VS: Facial Sculpting in the Virtual World

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Abstract

Facial recognition systems, one of the fastest growing biometric technologies today, require the development of new quality assurance and assessment procedures on their performances for national and personal security. Recent progress on Virtual Reality (VR) has introduced a great number of techniques to generate realistic facial models in order to develop a database for face identification and recognition purposes. In this paper, we describe a framework which integrates VR tools to traditional facial modeling process. Such framework does not only give more freedom to the sculptors, but also the potential to create a more comprehensive facial database for further facial recognition.

Key words: Geometry Construction Deformation, Gesture Recognition, and Virtual Environment

1. Introduction

The lack of appropriate face database is one of the major problems to experimental validation and 3D face recognition as stated by Bowyer et al. [1]. The significance of this research project is the exploration of a new methodology to integrate 2D and 3D face data for modeling the generic face of an individual. The experimental and theoretical work in this project is expected to lead to useful discoveries in the implementation of intelligent facial modeling interfaces.

A major research problem in computer graphics area is the development and manipulation of complex 3D objects. Recent progress has enabled forensic artists to generate 3D objects in a virtual space. Compared to commercial 3D modeling systems such as 3DMAX and SoftImage, a virtual sculpting system is more flexible. Users are more likely to be confused by a great number of buttons and hotkeys in a commercial 3D modeling system. Moreover, users have to follow specific modeling procedure such as: select->edit->render. In a virtual sculpting system, users are not restricted by menus and buttons, instead, they are provided with a set of virtual brushes and chisels. In virtual sculpting, there are only two basic operations involved: cut and paste. Given a list of basic shapes, users can generate 3D objects much faster than in a commercial 3D modeling system. Therefore, sculpting can be regarded as a more efficient and effective design method for 3D modeling [2].

Section 2 will be review of related work on virtual sculpting. In section 3, 4, 5 and 6, we will propose two models which describe the framework and implementation of a virtual face sculpting system.

2. Related Work

The first effort on virtual sculpting can be traced back to late 70's. Parent [2] proposed a system which was capable of sculpting 3D-data. The significant problem solved within the system was hidden-line elimination by choosing planar polyhedral representation. The deficiency of the system was the hardware acceleration. That affected the real-time performance of the system.

Parry [3] forwarded a system developed

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by constructive solid geometry (CSG) [4]. Satisfactory results were derived from the system. However, the system took traditional devices such as mice and keyboards as input medium. The system can only carry out a number of simple sculpting tasks.

Coquillart [5] developed a system which extended 3D free-form deformation [6] by sculpting. The system was based on 3D lattice regular free-form deformation. Compared to Parry's system, 3D lattice free-form deformation was more capable of generating arbitrarily shaped objects.

Mizuno et al [7] built up a system for virtual sculpting and virtual woodblock printing by carving a workpiece in the virtual world. This was efficient as a technique based on CSG. The system synthesized non-photorealistic images.

Non-uniform rational b-spline (NURB) [9] deformation was introduced to Lau's Vsculpt system [8] with the integration of CyberGloves. The users could generate arbitrary-shaped objects by manipulating a number of control points. However, users had to learn the parametric control on the points. Therefore, the proposed system was not dedicated to ordinary forensic artists.

Haptic displace map was defined to represent model local features as a displacement of a surface of a coarse mesh [10]. It was applied to Jagnow's and Dorsey's system [10] to process the graphics data in an efficient manner. Models could be described by a series of partitioned local slabs, each one of which represented a vector field. The complexity of the visual scene was not affected by the efficient interactions among the local slabs. However, haptic displacement map did not apply to the scenes that change frequently.

From the literature, we can conclude that there have been two types of research foci on virtual sculpting: usability studies and graphics methodologies.

3. Overview of Facial Sculpting in the Virtual World

Our interactive sculpting system is composed of five modules (Fig 1).

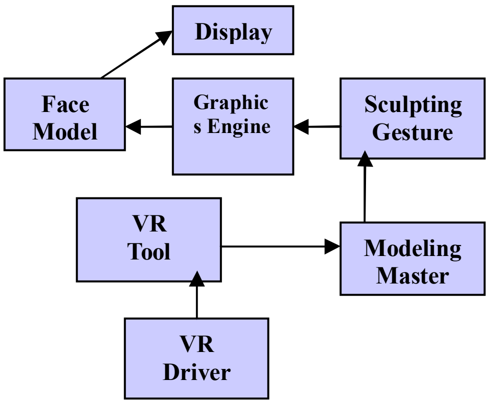

Figure 1. A system for virtual face sculpting

The face model module functions as a 3D face database. It can manage face data by grouping different expressions on the same face and providing resultant face data to modeling master through a display.

The hand gesture module creates gesture histograms for sculpting poses and gestures. It provides respective gesture to the graphics engine so that graphics engine can manipulate the face via sculpting.

Face model and sculpting gesture constitute the non-physical linguistic part of the system.

The graphics engine is the core of the proposed system. It receives the information from all of the others, processes such information and sends the results back to the destination module so as to trigger certain deformation actions. A sample procedure for modeling a face would be it receives hand gestures from VR tools and sends them to hand gesture module. The corresponding gesture would be retrieved from hand gesture module for applying sculpting gesture to generic faces to create a face. The resultant face will be shown by the face model module via display.

The VR tool and VR driver modules constitute the physical part of the proposed system. The VR tools are used in this project are data 5DT gloves

For the graphics engine, it processes the entire finger movements detected by hardware drivers and collaborate with the graphics library to send the bundled information to create a face model. Therefore, a complete record of a hand gesture can be sent to modeling master rather than sending it piece by piece. The problem here is the real-time rendering,

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because it takes a while for the graphics engine to bundle such information. However, the time slice spent on a complete hand gesture can be much more economic compared to collecting a set of incomplete sculpting gestures.

4. Overview of Implementation Model

Our implementation model consists of six modules: Python, VPython, Texture Loader, 3D Model Loader, 3D Model Exporter and Face Mesh Sculpting.

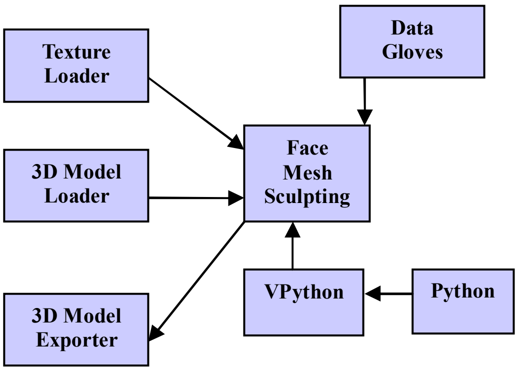

Figure 2. Implementation for virtual face sculpting

Python compiler is the foundation that the virtual sculpting system is running on. It is a dynamic Object-oriented programming language. It can integrate with other languages and a variety of tools [11].

Vpython [12] is an extension to Python based on OpenGL and it is capable of providing a variety of graphics mechanisms to the application. For example, VPython supports stereoscopic effect which leads to the depth information of the virtual sculptures.

We integrate texture loader and model loader separately for the sake of face model synthesis. Real world sculpting does not include any texture mapping. To give more information to the sculptures, we introduce texture loader which contains the details of the sculpture's skin. Based on ethnic, gender and age background, sculptures will be mapped with specific textures. The model writer mimics face database

Data gloves act as a receptor of sculpting gestures and transfer to the sculpting application.

Sculpting is the main program that communicates with all of the other components.

5. Implementation of texture loader and 3D model loader

Vpython does not include any library for loading complex 3D objects such as facial models; therefore, we implemented a texture and a model loader. The format of models we used was 3DSMAX (3DS). 3DS models contain the position information of model vertices as well as the relationship between them [13]. The following figure describes the structure of a typical 3DS model.

Meaning	Data
MAIN 3D CHUNK	0x4D4D
EDITOR CHUNK	0x3D3D
OBJECT BLOCK	0x4000
TRIANGULAR MESH	0x4100
VERTICES LIST	0x4110
FACES DESCRIPTION	0x4120
FACES ATERIAL	0x4130
MAPPING COORDINATE LIST	0x4140
SMOOTHING GROUP LIST	0x4150
LOCAL COORDINATES SYSTEM	0x4160
LIGHT	0x4600
SPOTLIGHT	0x4610
CAMERA	0x4700
MATERIAL BLOCK	0xAFFF
MATERIAL NAME	0xA000
AMBIENT COLOR	0xA010
DIFFUSE COLOR	0xA020
SPECULAR COLOR	0xA030
TEXTURE MAP 1	0xA200
BUMP MAP	0xA230
REFLECTION MAP	0xA220
[SUB CHUNKS FOR EACH MAP]	
MAPPING FILENAME	0xA300
MAPPING PARAMETERS	0xA351
KEYFRAMER CHUNK	0xB000
MESH INFORMATION BLOCK	0xB002
SPOT LIGHT INFORMATION BLOCK	0xB007
FRAMES (START AND END)	0xB008
OBJECT NAME	0xB010
OBJECT PIVOT POINT	0xB013
POSITION TRACK	0xB020
ROTATION TRACK	0xB021
SCALE TRACK	0xB022
HIERARCHY POSITION	0xB030

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Figure 3: 3DS File Structure

Here is how we load and export a 3DS model:
-load the whol model in using file input/oupt;
-read the chunk_id and the chunk_length each iteration of the loop;
-determine the content of the chunk_id;
-if the chunk allows us to reach another chunk that we need, or it contains data that we need, then we read its data if needed, and then move to the next chunk;
-when we reach the chunk we need, store the chunk in a graphics pipeline and search for the next chunk;
-when we reach the end of the model, render the scene by rendering the graphics pipeline.

Similar method was applied to texture loader and it can be found at [13].

6. Face Mesh Sculpting

There are two basic operations for face mesh sculpting: push and pull. The method we introduced here is based on extrusion along normalization.

Data gloves worn by the user can select the vertices for extrusion. The normal vector which is determined by the selected vertices (constitutes a face mesh) using cross product [15]. Extrusion along the movement of data gloves can realize the growing or shrinking effects of the face meshes. There is one problem here: the smoothness of the resultant face mesh. Our method to solve this problem is to rotate about the normal point as a center and the surrounding vertices about the selected vertices as the radius to sculpt a bump with a fall of on the mesh which was introduced by Blender 2.4 [14]. The following screenshot was taken from [14] as an example.

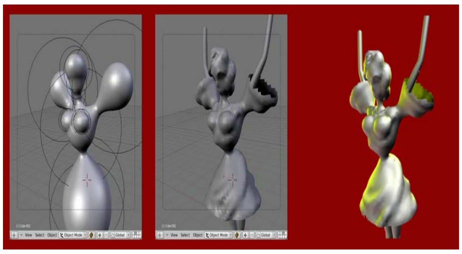

Figure 4: Mesh Sculpting [14]

7. Discussion

One important objective of this research is to relate virtual face sculpting to face recognition. There are two reasons to that:

Firstly, virtual face sculpting can provide an intuitive interface to face modelling. Most of the previous virtual sculpting systems took mice or keyboards as input medium. Recent progress on VR technology has enabled us to capture more accurate and real-time motion information [14] and transfer such information between the user and virtual face models. During actual practice, sculpting is carried out by human hands. So we can take the advantage of VR by wearing a pair of data gloves and a couple of motion sensors to detect and transfer the information of sculpting gesture to the virtual faces.

Secondly, our future plan is to focus on the facial expression sculpting. Facial expression is a significant problem in face recognition research area [17]. Facial expressions can be applied on facial models via sculpting. We have a hypothesis that there exist factors to determine expressions. By the analysis of the face features with different expressions, we can deduce the factors that constitute different expressions and parameterize such factors. By studying the transformation pattern among facial expressions and changing the facial appearances correspondingly, we can possibly expand a face database with various expressions. This will be our future research problem and will be conducted shortly.

8. Future Plan

We have proposed the framework for a virtual face sculpting system. We have not tested the usability of it. The other research problem is the face mesh sculpting method. Compared to other material, face skin is a multi-layer tissue system. There are three layers involved in the face skin, which are described in [16]. Our future plan is to improve our current sculpting method by introducing neural networks to deduce the relations between facial tissues from different layers.

9. Conclusion

In this paper, we describe the framework to implement a virtual face sculpting system and the potential of relating the system to further face recognition applications.

The system was founded on Python by integrating VR tools, 3D model loader, exporter and texture loader. We applied the techniques as introduced by Blender Organization [15] for mesh deformation and rendering.

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