Online Calibration of Gaze Tracking on the Computer Screen using Particle Filtering

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1 Introduction

Visual salience is usually not evenly distributed on the computer screen. Most of the time, there is only a limited number of highly salient points instead. These points naturally attract fixations. If the points of visual salience are known to a gaze tracking system, its calibration could be inspected and also enhanced on their basis. But how should gaze be mapped to one of the salient points during this process? This mapping can not be established from a single observation. Particle filtering (Kantas et al., 2009) allows to maintain several hypotheses about where the user is currently looking and integrates this with where the user has looked before, finally converging to a most likely gaze position. We are presenting a particle filter that estimates the calibration drift of a head-based gaze tracking system.

2 The Problem of Calibration in Eye-Tracking

Eye-tracking, whether applied in the lab or in the field, needs calibration (Poole and Ball, 2005). While this is usually bearable for normal subjects, standard gaze calibration procedures often fail for children or some patient groups because they cannot keep their gaze on a fixation point for the required amount of time. In this case, the identification of “correct” gazes during calibration has to be done by the experimenter in a tedious and lengthy process (c.f., Franchak et al., 2011). Pursuit calibration (Pfeuffer et al., 2013) could be a solution to this, but is still in its infancy.

How can we alleviate this situation? We propose to use particle filtering to estimate the gaze position. Particle Filters have been applied to the machine vision side of eye-tracking, i.e., iris detection and tracking, before (Hansen and Pece, 2005).

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Here we extend this idea to the calibration and gaze estimation part of the problem. As a starting point, we try to estimate a time dependent drift of the estimated gaze position. Drift may be caused by, e.g., the headband being dragged down by the weight of the tracker, or subject actions like lifting the eyebrows.

3 Gaze Controlled HTML5 Shooting Game

As empirical basis for the drift estimation, data collected using a simple gaze controlled HTML5 shooting game based on Halbrügge (2015) was chosen. Task of the game was to “shoot” rectangles of a specific color by looking at them. To make gaze control easier, a small fixation cross was added to the center of the target objects (see Figure 1). The game took about three minutes to play with about 250 targets to shoot. The players’ gaze was tracked using a head-based SR Research EyeLink II with 250 Hz sampling frequency; no chinrest was used.

The connection from the eye tracker to the game was established using SR Research’s proprietary ethernet link and the web browser bridge described in Halbrügge (2015). Gaze interaction was provided by triggering virtual clicks on the browser’s JavaScript layer after a dwell time of 300 ms. Neither eye tracker nor display latency was compensated as both were negligibly small relative to the dwell time.

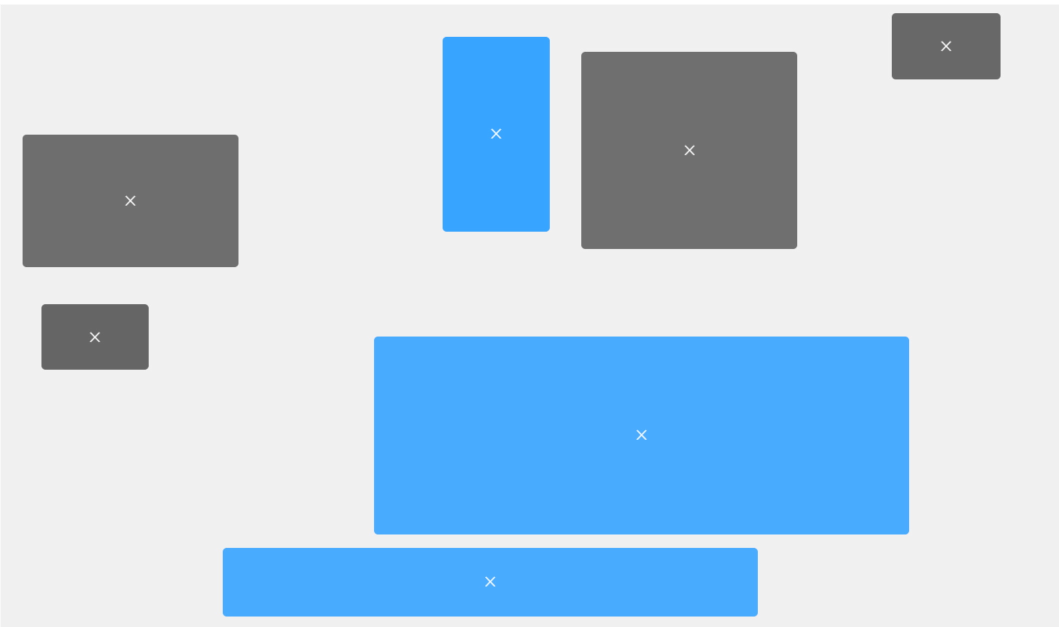

Fig. 1 Gaze controlled HTML5 game. The players have to “shoot” colored rectangles by looking at them. White crosses at the center of each target act as points of maximum salience.

Subsequent analysis showed that significant detoriation of the calibration happened during the gaming episodes. A fitted linear model showed substantial drift,

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especially in the vertical dimension. This is consistent with the rather bulky and heavy headmount of the gaze tracker used for the game.

4 Particle Filter Results and Conclusions

Post-hoc analysis of the data using the particle filter approach showed that the detoriation of the calibration could easily be counteracted. As few as 1000 particles were enough to attain convergence and considerable error reduction. Each filter step needed less than 2 ms computation time on a consumer laptop computer, which would fast enough to run it in sync with the 250 Hz eye tracker used for the game.

As next step, we are planning to integrate the drift estimator into the tracking system. This should bring us closer to the goal of less intrusive calibration of gaze tracking systems. In the future, calibration could be performed by playing a simple game or watching a funny stickman video.

While this research has been guided by the goal of easier eye tracking for specific subject groups like children, and although it is currently restricted to HTML applications, it is not necessarily bound to these domains. Future applications could include calibration-free gaze interaction with large public displays, or continuous drift correction during mobile eye tracking.

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