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APPLICATION OF CLOSE RANGE PHOTOGRAMMETRY IN CRIME SCENE INVESTIGATION (C.S.I.) MAPPING USING IWITNESS AND CRIME ZONE SOFTWARE

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ABSTRACT

Crime scene investigators in law enforcement were always looking for new methods to make their job easier, more accurate and more efficient. To process a crime scene in an organized approach, one of the vital stages in processing is scene documentation. The scene documentation is an important stage because it is visualization record of evidences on the scene. Hence, this study focus on how to do the scene documentation by mapping those evidences using the *iWitness* and *Crime Zone* software. Close range photogrammetry method used in *iWitness* software to help crime scene investigators dealing with non contact measurement data acquisition. Physical evidences on the crime scene were measured and verified with tape and laser scanner measurement. Then the output .dxf data from *iWitness* exported to *Crime Zone* in order to generate 3D visualization of the crime scenes whether it is homicide scenes, evidence and bullet trajectories. Combination of *iWitness* and *Crime Zone* software is a vital tool in forensic mapping applications for law enforcement and investigators. It provides the practical solution to mapping crime scene by using close-range photogrammetry methodology.

Key words: Crime scene investigation, close range photogrammetry, iWitness, Crime Zone

1.0 INTRODUCTION

Nowadays, current local scenario at the Crime Scene Investigation Department in Royal Malaysia Police is still using conventional method in investigating a crime scene (Shafizan, 2009). There are a variety of techniques and technologies being utilized to acquire the physical evidences from the crime scene such as measurement tape, note taking, photogrammetric method, video tapping etc. Measurement tape was used by investigator to measure physical evidences for the crime scene documentation with only centimeter level measurement accuracy. Meanwhile, at the international level numerous law enforcement agencies have proven close-range photogrammetry to be an accurate and viable measurement tool. Equipment requirements and costs are minimal, consisting primarily of a modestly priced consumer-grade digital camera, a photogrammetry software program, and a drawing program able to accept .DXF files to produce the 3D diagram (Galvin, 2004).

Thali *et al.* (2003) mentioned that conventional methods give disadvantages which include being time consuming, reliance on the capability of operator and highly subjective. The usage of sketches and tapes that are shown in **Figure 1** and **Figure 2** requires a long period in collecting the evidence (Chan, 2010). Usually, Royal Malaysia Police use tape measurement to collect the measurement of physical evidences with required accuracy is in sub-centimeter level (Yew, 2009; Ummi Kalsom, 2009).

Figure 1: Crime scene sketch

Figure 2: Measuring tape

There are ten main procedures (**Figure 3**) to be followed by U.K. forensics team according to National Occupational Standards (NOS) (Hadley and Fereday, 2008).

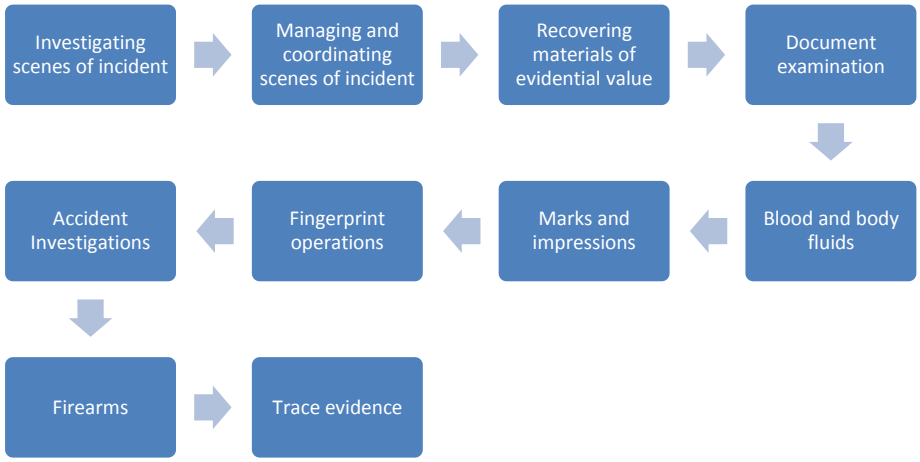

Figure 3: National Occupational Standards (NOS)

Crime scene investigation is a complex activity that recently has known a radical and decisive development due to the contributions of techniques coming from a number of different disciplines and field (Cavagnini *et al*, 2007). One of the disciplines involve in crime scene investigation was photogrammetry method. The role of the photogrammetrist in forensics should be expanding with more exposure to the legal and law enforcement agencies (Robertson, 2000). Based on Horswell (2004), the information obtained in the crime scene can provide investigators to assist investigation process.

Due to the scenario mentioned before, this study conducted by using *iWitness,* photogrammetry software to map a crime scene. A crime scene simulation had been set up at 3D Measurement Lab, Faculty of Geoinformation Science and Engineering, Universiti Teknologi Malaysia. From digital images taken from digital SLR camera SONY F828 at the crime scene simulation, non contact measurement of physical evidences carried out. Later on, *Crime Zone* software is used in order to carry out scene documentation with 3D visualization for better understanding of the crime scene.

2.0 PHOTOGRAMMETRY SOFTWARES

2.1 iWitness software

iWitness was primarily designed for traffic accident reconstruction and forensic measurement. This software system enables a user to convert two-dimensional (2D) coordinate (X,Y) information of feature points on an object recorded in two or more images of a photographed scene into three-dimensional (3D) coordinates (X,Y,Z).From the intersecting rays (**Figure 4**), user can determine object point coordinates (X,Y,Z). *iWitness* was designed to interface with CAD and modeling packages, especially with CAD systems from The CAD Zone (Fraser and Hanley, 2004).

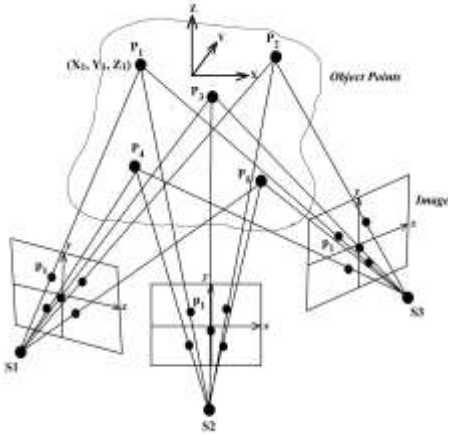

Figure 4: Photogrametry triangulation of intersecting rays (source: *iWitness*)

2.2 Crime Zone software

Crime Zone is CAD systems from The CAD Zone software. The *Crime Zone* creates compelling crime scene diagrams and 3D courtroom exhibits such as:

i. Create accurate 3D surfaces.
ii. Easily align symbols to any surface.
iii. Quickly create profiles to show perspective views and sight lines.
iv. Includes thousands of 2D and 3D pre-drawn symbols

Figure 5 shows a crime scene processed in *iWitness* and 3D visualization in *Crime Zone. iWitness* transfers the XYZ coordinate in .dxf data format into *Crime Zone* in order to simulate the crime scene documentation.

Figure 5: *iWitness* interface (left) and *Crime Zone* 3D visualization interface (right)

3.0 METHODOLOGY

3.1 Camera calibration

Digital images of crime scene captured using digital SLR camera SONY DSC F828 (**Figure 6**) Camera calibration has been done using fully automatic camera calibration function in *iWitness* as shown in **Figure 7**. This type of calibration is using color coded target. **Figure 7** shows several images of these coded targets. The camera calibration was done at 3D Measurement Lab. A total of 7 images taken referred to the software requirement.

Figure 6: Digital SLR camera SONY DSC F828

Figure 7 shows the example of images based on the requirement *iWitness* software for camera calibration procedure:

i. Four or more images from each camera in the project.
ii. At least one image orthogonal (+/- 90°) to other images in the network.
iii. There are 12 or more object feature points referenced in each and every image.
iv. Angles of intersection between a number of imaging rays of >30°.

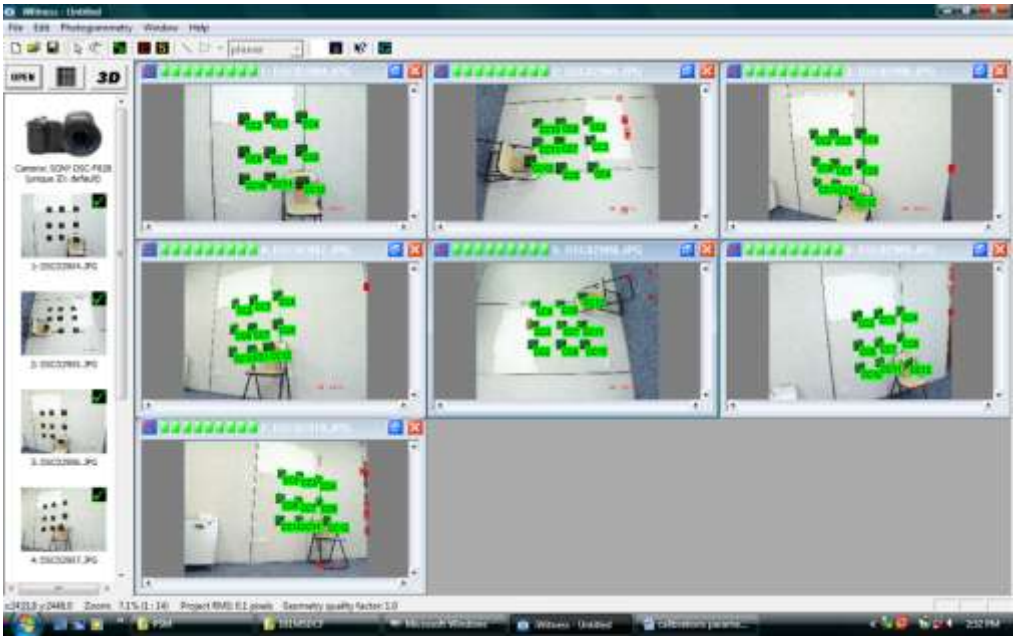

Figure 7: Images of camera calibration in *iWitness*

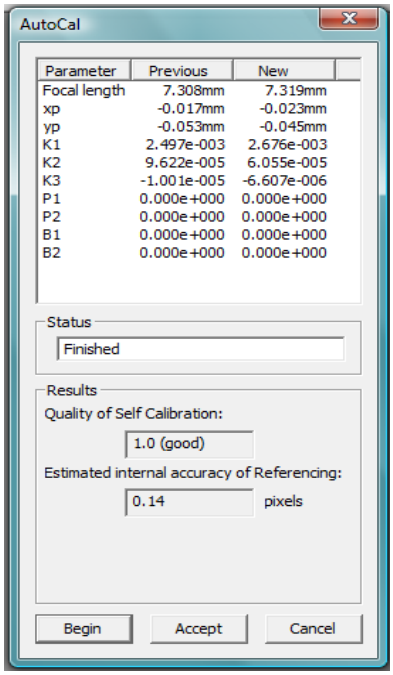

Figure 8: Result from camera calibration in *iWitness*

The result from **Figure 8** shows the quality of camera calibration was 1.0 and this value classified by good. According to User Manual for *iWitness* (2006), it can be achieve because the referencing in the calibration was using color coded target. Ranges for quality of self calibration are:

i. Good (1.00 - 1.50)
ii. Average (1.50 – 3.00)
iii. Poor (> 3.00)

While for the estimated internal accuracy of referencing was 0.14 pixels and it categorized in the range of 0 to 2 pixels which is good geometry of camera station.

i. Less than 0.25 (SLR Camera)
ii. More than 0.25 (commercial / non metric camera)

These parameters being used in *iWitness* in order to generate a better and accurate result from non contact data measurement. It was important not to adjust the focus or zoom mode during capturing images because it will affect that parameter that had been calibrated.

3.2 Data collection

A crime scene simulation had been set up at 3D Measurement Lab, Faculty of Geoinformation Science and Engineering, Universiti Teknologi Malaysia. A total 9 digital image captured covers the whole crime scene simulation. **Figure 9** shows few examples of those images. These images were captured based on Royal Malaysia Police requirement of physical evidences such as:

i. The length and width for fingerprints or footprints.
ii. The length and width of evidences such as knife, sword, or any other weapon in the scene.
iii. The length and width of victim body part of body.
iv. The length and width of injuries on the victim body.

Figure 9: Example of images of crime scene simulation

3.3 Non contact measurement

Those images of the crime scene simulation are referenced each other and digitized points of interest which are the physical evidences based on iWitness requirement:

i. Camera stations are separated such that the angle between the two intersecting rays at each point is greater than a few degrees (i.e., the rays are not near parallel).
ii. The second is that there must be at least five corresponding feature points referenced for the two images and these cannot all lie within a straight line such as **Figure 10**.

Figure 10: Corresponding feature points referenced for the two images in *iWitness*

After referencing process, the scale was set in *iWitness* so that the measurement process can be done. A ruler used as a scale in this study (**Figure 11**). Measurement of physical evidences was done by measure two points that referenced before such as **Figure 12**. **Table 1** shows the non contact measurement of physical evidences measured in iWitness software and compared with conventional method which tape measurement.

Figure 11: Set scale

Figure 12:Non contact measurement

Table 1: Non contact measurement of physical evidences

Physical Evidences	*iWitness* measurement (m)	Tape measurement (m)	Differences (m)
Shoe (length)	0.276	0.290	- 0.014
Knife(length)	0.171	0.160	+ 0.011
Finger(length)	0.084	0.090	- 0.006
Finger from knife (distance)	0.269	0.260	+ 0.009
Finger print (length)	0.165	0.170	- 0.015
Fingerprint A & Fingerprint B(distance)	0.329	0.320	+ 0.009
Victim height	1.752	1.750	+ 0.002

Based on the comparison between *iWitness* and tape measurement result, it shows that the close range photogrammetry technique gave measurement to millimeter level. While as for tape measurement the result only in centimeter level. From that result, there were a few things can be conclude for measurement of the physical evidences in the crime scene simulation which are:

i. *iWitness* gave measurement until millimeter level compared with tape that just gave centimeter level measurement.
ii. Only a slight different between *iWitness* and tape measurement which is +-1cm.
iii. The highest difference was on finger print which is – 0.015m.
iv. The lowest difference was on victim height which is + 0.002m.

Based on **Figure 16**, the total R.M.S. value for *iWitness* measurement was 1.59 pixels and this classified by a good quality if referencing points using physical evidences (natural features). If referencing using coded target, it should get 0 to 1.0 pixels accuracy. Based on User Manual for iWitness, 2006), the quality of referencing can be determined as follows:

i. If using color coded target marker, range for good R.M.S. is 0.00 to 0.20 pixels.
ii. If using natural features / markers, range for good R.M.S. is 1.00 – 2.00 pixels.

Figure 13: Coded target marker (left) and natural feature marker (right)

Table 2: *iWitness* and laser scanner measurement results

Physical Evidences	*iWitness* measurement (m)	Laser Scanner Measurement (m)	Differences (m)
Shoe (length)	0.276	0.299	- 0.023
Knife(length)	0.171	0.170	+ 0.001
Finger(length)	0.084	0.091	- 0.007
Finger from knife (distance)	0.269	0.267	- 0.001
Finger print (length)	0.165	0.164	+ 0.001
Fingerprint A & Fingerprint B(distance)	0.329	0.317	+ 0.002
Victim height	1.752	1.751	+ 0.001

Table 2 shows the comparison between *iWitness* and laser scanner measurement results. These comparisons carry out as to verify *iWitness* measurement data with other non contact method such as laser scanner. Laser scanner method used FARO Photon LS 120/20 (**Figure 14**) to scan the crime scenes to produce registered 3D points clouds. The 3D data are processed by FARO Scene software by data filtering and data colouring. The measurements in 3D view (**Figure 15**) of the objects in the crime scene were also done in the FARO Scene software (Chan, 2010).

Figure 14: FARO Photon LS 120/20

Figure 15: 3D view from laser scanner

Figure 17 shows the *iWitness* Project Status Summary. It shows the 'strength' of network characteristics such as number of images processed, number of points referenced and quality

of geometry with measurement accuracy analysis that shows the estimated accuracy for 3D point's measurement and the quality of the camera calibration.

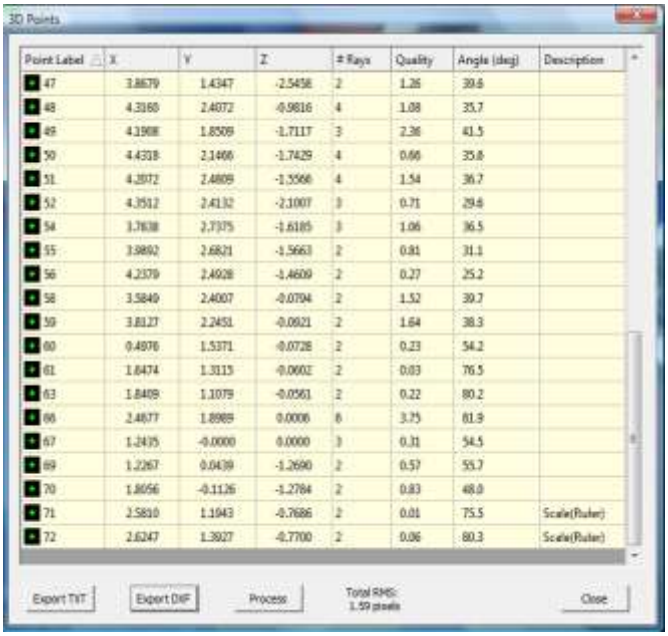

Figure 16: 3D points referencing result

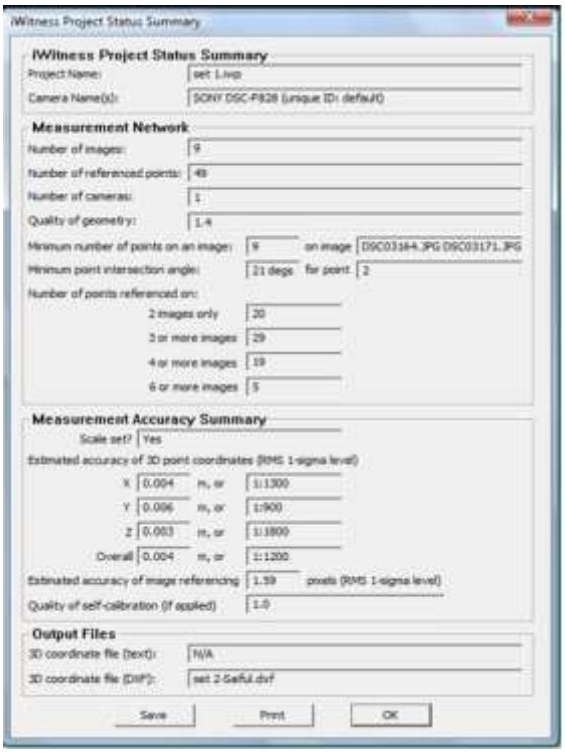

Figure 17: *iWitness* Project Status Summary

3.4 3 D visualization

After the measurement part in the *iWitness* were done, the crime scene simulation need to be process using *Crime Zone* software. The output file from *iWitness* was .DXF format. This file was transferred into *Crime Zone* to do the sketching and later on the 3D visualization of the scene. These physical evidences drawing was done using some easy drawing and editing features such as pre-drawn symbols, easy builders, wall evidences and easy body posers (**Figure 19)**. The wall, door and windows of the simulation were drawn using the easy builder tool (**Figure 18**). After complete the drawing, a 3D mode shows the 3D visualization of the crime scene simulation.

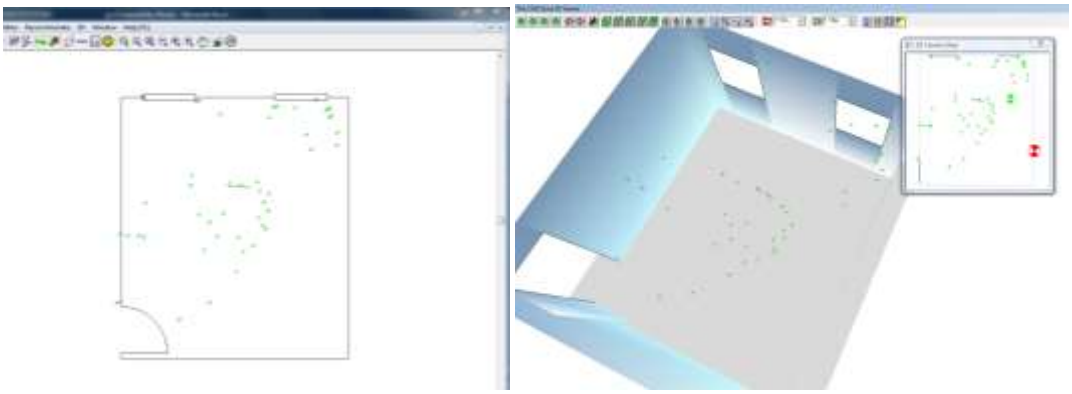

Figure 18: Easy builders function in *Crime Zone*

Figure 19: Easy body poser function in *Crime Zone*

Figure 20 show the final 2D diagram and physical evidences sheet as the final output for 2D view in *Crime Zone*. The 3D visualization generated from this 2D diagram sketching shows in **Figure 21** with comparison from digital images of the crime scene simulation. **Figure 21** shows digital image on the left and 3D visualization of crime scene on the right. From 3D view, it seems that it is much easier to interpret the physical evidences in crime scene compared conventional method currently being used (**Figure 22**).

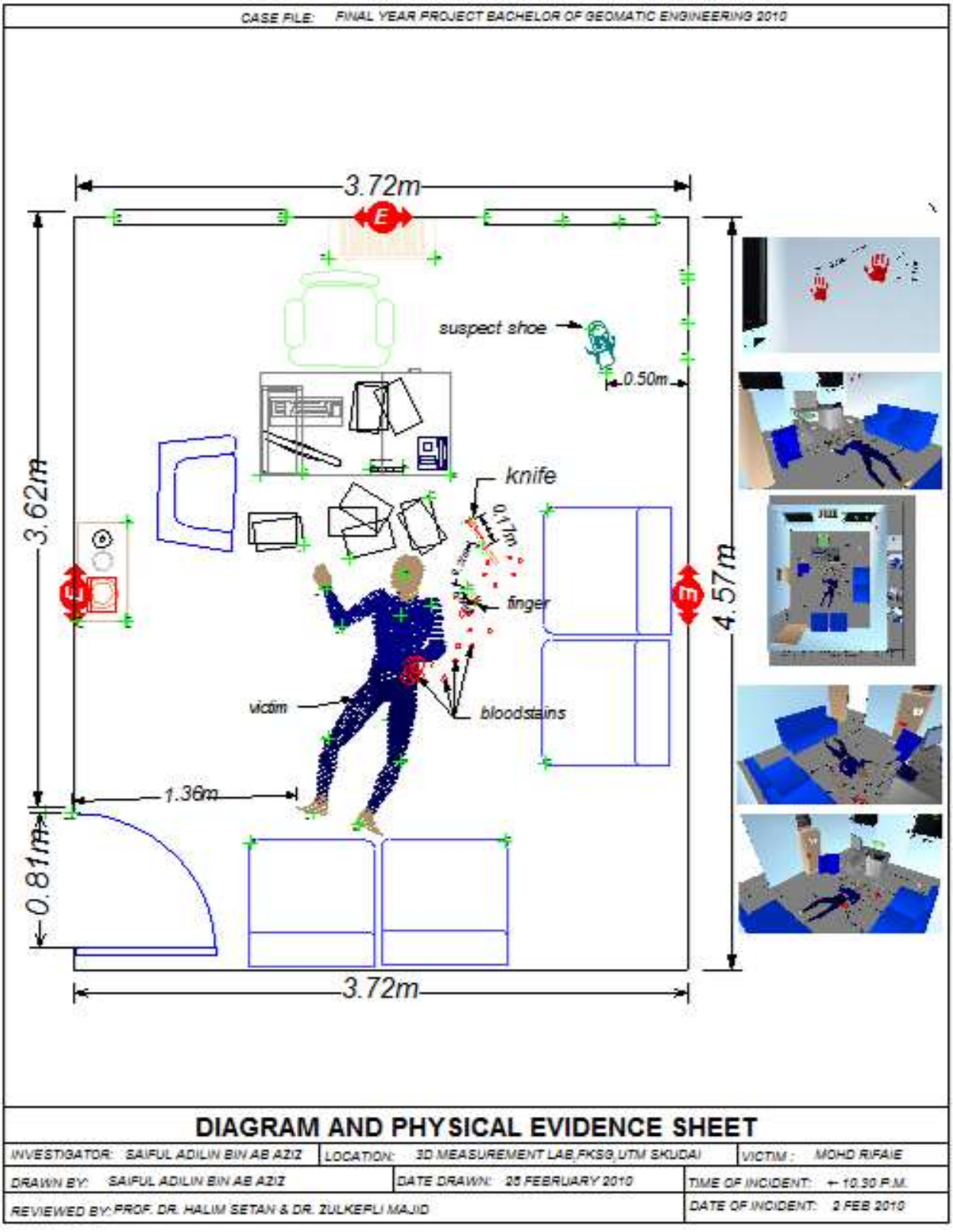

Figure 20: Diagram and Physical Evidence Sheet

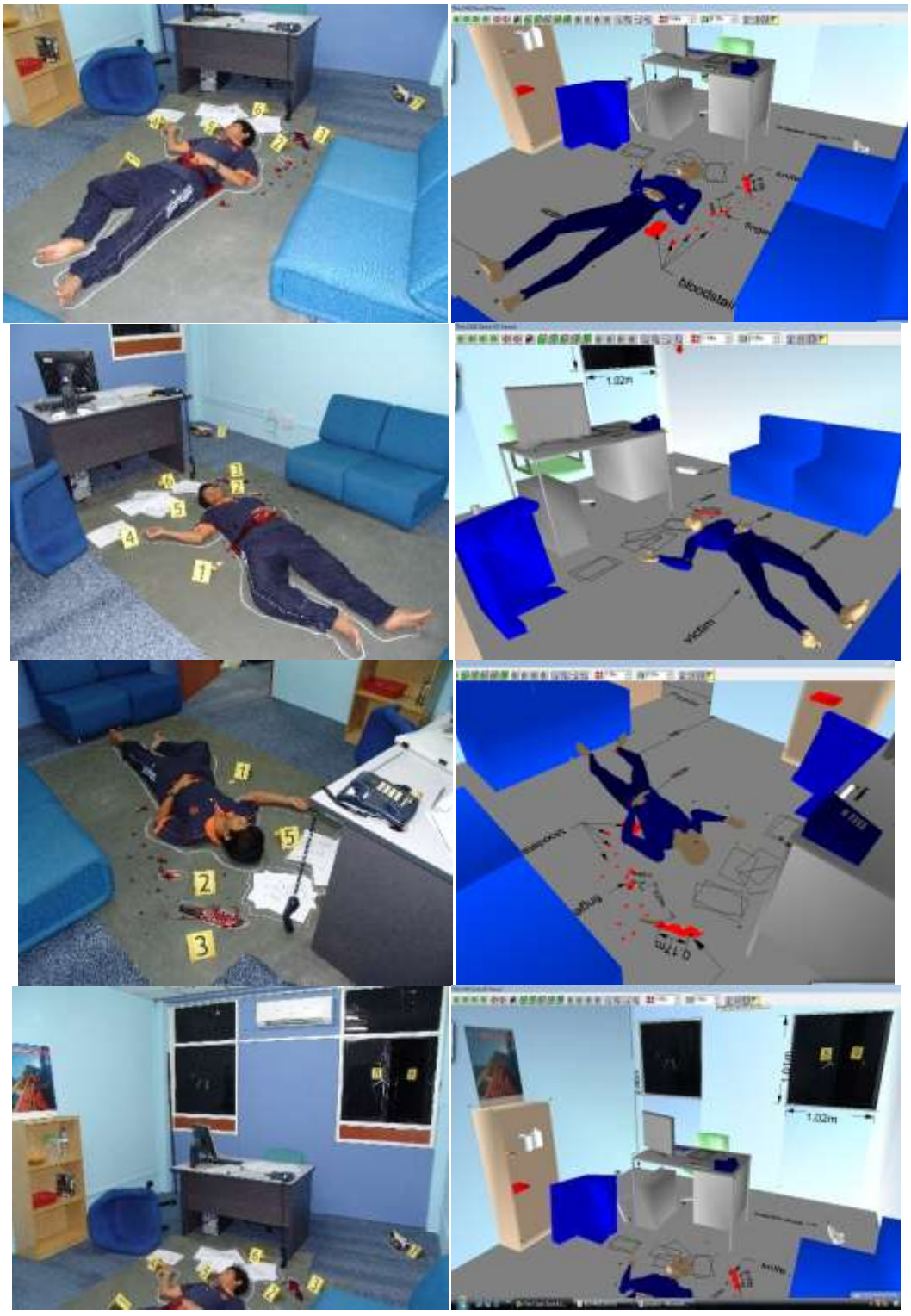

Figure 21: Digital images (left) and 3D visualization of crime scene (right).

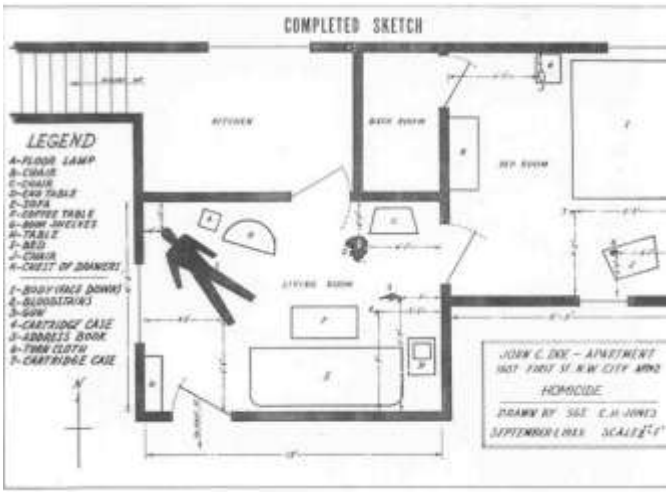

Figure 22: Sample of crime scene sketch

4.0 CONCLUSION

iWitness applying the digital close range photogrammetry method in processing crime scene digital images. It will produce more accurate measurement and analysis in terms of quality and verification with other method such as laser scanning. From this value, user can determine how good the measurement made. Besides that with 3D visualization, crime scene investigators and law enforcement will get a better understanding of the crime scene. Measurement also can be carry out in *Crime Zone* but with no control on accuracy. Besides, the measurement made was generated based on *iWitness* non contact data measurement.

This study would beneficial for Royal Malaysia Police to enhanced the measuring technique with the power to analyzes and visualize crime scene data. Relationship between evidences in crime scene also can be manipulated and documentation process will be a vital tool for the law enforcement to make jurisdiction and court litigation.

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