

HD aerial video for coastal zone ecological mapping

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**Presented at SIRC 2007 – The 19th Annual Colloquium of the Spatial Information Research Centre
University of Otago, Dunedin, New Zealand
December 6th-7th 2007**

ABSTRACT

The paper discusses a recent test of using High Definition (HD) video camera to obtain aerial mapping images for coastal zone study. Real-Time GPS was used to capture the ground control. It was revealed that the vibration from the aircraft has an adverse effect on the video footage. Consequently, each video frame was deinterlaced to obtain the odd and even fields as sub-frames. Deinterlacing removes the effect of aircraft vibration; however the process reduces the video frame format size to a sub-frame size which is a half of the original format size. The video camera was calibrated at full format size so the image must be rebuilt to full format size in order to achieve the required spatial accuracy. Tests show that the stereo-digitized 3D coordinate of beach features is similar to still-frame digital images at the same flying height. Because videoing does not require precise exposure timing as in the case of still-frame photography, HD video has a very important advantage over conventional still-frame aerial photography for aerial mapping.

Key words and phrases: HD video, aerial images, coastal zone ecological mapping.

1.0 INTRODUCTION

The objective of this paper is to introduce a technique of using HD video for aerial mapping of coastal zone. The technique has more benefits than the conventional method of using digital small-format still frame photography. It is straightforward to obtain quality stereophotography and there are more redundant stereo-pair of image for aero-triangulation (control densification).

Small format aerial photographs are often obtained by professional hand-held camera with a format size of 56 mm by 56 mm or smaller (Warner et al. 1997). Digital hand-held cameras are more convenient than their film-based counter-part as no film-scanning is required for input into computers. However, the downloading time (storing of the captured image on to camera memory sticks) can take up several seconds depending on the image size. A typical 8.3 Mega-pixel (MP) digital Sony Cyber-Shot camera (f=28 mm) takes 4.25 seconds before another image can be taken. At an aircraft cruising speed of 120 knots, the aircraft would have travelled 260 m during the duration. To obtain a nominal stereo-overlap of 60%, the minimum flight height is 500 m. Consequently, it would not be possible to fly at a lower altitude for larger scale photography. The smallest object size recognisable on the acquired image would be 400-500 mm (at 2 to 3 pixels resolution). For many engineering applications such as drainage planning along the beach the resulted image resolution would be too coarse.

The alternative is to have two digital cameras running at the same time (Figure 1). It was found to be difficult to operate the cameras manually as accurate time-keeping (in seconds) is essential and mistakes can be costly. In addition, there is the cost of purchasing an additional camera. It would be necessary to purchase three cameras so that one could be used as backup as the hiring of an aircraft could be an expensive undertaking.

2.0 EQUIPMENTS AND SOFTWARE

Two HD video cameras were acquired for the study. The existing aircraft camera-mount for small format camera was modified to take the HD video camera (Figure 1). A free-ware, VirtualDub (Virtualdub organisation; <http://www.virtualdub.org/>), was used to pre-process the video clip. Australis, aerotriangulation software was utilized to increase the ground control for stereo-mapping (Fraser 2000). DVP ((DVP-GS, Canada) was used to obtain 3D spatial data from the stereo-images. In addition, RTK-GPS was exploited to determine the ground coordinates of control points for the beach erosion mapping.

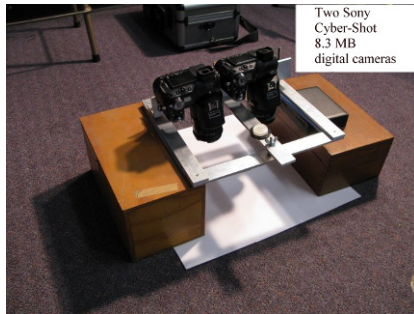


Figure 1: A dual-camera mounting device for aerial photography

3.0 METHODOLOGY

3.1 Aerial photography

Test flights were carried out over a local beach erosion site at St Kilda beach, South Dunedin. The test flight would determine whether low-cost video clip has sufficient accuracy for mapping local beach erosion. A Cessna single engine aircraft was used for the aerial photography. The video camera was mounted on a custom-made mounting which was secured to the under-belly camera port of the aircraft (port 1 of the mounting shown in Figure 1). No specific material or devices were used to reduce the aircraft vibration to reach the video camera. Aerial video was shot at 700, 1000, 1200 m above the ground.

3.2 Video-clip pre-processing

Video clip was down-loaded in MPG-4 format using VirtualDud. The same software was used to de-interlace the video clip into odd and even fields as sub-frames. De-interlacing is essential because aircraft vibration created double image of features as shown in Figure 2. After the deinterlacing (Figure 3a) exercise a re-sampling technique was utilized to re-build the video clip to the original format size (Figure 3b). The re-sampled video clip was saved as image sequences.

3.3 Image selection

The saved image sequences were checked for consistence (i.e. no mistakes in the de-interlacing of odd and even fields) and individual images were selected for subsequent photogrammetric aerotriangulation and mapping. To optimize the accuracy of aero-triangulation, images were selected for an 80 % overlapping. At a flying height of 700 m, an 80 % overlap means that every eighth image in the sequence should be selected for aero-triangulation (Figure 4). Aerotriangulations were also conducted for 60 and 70 % overlap images (roughly every 15 and 12 frames respectively).

3.4 Aerotriangulation

Generally, very few ground control points are surveyed on the ground for photogrammetric mapping and each stereo-model requires six good quality control points for digital stereo-orientation, DTM generation or image rectification. To increase the number of control points, six points were selected in the overlapping area of every two adjacent photos for stereo-digitizing. These points known as photo control point were features which could be easily identified in two or more photos. In addition, the surveyed control points were digitized for inclusion in a bundle adjustment. Subsequently, bundle adjustment

software (i.e. Australis, Photometrix Pty Ltd. Australia) was used to compute the ground coordinate of the photo control points.



Figure 2: Raw video image. Note the doubling of image features



Figure 3: Pre-processed de-interlaced image (a) and re-sampled image (b). Note the distorted features (along the y-axis) in the de-interlaced image (a)



Figure 4: A stereo-view of a stereopair overlapping at 80%. The roll (ω), Pitch (ϕ) and Yaw (κ) between the pair were minimal.

4.0 VIDEO IMAGE EVALUATION

4.1 Video camera calibration

Video clips were analysed photogrammetrically to determine the 3D measurement accuracy. In general, camera calibration is needed to obtain the optimum focal length of the lens and the lens distortion parameters before the image can be analysed photogrammetrically (Atkinson 1996; Chong, and Scarfe

2000). The calibration involved the recording of the image of a calibration test field which has 120 photogrammetric targets of known coordinates (Figure. 5). Special retro-targets were placed on the tip of steel rods and these rods have different heights from the base (0, 25, 50 and 75 mm). The focus of the video camera was set to wide angle as this is the mode used in the aerial videoing. Figure 6 shows the four positions of the video camera to capture the convergent video clip of the test field for calibration. In this exercise the focal length the optical centre offset (in x and y image coordinates) and the first parameter of the balanced lens distortion polynomial function were computed (Beyer 1992). The computed numerical values were required in the digital stereo-orientation of all stereo-pair of images which were used in the mapping of the erosion.

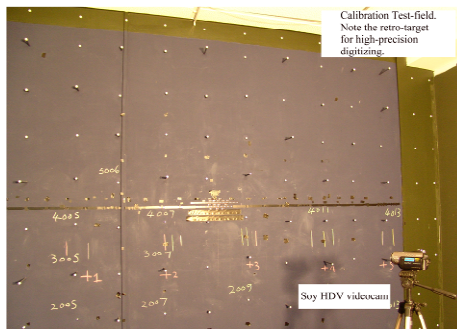


Figure 5: Calibrating the stereo-imaging system. Note the control test field and its targets

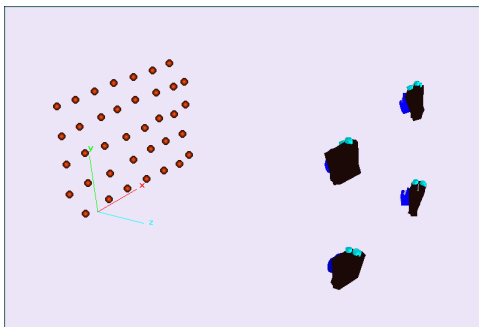


Figure 6: The configuration of the captured video frames for calibration

4.2 Aero-triangulation

As discussed elsewhere in the paper images obtained from the video clips were selected for aero-triangulation. Figure 7 shows the position of ground features used as photo control points (such as clearly defined roof-top features). In addition, ground surveyed marks were digitized. Ground surveyed marks are usually located in easily identifiable position such as car park markings. To improve the computational accuracy, an overlapping percentage of 80% was selected for the test. It would be possible to select a higher overlapping value such as 90%, however experience shows that the accuracy improvement would be minimal. If a 90% is selected, the additional images to be digitized would increase from every eighth image to every 5 image, an increase of 3 images or 15 minutes of digitizing time.

After all the selected images were digitized, Australis bundle software was used to compute the ground coordinates of photo control. The adjustment required the input of the coordinates of the surveyed ground marks. In addition, the computed camera calibration parameters values should be available.



Figure 7: Aero-triangulation of the processed video-image to increase ground control over a strip of image. Note the digitized point on the roof top.

4.3 Stereo-orientation and beach feature mapping

Recent beach erosion next to the surf club building was selected for DTM mapping. Selected stereo-pair of images were digitally orientated in a DVP workstation. A semi-automated technique was used to obtain a DTM of the area.

5.0 RESULTS

The error ellipsoid of the computed photo control is shown in Figure 8. The maximum size of the horizontal error from a strip of 26 images is 260 mm while the maximum size of the vertical (terrain height) is 300 mm. These values were comparable to the results of the adjustment of still-frame photography obtained by the Sony Cyber-Shot. The latter has values of 230 and 260 mm respectively.

All the stereo-pairs at 60% overlapping were easily stereo-orientated in the DVP digital photogrammetric stereo-workstation. The roll (ω), pitch (ϕ) and yaw (κ) between individual stereo-pair were less than four degrees. These values are slightly above the allowed nominal value of three degrees. But there were no adverse effects on the mapping accuracy.

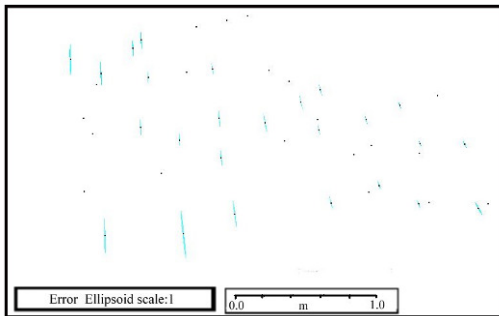


Figure 8: The error ellipsoid of the aero-triangulation. Note the size of the error increases from the centre of the flight line toward the edge

6.0 CONCLUSION

An HD video camera was used to obtain video clips which were exploited in the mapping of local beach erosion. The video camera and camera mounting was easy to operate and the video deinterlacing software was very user friendly. The processed images were analysed photogrammetrically without any difficulties. The results of test run show that the HD video camera can provide good quality 3D measurement that are comparable in accuracy with measurement obtained using still-frame good quality digital camera such as Sony Cyber-Shot F-828. The stereo-images can be used to produce digital topographic maps, DTM and orthoimage or rectified photos.

Further tests could be carried out using remotely operate aircraft (UAV). The discussed tests shows that the effect of platform vibration could be removed by deinterlacing of the video clips and consequently, the same could be applied to reduce the effect of vibration of UAV as it is known to produce severe vibration. For applications similar to beach erosion the saving could be substantial using UAV as photography may be needed frequently when erosion is active during period of surge in the tide.

ACKNOWLEDGEMENT

The author acknowledges the outstanding GPS works carried out by Messrs Alastair Neaves and Mike Denham for the project.

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