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Lightweight 3D Modeling Systems in Mobile Camera Environments

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Abstract

Recently 3D-related technology has become a major topic in IT. This work has the goal to the public easily exposed to 3D technology. We have developed an application to obtain a 3D modeling results as smartphones picture. The user can be modeled on their face to 3D without any special equipment from anywhere by using a mobile camera. This work can be used molding sector, production figures, facial restoration etc. When a more advanced future technologies, as well as 3D modeling enables face of things, it seems to be applicable in many areas

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Keywords*: 3D Modeling, Mobile Camera, Image-processing, Virtual Reality*

1. Introduction

3D modeling technology has been utilized in various fields such as aerospace, defense, military, medical. NASA was actively introduced in the 3D printing technology for parts procurement of the International Space Station (ISS), The Lego plans to introduce this technology to custom-brick, the production figures. Areas that use 3D printing technology will increasingly grow [1].

Despite these advantages, it is not easy to commonly found in the around. Because 3D printers are expensive, 3D modeling tool is difficult to use.

Therefore we would like to implement 3D modeling using an easy to use mobile camera so that the user can experience a lot of 3D printing technology in various fields. We need a face photograph taken by the mobile camera. Our system gets the information needed to generate 3D coordinates for each picture using the ASM [2-4] and skin binary technique [5-6]. This information may change the standard face model.

The photograph of the face detection control point generates a texture image with RBF interpolation [7-8]. The resulting 3D model and the user's face image may determine the 3D modeling results in a web browser.

2. Related Work

2.1. Corresponding Feature-Based 3D Face Modeling

Three-dimensional (3D) face modeling is a challenging topic in computer graphics and computer vision. Unlike 2D face models, 3D face models can realistically express face deformation and pose variation with depth information. With these advantages, 3D face models have been applied to various applications, including movies, 3D animation and telecommunications [9-10]. Three dimensional modeling systems can be categorized into active and passive vision systems [11]. An active vision system calculates 3D information by measuring a beam of light radiated from an external device such as a beam projector or laser. The typical 3D face modeling method using an active vision system constructs a 3D face mesh using a captured 3D point cloud [12–15].

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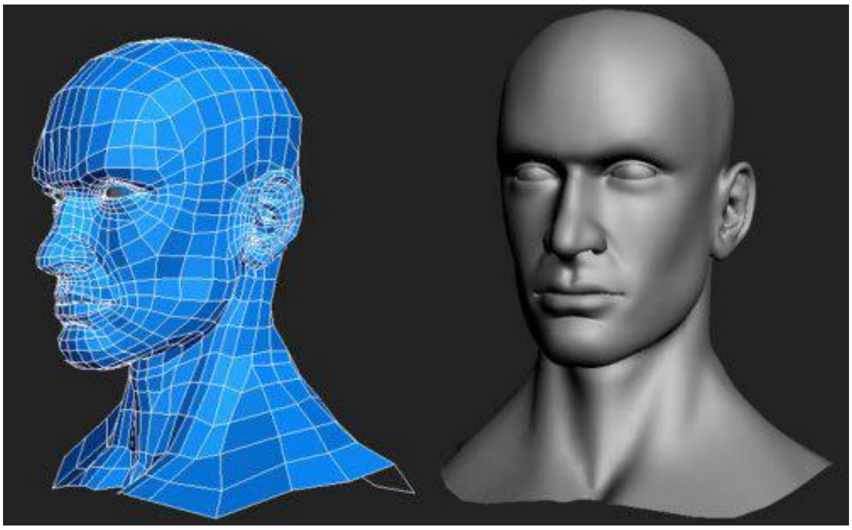

Figure 1. 3D Face Mesh

In such systems, a 3D laser scanner or calibrated stereo camera with structured light can be used to capture 3D coordinates and texture information. While these methods are highly accurate, they are also time consuming, and the necessary equipment is expensive. Nowadays, the passive vision-based 3D modeling system is preferred for human faces because the glare from light-emitting devices can be unpleasant for the users. Passive vision-based system means a system that needs no light-emitting devices and estimates 3D information from 2D images. In passive vision-based 3D face modeling, 3D information can be calculated by analyzing camera geometry from corresponding features in multiple views [16] or adjusting the statistical 3D face model to captured facial images. For convenience, we call the former the corresponding feature-based 3D face modeling method and the latter the statistical model-based 3D face modeling method. Among the 3D face modeling methods using the passive vision system, the most commonly used one is the corresponding feature-based 3D face modeling method. This method is less computationally expensive because it uses only a few feature points to generate a 3D facial shape. Additionally, this method can generate highly accurate 3D facial shapes by using real 3D information calculated from the camera geometry. However, the accuracy of the 3D facial shapes declines rapidly if the extracted locations of the corresponding points are not exact. This problem should be solved to apply to automatic 3D modeling system because even excellent feature extraction techniques such as the active appearance model (AAM) and the active shape model (ASM) can produce erroneous feature extraction results for indistinct parts of the face.

2.2. Statistical Model-Based 3D Face Modeling

In 3D face modeling using statistical model, the 3D morphable face model suggested by Blanz and Vetter [14] is the most well-known. To generate a 3D morphable face model, they construct a database including the 3D coordinates and skin texture from a real human face captured by a 3D laser scanner. Then, statistical analysis is carried out to determine control parameters for the 3D face shape and skin texture deformation. During the modeling procedure, the model parameters are iteratively adjusted in order to fit the model to the input image. This gives remarkably realistic results, but the computational cost is very high. To improve the speed, researchers have proposed 3D face modeling methods using a single-view image. Kuo et al. [15, 16] proposed a method to synthesize a lateral face from a single frontal-view image. They construct a facial image database containing both frontal and lateral views and then define anthropometric parameters that represent the distance between two features manually extracted by anthropometric definition. In the modeling stage, they estimate the lateral facial parameters from the input frontal image using the relationship between the frontal and lateral facial parameters.

Baek et al. [17] suggested an anthropometry-based 3D face modeling technique. They built a database after measuring anthropometric information from anatomically meaningful 3D points among a 3D point cloud captured by a 3D laser scanner. Then, they created a statistical model to control the overall 3D face shape after statistical analysis of the database. This method is much faster than the 3D morphable face model, but the depth estimation results are sensitive to head poses, which may result in inaccurate distance measurement between landmarks. Importantly, this approach is also limited to the reconstruction of frontal views.

2.3. FaceGen

FaceGen is a 3D face-generating 3D modeling middleware produced by Singular Inversions. It is used where there is a need for a large number of different possible faces, either at random or from photographs. FaceGen shows the results of a 3D model upload a photograph of the face and give points to hold only the contours of the face. For the three-dimensional modeling it requires a total of three pictures, but it is possible to get results even if only the front picture.

Because the user is required to pay a lot of cost to use the FaceGen, there is a stress of the user purchased. Since the deployment of the trial in FaceGen website, you can simply model a 3D face and then save it to your computer as an image file. However, there is inconvenience that the user upload pictures and give yourself a certain point.

Figure 2. FaceGen Service

2.4. Virtual Plastic Applications

Virtual cosmetic surgery application has been serviced by one plastic surgery in the Korea. Recently, people imagine their own virtual cosmetic appearance. Among people who also can implement themselves a virtual cosmetic using Photoshop. But it takes a lot of time when using Photoshop.

If people cannot easily deal with by Photoshop it is difficult to experience the virtual molding. Plastic Surgery in Korea solves the above problem in mobile applications. They implement a 3D face model within a short time 2D-to-face photograph of the guests. They are providing a virtual cosmetic capabilities by implementing the eyes, nose, or mouth. Although this is the advantage of being able to predict the appearance after their cosmetic, modeling results are not accurate, there is a problem shown as if the avatar.

Figure 3. Virtual Plastic Application

3. 3D Modeling using a Mobile Camera

The user taking a face into front and two side angle. You may select a front and side pictures stored in the PC.

Pictures are stored in the database of the server, when the server detects that an image signal to be processed arrive in the database under the photograph sent by accessing the database executes the image processing function.

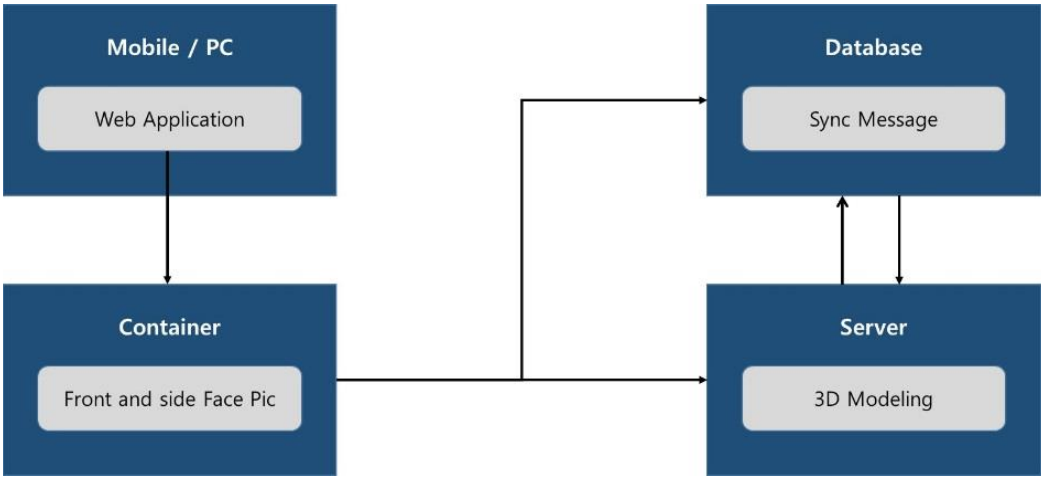

Figure 3. Structure of 3D Modeler

When you run the image processing functions, 3D modeling module extracts 77 facial features from the front Photo by ASM algorithm. And modeling module gets information about the height of the side face using a binary method in terms of skin color photos.

The combined information from two pictures produce a three-dimensional coordinates and using the RBF interpolation of the resulting coordinate transform the standard face model. Save a modified face model to the database, and can see a 3D model is sent to the user.

3.1. ASM (Active Shape Model) Algorithm

This system is the most important in the process of converting a 2D image into a 3D image of the face. Therefore, the percentage that we can accurately detect the face closely associated with the quality of work. In the first production process, we wrote the source code manually to find characteristic point of the face. Eventually, we used a modified algorithm ASM (Active Shape Model) for better detection face.

ASM is a model algorithm techniques to find the point spread distribution of the image of a specific point on the input image to the area best (point distribution model).

The initial form of the model is set as the human face, and by applying to the front picture obtained from the user was taken feature points of the face. The resulting feature points of ASM appear each point representing a total of 77 pieces in a unique position to face. The above table is shown by clustering the feature points of each specific location.

Table 1. 77 Pieces in a Unique Position to Face

Component	Feature point number
Face type (include chin, forehead)	No. 0 – 15
Left eyebrow	No. 22 – 27
Right eyebrow	No. 16 – 21
Lift eye	No. 29 – 39
Right eye	No. 28, 40 – 47
Nose	No. 48 – 58
Mouth	No. 59 – 76

3.2. ASM (Active Shape Model) Algorithm

The 3D image is used to coordinate consisting of three axes. But if you use a single sheet of 2D images the, you cannot be obtained only two-dimensional information area Height information in the image from the side picture can solve the z-axis information. The Side facial skin is detected by take advantage of the video edge detection and binary image from a picture. We were designed to be easily measured by calculating the necessary reference points to calculate the height of the sides at the highest point of the nose.

3.3. RBF (Radial Basis Function) Interpolation

$$\overline{u} = T(\overline{x}) = [f_1(x), f_2(y), f_3(z)],$$

$$f_k(\overline{x}) = \sum_{i=1}^{n} A_{ik}\phi(r_i),$$

$$\phi(r_i) = e^{(-r_i^2/\sigma)},$$

$$r_i = [(x-x_i)^2 + (y-y_i)^2 + (z-z_i)]^2$$

f is a function that represents the displacement of each axis from the initial vertex to the goal vertex, A is the weight, e is a parameter, and x, y, z of the three-dimensional feature points coordinates of each axis control point is obtained from the 2D image. We are seeking to start a weight information and information purposes and objects of the control points to adjust the parameters, it is possible to obtain the formula for the standard model's face.

3.4. Extract Feature Points of Face

```
<OpenCV>
CVAPI(CvMat*) cvGetAffineTransform ()
CVAPI(void) cvWarpAffine ()
```

Texture maps in the standard face model has a fixed coordinate. Accordingly, it generated using a matrix corresponding to the feature points of the face picture to the coordinates of the texture map is set.

In order to smoothly perform this task we were used *cvGetAffineTransform()* function and *cvWarpAffine()* function of OpenCV.

cvGetAffineTransform is makes the transformation matrix as the parameters of the point and vertices of the original image object image. *cvWarpAffine* maps the frontal photos to texture maps using this matrix.

- Extracting feature points and the height of the face

The photo above shows the result of the will of 77 detects facial features ASM leverages algorithms from the front picture, the picture below shows the results by utilizing the height of the side skin and the binary edge detection techniques from the side pictures.

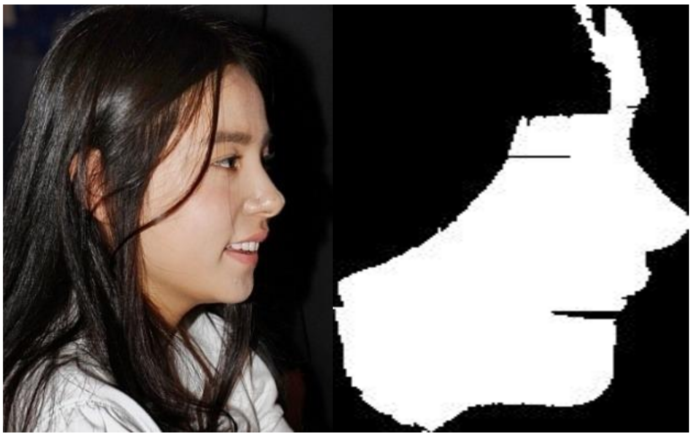

Figure 4. Extract Feature Points

- Variant of the standard face model

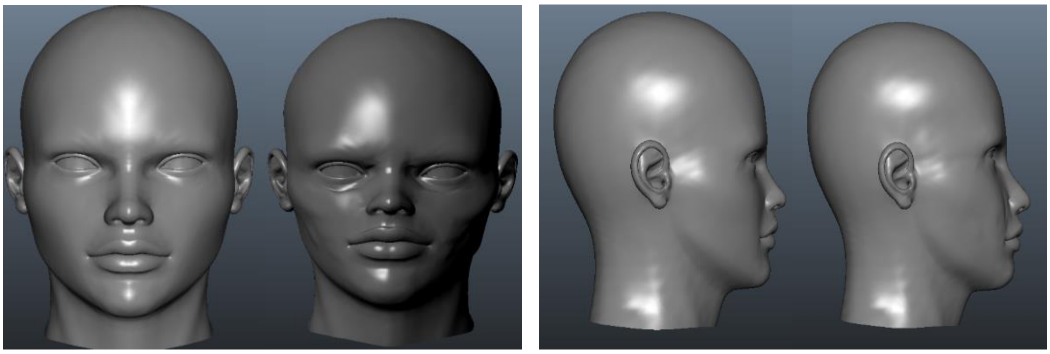

Figure 5. Standard Face Model

Deformation of the model to generate a three-dimensional coordinate values of the feature points by using the elevator and the front side picture of picture and converts the standard face model to the face using the RBF interpolation type of picture.

3.5. User Interface

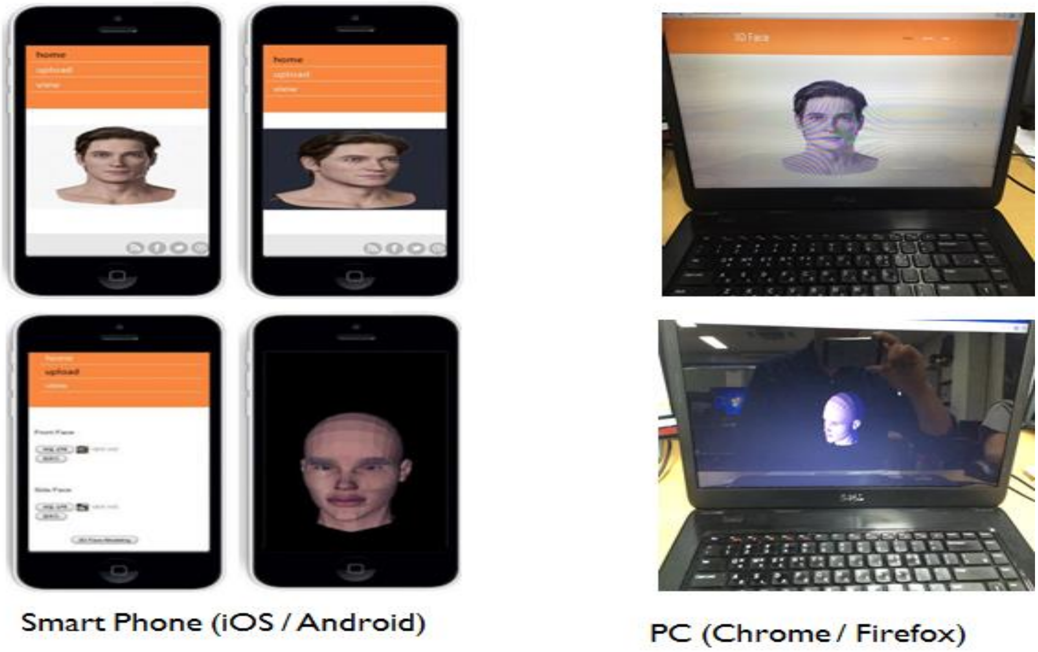

Figure 6. System User Interface

The user connects to the system is transmitted to the front side picture of a person.

Because we created a system to OpenCV and WebGL, people can easily access in a mobile environment.

6. Conclusion

This work implements 3D modeling using only the mobile camera without special devices. This system differs from conventional 3D modeling and the public could not easily accessible because the equipment is expensive and requires a high degree of difficulty. Our system gets the information needed to generate 3D coordinates for each picture using the ASM and skin binary technique. This information may change the standard face model. This work can be used molding sector, production figures, facial restoration etc.

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