Chapter 3.13
Quasi–Facial Communication for Online Learning Using 3D Modeling Techniques

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ABSTRACT

Online interaction with 3D facial animation is an alternative way of face-to-face communication for distance education. 3D facial modeling is essential for virtual educational environments establishment. This article presents a novel 3D facial modeling solution that facilitates quasi-facial communication for online learning. Our algorithm builds 3D facial models from a single image, with support of a 3D face database. First from the image, we extract a set of feature points, which are then used to automatically estimate the head pose parameters using the 3D mean face in our database as a reference model. After the pose recovery, a similarity measurement function is proposed to locate the neighborhood for the given image in the 3D face database. The scope of neighborhood can be determined adaptively using our cross-validation algorithm. Further-more, the individual 3D shape is synthesized by neighborhood interpolation. Texture mapping is achieved based on feature points. The experimental results show that our algorithm can robustly produce 3D facial models from images captured in various scenarios to enhance the lifelikeness in distant learning.

INTRODUCTION

In traditional education, face-to-face communication is natural among students and teachers. The situation in virtual education (Chang, 2002) and e-learning (Zhuang & Liu, 2002) is different, where facial interaction is not commonly used. Students using a computer-based learning system are likely to study alone with relatively little classmate support (Ou et al., 2000).

Online interaction with facial animation over the network is an alternative way of face-to-face communication. 3D facial modeling is essential for building interactive virtual educational environments. In general, the use of facial modeling techniques in distance education mainly has three practical requirements. First, the method should be easily applied to new individuals. Second, it should require no exorbitant equipments and computation cost. Third, the results should be robust and realistic.

RELATED WORK

The pioneering work of facial modeling for animation was done by Parke (1972). Currently, there are several main streams of available solutions:

- **Modeling by 3D scanners:** Special equipments like 3D scanners can be used to capture the 3D shape of human heads. The data produced often need a lot of post-processing in order to reduce noise and fill the holes. Besides, in order to animate 3D scanned models, the shape must also be combined with an animation structure, which can not be produced by the scanning process directly.
- **Physical-based modeling:** (Terzopoulos & Waters, 1990; Kahler et al., 2002; Sifakis et al., 2005) One of the approaches to facial modeling is to approximate the anatomical structures of the face, that is, skull, muscles and skin. The animation from physical models reflects the underlying tissue stresses. Due to the complex topology of human faces, it requires tedious tuning to model a new individual's face.
- **Feature-points-based modeling:** (Pighin et al., 1998; Lee & Magnenat-Thalmann, 2000) Starting with several images or a 3D scan of a new individual, the generic model is deformed by the extracted facial feature points. Images are ubiquitous nowadays and a good source for facial modeling. In order to recover the 3D information, it needs orthogonal pair or more uncalibrated images.
- **Example-based modeling:** Blanz and Vetter (1999) propose a method named morphable model, which builds new faces by a linear combination of examples. Their work can be applied to reanimating faces in images and videos (Blanz, 2003; Vlasic et al., 2005). Supported by the examples, the input constraints can be released to only one image of the individual to generate plausible 3D results. The convergence process takes nearly an hour on SGI workstation, which limits its applications.

OUR APPROACH

The example-based approaches work well when there are a small number of examples. The iteration process converges and gets reasonable synthetic shapes and textures. However, as the number of examples increases, the structure of the 3D face space becomes more complicated and the global Euclidean distance measurement becomes invalid. The iterative optimization algorithms such as gradient descent need a lot of time to converge and easily get lost or trapped in local minimums. On the other side, in order to span a complete range of facial shapes, a large set of examples needs to be built. Due to the development of 3D scanners and the demand of realistic facial modeling and animation, the number of examples may increase dramatically. For instance, the facial animations of Gollum in the feature film The Two Towers employed 675 example shapes (Fordham, 2003).

In order to solve this problem, we introduce nonlinear learning algorithm from dimension reductions (Roweis & Saul, 2000), which maps its inputs into a single global coordinate system of lower dimensionality, and its optimizations—

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