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Title(English)	Study on Inspection and Verification of 3D Point Cloud Datasets Registration for Reverse Engineering Application
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論 文 要 旨

THESIS SUMMARY

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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Title：

Study on Inspection and Verification of 3D Point Cloud Datasets Registration for Reverse Engineering Application

The objective of this work is to assure 3D model built from point cloud datasets registration conform to the reversed object. Dataset errors and registration errors are the primary sources of failure in pursuing a precise duplication part. Firstly, two new segmentation methods are proposed, i.e., ICP (*Iterative Closest Point*) registration utilized extracted plane features, and ICP registration used extracted point features. Secondly, a novel method of inspection and verification of point clouds registration using CMM (Coordinate Measuring Machine) data taken in correspondence with pre-defined object features. Thirdly, Direct NC (Numerical Control) tool path generation from the point clouds is proposed as an addition topic to provide a practical overview.

In Chapter 1, introduces the background of reverse engineering. Review of registration of point cloud data from laser scanning devices and current problems in this field. Problem statement and objective of the thesis with the motivation are proposed in this chapter.

Chapter 2 This chapter explains the overall algorithm and the connection of one algorithm to the other algorithm briefly.

In Chapter 3, This chapter discussed the registration of point clouds by utilization of the pairwise plane features. Plane features are extracted and then validated by using certain criteria based on the pairwise grid with the same ID. ICP-based fine registration is applied using point-to-point and plane-to-plane of the selected validated planes with the brute force and kd-tree scenario. The parameters of rotation and translation obtained from this registration is used to transform a transformed dataset into a reference dataset. Based on the registration result, some conclusions are below:

a) The method able to use to solve 3D registration problem of the pairwise datasets with different form and distribution datasets. This method is mainly applied for registration datasets of reverse engineering of a product with plane feature dominant.

b) The result shows that the proposed method significantly improves the accuracy with lower fitting error (lower RMS) and reduces the computation time (faster

convergence) in all scenarios. The smallest RMS will produce smooth surface or solid of 3D CAD model.

c) The performance of kd-tree can improve convergence and computation time better than brute-force.

Chapter 4 discussed the registration of point cloud datasets by utilization of extracted features. Automatic feature segmentation and identification of point cloud data of laser scanning are presented in this chapter. However, only extracted point features of pairwise datasets are used in ICP-based fine registration. Region growing based on the normal vector and curvature of each point is carried out to segment unstructured point cloud from laser scanning into clustered regions. Features such as a plane, cylinder, and point including line are extracted from the regions and then identified by using feature fitting criteria. Based on the application, this method is more robust than the method proposed in Chapter 3.

Chapter 5 discussed the method of inspection and verification of laser scanning datasets registration for reverse engineering purpose is proposed. Datasets and registration result is evaluated by this proposed method in which the errors of registration result can be calculated. Each key feature extracted from datasets registration is separated by using grid method and then evaluated by using correspondence CMM data points. Segmentation, feature extraction, and validation of each feature of the main features are carried out automatically. All key features are then inspected and verified automatically.

The proposed method able to evaluate extracted features both of primitive features such as the plane and cylinder, and non-primitive form such as ruled-surface and free form. This approach is useful for reverse engineering of a product with and without datum. Moreover, this method can be applied for inspection and verification of point cloud datasets registration and for inspection of different data type registration to produce an accurate 3D CAD model. This approach can be implemented in reverse engineering of a wide variety of product such as mechanical product, molding, casting, forging product and so on.

Chapter 6 discusses the generation of efficient NC tool path directly from point cloud data. Firstly, machining process and cutter used are defined. Secondly, selecting the type of path will be used in this system. Thirdly, the tool path type is defined. In this case, iso-parametric method is selected. Fourthly, parameters of the tool are defined. In this case, the flat-end mill for rough cutting and ball-end mill for the semi-finished and finished surface are used. Fifthly, tool path with tools parameters selected are generated. In this case, grid method is used to evaluate next tool moving direction. By implementation into a real case, it can be concluded that the proposed method is very useful to create point NC-tool path directly from point cloud data.

Finally, the conclusions of the study and the recommendations for further research are given in Chapter 7.