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PursuitAdjuster: An Exploration into the Design Space of Smooth Pursuit–based Widgets

Motivation

Pursuit movements generated when a person follows a moving target can be used for interaction with “uncalibrated“ trackers. The system can measure which target is being pursued as long as the gaze moves on a trajectory that is similar enough to the trajectory of the desired target despite possible large offset in the actual gaze point location.

We investigated smooth pursuit in adjusting a continuous value using a linear (scroll bar) and circular (knob) widgets.

Design

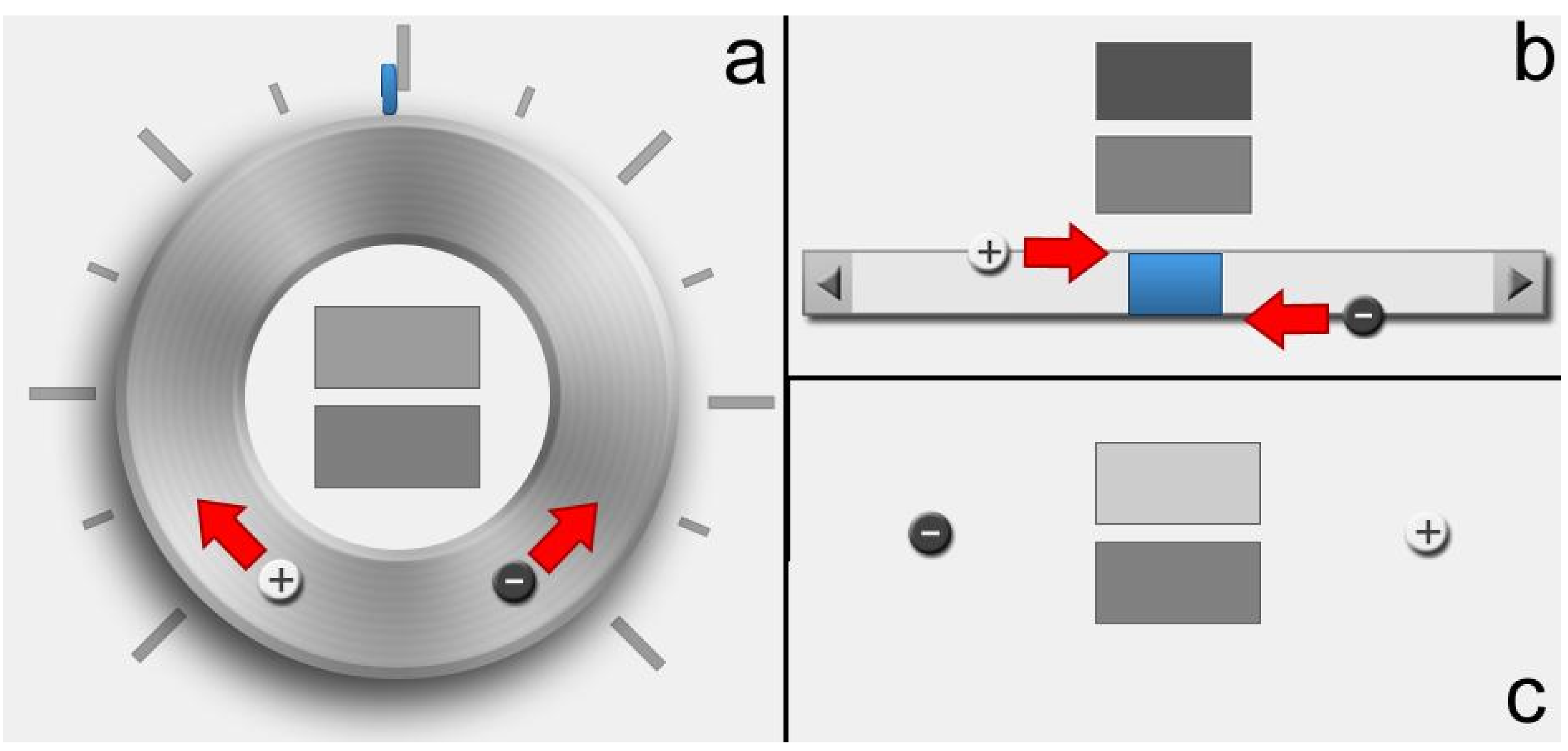

Figure 1. Smooth-pursuit operated widgets (a – circular, b – linear) were compared against dwell-time operated widget (c). Red arrows show the gaze targets movement direction

The circular widget (see Fig. 1a) was inspired by a rotary knob. It is operated by following one of the gaze targets (small circular object with + or - on it) with the gaze. These targets circulate around the control into opposite directions.

The linear widget (see Fig. 1b) was inspired by a scroll bar. The targets travel to one end of the control and then jump back to the other end. This causes a discontinuity in the following, but the widget occupies a smaller space than the circular widget.

The speed of the targets was 3.3 °/s; the rate of change of color was 33 levels/s. The path radius in the rotary control was 3.5°, i.e. the length of the path was 22.3°, and targets made a full circle in 6.8 s. The length of the scrollbar was 11°; the targets traveled it in 3.3 s.

We compared these smooth-pursuit operated widgets against dwell-time operated widget with nonmoving gaze target (see Fig 1c). To match the smooth pursuit techniques, the dwell time threshold was set to 600 ms, and the gray level changing speed was also 33 levels/s.

Pursuit detector

The pursuit detection algorithm was based on estimating the standard deviation (SD) of distances between the gaze points and the targets during 600 ms. The target with the smallest SD becomes selected if its SD < 0.4°. Another target may become selected if its SD stays smaller than the current’s target SD for at least 200 ms (rapid target switch prevention). The required length of gaze path was in the range of 0.5 – 1.5 times of the length of the target path.

Experiment

The widgets were compared against each other in a study where 12 participants adjusted the brightness level (0-255) of a rectangle to approximately match the target tone given on a rectangle above it (grey rectangles in Fig. 1). Twenty practice trials and 40 recorded trials were completed. A short “tick” sound was heard every 100 ms as long as the adjustment continued.

Tobii T60 eye tracker was used. We needed a well calibrated tracker for the dwell control condition. We did normal calibration and applied a random offset (5-11°) to the tracker data before our algorithm processed it for the pursuit operated widgets

Results and Conclusions

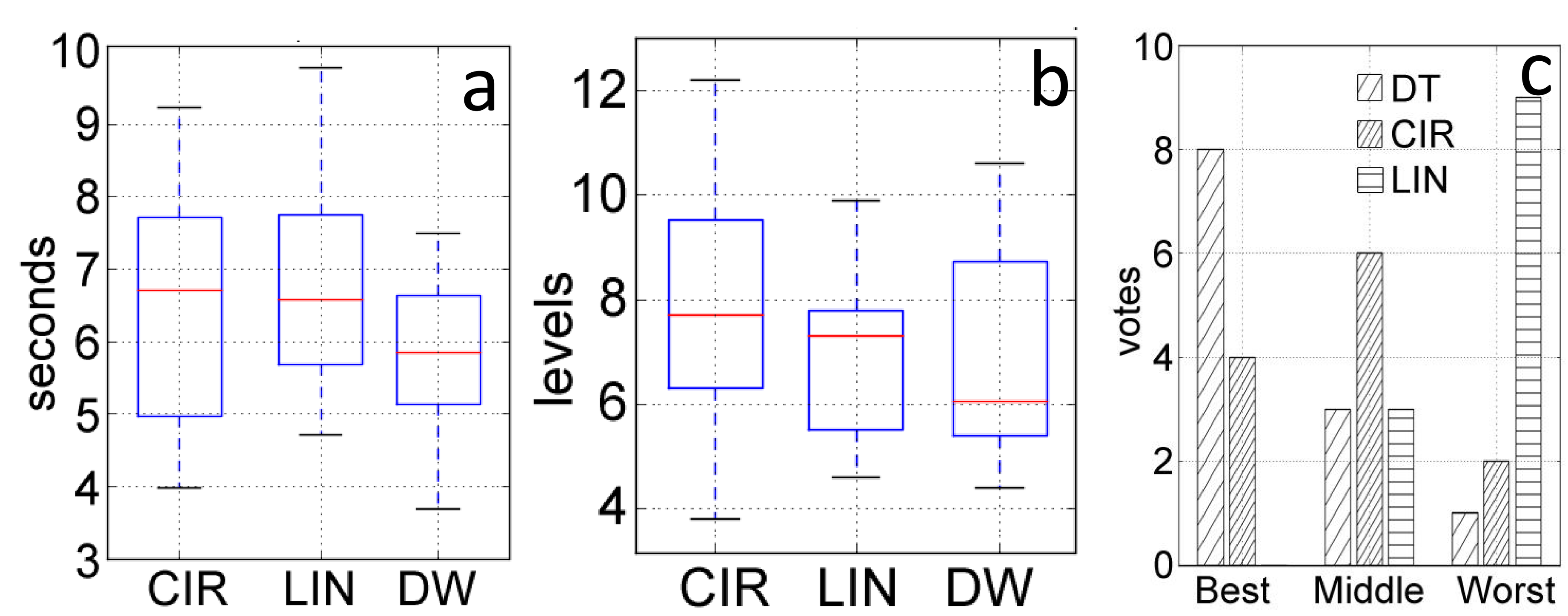

Figure 2. Trial completion time (a), average error (b) and rating statistics (c) for circular (CIR),.linear (LIN) and dwell-time (DT) operated widgets

The smooth pursuit techniques were competitive with dwell time in performance and user preference. The linear technique was somewhat inferior to the others due to the inherent handicap of a 600 ms pause at each jump. The adjustment error was about equal for all widgets.

The smooth pursuit techniques showed great promise in allowing precise control with an eye tracker regardless of the tracker offset. They can be valuable interaction techniques with wearable trackers in real-world control tasks.