AUTONOMOUS AND CONTINUOUS GEORECTIFICATION OF MULTI-ANGLE IMAGING SPECTRO-RADIOMETER (MISR) 1MAGER%

ABSTRACT

The Multi-Angle imaging Spectro-Radiometer (MISR) is part of an Earth Observing System (EOS) payload to be launched in 1998. The purpose of MISR is to study the ecology and climate of the Earth through the acquisition of systematic, global multi-angle imagery in reflected sunlight. The instrument flies in a sun-synchronous 705-km descending polar orbit, and is capable of global coverage every nine days. MISR will acquire multi-spectral images at nine discrete angles relative to the local vertical. Four of the nine push-broom cameras are pointed forward of the spacecraft position, one pointed at nadir, and four pointed in the aftward direction.

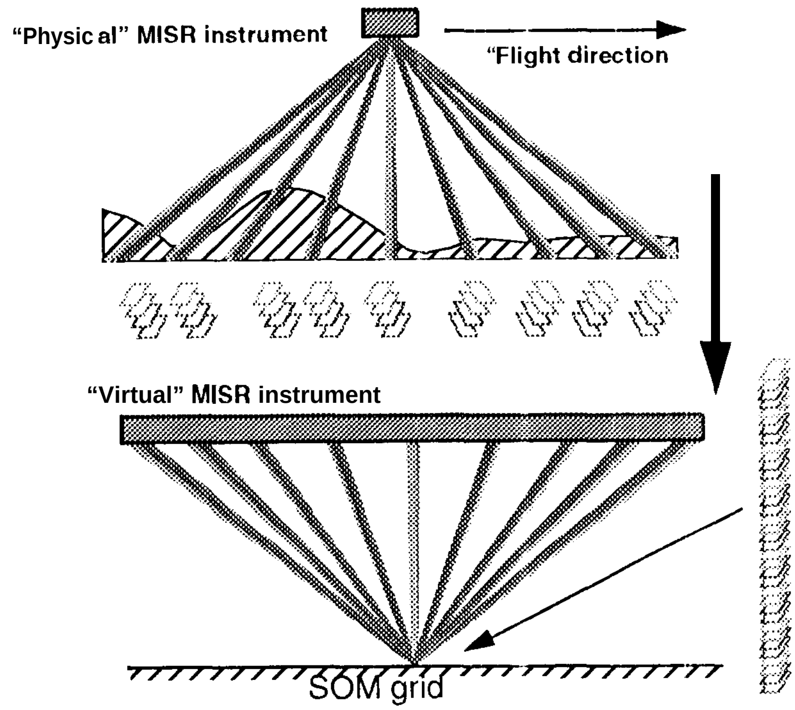

Figure 1: Georectification of MISR imagery: From "physical" to "virtual" instrument,

in order to derive geophysical parameters such as aerosol optical depth, bidirectional reflectance factor, and hemispheric reflectance, measured incident radiances from all nine cameras must be coregistered. Furthermore, the coregistered image data must be geolocated in order to meet experiment objectives such as: a) produce a data set of value to long-term monitoring programs and allow intercomparassions of data on time scales exceeding that of an individual satellite, and b)

provide Earth observing System (EOS) synergism, and allow data exchange between EOS-platform instruments.

This paper describes theoretical concepts underlying the algorithm responsible for the automatic and continuous coregistration and geolocation capability of MISR ground data processing software. The final product of this part of MISR standard processing is a set of orthorectified images projected to a georeferenced grid based on the Space Oblique Mercator (SOM) map projection. These images are known as the Georectified Radiance Product (GRP) and they are required input to the segments of standard processing that produce geophysical data products. If the GRP is looked upon as the data collected by the "virtual" MISR instrument (see Figure 1), then the subject of this paper is the approach taken for on-line transformation of the data taken by the "physical" MISR to the data which would be taken by the "virtual" MISR.

Major challenges in designing the approach to be used occur in the areas of:

a) Removal of the errors introduced by inaccurate navigation and attitude data.
b) Removal of the distortions introduced by surface topography.
c) Achieving a balance between limited hardware resources, huge data volume and processing requirements.
d) Autonomous and non-stop aspects of the production system.

The selected approach makes use of ancillary datasets such as a set of Projection Parameters (PP) and Reference Orbit Imagery (ROI) produced at the beginning of the mission. The major information indirectly contained in these datasets are error free navigation and attitude data, georeference, and surface topography relative to the various geometries of the nine MISR cameras. This information is routinely exploited through a hybrid image registration algorithm. In particular, image registration between ROI and new MISR imagery, consist of the following elements:

a) Image Point Intersection (IPI): a backward projection function used to provide initial location of the conjugate points.
b) Image matching for the precise identification of the conjugate points.
c) Transformation (mapping) function between two images.

The registration method is adaptive with regards to the character and size of misregistration, in order to minimize the size of the processing load. The adaptive nature of the algorithm is attained by recursively dividing images into subregions until the required registration accuracy is achieved. initially, due to the push-broom nature of the MISR cameras, subregions are rectangles extending over the image in the cross-track direction. The mapping function associated with a subregion is a modification of the affine transform which includes known geometric characteristics of the MISR imaging event. Once the mapping, between two images is established, the last processing step is the assignment of the appropriate radiance value to the grid point of the SOM map. This is done by one of the standard (e.g. bilinear) resampling methods.

Additional techniques are required so that autonomous production runs are unaffected by the less than perfect input data. Some of the more obvious examples are the presence of cloudy regions, water bodies, and deserts. These types of condition significantly reduce the number of the conjugate points available to determine the transformation function. In such cases additional techniques must be implemented. **in some** cases, search for the cloud-free land in the local neighborhood may be sufficient. In another case, where a large region of data is without conjugate points, use of the information obtained through the registration of the closets subregion is applied. The idea is to correct for slowly varying parameters through the use of a Kalman filter built while processing previous subregions. Also included in the algorithm is a blunder detection technique aimed at removing possible blunders coming from the image matching. This utilizes statistic results obtained from the least-square estimation of the transformation function.

Delivery of the beta version of the production software is expected to be in February of 1996, following an extensive prototype and testing phase. Landsat TM images and associated DEM have been used to produce simulated MISR data, and navigation and attitude data errors are included. The ERDAS "Imagine" image processing and GIS software is used as the environment for the visual and qualitative assessment of the test results. The various test cases targeting separate elements of the algorithm and ultimately coregistration and geolocation accuracy of the final product are discussed in the paper. Testing has demonstrated that accurate georectification of MISR imagery is feasible in a autonomous and continues process.