3D Modelling and Dimensional Measurement of a Car using a Low-Cost Digital Camera

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Abstract

The development of digital technology in close range photogrammetry has many potential applications in industrial measurement. This study focuses on the applications of a low-cost digital camera (Kodak DC210SP) and PhotoModeler Pro 3.1 software for 3D modeling and dimensional measurement of a car. The resulted 3D model of the car can be exported to other formats, such as AutoCad. For verification, the measurement obtained was compared with tape and intersection measurement. The results show differences of 1-7 mm, indicating the suitability of the low-cost photogrammetric systems for applications requiring an accuracy of a few millimeter.

1. Introduction

In close range photogrammetry, the distance from the camera to the object ranges from several millimeter up to 300 m (Karara, 1989). The main applications of close range photogrammetry are in industry, engineering, architecture and medicine. To date, the development of digital technology has resulted in close range digital photogrammetry. Consequently, digital cameras are becoming standard tool for photogrammetric data acquisition and photogrammetric data processing using computer software is now considered as routine work (Atkinson, 1996).

This study focuses on the application of a low-cost digital camera (Kodak DC210SP) and PhotoModeler Pro 3.1 software for 3D modeling and dimensional measurement of a car, namely a Proton Wira. For comparison purposes, the measurement data obtained was assessed against tape and theodolite intersection measurement. This paper describes the photogrammetric method followed and analyses the results produced.

2. Camera and Processing Software

The Kodak DC210SP (Figure 1) is a portable, low-cost digital camera with a resolution of 1.3 megapixels (i.e. 1152 x 864 pixels) and a CCD format of 5.3 x 4.0 mm (4.6 μm pixels). With this resolution the expected photogrammetric measurement accuracy is within several millimeter for objects with dimensions of several metres.

Figure 1: Kodak DC210SP digital camera.

PhotoModeler Pro 3.1 is a windows-based software (developed by Eos System Inc, Vancouver, Canada) for measurement and modeling of objects using digital images. It is also known as a *Soft Copy Analytical Close Range Convergent Photogrametric Sofware System* (Eos System Inc., 1999).

3. Method

The procedure employed in this study comprised camera calibration, planning, data acquisition and data processing. Camera calibration was performed by recording 8 images of 4 fixed control points on the A1-size Photomodeler calibration slide, followed by processing via the Camera Calibrator function within the PhotoModeler software system (Andrew, 2001). The estimated calibration parameters for the DC210SP at the selected zoom setting are shown in Figure 2, with the focal length being 9.29 mm.

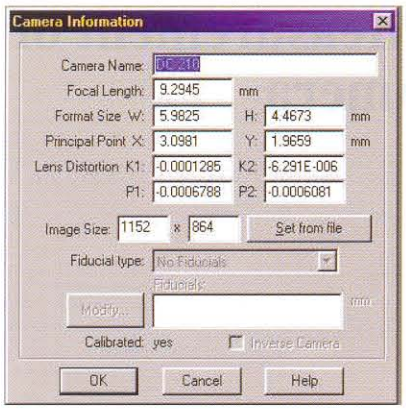


Figure 2: Camera calibration parameters

In the planning stage it is very important to ensure that all object feature points of interest are clearly seen and easily identified within a sufficient number of images. In the image acquisition stage, full coverage of the car was obtained by recording eight images from eight equidistant camera positions (Figure 3), using the same camera focal length (same zoom setting). To check the dimensional measurement of the car, targets as shown in Figure 4 were used, and additional observations were taken by theodolite intersection from four survey stations (using a Sokkia Set 3F total station) and direct tape measurement (Figure 5).

Figure 3: Camera locations (plan view)

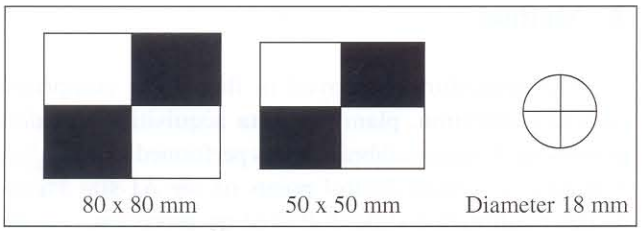


Figure 4: Target designs

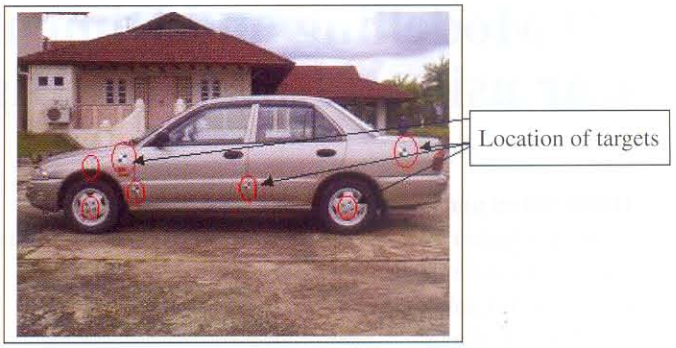


Figure 5: Targets for dimensional measurement

The photogrammetric data processing of the eight images (after data downloading from camera to computer) involves the following processes: manual point marking or digitizing, referencing and point matching, scale determination, creation of the object surface, display of the 3D model (wireframe and solid), object feature point measurement, and export of the 3D model (Figure 6). In point marking, 615 points were marked on the car for generating the 3D model (Andrew, 2001).

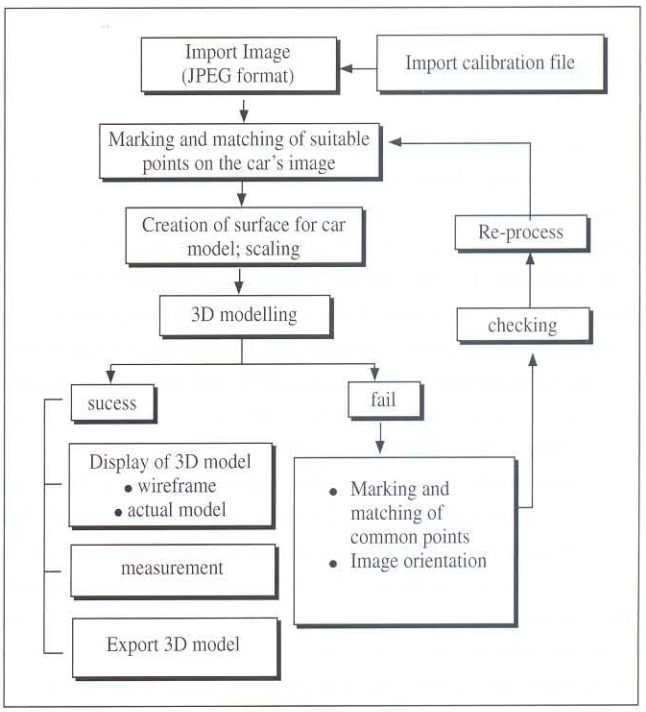


Figure 6: Photogrammetric data processing via PhotoModeler

4. Analysis of Results

This section discusses the results of 3D modelling and dimensional measurement of the car. Figure 7 shows the tested dimensions, and Table 1 provides the results of dimensional measurement via PhotoModeler, tape measurement, and theodolite intersection.

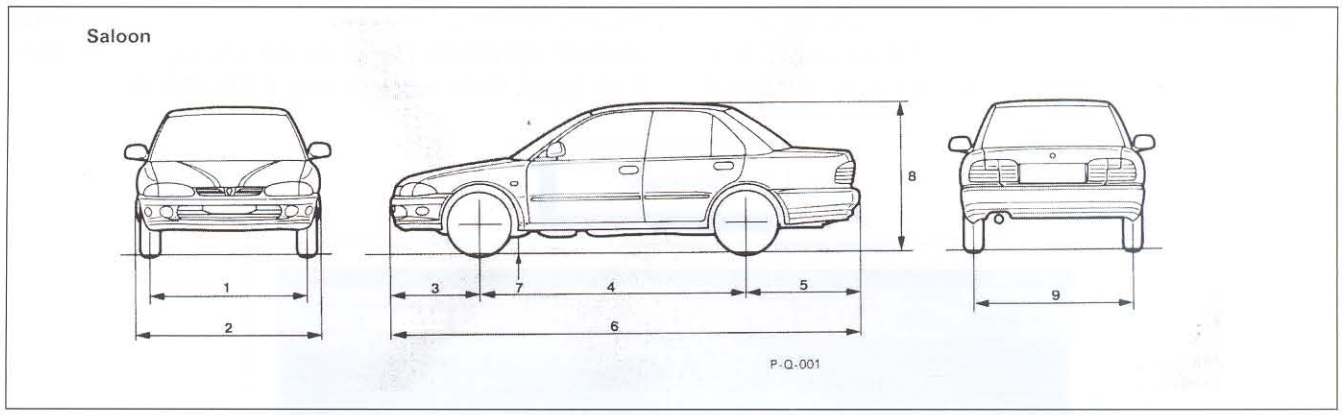


Figure 7: Tested dimensions of Proton Wira 1.3

Table 1: Dimensional measurement results for the Proton Wira 1.3

	Item	Tape measurement (mm)	Teodolite intersection (mm)	Photo Modeler Pro 3.1 (mm)
1	Front track	1473	1473	1475
2	Overall width	1685	1682	-
3	Front overhang	0814	-	-
4	Wheel base	2501	2502	2508
5	Rear overhang	1046	-	-
6	Overall length	4361	4371	-
9	Rear track	1475	1479	1472
10	Check line B1	2705	2704	2704
11	Check line B2	1082	1081	1087

For comparison purpose, tape measurement has been assumed to be the 'true' value, and only the following measurements are considered: front track, wheel base, rear track, check lines B1 and B2 (Figure 7). The comparison between the Photomodeler and tape measurement results (see Table 2) shows differences ranging from a minimum of 1 mm to a maximum of 7 mm, indicating an overall measurement accuracy of better than 10 mm. Measurement of further features on the car via PhotoModeler was precluded to a large extent due to the difficulty in marking and matching points on surfaces with homogeneous textures.

Table 2: Comparison between the measurement approaches

	Item	Photo Modeler vs tape measurement (mm)	Phto Modeler vs theodolite intersection (mm)
1	Front track	+2	+2
2	Overall width	-	-
3	Front overhang	-	-
4	Wheel base	+7	+6
5	Rear overhang	-	-
6	Overall length	-	-
9	Rear track	-3	-7
10	Check line B1	-1	0
11	Check line B2	+5	+6

In generating the 3D model of the car, all eight photos were employed in the photogrammetric processing (Figure 6). As is indicated in Figure 8, the resulting 3D digital model could be rendered similar to the actual car in terms of shape and colour. The model was also exported to Auto-Cad (Figure 9) for supplementary CAD analysis.

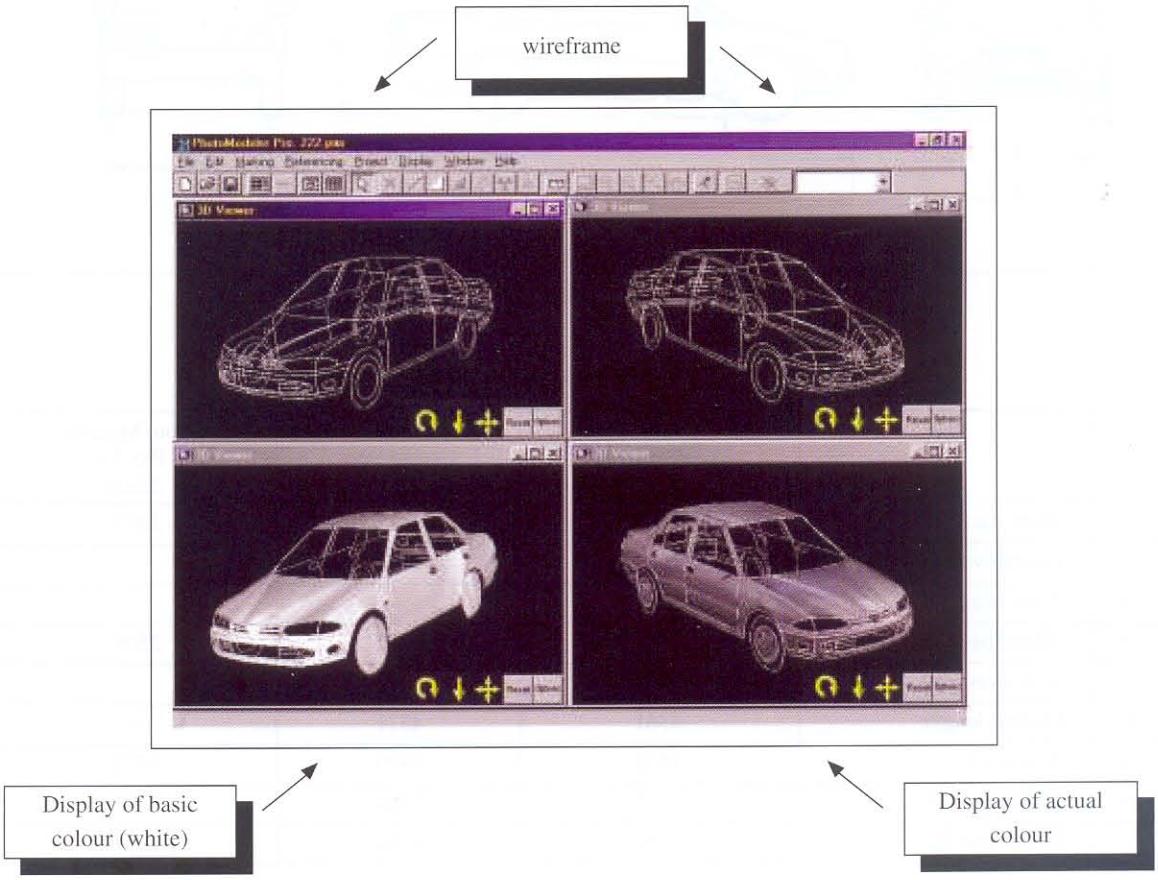


Figure 8: 3D image in PhotoModeler

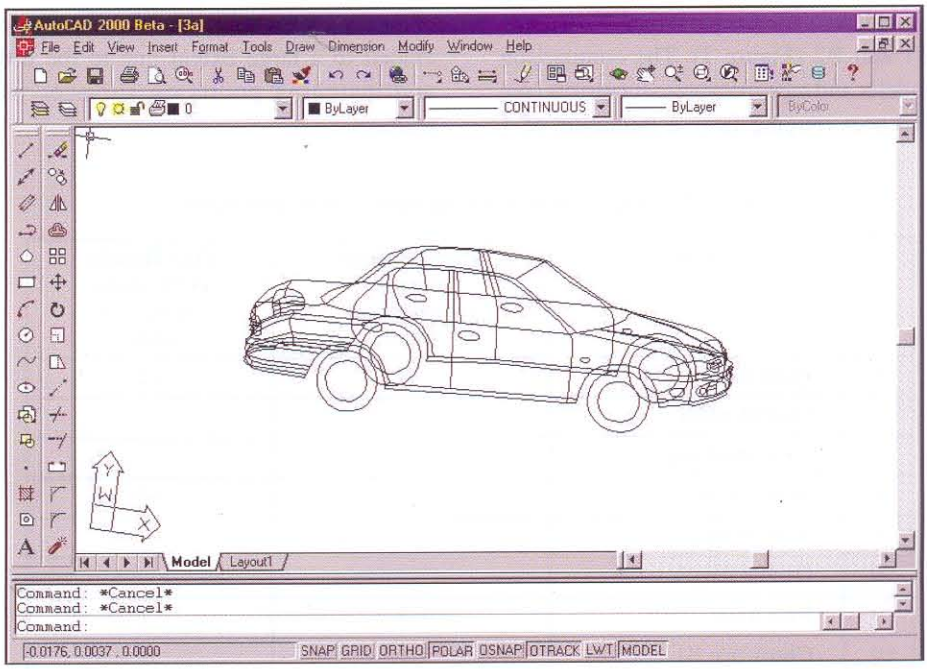


Figure 9: Wireframe in AutoCAD

5. Conclusions

This study has focused on an industrial surveying application of close range digital photogrammetry using a low-cost digital camera (Kodak DC210SP) and PhotoModeler Pro 3.1 processing software. The results obtained demonstrate the effectiveness and capability of low-cost systems for 3D modelling and dimensional measurement of cars and similar sized objects to better than 10 mm accuracy. Higher accuracy can be anticipated from higher resolution digital cameras and photogrammetric software systems more suited to precise industrial metrology applications. The resulting 3D model can be readily exported to other formats, such as AutoCad, to facilitate more comprehensive modelling and visualisation.

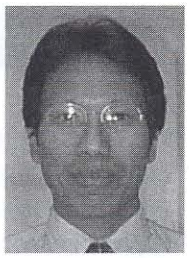
References

Andrew, Tiong Chew Shien, 2001, Aplikasi perisian Photomodeler Pro3.1 untuk pembentukan model kereta 3D. *B. Sc. Thesis,* Universiti Teknologi Malaysia, Johor.

Atkinson, K.B. (Editor), 1996, *Close range Photogrammetry and Machine vision.* Whittles Publishing, Scotland.

Eos System Inc., 1999, *User Manual of PhotoModeler Pro Version 3.1.* Vancouver, Canada.

Karara H.M., 1989, *Non-Topographic Photogrammetry.* American Society Of Photogrammetry and Remote Sensing, Virginia.



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