A binocular evaluation of pupil-size dependent deviation in measured gaze position

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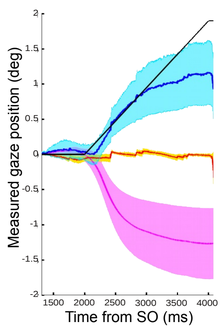
Introduction

Camera-based eye trackers are the mainstay of eye movement research and countless practical applications of eye tracking. Recently, a significant impact of changes in pupil size on gaze position as measured by camera-based eye trackers has been reported [Wyatt 2010], and a first attempt at compensating for this drift was proposed [Drewes et. al. 2012].

While ground truth was presented in Drewes et al., all previous studies used very few subjects to demonstrate this effect (5 and 2 respectively), and only monocular measurements were performed.



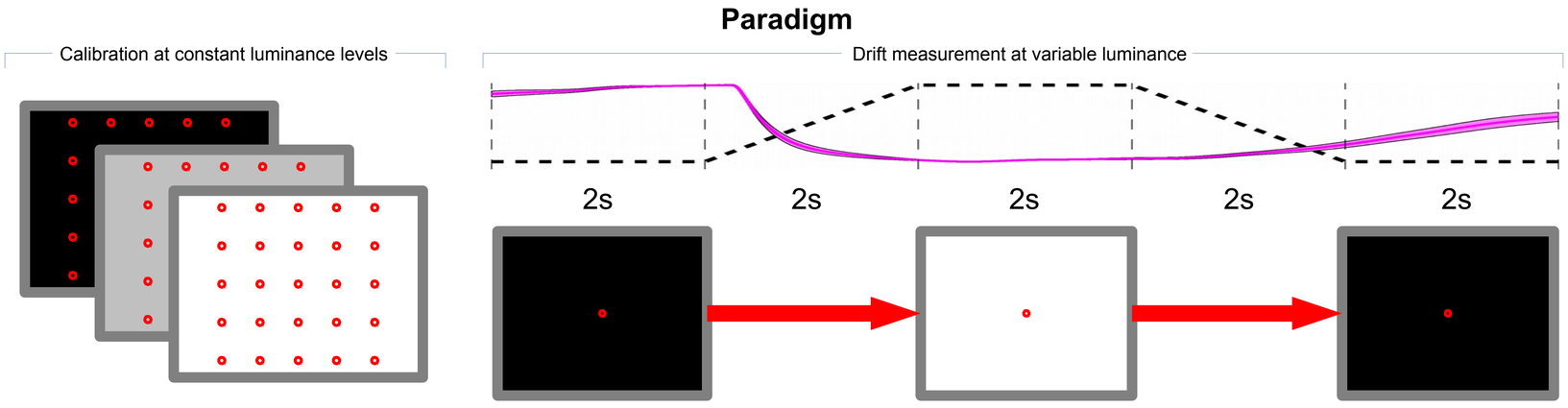
Drewes, J., Masson, G. S., & Montagnini, A. (2012). Shifts in reported gaze position due to changes in pupil size: ground truth and compensation. *In Proceedings of the Symposium on Eye Tracking Research and Applications* (pp. 209–212). New York, NY, USA: ACM. doi:10.1145/2168556.2168596

Wyatt, H. J. (2010). The human pupil and the use of video-based eyetrackers. *Vision Research*, 50(19), 1982–1988. doi:10.1016/j.visres.2010.07.008

Methods

To improve understanding of the magnitude and population-wise distribution of the pupil-size dependent shift in reported gaze position, we present the first collection of binocular pupil drift measurements recorded from 20 subjects. Subjects were students at Yunnan University. Eye movement data was recorded binocularly using an SR Research Eyelink 1000. Pupil size changes were induced by changing the background luminance of the screen. Gaze measurements were calibrated on 5x5 point grids with 5 degree spacing, using several background luminance levels. We evaluate 3 different approaches to compensate for the pupil-size induced drift.

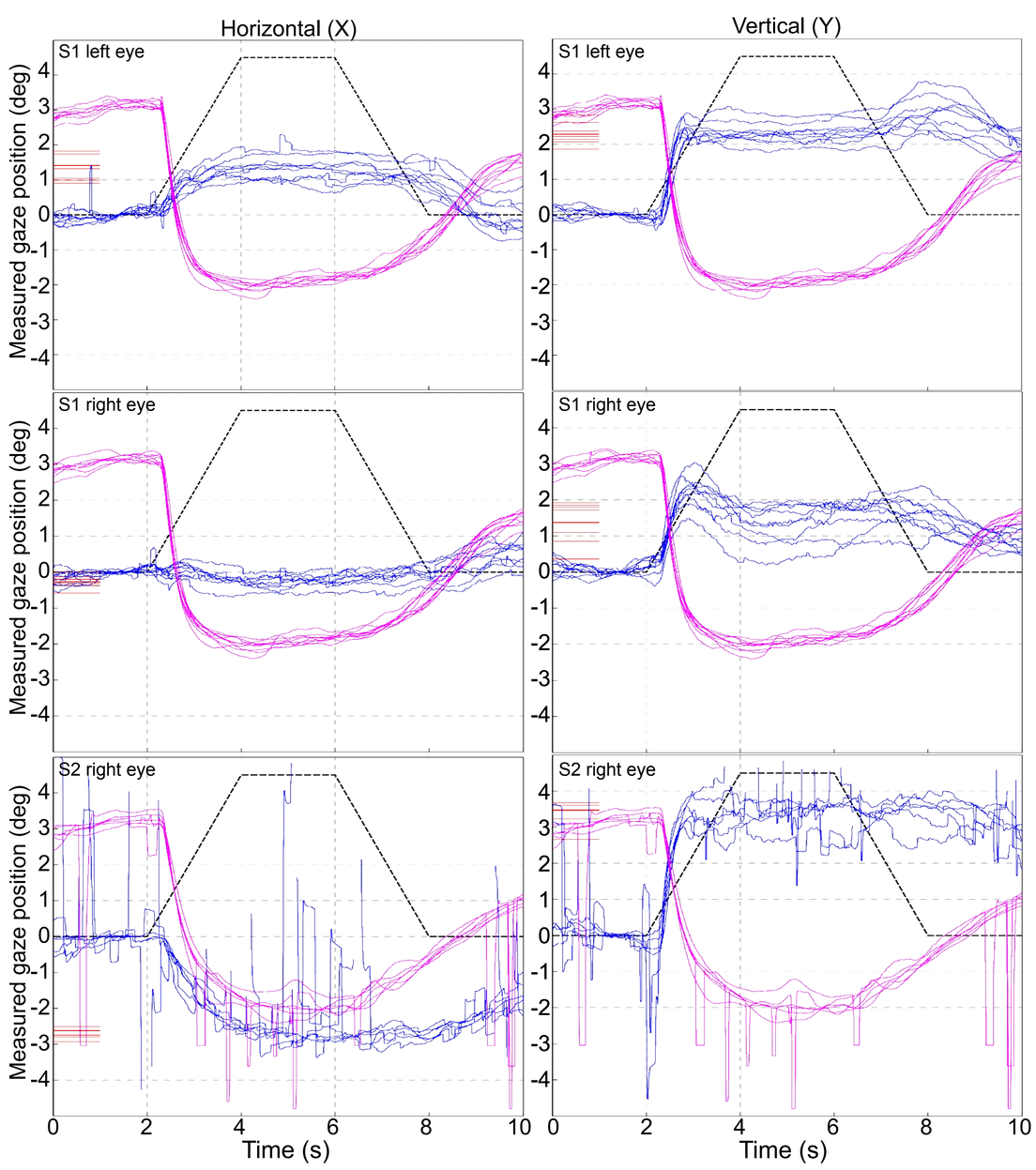
Paradigm



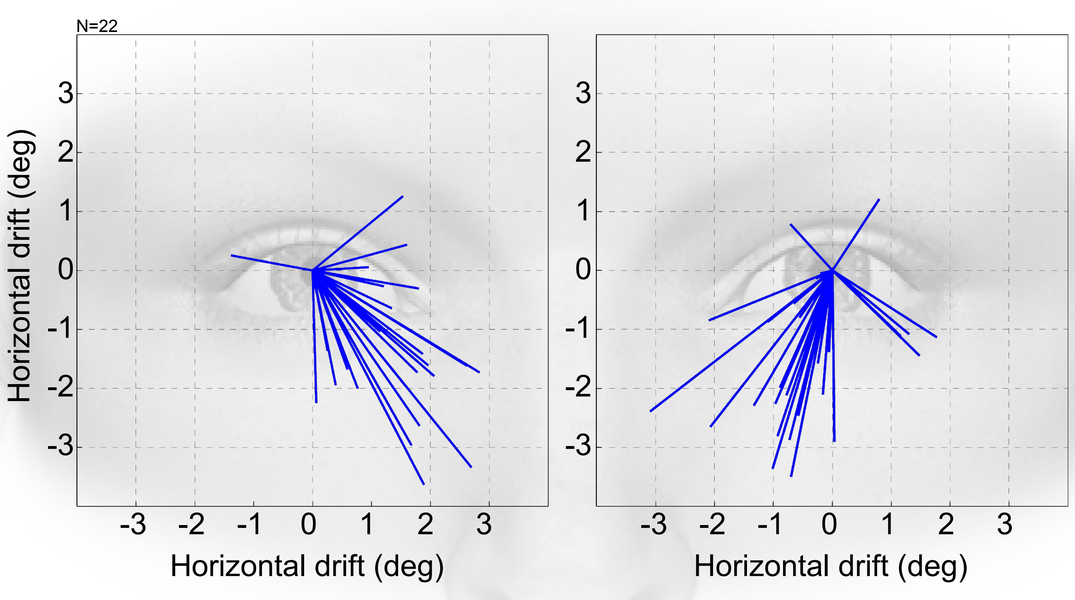
Results

Raw Data

Subjects were asked to fixate steadily, while background luminance changed

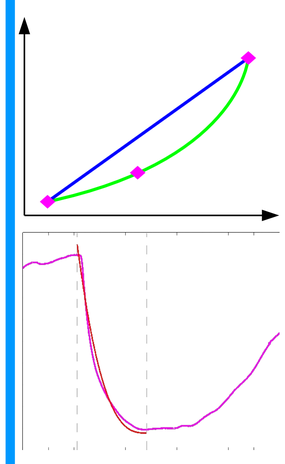


Drift Direction Distribution



Mean drift amplitude: 2.4 degree (0.8 – 4.3)

Drift Compensation

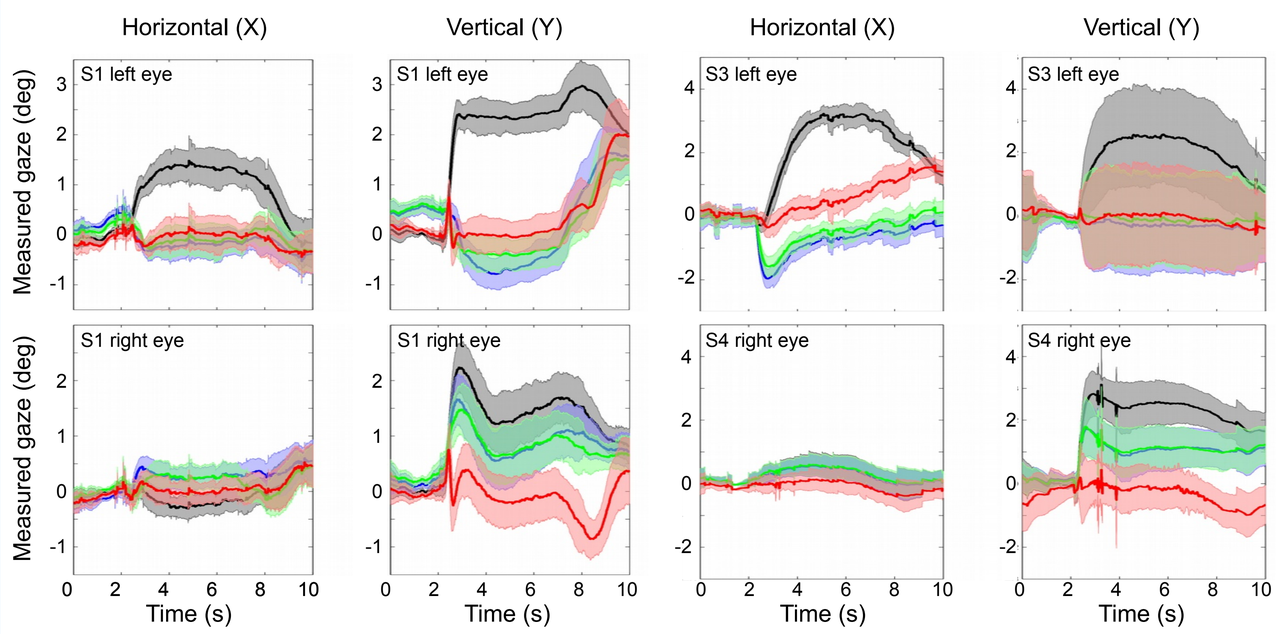


2-Point: Gaze data is interpolated between **2 calibrations at maximum and minimum luminance**, with pupil size as interpolation index. Fast, simple, but only linear – not very precise.

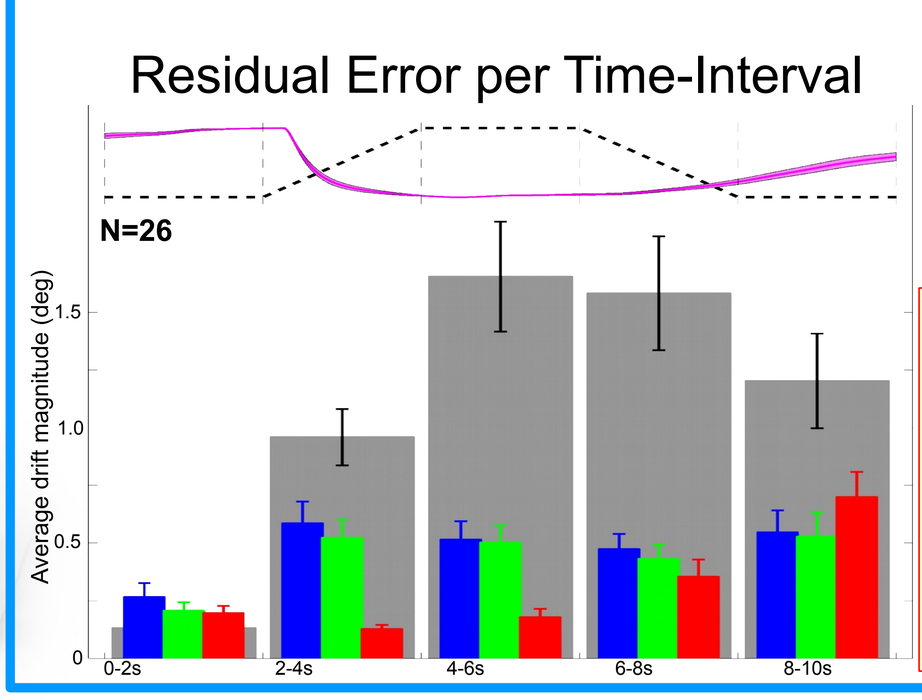
3-Point: Gaze data is interpolated by fitting a quadratic function to **3 calibrations at maximum, minimum and intermediate luminance**, with pupil size as interpolation index. Still fast, more accurate than 2-Point.

LUT: Gaze data is corrected by means of a **look-up-table mapping pupil size to drift magnitude**. The LUT is constructed in direction of pupil constriction, resulting in best accuracy during constriction, but reduced accuracy during dilation (hysteresis).

Drift Compensation Results



Residual Error per Time-Interval



Raw gaze
2-Point
3-Point
LUT

Average Residual Error:

2-Point: 43%

3-Point: 40%

LUT: 28%

Conclusions

The **absolute pupil-size dependent drift** varied greatly between subjects (**0.8 to 4.3 degree**, **mean 2.4 degree**), but also between the eyes of individual subjects (0.16 to 1.7 degree difference)

The **preferred drift direction was inwards and down**, in direction of pupil constriction

Our **compensation method** optimized in direction of constriction **reduced drift by 72%** (avg).