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Automatic 3D wig Generation Method using FFD and Robotic Arm

Md Saifur Rahman[1], Chulhyung Choi[2], Young-pil Kim[3] and Sikyung Kim [4*]

[1, 2, 3, 4] Institution: Kongju National university, Computer Science and Engineering Department
#214 office, #8 engineering building,1223-24, Cheonan-daero, Seobuk-gu, Cheonan-si,
Chungcheongnam-do, 31080, republic of Korea.

[1]ORCID: 0000-0001-8345-0952 *[2]ORCID: 0000-0003-1186-9812*

[3]ORCID: 0000-0002-3232-4136 *[4]ORCID: 0000-0002-2635-9332 (*corresponding Author)*

Abstract

In this paper, a novel approach is proposed to generate an automatic 3D wig which can take place of the manual conventional system. To establish this approach, we used the robotic arm which takes seven landmark points used on FFD (Free form deformation) algorithm to produce human 3d shape from seven 3d landmarks points. Earlier most of the researcher made wig using the scanner and process it using various softwares. However, these methods are the long process to make the 3d wig and they could not take actual head shape because of hair. Our system works for the head with hair to give the original head shape. Only seven landmark points can make custom wig quickly and efficiently.

Keywords: ARM, FFD, Landmarks, Encoder, CORTEX

INTRODUCTION

EXPEDITIOUS evolution of computer graphics and computer vision, there is the number of software to make the 3d human dummy. There have been several studies about making of the 3D wig. Most common method is the 3d scanner scheme for scan head shape and needs the post-processing to make 3d wig [1]. However, the 3d scanner and this procedure take more time and it also expensive. Our proposed method is cheaper and effective way to make 3d wig without complex processing. Make 3d head from seven landmark points and split hair area for 3d head and make the 3d wig. Our approach can be summarized by these following steps.

- Measuring the seven landmark using the robotic arm
- The encoder moving and measure angle of robotic arm
- Synchronize with software
- Sensing seven landmark data
- Imposed FFD to match landmark data with standard head shape.

PROCEDURE FOR 3D WIG

Assemble of Robotic arm :

To take the seven landmark point we make robotic arm with four encoders and 32-bit arm cortex-m3 module. This module is connected to PC USB port to measures the seven landmark point. The four robotic arm's length is 115 mm(Arm1),170mm(arm2),275mm(Arm3) and 245mm(Arm4) which is shown in figure 1(a).The fourth (Arm4) robotic arm includes a button which is shown in figure1(a). Figure 1(a) X, Y view and Figure 1(b) Y, Z view of the robotic arms.However, creating the 3d wig seven point's location is important. As a result, the robotic arms separated into three axes. Encoder-4 rotated along the Z axis. Another three encoders rotate along Y and X axis. Using this rotation, the robotic arm can detect the three-dimensional position.

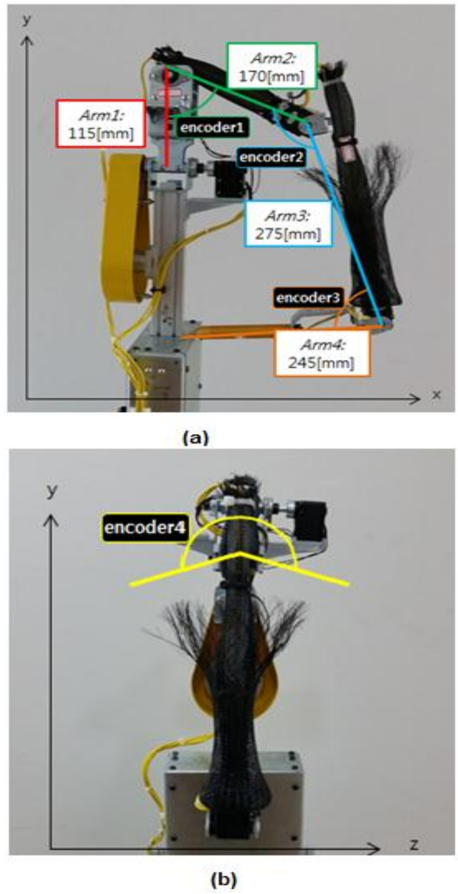

Figure 1(a) X, Y axis view of arm (b) Y, Z axis view of arm

3D head measurement algorithm :

The robotic arms are transformed into the Cartesian coordinate system according to their rotation direction which is shown on the right side of figure 2.Geometrical representation of the robotic arms shown on the left side of figure 2.

CASE: 1 in the lower right corner shows that the gamma (γ) angle is between 0 and 90 °.

CASE: 2 in the lower right is a situation where the gamma (γ) angle is between 90 and 180 Inverse kinematics is used in the Cartesian coordinate system shown on the right to calculate the position information of the end effect of the 3D head measuring instrument using 'α', 'β', 'γ' and 'δ' measured by the sensor (MX-12W).

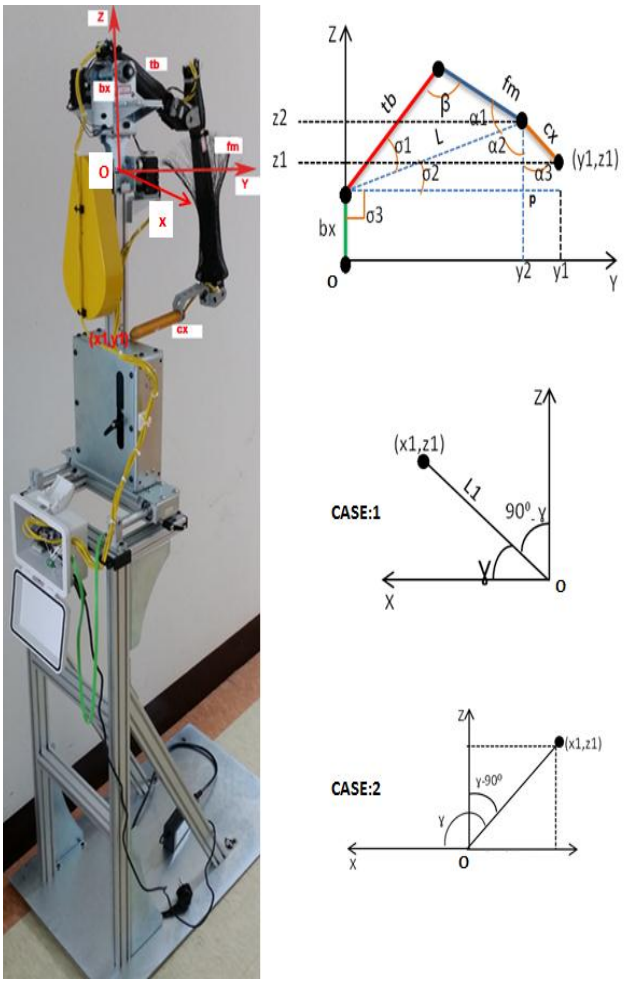

Figure 2 3D head position measurement

The parameters in figure 2 can be expressed

$$L=\sqrt{tb^2+fm^2-2\times tb\times fm\times cos\beta} \ldots\ldots\ldots (1)$$

$$\delta1=acos(\frac{L^2+tb^2-fm^2}{2\times L\times tb})\ldots\ldots(2)$$

$$\delta3=(\frac{\delta-\delta1+90^0}{2})\ldots\ldots(3)$$

$$\delta2=(\delta3-90^0)\ldots\ldots(4)$$

$$\alpha1=acos(\frac{L^2+fm^2-tb^2}{2\times L\times fm})\ldots\ldots(5)$$

$$\alpha2=(180^0-\delta2-90^0)\ldots\ldots(6)$$

$$\alpha3=(\alpha-\alpha1-\alpha2)\ldots\ldots(7)$$

$$y2=L\times cos(\delta2)\ldots\ldots(8)$$

$$P=L\times cos(\alpha2)\ldots\ldots(9)$$

$$z2=p+bx\ldots\ldots(10)$$

$$z1=z2-cx\times cos(\alpha3)\ldots\ldots(11)$$

$$x1=z1\times tan(90^0-\gamma)\ (case:1)\ldots\ldots(12)$$

$$x1=z1\times tan(\gamma-90^0)\ (case:2)\ldots\ldots(12)$$

bx=first arm length
tb= second arm length
fm= third arm length
cx=fourth arm length
Joint angle α, β, γ ,δ sensing from decoder

Arm Synchronizing with software:

For visualisation, we have developed the visuality software based on the processing tool [2] and synchronized with robotic arms shown in figure 3.

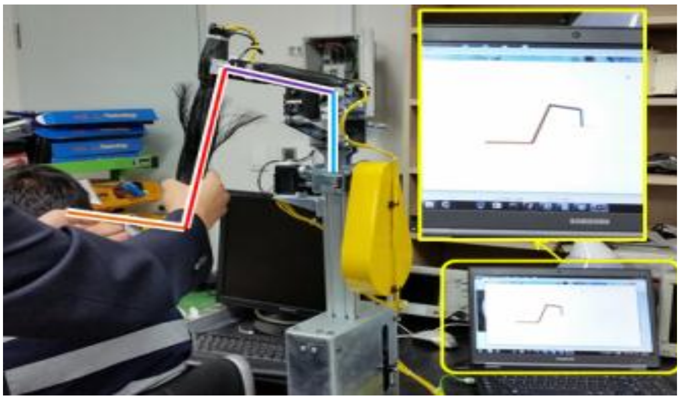

Figure 3 Hardware and software synchronization

Ideal head points length :

We select seven landmark points based on the ideal human head shape which is shown in figure 4.

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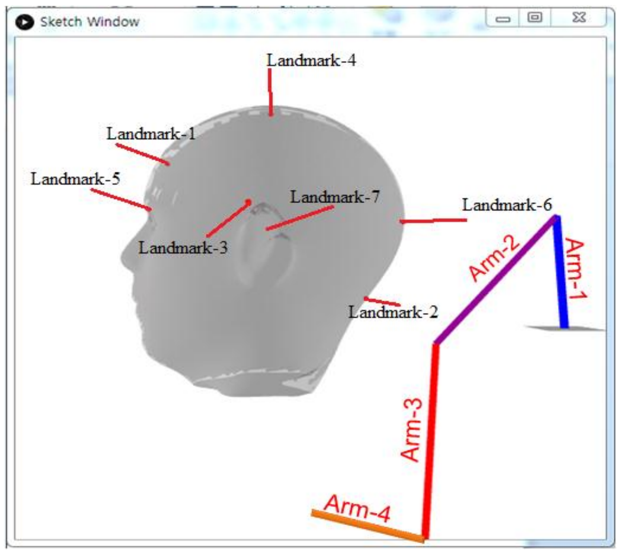


Figure 4 Seven landmark points setup based on human ideal head

Ideal seven head landmarks length which is found from analytical analysis of human head.

- Head circumference,
- The head of the head, the back of the head (ho) length,
- Head marble between ear beads (arcs) Length,
- Head of floor _ Left ear ball point Vertical length,
- Left eyeball posterior head protruding horizontal length,
- Width between ears bars (wrong picture above length of horizontal line penetrating between ear buds)

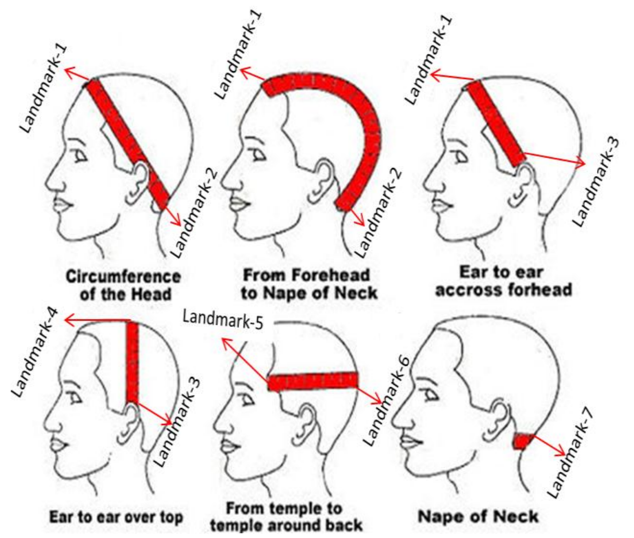


Figure 5 Seven ideal head landmarks length

These seven landmark points lengths change over the age and deform human head shape [3] shown in Figure 5.

Table: 1: data show six ideal distances for human head based on age.

Points	40 years old(length in mm)	50 years old(length in mm)	60 years old(length in mm)
1	540	540	540
2	263	263	263
3	344	344	344
4	129	129	129
5	169	169	169
6	118	118	118

Table 1 present ideal length of six points according to the age of Korean people head shape after statistical analysis.

Free Form Deformation :

In computer graphics, free form deformation has the great impact for 3d mesh designing. Our aim to generate 3d wig for different head based on ideal head shape. The ideal shape of the head needs to deform according to the individual head shape. There are many studies about free form deformation. Multi-resolution shape deformations for meshes with dynamic vertex connectivity [3], recursive B-spine surface [4] and another method. Coquillart technique [4] uses the arbitrary curve for blending existing shape of the surface. In our studies, we use 64 local control point and match with 3d mesh object using Bernstein polynomial equation.

$$\nu = [1, 2, 3, \ldots\ldots\ldots\ldots\ldots, n]$$

=1xN original vertex array

Using processing IDE mapping [6] function scales original vertex values and bound into 0 and 1. Øi,j=

is a 4×4×4=64 control point for control the deformation mesh. u,t,s is a parameterized of original vertex value x,y,z. **v'** is the new vertex of deform mesh based on control points.

$$\nu' = \sum^{n_u} \sum^{n_t} \sum^{n_s} B_i^{n_u}(u) B_j^{n_t}(t) B_r^{n_s}(s) \phi_{i,}$$

EXPERIMENTS AND RESULTS

In our experiments, we take seven control points and set within the ideal head shape shown in Figure 6. For 3d wig generation, no need concentrate about face. In this study, a robotic arm senses real time seven landmark points for the human head. Then apply FFD (Free from deformation) to create custom wig shape based on seven landmark points shown in Figure 7.

$$\Delta\phi_{x,y,z} = \kappa(\eta_{x,y,z} - \phi_{x,y,z})$$

$$\phi_{x,y,z} = \phi_{x,y,z} + \Delta\phi_{x,y,z}$$

The control points value increase and decreases based on the following equation for the match with sensing landmark points. Here ǿx,y,z Control point, Ꝁ=p gain value, ɳx,y,z = sensing landmark points coming from the robotic arm.

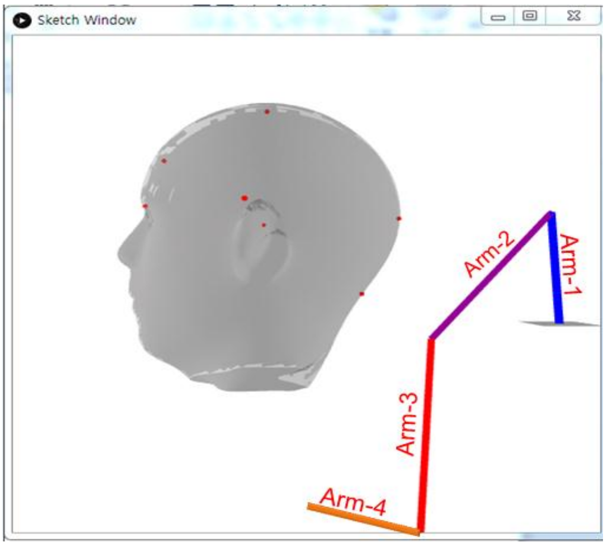


Figure 6 seven control points for backside of a standard head shape

Number equations consecutively with equation numbers in

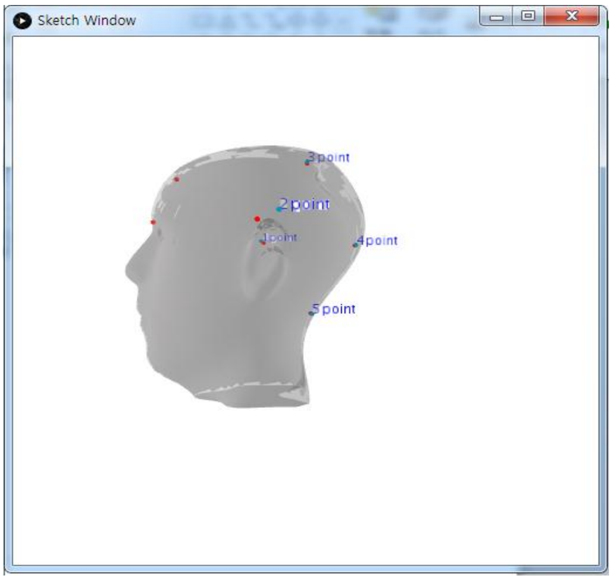


Figure 7 after deformation based on seven landmark points

In Figure 8 illustrated different deformation of standard head shape according to the sensing landmark points.

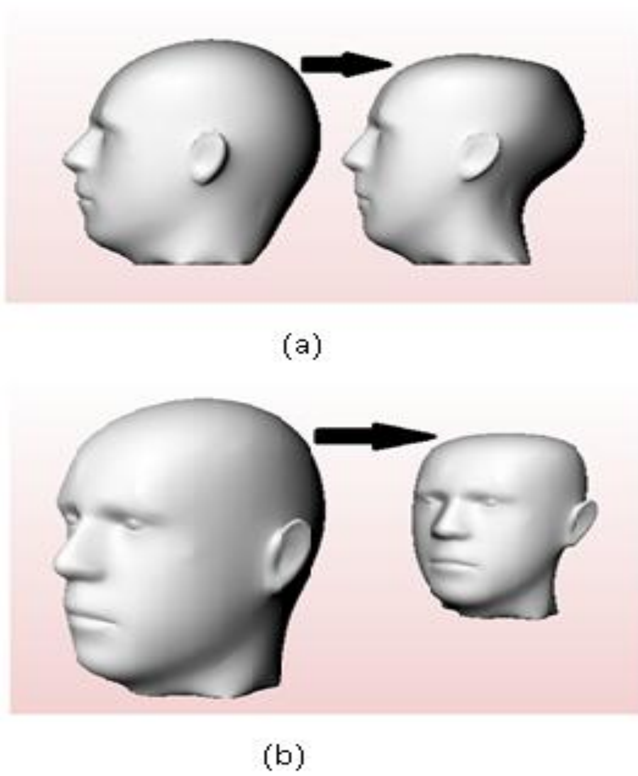
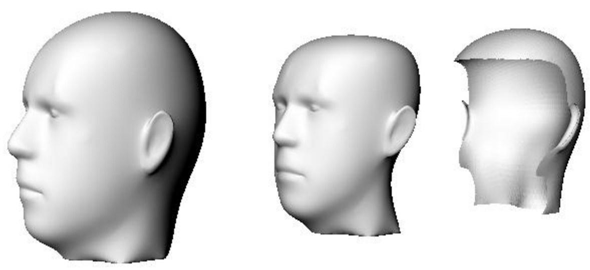


Figure 8 (a) Deform head based on 5th landmark point (b) Deform head based on 3rd landmark point

3.1 3D WIG SHAPE GENERATION

In this research, robotic arm scan real human head shape and deform standard head shape (fig a) into real human head shape (Fig b). After deforming the standard head shape, Rhino software makes wig shape by subtracting the scan and standard head shape (Fig c). Figure c shows that actual 3d wig shape of the customer.



(a) (b) (c)

Figure 9 (a) standard head shape, (b) deform head shape based on sensing data, (c) After subtract deform shape from standard shape using Rhino software.

Many scientists have applied a lot of ways to make a wig, which is time-consuming. Moreover, these methods can not make proper wig shape due to hair.However, in this study, there is no expensive method implemented. This research can be done by any of the head surface measures by the scanner, which is impossible.This method can make 3d wig using only seven landmark points, which is very convenient.

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