Age Estimation of Adolescents Using Eye Measurements from Various Angles in Videos

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Abstract

Photographs of oneself, or "selfies" and "selfie-style" videos, have become popular. While an individual's appearance may be natural, it may also be due to make-up, posing, or filter technologies available. Using measurements of facial features, including the pupils, the age of an individual can be estimated with fewer hindrances. Since these "selfies" can be taken at any camera angle relative to the front of the face, having a way to estimate age while taking the angle into account is necessary. Measurements from videos indicated that the angle of camera yaw mattered, but the measurements did not have a consistent relationship with angle. Due to the minimal participation, more research is necessary to determine the exact relationship of camera angle with age.

Background

Forensic science uses hard biometrics like DNA and fingerprints to identify people. Soft biometrics, like hair and skin color, are also used to help narrow down a list of possible individuals. Age is also a soft biometric. Age estimation can be done manually or by an automated process. Some of the automated methods take the whole face into account while others only consider specific aspects. One aspect that is often used for age estimation is the eyes. The iris can be used for hard biometrics and its reaction to light controls the size of the pupil.

Pupil diameter has been related to age in children and teenagers in two notable studies. One of these, performed by Lavezzo, et al., used two different gazes in preschool children: attentive and spontaneous. The attentive gaze was found to have the larger pupil diameter than the spontaneous gaze. The researchers also found that there was an increase in diameter with age. The other study, performed by MacLachlan and Howland, examined two measurements with relationship to age: pupil diameter and interpupillary distance (PD). This study was performed in mesopic, or low-light, conditions. The relationship of each with age was determined for both male and female participants. While the relationship of pupil diameter with lighting is generally well-understood, the exact relationship of pupil diameter with age in everyday office lighting may not follow the same relationship as in mesopic conditions.

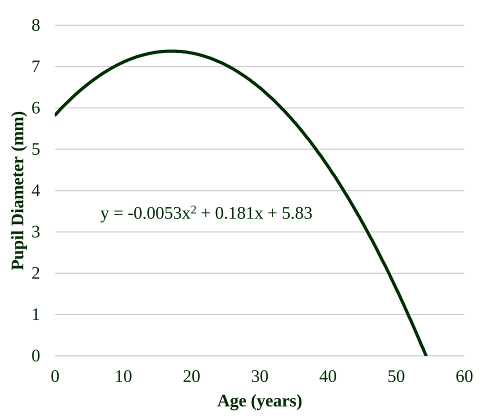

Figure 1. Male Pupil Diameter vs. Age. Female pupil diameter had a similar relationship, with a smaller maximum at a younger age.

Figure 2. Male PD vs. Age. Female PD had a similar relationship, with a smaller maximum at a younger age.

Introduction

Many of the problems associated with facial recognition biometrics can also be found in the analysis of images taken using smart phones, especially with "selfies". The lighting conditions are often unknown; facial expressions vary depending on the cooperation level of the subject or incentives behind the image; make-up may be used to make someone appear older; position and orientation are variable; and/or only part of the face may be visible. The angle at which the face is registered can also cause problems with facial recognition biometrics since most biometrics systems are not designed to account for various poses. Since selfies and other digital images of people can be taken at any given angle, an examination of how various angles affect these measurements is necessary.

Materials

- Nikon® D3100 and tripod
- Apple® iPad® (iOS version 7.1.2)
- Adobe® Photoshop® CS6 Extended
- Adobe® After Effects® CS6
- Chair, ruler, tape measure

Methods

Nikon®: still photographs and tripod pan videos

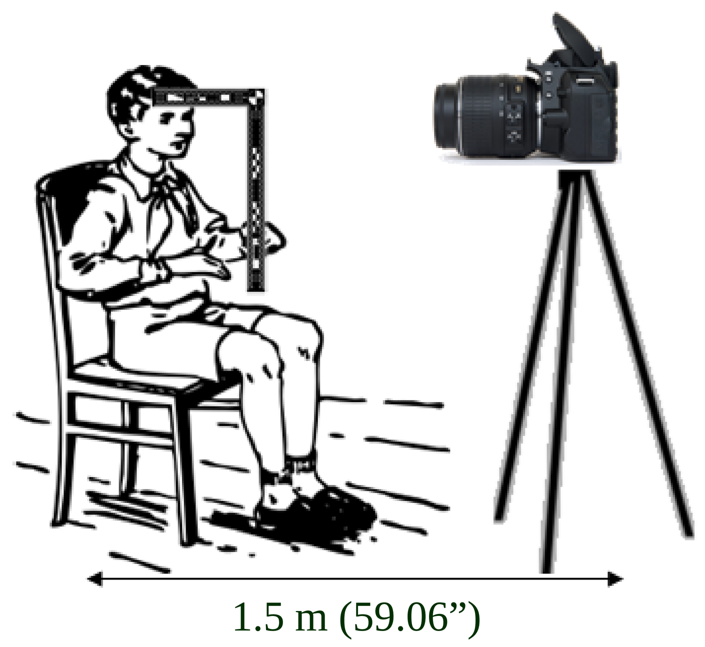

Figure 3. Nikon® camera setup. This same setup was used both for stills and for a tripod pan video with each participant.

iPad®: selfie photographs and selfie-style videos. The setup was the same, except the distance the iPad® was held away from the face was measured for each participant. All videos and iPad® images were taken with the participant in his/her most comfortable vision state.

Each image and selected video frames were processed in Photoshop®.

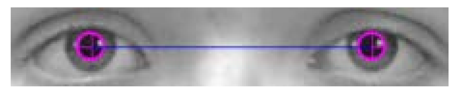

Figure 4. Example Markings. Each pair of eyes was marked at the pupil/iris boundary, the diameter of the pupils, and the interpupillary distance.

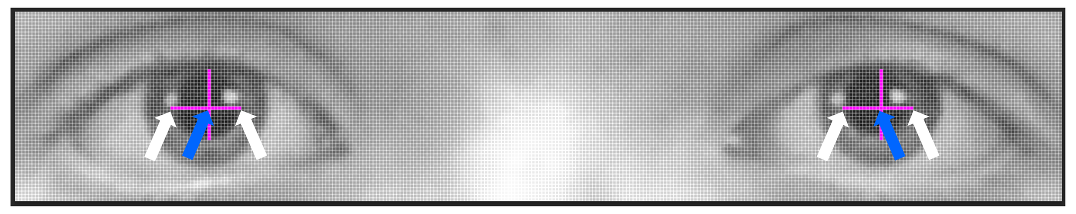

Figure 5. Measurement Points. White arrows indicate the points used for pupil diameter while blue arrows indicate the points used for interpupillary distance.

Results

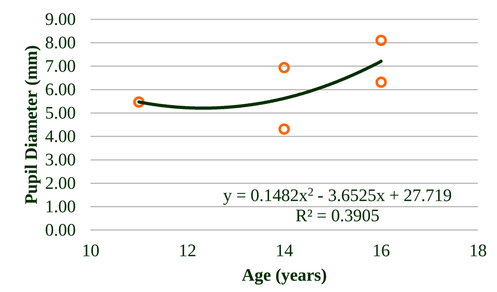

Figure 6. Nikon® Male Pupil Diameter vs. Age. The female pupil diameter had a negative linear relationship with age.

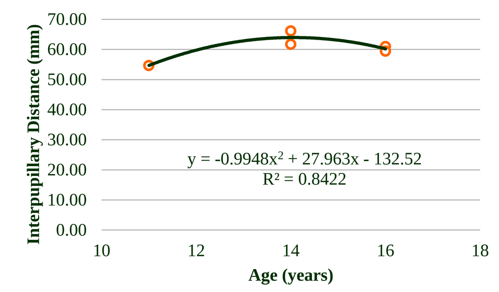

Figure 7. Nikon® Male PD vs. Age. The female PD had a positive linear relationship with age.

Table 1. Pupil Diameter and Interpupillary Distances Resulting from Camera Yaw Rotation. Measurements from one individual are presented as an example.

Angle (°)	Pupil Diameter (mm)	PD (mm)
0	5.95	59.88
5.0	5.42	60.72
23.6	5.94	61.29
5.0	6.34	57.82
22.8	5.59	60.90

All of the iPad® videos showed 6 forms of motion instead of the desired 2.

Discussion and Conclusions

It was generally only possible to distinguish pupils from brown irises in the Nikon® photographs, thus decreasing the possible participants for measurements. The relationships of pupil diameter and PD with age in normal office lighting did not match up with the relationships determined by MacLachlan and Howland. This might be because of the smaller number of participants whose pupils could be distinguished.

With the Nikon® videos, there was no readily observable pattern between the angle from the starting point and the measurements made. Both the pupil diameters and the PDs increased and decreased regardless of angle. The changes may have been the result of: the angle; the camera quality; changes in thought pattern; hippus. It was also observed that the camera was pitching and rolling in some of the frames. Each of these was less than 2° in any given frame.

These issues were complicated further in the iPad® images and videos.

Due to the minimal participation and the difficulty of distinguishing pupils from brown irises, more research is needed to confirm the relationship of the measurements with age and the relationship of the measurements with angle.

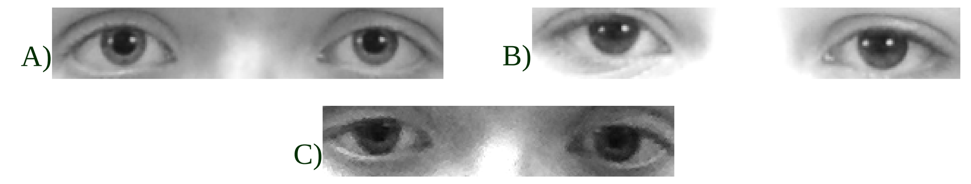

Figure 8. Pupil/Iris Boundary. A) Nikon® image of blue eyes. B) Nikon® image of brown eyes. C) iPad® image of blue eyes.

Future Directions

Since only yaw camera motion was analyzed, pitch and roll as well as each translational motion should be analyzed, individually and in various combinations. The effect of the lenses of glasses and contacts should also be examined. Cameras of various qualities should be used to determine the minimum camera quality for consistently identifying pupils. Features that can be reliably measured even in low quality images should be identified and examined for a relationship to age. Finding a way to make accurate measurements from an image without a specific scale is necessary before this can be applied to forensic casework.

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