A STEREOPHOTOGRAMMETRIC TECHNIQUE FOR FORENSIC MEASUREMENT OF SURVEILLANCE IMAGES

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Abstract

The paper provides a discussion about new approach to detect criminal suspect through camera images with the integration of surveillance camera system and close-range photogrammetry technique. The setting up of the surveillance camera system is based on the stereo photogrammetric mode. For high accuracy photogrammetric measurement, the space which was covered in the surveillance cameras field of view (FOV) was calibrated using special-built a portable high precision control frame. Via close-range photogrammetry technique, the physical morphology (example: anthropometry of facial features) of the suspect can be measured accurately in 3D environment (stereo measurement).

1.0 Introduction

Until now, most of the surveillance work has been done in a 2D setup. In most existing systems, a single camera is used to observe an area (Figure 1). Using 2D techniques it is very hard to resolve occlusions and track multiple people, whereas 3D techniques can take care of the occlusion problem and can distinguish multiple objects from the scene quite accurately (Mishra *et.al*. 2007).

Figure 1: Camera surveillance system (setup in mono mode)

In the existing surveillance camera system, the identification of the suspect was based on the 2D image (single image), which was limited for visualization. Previously published works on single photograph analysis of crime suspects were provided in Chong (2002), Fryer (2000), Klasen and Fahlander (1997), Proesman *et.al*. (1997), Richards (1984), Whitnall (1984), Whitnall and Moffitt (1989). Additionally, Williamson and Brill (1990) wrote a reference manual on the subject of photogrammetric measurement technique using a single photograph. Richards (1984) gave four techniques: (i) direct ratio, (ii) ray tracing, (iii) resection, and (iv) reverse perspective analysis. Direct ratio used the dimensions of objects near the crime suspect to determine the height of the suspect. The other three techniques required more sophisticated construction of light rays, which needed special skills to interpret the measurement.

The 3D (stereo-image) camera system provides the capabilities of suspect identification in three-dimensional environment. Using stereophotogrammetric concepts, the physical behavior of the suspect can be identified and visualized accurately. With the stereo-images captured by the 3D camera system, the measurement of suspect morphology can be carried out based human body anthropometric concepts (examples: height, facial anthropometry and etc) (Figure 2). The measurement results provide high accuracy forensic evidences for suspect identification.

Figure 2: The measurement of suspect morphology based on human body anthropometric

The objective of this paper is to introduce a new approach about computation technique using stereo-image of surveillance images to provide accurate measurement of the physical features of the crime suspect. The paper includes s detailed discussion of the *in situ* camera lens calibration and the analysis of the computed forensic measurements.

2.0 Methodology

2.1 In Situ Surveillance Camera Lens Calibration

In this section, the construction and calibration of low-cost portable control frame is described. An *in situ* camera lens calibration technique, which requires a portable control frame, is also discussed. The camera system consisted of two DSLR (Digital Single Lens Reflex) cameras (Figure 3).

Figure 3: Sony DSC F828

For the calibration purposes, each sensor was calibrated simultaneously. A camera lens calibration will be carried out using Australis, a state-of-the-art bundle software, developed at the University of Melbourne, Australia and using a high accuracy calibration testfield (a portable control frame).

2.1.1 A Portable Control Frame

Figure 4 shows, a portable 1.5-m by 1.0-m used in the research. Rectro-targets were placed on the frame and on the bracing at three level of depth (0-mm, 75-mm & 150-mm). Rectro-targets are highly reflective targets, which are specially made for precise automated digitizing using computer software (Atkinson, 1996). The coordinates of the rectro-targets on the control frame were obtained photogrammetrically. The frame was placed over multi-purpose camera calibration range and a set of six convergent digital images was taken with a Sony DSC F828. A bundle adjustment was carried out using the Australis photogrammetric bundle adjustment software. The root mean square (RMS) values of the computed coordinates were 0.11, 0.09 and 0.13 in the *x*, *y* and *z*-axes, respectively. The mathematics of RMS computation is provided in Slama (1980).

Figure 4: A portable control frame

The frame was fastened to a piece of steel bar, which could be attached to a set of surveying tripods for precise leveling and orientation. A circular spirit bubble, mounted on the steel bar, was used to level the control frame. Leveling the frame reduced the kappa rotation (or rotation along the Z-axis) and the omega rotation (or rotation along the X-axis) to a minimum.

2.1.2 Camera Lens Calibration

The cameras were mounted on a platform, which was anchored to a wall at 2.5 above the lab floor. The cameras lens focus was set at infinity. An object distance 3.0 was selected for the calibration (similar distance was measured between the cameras and the crime suspect). Convergent imagery of the portable control frame was taken by tilting the control frame through four different rotations (Karara, 1989). These rotations simulated a set of four convergent image of the set-up for each camera. Each set-up was repeated three times. Again, the Australis software was used to compute camera lens parameter using these images.

2.2 Case Study

To the test developed technique rigorously, it was necessary to set up tests in a laboratory prior to introducing the technique onto crime scene. The camera position was the same as that discussed in the previous section. A suspect was set up at a short distance in front of a portable control frame as depicted in Figure 5. The suspect represented the crime suspect in the test.

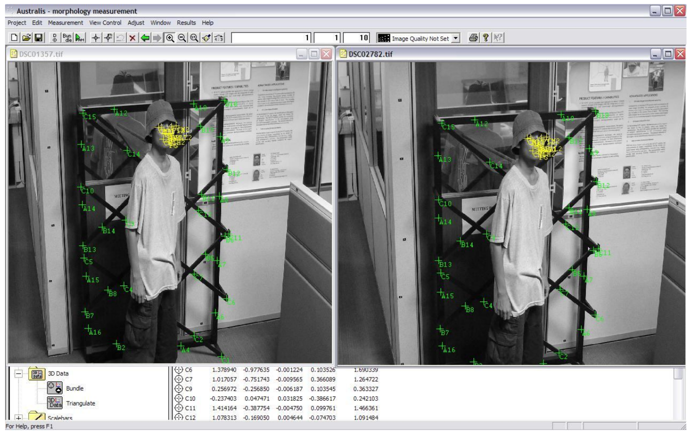

Figure 5: A suspect was set up at a short distance in front of a portable control frame

3.0 Results and Analysis

3.1 Camera Calibration

The results of the *in situ* camera lens calibration of the two cameras using Australis camera calibration software are provided in Table 1. From the table we can conclude that the value for lens distortion parameters k_1 and k_2 was repeatably stable for each cameras. As the camera-to-object distance and lens setting were set approximately the same, no error was expected from this source.

Table 1: Camera calibration results

Parameters Camera ID	c	x_p	y_p	k_1	k_2	k_3
Sony 01	7.42334	-0.1232	-0.0181	3.1E-03	-2.3E-05	-5.2E-07
Sony 02	7.41182	-0.1452	0.0204	3.1E-03	-2.3E-05	-6.3E-07

3.2 Anthropometric Measurements

Only preliminary results are availably in this section. The stereo-images of suspect were measured using Australis software. The measurements are based on anthropometry human face (craniofacial landmarks). Recent publications such as D'Apuzzo (2003) and Majid *et.al*. (2005) showed that photogrammetry is the most suitable method for capturing anthropometric landmarks. Standard (traditional) methods to measure anthropometric landmarks are using tools such as sliding calipers or digital calipers (Kolar and Salter, 1997).

Table 2 shows the results of measurement between Australis software and caliper. A few points are measured (Figure 6) and each measurement was repeated three times. For analysis, the comparisons are based on the distance value (straight measurement).

Table 2: Anthropometric measurement (Australis vs. caliper)

Craniofacial Landmarks	ch 1 –ch 2 (mean) (mm)	sbal 1 – sbal 2 (mean) (mm)	pi 1 – pi 2 (mean) (mm)	CM 1 – CM 2 (natural points-mean) (mm)
Australis	70.85	38.10	73.01	117.20
Caliper (± 0.05mm)	55.15	35.85	70.20	115.85
Error	15.70	2.25	2.81	1.35

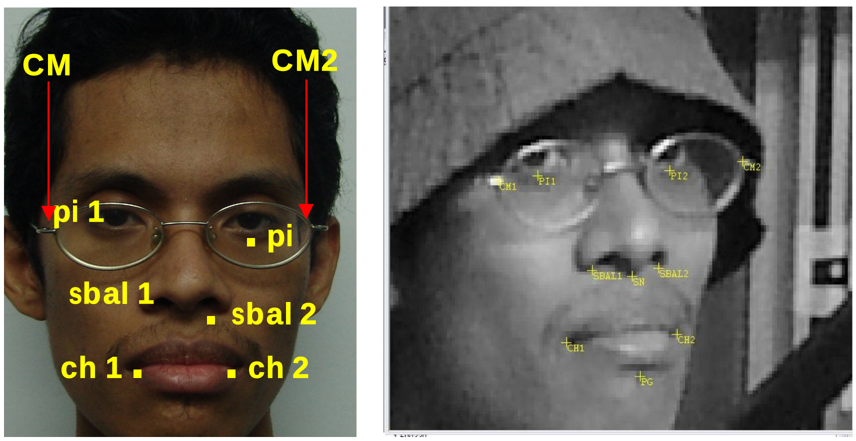

Figure 6: Measured points are based on craniofacial landmarks

Based on Table 2, the errors for every set of data (sbal1–sbal2; pi1-pi2; CM1-CM2) are below 3.0 mm. Only one set of data (ch1-ch2) provide error more than 10 mm. The errors maybe could be cause by manual digitizing, very difficult to indentify craniofacial landmark, suspect face impression and other factors.

4.0 Conclusions

With the stereo-images captured by the 3D camera system, the measurement of suspect morphology can be carried out based on human body anthropometric concepts. The measurement can provide high accuracy forensic measurements for suspect identification. Based on the results, we found that there could be a few important factors which could reduce the accuracy of anthropometric measurement data. Consequently these factors were studied in more detail and the results show that accuracy could be degraded considerably.

For further research, stereo camera will be replaced with the combination of one high definition (HD) video and stereo adapter. High definition video will be provided high details video (image), while the stereo adapter will be used in order to provide a true Stereoscopic 3D image (stereo images).

More research is needed to improve the technique in order to achieve optimum photogrammetric measurement. Certainly, there is potential for sterophotogrammetric techniques for forensic measurement of surveillance images.

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