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Cad Modeling Strategy For Complex Engineering Objects By Reverse Engineering Approach

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ABSTRACT

In today's word Reverse engineering is the backbone of the industry development. In Reverse engineering with the help of already existing product a new product is developed. To develop a new product CAD model is necessary. For this purpose already existing object is scanned using CMM machine, laser scanner etc. Output of Scanner is Point cloud data. It is big challenge to get CAD model from point cloud data. Various techniques are developed to convert point cloud in to surface or solid geometry. These techniques are called segmentation techniques.
In this paper study of reverse engineering is done and various segmentation techniques are studied. Slicing approach of segmentation is explained in detail, as it is very useful in the surface reconstruction.

Keywords- **CAD, Point cloud data, Reverse Engineering, Segmentation.**

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I. INTRODUCTION

In recent year there is rapid change in the manufacturing process. Most of traditional processes are replaced by Computer Aided Manufacturing (CAM) process. For CAM there is necessity of Computer Aided Design (CAD) model. Different software's are available in the market to develop a cad model of the product. But to use this method we should know all the dimensions of product. There is another method to get the CAD model is by using reverse engineering approach. It is helpful in industries to develop a new product using the already existing product. In reverse engineering already existing product is scanned to get point cloud data and from this data CAD model is generated by segmentation technique.
CAD model developed by RE approach can be further used for Rapid prototyping (RP). So accuracy of manufactured product is totally depends on the accuracy of the CAD model developed. For better output highly accurate model should be developed. Accuracy of CAD model is depends on the accuracy of scanning and Segmentation technique. For this purpose it is necessary to overview all the segmentation techniques which gives the better results.

PHASES OF REVERSE ENGINEERING

A. Data Capture

This phase includes the deciding the proper scanning technique and actual scanning of object to get information about all the features of the object. All the scanning devices give the output in form of point cloud data. There are two types of scanning devices, Contact and non-contact type. In contact type devices there is direct contact between object and Scanner probe.eg. Coordinate measuring machine. In non-contact type devices there is no direct physical contact.eg. Optical scanner, Laser scanner etc. Mostly non-contact type devices are preferred.

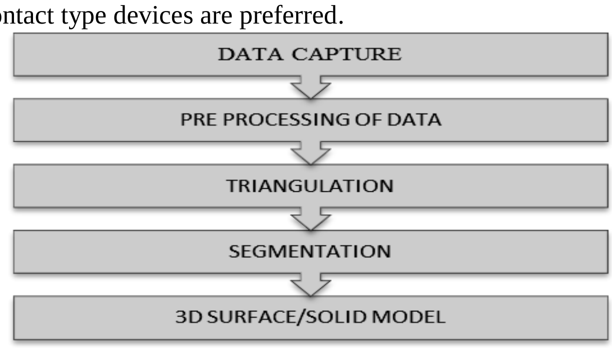

Fig 1: Phases of Reverse Engineering

B. Preprocessing of Data

This phase includes reducing noise from collected data, point reduction and merging of multiple data sets. Predefined filters are used for noise and point reduction. To improve the quality of data multiple data sets are taken and merged together. This phase gives the merged, clean point cloud data.

C. Triangulation

In triangulation process polygon mesh can be easily created for given point cloud data. Delaunay triangulation is the concept behind this process. There are many algorithm exists for triangulation including alpha shapes, marching cubes, ball pivoting algorithm, , moving least squares Poisson surface reconstruction etc.

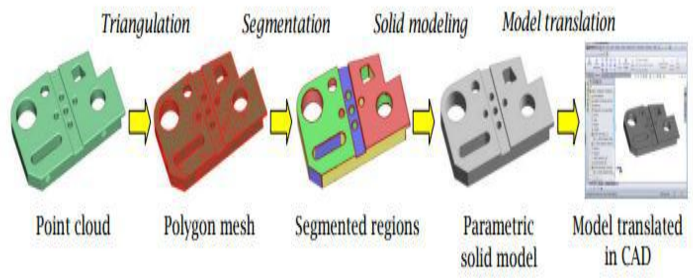

Fig 2: General process of 3D model generation

D. Segmentation

Segmentation is the most important and complex step of the reverse engineering. Segmentation groups the original data points or mesh into subsets each of which logically belongs to a single primitive surface. Segmentation process, involves a fast algorithm for k-nearest neighbors search and an estimate of first- and second-order surface properties. The first-order segmentation, which is based on normal vectors, provides an initial subdivision of the surface and detects sharp edges as well as flat or highly curved areas. The second-order segmentation subdivides the surface according to principal curvatures and provides a sufficient foundation for the classification of simple algebraic surfaces.

E. 3D Surface/ Solid Model

Boundary representation and feature-based are the two basic representations for solid models.

Various methods are proposed to automatically construct B-rep models from point clouds or triangular mesh. Some focused on manufacturing feature recognition for process planning purpose. One promising development in recent years was the geometric feature recognition, which automatically recognizes solid features embedded in B-rep models.

1) Boundary Representation:Based on segmented regions, a region adjacent graph is built, which reflects the complete topology and serves as the basis for building the final B-rep model, where the individual bounded surfaces are glued together along their common edges. Three steps involved in constructing B-rep models, flattening, edges and vertices calculations, and stitching. In flattening step, regions are extended outwards until all triangles have been classified which is necessary to remove gap between regions. Sharp edges can be calculated using surface-surface intersection routines, and vertices where three surfaces meet are also determined. During the process, a complete B-rep topology tree is also constructed. B-rep model can be created by stitching together the faces, edges, and vertices.

2) Geometric Feature Recognition*:* B-rep models are not feature-based. In order to convert a B-rep model into a feature-based solid model, the embedded solid features must be recognized, and a feature tree that describes the sequence of feature creation must be created.

CAD model generated from this method are converted in to neutral formats like IGES, STEP. So we can use these models in any CAD package for further use.

I. LITERATURE REVIEW

[1]C.K. Au and M.M.F. Yuen [99] propose a feature-based reverse engineering method for mannequin in garment design. It is an automated reverse engineering approach for human torsos that creates accurate parameterized models. A key concept in their method is creating a generic mannequin model of a human torso appropriately aligned with the 3D point cloud of the desired human torso model.

[2]H. Woo, E. Kang, Semyung, Wang, Kwan H. Lee (2001) A new method for segmenting the point cloud data is proposed. The proposed algorithm uses the octree-based 3D-grid method to handle a large amount of unordered sets of point data. The final 3D-grids are constructed through a refinement process and iterative subdivision of cells using the normal values of points. This 3D-grid method enables us to extract edge-neighborhood points while considering the geometric shape of a part.

[3]YinlingKe, Shuqian Fan, Weidong Zhu, An Li, Fengshan Liu, Xiquan Shi (2005) Presented two integrated solution schemes, sectional feature based strategy and surface feature based strategy, for modeling industrial components from point cloud to surfaces without using triangulation. For the sectional feature based strategy, slicing, curve feature recognition and constrained fitting are introduced. The surface feature based strategy relies on differential geometric attributes estimation and diverse feature extraction techniques. The methods and algorithms such as attributes estimation based on 4D Shepard surface, symmetry plane extraction, quadric surface recognition and optimization, extruded and rotational surface extraction, and blend feature extraction with probability and statistic theory are proposed.

[4]J. Roca-Pardiñas, H.Lorenzo, P. Arias b, J.Armestob(2008) presents a new method for the reconstruction of three-dimensional objects surveyed with a terrestrial laser scanner. The method is a 2.5D surface modelling technique which is based on the application of statistical nonparametric regression methods for point cloud regularization and mesh smoothing, specifically the kernel-smoothing techniques. The proposed algorithm was tested in a theoretical model-simulations being carried out with the aim of evaluating the ability of the method to filter random noise and oscillations related to the acquisition of data during the fieldwork.

[5]Herbert J. Koelman(2010)An industrial application of CAD is presented, which concerns the measurement and reengineering of the shape of a complete ship hull and of ship's parts, which is a frequently recurring task in the shipbuilding and ship repair sector One of the considerations in this respect was that with photogrammetry not only the 3D geometry can be measured, but that also topological properties will implicitly be taken into. So a reengineering system was developed, which consists of two major parts: the shape processing software and the photogrammetric measurement, which are tightly coupled. This system has proved to work fine for large-scale 3D objects.

[6]Enrico Vezzetti (2011) the morphological analysis of a surface cannot be carried out without subdividing the point cloud into subsets characterized by the same morphological complexity. There are many different solutions, strongly correlated with the specific context where they can be applied. Firstly, a variable set, composed by acquired geometry and the acquisition device parameters, has been introduced in order to describe the possible working conditions that users.

[7]cloudsJinLiua, Zhong-keWuaa(2012) Adaptive approach for primitive shape detection from point clouds is presented. Approach is based on RANSAC primitive shape detection algorithm, and we make the primitive shape detection procedure adaptive by histogram analysis of points deviation from their corresponding fitted primitive shapes.

[8]YutaoWanga, Hsi-YungFenga, Félix-Étienne Delormeb, SerafettinEngin(2013) A robust normal estimation method to reliably estimate normal for noisy point clouds with outliers. The proposed method incorporates three weights to effectively reduce the influence of outliers both in the spatial and in the normal field on the normal estimation. Also, the proposed method is applicable to points in smooth regions as well as around sharp features via employing locally adaptive bandwidth parameters for the weights.

[9]Atul Kumar, P. K. Jain, P. M. Pathak(2013) The K-means algorithm has good ability to handle the large number of scanned data. It is best suited for creation a desired shape curve-likes shape for near-best approximation of the scanned data point set. Reconstructing the smooth curve is achieved by proposed algorithm in MATLAB environment.

[10]Gabor Erdos , Takahiro Nakano, JozsefVancza (2014) The presented CAD model matching method takes widely supported input in form of mesh models, works also for partially measured objects, and for any type of features. It only needs an appropriate distance function for assessing the degree of match between a feature and its respective point cloud data. Tolerance of matching can be adjusted, so the method is capable of handling noisy data.

I. SLICING APPROACH FOR SEGMENTATION

Segmentation of point cloud is an important step in the process of direct RP model construction. In general, there are two slicing approaches for determining the layer thickness, i.e. uniform slicing and adaptive slicing. Uniform slicing is the simplest approach in which point cloud is sliced at equalintervals.

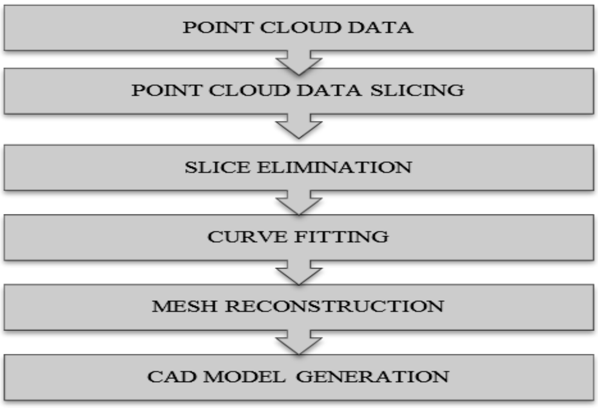

Fig 3: Phases of Slicing Approach

In this approach input is the point cloud data from the scanning devices. Reconstruction starts with the slicing of the data in number of layers along the used defined direction. Distance between two layers is controlled by user defined value. For lower layer thickness shape error is low. The data points in each layer are projected onto an appropriate plane.The slicing distance parameter should be set according to the object particular features.Depending on the data acquirement and slicing process a cross-section may contain points that form a shape with thick border. Thinning is the process that identifies the specific points from the data set that are essential to form the actual 2D shape of the cross-section. We call the outcome of this thinning process a thin data set. In many cases we obtain adjacent slices that are very similar. This might happen when the sliced object feature has symmetric shape such as a cylinder or parallelepiped part. Many of these slices may be eliminated from the entire process of reconstruction. If three adjacent slices are of similar shape, then the middle slice may be eliminated. Once a layer is obtained, the points within the layer are projected onto the projection plane. The next step is to construct one or several closed polygon curves to accurately represent the shape defined by these points. Since each polygon curve is closed, these polygon curves are constructed one by one and different curves are split naturally. This model in the form of curves can be directly used for Rapid prototyping.

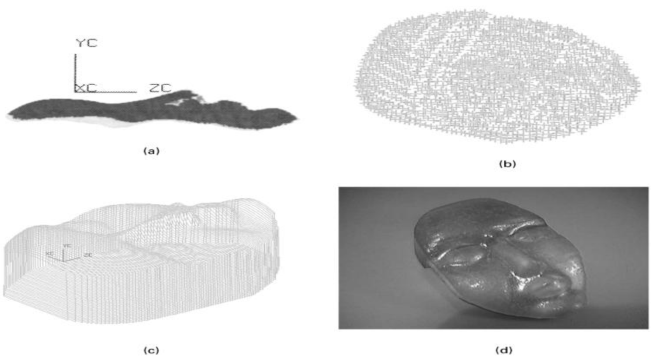

Fig 4: Details of Slicing Approach

II. CONCLUSION

As computer aided design (CAD) has become more popular, reverse engineering has become a viable method to create a 3D virtual model of an existing physical part for use in 3D CAD, CAM, CAE and other software. The reverse-engineering process involves measuring an object and then reconstructing it as a 3D model. A detail review of Reverse engineering is done. Various segmentation techniques are studied from literature. Slicing approach of segmentation is explained in detail as it is the best and simplest approach to produce the RP models. Also the shape error in model can be controlled by using slice thickness.

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