

A Gaze-Estimation Algorithm for Single-Camera Remote Eye Tracking

Martin Böhme, Thomas Martinetz, and Erhardt Barth

Institute for Neuro- and Bioinformatics
University of Lübeck, Ratzeburger Allee 160, 23538 Lübeck, Germany

Many eye-tracking systems either require the user to keep their head still or involve cameras or other equipment mounted on the user's head. While acceptable for research applications, these limitations make the systems unsatisfactory for prolonged use in human-computer interfaces. Since the focus of our research is on improving visual communication using gaze guidance [1], we are interested in less invasive eye tracking techniques.

So-called "remote" eye-tracking systems, which do not require any equipment to be mounted on the user and allow the user to move their head freely within certain limits, have been described in the literature [2, 3], but the results appear to be not as accurate as those achieved using fixed or head-mounted devices, which achieve 0.5 to 1 degree of accuracy. Commercial remote eye trackers with high accuracy are available [4], but no implementation details have been published.

An important part of any eye-tracking system is the gaze estimation algorithm, which takes the position of the pupil and corneal reflex (CR) in the camera image and computes the user's direction of gaze from this information. In fixed eye trackers, bilinear or biquadratic interpolation schemes are usually employed for this task, but interpolation is not feasible in remote eye trackers because of the number of degrees of freedom is much greater.

We present a gaze-estimation algorithm that is based on an optically realistic model of the human eye. The model contains several user-dependent parameters, whose values are estimated during a calibration phase. The performance of the algorithm was assessed on simulated test data that contained a certain amount of noise in the measured position of pupil and CR to simulate camera errors. For moderate amounts of camera error, we obtain an average gaze estimation error of 0.5 degrees.

References

- [1] Information technology for active perception., 2002. URL <http://www.inb.uni-luebeck.de/Itap/>.
- [2] Carlos H Morimoto, Arnon Amir, and Myron Flickner. Detecting eye position and gaze from a single camera and 2 light sources. In *Proceedings of the 16th International Conference on Pattern Recognition*, volume 4, pages 314–317, 2002. ISBN 0 7695 1695 X.
- [3] Takehiko Ohno and Naoki Mukawa. A free-head, simple calibration, gaze tracking system that enables gaze-based interaction. In *Eye Tracking Research and Applications (ETRA)*, pages 115–122, 2004. ISBN 1 58113 825 3.
- [4] Tobii 1750 eye tracker, Tobii Technology AB, Stockholm, Sweden.