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Automatic craniofacial anthropometry landmarks detection and measurements for the orbital region

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Abstract

Facial landmarks detection is undoubtedly important in many applications in computer vision for example the face detection and recognition. In craniofacial anthropometry, consistent landmarks localization as per standard definition of the craniofacial anthropometry landmarks is very important in order to get accurate craniofacial anthropometry data. In this article we demonstrated an automatic detection of craniofacial anthropometry landmarks at the orbital region. 3D images of 100 respondents' were photogaphed using Vectra-3D in controlled environment. Craniofacial measurements of 30 3D images were measured using VAM software. Two data sets of left and right eyes positive training data were created to train 'en' and 'ex' haar cascade classifiers. These classifiers were used to detect and locate the inner (en) and outer (ex) eye corners. We automatically measured the left and right eye fissures length (en-ex), the intercanthal (en-en) and the biocular (ex-ex) width. Statistical analysis was performed on the measurements taken by Vectra 3D and by our software with paired t-test and calculated the ICC indices. We observed quite amount of false positive detections. We removed the false positive and predicted the eye corners. Our classifiers able to detect and locate the 'en' and the 'ex' in 59 out of 60 test images. Our results show accurate detection of 'ex' and 'en' craniofacial landmarks as per standard definition. The paired t-test showed that all four (4) measurements are no significant difference with the p values on 95% confidence level are above 0.05. The ICC indices for the measurements were from 0.4 to 0.78. In conclusion, our trained enHaar and exHaar cascade classifiers were able to automatically detect the 'en' and 'ex' craniofacial anthropometry landmarks in controlled environment. The measurements were clinically no significant differences with the mean different were less than 1 mm in both eye fissures and intercanthal except the biocular width (1.16 mm). The consistency of the measurements between the two methods are good for the intercanthal width and moderate for the biocular width and for both eye fissure lengths.

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Keywords: Craniofacial Anthropometry; facial landmarks; Haar Cascade Classifier.

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1. Introduction

Craniofacial Anthropometry is a standard facial measurement used in a wide range of applied and research contexts, hence, reliable and accurate data are very important and cannot be compromised [1-2]. The use of computer technology such as Vectra 3D stereo-photogrammetry system and other similar systems helped the researchers in acquiring the data fast, reliable and accurate [3-5]. Unfortunately, the systems require human interaction in locating the facial landmarks. Consistency in locating the landmarks is an important parameter in contributing the measurement errors as discussed in [2]. Toma and Zhurov studied the intra and inter examiners error in reproducing the facial landmarks on the 3D image at 3 planes x, y and z [6]. Their results showed 11% of inter examiners and 17% of intra examiners reproduced landmarks with more than 1 mm difference.

Dauglas had attempted to locate the eye landmarks automatically in her study of Fetal Alchoholic Syndrom (FAS). She proposed an automatic measurements of the orbital region to compare the measurements of normal and the FAS group. She used genetic algorithm and eye template to automatically locate the eye landmarks in her study [7]. Mutsugawa and Douglas extensive study on the used of stereophotogammetry craniofacial anthropometry as a tool in FAS screening has been accepted as a standard procedure to screen FAS in children[8-9]. Automatic locating and extracting the facial landmarks proposed by Douglas is an alternative method to reduce the inter and intra examiner errors in craniofacial anthropometry.

Abbreviation	
en	endocathion
en	exocanthion
en-ex	eye fissure length in mm
en-en	inter canthal length in mm
ex-ex	biocular width

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1.1. The Cascade Classifier

Viola and Jones object detection framework is robust and accurately detect face in image. Viola and Jones used Haar-like features proposed by Papageorgiou in their algorithm to detect a face. These features encode differences in average intensities between two rectangular regions, and they are able to extract texture without depending on absolute intensities. The contrast variances between the pixel groups are used to determine relative light and dark areas. Viola and Jones used three kinds of features, a two rectangular feature, a three rectangular features and a four rectangular feature as shown in figure 1. The sum of the pixels which lie within the white rectangles are subtracted from the sum of pixels in the grey rectangles. Two-rectangle features are shown in (A) and (B). Figure (C) shows a three-rectangle feature, and (D) a four-rectangle feature. [10]

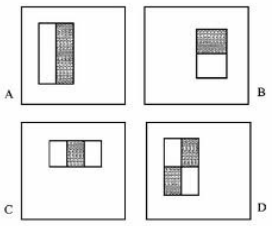

Figure 1.Example rectangle features

They proposed an efficient system for evaluating these features which is called an integral image to reduce the exhaustive calculation of the rectangular regions. To construct the object classifier they used adaboost algorithm to

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