Dimensional inspection of 3D laser scanner, coordinate measuring machine and image processing

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ABSTRACT – Measurement can be conducted either using contact or non-contact methods. Production components can be small, soft and fragile. Therefore a non-contact method such as 3D laser scanner is preferred due to no contact force and not affecting production time. This makes the technology tempting and has been widespread used by industries due to reverse engineering capability. However, the accuracy of the measurement is dependent on the quality of the digitization. Therefore, this study is to report dimensional measurement comparison between 3D laser scanner with a coordinate measuring machine (CMM) and image processing. The errors are calculated and the best measurement method is proposed. It is found that contact method using CMM produced the least error.

1. INTRODUCTION

Nowadays, measurements are quite demanding because of size and complexity of consumer products. In some cases parts can be flexible, soft and fragile thus, the contact methods are less significant compared to non-contact method. 3D laser scanner is one of the non-contact measuring methods. It is widely spread technology accepted by the industries because of the reverse engineering and prototyping capability. Additionally, the laser scanners in known to be fast compared to the contact methods. 3D laser scanner is able to produce 200 000 points/sec [1], while the CMM touch probe, it is stated to be around 400 to 2 000 points/sec [2]. Other technique of non-contact method is image processing using programming language such as Matlab. This method is well established which capable of producing accurate measurement. The technology is also low in cost which makes it a competitive technology. However, at current stage it has long processing time and limited capability. Image is lack of details and required high programming skills.

Therefore, 3D laser scanner is more preferred. However, all non-contact methods dependent on the quality of the digitisation which is strongly influence by surface quality, orientation and scanning depth [3-5]. It is very difficult to measure shiny and dark surfaces because diffuse reflection is needed in order to capture the projected laser line by the camera. The scanner has a limited field of view and can be easily affected by the geometries of the products such as angle feature. In the case of 3D laser scanner, false data points or no detection can be occurring. Therefore, the accuracy of the 3D laser scanner is found dependent to many factors [6].

It can be noted that each measurement technology has its own limitation. This study is to compare the best scanning strategies for 3D laser scanner and with other with other measuring methods that are CMM and image processing. This will provides clear identification of measurement accuracy which help practice engineer to select their measuring equipment suitable for their application.

2. METHODOLOGY

In this study, the workpiece used to be measured are 50mm gauge block and 32mm ring gauge. The first measurement method is by using CMM bridge type model LH54 manufactured by Wenzel. The second measurement method is conducted by using Faro Laser ScanArm V3 platinum 6 feet model. This is an articulated arm which has 3D laser scanner model attachment. The best scanning approached of the scanner has been explained in [3]. It is based on scanning angles and distances which are illustrated in Figure 1.

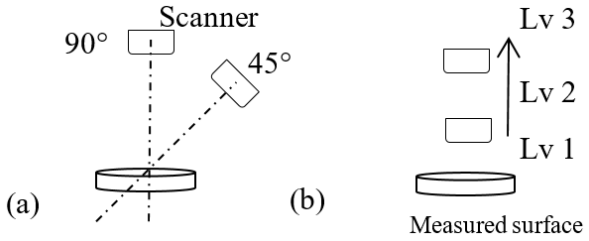

Figure 1 Scanning approach: (a) angle and (b) distance.

The test found that scanning at 45° at a distance of level 2 produced less error. Thus, in the empirical work this setting is adopted. Before scanning is performed, the workpiece is coated with a power based white coat. A light application of the coating is used in order to minimize the buildup error. In obtaining the dimension of the scan parts, Geomagic Studio and Qualify are used in facilitating and extracting the information captured by the scanner. In Geomagic Studio, the workpiece is digitized and editing can be done. In this study, the

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editing is minimized by only removing isolated points, false reflection or scanning noise. After using the Geomagic studio, the edited scan image is then inspected by using Geomagic qualify in obtaining the dimensions. The measurement is done by using cross section plane cut through the clouds of points. The points which located on the cross section plane are then fit together by using best fit formula. Triplicate of cross section planes are selected at the interest area for the average measurements dimension value.

The third measurement method is the image processing using MATLAB software. Image is captured using 8 megapixel camera. A program has been developed using canny edge detection. The develop program consist of input selector, image converter from RGB format to Gray Scale format and from Gray Scale format to Black and White (BW), resizing, edge detection, feature extraction, and measurement element.

In each measurement methods, calibration was conducted before actual measurements are carried out. During the measurement, 30 readings are collected. Error is calculated by deducting the measured valued from the actual reading. The mean of error is the computed representing the errors produced by each method.

A simple test is also conducted by using the best approach of laser scanning to represent potential errors that can be produced when scanning complex production components.

3. RESULTS AND DISCUSSION

The error comparison is to determine the most accurate method. The minimum error is the value near to zero, and it's been used as a benchmark for determining the accuracy of measurement methods. Table 1 and Table 2 shows the measurement error of CMM, Geomagic and MATLAB program. For specimen gauge block size of 50mm, the error value of, CMM is -6.9µm, Geomagic is -298.3µm and MATLAB Develop Program is -3.3µm. The lowest displacement value is made by MATLAB, followed by CMM and Geomagic software.

Table 1 Measurement for 50mm gauge block.

Method	CMM	Geomagic	MATLAB
Error (mm)	-0.0069	-0.2983	-0.0033

Table 2 Measurement for 32mm ring gauge.

Method	CMM	Geomagic	MATLAB
Error (mm)	0.0019	-0.2981	-0.2387

However, for ring gauge specimen size of 32mm, the error value for CMM is 1.9 µm, Geomagic is -298.1µm and MATLAB is -238.7. The lowest displacement value is made by CMM, followed by MATLAB and Geomagic. This shows that, the image processing measurement is better than Geomagic software and comparable with the CMM measurement.

Further testing is then conducted for scanning complete object using the best scanning approach. Figure 2 shows the results that typically used for reverse engineering. It can be clearly seen that incomplete scanning and noise can be present in the results. This reduces the accuracy of the laser scanner due to no detection or false detection occurred. Although this result can be acceptable for this type of application due to lost information can be built using the software, but it is required to be aware by practice engineer that the size produced will be not accurate as the actual components. In [6] the researcher has identified the error propagation that can be present in the measurement of 3D laser scanner. This explains the reason of manufacturer specification accuracy could not be achieved.

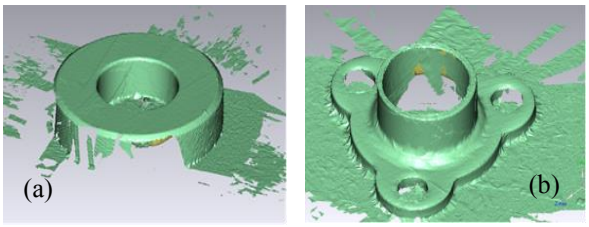

Figure 2 Scanning results: (a) incomplete scan (b) noise.

4. SUMMARY

The work has presented measurement attempt by using different measuring methods. 3D laser scanner is found to produce the highest error, but repeatable, although different complexities of workpieces were used. This is as expected due to the potential of many factors affecting the measurements compared to contact method. Factors like edge features, reflectivity, deep features can affect the registered points. The error recorded is higher than the specified by the manufacturer thus, practice engineer should expect that results for real application. It can be concluding that contact method that is using CMM produced the least error followed by image processing in Matlab.

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