Joint Gender, Ethnicity and Age Estimation from 3D Faces

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An Experimental Illustration of their Correlations.

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Abstract Humans present clear demographic traits which allow their peers to recognize their gender and ethnic groups as well as estimate their age. Abundant literature has investigated the problem of automated gender, ethnicity and age recognition from facial images. However, despite the coexistence of these traits, most of the studies have addressed them separately, very little attention has been given to their correlations. In this work, we address the problem of joint demographic estimation and investigate the correlation through the morphological differences in 3D facial shapes. To this end, a set of facial features are extracted to capture the 3D shape differences among the demographic groups. Then, a correlation-based feature selection is applied to highlight salient features and remove redundancy. These features are later fed to Random Forest for gender and ethnicity classification, and age estimation. Extensive experiments conducted on FRGCv2 dataset, under Expression-Dependent and Expression-Independent settings, demonstrate the effectiveness of the proposed approaches for the three traits, and also show the accuracy improvement when considering their correlations. To the best of our knowledge, this is the first study exploring the correlations of these facial soft-biometric traits using 3D faces. This is also the first work which studies the problem of age estimation from 3D Faces.[1]

Keywords 3D Face · Gender · Ethnicity · Age · Correlation · Random Forest · Feature Selection.

1 Introduction

In daily life, human beings perform gender and ethnicity recognition as well as estimate the age of their peers naturally and effectively. Several studies from different backgrounds (face and head anthropometry, cognitive psychology, clinical studies, etc.) have tried to understand how the process works. In particular, a number of anthropometric studies [65] have revealed that significant facial morphology differences exist among the gender, the ethnicity and the age groups. For example, when studying the *Sexual Dimorphism* (Male/Female differences) [9], researchers have found that male faces usually possess more prominent features than female faces. Male faces usually have more protuberant noses, eyebrows, more prominent chins and jaws. The forehead is more backward sloping, and the distance between top-lip and nose-base is longer. [65] have also demonstrated that all the concerned anthropometric measurements of females are smaller. In the study of the ethnic differences [16], researchers have found that compared to the North America Whites, Asians usually have broader faces and noses, far apart eyes, and exhibit the greatest difference in the anatomical orbital regions (around the eyes and the eyebrows). In the clinical study reported in [35], *Alphonse et al.* have revealed that Caucasians have significantly lower fetal Fronto-Maxillary Facial Angle (FMFA) measurements than Asians. In [65], sixteen anthropometric measurements have been recognized as significantly different between Asian and Caucasian faces. When studying the face aging [48, 49], researchers have concluded that the craniofacial growth is the main change in baby and adolescent faces, which results in the re-sizing and redistribution of facial features. During this period, generally, the larger is the age, the bigger is the size of the face. When the craniofacial growth stops at 18-20 years old, the face contour and texture changes become the dominant changes. Young adults tend to have a triangle shaped face with small amount of wrinkles. In contrast, old adults are usually associated with a U-shaped face with significant wrinkles on the face. Besides the existence of these *Soft-Biometric Traits*[2] [11, 34] in the face, gender, ethnicity and age are also correlated in characterizing the facial shape [65]. For example, according to the anthropometric studies cited above, the shape of the nose is influenced by all the three soft-biometric traits. In human perception, female faces usually look smoother and younger than male faces, and the Asian faces usually look younger than Non-Asian faces [50]. In [58], *Vignali et al.* have

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[1] Part of this work has been published in the International Conference on Computer Vision Theory and Applications 2014 [61] and won the **Best Paper Award** in the area of **Image and Video Understanding**.

[2] A.K. Jain defined Soft-biometric traits as a set of traits providing information about an individual, though these traits are not sufficient to individually authenticate the subject because they lack in distinctiveness and permanence [34].