Fitter: A System for Easily Printing Objects that Fit Real Objects

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ABSTRACT
When printing both self-making and existing 3D models, users often create models to fit to a real object within it. Fitting models to the size of a real object is a delicate problem. To address it, we present a concept to capture the size of a real object, create or modify a model that conforms to the captured image, and print the model on the spot. We create a 3D printer to realize this concept by installing a touch panel display in the build plate system. In this paper, we focus on creating containers that fit accessories. We create containers for a pair of scissors, a smart watch, a drone, a pair of glasses, and a pen holder.

Author Keywords
Fabrication; 3D Printer; Fused Deposition Modeling; What You See Is What You Get; Fit Real Objects

ACM Classification Keywords
H.5.m. Information Interfaces and Presentation (e.g. HCI): Miscellaneous

INTRODUCTION
The ability to print both self-making and existing 3D models is of little value if these models do not fit real objects after printing. Eventually, users will expect to use 3D models with real objects in mind. Assuming that printed objects are used in real situations, users need to print them to match their applications. For instance, we cannot sit on a chair whose height is 2 m. Printing a cap for a USB memory stick that cannot fit it is meaningless. Solving this problem is a delicate task.

We present a concept to address this problem that involves a 3D printing method and extends the idea of "What You See Is What You Get." This concept involves capturing the size of real objects, creating or modifying a model that conforms to the captured image, and printing the model on the spot. We present a system that uses this process to print objects (Figure 1). With our system, users can design 3D models, which fit real objects, on a 2D surface. The modeling system uses Teddy [2], and users can automatically create a container of a 3D model by drawing. Our system employs a modified fused deposition modeling 3D printer. A display for editing the 3D models and capturing real objects is installed in the build plate. A webcam is placed on top of the build plate so that its capture range covers the entire build plate and the captured image is displayed on the build plate display in full size. Users create a 3D model and adjust it to fit to the real object in the image. The system targets users that are not familiar with 3D modeling.

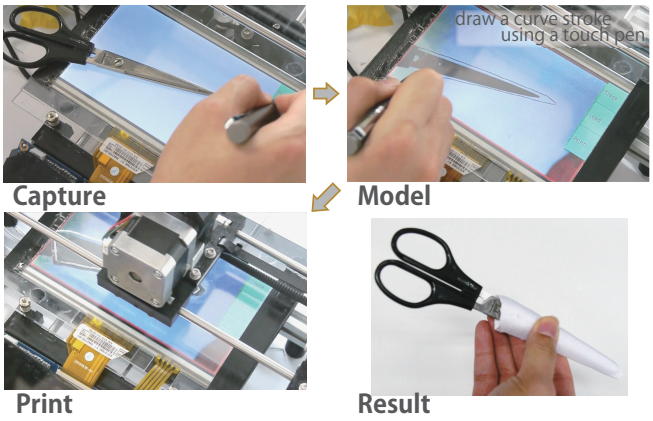

Figure 1. Modeling process

OUR SYSTEM
The build plate of our system is modified with a touch display (build display). Hence, users can input touch operations on the build plate to create, move, and scale a 3D model (Figure 2). Moreover, a webcam is placed on top of the 3D printer; it can capture a real object on the build plate and display it in full size. There are only three buttons on the build display: the trace button captures an object with the webcam and prepares the work, the load button searches for the 3D model data on the PC, and the print button begins printing an object. In addition, users need to set up the temperature of the extruder and the serial port in advance.

When a user prints an object that fits a real object using our system, they place the real object on the build plate, press the trace button, and capture it. They can then perform two actions with our system: create a new 3D model or scale an existing 3D model to fit to the captured image. Finally, users

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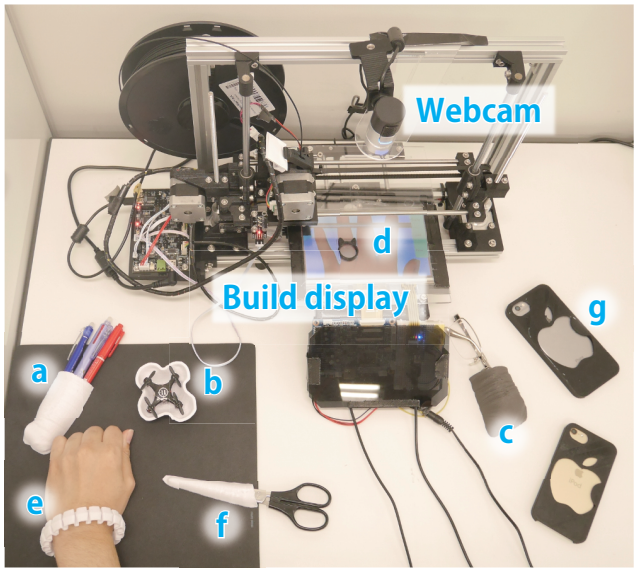

Figure 2. System appearance and examples (a-g)

press the print button, and our system prints the 3D model at the display position of the build display.

Our system employs a modified Prn3D system[1] and a RepRap 3D printer. The heated bed is removed and an acrylic board processed by a laser cutter is added. A 7-inch LCD and a resistive-film-type touch panel are stacked in an acrylic frame. There is nothing on the touch screen, so the user prints 3D models on it directly. The temperature of the system extruder ranges from 190°C to 210°C for printing objects. Nevertheless, there is no effect on the touch screen. We speculate that there will be no problem if there is no contact between the extruder and the touch panel.

Creating a New 3D Model

In order to create a new 3D model, users draw the shape of the model that they want to create using a touch pen on the build display. The modeling system can create models of containers and users can design two types of containers by changing the drawing style. If the start and end points of a user's input stroke are far apart, the system creates a container with an opening between these points. If these points are close and the input stroke is likely to be a loop, the system creates a container with an opening at the bottom. If a user inputs a new stroke, the previous stroke is canceled and the system creates a new 3D model.

Scaling an Existing 3D Model

Our system can both create a new 3D model and scale an existing 3D model. By pressing the load button on the build display, a user can search for the latest 3D model file in a particular folder specified in advance. The system loads the searched 3D model data and displays its shape. Users can move the model by grasping and dragging the inside of the shape or scale it by grasping and dragging its frame.

[1] `http://www.micro-factory.net/`

EXAMPLE OUTPUT

We created and scaled 3D models that fit to real objects using the prototype system (Figure 2(a-g)). We created containers for a pair of scissors (f), a drone (b), a pair of glasses (c), and a pen holder (a), which are all made of PLA. Because PLA is hard to warp. Here, we describe the process of creating containers for the glasses and drone. First, we placed the glasses on the build plate and pressed the trace button. Thus, a full-scale image of the glasses was displayed on the build display. Next, we drew a U-shaped curve stroke using a touch pen to cover half of the glasses. Finally, the object was printed by pressing the print button. We used magnetic iron PLA as the printing material. After printing, we verified that it could contain the glasses and attached it to the side of a table using a magnet. In the case of the drone, we drew a loop in a shape that covered the drone. We constructed the container such that it would have adequate room to contain its propellers.

In addition, we printed existing 3D models of accessories such as rings (d), an iPhone case (g), and bracelets (e). Here, we describe the process for creating a ring. First, we selected the ring that we wanted to create from Thingiverse[2] and downloaded the STL file. Next, we placed our hand on the build plate and pressed the trace button. We then pressed the load button, and the system displayed the downloaded ring. We moved and scaled it to fit to the middle finger in the captured image and pressed the print button. Thus, the ring was printed on the spot. We verified that it fits on the real middle finger. We printed six rings that fit on the middle or third finger of four users using the same 3D model. In addition, we created one ring in a size such that the ABS did not warp. In the case of the bracelets, the system has to capture an arm, which is not flat. Therefore, the arm in the captured image was little larger than the real arm; thus, a slightly larger bracelet was printed. The iPhone case was created for an iPhone 5; however, we were able to use the system to modify it for an iPhone 6.

RELATED WORKS

Igarashi et al. presented a design method for covers in which users can create close-fitting customized covers [3]. AutoConnect is a system that notes the connectors attached to two real objects and automatically creates connectors [5]. Chen et al. presented a method in which 3D printed objects are attached to real objects [1]. MixFab is modeling environment using gesture operation [7]. In interactive construction, users utilize laser pointers that are allocated a function at a plate, and a laser cutter traces the motion of the laser pointers and cuts the plate [6]. In DrawForming, users can create 3D topographical models that fit to real objects by drawing contour lines on a surface [9]. In MARCut, users can cut a plate that fits to real objects using a laser cutter with a marker-based laser cutting method [4]. In interactive fabrication, they presented a system, Shaper, that interactively outputs a polyurethane foam using a three-axis CNC machine [8].

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[2] `https://www.thingiverse.com/`

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