The Development of an Intelligent Web-Based Rapid Prototyping Manufacturing System

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***Abstract*—A rapid prototyping (RP) machine system which combines a PC-based controller with the thermal-extrusion method is presented. The proposed RP system offers a three-axis platform, an extrusion head, a temperature controller, and a PC-based control system. Low-cost acrylonitrile-butadiene-styrene (ABS) pellets/powder are used for thermal extrusion, although the system is easily adapted to other not-too-dissimilar materials. In order to improve the quality of RP part, the Taguchi method was used to analyzing the process parameters of the proposed RP system. Based on the experimental results, the proposed RP mechatronics system can produce good quality RP parts. The RP software technique includes slicing, support, tool path, and motion code generation. This paper also presents a new adaptive slicing algorithm for RP system. According to this algorithm, the three-dimensional (3-D) computer-aided design (CAD) model can be sliced with different thickness automatically by comparing the contour circumference or the center of gravity of the contour with those of the adjacent layer. With this adaptive slicing method, the part can be fabricated faster than it uses uniform slicing method with identical accuracy. Finally, the intelligent web-based RP system allows remote users to upload an STL file, to directly building up of the physical model, and to monitor the actual fabrication process from a charged coupled devices (CCD) camera located in the RP machine itself. The user does not need to buy an expensive RP machine; instead, he can rent time and uses the machine remotely via the Internet.**

***Note to Practitioners*—RP has being used as an essential augmented tool between CAD and computer-aided manufacturing (CAM) for product manufacturing. RP uses layered manufacturing technology to produce complicated prototypes directly from a CAD model. As imaging, materials, and processing techniques improve, RP functions such as assembly fit, tooling masters, prototype tools, and prototype parts are made possible. RP technology that can construct parts of multiple materials, colors, and even parts composed of composite materials will soon be available. In this paper, an RP machine system which combines PC-based controller with thermal extrusion method is presented. Low-cost ABS pellets are used for thermal extrusion, although the system is easily adapted to other not-too-dissimilar materials. Based on the experimental results, the proposed RP mechatronics system can produce good quality RP parts. In this paper, a new adaptive slicing algorithm is developed to decrease fabrication time without much reducing the model accuracy. According to this algorithm, the 3-D CAD model can be sliced with different thickness automatically. With this adaptive slicing method, the part can be fabricated much faster than it uses traditional uniform slicing method. Finally, the intelligent web-based RP system has been developed which allows remote users to upload a CAD file of the part, direct building up of the physical model, and monitoring of the actual fabrication process from a CCD camera located in the RP machine itself. The greatest advantage is that user does not need to buy an expensive RP machine; instead he rents time and uses the machine remotely via the Internet. This really drastically reduces the production development cycle for the highly competitive time-to-market challenge.**

***Index Terms*—Adaptive slicing, rapid prototyping (RP), thermal extrusion, web based.**

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I. Introduction

RAPID prototyping (RP) is being developed to shorten and simplify the product development cycle. As imaging, materials, and processes improved, RP functions such as assembly fit, tooling masters, prototype tools, and prototype parts were added. Soon, RP technology was constructing parts of multiple materials, colors, and even parts composed of composite materials.

A. Thermal-Extrusion-Based RP System

Previously, only Stratasys Inc.'s, fused deposition modeling (FDM) RP system offered acrylonitrile-butadiene-styrene (ABS) as RP model material. ABS provides good impact resistance, toughness, heat stability, chemical resistance, and rigidity for functionally testable sample parts, so, it is widely used in the automotive and other industries.

The FDM technique has recently been extended to what is called fused deposition of ceramics (FDC) [1]. With the aid of computer-aided design/computer-aided manufacturing (CAD/CAM), the FDC system can produce three-dimensional (3-D) green ceramic, bioceramic, or metallic parts. The FDC system had been further extended to the technology of fused deposition of multiple ceramics (FDMC) [2]. Tseng and Tanaka [3] had developed two newly invented deposition techniques for the freeform fabrication of RP parts. The first technique is called adaptable filament deposition (AFD), which is capable of depositing variable sizes of filaments in a controlled manner. The second is the planar layer deposition (PLD) which uses an adjustable planar nozzle to deposit layers directly.

The extruder head in the FDM system is similar to a conventional piston extruder, where the filament not only acts as a continuous feed material for the extruder, but it also acts as the piston in the system. The ABS filament material, however, requires extra cost in manufacturing. Thus, the current study presents an RP system that directly uses ABS pellets or powder commonly used in conventional injection molding.

B. Development of Intelligent Web-Based RP System

The Internet is currently an underexploited resource for engineering and manufacturing purposes. RP using the Internet