AUTOMATED TRIANGULATION OF VIDEO IMAGERY BY SUCCESSIVE RELATIVE ORIENTATION

Jae Sung Kim, Major Professor: James Bethel

ABSTRACT

Automatic orientation of strips of video frame imagery would facilitate the construction of three dimensional models with less demand on a human operator for tedious measurement. Often one has no control points, so only relative orientation is possible. The relative orientation process gives camera parameters such as attitudes and selected baseline components and it can be implemented by using either collinearity or coplanarity equations. To automate the point selection, the pass and/or tie points were detected by the Colored Harris Laplace Corner detector along a strip of images and they were matched by cross correlation across multiple scales. However, the matched points from cross correlation still include the outliers. Therefore, the Random Sample Consensus (RANSAC) method with the essential matrix was applied to detect only inliers of point pairs. Then relative orientation was performed for this series of video imagery using the coplanarity condition. However, there is no guarantee that three rays for a single point will intersect in a single point. Therefore for all photos, subsequent to the first one, the scale restraint equation was applied along with the coplanarity equation to ensure these three rays' intersection. At this point, the Kalman Filtering algorithm was introduced to address the problem of

uncompensated systematic error accumulation. Kalman Filtering is more parsimonious of computing effort than Simultaneous Least Squares, and it gives superior results compared with Cantilever Least Squares models by including trajectory information.

To conform with accepted photogrammetric standards, the camera was calibrated with selected frames extracted from the video stream. For the calibration, minimal constraints are applied. Coplanarity and scale restraint equations in relative orientation were also used for initial approximation for the nonlinear bundle block adjustment to accomplish camera calibration. For calibration imagery, the main building of the bell tower at the University of Texas was used as an object because it has lots of three dimensional features with an open view and the data could be acquired at infinity focus distance. Another two sets of calibrations were implemented with targets placed inside of a laboratory room.

The automated relative orientation experiment was carried out with one terrestrial, one aerial and another simulated strip. The real data was acquired by a high definition camcorder. Both terrestrial and aerial data were acquired at the Purdue University campus. The terrestrial data was acquired from a moving vehicle. The aerial data of the Purdue University campus was acquired from a Cessna aircraft. The results from the aerial and simulation cases were evaluated by control points. The three estimation strategies are stripwise Simultaneous, Kalman Filtering and Cantilever, all employing coplanarity equations. For the aerial and simulation case, an absolute comparison was made between the three experimental techniques and the bundle block adjustment. In all cases, the relative solutions were transformed to ground coordinates by a rigid body, 7-parameter transformation. In retrospect, the aerial case was too short (8 photographs) to demonstrate the compensation of strip formation errors.

Therefore a simulated strip (30 photographs) was used for this purpose. Absolute accuracy for the aerial and simulation approaches was evaluated by ground control points. Precision of each approach was evaluated by error ellipsoid at each intersected point. Also memory occupancy for each approach was measured to compare resource requirements for each approach. When considering computing resources and absolute accuracy, the Kalman Filter solution is superior compared with the Simultaneous and the Cantilever methods.