# Hair Reconstruction
# SJTU Computer Graphics Final Report

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**Abstract**—RD3 requires us to reconstruct a 3D hair model from a 2D photo. This technology has a great use in different fields such as hairstyle designing, photo distinguish and other ways. We divided this project into three pieces and use python and C++ to complete it. Our achievement has a good adaptability in different hairstyle. Our future work is increasing the accuracy of the match algorithm.

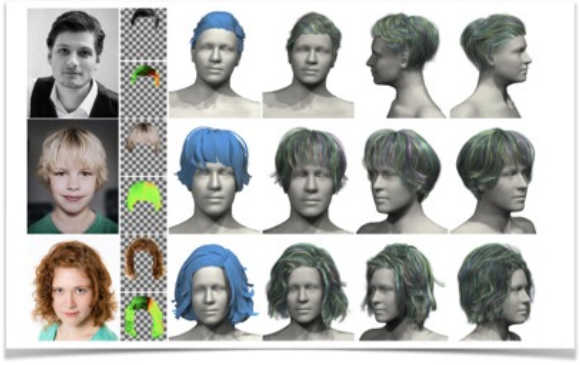
**Index Terms**—Computer Graphics, CS.

## 1 Introduction

This project named RD3 is about reconstructing a 3D hair model from a 2D image. We refered to the paper named AutoHairFully Automatic hair modeling from a single image. We diveded this project into three pieces.

First part is Expanding the database. Because our every datafile's format is 10000*100*3f, and every 100*3 float reprensts one hair. It contains of a cluster problem and a replace problem. About expanding the database we find three different ways to solve it. Second part is Getting the hair data from photo and Finding the best match in the database. We get the photo's all pixels and count the num of pixels in every area. In the refered paper, we find a great way named hair shade. Third part is Reconstructing hair model by using the data we find in the database. We can rotate the hair model in every angle so it looks like a 3D model.

However, there are still some work remain to finish. The realization of expanding database and increasing the accuracy of match still need to do.



## 2 Expand the database

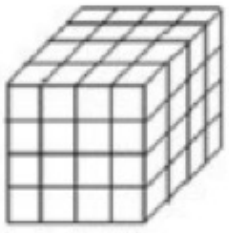
Our reconstruction work is based on the database. So it is necessary for us to figure out the compositions of the data in the database. According to the hints from dear assistant teacher and the trials done by us, we found each data includes 10000 hairs. Every one of these hairs is captured by 100 3-dimension dots. To make our reconstruction much exacter, we first want to expand our database. It is a work, which can be divided into two relatively simple tasks—a cluster problem and a replace problem.

### 2.1 Cluster problem

In order to do the replace problem better, we prefer to dividing the hairs first. In this scheme, we experience a quite long update process, from naïve to mature. We think it maybe useful for the readers too, so we present them here.

### 2.2 Divide according to the sphere

Think of that the shape comes from a cube. When we are going to divide the shape, it is easy for us to think about judging the region according to the sphere. So we first choose the 4*4*4 way just like the figure to cluster. Every dots we calculate its x, y, z and judge if it belongs to the sphere with the formula that x2¡x¡x1 and y2¡y¡y1. Finally, we get 64 different little cubes. However, when we use this to continue our work, we found that the dot in the cube could not match the other cubes very well. It is not only hard to show the dots belong to which hair but to make the image look suitable, it may wide-narrow-wide, which looks very strange.



### 2.3 Divide according to the plane

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THOUGH the strange seems occur in the height, if we do not change among the straight side, we just divide the plane the result may be better. So we choose the 4*4*1 way to get our results. But it still seems not so good, it is really well in the straight side, but a new problem stand out, the image may become shorthair-longhair-shorthair which is obviously could not fit people's common hair style. The problem holds up us until we come across the plan C

### 2.4 Divide according to the whole hair

TO be honest, we think of this from the first glance. Just as what you realize, this solution also has many obstacles.

#### *2.4.1 Idea*

FIRSTof all, how to capture a hair? A hair is located in a three dimensional sphere, it is hard to be describe by a traditional formula. What's more, how to describe the feature of each hair? The hair is composed of 100 random dots which feature could represent itself very well. Last but not least, what is the range between them? We do not have exact data that show the boarder between the hairs, so it is necessary for us to find out the judge range.

#### *2.4.2 Methods*

LUCKILY, we find the suitable solution at last. We first ascending dimension, now that the hairs have already in the three dimensional sphere we give up find the characteristic equation to capture them and just use the whole 100 dots as a description. We consider these dots as a 100 dimensional vector, because every hair has 100 dots so they are able to be compared between each other. Then we use the dimension reduction thought, consider the vector in a plane, use the classic thought that change the non-Euclidean question into Euclidean question. We calculate the Euclidean distance between two different hair to figure out their difference. The whole process is like the following. First we randomly get a hair as the center, then we ergodic the hair assemble, calculate the distance between them, if the result below x then it is classified in the same team, else if the distance is larger than the 2*x then it is picked as a new team and do this one turn by one turn until there is no single hair. In this way because of the failed control of x we may get several big teams, however after several trails the x is suit when it is 0.4.

### 2.5 Replace problem

WHEN we get the classified teams, it comes to the replacement, because we have already set a team center for each team, so the replace problem could be translate to the judgement between the team centers. Once we randomly pick a team from a data, which is different from the source one, we then calculate the range of it and find out weather it is conflict with the teams in the source data. We take out the teams with problems and ergodic each hair in the team to find if its distance with the picked team center is lower than the x. after doing all of this we could insert the picked team in to the data and generate a new data. Finally we could expand the database to a quite large scale.

## 3 GET DATA AND FIND BEST MATCH

THIS part consists of two parts. The first part is get data from a 2D image, transporting image data into digtal data. The second part is find the best match in the database.

### 3.1 Get digtal data

THE work we need to do is getting the digtal description of the image.

#### *3.1.1 Image handle*

AFTER given an person image, in this part, we need to know what's the hair look like in digtal. First we use PIL of python to get the RGB value of every pixels in the photo and change it into binaryzation photo. In the refered paper, it describes a method named hair model shade distance which means calculate every distance and find the minimum. The minimun distance is the best match. We simplify this method into count the num of pixels in hair area.

#### *3.1.2 Output data*

IN this section, first, we need to comfirm the hair area. In this case, we need find the max x,y index and min x,y index of the hair. However, because our algorithm is find all the pixels, so we can't distinguish the photo which the color of hair is similar to the color of cloth or other things. Our next step is find a more accurate algorithm to distinguish them. The range of pixels is very important, because the unaccurate diveded will lead to a big deviation. After find the all index we need, we divided this area into 16 pieces.(the more parts we diveded, the more accurate the method is) And then we count the pixels of black in 16 parts and output the count result into a file. So far, we have get the digtal data of the photo given to us. The next work we should to do is match every data file in the database.

### 3.2 Data match

SINCE we get the digtal data of the photo, the next step is using the datafile in the database. However, the data in the database is a 3D model and the digtal data we get from a photo is a 2D model. So we should transport the 3D data into 2D data in order to let the match make sense.

```
x_max= 0.317976
x_min= -0.320277
y_max= 1.96973
y_min= 0.929746
z_max= 0.287836
z_min= -0.273827
Program ended with exit code: 0
```

Fisrt we should find the max x,y,z index and min x,y,z index of all file. After find almost 400 file the range of x,y,z index, we diveded this space into 64(4*4*4) pieces. Because it need to transport into 2D data, so we ignored the y index so that make the data into 16 pieces and also count the num of points in every area. Second we calculate the delta of points amount in every parts and find the minimum delta in 400 files. We use the delta to replace the hair model shade distance and find the correct file.

```
open /Users/Fanzhedong/Desktop/hairstyles/strands00498.data failed!
open /Users/Fanzhedong/Desktop/hairstyles/strands00499.data failed!
open /Users/Fanzhedong/Desktop/hairstyles/strands00502.data failed!
open /Users/Fanzhedong/Desktop/hairstyles/strands00503.data failed!
open /Users/Fanzhedong/Desktop/hairstyles/strands00504.data failed!
open /Users/Fanzhedong/Desktop/hairstyles/strands00505.data failed!
open /Users/Fanzhedong/Desktop/hairstyles/strands00506.data failed!
open /Users/Fanzhedong/Desktop/hairstyles/strands00507.data failed!
open /Users/Fanzhedong/Desktop/hairstyles/strands00508.data failed!
min_dlt:= 434332
min_dlt_file:= /Users/Fanzhedong/Desktop/hairstyles/strands00372.data
Program ended with exit code: 0
```

## 4 RECONSTRUCT THE HAIRSTYLE

### 4.1 Choose the suitable program

CONSIDERING the large data processing and the ability to show graph, we choose pyopengl as our main paint program. Because of the database expending may lead to the change of the number of the hairs, we take the dynamic draw technology to do this job. During the realization of our program we learn the following things. First thing is the binary stream, because the database is always very big so it is always saved with binary stream. When we successfully read out the data, we are so excited. One more thing is the glut of opengl we used to try to do the camera visual angle which could make the user see the hairstyle from all perspective views. We make all the hairs with random colors so that we could figure out the hairstyle more clearly. With the help of this we could make the users know the most similarly hairstyle whenever and whatever they want.

Based on the realization of this technology, it is easy for the users to do the following three things. First, when someone saw a very fantasy hairstyle in the street and want to try it for himself. He could just take the photo of the guys and apply it to this program to find out the only hairstyle without the face. It can give the users more considerable thought before he really do something to his hair. What's more, if the users are hairdressers, he will be able to use this to find out whether the small change of the hairstyle could have a better show. Last but not least, with the development of this technology, one day we may just change our hairstyle.


## 5 CONCLUSION

In this project we use c++ and pyopengl to finish the task that recognize the hairstyle from 2-D image and show out the 3-D model based on the data in the database . What's more we proposed the algorithm about how to expand the database, and compared the differences between different solutions. It firmly indicate the accuracy of the basic idea in AI such as Dimension elevation before dimensionality reduction and Transforming the Non-Euclidean Problem into the Euclidean Problem. However, there is no doubt that we still have much room to improve, such as the accuracy of the hair recognition and the intricacy of our model. There is still a long way to go.

## REFERENCES

[1] Menglei. Chai and Tianjia. Shao., *AutoHair: Fully Automatic Hair modeling from A Single Image* , State Key Lab of CADCG, Zhejiang University.

**Zhedong Fan** In this project, I finish the part two, which is getting the data from the 2D Image and operating the data to find the best match. I also compose the powerpoint of the presentation and the final report. The cooperation of our group let this project can be finished well. I learn something about lamge operation and large scale data operation. I also learn a lot from this project and appreciate the help from teacher and TA.

**Zhiyu Lang** In this project, I finish the part one, designing the suitable algorithm and compare advantages and disadvantages between. I also finished the part three, drawing the hairstyle depend on the database. Last but not least, help team member do the relevant work, describing my own job. From this project, I know something about how to cluster and know much about the opengl, draw some pictures is not hard to me. Thanks for the help from teacher and TA very much.