Associated Design System for Individual Physical Feature

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ABSTRACT

The popularization of 3D printers and laser cutters brought the revolution to the manufacturing industry. This trend enabled private customized production design according to users' needs. However, the design method of the customized production so far requires a long time and expensive service cost in the design process. Meanwhile, consumers can easily purchase Mass Products at lower prices in the Net Age that it cannot be said the superiority from the viewpoint of customization. It is considered necessary to develop a customization service method suitable for the manufacturing of open innovation, one of the challenges is to reduce redesign costs to the utmost and to avoid duplicated design activities. In order to cut the customization service to zero cost, this study proposed a method which eliminates the repeating routines in the design phase. Therefore, a support system which took up a bicycle as an example of customization service was proposed. The system captures the physical information of user merely by camera and generates the customized 3D data of an artifact usable in a 3D printer immediately. In this paper, a process for developing prototype system has been proposed. The cost has been took up as the evaluation of the execution result of the prototype system. Referance to Bioracer 5000 as the conventional customized service system, the prototype system has been evaluated from two aspects of weight reduction of facility and simplification of service. The conclusion is that the prototype system realized the cost reduction of customization service to a great extent.

1. INTRODUCTION

Current society is a product manufacturing and consuming society based on mass production that consumers can select and consume their preferred ones produced at the factory. The concept of product design, which was the mass production-oriented manufacturing in the premise is to collect and analyze information, such as the size and hobbies of consumers, to build a production line based on a prototype model for re-production.

Meanwhile, due to the popularization of 3D printers and laser cutters, the manufacturing of open innovation that shaping with various materials has become possible. Especially in the bicycle manufacturing industry, that bicycle parts made by 3D printers are popular in bicycle DIY. This trend enabled private customized production design according to users' needs.

For example, a number of companies provide customization services to design a personal bicycle in the DIY industry of bicycles. One of them is a bicycle design system called Bioracer that calculates the position of a bicycle by the body size of the consumers and the trajectories of the knees. However, the design method of the customized production so far requires a long time and expensive service cost in the design process.

Meanwhile, consumers can easily purchase Mass Products at lower prices in the Net age that it cannot be said the superiority from the viewpoint of customization.

It is considered necessary to develop a customization service method suitable for the manufacturing of open innovation to solve this problem. One of the challenges is to reduce redesign costs to the utmost and to avoid duplicated design activities. In order to cut the customization service to zero cost, this study proposed a method which eliminates the repeating routine in the design phase.

2. METHOD

An automation customization service system for bicycle had been picked up as an example of customization services. The system captures the user's physical information merely by a camera, and the design of bicycle 3D model that used in 3D printing can be generated immediately.

In this paper, a process for developing prototype system has been proposed. The cost has been took up as the evaluation of the execution result of the prototype system. The research of user satisfaction is a future task. Referance to Bioracer 5000 as the conventional customized service system, a cost-less method has been proposed and a prototype system has been developed.

The following describes the process of Bioracer 5000. At first, measure the user's body size data and calculate the theoretical position of the bicycle based on that data. After that, the fine adjustment of the calculated position is performed based the data from the user used the electric position simulator. Finally, the result of the position by electric position simulator would be took a perform fitting on a real bicycle and provide the recommended position of the bicycle according to the physical characteristics of the user.

The automation customization service system was proposed that based on these process but the cost was reduced. Just took capture by a camera at the shop or home, a 3D model of bicycle would be generated immediately. The 3D model of bicycle fits to a customized designed position like the recommended position of Bioracer 5000.

2.1 Sample Preparation

The proposed system creates a virtual skeleton by measuring individual body features at first. The process is automatically completed in real time and corresponds to the theoretical position process of Bioracer 5000.

A 3D camera "Kinect" has been used to track the body features of user. The positions of 25 joints on whole body like "Ankles""Shoulders" have been tracked as a virtual skeleton and makes to a real world coordinate form. The distance of the joint point would be calculated as the real world Skeleton Distance.

A hierarchical standard human body 3D model combined by 110 thousand polygons has been prepared and 25 joints of the human body on the corresponding skeleton has been placed. Also, in order to produce the movement of feet naturally, "RootLeft" and "RootRight" of the corresponding joints at the feet has been added and the total number of joints was become 27. A height 170.9 cm and weight 65.5 kg twenties male had been choice as a sample that distance of the 27 joint points was made in this model.

The joint points on the hierarchical standard human body 3D model would be transformed with the Skeleton Distance data from the virtual skeleton by 3D camera and a human body 3D model that can embody an individual characteristic can be generated by this transform.

The deforming program was introduced on the left side of the model, and was not introduced on right side shown on Fig.1. The deformation of 3D human body model with a subject height 180.5 cm, especially the deformation of the left foot can be indicated.

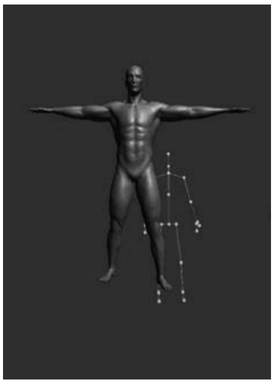

Figure 1: The deformation of human body model

The proposed system generated 3D model of bicycle by the deformation on a bicycle 3D model conforming the standard human body 3D model instead of creating a recommended position on the electric position simulator.

The bicycle 3D model had been prepared in seven types like "Mountain Bicycle""Triathlon Bicycle" and the animations of posture riding these bicycles had been made. These bicycle 3D models had been made in hierarchy and can be deformed according to movement of the Parts Point joints such as "PedalLeft""HandlebarLeft".

When the system starts up, the animation of posture riding the bicycle would be played and the positions of saddle, both pedals and both Handlebars would move to be in accordance with the positions of both hands, both feet, buttocks. The positions of other parts would be calculated based on the positions above and finish the deformation in real time.

The effect of the deformation is shown on the Fig.2. The left model is a bicycle 3D model before deformation and the right model is a deformed bicycle 3D model with a subject whose height was 180.5cm.

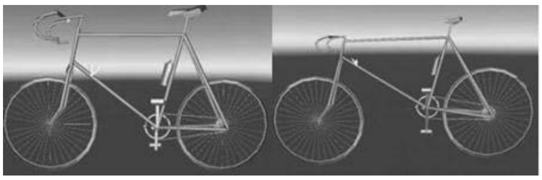

Figure 2: The deformation of the bicycle 3D model

2.2 Experimental Procedure

A prototype system has been implemented with the processes proposed above. The prototype system consists of one personal computer and one 3D camera and the 3D camera should be put on a height about 1m desk.

The system was activated by pressing the "Start" button on the execution interface. User stand on the ground at a distance of 1.5 m to 2.5 m in front of the camera and his body features was be captured by the system in real time. Pressed the "pause" button if it is stable, the bicycle 3D model was generated in the system.

Running experiments with random background were taken 20 times, the average time consumption was 50 seconds by the whole process from starting up the system to generating the 3D model of the bicycle.

During the experiment of the length of upper arm measurement, the disparity of the data measured by system and by measurement tool can be within 0.6 cm.

3. RESULTS AND DISCUSSION

The cost of the fitting service of the conventional system is 5000 yen and one hour, but it is become free service and 1 minute by the propose system. Due to miniaturization and simplification of the main body of equipment, the cost such as the use section of shop, maintenance of facilities, workload of staff, can be reduced in a large extent (Table 1). The disparity of the measured data is maintained within 0.6 cm, can be approved within the pardon range of embodying the body features.

Table 1 The contrast of cost

	Main Body	Used Space	Place Restriction	Measure Error	Cost of time	Cost of money
Bioracer 5000	Complexity	0.5m * 2 m	The Shop	None	1 hour	5000 yen
Proposed System	Simple	0.5m * 1.5 m	None	0.6 cm	50 seconds	None

And regarding the simplification of service, the operation of the proposed system became very easy. The guidance of the staff is unnecessary, the consumer's physical strength and language communication can be reduce. Consumers can see bicycle shaping intuitively and decide whether to buy a bicycle more easily. It is concluded that the cost reduction of the customization service was realized to a large extent in the proposed system through above.

4. CONCLUSIONS

In this paper, a process for developing prototype system has been proposed and the cost has been took up as the evaluation of the execution result of the prototype system. By the running experiments has been taken on the prototype system and the conclusion is that the proposed system realized the cost reduction of customization service to a great extent.

ACKNOWLEDGEMENTS

I would like to thank Prof. Igarashi and Prof. Koyama for useful discussions. I am grateful to Qi. ZHOU for assistance with the data of physical features.

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