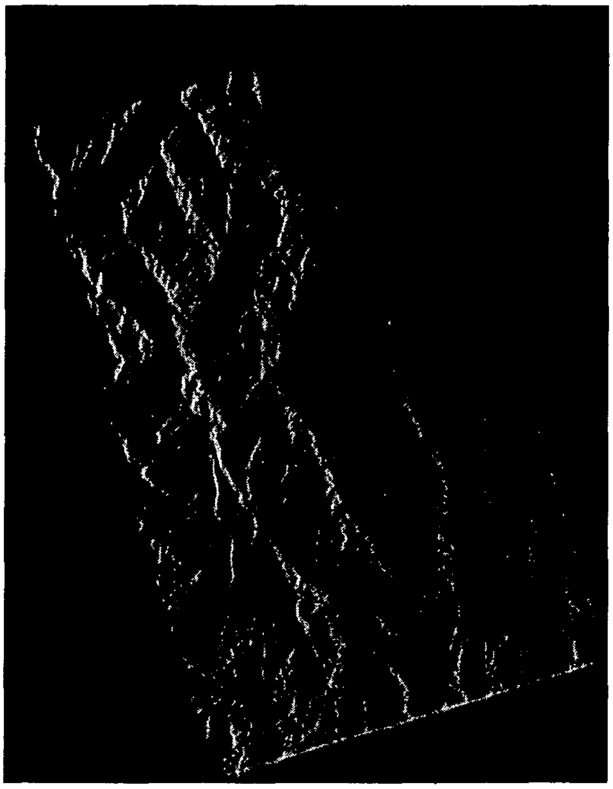

Fig.9: Simulated SAR image including national highways.