EyeTab: Model-based gaze estimation on unmodified tablet computers

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https://www.cl.cam.ac.uk/research/rainbow/projects/eyetab/files/eww23_etra2014.pdf

Summary

The selected Paper provides the system called Eyetab for gaze estimation on hand held devices with low cost cameras. It could capacitate the user to visually interact with the device without using any external hardware. The system first extracts the small region of face containing both the eyes to reduce the search space. This minimizes the computational cost. It uses wavelets for detecting region of eyes and further segments it to get two rough regions of interest, each containing an eye. For theses ROIs it calculates the image gradient to achieve the eye centre region where most of the gradient vectors intersect. This gives the precise location of both the eyes and ROI is made finer to just fit the eye region. By using radial derivative of the eye ROI, it detects the elliptical boundary of the iris. It then maps the 2D ellipse to its position and orientation in 3D space from the prior knowledge of camera focal length and its distance from the user. And estimates the point of gaze from the intersection between eyes' optical axis and the screen.

Contribution

The main contribution of the method lies in the fact that it provides a low cost solution for gaze estimation. Thus this method can be integrated in handheld devices. Its strongest point lies in the fact that it detects radial edges by analyzing radial derivative to estimate the elliptical limbus points which makes the algorithm computationally less intensive but still maintaining the accuracy. Not using hough transform or canny edge detector ensures the robustness under various lighting conditions and blurriness of images(out of focus). To fit the semi-closed eyes, it approximates the eyelid with parabola and remove the limbus points that belong to the parabola.

Weak Points

The algorithm assumes the knowledge of user's distance from the screen. Although this approach is used to eliminate the requirement for camera calibration, but any significant deviation from this assumption can lead to inaccurate results. There are wide variety of users, some stick close to screen and others further off. Moreover using image gradient to achieve the eye ROI assuming the eye centre to be darkest can give wrong results under various conditions. For example, a dark skin tone with an illuminated spot in the eye centre will not give fine ROI for eyes and can make the fitting for limbus points difficult.

Experimental Methodology

For estimating the accuracy of the system, users are made to look on the screen at nine locations (in 3x3 grid pattern) at a distance of 20cm from the eyes. This gives a very restricted output range for gaze estimation. (for such a distance). We could have got better insight on the accuracy of the algorithm, had more number of participants were involved. This would have given method's response to different amount of eye opening and skin tone.

Future work

The system can be enhanced to give more smoother gaze position output by integrating the knowledge of head pose. If head pose is visible, it means user is at a greater distance which would mean more range for gaze movement.