Pupillary measurement during an assembly task
We conducted an empirical study of 57 children using a printed Booklet and a digital Tablet instruction for LEGO® construction while they wore a head-mounted gaze tracker. Booklets caused a particularly strong pupil dilation when encountered as the first media. Subjective responses confirmed the booklet to be more difficult to use. The children who were least productive and asked for assistance more often had a significantly different pupil pattern than the rest. Our findings suggest that it is possible to collect pupil size data in unconstrained work scenarios, providing insight to task effort and difficulties.

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A Fitts' law study of click and dwell interaction by gaze, head and mouse with a head-mounted display

Gaze and head tracking, or pointing, in head-mounted displays enables new input modalities for point-select tasks. We conducted a Fitts' law experiment with 41 subjects comparing head pointing and gaze pointing using a 300 ms dwell (n = 22) or click (n = 19) activation, with mouse input providing a baseline for both conditions. Gaze and head pointing were equally fast but slower than the mouse; dwell activation was faster than click activation. Throughput was highest for the mouse (2.75 bits/s), followed by head pointing (2.04 bits/s) and gaze pointing (1.85 bits/s). With dwell activation, however, throughput for gaze and head pointing were almost identical, as was the effective target width (∼55 pixels; about 2°) for all three input methods. Subjective feedback rated the physical workload less for gaze pointing than head pointing.

General information

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A gaze interactive assembly instruction with pupillometric recording

This paper presents a study of a gaze interactive digital assembly instruction that provides concurrent logging of pupil data in a realistic task setting. The instruction allows hands-free gaze dwells as a substitute for finger clicks, and supports image rotation as well as image zooming by head movements. A user study in two LEGO toy stores with 72 children showed it to be immediately usable by 64 of them. Data logging of view-times and pupil dilations was possible for 59 participants. On average, the children spent half of the time attending to the instruction (S.D. 10.9%). The recorded pupil size showed a decrease throughout the building process, except when the child had to back-step: a regression was found to be followed by a pupil dilation. The main contribution of this study is to demonstrate gaze-tracking technology capable of supporting both robust interaction and concurrent, non-intrusive recording of gaze- and pupil data in-the-wild. Previous research has found pupil dilation to be associated with changes in task effort. However, other factors like fatigue, head motion, or ambient light may also have an impact. The final section summarizes our approach to this complexity of real-task pupil data collection and makes suggestions for how future applications may utilize pupil information.
Enhancing User Experience in Next Generation Mobile Devices Using Eye Tracking as a Biometric Sensor

A good User Experience is not about just “getting the job done” in the most efficient way. It is also about the subjective elements, providing a positive experience to the user while doing so; emotionally and affectively, having the user engage with the service or product.

Knowing when this takes place means we need ways of measuring concepts like attention. The basis for this should preferably be rooted in our understanding of the anatomically based attention networks of the brain.

This thesis looks at biometric markers of cognitive and affective processes; at the overview level Electroencephalography (EEG), Galvanic Skin Conductance (GSR), Heart Rate and Heart Rate Variability as well as Face Expression Detection – and in much more detail Eye Tracking.

A simple framework for relating eye movements and pupil dilations to the visual processing system and to the attentional networks is suggested. It is demonstrated that it is possible to identify components of attention and cognitive load using low cost eye tracking in conventional office settings. It is also shown that aspects of surprise, similar to negativity feedback error coding, is measurable. Behavioural patterns possibly related to time on target, cognitive load, performance or stimuli are inferred. The existence of possibly unique individual gaze patterns related to visual stimuli or to the brain’s Default Mode Network are shown.

A way of synchronizing EEG and Eye Tracking is also suggested, and in addition, a few software assets (a Python interface to The Eye Tribe tracker and an implementation of the Attention Network Test (ANT)) have been created.

SensibleSleep: A Bayesian Model for Learning Sleep Patterns from Smartphone Events

We propose a Bayesian model for extracting sleep patterns from smartphone events. Our method is able to identify individuals’ daily sleep periods and their evolution over time, and provides an estimation of the probability of sleep and wake transitions. The model is fitted to more than 400 participants from two different datasets, and we verify the results against ground truth from dedicated armband sleep trackers. We show that the model is able to produce reliable sleep estimates with an accuracy of 0.89, both at the individual and at the collective level. Moreover the Bayesian model is able to quantify uncertainty and encode prior knowledge about sleep patterns. Compared with existing smartphone-based
systems, our method requires only screen on/off events, and is therefore much less intrusive in terms of privacy and more battery-efficient.

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Assessing Levels of Attention Using Low Cost Eye Tracking

The emergence of mobile eye trackers embedded in next generation smartphones or VR displays will make it possible to trace not only what objects we look at but also the level of attention in a given situation. Exploring whether we can quantify the engagement of a user interacting with a laptop, we apply mobile eye tracking in an in-depth study over 2 weeks with nearly 10,000 observations to assess pupil size changes, related to attentional aspects of alertness, orientation and conflict resolution. Visually presenting conflicting cues and targets we hypothesize that it’s feasible to measure the allocated effort when responding to confusing stimuli. Although such experiments are normally carried out in a lab, we have initial indications that we are able to differentiate between sustained alertness and complex decision making even with low cost eye tracking “in the wild”. From a quantified self perspective of individual behavioural adaptation, the correlations between the pupil size and the task dependent reaction time and error rates may longer term provide a foundation for modifying smartphone content and interaction to the users perceived level of attention.

Thinking outside of the box or enjoying your 2 seconds of frame?

The emergence of low cost eye tracking devices will make QS quantified self monitoring of eye movements attainable on next generation mobile devices, potentially allowing us to infer reactions related to fatigue or emotional responses on a continuous basis when interacting with the screens of smartphones and tablets. In the current study we explore whether consumer grade eye trackers, despite their reduced spatio-temporal resolution, are able to monitor fixations as well as frequencies of saccades and blinks that may characterize aspects of attention, and identify consistent individual patterns that may be modulated by our overall level of engagement.
In the twinkling of an eye: synchronization of EEG and eye tracking based on blink signatures

ACHIEVING ROBUST ADAPTIVE SYNCHRONIZATION OF MULTIMODAL BIOMETRIC INPUTS: The recent arrival of wireless EEG headsets that enable mobile real-time 3D brain imaging on smartphones, and low cost eye trackers that provide gaze control of tablets, will radically change how biometric sensors might be integrated into next generation user interfaces. In experimental lab settings EEG neuroimaging and eye tracking data are traditionally combined using external triggers to synchronize the signals. However, with biometric sensors increasingly being applied in everyday usage scenarios, there will be a need for solutions providing a continuous alignment of signals. In the present paper we propose using spontaneous eye blinks, as a means to achieve near real-time synchronization of EEG and eye tracking. Analyzing key parameters that define eye blink signatures across the two domains, we outline a probability function based algorithm to correlate the signals. Comparing the accuracy of the method against a state of the art EYE-EEG plug-in for offline analysis of EEG and eye tracking data, we propose our approach could be applied for robust synchronization of biometric sensor data collected in a mobile context.

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In the twinkling of an eye: synchronization of EEG and eye tracking based on blink signatures

Your heart might give away your emotions

Estimating emotional responses to pictures based on heart rate measurements: Variations in Heart Rate serves as an important clinical health indicator, but potentially also as a window into cognitive reactions to presented stimuli, as a function of both stimuli, context and previous cognitive state. This study looks at single-trial time domain mean Heart Rate (HR) and frequency domain Heart Rate Variability (HRV) measured while subjects were passively viewing emotionally engaging images, comparing short random presentations with grouped sequences of either neutral, highly arousing pleasant or highly arousing unpleasant pictures. For the grouped sequences, we found a trend in the mean HR that could correlate with the emotional content of the images, but no such trends was seen in the random trials. We were, however, not able to demonstrate HRV variations that correlated with the presented emotional content, nor could we reproduce earlier studies, with different experimental setups that were based on average values over many subjects, that had revealed small changes in the mean HR only seconds after presentation.

General information
Enhancing User Experience in Next Generation Mobile Devices by Combining Eye Tracking with Biometric Data
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