Some Aspects On Developing a Truly Low-Cost Mapping System Using Handheld GPS and Camcorder

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ABSTRACT

There are some characteristics for the mapping systems that need to be developing which are low-cost, easy in operation, fast in production, and the appropriate quality. The aerial videography (AV) is one of the interesting low-cost systems. Further, this paper explains some aspect on hardware, processing, and operation. These explanation aspects are include: video camera, airborne platform, handheld GPS, the information extraction, and practical implementation.

Some aspects of the processing function such as: ortho-mosaic, stereo-mosaic, motion extraction, and georegistration will explained. Some aspects on using the handheld GPS for sub-meter accuracy are showed. Some of operational aspects show the effectiveness coverage volume and the production time. It is suggested to implement the AV system for producing an ortho-mosaic and DTM with coverage area less than 5000Ha. Both of combinations camcorder and handheld GPS can be fulfilled to produce accuracy up to map scale 1/5000.

Key words: low-cost, aerial videography, handheld GPS.

1. INTRODUCTION

The aerial videography (AV) technique is defined as a system that use a camcorder (handycam) mounted on the light aerial platform (speed < 180 km/hr) to record video data of the surface of the earth. The GPS navigation type receiver has added to navigate the pilot during the aerial photo flight and also can be used for the ground control survey later. The camera mounting has been made just to keep the nadir view direction. All the equipments that used can be found easily in the electronic consumers market. The definition of the low-cost is limited by the total cost of the main hardware is less than 5000 US $, and the operating cost is less than 2.5 US $/Ha.

One of the reason why the AV has been use is because it's cost effectiveness. Furthermore, there are some other characters such as easy in operation, fast in production, and the appropriate quality. In practice, the AV has been use for the thematic map, monitoring, map up-dating, and the area assessment. Although, there are still some limitation in contrast with the aerial photography. Today, there are some vendor that provide the aerial video system with some variation such as Raven-View (observera, Inc), Stora Enso Mosaic, CamNav Mapper (BlueGen) dan Pyramid-Vision (Sarnoff). Some researcher has tested the aerial videography and enhanced the data processing (see Zhu, et.al, 2002; Rokhmana, 2005; Dare, 2006). Further, this paper shows some aspect for choosing the instrument for developing the combination of the camcorder and handheld GPS as a low-cost mapping system. Some notes in processing to improve the final quality will also explained.

2. SOME ASPECTS ON HARDWARE

The following equipments are the main hardware that can be used to make a low-cost imaging system:

1. The digital video camera (camcorder/handycam) with auto white balancing and image stabilizer is enough. Typically, the price of this handycam is under 800 US $. Some others consideration for choosing the camcorder are related to the pixel resolution (VCD or DVD); lens quality; and scanning mechanism. Generally, the camcorder use non-metric with zoom lens capability. The non-metric lens need to be calibrate for removing the geometry error from the lens distortion. Usually, the lens distortion is a dominant error. The zoom lens makes the lens geometry not stable, so the calibration need to be done in every zoom lens position or just before the camera will used. Further, the wide-angle lens (> 80 degree) is better, because the quality of the position and elevation is related to the base-high ratio.

   There are two types of the scanning mechanism, which are interlace and progressive. The time for scanning mechanism is close to the meaning of shutter speed in photography. For video with interlace scanning the shutter speed is between 1/50-1/120 second that depend on the video format (PAL, NTSC, or High Definition). The interlace can be a problem if the airborne platform is too fast or there is an image motion that are large than the ground pixel resolution. This error effect can be viewed as *"jigsaw"* pattern at the linear object. The image motion is a function of some parameters such as focal length, flying high, pixel size, and shutter speed. So, those parameters can be configured to eliminate the image motion effect.

   There are some additional instrument to support the camcorder such as the camera mounting, receiver GPS and decoder for tagging position on video recording, and the portable digital video storage. A simply mounting rod with plumbline principle should be made to keep the nadir viewing direction (see Figure 1).

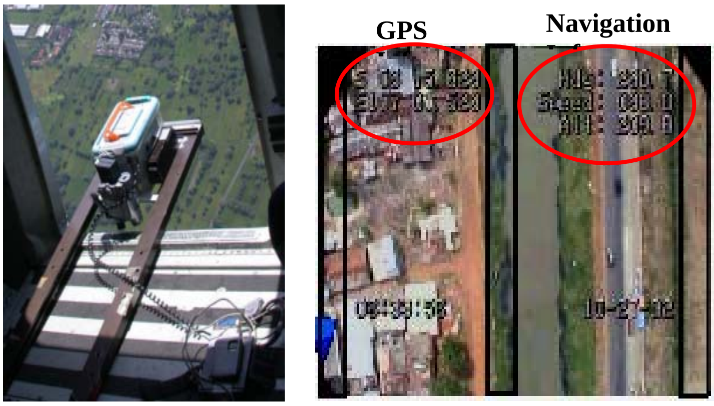

Figure 1. Simple camera mounting and video frame with GPS position tagged on.

2. Airborne platform for the recording of aerial videography suggested to own the speed which less than 180 km/hr for the flying high under 1200m Some platforms type which have been used such as ultralight, trike, paramotor, Cessna, and piper, all others that use the single engine. This matter is intended to avoid the effect of image motion. Beside that, sometime platforms require to be flown under the cloud.

   Using The Platform cause the ability of the photo flight depend on weather, especially turbulence. So that, generally execution of photo flight conducted by morning or evening where weather more stable.

3. The GPS navigation type receiver or CF-GPS integrated with PDA. The GPS receiver should able to be injected by digital map or PDA with Arc Pad software. This should equip with a small external GPS antenna also. The GPS navigation is used in photo flight for keeping the airborne follow in the flight line. There is no need to reach point exposure position, because the video camera is working as the scanner mechanism.

   The GPS navigation receiver also applicable for the ground control survey (GCP). For this purpose is needed to use minimum two of GPS receivers.

4. Some scanning systems generally are equipped by the INS/IMU (inertial/motion sensor) instrument for recording the camera attitude. Information from this sensor applicable to reconstruct the attitude of camera at the moment of exposure (exterior orientation). Unfortunately, the price of the INS is relative expensive. So, it is suggested not to use the INS, because the camera attitude can be calculated by using relative orientation on sequence video frames.

3. SOME ASPECTS ON PROCESSING AERIAL VIDEO DATA

Some researcher has tested an aerial videography as a low-cost mapping system (see Zhu, et.al, 2002; Rokhmana, 2005; Dare, 2006). The challenge in the data processing is keeping the quality of image to a level comparable to classic aerial photography. Furthermore, the processing should be outomated, and for the mapping purposes it is should be able to make ortho-image and stereo viewing also (see Rokhmana, 2004a). The following information can be processed from the aerial videography data with PAL-VCD format, such as:

1. The ortho-image can be formed from the nadir view. This nadir view is a slit window (about 10 colomn pixel size) at the center of each video frames (see Figure 2). The nadir view can form the orthogonal image mosaic which it's geometry is near true-orthophoto. The effect of the orthogonality can be seen from the high building that can not show the relief displacement effect.

2. The stereo viewing can be formed from backward and forward view. Both of the view are the two slit windows at both of the edge of each frames (see Figure 2). Both of the views can form the stereo mosaic, which its geometry is close to epipolar.

Figure 2. Illustration of the processing result by applying the three viewing angle.

3. The aerial video record has opportunity for extracting the camera attitude by utilizing the adjacent video frames (image sequences). So, the recording frequency for the camera attitude is equal to the frequency of video system that is about 1/50-1/120 Hz. The motion vector between the adjacent frames show dominantly linear. In practice, the adjacent frames can be sufficiently related by the 2D conform transformation. The shearing and projective parameter is not significant (see Figure 3). This transformation function is used for building image mosaic.

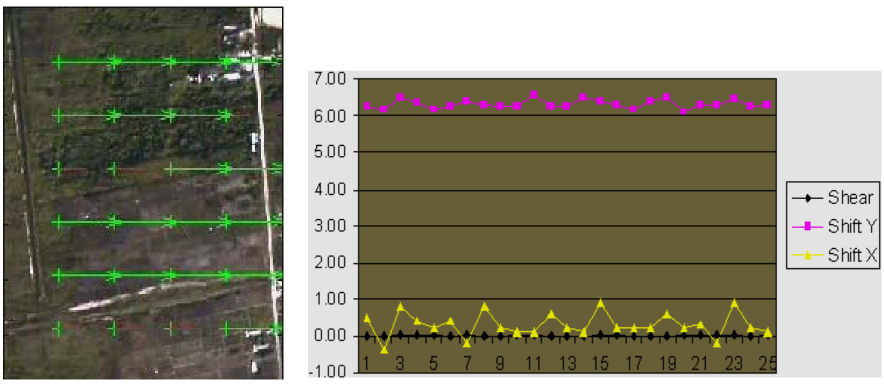

Figure 3. Motion vector and transformation parameter between the adjacent frames.

Using Matlab script can do the processing for building the uncontrolled image mosaic automatically. Some aspects of automation are such as tie-point matching by cross correlation, image registration and mosaicing. Further, the Global Mapper software can be used for the georegistration process. It is suggested to use Affine transformation with the triangulation network (piecewise) method for the georegistration process. To keeping the low-cost, it should avoid to use the commercial software.

4. SOME PRACTICAL ASPECT ON OPERATIONAL

The following questions are related to the practical aspect in implementation of the aerial videography (AV) technique:

1. How wide the coverage area scopes that it still efficient? There is not exact answer for this question, but practically it is depend on some variable such as the map scale, the mapping purposes, and the condition of the area. In shortly, it is good to use the AV for coverage area under 5000Ha. Furthermore, the shape of the area influence also. The corridor shape area is the best shape on applying the AV technique, because there is no sidelap needed.

2. How optimal is the geometric quality? The scale of the video image can be varied and depend on the flying high. Generally, the geometric quality of the orthoimage product is about 0.33-0.2 times the video image scale. Practically, it is good to use the AV for production map in scale 1/5000.

3. How much the cost? The production cost for the orthophoto image is about 1.5-2.5/ Ha. This price can be 2 times more expensive for producing DTM. One of the factors that dominantly expensive is related to the ground control survey. This can be reduced significantly if it can use the existing map or captured from the google earth for the remote area. The required time for otho-mosaic production is about 2-3days for 1.5hour video recording.

5. HANDHELD GPS FOR GCP SURVEY

The Motivation on using the handheld GPS navigation receiver for the ground control survey is it's low cost. Although there is other alternative which is assembling from the GPS-Card. But using the handheld GPS become more simple because do not need electronic knowledge. The sub-meter accuracy from GPS can only be reached by the differential processing (data code or data phase). This matter is enabled after the existing some program for recording the raw-data from handheld GPS. Some of programs such as: ASYNC/GAR2RNX (Prof. Galan, http://artico.lma.fi.upm.es/numerico/miembros/ antonio/async/); GRINGO (www.nottingham.ac.uk/ieessg/gringo); GARBIN (Milbert, http://mywebpages.comcast.net/dmilbert/softs/garbin.htm); Rhino Rover (http:// www.uspositioning.com).

The following aspects are taken from some results on using L1-phase processing:

1. The data quality of the pseudorange and phase-range is about 2-3 times lower than the data that taken from the geodetic receiver (see Figure 4).

2. The coordinate precision is varies from millimeter up to sub-decimeter.

3. The accuracy of the coordinate, which compared with the result from the geodetic receiver is varies from centimeter up to sub-meter. This result is taken from the baseline length under 20km (see. Abidin, et. al., 2005)

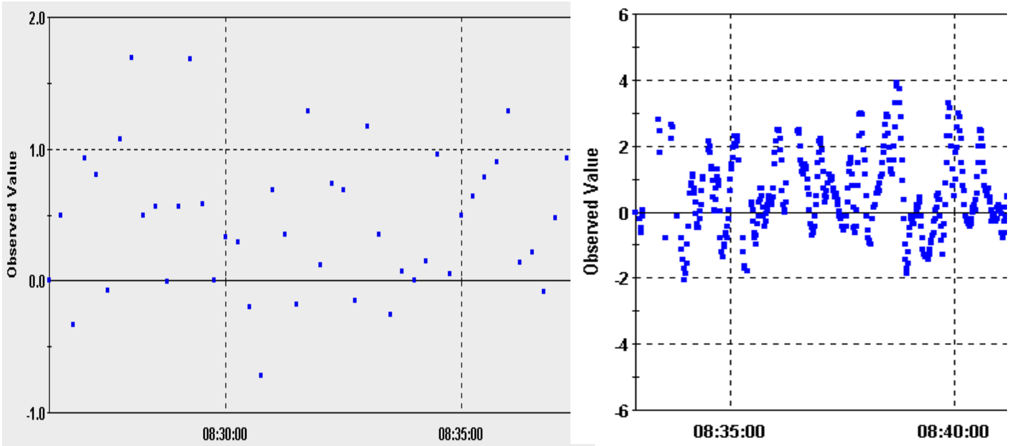

Figure 4. Plotting pseudorange minus phase range from Handheld and Geodetic

4. The accuracy from the float ambiguity resolve is more accurate than the fixed ambiguity. This caused by the use of the commercial software that cannot process the half-cycle data. The phase data recording from the handheld GPS (squaring type receiver) is included a half-cycle data.

5. Choosing the interval data recording longer than 10 second give more stable results than using 1 second interval data recording.

6. Using an external antenna can raise the signal indicator and helping the centering activities also.

6. CONCLUSION

This paper shows some aspect on developing a low-cost mapping system, which utilizes the low-cost instrument such as the camcorder and the handheld GPS navigation receiver. Some notes related to the practical aspect on system implementation have explained. Those are including hardware, software, and operational aspect. It is suggested to implement the AV system for producing an ortho-mosaic and DTM with coverage area less than 5000Ha. Meanwhile, the handheld GPS can be used for the ground control survey with the worse accuracy up to sub-meter. The both combinations of the camcorder and the handheld GPS can be fulfilled to produce accuracy up to map scale 1/5000.

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