CHAPTER 1

INTRODUCTION

Caricature is a kind of humorous or sarcastic drawing. It is often carried on magazines or newspapers to illustrate political events or news occurred recently. Additionally, a caricatured portrait is also an interesting and popular artistic creation nowadays. At lots of famous scenic spots we can see many caricaturists drawing for visitors as a souvenir. As a satire drawing, it attempts to maintain fidelity with a bit of exaggeration to make it more impressive. A good work is able to bring viewers a vivid impression and touches off their response immediately, as experienced artists can often capture and emphasize unique characteristics of models then depict them with simple but powerful strokes. An example portraying the caricature of Mr. Katsuhiko is shown in Fig.1-1.[1]

3D caricature works are also commonly seen in our daily life. For example, increasing numbers of the sculptures of celebrities are sold in the market. Personalized portraiture design is also available, and has become increasingly popular recently. These works are referred to as “solid caricatures”. When someone asks for a personal sculpture service, pictures with different viewing angles are often requested before production. Creators observe the characteristics from these images and exaggerate features by their experience and sense. Some of these works combine special theme (such as Fig. 1-2[19]) to make it more attractive. Moreover, works such as models for pre-rendering computer graphics or animation can also be considered as the applications of 3D caricature.

Fig. 1-1: Illustration of Mr. Katsuhiko Yoshida [1]

Fig. 1-2: A personal portraiture with theme service

Simulating human's abilities has always been the core of computer science, and an interesting topic is automatic painting generation. Recently, Non-Photorealistic Rendering (NPR) has gained much attention. In contrast to photorealistic rendering which concerns fidelity, NPR leans toward the illustration of overall impressions. Artistic NPR creations can be comical, such as cartoons, or elegant, like oil-paintings. As a result, a great variety of methods exist for creating NPR images. Generating drawing with artistic styles by simulating human's stroke, NPR algorithms enable people without prominent talents in art to create a work with similar effects. With the advancement of hardware in the past decades, many NPR algorithms have been introduced. Some of them deal with static images. Some are designed for dynamic scenes. Both 2D and 3D cases have been investigated.

1.1 Objective

Hardware of personal computer has progressed at an astonishing pace. It is hard to imagine that programs once only run on high-end graphic workstations are now executable on a low cost PC with an inexpensive graphic card. With such drastic improvements, 3D modeling technologies have become affordable and accessible.

Consequently, a 3D caricature algorithm that can generate nice visual effects without relying on expensive devices is introduced in this thesis.

Previous researches have exploited several approaches to render caricatures with high quality, but few methods are designated for 3D caricature modeling. In most existing 3D caricature modeling algorithms [1][3][8], a 3D model is initiated by either laser scanning to recover depth information or pre-defined animation models. Certain features are then exaggerated to create a caricatured model. Using these approaches, facial features and countenances can be located precisely. However, it requires either large and expensive equipment or complex calculation and labors to simulate actions of facial muscles. If the resulting model is not utilized for photo-realistic animations, the high cost involved in the creation process seems not justified. In addition, some of these algorithms simply make reference to the "3D average face" to decide the exaggerating rate for caricature. They are more concerned about the deformation to exhibit the noticeable features. A commonly observed phenomenon is that the outcome is just a monotonically deformed version of the original model, lacking distinct artistic styles. To address the aforementioned issues, we propose to develop a 3D caricature modeling method based on the stylized 2D caricature generation algorithm described in [2].

Chiang *et al*. [2] developed an algorithm to generate caricature automatically. Caricature of different drawing styles can be created simply by replacing the reference painting. The objective of this research is two-fold. Firstly, we will improve the Chiang's work by incorporating a more accurate facial feature detection algorithm. Secondly, we will extend the original 2D model to stereo. We wish to implement a simple and effective solution so that users without sophisticated equipments can create a stylized 3D caricature for personal sculpture production, web animation or cartoon rendering.

1.2 Related work

1.2.1 Methods of 3D modeling

At present, there are three types of approaches for 3D modeling [3]:

- **Digital Analysis Based Modeling**

This implementation requires positioning of styluses at points on the surface of an object. The three dimensional coordinates of these styluses can then be calculated using specially designed sensors. After coordinates of all points on object's surface are evaluated and recorded, the 3D model can be reconstructed accordingly. This technique is also commonly used in tracking moving objects. The advantages are its accuracy, speed and without large space requirement. However, no texture information can be retrieved, and extra equipment is required.

- **Laser Scan Modeling**

By scanning the surface of objects with laser or red light, we can calculate its depth map based on the reflection. Such techniques can also get the texture information at the same time when scanning is progressing. The color data can be used to build a texture map for the subsequent reconstruction process. Fig. 1-3 is a range image and its texture map obtained by the range scanner developed by Cyberware [4,5]. Although we can get both accurate depth and texture information via range scanning, it is not a practical solution for average users because of its high cost and huge volume.

Fig 1-3: A range image (left) and its texture map (right)

- **Photographic Modeling**

If we have a series of images captured from different viewpoints, it is possible to reconstruct the original surface model. For example, the central image in Fig. 1-4[6] is an interpolated from the left and right images. Disparity map can be recovered at the same time. In principle, a textured 3D model can be reconstructed using this approach, although the accuracy is generally not as good as that obtained by the two methods discussed previously.

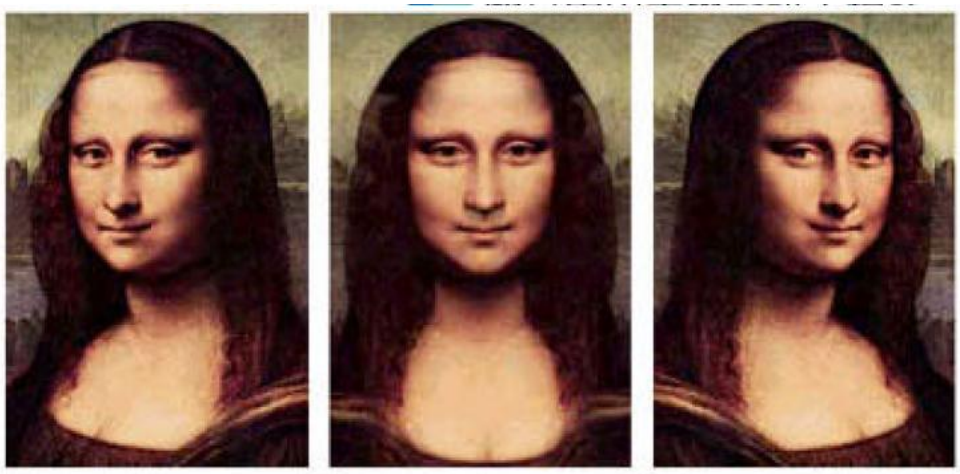


Fig. 1-4: Front view synthesis by left and right view

Among these methods, photographic modeling is most feasible in terms of cost. Two cameras can provide sufficient information, as images at other viewing angles can be estimated using view morphing techniques. Therefore, we will adopt photographic modeling in this thesis. An example is demonstrated in Fig. 1-5 and 1-6.

[7]. Fig. 1.5 is a stereo pair captured from different viewpoint. The left image in Fig. 1-6 is the depth map calculated from the stereo pair, and the right one is the 3D mesh constructed according to the depth map.

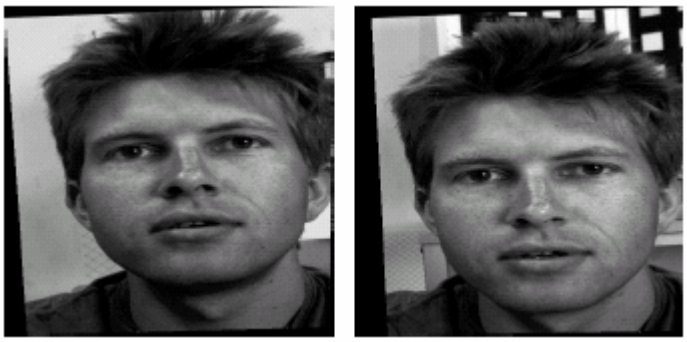


Fig. 1-5: A stereo pair of a face

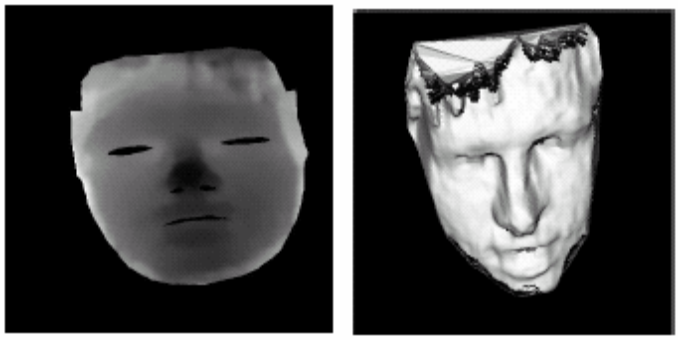


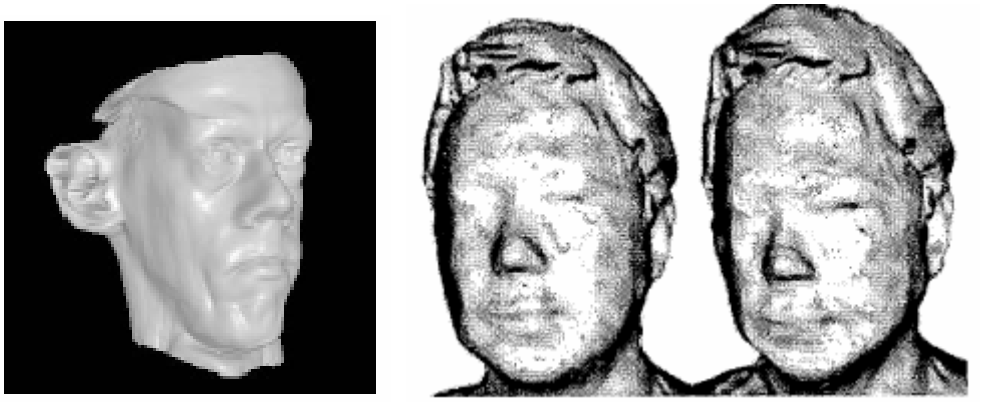
Fig. 1-6: The depth map and the initial mesh

1.2.2 Survey of 3D caricature generating system

O'Toole *et al.* [8] asserted that look of beauty and age on human face maintained a high correspondence with the average facial feature parameters, and implemented a model based on their theory. Proper modulation of these parameters can alter the age of original model (Fig. 1-7(a)) and beautify its appearance.

Fujiwara *et al*. extended their 2D Picasso algorithm to implement a 3D caricature generating system named 3D Picasso. They used 44 points and 82 polygons

to model the head. Exaggeration rate is determined by comparing the input with the 3D average face. A final caricature model is generated by deforming the initial 3D model accordingly. Figs. 1-7(b),(c) depict an input face and its caricature produced by 3D Picasso.



(a) (b) (c)

Fig 1-7: (a) A face model with old look generated by modulating parameters.
(b) An input face acquired by range scanner.
(c) corresponding facial model generated by 3D Picasso

In general, work on 3D caricature system is relatively few compared to the 2D counterpart. Moreover, most algorithms that achieved good results often require special equipments, such as range scanner, to obtain accurate depth and texture information, making them hard to popularize. Therefore, the design and implementation of effective algorithms for stylized rendering of 3D caricatures will definitely prove valuable.

1.3 Overview

Our goal is to provide a solution with minimal human intervention. No additional action on the user's part is required from the initial stereo image acquisition to the final generation of 3D caricatures. Fig. 1-8 illustrates the overall architecture of the proposed 3D caricature system.

First, a set of nodes corresponding to distinct facial features are selected to define the face mesh. Active appearance model is then employed to estimate the positions of the control points. Details regarding the definition and estimation of feature nodes will be discussed in Chapter 2. Subsequently, texture and depth information will be prepared for 3D modeling. We will discuss how to perform disparity computation in Chapter 3 and reveal some improvements of the 2D caricature production system developed in [2] in Chapter 4. Finally, after all required materials have been prepared, a 3D caricature facial model is ready to be generated. The details of constructing such a model will be presented in Chapter 5.

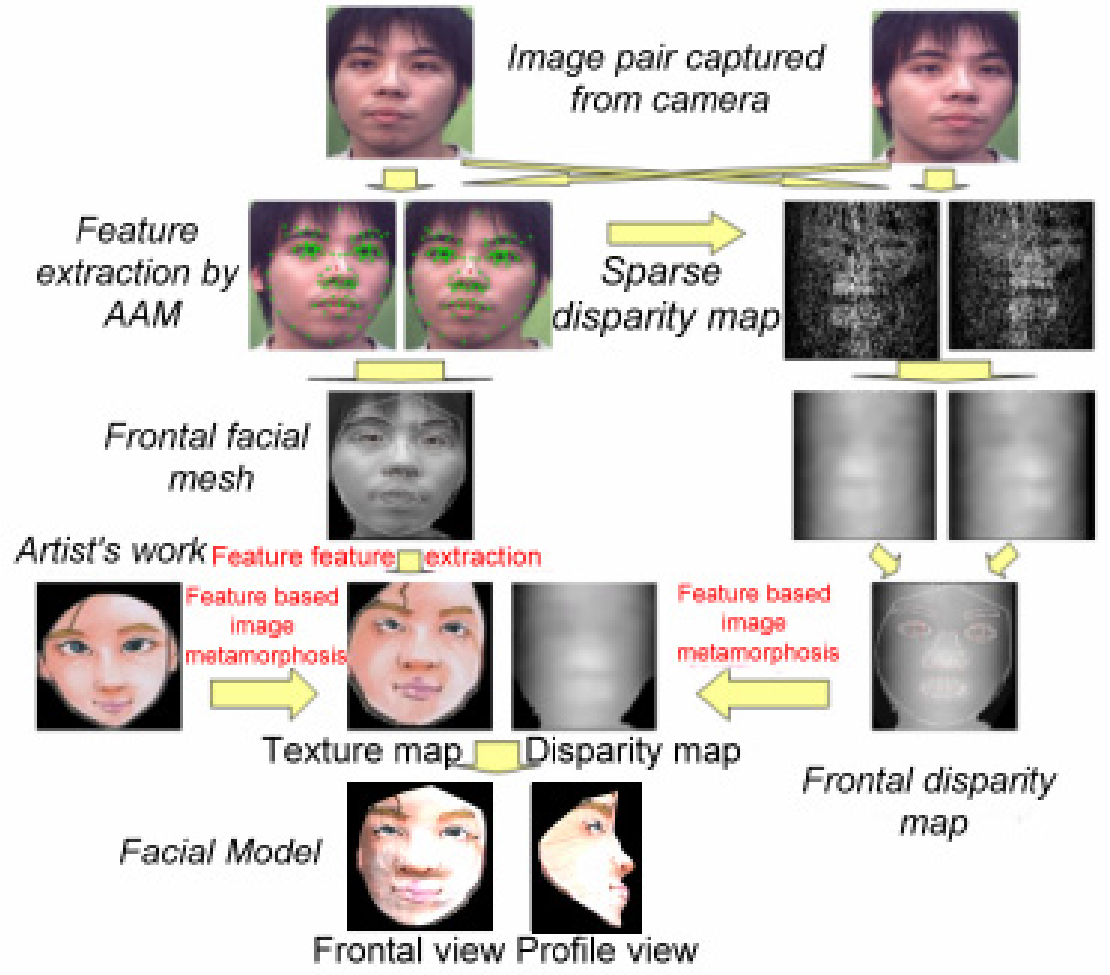


Fig. 1-8: An overview of the proposed 3D caricature system