Face Reconstruction from Shading Using Smooth Projected Polygon Representation NN

Mohamad Ivan Fanany, Masayoshi Ohno, Itsuo Kumazawa

Dept. of Computer Science, Graduate School of Information Science and Engineering
Tokyo Institute of Technology, Japan
West 8E building, Oookayama Meguro-ku, Tokyo 227-0052
email: fanany@kml.cs.titech.ac.jp

Abstract

In this paper, we present a neural-network learning scheme for face reconstruction. This scheme, which we called as Smooth Projected Polygon Representation Neural Network (SPPRNN), is able to successively refine the polygon's vertices parameter of an initial 3D shape based on depth-maps of several calibrated images taken from multiple views. The depth-maps, which are obtained by deploying Tsai-Shah shape-from-shading (SFS) algorithm, can be considered as partial 3D shapes of the face to be reconstructed. The reconstruction is finalized by mapping the texture of face images to the initial 3D shape. There are three interesting issues investigated in this paper concerning the effectiveness of this scheme. First, how effective the SFS provides partial 3D shapes compared to if we simply used 2D images. Secondly, how essential a smooth projected polygonal model is needed in order to approximate the face structure and enhance the convergence rate of this scheme. Thirdly, how an appropriate initial 3D shape should be selected and used in order to improve model resolution and learning stability. By carefully addressing those three issues, it was shown from our experiment that a compact and realistic 3D model of human (mannequin) face could be obtained. This result is ensured through quantitative measurement of average pixel-error and vertex-error between generated model and actual 3D data obtained by 3D scanner device.

1 Introduction

Three-dimensional (3D) face reconstruction is currently receiving a lot of attention in the Computer Vision and Computer Graphics communities. It is a fast growing research field with many application such as virtual reality, animation, face recognition. In all these cases, the recovered model must be compact and accurate, especially around significant areas like the nose, the mouth, the orbits, etc. Since the earliest work in facial modeling to more recent studies [1]-[3], generating realistic faces has been a central goal. However, this remains as a challenging task due to the complex and individual shape of face, and also the subtle and spatially varying reflectance properties of skin.

Artificial neural networks (ANNs), have shown considerable promise in a wide variety of application areas, and have been particularly useful in solving problems for which traditional technique have failed or proved inefficient. Typically, NNs have been shown to be particularly suitable (and have been used extensively) for pattern recognition problems, namely classification, clustering and feature selection. ANNs are also utilized for many other tasks, like optimization, prediction, control, and, more recently, data mining and information retrieval. However, there are still very few studies about the used of NNs for shape representation or surface reconstruction. Rather than directly used NN for reconstruction problem, Braines [4] used NN only to evaluate and verify the reconstruction result of volume rendering technique. Even though NN has been involved further in shape reconstruction process as shown by Cho [5] in the development of a hybrid structure of feed forward NN and radial basis function NN to optimize reflectance model, the recovery of 3D object shape using this optimized model is still be accomplished by ordinary shape-from-shading techniques. There are still not many literature which directly utilized NN for surface reconstruction. Among those literature, Wei [6] proposed a method of shape-from-shading by using radial basis function to parameterize the object depth, and in [7], Iwahori has pursued NN implementations of photometric stereo by estimating the unknown parameters included in the reflectance function and surface gradient distribution using error back propagation learning.

Recently, we developed a unique NN scheme [8] that could store and represent vertices of 3D polygonal object shape. By comparing the projected images of the model (as the outputs of the NN) with the real images taken from different views, the vertices of the object model in 3D space are updated using error back propagation method to approximate the actual 3D object shape. The design setting of updating the NN parameters based on images instead of based on 3D geometrical structures, was inspired by image based rendering techniques [9] that recently caught many attention. These techniques representing a scene as a collection of