A Practical Spatial Data Capture Technique for Human Motion Research

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ABSTRACT

The paper discusses the evaluation of a video image-splitting device for human motion research. NuView, a commonly available device and a digital video camera (DV) were used to capture stereo-video footage of athletes in training. The device permits two distinct views (left and right perspective views) to enter a single lens DV. A single convergence control in the device allows users to obtain stereo view of near and far objects. The research involves the calibration of a customized system for optimum motion tracking accuracy. A stereo-digitizing photogrammetric technique was used to determine the accuracy of the system. The results show that system can achieve optimum spatial data accuracy of 15 mm at an object distance of 8 m. The different in the horizontal and vertical accuracies are similar to those obtained by conventional stereo-aerial photogrammetric technique, i.e. the horizontal component is approximately two times better than z component.

***Key words and phrases**: digital video footage, video camera calibration, motion research, Motion tracking, DV image-splitting.*

1.0 INTRODUCTION

The objective of this paper is to introduce a low cost spatial data capture technique for human motion research. Good quality stereo-video footages could be obtained by filming objects using an image-splitting device, which could be mounted onto the lens barrel of a Digital Video (DV) camera. The paper includes a discussion of the basic principle of the image-splitting device, the technique for calibrating the customized system and an evaluation of the accuracy of the computed spatial data.

A number of low cost 3D imaging systems can be purchased off-the-shelf. However, we found that NuView is probably the best for motion tracking because there was no degradation in the speed of recording (number of frames per second). The device uses a field–sequential technique to capture stereo-images using a single lens DV. Commonly, video image consists of odd and even fields. Accordingly, the device uses mirrors to direct the incoming light rays onto the left and right viewing windows. A set of alternating shutters allows the right and left perspective view to be imaged onto the sensor as odd and even fields. Hence, each frame of video footage consists of view from the left window as odd fields and view from the right window as even fields. Consequently, each frame can be field-decoded (deinterlaced) to form left and right stereo-images.

Image-splitting devices are usually used for home movie and virtual reality production (e.g. visual fly-through products for computer games). However, stereo-video footage for other applications is not new. An application on crime investigation has been reported by Baldwin (2005). The author argued that the use of 3-D images, whether photographs or drawings, does have an important role in visualizing an incident. Modern equipment such as digital cameras/video camera and 3D viewing system are readily available to capture and display stereo-image for proper viewing. Video animation is currently used in criminal, traffic, and civil cases by both prosecution and the defence attorneys to depict object (human) motion. In the research, the device was used to investigate the suitability of the system to capture accurate spatial data for motion human research.

2.0 EQUIPMENTS

2.1 NuView image-splitting system

The device allows recording of field-sequential video image onto a DV tape or onto a computer disk (Fig. 1). The field of focus can be adjusted by the users. For example, a user may want to start the 3D viewing at a distance of 1, 2 or more metres away from the camera. The stereoscopic parallax is zero at the set object distance and the value increases from that point away from the camera. Consequently, the depth increases as the stereo-parallax increase.

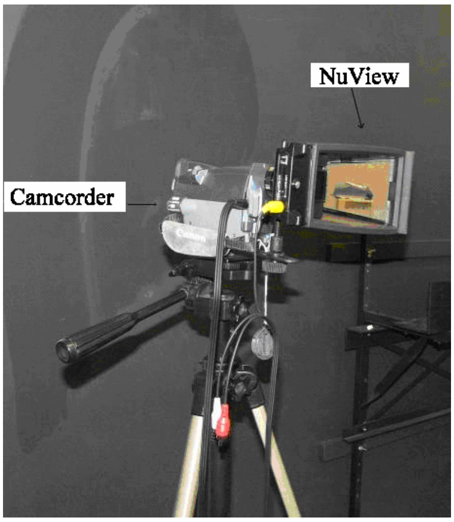

Figure 1. NuView 3D imaging device.

2.2 Video recorder

A Cannon DV was selected for the research project. The DV has a focal length ranging from 7.1 to 105 mm. The DV becomes a complete stereo-imaging system when NuView is mounted onto the DV lens barrel.

2.3 Software

Five types of software were required for the research. They were: 1) Field deinterlacing software; 2) Imaging processing software; 3) Camera calibration software; 4) Stereo-image digitizing software; and 5) 3D spatial data editing/modelling software. All software are available at the School of Surveying.

3.0 METHODOLOGY

3.1 Customised system calibration

Calibration of the system was carried out using a calibration range as shown in Figure 2a. Both the DV lens and the image-splitting device were set to focus at infinity. Five sets of four short convergent video footages of the range were recorded during the calibration (Fig 2b). Australis, camera calibration software was used to compute the system lens parameters using the images (Chong 1999; Fraser 2000). The left and the right view optics were calibrated separately.

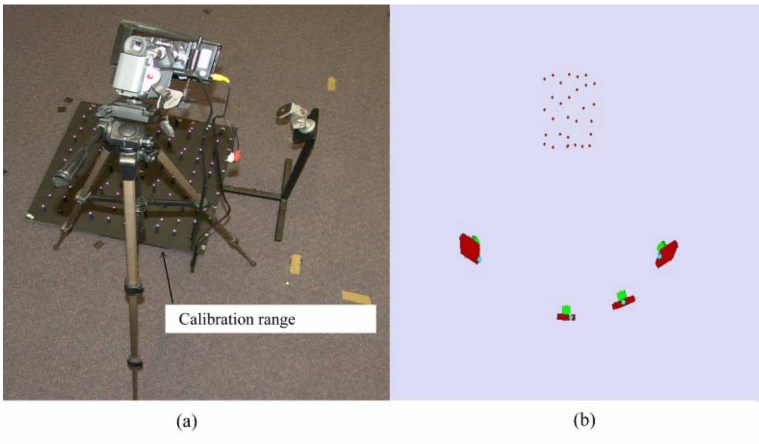

Figure 2. (a) Camera calibration range; (b) Geometry of convergent photography. Note that position of the camera and the calibration range in (b) to achieve optimal results.

3.2 Evaluating the accuracy of the captured spatial data

The imaging system was set up to record a human subject in a jogging exercise (Fig. 3). To determine the accuracy based on the distance of the subject from the camera, a set of distances was used. They were 3, 4, 5, 6, 7, 8 and 9 m. The minimum distance was set at 2 m because a preliminary test showed that the area of stereo-coverage was too small for any significance application in human motion research. The video frames were deinterlaced to extract individual left and right view of the subject at each object distance. Three stereopairs were selected from footage of each object distance. DVP digital stereoscopic workstation was used to carry out interior and exterior orientations of these stereopairs. Test points of known position were used to compare with the captured data to determine the accuracy of tracking.

Figure 3. A stereopair of image showing a human subject movement being tracked. Note the white targets in the background which were used for the exterior orientation of images.

4.0 RESULTS

The test results of human subject motion tracking are shown in Figure 4. In the figure, it can be seen that the optimum accuracy is at the 8 m object distance.

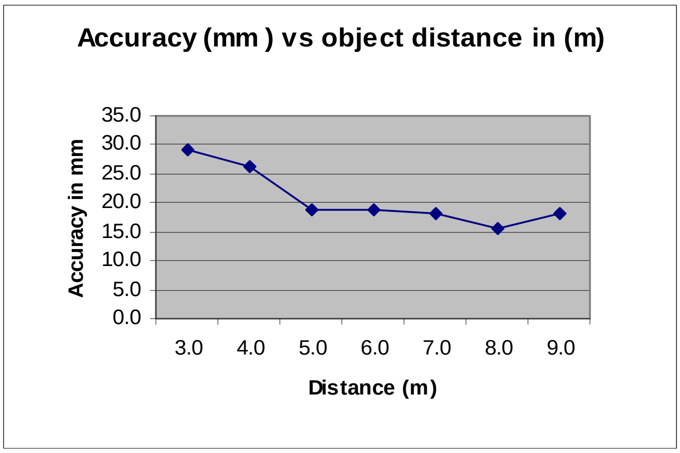

Figure 4. A plot of accuracy against the object distance. Note the minimum value in accuracy at the 8 m mark.

5.0 CONCLUSIONS

A customized stereo-imaging system was evaluated for application in human motion research. The system is easy to operate; it is efficient for stereo-image capture; and the amount of stereo-overlapping is always the same. The results of the research show that the system is capable of obtaining accurate spatial data using a single video camera. As the resolution of off-the-shelf video camera is coarse, the video footage can only achieve sub-centimetre accuracy under ten metres object distance. Nevertheless, the stereo video footage can be used for other applications too such as virtual athletic training, medical research and field performance study. The suitability of the customized system for these applications will be assessed in future research.

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