The accuracy of Locarna's eye tracker (Pt-Mini)

We measured the accuracy of Locarna's eye tracker on 10 subjects. Out of these 10 subjects, 4 persons were wearing contact lenses, and the other 6 persons had normal vision. The subjects were graduate students in the School of Engineering Science at SFU. We designed an experiment similar to what you described, as follows.

The subjects were placed in the same experimental setup as we used in the original eye tracking study (same monitor, distance from the monitor, etc.) as described in Section II.C of the correspondence. We first displayed the nine blue calibration dots shown in Fig.1 on the monitor to calibrate the eye tracker. The calibration procedure was the same as explained in the correspondence. We then asked the subjects to fixate at each of the 12 red test dots shown in Fig. 2 for about one second, starting with the dot labeled 'A', then moving to dot labeled 'B' and so on up to dot labeled 'L'. The radius of the dots was 32 pixels. The relative position of the red test dots with respect to the blue calibration dots is shown in Fig. 3. As seen in Fig. 3, the test dots are positioned in between the calibration dots. The goal of this first test was to examine the accuracy of the eye tracker immediately after the calibration.

After the first test, we displayed a video (*Stefan*, CIF resolution) at the center of the screen (for about 7 seconds). The subjects were instructed to look wherever they wish in the video during this time. After they were shown the video clip, the measurement accuracy test was repeated on the red dot pattern shown in Fig. 2. The subjects were again asked to look at the test dots in sequence, starting with the dot labeled 'A', down to the dot labeled 'L'. The goal of this second test was to examine the accuracy of the eye tracker some time after the calibration.

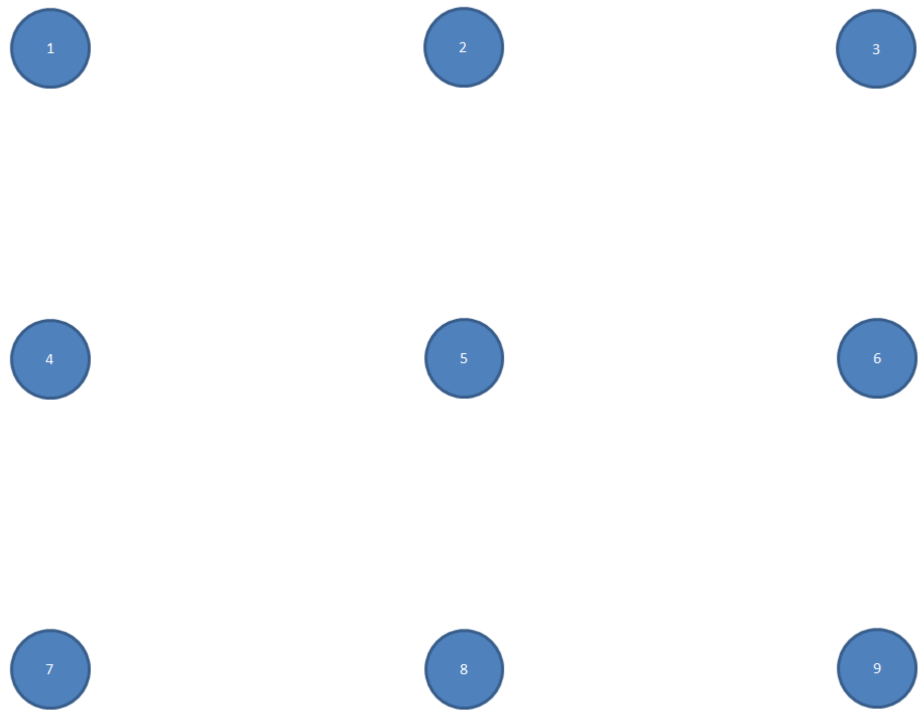

Fig.1. The calibration dot pattern used in the experiment.

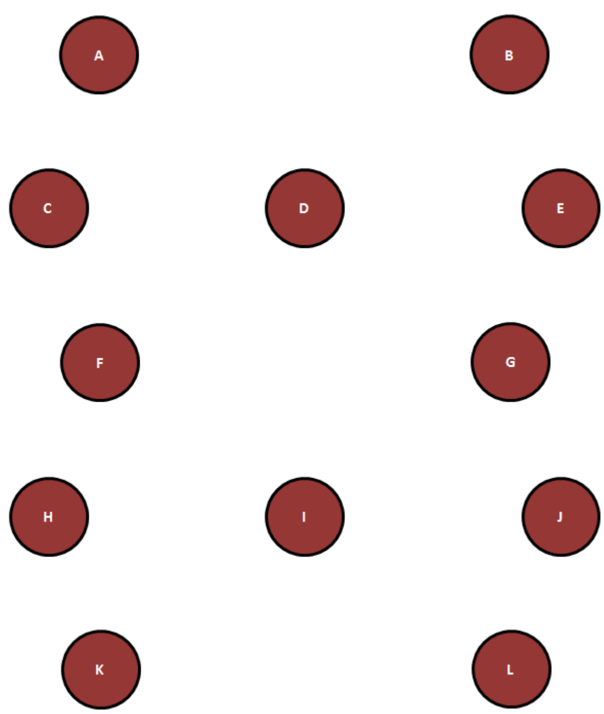

Fig.2. The test dot pattern used in the experiment.

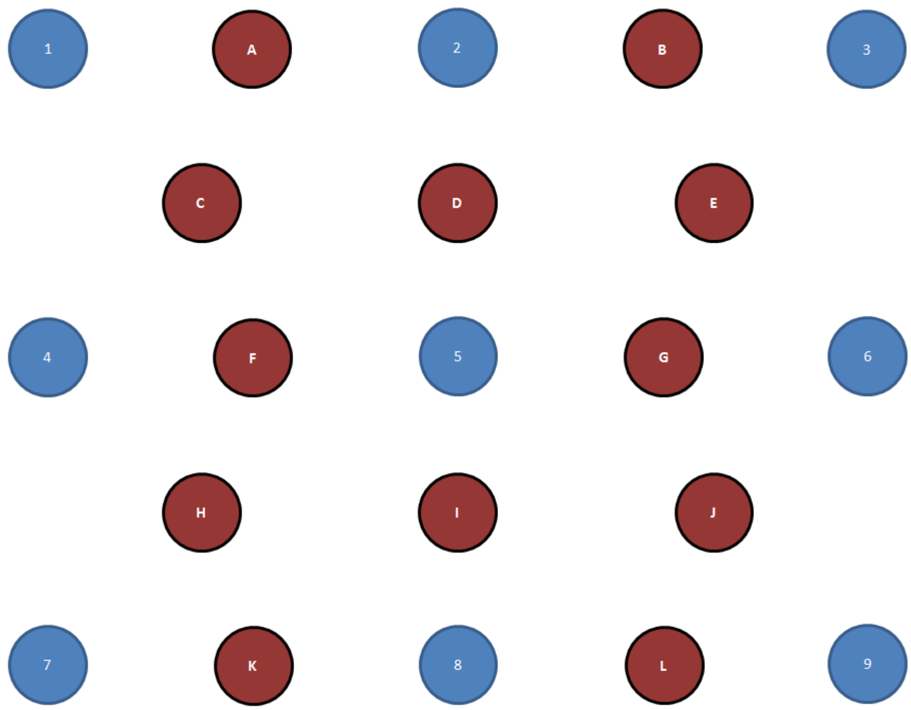

Fig.3. The relative position of the test dots with respect to the calibration dots.

In order to measure the accuracy of the eye tracker, we first isolated those frames that recorded the fixation. These were the frames where the point of gaze did not move by more than N pixels in M consecutive frames. In other words, in a fixation group of frames, the gaze point is allowed to move by at most N pixels in M consecutive frames. In our experiments, we set $N = 50$ pixels and $M = 7$ frames. There were 6770 fixation frames in total, hence, on average, 677 per subject.

We then computed the Euclidean distance between the centre of each test dot and the gaze location provided by the eye tracker in each frame of the corresponding fixation group. The computed distances were considered as the measurement errors in estimating the gaze location by the eye tracker. The obtained measurement errors are reported in Tables 1-3.

Table 1. Measurement error on all ten subjects

Mean	**Standard Deviation**
16.56 pixels (0.45 degree)	13.36 pixels (0.36 degree)

Table 2. Measurement error on subjects with/without contact lenses

Subjects	Mean	Standard Deviation
without contact lenses	15.61 pixels (0.42 degree)	11.25 pixels (0.30 degree)
with contact lenses	18.78 pixels (0.51 degree)	16.86 pixels (0.45 degree)
Difference	3.17 pixels (0.08 degree)	5.61 pixels (0.15 degree)

Table 3. Measurement error before and after watching the video clip

Viewing	Mean	Standard Deviation
before watching the video clip	15.63 pixels (0.42 degree)	13.24 pixels (0.35 degree)
after watching the video clip	18.25 pixels (0.49 degree)	13.16 pixels (0.35 degree)
Difference	2.62 pixels (0.07 degree)	0.08 pixels (0.00 degree)

We then performed a t-test to examine whether the measurement errors with and without contact lenses in Table 2 come from distributions with different means. The null-hypothesis was that the errors come from distributions with the same mean but unequal variance. The two-tailed p-value in this case was 9.3543×10^{-5}, indicating that the null-hypothesis needs to be rejected, and that the errors do come from distributions with different means. A similar test was performed for the two cases in Table 3 (before and after watching the video clip). The p-value was 7.8772×10^{-5} in this case, again indicating that the errors come from distributions with different means.

Based on the obtained results, the measurement error in the case of contact lenses tends to be higher than the error without lenses, and its distribution is different from the distribution of the error without lenses. However, the difference in the mean error in the two cases is very small, less than 0.1 degrees. Similarly, the measurement error was higher on the second test (after watching the video clip) than on the first test, but again the difference in the mean error was very small, less than 0.1 degrees. Overall, the mean measurement errors were around 0.5 degrees, well below the advertised accuracy of the Locarna eye tracker of 1 degree. Even the mean error plus one standard deviation of the error was less than the advertised accuracy. We believe this confirms the advertised accuracy of the Locarna eye tracker.

We uploaded a sample video of the performed experiment at http://www.youtube.com/watch?v=lOL38F2VBFE. This video shows the accuracy of the eye tracker on a subject wearing contact lenses with a mean error of about 0.52 degrees of visual angle, which was roughly the mean error on the subjects with contact lenses. The video shows the measured gaze point with a cross-hair, along with two concentric circles. The smaller circle has a diameter of 1 degree (i.e., radius of 0.5 degrees), and the larger circle has a diameter of 2 degrees (radius of 1 degree).