Sketch-Based Pipeline for Mass Customization

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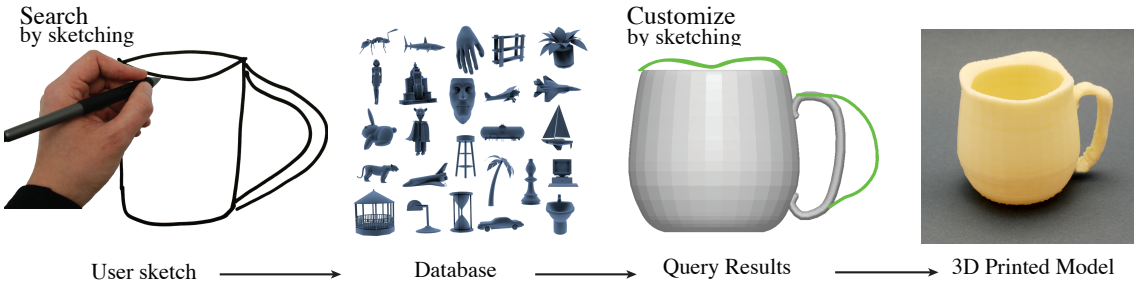

Figure 1: *We present a sketch-based pipeline guiding the process of manufacturing. We start by sketch-based retrieval of a user sketch in a large 3D model database. We show the possibilities of sketch-based modeling to customize the results intuitively. Customized 3D shapes are manufactured using a 3D printer.*

Abstract

We present a novel application workflow to physically produce personalized objects by relying on the sketch-based input metaphor. This is achieved by combining different sketch-based retrieval and modeling aspects and optimizing the output for 3D printing technologies. The workflow starts from a user drawn 2D sketch that is used to query a large 3D shape database. A simple but powerful sketch-based modeling technique is employed to modify the result from the query. Taking into account the limitations of the additive manufacturing process we define a fabrication constraint deformation to produce personalized 3D printed objects.

1 Introduction

The evolution from handcrafted personalized manufacturing to intuitive and easily accessible mass customization is one of the central challenges for the digital manufacturing age. Successful implementation of this process is dependent upon the development of high quality interfaces for end users. Sketching, because of its ability to act as a common means of visual communication, provides an exceptional input tool for searching large image and 3D shape databases, as well as modeling 3D surfaces.

This work contributes, for the first time, a closed workflow from a user drawn 2D sketch to a 3D printed personalized object by taking manufacturing limitations into account. This is achieved by combining different sketch-based retrieval [Eitz et al. 2012] and modeling aspects [Zimmermann et al. 2008], enabling the user to control the process with a sketch-based input metaphor The components of our approach include:

1. A simple 2D view of a 3D shape is sketched by the user and used as a query image for a large 3D model database. The retrieval system returns a set of matching 3D models.
2. Users select one model of the retrieval set, and modify it using simple strokes along the shape's silhouette.
3. The final modified object is printed using a standard off-the-shelf 3D printer.

2 Shape Retrieval

The presented retrieval method is based on a preprocess over the 3D models in the database. Important features of the models are extracted to match the sketched input images with the 3D shapes. To this end, non-photorealistic rendering algorithms are employed to render the object with selected feature lines from several virtual viewpoints. This results in the creation of a set of line renderings for each model. An image descriptor based on Gabor filters, which is specifically designed to match the sketch-based user input and rendered images is then used to generate a bag-of-features representation. Thereby the user is able to search the shape database quickly and accurately even if the database contains millions of 3D models and the sketch is drawn by a non-expert user.

3 Shape Modeling and Fabrication

The sketch-based modeling process enables the user to modify the model by sketching new silhouettes of the mesh. For each stroke drawn by the user, a corresponding feature-preserving deformation is computed. This deformation, however, might introduce changes that cannot be manufactured with a 3D printer, such as,

- thin and fragile structures, which produce unstable results,
- self-intersections,
- meshes that exceed the boundaries of the available printing volume.

We avoid these production difficulties by simulating the additive manufacturing process during the modeling process. To this end, a set of slices along the printing direction of the deformed shape is generated. These slices are tested whether they violate the above constraints, and the deformation is reduced stepwise using linear interpolation until the constraints are satisfied.

The demonstration of our system uses a database of several thousand 3D models, creating a variety of personalized 3D printed examples.

References

EITZ, M., RICHTER, R., BOUBEKEUR, T., HILDEBRAND, K., AND ALEXA, M. 2012. Sketch-based shape retrieval. *ACM Transactions on Graphics (Proceedings SIGGRAPH) 31*, 4, 31:1–31:10.

ZIMMERMANN, J., NEALEN, A., AND ALEXA, M. 2008. Sketch-based interfaces: Sketching contours. *Comput. Graph. 32*, 5 (Oct.), 486–499.

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