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Estimating Interpupillary Distance from Eyeball Size

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ABSTRACT

The interpupillary distance (IPD) of a user's face is used to frame prescription or non-prescription glasses, or other eyewear. The requirement for an IPD measurement necessitates a physical visit to an optometrist, making online glass (or frame) orders or virtual try-ons (VTO), difficult or infeasible. This disclosure leverages the near constancy of eyeball diameter across the human population to predict the IPD using geometric and/or machine learning techniques. The visible portion of the eyeball (the iris) is used to infer eyeball position. The eyeball position and a priori known size serve as reference dimensions to determine the IPD and/or dimensions of other facial features.

KEYWORDS

- Interpupillary distance (IPD)
- Eyeball size
- Virtual try-on (VTO)
- Virtual fitting
- Digital outfit
- Virtual fashion
- Virtual sizing
- Eyeglasses
- Smartglasses
- Eyewear

BACKGROUND

Dimensions of a user’s face, including the interpupillary distance (IPD), are used to frame prescription or non-prescription glasses. Generally required for all types of glasses, accurate measurement of IPD is particularly important for patients with high lens power. The requirement for IPD measurement necessitates a physical visit to an optometrist, making online glass (or frame) orders or virtual try-ons (VTO), difficult or infeasible.

One way to remotely obtain the scale of a user’s face is to have the user send an image of herself holding a reference object such as a credit card or a quarter dollar. Such a measurement can be inaccurate if the user doesn’t hold the reference object at the exact plane of their eyes. Scale determination based on reference objects becomes more accurate with a depth sensor or with stereo cameras or with a moving single camera, but these add to cost and complexity.

DESCRIPTION

At 24 mm in average diameter with only a 0.8 mm standard deviation, the human eyeball is relatively fixed in size across the population, such that there is potentially a reference object embedded in the user’s face. This disclosure leverages the near constancy of eyeball diameter to predict the IPD using geometric and machine learning techniques. The visible portion of the eyeball (the iris) is used to infer eyeball position. The eyeball position and a priori known size serve as reference dimensions to determine the IPD and dimensions of other facial features.

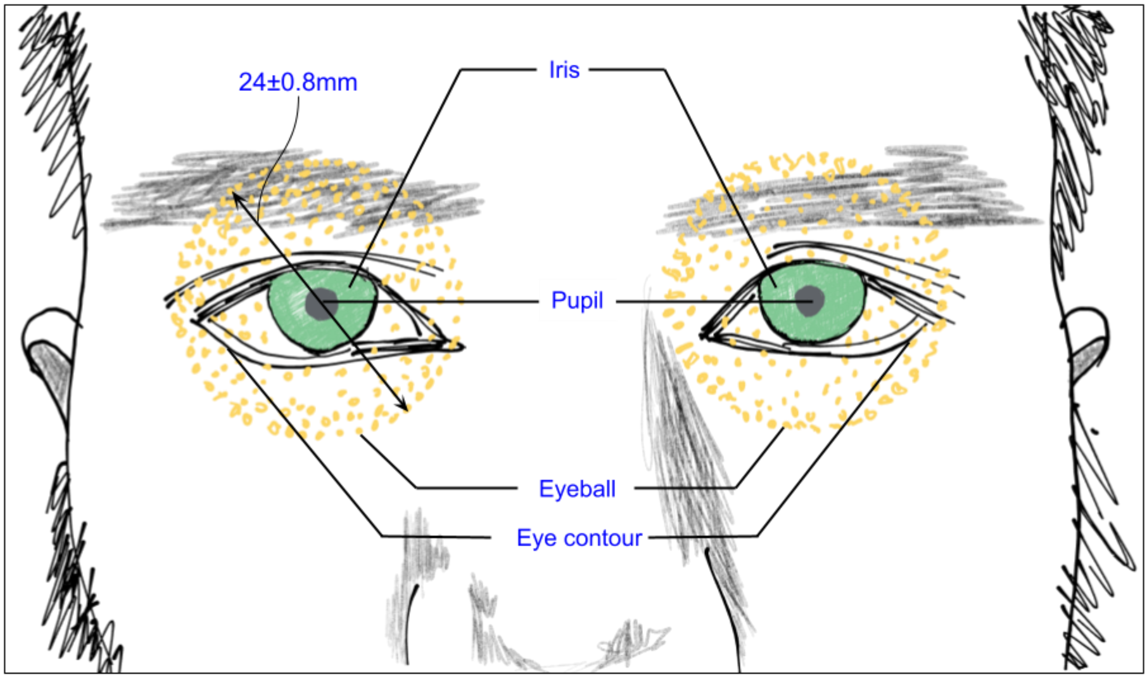
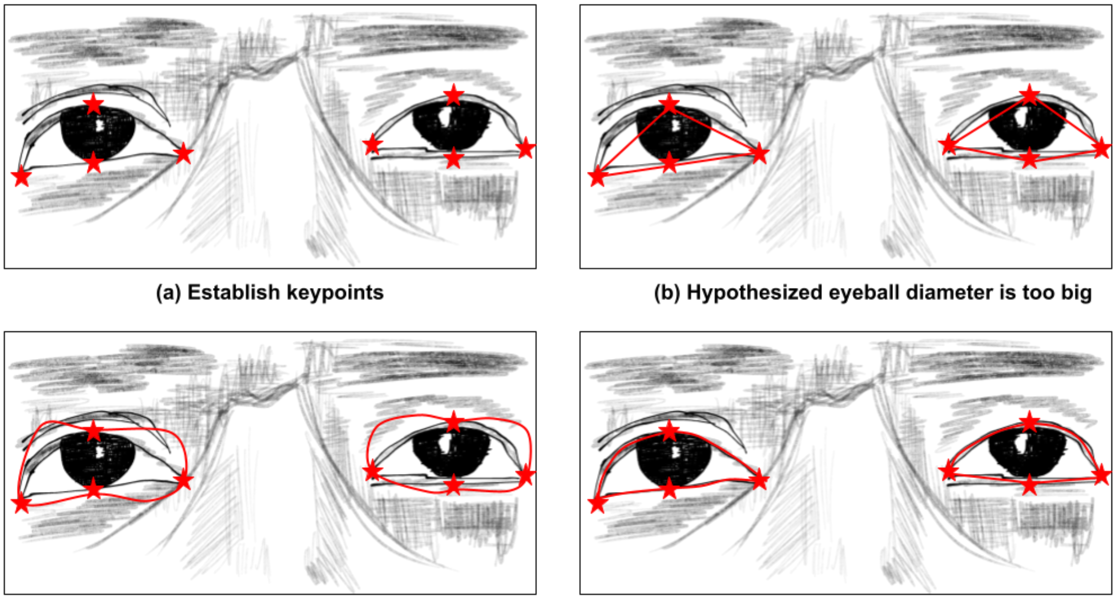


Fig. 1: Eyeball, iris, and pupil

In the facial image illustrated in Fig. 1, only a small portion of the eyeball is visible. The visible portion is referred to as the iris (in green). The iris ranges widely in size, e.g., between 8 to 15 mm, and as such isn't useful as a reference object. At the center of the iris is the pupil (gray) that controls the amount of light entering the eye. Far interpupillary distance is the distance between the centers of the pupils when looking far away.

The bulk of the eyeball (yellow flecks forming a sphere) is embedded inside the eye socket, out of view. It is the diameter of the yellow-flecked eyeball that is known to be 24 mm with a standard deviation of 0.8 mm. The eye contour is the boundary of the white of the eye. As explained earlier, although the diameter of the eyeball is nearly constant across the population, the fraction of the eyeball visible through the eye contour varies widely. The diameter of the eyeball in pixels is to be estimated from just the visible portion. Once the diameter of the eyeball and the center of the pupil is determined in pixels, interpupillary distance can also be measured in pixels and translated to millimeters using the known diameter of the eyeball.



(a) Establish keypoints

(b) Hypothesized eyeball diameter is too big

(c) Hypothesized eyeball diameter is too small

(d) Hypothesized eyeball diameter is correct

Fig. 2: Estimating the diameter of the eyeball

Fig. 2 illustrates an example technique to estimate the diameter of the eyeball. Keypoints are established using standard feature recognition techniques. As illustrated in Fig. 2(a), the keypoints can represent extremities of the eye contour (red stars). An eyeball diameter is hypothesized and the eye contour is projected based on the hypothesis. That eyeball diameter which results in a near exact overlap with the true eye contour is selected.

For example, in Fig. 2(b), the hypothesized eyeball diameter is too big, such that the projected eye contour (the red curve) falls entirely within, e.g., incoincident with, the true eye contour. If the hypothesized eyeball diameter is too big, the hypothesized eyeball surface becomes nearly flat, such that the projected eye contour comprises straight lines, as in Fig. 2(b). In Fig. 2(c), the hypothesized eyeball diameter is too small, such that the projected eye contour (the red curve) falls completely without, e.g., incoincident with, the true eye contour. If the hypothesized eyeball diameter is too small, the hypothesized eyeball surface exhibits very high curvature, such that the projected eye contour becomes too curvy, as in Fig. 2(c).

In Fig. 2(d), the hypothesized eyeball diameter is just right, such that the projected eye contour (the red curve) is almost exactly coincident with the true eye contour. The procedure is similar to drawing an eye contour on the surface of a spherical balloon and expanding or contracting the balloon until the drawn eye contour matches the actual eye contour in the given user image.

Once the diameter of the eyeball is established in pixels and the position of the center of the pupils established using feature recognition techniques, the IPD is known in pixels. The correspondence between the diameter of the eyeball in pixels and its known diameter in millimeters can be used to calculate the IPD value in millimeters.

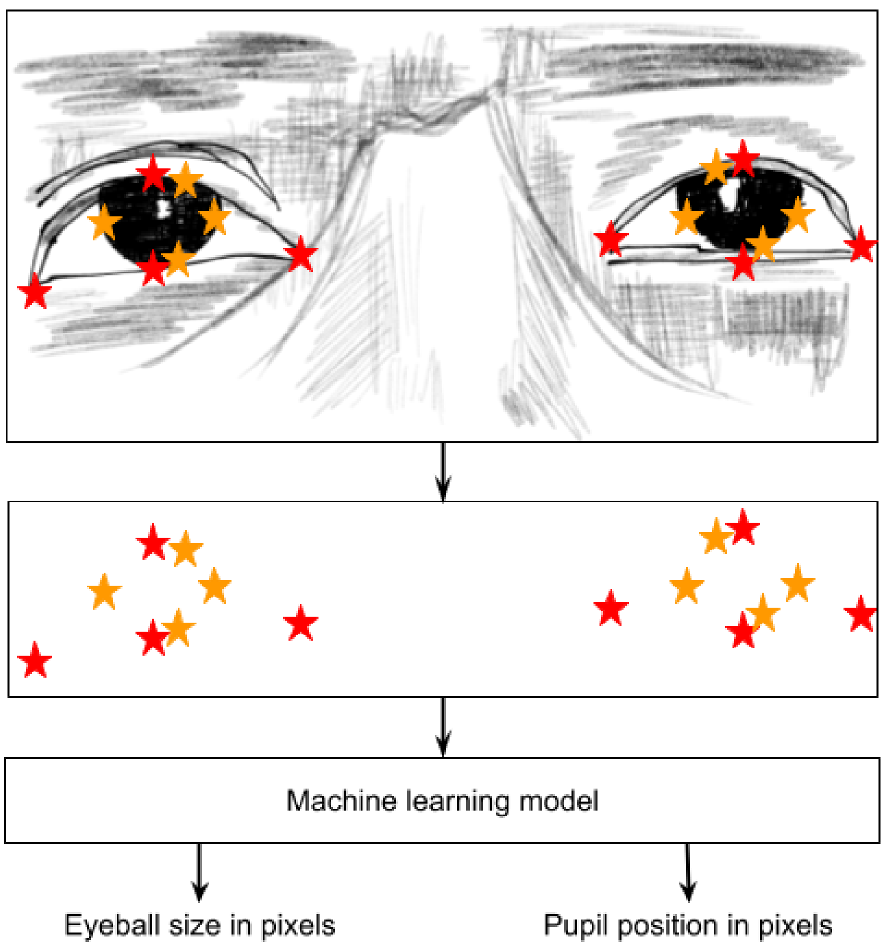


Fig. 3: Another example technique to estimate the diameter of the eyeball and the IPD

Fig. 3 illustrates another example technique to estimate the diameter of the eyeball and the IPD. Feature recognition techniques are used to identify keypoints along the boundaries of the iris (orange stars) and the eye contour (red stars). The keypoints are fed into a machine learning model that has been trained to output the eyeball size in pixels and the pupil positions in pixels. The IPD in millimeters can be computed using the correspondence between the eyeball size in pixels and the known average eyeball size in millimeters.

The techniques apply generally to determining dimensions of facial features for fitting facial products virtually. For example, the mouth-ear distance can be determined from an image to virtually try on or fit a mask. As another example, a user can send a selfie for an optometrist to remotely prescribe an eyeglass frame.

Further to the descriptions above, a user may be provided with controls allowing the user to make an election as to both if and when systems, programs, or features described herein may enable the collection of user information (e.g., information about a user's face, facial features, a user's preferences), and if the user is sent content or communications from a server. In addition, certain data may be treated in one or more ways before it is stored or used so that personally identifiable information is removed. For example, a user's identity may be treated so that no personally identifiable information can be determined for the user. Thus, the user may have control over what information is collected about the user, how that information is used, and what information is provided to the user.

CONCLUSION

This disclosure leverages the near constancy of eyeball diameter across the human population to predict the IPD using geometric and/or machine learning techniques. The visible portion of the eyeball (the iris) is used to infer eyeball position. The eyeball position and a priori known size serve as reference dimensions to determine the IPD and/or dimensions of other facial features.

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