Sketch-Based 3D Hair Posing by Contour Drawings

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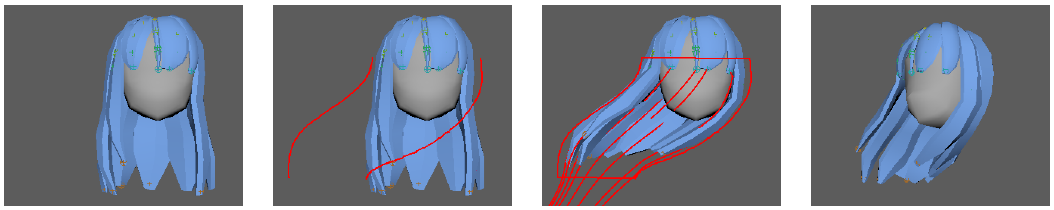


Figure 1: Overview of the hair posing process in our system. Left: original rigged model, middle-left: user input (red lines), middle-right: result of deformation, right: the result from another view.

ABSTRACT

We propose a sketch-based method for posing a three-dimensional (3D) hair model that enables artists to create attractive hairstyles more easily and intuitively. The system takes partial contour drawings of a preferred hair shape to modify the rig parameters so that the hair model fits into the sketch. Our method consists of two parts: flow extraction from a sketch and pose construction using the flow. The method was evaluated by a user study and an interview with a professional 3D artist.

CCS CONCEPTS

• **Computing methodologies** → **Animation**; **Graphics systems and interfaces**;

KEYWORDS

Sketch-based posing, hairstyling

ACM Reference format:
Shogo Seki and Takeo Igarashi. 2017. Sketch-Based 3D Hair Posing by Contour Drawings. In *Proceedings of SCA '17, Los Angeles, CA, USA, July 28-30, 2017,* 2 pages.
DOI: 10.1145/3099564.3106638

1 INTRODUCTION

The creation of natural motion of hair is an important but difficult task in three-dimensional (3D) character animation. 3D artists usually use a physical simulation to achieve it; however, the results are not always reliable, and manual modification is required. In these cases, they commonly adjust rigs by using forward kinematics (FK), which is a time-consuming method, even for professional artists. Although some methods have been proposed for intuitive skeleton posing [Bessmeltsev et al. 2016; Öztireli et al. 2013], their target is a rather simple structure. We propose a sketch-based skeleton posing method that is suited for editing 3D hair models intuitively by contour drawings.

SCA '17, Los Angeles, CA, USA

DOI: 10.1145/3099564.3106638

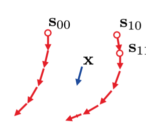
2 RELATED WORK

Recent sketch-based skeleton editing methods [Bessmeltsev et al. 2016; Öztireli et al. 2013] are applicable to the hair posing task; however, they do not fully match because they can deform only one chain (or tree) of joints at a time [Öztireli et al. 2013], or they consume too much time to be used in an interactive system [Bessmeltsev et al. 2016].

The use of flow information is a common method for modeling hair [Fu et al. 2007; Hadap and Magnenat-Thalmann 2000]. In particular, [Fu et al. 2007] used sketches to designate flow vectors, as in our method. However, the sketches required in that method are not contour drawings from a certain viewplane but strokes in multiple planes that start from the scalp, and the target is not modifying but designing hairstyles. [Malik 2005] also proposed a sketch-based hair editing system that supports a *combing* operation. The operation takes one stroke and tweaks hair by applying combing force along the stroke. Our method aims to utilize users' ability to create contour drawings, which is very powerful and familiar among artists [Bessmeltsev et al. 2016] but ignored in these methods.

3 METHOD

Our system takes a rigged hair model and contour drawings as the input. Closed polylines are generated by connecting the end points of strokes, and the joint chains inside the closed polylines are selected as the targets of deformation.



Then, the system calculates the flow field. Let $\mathbf{s}_{ij}$ be the j-th point on the i-th stroke in the world coordinates and m be the number of strokes. The order of the points on each stroke is determined by the drawing order; in other words, the direction of a stroke matters. The flow direction $\mathbf{v}(\mathbf{x})$ is then calculated by

$$\mathbf{v}(\mathbf{x}) = \sum_{i=1}^{m} \sum_{j=2}^{|\mathbf{s}_i|} \frac{\mathbf{s}_{ij} - \mathbf{s}_{ij-1}}{||\mathbf{s}_{ij} - \mathbf{s}_{ij-1}||} \frac{1}{||\mathbf{x} - \mathbf{s}_{ij}||^d}.$$

By changing the value of d, the influence of each stroke on the flow field can be controlled. Here, we choose $d = 2$ in our implementation. *Guide strokes* are then generated on the basis of a streamline whose start point is on the root joint of the chain that should not sink into the head mesh. Finally, each selected joint chain is deformed to fit into the guide stroke.

4 RESULTS

We implemented our method as a plugin in Maya. The average calculation time on a 4-core 2.5GHz Intel Core i5 was 87.7 ms for 269 deformations observed in the user study for a model consisting of 12 joint chains that contain 80 joints in total (the model in Fig. 1). We show examples of the hairstyles created by our method in Fig. 3.

5 USER STUDY

First, we compared our method to a previous method that was proposed by [Öztireli et al. 2013] in terms of the editing efficiency. The previous method takes a single stroke sketched by a user and a chain of joints in the character's skeleton. The joint chain is deformed to fit into the stroke. We prepared three target hair poses using one reference model (Fig. 1, left) and asked four novice participants to deform the reference model into the target models using the previous method and our method. The order is counter-balanced. Fig. 2 shows the results of the user study.

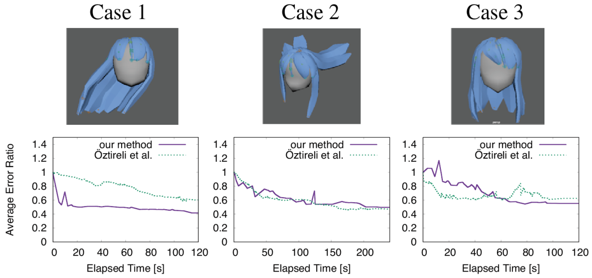


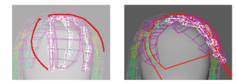
Figure 2: Results of the user study. The graphs represent the temporal transition of the average error ratio in each test case (obtaining a lower value earlier is better). The three pictures represent the target models.

Second, we interviewed a professional 3D artist without honorarium. We first asked him how artists pose hair. He answered that they usually set rigs composed of chains of joints similar to our setting, generate rough motions by a physical simulation or motion capture, and finally modify the undesired motions by hand. Next, we introduced our system and demonstrated how users can deform hair models by contour drawings. He said, "In typical scenes, I will be able to finish editing hair in a few seconds by using this system that usually takes 2–3 min." The interview took about 20 min.

6 DISCUSSION

The results of user study suggested that our method has an effect on reducing the editing cost when the target is simple (case 1). However, this was not the case for a somewhat complicated target (case 2) or when editing details (case 3). These results imply that the previous method is suitable for editing precisely, and our method is suitable for global shape modification. A combination of the two methods will complement each other and perform better.

A major limitation of our method is an artifact that appears when there are mismatches between the flow direction of hair and the input strokes (right image). We will consider using an optimization that maximizes the area covered by hair to improve the result.



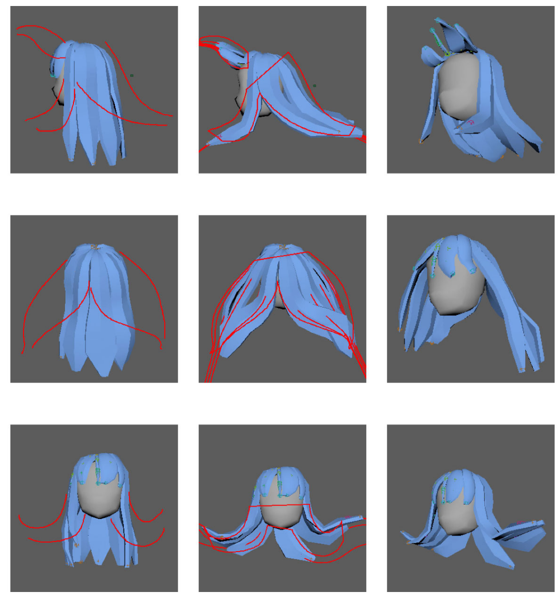


Figure 3: Examples of deformation flow in our system. Left column: user input, center: deformed model, right: the deformed model from another view.

ACKNOWLEDGMENTS

We greatly appreciate the comments from Yoshinori Kawamatsu, who provided the viewpoint of a 3D artist. We also thank the participants of the user study.

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