

## 摘 要

随着计算机多媒体和网络技术的迅速发展,人们对各种人机交互界面的人性化要求越来越高。三维人脸合成技术作为虚拟人合成技术的一个重要组成部分,近 30 年来在动画工作者们的不懈努力下取得了长足的进步和发展。真实感三维人脸合成技术的应用范围非常广泛,其成果可以应用于虚拟主持人、虚拟会议、辅助教学、医疗研究、电影制作、游戏娱乐等等,具有重大的理论意义和应用价值。

本文在三维人脸建模、基于 MPEG-4 的人脸动画、人脸动画重定位、细微纹理动画、人脸动画驱动等人脸合成的关键问题上展开研究,取得如下成果:

1) 在三维人脸建模方面,如何便捷、快速、准确的构造三维人脸模型一直是计算机动画工作者在努力解决的难题。本文提出一种从二维人脸照片到三维人脸模型的构造方法。该方法输入简单,只需要一张正面人脸照片;建模速度快,比国际上同类的三维重构方法快 15 倍左右;整个重构过程完全自动。该技术还可以应用到基于合成的人脸识别方法中,扩充了训练数据,能够在识别算法不变的前提下,大幅提高人脸识别准确率。

2) MPEG-4 的三维人脸动画框架具有通用性强,便于扩展、数据量小等特点。本文提出了一种构造特定人脸模型 FAT (facial animation table, 人脸动画表)的方法,可以驱动本文的标准模型以及与标准模型拓扑结构相同的人脸模型。

3) 动画重定位(animation retargeting)是近年来国际上热门研究课题。本文在已有标准模型 FAT 的基础上,提出了一种构造任意拓扑结构三维人脸模型 FAT 的方法,从而实现了人脸动画数据的复用,并解决了驱动任意人脸模型的难题。该方法只需要在模型上提取若干特征点就可以应用,具有自动化程度高,速度快,通用性强等特点。

4) 传统的人脸动画只采用一张固定的纹理,纹理上的褶皱无法表现。本文提出一种 PERI (partial expression ratio image, 局部表情比率图)的概念,并建立了 PERI 库,利用 PERI 包含细微纹理特征的特性来表示纹理上的褶皱。在此基础上提出用 MPEG-4 的 FAP (facial animation parameter, 人脸动画参数)来参数化控制细微纹理特征的动画方法。为解决不同角度纹理视觉效果的真实性的问题,又提出了多方向 PERI 技术,从而实现了具有细微纹理特征的真实感三维人脸动画方法。

5) 动画数据是驱动一个动画系统必不可少的组成部分。本文介绍了通过视频来获取动画数据的方法,还介绍了用运动跟踪设备来采集人脸特征运动的数据。最后提出了一种解决文本驱动中唇动与手语同步问题的方法。

**关键词:** 人脸动画, 人脸建模, MPEG-4, 动画重定位, 细微纹理, 动画驱动

## **Realistic 3D Facial Synthesis**

### **Abstract**

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With the quick development of multimedia and network, the higher quality humanlike human-computer interfaces are required. As one of the most important parts of virtual human synthesis technology, 3D human face synthesis technique has been greatly developed in the recent 30 years. It can be used widely in the area of virtual reality environment such as virtual presenter, net meeting, videophone, remote education, remote medical diagnosis, movie effects and games etc. Research on 3D face synthesis has the great value in both theory and application.

This dissertation researched some key problems in human face synthesis, such as 3D face modeling, MPEG-4 based facial animation, facial animation retargeting, animation with subtle texture, animation driving etc. The following are the main achievements in this dissertation:

1) In the field of 3D human face modeling, the major problem is how to construct 3D face models correctly, easily and quickly. In this dissertation, an efficient 2D-to-3D integrated face reconstruction approach is introduced to reconstruct a personalized 3D face model from only one single frontal face image. This approach is fully automatic and the speed is fast. It is about fifteen times faster than the similar methods. This technique can also be used for the face recognition to expand the training data. The accuracy of face recognition is significantly improved, while the algorithms of face recognition are the same.

2) MPEG-4 based 3D facial animation framework has the advantages of currency and few data. This dissertation presents a method to construct FATs(facial animation tables) for special human face. The FATs can be used to drive the standard face model defined by this dissertation and the models, which have the same topology with the standard model.

3) Animation retargeting becomes a hot research topic of computer animation in the recent several years. Using the FATs for the standard model, this dissertation presents an approach to construct the FATs for any topology 3D face models. The method solves the problem of animation data reusing for any face models. Furthermore, it is highly automatic and the speed is quite fast.

4) Traditional facial animation methods usually use a facial image with neutral expression, which cannot simulate the subtle texture changes on the face. In this dissertation,

The concept of PERI(partial expression ratio image) is given and a library of PERI is set up. The FAPs(facial animation parameters) are used to parameterize the PERI and thus parameterize the subtle facial expression change in facial animation. At last, the multi-view PERI method is presented, which can generate realistic facial expression in different viewpoints

5) Animation data are absolutely necessary in an animation system. This dissertation introduces the methods to acquire animation data by video and 3D motion capture. The method to synchronize the lip motion and gesture in text driven system is also discussed.

**Key words:** facial animation, face modeling, MPEG-4, animation retargeting, subtle texture, animation driving