

RECONSTRUCTION OF TRAFFIC ACCIDENT SCENE USING CLOSE-RANGE PHOTOGRAMMETRY TECHNIQUE

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ABSTRACT

Police investigators and forensic scientists in Malaysia these days face challenges when documenting traffic accident scenes in obtaining accurate measurements. They are still using the conventional method which is impractical to map the scene due to traffic jam, the environment of the road, unstable flooring, and line of sight issues. By using measuring tape, this method is often inaccurate for 3D data, as well as even 2D mapping tasks. Furthermore, they only depend on the rough sketch which is difficult when it comes to retrieve the data. Once the accident scene investigation is cleared out, there is seldom a chance to go back for other 'missed' evidence data, without the evidence being possibly compromised. The application of close range photogrammetry is implemented in this study to overcome the problem by using calibrated digital SLR camera SONY DSC F828 (3264 x 2448 pixel). The collision scene which is located in UTM is captured and imported into iWitness software afterwards to measure accurately the physical evidence data without contaminating them (non-contact measurement). Subsequently, Crash Zone software is used to generate 3D model of the crash scene. The outcome of the research are 2D plan and 3D model showing how the situation occurred. This product can be analyzed by law enforcement, insurance agency, and can be as evidence in court litigation as well.

Keywords: *Accident Reconstruction, Close Range Photogrammetry, Camera Calibration, SLR Digital Camera, iWitness, Crash Zone*

1.0 INTRODUCTION

Traffic accident is the situation that occurred on the road when a road vehicle collides with another vehicle, pedestrian, animal or any geographical objects. It can result in injury, property damage and death. While reconstruction is the process to get a picture or idea of something or how something happened by using all the details that are known. Mapping is one of the methods to give an idea on how the accident can happen by reconstruct the scene. Laser scanning and photogrammetry methods have been used widely in other country such as Australia to map the accident scene. The most attractive attributes of the photogrammetric approach to accident reconstruction are that the scene can be recorded in a very short time and that the imagery provides a permanent archival record that will support further measurement after the incident (Fraser et al., 2008). Close-range photogrammetry (CRP) can be classified as one part of photogrammetry field. The concept of CRP is almost the same with aerial photogrammetry but the distance from the camera is closer to the object during capturing the image. Based on Mathews (2005), CRP has an object-to-camera distance of less than 300 m. From CRP, this method can produce map such as accident scene mapping and the result may be in 2D plan as well as 3D mapping that can provide

some idea on how the collision occurred. Hence, CRP method is more practical than the conventional method.

In Australia, the law enforcement has implemented CRP to reconstruct the traffic accident. As for local police investigators and forensic scientists, they only use conventional method in acquiring measurement by using measurement tape. In Malaysia, the requirement for accuracy in measuring the evidence is only in centimeter (cm) level manually by using measurement tape (Yew, 2009). By using this tool, they will face challenges in obtaining accurate dimension when documenting traffic accident scenes since the measurement is inaccurate for 2D data or 3D mapping task. Once the location of the accident scene is cleared out, there is seldom a chance to go back for other 'missed' evidence data (Yew, 2009).

According to Saidatul Rezma (2009), police investigators in Malaysia only depend on the rough sketch that are recorded by them while handling the accident case. The sketch is kept as reference afterwards. In this form of hardcopy shows how difficult it was when it comes to retrieve the data. As the result, this conventional method will leads to a longer period for investigation and make the traffic congested for certain time in sequence.

This paper describes the usage of iWitness software which is an integral part of accident reconstruction and forensic measurement work due to its ease of use and flexibility. According to Clark (2006), this software is an image-based, 3D measurement that allow for object modeling. The software is designed to determine 3D object point coordinates from 2D images recorded with a digital SLR camera. Galvin (2004) explained that the 3D photogrammetry modelled points and lines are then converted into 3D diagram using a CAD (computer-aided) drawing program. From these pictures, Crash Zone software is used to visualize the scene in 2D plan and 3D view as well (The Crash Zone, 2009). As the result, the 3D model can be used by law enforcement or reconstructionist to do further analysis.

Therefore, this research was conducted to reconstruct accident scene using close-range photogrammetric technique to ensure every data of the accident scene recorded only by low-cost and off-the-shelf digital camera technology. Hence, the process will reduce the adverse consequences of traffic incidents through fast and comprehensive dimensional recording incidents scenes for later forensic analysis and legal purposes and indirectly minimizing the traffic disruptions times. In combination with iWitness and Crash Zone software, the crash scenes can be accurately mapped.

2.0 RECONSTRUCTION OF TRAFFIC ACCIDENT USING IWITNESS SOFTWARE

For this research, iWitness software is used for image measurement, orientation, subsequent photogrammetric triangulation and post-orientation processes. Its primary application domain is accident reconstruction and forensic measurement where it is used by police. Fraser and Hanley (2005) claims that "this software is low cost, and offers the user the prospect of assembling a photogrammetric measurement system comprising camera and all necessary data processing software, which is capable of accuracies to about 1:20,000, for as little as \$US 1500." This is because of the ready availability of consumer-grade digital cameras has made photogrammetric measurement accessible and more widely employed for many applications.

PhotoModeler is software that has similar function with iWitness. It is also a close range photogrammetry software package for various traffic accident reconstruction applications.

O'Shields (2007) explained that this software gives the accuracy for about 1:750 for crush measurement projects and up to 1:5400 for a bank robbery project (forensic photogrammetry).

Fraser and Hanley (2005) stated that full automation in close-range photogrammetric measurement has long been a practical reality. Previous study by Fraser and Simon (2008) has reported that hybrid measurement approach for close range photogrammetry was referring to incorporation of automatic 3D measurement of targeted points, with supplementary operator assisted and semi-automatic 3D digitizing of unsignalized features. Hence, this approach will minimize the operational constraints including imaging conditions and the provision of targeting while full flexibility is retained.

The main purpose of traffic accident reconstruction is, as the name implies, to reconstruct motor vehicle collision scenes (Fraser, et. al 2008). An essential first step to analyze the dynamics of the collision event, to provide evidence in a subsequent court case or for some other purpose is to accurately characterize the dimensions of the accident scene.

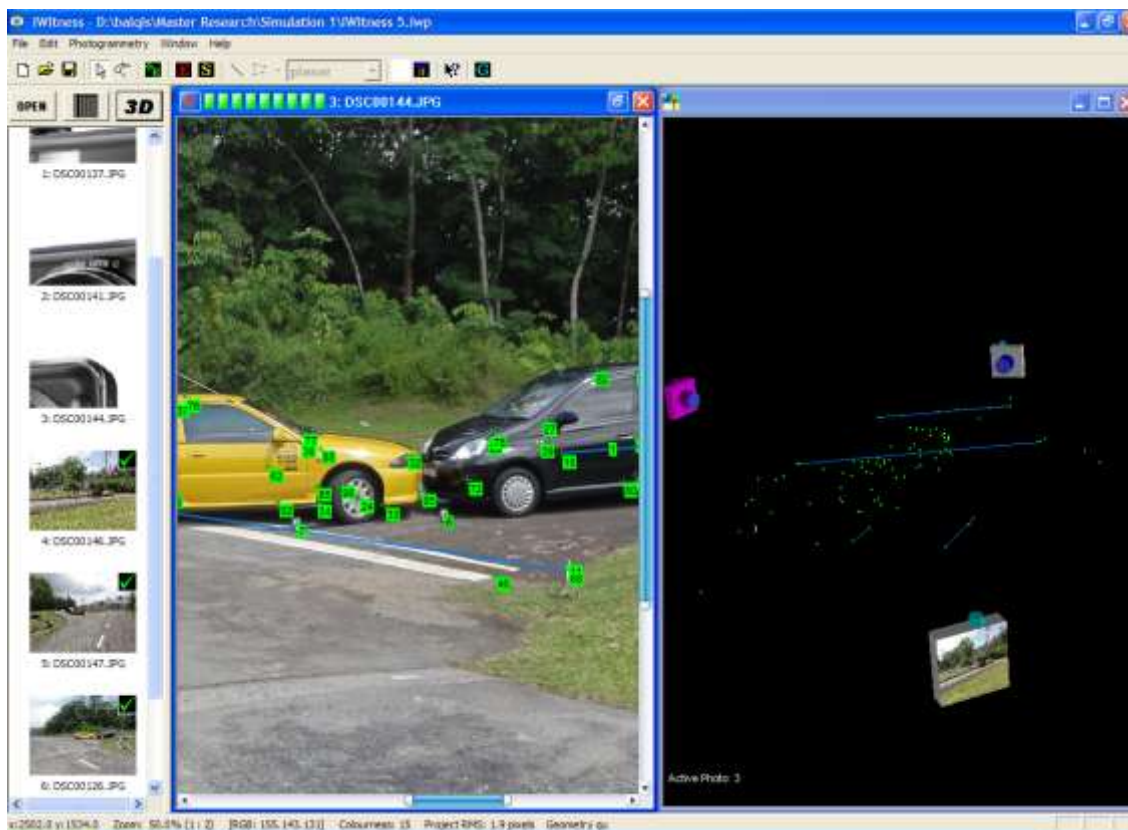


Figure 1: iWitness User Interface

Shown in **Figure 1** is an example of the graphical user interface of iWitness. According to Fraser and Hanley (2005), its features are currently restricted to attributed point cloud generation, with the attributes primarily being line connections which are preserved in the export of XYZ point coordinate data in DXF format. This is due to the system which was primarily designed for traffic accident reconstruction and forensic measurement. iWitness is designed to interface with CAD and modelling packages, especially with CAD systems from The CAD Zone.

Since the final result is typically CAD drawing in the first instance, the term diagramming is used to describe this documentation process, which may be further advanced into 3D model

an even animation in Crash Zone as shown in **Figure 2**. This software has even more tools for crash investigators, including easy 3D animations, a vehicle specifications database, skid analysis and momentum calculations, and an easy-to-use 3D body poser (The Crash Zone, 2009).

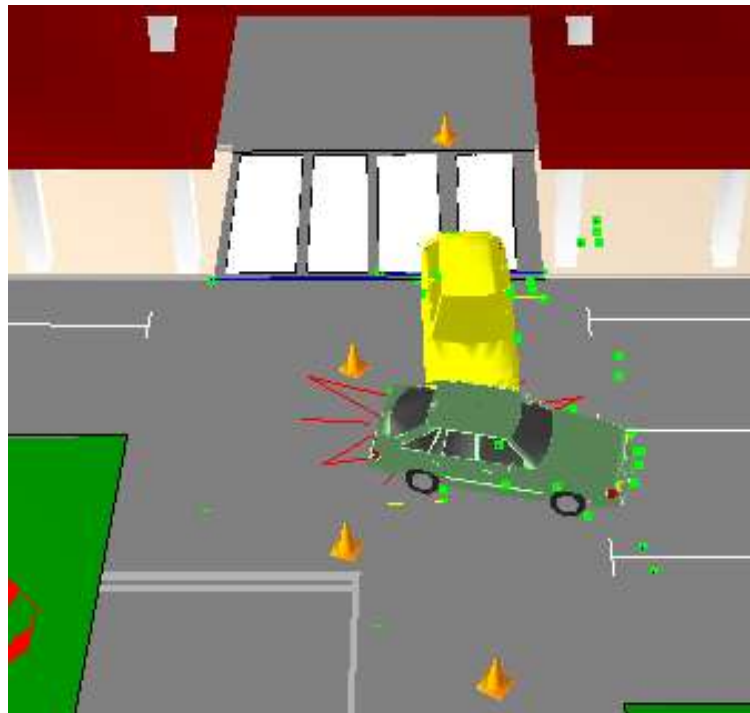
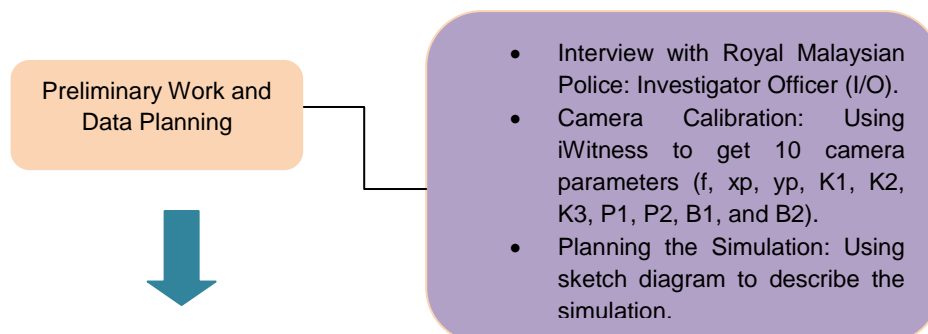


Figure 2: 3D Model of Accident Scene

A study conducted by Fraser et al. (2005), the comprehensiveness of reconstruction required can vary depending upon the ultimate use of the ‘mapping’ data produced. For instance, a vehicle producer or traffic engineer might require a detailed 3D reconstruction, while the law enforcement may only need simple 2D documentation in recognition of the fact that if the accident does not result in subsequent legal proceedings, the accident reconstruction data will likely never be used. But it is not always known at the time of the accident whether court proceedings will eventuate. Accidents involving fatalities must be surveyed and mapped in most jurisdictions.

3.0 METHOD AND RESULTS

To explain the sequences involved, some visualization on the research process and the way of every process being carried out is provided. **Figure 3** below shows a brief flowchart to describe the methodologies that have been adopted in this research. Further explanations of each stage are discussed in the next subtopic.



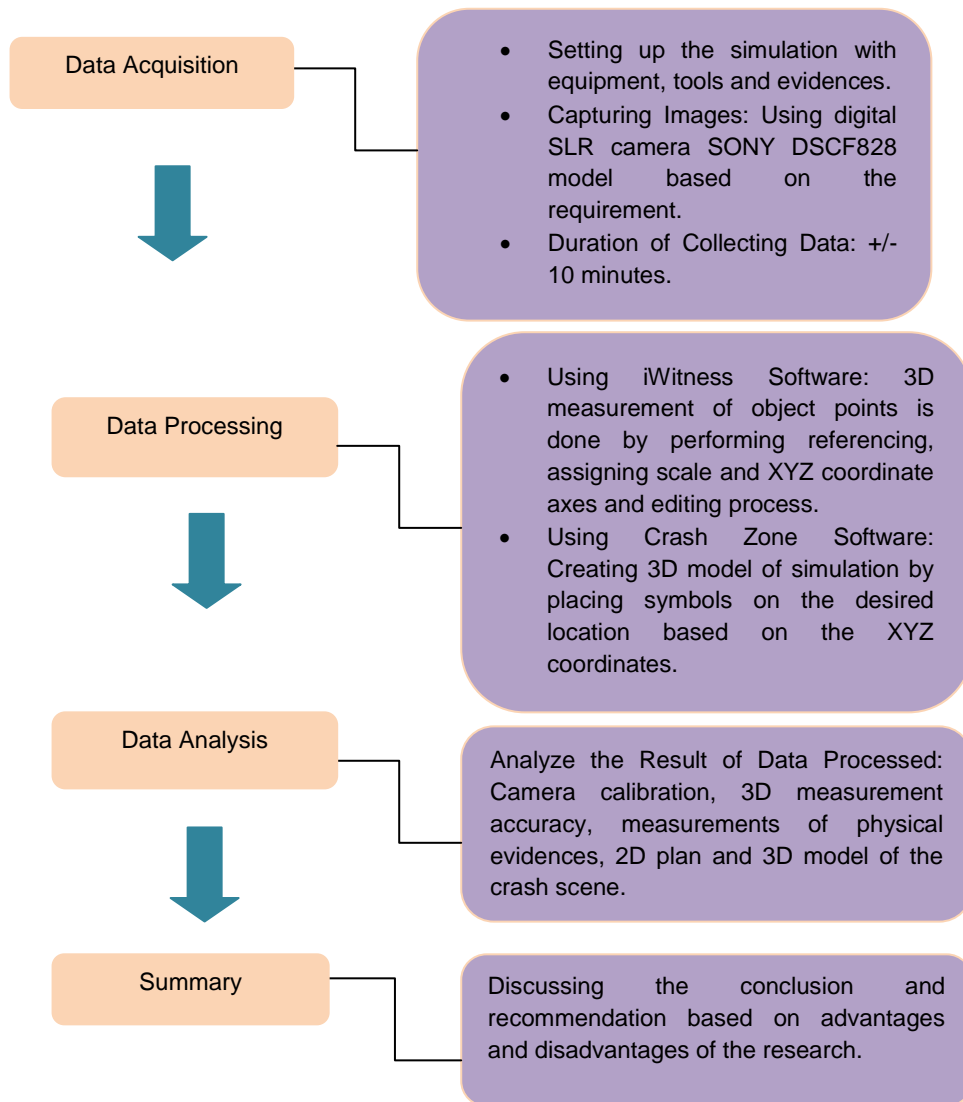


Figure 3: Flowchart of Research Methodology

3.1 Camera Calibration

Camera calibration is an important prerequisite to performing accurate 3D measurement with iWitness. According to Kenneth (2000), camera calibration is the recovery of the intrinsic parameters of a camera. Therefore, iWitness need accurate approximation of the camera’s focal length (principal distance), lens distortion characteristics and other calibration parameters. As stated in iWitness (2006), the camera parameters (**Figure 4**) for this project are as follows:

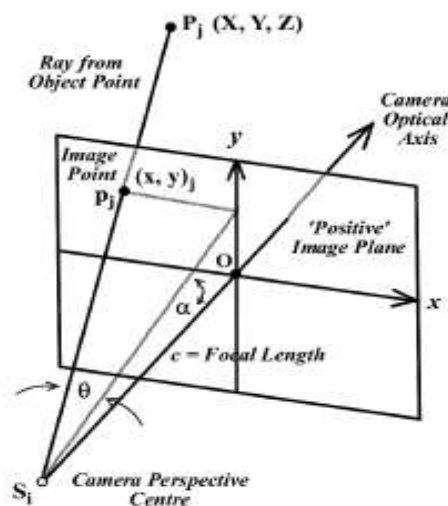


Figure 4: Camera Parameters
Source: iWitness Manual 2006

3.1.1 Focal Length and Principal Point: The distance of optical axis of the lens from the centre of the image format is indicated by focal length and the principal point offsets. The 'focal length' actually refers to the Principal Distance, which changes with focusing. Even though this focal length value can vary dramatically with zoom cameras, but only one value for the camera is used in the survey. So, it is important not to change zoom or focus during the photographic session. Generally x_p and y_p are close to zero.

3.1.2 Radial Distortion: Radial lens distortions of the camera lens are described by three parameters K_1 , K_2 and K_3 . They need to be corrected when computing 3D feature point position to even modest accuracy levels and they can reach significant levels in digital camera lenses. Radial distortion also varies with focusing which is a further reason not to alter focus or zoom within a measurement network.

3.1.3 Decentering Distortion: This error source is generally quite small and can typically be ignored in all but very high accuracy applications. The parameters P_1 and P_2 express the effect of the decentering of optical elements within the lens assembly.

3.1.4 Linear Distortion: These parameters, B_1 and B_2 , can usually be set 'fixed' to zero and ignored since they can effectively model any relative error in the specified pixel size.

Camera calibration is done using fully automatic camera calibration function in iWitness. The calibration is carried out in 3D Measurement Lab using a digital SLR camera SONY DSC F828 model to capture nine sheets of color coded targets. Each code comprises of five dots, either red or green, in a 'T' arrangement. Target arrays are established by arranging them as shown in **Figure 5**. A network of seven images are captured with at least one image orthogonal ($\pm 90^\circ$) to other images in the network. The zooming function is locked to avoid any adjustment of the function after the calibration. It is preferable for the target field to have 'depth' (**Figure 6**). The angle of intersection between a number of imaging rays was $>30^\circ$ as the requirement in the calibration. The pictures are then imported and processed in iWitness to run the automatic calibration. Each image is sequentially processed and once the calibration is completed the calibration results are displayed (**Figure 7**). **Figure 8** and **Figure 9** respectively show the positions of camera with and without imaging rays.

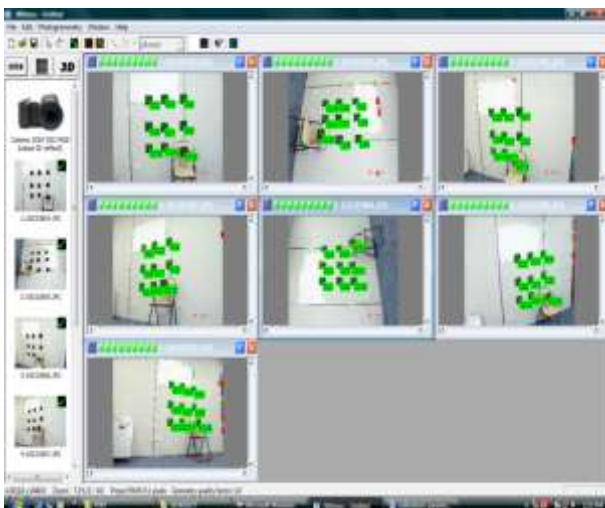
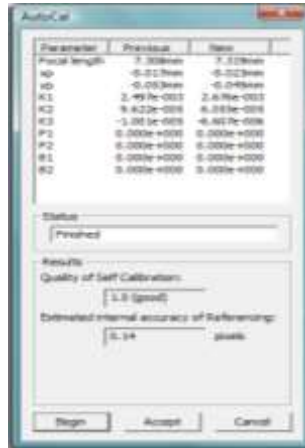


Figure 5: Camera Calibration at 3D Measurement Lab



Figure 6: Target Array in 3D View



Parameter	Previous	New
Focal length:	7.308mm	7.308mm
K0	-0.003mm	-0.003mm
K1	2.491e-005	2.616e-005
K2	9.622e-006	6.285e-006
K3	-3.003e-005	-6.803e-006
P1	0.000e+000	0.000e+000
P2	0.000e+000	0.000e+000
B1	0.000e+000	0.000e+000
B2	0.000e+000	0.000e+000

Status:

Results:
Quality of Self Calibration:
Estimated internal accuracy of Reference: pixels

Buttons: [Begin] [Accept] [Cancel]

Figure 7: The Quality of Camera Calibration (Before and After)

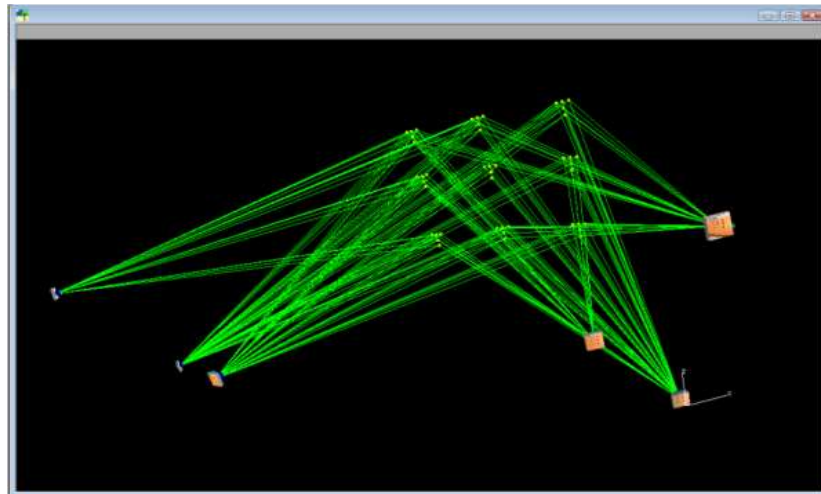


Figure 8: Positions of Camera with Imaging Rays

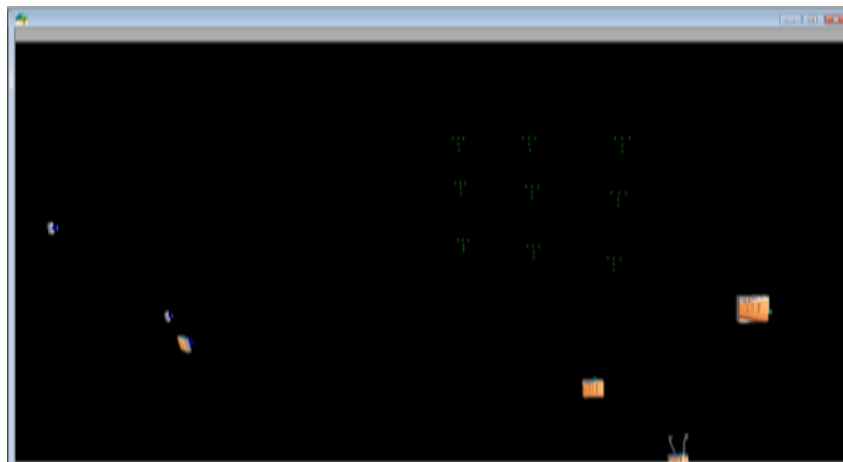


Figure 9: Positions of Camera without Imaging Rays

The previous and new values of parameters of the camera are stated in **Figure 7**. There are listed as focal length, pixel size (xp, yp), radial distortions (K1, K2, K3), decentering distortions (P1, P2) and linear distortions (B1, B2). Note that the value for P1, P2, B1, and B2 is not changing at all because of these value is quite small and can typically be ignored. While for other parameters, their differences are only in millimeter level compared to the previous value. In projects where camera self-calibration is employed, iWitness will generate a quality rating of good, average or poor. For this project, the quality of self calibration can be seen in the same dialog box showing the value is good. An acceptable calibration is generally indicated by an internal accuracy of referencing value of 0.25 pixels or smaller. The value for this camera calibration is 0.14 pixels which are in the range of acceptable value thus can be proceed to the next stage. The project is saved and the process is completed.

3.2 Simulation of the Crash Scene

This stage also included the plan on how to simulate the accident scene on a sketch diagram (**Figure 10**). The simulation is carried out on 3rd February 2010 at 6.00pm and took place at car park between Faculty of Geoinformation Science and Engineering (FKSG) and Faculty of Science along Jalan Hikmah. Two cars specifically Vehicle 1, Satria and Vehicle 2, Iswara are set in accident position with broken glasses located on the road surface between both vehicles. The arrangement for Vehicle 1 is placed in straight parallel to the road while for Vehicle 2 is set in reversing position. Black aerosol spray is used to spray on the road surface behind the Vehicle 1 as for the scratch tyre while four traffic cones are positioned within the crash area.

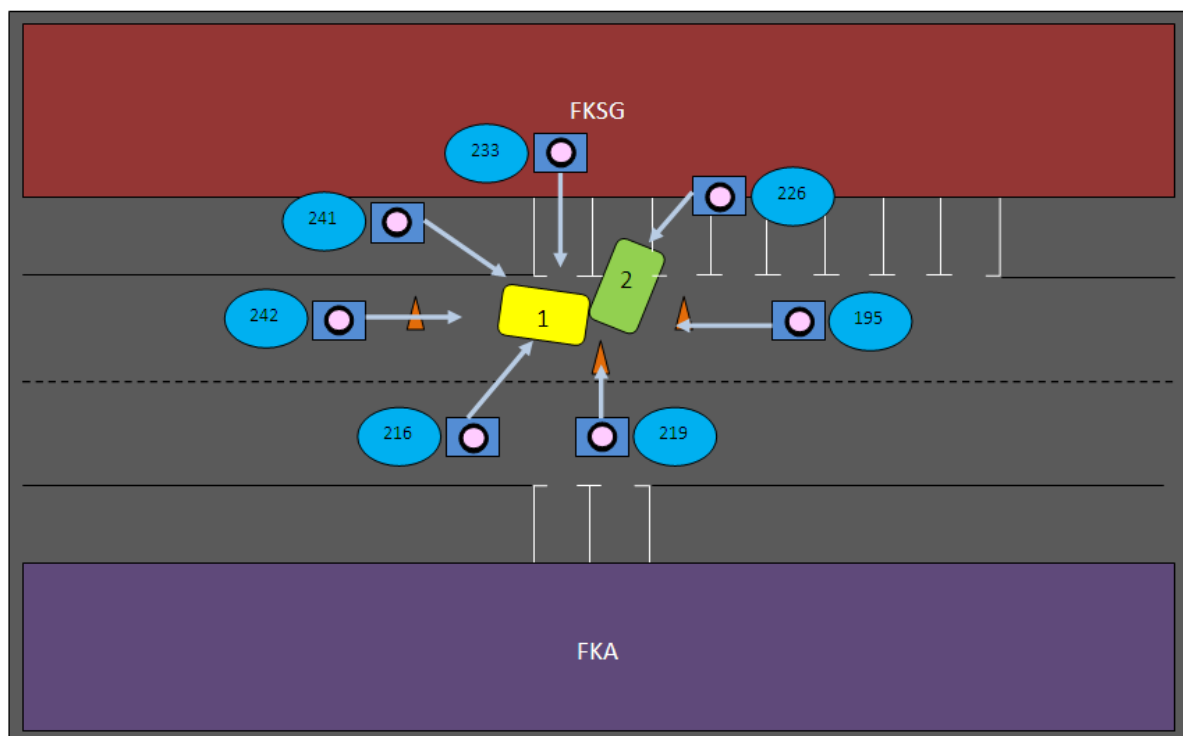


Figure 10: Sketch of the Crash Scene

The positions of camera are situated at 7 different locations as indicated in the same figure to cover the whole area of the accident scene. A network of seven convergent images are captured (**Figure 11**) with at least 1 different orientation ($-90^{\circ}/+90^{\circ}$) by using a calibrated

digital SLR camera SONY DSCF828. The camera stations should be separated by a distance that is desirably 15% or more of the average distance from the camera positions to the object points of interest. The numbers in the blue circle represent the image numbers that have been chosen to give the best view among the pictures taken at 7 camera positions respectively. The physical evidences that are captured are based on the requirement of Royal Malaysia Police. Physical evidences that need to be identified are length of scratch tyre (braking distance), width of tyre, distance Vehicle 1 and Vehicle 2 from side of the road, and width of the accident impact. The duration of collecting the data was in approximately +/-10 minutes. The pictures are saved in the camera memory and loaded into iWitness software.

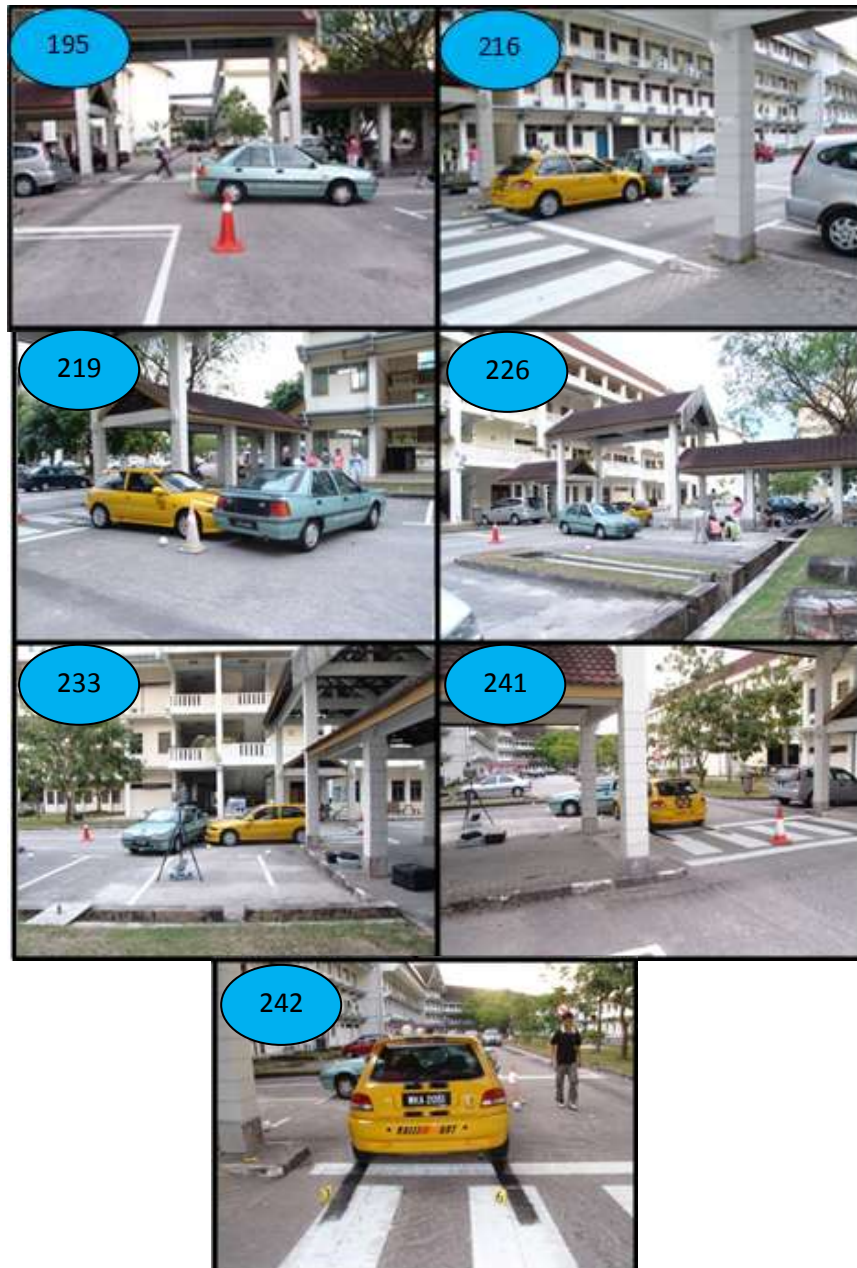


Figure 11: Seven Images of Traffic Collision

3.3 3D Measurement Accuracy

The captured images of accident scene are then processed using iWitness by referencing as illustrated in **Figure 12** which is identifying and measuring the corresponding feature points in those images. Referencing simply entails the successive marking of the same point, sequentially in the two images, with the order being either right to left or left to right. This is followed by referencing the third and subsequent images.



Figure 12: Image Referencing Using iWitness Software

The total amount of referenced points is 61 points including points of evidences. A point is in good quality when the value in quality column is in the range of 0 to 2. The points which exceeded 2 were improved by moving the point to make it in good range values. While from **Figure 13**, the object points that are referenced recorded in a table with the quality of referencing of the points respectively. These values are obtained from the referencing process for each point. The points that are correctly referenced in those images give the lower value.

Point Label	X	Y	Z	# Rays	Quality	Angle (deg)	Description
1	2.3488	-0.0237	-0.7403	7	0.47	88.0	
2	2.8419	-0.0268	-0.6786	7	0.53	88.2	
3	3.0006	-0.5227	-0.5437	7	0.58	88.4	
4	2.2104	-0.7185	-1.2483	7	0.67	87.8	
5	2.8803	-0.7647	-1.1828	7	0.55	85.8	
6	4.0748	-0.7982	-1.1025	7	1.43	84.3	
7	4.4507	7.4436	-1.1519	6	2.01	88.0	
8	1.2440	-0.3822	-1.3372	7	0.51	88.2	
9	0.5279	0.3281	0.0146	7	1.98	87.8	
10	1.8019	-0.4213	-1.2811	7	0.88	88.2	
11	3.1970	-0.4883	-1.1780	7	1.28	89.1	
12	1.2302	-0.0738	-1.3181	7	0.58	88.8	
13	0.9908	-0.4377	-1.2576	7	0.53	88.7	
14	2.6311	-0.1934	0.1086	7	0.47	88.6	
15	3.3624	-0.4944	-1.1891	7	0.43	88.1	
16	2.2544	-0.5271	-0.8386	7	0.53	88.1	
17	2.6763	-0.5040	-0.5482	7	0.43	87.8	
18	3.8403	3.1231	-0.3000	7	1.34	86.7	
19	0.3688	3.0320	-0.4381	7	1.08	88.3	
20	3.2645	0.8236	-0.3288	7	0.68	88.3	
21	3.1941	3.0794	-0.3011	7	0.86	86.1	

Figure 13: Quality of Image Referencing of Object Point Coordinates

After the process of referencing, Project Status Summary will appear as shown in **Figure 14** listed both characteristics of the iWitness measurement project and a short summary of important results. The first page is as shown in the figure, whereas second and third pages list camera parameters and object point XYZ coordinates. The accuracy of referencing is indicated by Total Project Root Mean Square (R.M.S) value. The estimated accuracy of the referencing process in RMS value is 1.28 pixels, which is in the expected range from 1 to 2 pixels for digital SLR camera. It is depending upon the camera, network geometry and especially the care taken in marking corresponding point locations. The accuracy of 3D measurement is a direct function of the referencing accuracy, so the more precise the point marking and referencing, the better.

The geometry quality factor indicates the strength of the network geometry, with 1 to 1.5 being good, 1.5 to 3 being average, and above 3 being poor. For this project where camera self-calibration is employed, the value shows 1.0 which is in the range of good quality. As for the third section in **Figure 14** listed the estimated accuracy (RMS, 1-sigma level) of the measured 3D point coordinates, along with the corresponding proportional accuracy, which is determined as the ratio of the estimated point standard error over the effective maximum diameter of the object point array. Values here are depending upon network geometry, accuracy of referencing, camera type and number of images. The proportional accuracy for this project is overall 1:3000, which is expected in the range of high quality result from 1: 500 to 1:10,000.

The screenshot shows the 'iWitness Project Status Summary' window. It is divided into several sections:

- iWitness Project Status Summary:**
 - Project Name: set 2-balqis.iwp
 - Camera Name(s): SONY DSC-F828 (unique ID: default)
- Measurement Network:**
 - Number of images: 7
 - Number of referenced points: 55
 - Number of cameras: 1
 - Quality of geometry: 1.0
 - Minimum number of points on an image: 41 on image DSC03219.JPG
 - Minimum point intersection angle: 47 degs for point 56
 - Number of points referenced on:
 - 2 images only: 10
 - 3 or more images: 45
 - 4 or more images: 43
 - 6 or more images: 42
- Measurement Accuracy Summary:**
 - Scale set? Yes
 - Estimated accuracy of 3D point coordinates (RMS 1-sigma level):
 - X: 0.004 m, or 1:2600
 - Y: 0.004 m, or 1:2600
 - Z: 0.002 m, or 1:4400
 - Overall: 0.003 m, or 1:3000
 - Estimated accuracy of image referencing: 1.28 pixels (RMS 1-sigma level)
 - Quality of self-calibration (if applied): 1.0
- Output Files:**
 - 3D coordinate file (text): N/A
 - 3D coordinate file (DXF): export set 2-balqis.dxf

Buttons at the bottom: Save, Print, OK.

Figure 14: Project Status Summary

By assigning scale (**Figure 15**) and XYZ coordinate axes (**Figure 16**), true scale was introduced since the photogrammetric orientation in iWitness results in 3D object point coordinates which have only an arbitrary scale. To assign a scale, two points 1 and 2 are selected from the point number list forming the known distance, and this distance is entered. As for XYZ coordinate axes, a point is first selected to define the origin (X, Y, Z values of zero). Next, a point through which the X axis will pass is defined, and finally a third point is selected to define the XY plane and therefore the direction of the Z coordinate axis (the Z axis is traditionally vertical). A final editing process (**Figure 17**) is carried out once all points have been fully referenced in all images. This is done by viewing all referenced point one by one in all images and moves the desired point to the suitable location. This process will increase the quality of referencing. The more accurate the marking and referencing process, the more accurate the determination of 3D feature point coordinates. The final XYZ coordinates in .dxf format are exported into Crash Zone software.



Figure 15: Process of Assigning Scale



Figure 16: Process of Assigning Coordinate Axes



Figure 17: Process of Editing

The XYZ coordinates are then appeared in the Crash Zone as indicated in **Figure 18**. From these points, symbols of objects such as vehicles, trees, signs, and others are placed in the diagram as pre-drawn symbols. Based on Galvin (2004), the photogrammetry data from the iWitness program has been brought into The Crash Zone diagramming program and is displayed here as a plan view. To place the symbol in the diagram, the Symbol Manager toolbox is first opened, any of the appropriate symbols in the Symbol Manager is clicked and the mouse pointer is moved back into the drawing window to see an outline of that symbol. The symbol is placed on the desired location based on the XYZ coordinates (**Figure 19**). To give description of these symbols, text function is used while for dimensioning purpose; dimension button is applied to label the symbols with the measurement value. Finally, 3D model of the whole accident scene is generated for viewing reason.

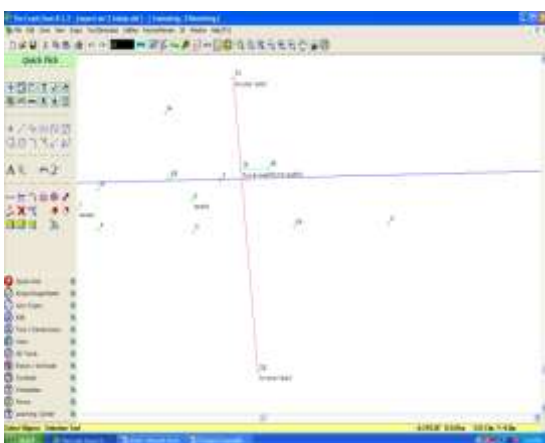


Figure 18: Points generated in Crash Zone Software

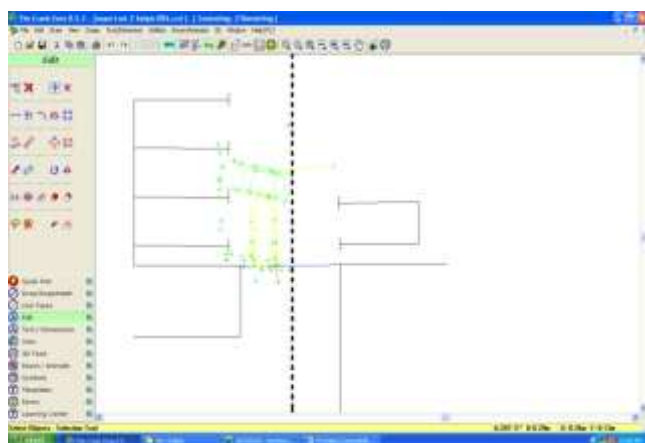


Figure 19: Placing Symbol of Car Based on 3D Coordinate Points

3.4 Measurement of Physical Evidences

The physical evidences that have been referenced before are then measured in centimeter level by using dimensioning function in iWitness software (Figure 20). Table 1 shows the comparison of measurement of the physical evidences by using different method which is iWitness, measurement tape and Terrestrial Laser Scanning (TLS). The values of measurement by using measurement tape are taken by stretching the tape nearer to the evidence. As from TLS, the values are taken by scanning the whole scene in different scanner position within the crash area. According to Wendt and Fraser (2005), laser scanning devices directly deliver the geometric shape of measured objects with an adequate resolution and accuracy. These two methods are carried out in the same simulation of the accident scene.

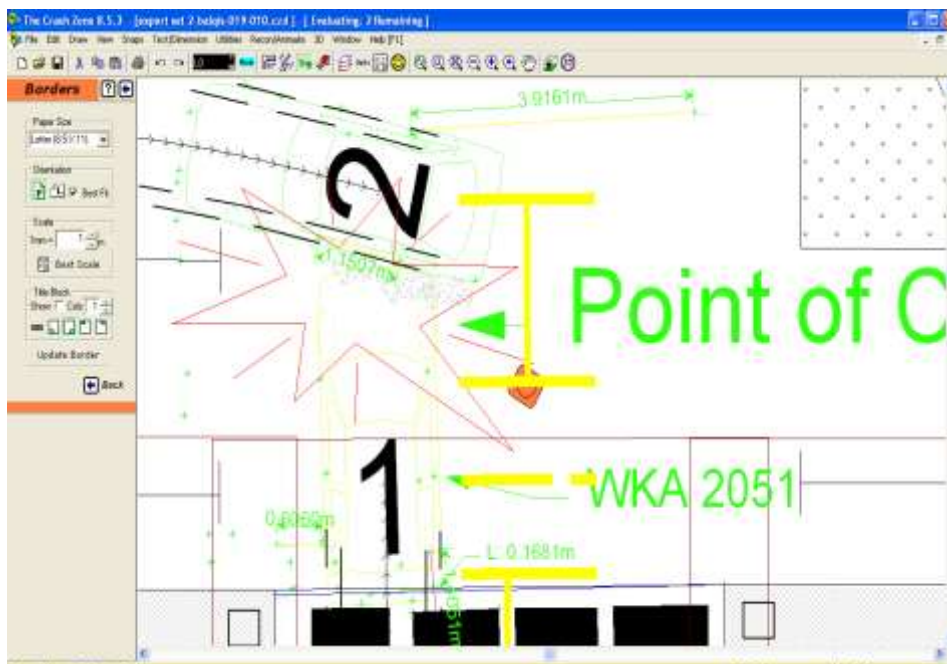


Figure 20: Sample of Measurements of Physical Evidences

Table 1: Dimensions of Physical Evidences Using iWitness, Measurement Tape and Terrestrial Laser Scanning (TLS)

No.	Physical Evidences	iWitness Measurement (m)	Tape Measurement (m)	TLS Measurement (m)
1	Length of scratch tyre (braking distance)	1.405	1.390	1.427
2	Width of tyre	0.168	0.160	0.167
3	Distance car A from side of the road	0.606	0.610	0.615

4	Distance car B from side of the road	3.916	3.900	3.904
5	Length of accident impact	1.151	1.140	1.451

Table 2: Comparison between iWitness with Measurement Tape and TLS Measurement

No.	Physical Evidences	Differences (m)	Differences (m)
1	Length of scratch tyre (braking distance)	+0.015	-0.022
2	Width of tyre	+0.008	+0.001
3	Distance car A from the side of the road	-0.004	-0.019
4	Distance car B from the side of the road	+0.016	+0.012
5	Length of accident impact	+0.011	-0.028

Table 2 shows the comparisons between iWitness, measurement tape and TLS measurement respectively. It is known that iWitness provide less accurate data than TLS method but more accurate data compared to measurement tape because it is depending on how well the referencing process is performed. These values between these types of measurements are experienced only slight differences in centimeter level compared to the requirement in centimeter level accuracy for law enforcement in Malaysia. Thus it is concluded that iWitness could help them to do the documentation even though implementing a non-contact measurement of the accident scene for example as illustrated in **Figure 2**



Figure 21: Example of a Non-Contact Measurement Using iWitness on Width of Tyre

In addition, using iWitness is more practical since the cost for software and equipment used is more feasible and economical for police to implement this method compared to TLS. Furthermore, the equipment used will cost less for maintenance. Another important aspect to be seen here is the purpose of the measurements on the physical evidences. For instance, from the measurement of scratching tyre, it can be identified where was the initial brake until the vehicle collides. By using this measurement, the speed of vehicle can be calculated by physics engineer for legal purpose. Length of accident impact is significance as well for law enforcement to investigate who is actually wrong in certain traffic cases. Besides that, the insurance agency can play their role too by discovering the damage for the owner to claim the insurance.

3.5 2D Plan of the Accident Reconstruction

The Crash Zone product is the CAD-based software that is used to produce the actual drawings of vehicles, road, or buildings used in the preplan (Berry, 2008). Based on **Figure 22**, the output of iWitness in .dxf file is exported to be as an input for Crash Zone whereas **Figure 23** shows that the data has been imported from iWitness. From this object point coordinates, 2D plan and 3D model of the accident reconstruction can be generated by using some related functions and tools available in the Crash Zone. For example, the vehicle placed on the diagram is referring to the points generated from iWitness.

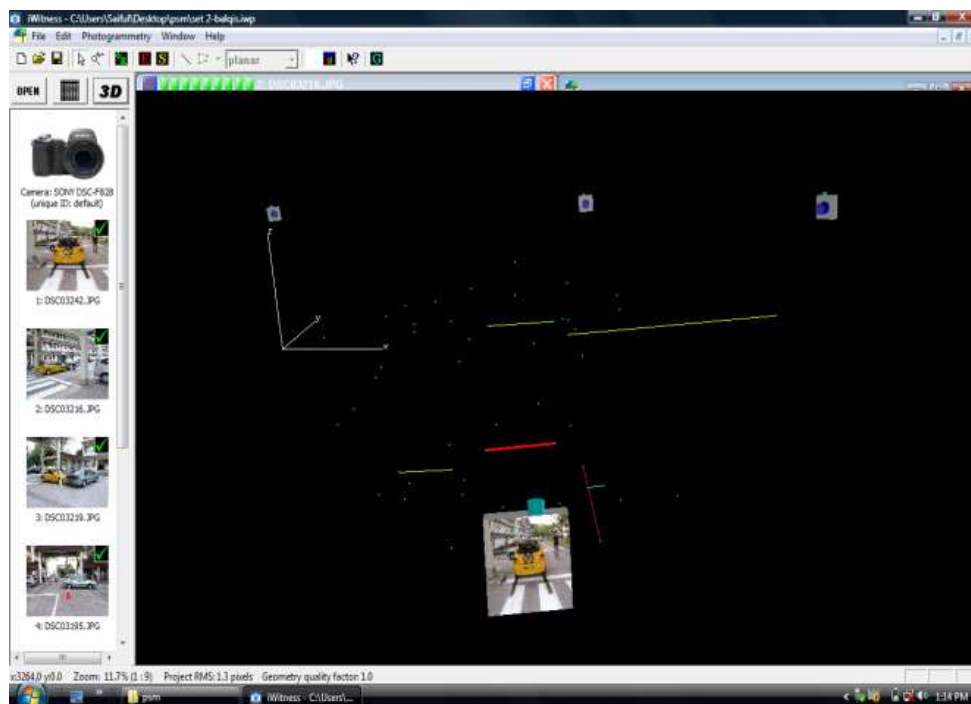


Figure 22: Object Points in iWitness Software in .dxf File

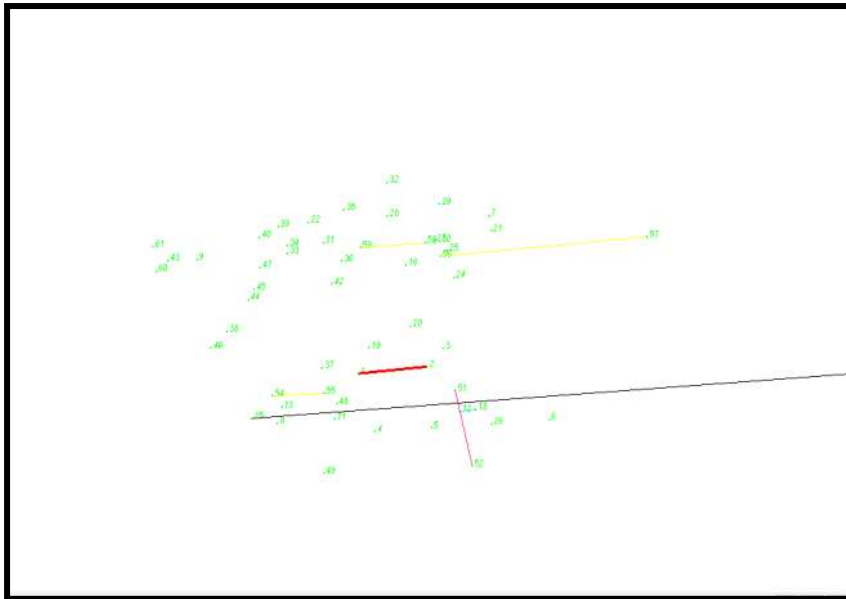


Figure 23: Object Points in Crash Zone Software

Shown in **Figure 24** is the final documentation of accident scene in 2D plan from top view. This can be observed that the object points that were referenced before appear in Crash Zone and the placements of the symbol on the object point are helped with the aid of text to label them. With the symbols and text placed in accurate position based on the point coordinates, it can provide 2D view of the crash area. This diagram can be used to replace the sketch diagram in conventional method which is only sketch by hand with no scale provided.

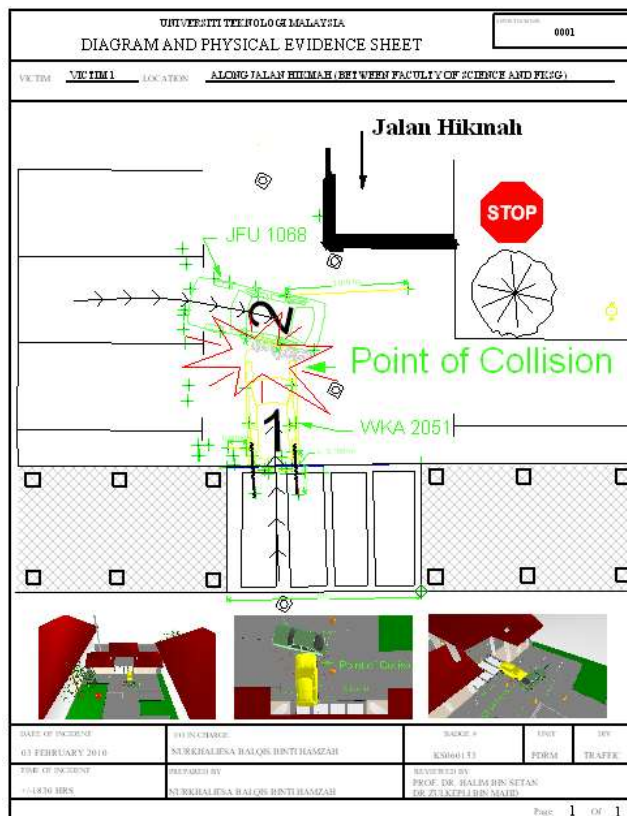


Figure 24: 2D Documentation of the Crash Scene

3.6 3D Model of Accident Scene

The 3D model of crash scene is generated after the data processing stage has been carried out as illustrated in **Figure 25**. This model can provide the background story of the accident. The collision occurred when Vehicle 1 (Yellow) collided with reversing Vehicle 2 (Green) from the parking lot. Vehicle 1 hit the left side of Vehicle 2 and left tyre mark behind. Two pictures from **Figure 26** show the digital image from camera and 3D visual of the same crash scene. These pictures show that the Vehicle 2 (Green) is found guilty. From this, it can be analyzed that the visual is easy to be observed and to be interpreted. Indirectly, the analyst can imagine how the accident may occur. The time for generating this 3D model can be saved by using symbols in the database rather than to draw it manually. Measurement can be performed in this software as well however there is no control on the accuracy. The 3D modeling can be used as viewing purpose for court litigation for jurisdictions and also for insurance agency to claim any damages.

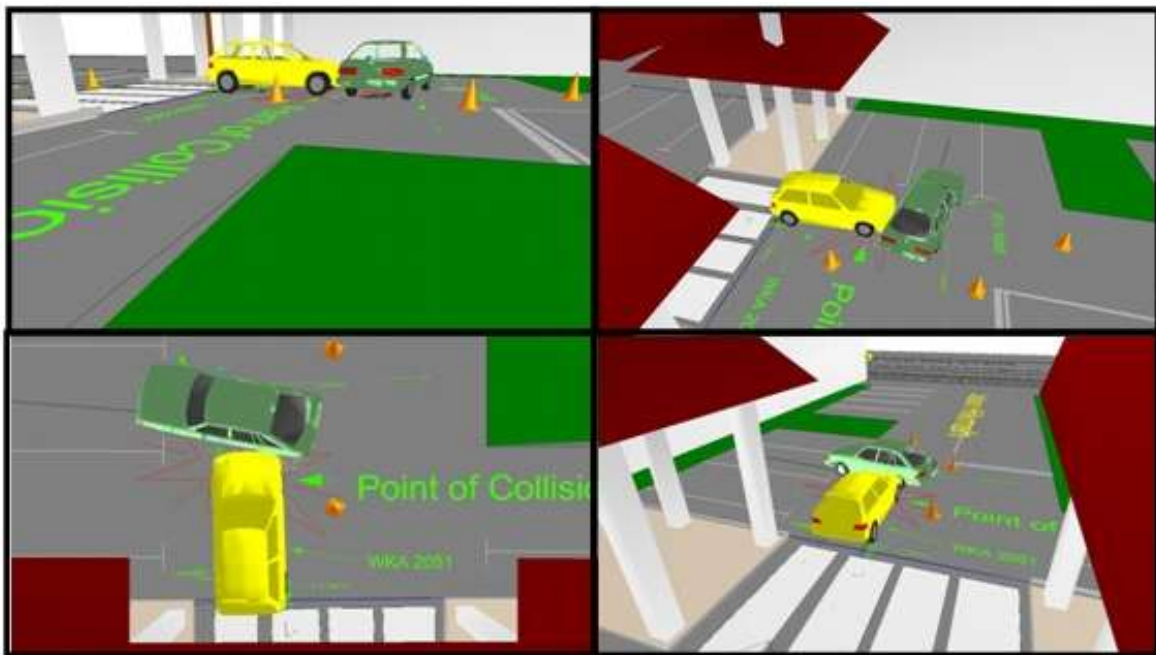


Figure 25: 3D Model of Accident Reconstruction



Figure 26: The Digital Image and 3D Visual of Collision Scene

4.0 CONCLUSION

This research has implemented close-range photogrammetric technique as the replacements of the conventional method to have more accurate data without contaminate other evidence in the scene. The quality of investigation is improved as well by ensuring every data of the accident scene is recorded. As the result, this technique will cut down the on-scene time for officers, lessening congestion and traffic disruption times through fast and comprehensive dimensional recording incidents scenes for later forensic analysis and legal purposes.

Nevertheless, there are several disadvantages identified during completing this project. The Crash Zone software can only be used in 10 evaluations since the software is in trial version. Besides that, this project is lack of types of physical evidences hence it has to be added more category for future study. Furthermore, the data is deficient due to policy of Royal Malaysia Police. Only authorized person or organization can receive the restricted data including the procedure of investigation for traffic accident scene.

In a nut shell, the combination of iWitness and Crash Zone software, the traffic collision scenes can be modeled to provide better measurement, viewing and analyzing purposes.

REFERENCES

Berry, T. B. (2008). *Pre-Incident Planning must go to the Head of Class for Nation's Schools*. (http://www.respondersafetyonline.com/Classes/Articles/ArticleDraw_P.asp) Retrieved on 27 July 2009.

Clark, P. (2006). *Traffic Incident Management-A Picture is Worth-Less Delay*. Tallahassee, Florida : Florida Department of Transportation.

Fraser, C.S. and Simon, C. (2008). *A Hybrid Measurement Approach for Close-Range Photogrammetry*. Department of Geomatics, University of Melbourne, Australia.

Fraser, C.S. and Hanley, H.B (2005). *Developments in Close-Range Photogrammetry for 3D Modelling: The iWitness Example*. Department of Geomatics, University of Melbourne, Australia.

Fraser, C.S., Hanley, H.H. and Cronk, S.C. (2005). *Close-Range Photogrammetry for Accident Reconstruction*. University of Melbourne, Australia : Department of Geomatics. (http://www.isprs.org/congresses/beijing2008/proceedings/5_pdf/22.pdf-global) retrieved on 27 July 2009.

Fraser, C.S., Hanley, H.H. and Cronk, S.C. (2008). *Close-Range Photogrammetry in Traffic Incident Management*. University of Melbourne, Australia : Department of Geomatics. (http://www.isprs.org/congresses/beijing2008/proceedings/5_pdf/22.pdf-global) retrieved on 27 July 2009

Galvin, B.G. (2004). *Focus on photography-Evidence Technology Magazine*. The Gulick Corporation. SW Watson, Beaverton.

iWitness Manual (2006). Photometrix Pty Ltd Australia. Version 1.107.

Kenneth, J. (2000). *Camera Self-Calibration*. Department of Engineering. University of Cambridge. (<http://mi.eng.ac.uk/~prdsm2/Research/SelfCalibration/>) Retrieved on 10 April 2010.

Mathews, N. (2005). *Close-range Photogrammetry*. Bureau of Land Management, National Science and Technology Center, Denver Federal Center.

O'Shield, L.L. (2007). *Photogrammetry in Traffic Accident Reconstruction*. Doctor of Philosophy Degree. University of Tennessee, Knoxville.

Saidatul Rezma Azra'ai (2009). *Pemetaan Kemalangan Jalan Raya Menggunakan Kaedah Fotogrammetri Jarak Dekat*. Tesis Sarjana Muda. Universiti Teknologi Malaysia, Skudai.

The Crash Zone (2009). *New version 8-More for Crash Reconstructionist*. (http://www.cadzone.com/Crash_Zone/Crash_Zone.htm). Retrieved on 27 July 2009.

Wendt, A.W. and Fraser, C.F. (2005). *Image-based Modelling of Architectural Sites: The iWitness Approach*. University of Melbourne, Australia : Department of Geomatics.

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