

SIDE-LOOKING RADAR USING ANALYTICAL PLOTTERS

Sherman S. C. Wu and Francis J. Schafer
and contributions by Loretta Barcus
United States Geological Survey
Flagstaff, Arizona 86001

ABSTRACT

The imagery from airborne side-looking radar is essentially a representation of line-scan geometry rather than a plane as in a point perspective projection. Using analytical plotters for radar mapping involves two approaches: off-line and on-line. The off-line approach uses current digital image-processing technology to computer-rectify and correct geometric distortions of side-looking radar imagery so that the analytical photogrammetric plotters, presently available, can be used for map compilation. The on-line approach directly programs all computations of geometric corrections into an upgraded analytical plotter so that corrections can be performed in real-time during map compilation. Along with test results, this paper discusses the off-line processing of the Phoenix test area using data from the NASA radar system and introduces the development of the on-line approach.

INTRODUCTION

High resolution side-looking radar is really an invaluable "all weather" mapping tool. It is perhaps the only reasonable way that mapping can be performed for the areas of the Earth which are almost always covered by clouds and for mapping the Planet Venus which is entirely covered by clouds. Because of this, map compilation using stereo radar imagery is very desirable and has previously attempted. Due to the uniqueness of radar geometry, which is essentially effected by its method of illumination and image formation, stereo radar imagery has not been thoroughly analyzed in the past to any great extent (Leberl, 1977), and topographic contour maps cannot be directly compiled on conventional stereo photogrammetric equipment. Research to solve the problems inherent in extracting topographic information from radar imagery using analytical plotters is approached in two phases (Wu, 1979). Phase 1 is to apply current technology of digital image processing to computer rectify the radar imagery so that the present available analytical plotters can be used for map compilation. Phase 2 is to interface a high-speed digital computer to an analytical plotter for enhancing the programming flexibility so that all computations of geometric rectification and corrections can be performed in real-time during the processing of model orientation and map compilation.

Research tests in the Phase 1 approach include off-line computerized rectification of stereo side-looking radar images for compilation on the AP/C analytical plotter. The images are of Huntsville, AL, Pinedale, WY, and Phoenix, AZ. All were acquired using different radar systems. Development in the Phase 2 approach

includes the use of an upgraded AS-11A analytical plotter and the interface of a Modcomp computer to the only existing radar stereoplotter developed by the Goodyear Aerospace Corporation for the Army Engineering Topographic Laboratory.

METHOD AND TEST RESULTS

Radar imagery constructed by a radar correlator processor represents a line-scan geometry. In order to use the AP/C analytical plotter, the radar imagery is first digitized by an Optronics device. By applying computer digital image-processing techniques, the digital data is then rectified from the line-scan geometry to an equivalent of a point-perspective frame picture. The rectification is performed using a gnomonic projection. The rectification can be performed pixel by pixel using a general purpose computer with magnetic tape output to an Optronics Photowrite. The Optronics writes the image on photosensitive film.

A pair of radar imagery of the Huntsville area taken by a UPD-4 radar system was tested for computer rectification. The original photo scale is 1:100,000 with a ground resolution of 10 feet. A stereo model was established on the AP/C analytical plotter using pre-computed model parameters. But due to the fact that this pair of radar imagery was taken from the same side the base-to-height ratio is so small that photogrammetric compilations and measurements could not be performed.

A second attempt was to rectify a pair of stereo radar imagery of a glacial lake of Pinedale, Wyoming, looking from the same side but using different modes of the NASA radar system. Different modes have different depression angles (the depression angle of mode 1 is 57° and mode 2 is 36°). This makes the base-to-height

ratio larger so that it is then possible to compile a contour map from the model on the AP/C analytical plotter. However, due to the fact that very severe distortions occurred in the model 1 imagery from an unknown error source in the radar system, the map compiled from the model has large errors when compared with a standard U. S. Geological Survey 1:62,500 topographic map.

Because the mode 1 of the NASA radar system has system errors, a third test was made. In this test a pair of stereo radar, mode 2, imagery was rectified. This imagery cover Phoenix (Arizona) area and was taken by the Defense Mapping Agency. This pair of radar imagery was taken from opposite side and therefore has very strong geometry. A stereo model was set up on the AP/C analytical plotter and photogrammetric measurements were made along with a map compilation.

The radar imagery was taken at an altitude of 60,000 feet and has a scale of 1:200,000. The resolution of the radar system is about 50 feet. However, the scale of the rectified photographs is 1:800,000. The map was compiled at a scale of 1:250,000 so that a comparison can be made with the U. S. Geological Survey 1:250,000 topographic map. But due to the fact that the covered area between Phoenix and the White Tank Mountains, is very flat, the planimetry was compiled from the model. Ground coordinates and elevations of about 150 discrete points were also measured. The planimetry compiled from the rectified radar model on the AP/C analytical plotter matches the U. S. Geological Survey topographic map fairly well. Eighty-eight elevations measured from the model were compared with the U. S. Geological Survey 1:250,000 topographic map, about one third of the elevation differences are less than 5

meters, 50% of the elevation differences are less than 10 meters, 68% less than 20 meters, 86% less than 30 meters and 92% less than 40 meters. However, when the horizontal coordinates read out from the model are compared with those measured from the map, about 60% of the horizontal displacements are less than 250 meters and 90% less than 400 meters, which are 0.3 and 0.5 millimeters at the photo scale.

The phase 2 approach is to use a Modcomp computer which is interfaced to an AS-11A analytical plotter. Since the Modcomp computer is Fortran programmable, all rectification and geometric distortion corrections can be programmed into the plotter and will be performed in real-time. The Modcomp computer has a 64k core memory. Peripherals include 2 magnetic tape drives, 3 disks, a card reader and DEC terminal. All computer components have been interfaced. The software modification is currently in progress.

In parallel with the development of the modification of the AS-11A analytical plotter, the phase 2 approach also includes interfacing of the Modcomp computer to the existing radar stereo plotter which is currently in progress.

DISCUSSION

In either the on-line or the off-line approach, the capability of the analytical plotter system is essential to the development of the stereo mapping problem using side-looking radar imagery. With computer rectification in the off-line processing, an ordinary analytical plotter can be used for mapping using radar imagery. The accuracy of the products is not yet adequate for standard mapping. However, through long range research the analytical plotter

system may be developed for stereo mapping with side-looking radar imagery.

REFERENCES

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