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SURF based Hair Matching and VR Hair Cutting

Changjo Sung[1] and Kyoungsoo Park[2] and Seongah Chin[3*]

[1]*Department of Media Software, Sungkyul University, XICOM LAB., Korea*
[2]*Department of Media Software, Sungkyul University, XICOM LAB., Korea*
[3*]*Department of Media Software, Sungkyul University, XICOM LAB., Korea*
tjdckdwh@naver.com, checking_pks@naver.com, *solideo@sungkyul.ac.kr*

Abstract

Hair styling has a significant influence on human social perception. An increasing number of people are learning hair styling and obtaining hair designer licenses. However, it takes a considerable amount of money and time to learn professional hairstyle and beauty techniques for hair styling. Since COVID-19, there has been a growing need for offline and video lectures due to the decline in onsite training opportunities. This study provides a field practice environment in which real hair beauty is performed in a virtual space. Further, the hairstyle that is most similar to the user's hair taken with a webcam or mobile phone is determined through an image matching system using the speeded up robust features (SURF) method. The matching hairstyle was created into a three-dimensional (3D) hair model. The created 3D hair model uses a head-mounted display (HMD) and a controller that enables finger tracking through mapping to reproduce the haircutting scissors' motion while providing a feeling of real hair beauty.

Keywords: *Hair styling, Hair Image matching, Hair Cutting, Non-contact, VR, AR.*

1. Introduction

Hair styling influences human social perception, and hair beauty has become a prominent feature of human physical appearance, contributing to beauty perception [1]. However, service satisfaction varies according to the hair designer's experience and sense, as well as the customer's head and hair condition [2]. As a result, the perception of the hair and beauty industry is changing to that of a specialized field that requires expert knowledge and skilled technology instead of a simple technology [3]. However, learning professional hairdressing techniques is costly and time-consuming. Recently, the need for offline and video lectures has increased as opportunities for field training have decreased after COVID-19 [4]. This study consists of the following processes.

In the hair styling step, to match the user's hair photo with a web cam or phone camera, only the hair part is extracted from the photo using fully connected network (FCN) as shown in [Figure 1], and the hair area is separated [5]. Among the separated hair region datasets, the most similar hairstyle is detected using speeded-

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Corresponding Author: solideo@sungkyul.ac.kr
Tel: +82-31-467-8198, Fax: +82-31-467-8067
Professor, Dept. of Media Software, Sungkyul Univ., Korea

up robust features (SURF). The photo with the highest number of outliers was selected by matching the detected outliers. The user was provided a 3D hair model which matches the selected photo, by importing it into the virtual space and combining it with 3D face modeling. Hair cutting in augmented reality is performed using a controller capable of finger tracking by mapping a 3D hair model to a head-mounted display (HMD).

(a) (b)

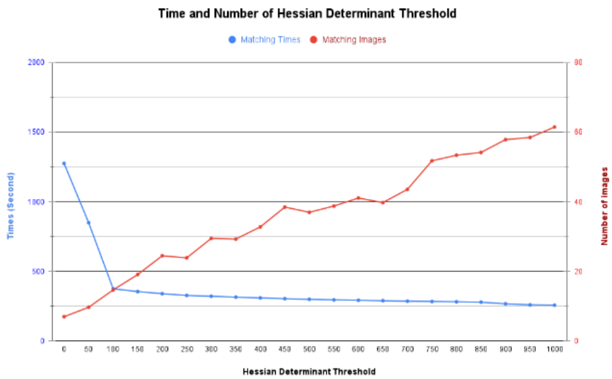
Figure 1. Hair Style Segmentation Database [5] in (a) and our extracted hair segmentation in (b).

2. Hair matching using SURF

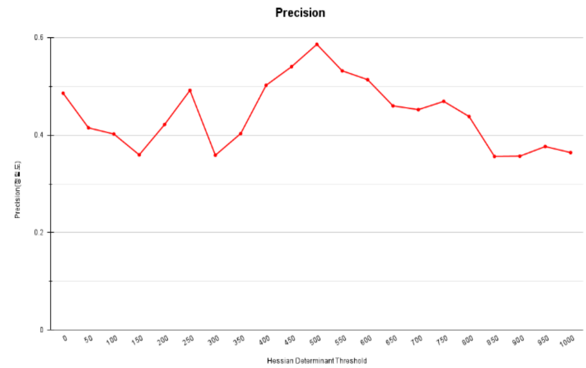
SURF was used to select hair pictures similar to the photographed hair pictures [6]. The SURF algorithm constructs a Hessian matrix through a convolution operation between an approximated second-order differential Laplacian of Gaussian (LoG) box filter and an integral image. It then calculates the determinant value of the matrix. When the Hessian matrix determinant is greater than the threshold and the determinant is the largest compared to the adjacent scale, it is determined to be a singularity [7]. In the SURF algorithm, the minimum value of the Hessian filter was set by specifying the threshold of the Hessian matrix to control the number of singularities. As shown in [Figure 2] (c), the larger the threshold, the fewer are the singularities generated. However, a small threshold, as shown in [Figure 2] (a) has more singularities but less prominent singularities. In [Figure 2], 100, 500 and 1000 represent found points based on threshold value.

(a) 100 (b) 500 (c) 1000

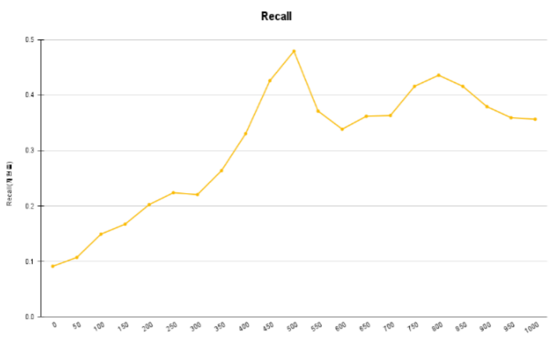
Figure 2. Found points based on threshold value



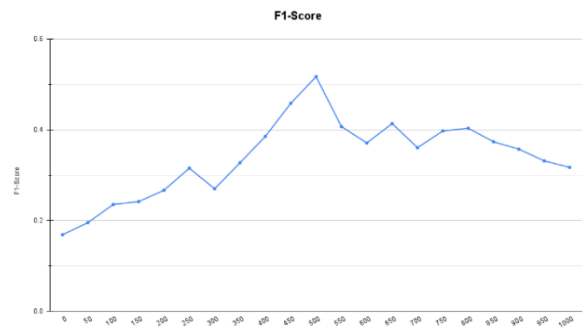
(a) Time and number of images



(b) Precision



(c)Recall



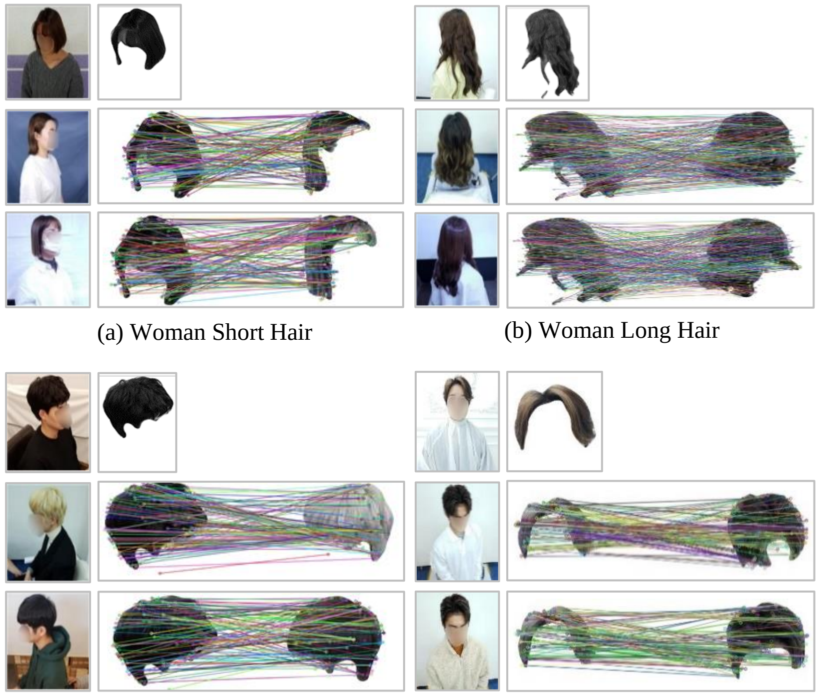
(d) F1-Score

Figure 3. Experimental results according to Hessian Determinant Threshold

The number of singularities according to the change in the threshold affects the time required. Moreover, the number of matching pictures vary [8]. In the case of matching, the singularity is computed in a brute-force manner using other images. Therefore, as the number of singularities increased, the time required for matching also increased. An experiment was conducted to confirm the time required for matching by the threshold and the number of matching photos. For the experimental conditions the threshold was set as a value ranging from 0 to 1000 in units of 50. For hair photos in the matching database, 12,279 Korean hairstyle data sets from the AI were used [9]. To increase the accuracy of the experiment, matching was performed using 10 pictures that comprised five male and five female pictures. The results were derived as the average time required for matching and the number of matched pictures for each threshold.

The experimental results showed [Figure 3] (a) that the time required for matching decreased significantly from 0 to 100, and then gradually decreased from 100 or more. The lower the threshold, the greater the number of outliers; thus, the number of matching photos decreased. As the threshold increased, the number of matched photos tended to increase and the number of outliers decreased.

As shown in [Figure 3] (d), the F1-Score increased as the threshold increased and then decreased from the threshold of 500. According to hair image matching, when the threshold with the highest F1-Score value was 500, the result was 0.517, indicating the most efficient result.



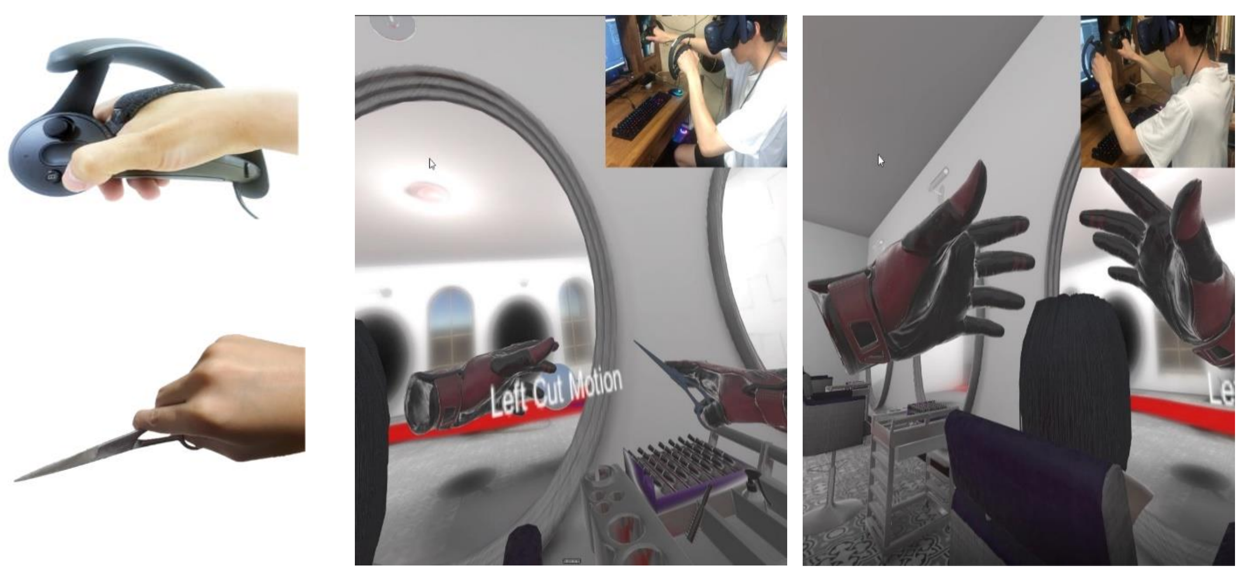
(a) Woman Short Hair (b) Woman Long Hair

(b) Man Short Hair (b) Man Parted Hair

Figure 4. Matching Hair in Dataset

In [Figure 4], the designs of similar hairstyles are matched in the case of different hair photos.

3. Hand motion and haircut process using HMD and finger tracking controller



(a) Finger-tracking controller (b) Hand motion in virtual reality

Figure 5. Hand Motion Using HMD and Finger Tracking Controller

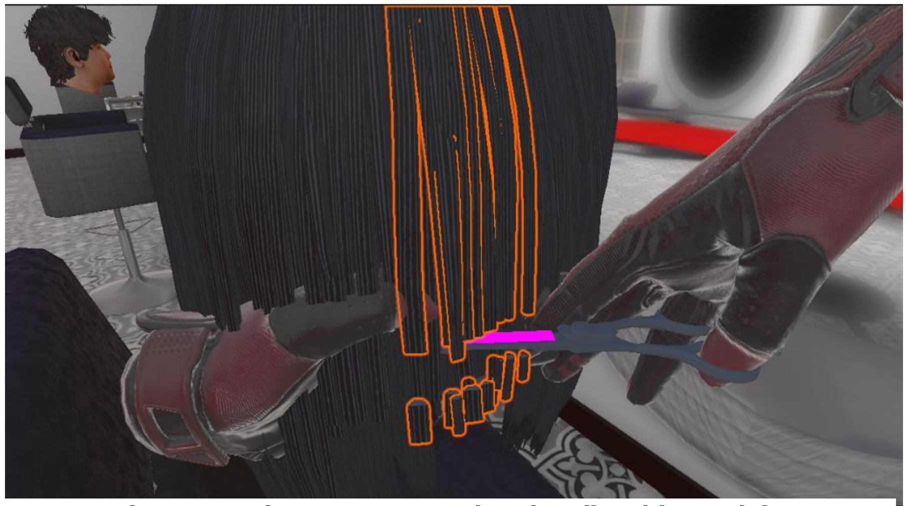
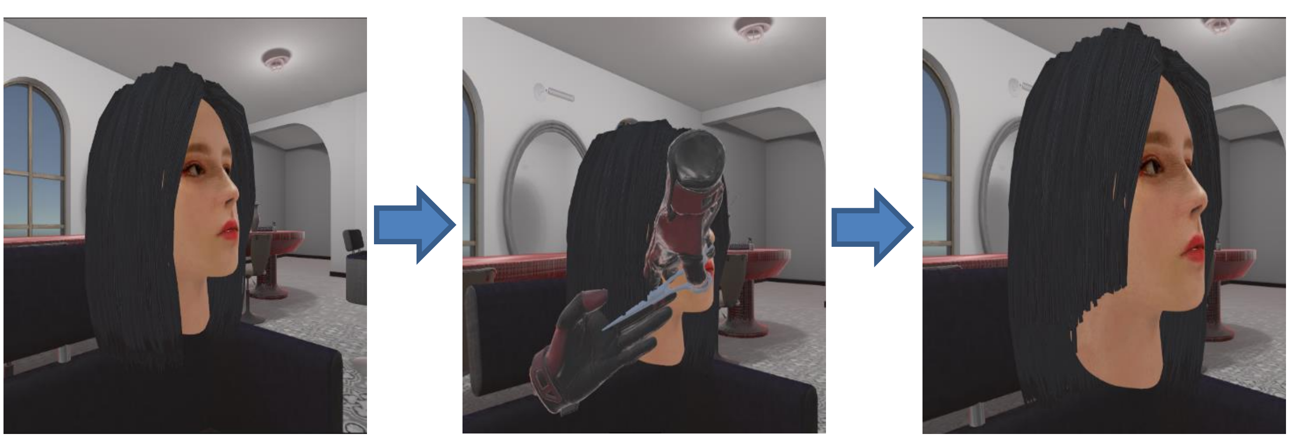


Figure 6. Haircut Process Using the sliceable module

[Figure 5] shows hand-based interaction in a virtual salon space operated through an HMD worn on the head and a finger-tracking controller allowing for delicate control that can be moved by each finger. As shown in (b), the figure of holding hairdressing scissors by hand was implemented through the controller [10], whose mapping was completed, which was the previous study in (a). The controller displayed a hand-based movement. The scissors are attached to the right hand when the hairdressing scissors interact with the right-hand controller. A user can take a hand motion as if picking up real hairdressing scissors through the skeleton poser function provided by Steam VR. [Figure 6] shows how the hair was cut. The left-hand controller used the motion of grabbing the hair, and the right-hand controller uses the motion of grabbing hairdressing scissors, as shown in [Figure 5]. For haircut, if the A button is pressed on the right-hand controller holding hairdressing scissors, an animation effect of the scissors opening occurs at the same time as the hand opening motion [10] through the blending editor function of the skeleton Poser. When the box collider with the scissors blade is attached (pink) and the cylinder collider of the hair (orange) collides, the lower part of the cut hair falls due to the gravity of the rigid body.

4. Result of hair cutting



(a) Before hair Cut (b) Hair Cut in progress (c) After hair cut

Figure 7. Hair cutting process in Virtual Hair Salon

Rigidbody's kinematic is applied to the upper part so that it is not subjected to gravity, and the hair is cut while being fixed. Hair cut occurs when the cylinder mesh, which is a 3D object of hair, is cut, referring to the sliceable module [11], which is used to cut the mesh. In addition, by using a specific layer called Sliceable for hair, the scissors blade was set to cut only on a specific layer, Sliceable, so that the cut is applied only to the hair.

[Figure 7] shows the hair cutting process in a virtual hair salon. [Figure 7] (a) shows a 3D hair model generated by matching through the SURF method. [Figure 7] (b) shows the process of cutting the hair of the 3D hair model in [Figure 7] (a). In [Figure 7] (c), after the cut is finished, it can be observed that only the cut part of the hair is cut by comparing it to the blade of the scissors.

5. Conclusion

Hair styling has a great impact on human social perception. More and more people are learning hair styling and getting hair designer licenses. However, it takes a lot of money and time to learn professional hairstyles and beauty techniques for hairstyling. As face-to-face education is limited, beauty education has been also significantly affected. In this study, Since COVID-19, there has been a growing need for offline and video lectures due to the decline in onsite training opportunities. This study provides a field practice environment in which real hair beauty is performed in a virtual space. A virtual environment was implemented for designing a user's hair styling. First, the user's head area was separated by taking a picture of the user's face model, and the most similar hair model was found using SUFR. In this study, an experiment for SURF optimization was conducted. The matched hair model was mounted on the 3D face to reproduce the hairstyle. In addition, hair style interactions were implemented including cutting motion, hair auxiliary motion, and hair tool handling motion.

Acknowledgement

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