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DATA REDUCTION BY POINT SAMPLING AND FILTER REDUNDANCY METHOD FOR LASER SCANNING.

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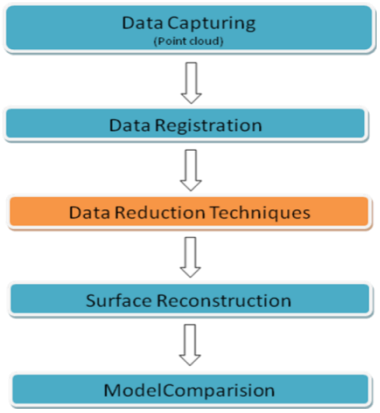
Abstract : This paper examines the procedures on reduction point data acquired by laser scanning device. From the evaluated procedures, applying point sampling and filter redundancy method are very useful for both freeform and primitive shape point cloud. From the tested procedures, applying filter redundancy on sampling point data can shrink the point cloud amount with good accuracy while maintaining the quality of the measured surface. The surface model generated from this proposed reduction procedures can be used in further modeling processes (e.g. registration, meshing and segmentation) in order to generated fine 3D model and perfect CAD model. For further research, the point reduction will be tested on 3D model generated from merging the mesh polygon using the procedure in this study.

Index Terms— Applying point sampling , filter redundancy, primitive shape point cloud, registration, meshing and segmentation.

1. Introduction:-

Reverse engineering is a reverse process of forward engineering to generate a computerized representation of an existing parts or objects. The reasons of using reverse engineering are, when the original product or the manufacturer of the product is no longer exists, but a customer needs the product. The documentation of product design has been lost. When the product encounter frequent design changes in the development cycle. And for inspection or quality control [1] [6].The aims of using reverse engineering are usually to create 3D model and CAD model. The process of reverse engineering begins from data capture of the objects surface either using contact e.g. Coordinate Measuring Machine (CMM) or non-contact method (e.g. laser). Contact type devices usually give accurate measurement but slow in data acquisition process especially when the parts have complex freeform shape .On the other hand, non-contact devices can speed up the data capture process with high accuracy .Using laser scanning usually produce high-density point clouds in order to maintain fine detail. Thus, the difficulty of processing million of points given by laser scanning device is the main problem in order to generate useful models surface. Most of the laser scanning software packages cannot work with large number of point clouds data sets easily .Almost 80% of the points in a point cloud are redundant in most cases of model reconstruction. Moreover, not all these point are necessary for generating a surface model. In practical situations, it takes too long time to generate models surface using large number of point clouds. In addition, data storage and data manipulating issue may also arise from large number of point clouds.



1.1 Big Picture.

1.2 Data capturing

There are many different methods for acquiring shape data, as shown in Figure 1. Essentially, each method uses some mechanism or phenomenon for interacting with the surface or volume of the object of interest. There are non-contact methods, where light, sound or magnetic fields are used, while in others the surface is touched by using mechanical probes at the end of an arm (tactile methods). In each case an appropriate analysis must be performed to determine positions of points on the object's surface from physical readings obtained. For example, in laser range finders, the time-of-flight is used to determine the distance traveled, and in image analysis the relative locations of landmarks in multiple images are related to position. Each method has strengths and weaknesses which require that the data acquisition system be carefully selected for the shape capture functionality desired. This section will discuss the principles of various methods and the next section will address the practical problems of acquiring data. Jarvis' paper is a very good survey on the different methods of data acquisition. Optical methods of shape capture are probably the broadest and most popular with relatively fast acquisition rates. There are five important categories of optical methods we discuss here: triangulation, ranging, interferometer, structured lighting and image analysis.

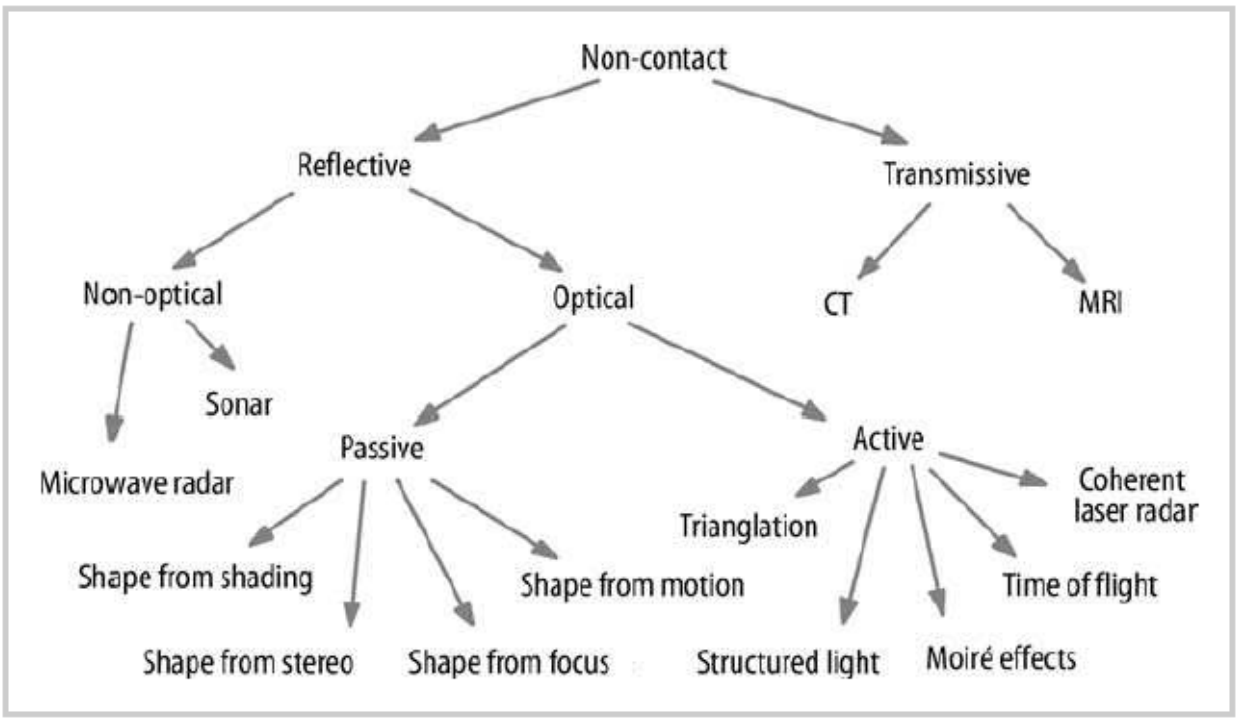


FIG 1:- NON –CONTACT METHODS [1]

By performing data reduction process on point cloud provides a solution to this problem, while maintained the accuracy and shape of point data. This paper presents the data reduction procedure test on point cloud from laser scanner device. The test applied to two types of sample model and the results are discussed.

2. Literature Review

Since laser scanners gives high density points of object surface, the large number of point clouds need to be reduced first before further process can be performed. Boehnen, C. and Flynn [5] indicates the amount of data need to be reduced as a large amount of point data cause problem for downstream reverse engineering operations (e.g. creating CAD models). However, the question is whether to reduce the point before, after or during of the model building stages [6]. Hamman [7] suggested the reduction process is applied after creating models surface by reducing the number of triangles on mesh polygon surface. However, this approach sometimes retains the large number of point on the generated surface model. Even though the accuracy of the generated model is maintained, the performance of the processing might be slow due to large amount of point cloud. Hamman introduced a reduction method which can be applied during the preprocessing stage including noise reduction, data sampling and Hole filling before triangulated into mesh polygon surface. This helps the user to manipulate point data before surface model are generated especially when deals with multiview data. Noise reduction is possible by applying statistical method in order to remove unwanted point while trying to preserve the measured features. Hole filling process closed the gaps in the point clouds by adding new points (manually or automatically) and using the curvature and density of the surrounding points. also presented an approach of data reduction procedure during preprocessing stages using sampling method. This step is mandatory for laser scanner data in order to reduce the input redundancy and to remove a certain amount of errors introduced because of the scanning device limitations [2]. Major research effort in current data reduction procedures suggested manipulating the point during pre-processing stages. However, none of these research papers evaluated the combination of the filtering method for point cloud reduction.

3. Reverse Engineering by Laser Scanning

Reverse engineering process can be divided into three stages: (1) data acquisition; (2) data processing; and (3) creating useful 3D and CAD model. Data acquisition is the most crucial step in reverse engineering because the quality of the raw data determines the quality of the surface model. One of the methods for fast data capture is laser scanning. Laser scanning captures the information of object surface by receiving the radiated laser beam emitted from the device. There are three laser scanner principle described by [3]. Time-of-flight laser scanner allows unambiguous measurement of distances up to several hundred of meters. The advantage of long ranges implies reasonable accuracy. Phase measurement laser scanner represents the other common technique for medium range and limited to one hundred meters. Accuracy of the measured distances within a few millimetres is possible. Triangulations based laser scanner, also known as close range laser scanner mostly use in industrial applications and reverse engineering. Typically, this system is suitable to measure small objects, where measurement distances range up to 2m. Accuracies of a few micrometers can be achieved with triangulation laser scanner [4]. Once the data have been captured, the raw point which containing noisy point must be 0eliminated before can be used to generate surface model. The quality of point data can be further improved by performing pre-process operations such as noise filtering. Noise filtering function removes unwanted points by determining where the points should lie and moves them to correct locations based on statistical information about the point data . After the noisy points are removed, redundant data should be eliminated by performing data reduction method. The most usual methods on data reduction are filter redundancy and point sampling.

3.1 Filter Redundancy

Filter redundancy uniformly reduces the number of point cloud on data when points are too close or overlapped on each other presented a filter redundancy approach by fitting a parabolic quadric surface patch to a set of points .The algorithm keeps removing one of the nearest two points in the data set and the filtering iteration will not stop until the points remain in the data set reach the pre-determined number (FIGURE 2).

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3.2 Point Sampling.

The point sampling method minimized the number of point data and to make the data well structured so that it is easier to handle. There are three types of sampling methods: curvature, random and uniform. Curvature point sampling [7] removes few points in region of high curvature than in a low curvature region to maintain the accuracy of the curvature. Random point sampling [6] removes the point based on the specified percentage of total points that need to be reduced. Uniform sampling uniformly reduces the number of points in a point set by subdivided the model space into equally sized cubic cells and deletes all but remained one point from each cell

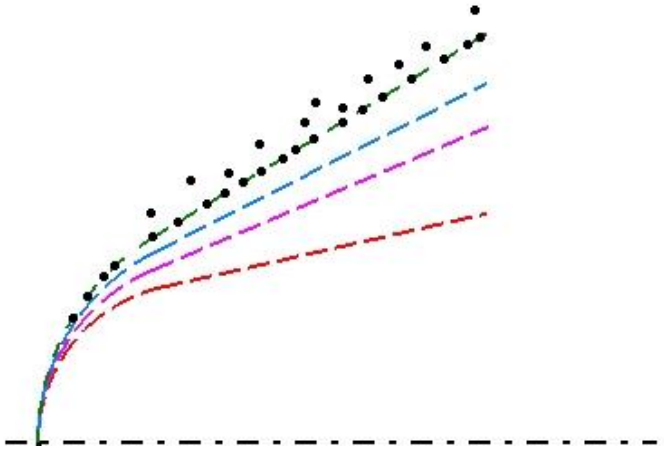

FIG 3A :- 2D Drawing

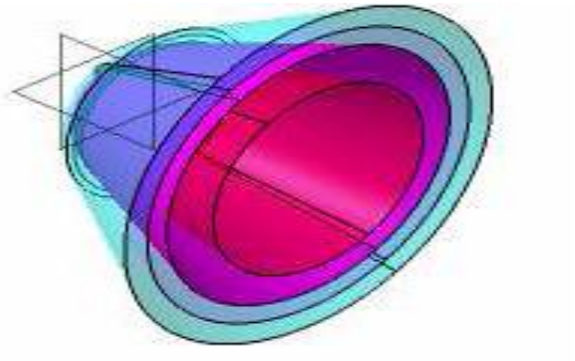

FIG 3B :- 3D Drawing

FIG 2:- PARABOLIC QUADRATIC SURFACE FITTING ON POINT SAMPLE

4. EVALUATION ON DATA REDUCTION PROCEDURE

In this paper, data reduction procedures have been evaluated in order to generate accurate and fine mesh polygon surface. The tested data reduction procedures were using two types of surfaces; freeform and primitive shape. Figure 4 (a) shows the sample model 1, which is containing freeform shape (curvature). Sample model 2 Figure 4 (b) is a simple plain

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shape model represents the primitive shape model in this study. Vivid 910 which employs triangulation principle was used for data capture in this study because it gives high accuracy [5]. The commercial laser scanning modeling software, RapidForm2004 was used to evaluate the proposed data reduction procedures

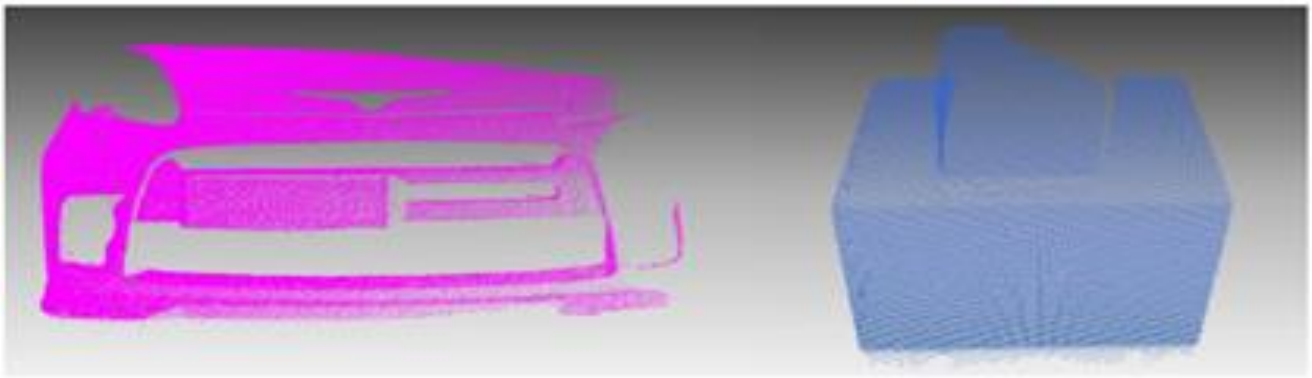

Fig 4 (a) Sample model 1

Fig 4 (b) Sample model 2

This paper evaluated four difference procedures (Figure 5). All procedures comprising of filter noise, filter redundancy, point sampling and triangulate process. The main difference between the techniques is the process applied in every tested procedure. Procedure 1 comprises of filter noise, filter redundancy and triangulate process for creating model surface.

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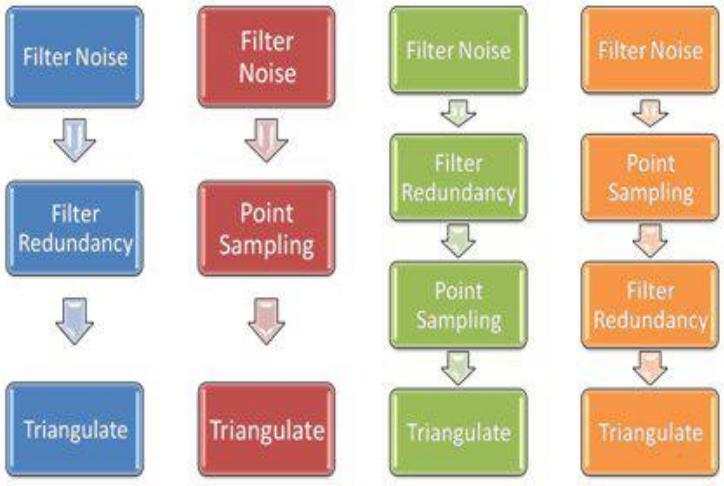
In Procedure 2, the point sampling method replaces filter redundancy in Technique 1. Procedure 3 and Procedure 4 apply both filter redundancy and point sampling methods. However, Procedure 3 performs the filter redundancy method first followed by point sampling, and vice versa in Procedure 4

FIG 3 : Sample model



5. RESULTS

5.1 TABLE 1.

Scanner	Scan Time	Color Image	Focal Range	User Comfort	Desgined for Faces
3DMD	<1s	Yes	Low	Medium	Yes
FR1	<1s	No	High	High	Yes
FR2	20s	Yes	Medium	Low	Yes
Minolta	2.5s	Yes	High	Medium	No
Polhemus	~30s	No	Low	Medium	No

A summary of the scanners assessed by Bohenn [5] paper appears in Table 1.The accuracy results shown here represent the accuracy of the distance from the points given by the scanner to the ground truth surface. If the scanner provided a small number of points but they were all highly accurate, then the scanner would appear to have a high accuracy rating. It is not possible to represent the detail level of the surface in such a measurement. As a result, it is important to look at the average number of points provided by the scanners as well. Table 1 gives a summary of the results. Polhemus scanner does not have a repeatability accuracy value because only one scan of each face was acquired (repeatability would also vary by operator for this scanner).Based on the results showed in the paper Fröhlich, C. and Mettenleiter [4], terrestrial laser scanning represents a great potential tool in bridges inspection based on geometric analysis. High accuracy combined with fast data acquisition involves the main advantages of this technology. The algorithm used for the geometric analysis in vaults, together with the graphical representation of overlapping semi-cross-sections allows visual inspection and quantification of asymmetries and distortions, facilitating diagnosis based on the arch geometry. Furthermore, by working with (X,Y,Z) coordinates, the damage is always located and measured in the structure. In this work Riscan Pro software is used which works on the Delauney Principle of triangulation.Hamman presented [7] new technique has been presented which uses the concept of iterative triangle removal principle.Key research areas are focused by Varady [6] which still need further work before general-purpose reverse engineering becomes widely available include: improving data capture and calibration, coping with noise, merging views, coping with gaps in the data, reliable segmentation, fair surface fitting, recognizing natural or human-intended structure of the geometry of the object, and ensuring that consistent models are built. From all of this references use for the paper the method explained by using the Laser scanning techniques and the data reduction techniques are efficient and precise one.

6. CONCLUSION

This paper examines the procedures on reduction point data acquired by laser scanning device. From the evaluated procedures, applying point sampling and filter redundancy method are very useful for both freeform and primitive shape point cloud. From the tested procedures, applying filter redundancy on sampling point data can shrink the point cloud amount with good accuracy while maintaining the quality of the measured surface. The surface model generated from this proposed reduction procedures can be used in further modeling processes (e.g. registration, meshing and segmentation) in order to generated fine 3D model and perfect CAD model. For further research, the point reduction will be tested on 3D model generated from merging the mesh polygon using the procedure in this study.

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