AERIAL VIDEOGRAPHY: LOW-COST, SIMPLE, FAST AND APPROPRIATE

Aerial Mapping by Consumer Camcorders

Developing countries still have a need for mapping systems that are low-cost, simple to operate by local operators, fast in production and yet meet the needs of the application. A satellite mapping system can be a good choice, but cloud coverage and revisit time often limit its application, especially in tropical areas. The author shows that Aerial Videography (AV) mapping based on a consumer camcorder meets mapping requirements.

Camcorders are low-cost, simple to operate and widely available. Compared to traditional metric aerial cameras, camcorders are far less accurate and have smaller fields of view. One of the strengths of AV is the high recording frequency of 25 frames per second. The frame redundancy offers possibilities to improve the poor geometric quality and low spatial resolution, and to get 3D information. These improvements can be achieved by applying alternative ways of processing. Improving geometric quality is also achieved by applying an appropriate camera calibration procedure.

History
AV has been used in practice since the 1980s. Its uses include:

- creation of general oblique overviews
- making inventories
- topographic and thematic mapping
- monitoring of features.

For 2D applications, a frame-based processing technique can be used as with normal frame cameras. The frames are cropped, and then the image coordinates are registered to grid coordinates with a 2D transformation. Grid coordinates can be taken from a base map and from Ground Control Points (GCP). Earlier AV research was done by measuring in stereo images using softcopy photogrammetry software. Another way to make stereo images is to crop data, which is similar to the working of three linear scanner sensors. The backward and forward viewing can than be processed to get a map in 3D.

System
Our AV system consists of a camcorder installed in a light airplane. Suitable platforms are ultra-light planes, Cessnas or Pipers. A cheap GPS receiver in combination with an ArcPad-equipped Personal Digital Assistant (PDA) was used for navigation. The aim was to keep all field equipment as cheap as possible and as easy as possible to operate. The swath width of the camera was such that the required area could be flown in one line thus requiring no overlap between flight lines. To register each individual image to grid coordinates, we made use of a medium-scale topographic base map. The resulting accuracy was good enough for our purposes. In this way we were able to avoid the need of costly GCPs.

Practical Experiences
Airplane speed, focal length, shutter speed and flying height should be balanced such that image motion effect is minimised. The footprint of each pixel should be bigger than the movement of the airplane between two frames. The pixel size depends on the CCD size of the camcorder. The flight plan was stored in the GPS receiver as a string of waypoints. During the flight the GPS receiver sends track points to the PDA. The ArcPad software displays these points together with an existing map in real time on the PDA screen. In this way, the pilot is able to navigate between the waypoints within a 20-metre range. In order to reduce vibration and to keep the camera pointing vertically downward, a mounting system was made of foam.

Results
Figure 3a,b shows the cropped frames in Video Compact Disc (VCD) format. One of these images has navigation information tagged to it. The navigation information causes missing data in the image. Another problem is that the VCD recording format will reduce the spatial resolution of the image to 352x288 pixels. This can be improved by choosing a Digital Video (DV) format with 576x768 pixels. Atmospheric conditions cause radiometric distortions, which can usually be adequately corrected by histogram stretching. The final results are sequential image frames with a certain along-track overlap. Overlap size and frame shape depend on the chosen processing technique.

Lens Calibration and Spatial Resolution

Lens distortion diminishes geometric quality. The camcorder has no metric lens and is not as rigid as a metric camera. A bundle adjustment with a self-calibration algorithm was used for camera calibration. The calibration process was done with the off-line method in the laboratory. The calibration reduced the distortion error to Â±0.2 pixels. To solve the limitation of the low spatial resolution, the same idea was adopted as in desktop scanner interpolation. Sub-pixel enhancement was achieved by making an interpolation (interleaving) between adjacent video frames. Another process taking much effort is orthomosaic generation. The video data has many frames with a large overlap. Near-orthogonal and small distortion images can be made by using the centre of each frame. Combining these cropped images produces a (near) ortho-gonal image mosaic..

Tie Point Matching

Tie point matching is one of the bottlenecks. Therefore automation will significantly improve production time. The point matching quality has a significant impact
on the final image mosaic quality. Therefore sub-pixel accuracy point matching is necessary. Since characteristic elements between adjacent frames have a good correlation, the normalised cross-correlation algorithm suffices. The correlation algorithm can find tie points up to one pixel accuracy. To arrive at sub-pixel accuracy, a maxima operation with quadratic equation is used to find a peak of correlation using eight pixels around the tie point. This tie point matching is done for each pair of adjacent images and for all images.

Concluding Remarks

The huge number of image frames enables the enhancement of the geometric and radiometric quality of video data to a level comparable to classic aerial photography. Camera calibration eliminates a dominant geometric error. Thanks to VirtualDub, Noobeed and Matlab programs, the need for costly commercial software was reduced.

Further Reading

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