

## ABSTRACT

Rujikietgumjorn, Wasin Ph.D., Purdue University, May 2010. Photogrammetric Model-Based Registration and Fusion of Multiple Types of Passive Imagery. Major Professor: Edward M. Mikhail.

Image registration is a broad topic which is not only applied to photogrammetry and remote sensing problems, but also to medical imaging, pattern recognition, and computer vision activities. Image registration can be categorized into non-photogrammetric (or non sensor model-based) and photogrammetric (or sensor model-based). Registration problems can also be classified into 2D-to-2D, 3D-to-2D, and 3D-to-3D. In this thesis, we mainly focus on 2D-to-2D and 3D-to-2D image registration.

The primary thrust of this thesis is in three main areas: replacement sensor model, epipolar image rectification, and image registration. Several types of image acquisition datasets, from aerial frame, airborne whiskbroom, and satellite pushbroom (linear array scanners) passive sensors, are used. Knowledge of sensor model can be used to relate three-dimensional object data to corresponding two-dimensional image data (i.e. 3D-to-2D registration). These can be categorized into the original physical/geometrical models, or their replacement models. A novel approach, termed “generalized True Replacement Model (TRM)”, is developed to satisfy the following characteristics: highly accurate ground-to-image function, rigorous error propagation, and an ability for model parameter refinement. More importantly, the generalized TRM can perform relative triangulation without any use of ground control points (GCPs) in a manner similar to the original model. The generalized TRM was suc-

cessfully implemented with no significant difference in triangulation results with the physical model.

Epipolar rectification of scan imageries is a challenging problem since unique epipolar geometry might not exist, unlike frame images. A new approach for epipolar rectification of scan imageries is proposed to minimize y-parallax in the rectified images. Several experiments are conducted to assess the effect of different stereo geometries, on epipolar rectification, from along-track and across-track stereo pairs. The results show that a reduction of y-parallax to the sub-pixel level for OrbView, QuickBird, and HyMap (whiskbroom) pairs. This allows stereo anaglyph images to be generated. It is concluded that very acceptable results can be produced for stereo images either from satellite or airborne scan sensors.

For 2D-to-2D registration, transformations such as affine, projective, or polynomials were investigated since they are commonly used in non-photogrammetric registration. Decrease in registration accuracy is found when terrain variation is increased. Several experiments on sensitivity analysis and error propagation are performed to evaluate this approach. Relative triangulation is the technique used in the 2D-to-2D photogrammetric registration. Similar experiments on sensitivity analysis and error propagation are performed and the two approaches compared. Photogrammetric registration requires object surface information. Therefore, a reconstruction technique, based on dynamic programming, for digital surface model (DSM) is developed. The DSM results show promise in that the results are comparable to those generated from NGATE in the Socetset commercial software. Finally, comparison of photogrammetric registration to non-photogrammetric registration clearly indicated that in urban areas the photogrammetric approach is superior. In general, caution should be exercised, when using non-photogrammetric registration, particularly when significant elevation variation, especially from man-made object, exists.