Chapter 7
Interactive Feature Visualization and Detection for 3D Face Classification

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ABSTRACT

A new visual approach to the surface shape analysis and classification of 3D facial images is presented. It allows the users to visually explore the natural patterns and geometric features of 3D facial scans to provide decision-making information for face classification which can be used for the diagnosis of diseases that exhibit facial characteristics. Using surface feature analysis under a digital geometry analysis framework, the method employs an interactive feature visualization technique that allows interactive definition, modification and exploration of facial features to provide the best discriminatory power for a given classification problem. OpenGL based surface shading and interactive lighting are employed to generate visual maps of discriminatory features to visually represent the salient differences between labeled classes. This technique will be applied to a medical diagnosis application for Fetal Alcohol Syndrome (FAS) which is known to exhibit certain facial patterns.

INTRODUCTION

In recent years, interactive visualization and 3D computer graphics techniques have started to play significant roles in data mining and data analysis applications. The feedback and involvement of human intuition and knowledge through graphical interfaces and interactive visualization can often lead to faster and more reliable data mining and analysis outcomes. This visual analytics approach is particularly effective for the analysis of visual/spatial data from 3D sensors, as spatial data have

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natural visual representations. On the other hand, the rapid advances of sensory technologies have led to the enormous proliferation of multimedia data and have created a great challenge and an urgent need for new and more effective data mining and analysis techniques for data from multimedia sources. Many applications, such as medical diagnosis and biometrics, can benefit greatly from more reliable and efficient 3D data analysis methods and techniques.

This paper presents a new visual approach to the analysis of polygon mesh surfaces of human faces for a medical diagnosis application: Fetal Alcohol Syndrome (FAS). FAS is a neurological disorder resulting from prenatal exposure to alcohol. It is the most common nonhereditary cause of mental retardation and is often associated with growth deficiencies and developmental abnormalities of the central nervous system, and a pattern of various facial anomalies (Moore, Ward, Jamison, Morris, Bader, & Hall, 2002). It is estimated that the prevalence of FAS in the general population is likely to be between 0.5 and 2.0 per 1,000 births (May & Gossage, 2001). While there are several FAS diagnostic criteria used in the medical community (Jones & Smith, 1973; Moore, Ward, Jamison, Morris, Bader, & Hall, 2002; Jacobson, 2008), identification of the distinctive pattern of facial features anomalies is a key and necessary component for the diagnosis and the only one at this time that can be readily detected and determined and potentially automated.

In this study, 3D facial images are collected using an eye-safe laser scanner. Multiple scans are made and then stitched together to form a dense and irregular polygon mesh surface. The analysis of polygon mesh surfaces is a new research approach in medical imaging, as existing 3D medical imaging technologies focus on volumetric images, such as CT and MRI scans. There is, however, a tremendous need in medical applications for the image analysis of surface scans that capture detailed surface geometry and texture information. For some neurological disorders, facial feature anomalies are highly characteristic and unique. 3D data analysis techniques that capture the correlation between face and disease can potentially provide effective diagnosis tools for medical research and clinical studies, especially in the pre-screening process and in early diagnosis of children. It has also been shown in Jain and Hoffman (2005) that the traditional 2D facial analysis approach is not effective for this type of diagnosis problems, since the features affecting the facial dysmorphology are highly three-dimensional and cannot be easily captured by 2D photos.

3D facial scans of both children with FAS and normal controls that were not exposed prenatally to alcohol were collected and processed. The analysis can be carried out using supervised classification techniques. A critical component in this type of data analysis is the identification of salient features that are most discriminatory in separating FAS faces and controls. Traditionally, the initial features are defined based on some pre-determined feature models that usually represent a small fraction of all available features. When sufficient prior knowledge is available, this feature model can be established as an "educated guess." But in most cases, the initial features are determined based on highly subjective assumptions, which can potentially lead to inaccurate or incomplete analysis results. To further add to the difficulties, a very large initial feature set can make the analysis even worse due to the infamous "curse of dimensionality." Since there are infinite numbers of potential features, a guided and intelligent mechanism needs to be installed into the feature search process. One way to provide an effective feature search is to utilize human knowledge and intuition by applying interactive visualization techniques to allow the users to make decisions based on visual feedbacks. Human vision combined with intuition and knowledge is often superior to machine vision in identifying color and geometric patterns. This approach