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Direct integration of reverse engineering and rapid prototyping

Kwan H. Lee*, H. Woo

Department of Mechatronics, Kwangju Institute of Science and Technology (K-JIST), 1 Oryong-dong, Puk-gu, Kwangju, 500-712, South Korea

Abstract

Reverse engineering (RE) technology enables us to create CAD models of new or existing products by capturing surface data. Rapid prototyping (RP) is another emerging technology that allows us to promptly fabricate the physical prototype of a new product using a layered manufacturing technique. In this research, a new method that creates a direct link between these two technologies, is proposed. In RE, an enormous amount of point data is gathered during data acquisition. This leads to a huge file size that requires a large execution time. Surface modeling using these point data is time-consuming and requires expert modeling skills. Some researchers suggested creating an STL file directly from the point cloud data to avoid surface modeling tasks. The STL file, however, has many drawbacks. In this research, algorithms that greatly reduce point cloud data are developed, and thereby, the data file sizes are decreased considerably. The efficiency of the algorithms is demonstrated by comparing them with existing ones.

Keywords: Rapid prototyping; Reverse engineering; Point cloud data reduction; STL file; Rapid product development

1. Introduction

As product varieties increase and life cycles shorten, the need to reduce product development time becomes more critical to maintain competitiveness in the market. The reduction of

* Corresponding author. Tel.: +82-62-970-2386; fax: +82-62-970-2384.
E-mail address: lee@kyebek.kjist.ac.kr (K.H. Lee).

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product development time, therefore, requires revolutionary improvements rather than gradual changes in technology. Both reverse engineering (RE) and rapid prototyping (RP) are emerging technologies that can play a promising role in reducing the product development time.

RE refers to the process of creating engineering design data from existing parts [1–3]. It recreates or clones an existing part by acquiring the surface data of an existing part using a scanning or measurement device. It is useful in recreating the CAD model of an existing part when the engineering design is lost or when the model has gone through many design changes. It enables us to capture the surfaces of design models that are otherwise impossible to determine. It also saves us from performing tedious manual dimensioning and tracing work. When a designer creates a new design using a mock-up, it is necessary to construct the CAD model of the mock-up for further use of the design data in analysis and manufacturing. The manual operation involved in RE requires a great amount of time and operator skills and is also subject to error. Coordinate measuring machines have been used to extract surface data but their data capturing operation is very slow for parts having complex free-form surfaces. In recent years, the laser scanning technology has improved significantly, and it has become a powerful tool in capturing the geometry of complicated design models.

Surface modeling in the RE process, however, is a challenging task. It takes a significant amount of time and skill to generate an accurate surface model from the point cloud data. This step is usually not automated and involves frequent manual interaction with the user even with a well-developed surface modeling software package [4,5].

The CAD model developed by an RE process can be converted to the physical prototype using an RP technique. Generally, in RP, physical parts are fabricated layer by layer. It uses additive manufacturing processes, which do not require any tools or set-ups compared to the subtractive techniques used in the traditional machining operation. It allows us to fabricate features that are difficult or impossible to fabricate by machining operation. Different fabrication methods exist for RP, but nearly all use the same geometry input format, called STL (Stereo Lithography), which consists of a list of triangular facet data. The STL format has advantages due to its simple structure and ease of use, but it also has serious drawbacks. It requires a large amount of memory as the accuracy of a part increases and also takes a significant amount of repair time when it has flaws such as gaps, overlaps, and mixed normal vectors. In order to bridge RP and RE technologies, efficient point cloud handling methods have to be developed first. Second, an accurate geometry input format for RP machines needs to be prepared. This paper proposes a procedure that allows fabricating RP parts directly from reverse engineered geometric data. With the procedure, algorithms that reduce the size of point cloud are developed.

2. Related work

Though both RE and RP are emerging technologies that have been well developed, little research has been done in integrating the two. The research activities described below deal with interfacing RE data to RP.

Hosni, et al. [6] developed a laser based system for capturing the geometric details of the object and tried to apply the captured data to RP using the STL format. Their research,