Combining low cost eye trackers for dual monitor eye tracking

Sebastian Balthasar[1], Manuel Martin[2], and Florian van de Camp[2] and Jutta Hild[2] and Jürgen Beyerer[2]

[1] University of applied sciences Karlsruhe, Germany
[2] Fraunhofer IOSB, Karlsruhe, Germany

1 Abstract

Today, typical input devices for computer systems are mouse and keyboard. Over the years, several techniques for user-interface enhancement have been investigated. Eye gaze tracking systems are such an enhancement [ZJ04], which provide input based on the current eye gaze of the user. In situations where manual input is challenging, e.g. due to physical limitations, gaze-based interaction provides a powerful alternative. Multi-monitor setups are becoming the norm and double-monitor systems are widespread in professional environments. Hence, it is worth considering gaze-based interaction also for multi-monitor setups. To our best knowledge, there are only sparse contributions on double monitor eye tracking [CXS+12], whether on how to build such a system or even on what performance such a system could provide. The few commercial solutions are prohibitively expensive for most use cases and require a complex setup.

We present an eye tracking system for a horizontal double-monitor setup. The system uses two self-designed remote single-monitor eye tracking devices using the pupil-corneal reflection method to determine the gaze position[QWLY13, GEVC04, HRF14]. Each device consists of a Point Grey Flea3 camera with an IR band pass filter, one Asus Xtion PRO Live camera system, two IR-LED clusters, and one processing unit (Figure 1). The detection pipeline consists of modules for face detection, pupil detection, corneal reflection detection, and gaze point determination. The basic approach is as follows: The RGB camera of the Xtion is used to detect the face of the user. The bounding box is transferred to the camera image of the Flea3 by means of coordinate transformation between the two calibrated cameras. The rough areas around the eyes are then extracted from the high-resolution Flea3 image using basic facial geometric assumptions. These eye patches are then used to detect the pupil and the two corneal reflections caused by the IR-LED clusters.

The depth information of the Xtion is used to compensate for the effect varying distances of the user to the eye tracker have.

To extend the single-monitor eye tracker to a dual-monitor setup, two eye trackers, as described above, one below each monitor are used. The use of two eye trackers causes four corneal reflections instead of just two in the image of each eye tracker. The placement of the eye trackers, however, causes two distinctive

pairs of reflections which can be separated and correlated to either eye tracker, by using their relative location to each other: the eye tracker to the right of the user will cause the pair of reflections on the left (looking at the eye) and vice versa. Figure 3 shows the right eye as seen from the right eye tracker (Figure 3a) and from the left eye tracker (Figure 3b). While this setup allows for eye tracking on two screens, an important question is how the additional corneal reflections affect the detection robustness and therefore, the accuracy of the whole system. For evaluation of the eye tracking system, 13 students volunteered in a user study (7 male, 6 female, average age 32.5). None of them wore glasses, one wore contact lenses. The apparatus consisted of two eye tracking devices, each placed in front of a monitor with a resolution of 1920x1200 pixels. The two monitors stood side by side, slightly turned towards the user (Figure 2). The participants sat in the center. We did not use a chinrest in our evaluation as this would not be accepted by our target users. For evaluation, the participants first calibrated each eye tracker with a 9-point calibration and then had to fixate fifteen points presented on each monitor. The points can be grouped into three sets: two sets followed the design provided by Tobii [Tob11] on their website, one containing points located within 30° of visual angle (main), the other set contained points laying at the upper corners of the monitors (top). The third group consists of two points located at the border where the monitors meet (border). The procedure is as follows: The points are displayed in order from the top left to the bottom right switching screens before showing points lower on the screen. The press of a button triggers the display of the next point. This evaluation was done on both screens with both eye trackers running and on the left screen with just the left eye tracker running. The results show that the additional corneal reflections do not cause any problems with the detection of reflections (see Table 1). The accuracy of the multi-eye tracker setup is not only as accurate as the single eye tracker case, it even outperforms it. Our best guess for this is the additional IR light sources, which improve the overall image quality and therefore, aid the accurate detection of the pupil and corneal reflections. We have shown, that with a simple adaptation, multiple single-monitor eye trackers can be combined to offer a cheap solution for multi-monitor eye tracking.

Point set	*main*	*top*	*border*
Dual right	$1.27^\circ (\sigma = 1.61^\circ)$	$1.63^\circ (\sigma = 3.07^\circ)$	$1.68^\circ (\sigma = 1.79^\circ)$
Dual left	$1.51^\circ (\sigma = 2.09^\circ)$	$2.09^\circ (\sigma = 3.44^\circ)$	$1.82^\circ (\sigma = 1.77^\circ)$
Single	$1.61^\circ (\sigma = 3.05^\circ)$	$2.23^\circ (\sigma = 4.72^\circ)$	$1.72^\circ (\sigma = 1.41^\circ)$

Table 1. Average error in degree for the different setups and target sets.

Fig. 1. Eye tracker setup with high resolution Flea3 camera, Asus Xtion, IR Led clusters and processing unit.

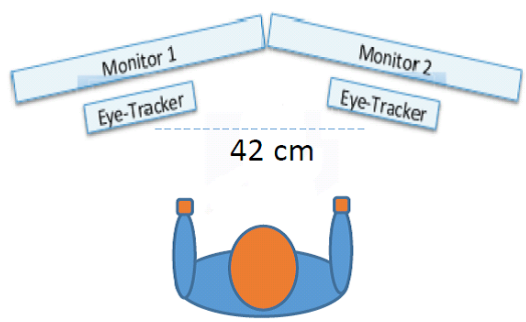

Fig. 2. Setup of two monitors and two eyetrackers for dual monitor eye tracking.

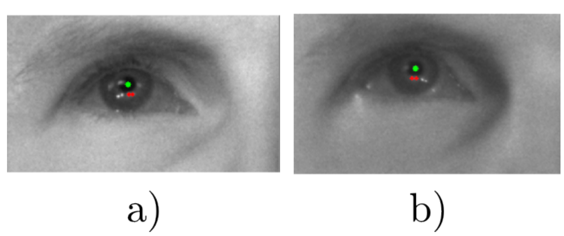

Fig. 3. Detected cornea reflections of the right eye tracker (a) and the left eye tracker (b)

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