

Executive Summary of Keynote Speech

Manufacturing Technology Development for Customer Involvement in Value Creation

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Advancement of technology has opened up a competitive market that led to the change of product development fundamental from manufacturer-oriented to customer-oriented. The competitive environment has powered customers to demand for better responsiveness, and has forced manufacturers to timely deliver quality products and service to satisfy customer expectations. Design of manufacturer in the early days has been replaced by design for customer at the present time.

However, customer involvement has been limited to expressing their voices until the debut of mass customization concept which each product is aimed to be made to meet a specific customer's need. Customers can take a proactive role in their needs and negotiate to meet their requirements. Manufacturers allow them to involve reconfiguring products during assembly stage. They can mix and match parts to form their own products. Nevertheless, the concept has some limitations when it comes down to implementation. To serve individual needs that quite vary from one person to another, exponential increase of variety will occur and lead to high cost and long lead time. With rigid manufacturing system, manufacturers are required to build up the inventory of variety of components to be ready. As a result, mass customization, in practice, remains at a group of customers with similar preference, not yet reached to individual customer.

Recently, we have proposed design by customer concept to satisfy individual customers by letting them to flexibly involve in defining product of their personal requirements at any stages of value chain, and framework has been established to assist manufacturers on realizing the concept. To encourage customer involvement, maximum possible channels in the value chain should be opened for ease of access, but the level of involvement that can vary from design from scratch to select available items is depended upon customer's interests as well as manufacturer's readiness. Therefore, product attribute analysis that takes key customer needs, manufacturer's capability and constraints has been developed as a tool for determining the level of involvement, and crowd screening process has also been introduced to manage product variety.

Presented in this talk is our ongoing research on manufacturing technology development to support customer involvement in design by customer concept. The research includes the development of hardware, software, algorithm, and their integration to form an intelligent manufacturing system that allows manufacturers to respond rapidly to individual customers. The system is customer-oriented. It has been developed to accommodate customer interest which maybe expressed in various formats such as CAD model, drawing, physical object, sketch or photograph. The system composes of three parts: input transformation, toolpath generation and fabrication technology, and can serve both 2D and 3D applications. It transforms these inputs to be a general form of contour images for 2D product or a stack of contour images for 3D product. Topological hierarchy contour tracing algorithm has been developed for automatic toolpath generation. This algorithm can trace a set of one-pixel wide closed contours that may appear as nested contours, interconnected contours or their combination. It is applied on the images to obtain coordinates on all contours. The ordered sequences of coordinates are then used to generate commands for fabrication a product.

Contour cutting and screen printing are examples of 2D application. Zero G-code two axes servo table has been developed for abrasive waterjet machining. It allows inexperience users to complete cutting any complicated contours in very short period of time without writing a single G-code. Its integration with contour tracing algorithm makes it possible for rapid contour cutting from a contour image. Multi-color screen printing system has also been developed to illustrate design by customer concept. The system is capable of creating screen quickly from customer design and used on a flat screen printing machine that is capable of adjusting screen automatically for multi-color printing.

Additive manufacturing has been our focus on 3D application. A few rapid prototyping techniques have been developed in house. Direct slicing approach has been researched for transforming 3D CAD model to be a stack of contours. However, it is quite often that customers do not come with 3D CAD models; instead they may bring physical objects, or rough sketches. Therefore, interfacing between rapid prototyping (RP) with reverse engineering (RE), geometric reconstruction (GR), and 3D sketch-based modeling have been researched also to transform rapidly those inputs to be physical prototypes.

For RE-RP interface, unlike all existing interface approaches which acquire entire surface data from an object and perform data reduction, our adaptive reverse engineering acquires data selectively and locally layer by layer according to the complexity of the object. Structure light system has been applied to induce feature on the object surface to appear explicitly for selective data acquisition algorithm that applies image processing to analyze the complexity of the object before recommending the scanning positions. The output is a stack of contours that can be used directly for toolpath generation. Similarly, GR-RP interface has been developed for direct fabrication of a physical prototype from an orthographic views drawing without reconstruction of its 3D CAD model. This success has led us to another development on direct fabrication of a prototype from a paper-based freehand sketch which is a natural communication channel used for expressing idea.

In conclusion, several manufacturing technologies have been being developed to support customer involvement in our design by customer concept but the development has not been completed yet. There is still big room for improvement to make these technologies more robust. Also, full implementation of design by customer is still waiting to be explored.

