EOG Glasses - an Eyewear Platform for Cognitive and Social Interaction Assessments in the Wild

George Chernyshov
chernyshov@kmd.keio.ac.jp
Keio Media Design
Japan

Benjamin Tag
tagbenja@kmd.keio.ac.jp
Keio University
Tokyo, Japan

Kirill Ragozin
kirill@kmd.keio.ac.jp
Keio University
Tokyo, Japan

Kai Kunze
kai@kmd.keio.ac.jp
Keio Media Design
Japan

ABSTRACT

In this work we present the smart eyewear demo setup consisting of the software platform for cognitive and social interaction assessments in the wild, with several application cases and a demonstration of activity recognition in real-time. The platform is designed to work with Jins MEME, smart EOG enabled glasses, The user software is capable data logging, posture tracking and recognition of several activities, such as talking, reading and blinking. In this work we present several applications and studies that the platform has been used for.

MobileHCI '19, October 1–4,2019, Taipei, Taiwan

ACM ISBN 978-1-4503-6825-4/19/10…$15.00
https://doi.org/10.1145/3338286.3344418

CCS CONCEPTS

• **Human-centered computing** → **Human computer interaction (HCI)**; **Ubiquitous and mobile computing systems and tools**; *Interaction devices*; *Interactive systems and tools*; *Interaction design theory, concepts and paradigms*; Information visualization; Visualization theory, concepts and paradigms.

KEYWORDS

eye wear, activity recognition, cognition awareness

ACM Reference Format:

George Chernyshov, Benjamin Tag, Kirill Ragozin, and Kai Kunze. 2019. EOG Glasses - an Eyewear Platform for Cognitive and Social Interaction Assessments in the Wild. In *21st International Conference on Human-Computer Interaction with Mobile Devices and Services (MobileHCI '19), October 1–4, 2019, Taipei,Taiwan.* ACM, New York, NY, USA, 5 pages. https://doi.org/10.1145/3338286.3344418

INTRODUCTION

The rise of commercially available wearable fitness-tracking devices capable of recognizing physical activities, recording heart rate, oxygen saturation, and even Electrocardiography (ECG) and Electrodermal Activity (EDA) has enabled the general public to track their own health condition daily without the need to visit a physician. Data gathered from these devices allows the research community to perform studies in the wild and in unprecedented scales. A major part of the fitness-trackers currently available on the market are worn on the wrist. However, we believe that by experimenting with the sensor placement and sensing modalities we can achieve better and deeper insights. For example, placing sensors on the head allows to read signals related to cognitive and social activities through enabling additional Electroencephalography (EEG) and Electrooculography (EOG) recording in additions to all the signals accessible on the wrist[1].

In this work we present the software and hardware platform for cognitive and social interaction assessments in the wild, with several application cases and a demonstration of activity recognition in real-time. The platform is built around Jins MEME (see Fig.**??**), smart eyewear capable of recording EOG and head movement. Lightweight design, modern appearance and long battery life make this device perfect for long term EOG recordings in everyday situations outside of controlled lab environments. These kinds of unobtrusive devices can be the next step in personal fitness tracking and could enable large scale research of mental, cognitive, and social dynamics. Especially, the use of EOG and placement of the IMU inside the glasses temples opens up many interesting perspectives for research.

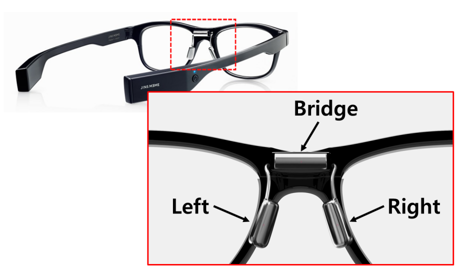

Figure 1: Jins MEME smart glasses with closeup on the EOG electrodes

UNOBTRUSIVE SENSING

Pervasive sensing solutions and study methods that allow for deducing information that describe contexts are traditionally intrusive by character. Even though they describe established and well researched methods, sleep diaries, rectal temperature readings, blood sampling, or the utilization of medical grade appliances such as fMRI, EEG, or Functional Near-Infrared Spectroscopy (fNIRS) tend to change the actual context of the user when being utilized. Even already available consumer product solutions often tend to distract their user or require active input which causes disruptions of the actual activity and thus, negatively influence productivity [4]. The challenge is how to reliably sense and monitor changes of cognitive and physical performance without overtly altering the context of the user.

Placement of the sensors on or near the head has multiple advantages compared to other body parts. It allows readings related to eye and brain activity. Placement of an IMU on the head allows tracking of user's posture, and allows to detect and warn the user in times of bad posture, potentially preventing the development of medical issues such as scoliosis and lordosis. Besides everyday tracking, gait monitoring can be beneficial to aid the wearer during athletic activities. Additionally, head motion is known to be related to speech and social interactions [2, 5], giving insights into the social domain without compromising user's privacy potentially caused by otherwise used microphones and cameras. The ability to record and track these parameters throughout the day using a wearable device, therefore, adding new dimensions to fitness and activity tracking in both individual, and group settings.

APPLICATION CASES

Activity and Cognition Recognition

Research by Ishimaru *et al.* [3] has shown that it is possible to use eye blinks and head motion patterns recorded on sensing glasses to distinguish between different activities, such as reading, talking, watching TV, mathematical problem solving, and sawing.

Another unique application field provided by smart eyewear are measurements of diurnal fatigue and alertness levels. It has been shown that EOG recordings in the wild, enable inference of fatigue levels throughout the day through analysis of blink frequency changes [8].

The monitoring of eye movement features such as eye blink patterns also enables us to identify more complex cognitive processes, such as anticipation and engagement. Studies on the blink patterns of subjects with Autism Spectrum Disorder (ASD) suggest that by observing eye blink features, levels of engagement of the subjects with their environment can be inferred [6, 7]. For example, researchers at Emory University used recorded video scenes to observe changes in blink patterns in children with and without ADS. The results showed that both groups delayed their eye blinks when scenes were especially interesting and engaging. Nevertheless, the inhibition of blinks by children without ASDs

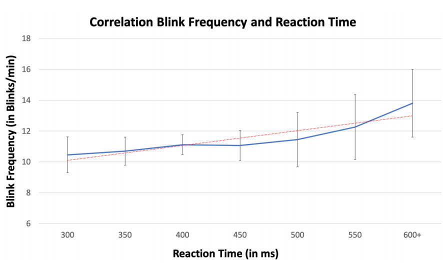

Figure 2: Correlation of blink rate with reaction time [8].

was quicker. This, so Schultz *et al* [7], is a sign of active anticipation of contents shown in videos. By following the storyline, they were expecting actions to unfold.

DEMO SETUP

The presented setup consists of applications running on Android, MacOS and Windows platforms with a cross-platform recording server and real time demos for activity recognition, potentially enabling long-term in-the-wild studies, too. In its present form the platform uses Jins MEME, but is flexible enough to be adjusted for any other similar device. Since MEME is not capable of running user applications it requires a Bluetooth Low Energy (BLE) enabled device for data recording and analysis.

The presented setup consists of data gathering tools and activity recognition systems developed over the years and used by our lab. We are proud to present and share with the community our tools, hoping to enable and inspire more research in this area. Presented tools allow large scale data recordings, real time activity recognition and demonstrate how smart eyewear can be used for input and implicit interactions.

The recording server software is developed using the Qt framework and is fully cross-platform, allowing us to record multiple users simultaneously all over the world without requiring complex infrastructure. The user software is capable data logging, posture tracking and recognition of several activities, such as talking, reading, blinking, etc. based on the data logged through the J!NS MEME. Although the EOG data is not sufficient for eye-tracking, relative eye movements, enable the identification of activities such as reading from repetitive rhythmical left-right eye movements. Talking can be characterized by increased blink rates and clearly identifiable patterns of head motion. Such activities cannot be recognized using traditional wrist-worn trackers and serve as a good example of the new approaches to personal fitness tracking and its possible expansion into cognitive and social domains, as it is demonstrated in the Application cases section.

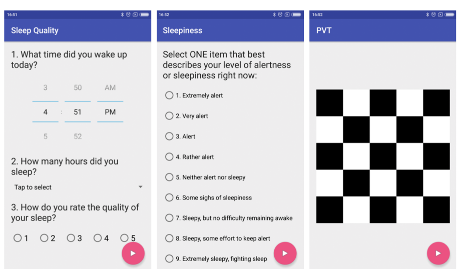

Figure 3: User application for data recording with customizable surveys.

CONCLUSION

The use of commercially available wearable sensing devices is often unnecessarily complicated due to lack of suitable software and closed protocols. Presented platform and application cases are intended to share our experience and tools with the community and inspire new research and collaborations.

ACKNOWELEDGEMENTS

The here presented work is partly supported by JST Sakigake grant number JP-MJPR16D4 and JSPS Kiban B 18H03278.

REFERENCES

[1] Oliver Amft, Florian Wahl, Shoya Ishimaru, and Kai Kunze. 2015. Making regular eyeglasses smart. *IEEE Pervasive Computing* 14, 3 (2015), 32–43.

[2] Carlos Toshinori Ishi, Hiroshi Ishiguro, and Norihiro Hagita. 2014. Analysis of relationship between head motion events and speech in dialogue conversations. *Speech Communication* 57 (2014), 233–243.

[3] Shoya Ishimaru, Kai Kunze, Koichi Kise, Jens Weppner, Andreas Dengel, Paul Lukowicz, and Andreas Bulling. 2014. In the blink of an eye: combining head motion and eye blink frequency for activity recognition with Google Glass. (2014), 15.

[4] Gloria Mark, Shamsi T. Iqbal, Mary Czerwinski, and Paul Johns. 2015. Focused, Aroused, but so Distractible: A Temporal Perspective on Multitasking and Communications. *CSCW '15 Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing* (2015), 903–916. https://doi.org/10.1145/2675133.2675221

[5] Evelyn Z McClave. 2000. Linguistic functions of head movements in the context of speech. *Journal of pragmatics* 32, 7 (2000), 855–878.

[6] Tamami Nakano, Nobumasa Kato, and Shigeru Kitazawa. 2011. Lack of eyeblink entrainments in autism spectrum disorders. *Neuropsychologia* 49, 9 (2011), 2784–2790. https://doi.org/10.1016/j.neuropsychologia.2011.06.007

[7] Sarah Shultz, Ami Klin, and Warren Jones. 2011. Inhibition of eye blinking reveals subjective perceptions of stimulus salience. *Proceedings of the National Academy of Sciences* 108, 52 (2011), 21270–21275.

[8] Benjamin Tag, Andrew W Vargo, Aman Gupta, George Chernyshov, Kai Kunze, and Tilman Dingler. 2019. Continuous Alertness Assessments: Using EOG Glasses to Unobtrusively Monitor Fatigue Levels In-The-Wild. (2019), 464.