研 究 報 告 書

Collective Open Eyewear – Glasses to Augment the Intelligence of Society

研究タイプ：通常型
研究期間： 2016 年 12 月 ～ 2020 年 3 月
研 究 者： カイ クンツェ

1. 研究のねらい

Alertness and other cognitive skills are a finite resource and we need tools to manage them better. This project makes the first step towards these goals by providing a way to quantify cognitive tasks (in particular alertness and cognitive load) with an unobtrusive eyewear design (that can also measure facial expressions) in everyday situations. The project presents work to infer alertness (measured over standard psychology tests) in everyday life using only eye and head movements from smart glasses connected to a smart phone. In addition, we developed an algorithm to estimate cognitive load using changes in the distribution of temperature in the user's face. We present the first step to a fitness tracker for the mind.

In the interaction space, we explore also the recognition of social interactions (especially looking into head nod and blink synchrony, a topic of interest in neuroscience and psychology). Additionally, the technology developed in this project made contributions to subtle interactions in public spaces (featured by The Verge and Gizmodo) and evaluating wearability of computing (making devices feel closer connected to the body), as well as large scale datasets (over 3200 hours of data) and open source tools.

2. 研究成果

（1）概要

The major outcome of this projects is summarized in the following:

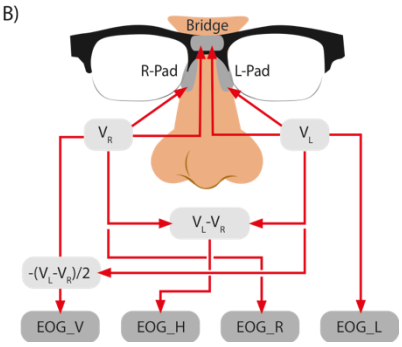
1. We quantify alertness in real life scenarios over recording head/eye movements (blinks etc.) using unobtrusive sensing integrated in everyday devices (specifically eyeglasses){1}. We also show that cognitive load can be measured in a similar unobtrusive fashion over facial temperature changes[5].
2. Present sensor processing and inference algorithms for alertness and cognitive load quantification, as well an evaluation of several other sensing modalities related to cognitive states (endodermal activity for stress, infrared distance sensors to detect facial expressions) integrated in a smart glasses design [4,5].
3. There are other contributions in the subtle interaction space (unobtrusive interactions over "Itchy Nose"[3]) and in quantifying social interactions, specifically relevant for social neuro science [2] and several large scale public datasets (over 3200 hours of sensor data from over 100 participants) as well as open source and hardware specifications.

This project provides the first glasses that see you. The first smart glasses that give you the

ability to quantify and introspect your cognitive behavior.

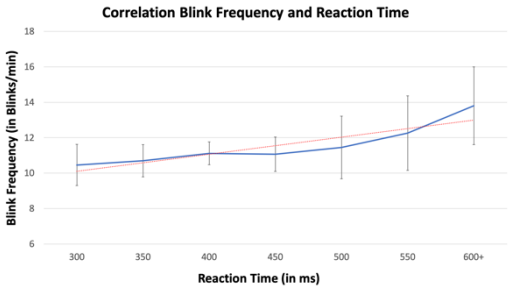
（2）詳細

研究テーマ A「Alertness Tracking」



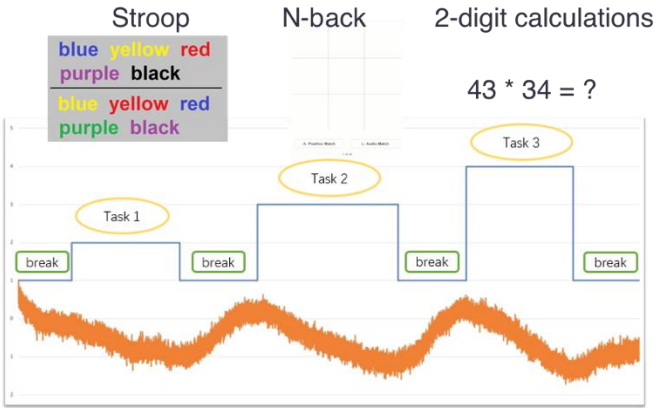
Our alertness varies throughout the day. Being aware of these changes can allow computing systems to proactively change interactions or schedule tasks for the user according to their alertness level. Comparing self reporting with psychological measures (specifically the Psychomotor Vigilance Task) also showed us that users are very bad in self reporting their alertness [1].

In contrast to normal alertness assessments usually done in often limited to lab conditions, bulky hardware, or interruptive self–assessments, we base our approach on eye blink frequency. Using electrooculography sensors integrated into regular glasses' frames, we obtained and analysed the eye movements of 16 participants over the course of two weeks in–the–wild and built a robust model of diurnal alertness changes. The picture on top shows the EOG signal we used for the analysis, of special relevance EOG_V the vertical component of the eye movement. It contains also information about the blink. There is a significant relation between reaction time over the day (measured by the Psychomotor Vigilance Task) and the blink frequency determined over EOG_V. This let's us estimate the alertness.



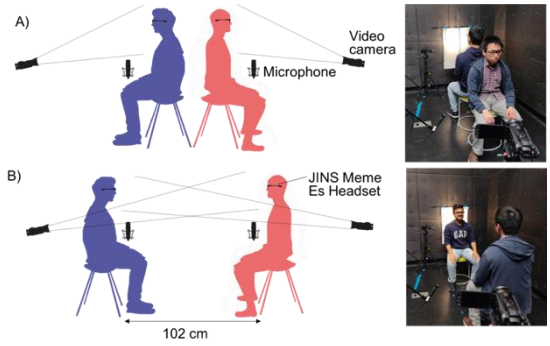
研究テーマ B「Cognitive Load Assessment」

Additionally, we developed an approach to detect and estimate cognitive load by measuring the temperature difference between the forehead and the nose bridge using contactless thermal sensors. The system consists of a pair of glasses with four temperature sensors attached. We have found signs of a correlation between the facial temperature changes and cognitive load using this approach, which makes it possible to develop a wearable device to quantitatively estimate cognitive engagement. The touchless thermal sensors embedded in the glasses are shown on the left.



As seen from the figure on the left, the user has to perform different cognitive load tasks (a stroop test, a memory test called N-back and 2 digit calculations). The bottom part shows the difference in forehead and nose temperature (it goes down every time a task starts that induces cognitive load) [5].

研究テーマ C「Interaction Design and Social Interactions」



The work presented also contributes to subtle interactions in everyday spaces, introducing new sensing modalities to enable novel HCI approaches [3]. Additionally, we use our eyewear platform as a novel toolset to explore some phenomenon social neuroscience, in particular eye blink and nod synchrony in dyads (shown in the picture above). Weshow significant interpersonal synchrony of blink and head nod behavior during conversation (at frequencies of 0.2 to 0.5 Hz).

We also released most of the datasets related to the top level publications and are in the process of providing the rest [1,2,3]. They can be found under http://eyewear.pro/

3. 今後の展開

The work presented gives a good start to quantify cognitive activities during everyday life. During the Project we will still improve on the cognitive load algorithm and detection. We also provide an eyewear with both functionalities (alterness and cognitive load tracking) in one. It's only the first step to provide tools on an individual level to better understand and manage alterness and other social/cognitive functions related to our behavior and decision processes. There are several promising directions in relation to learning and learning processes that we will explore.

4. 自己評価

Besides being well published with over 30 publications some at top level venues like CHI2019 (the premier international conference of Human-Computer Interaction) and UbiComp/ISWC 2017/2018/2019, the papers related to this JST Sakigake already accumulated a significant citation count (about 90 citations according to google scholar[1]) showing that the work is well

[1] https://scholar.google.com/citations?hl=en&user=aBBK-psAAAAJ

received by the research community. In addition, the principle investigator continues working with J!NS and received follow-up funding to continue tracking cognitive fluctuations using smart eyewear (Kiban-B "Deep Learning the Human Mind", Osaka Grand Challenge Society 5.0).
Research based on this JST Sakigake work also made it into the media (coverage by Gizmodo and theVerge[2]). As an additional result, from our JST Sakigake group, we co-organized the SuperhumanSports Design Competition[3] together with Prof. Kurita (Hiroshima University).
Overall I'm satisfied with the progress made in the project and energized by the many potential continuations and novel research ideas it generated. I'm also looking forward to what other researchers will be able to do with the enabling technologies we built in this project.

5. 主な研究成果リスト

(1)論文(原著論文)発表

1. Tag, B., Vargo, A.W., Gupta, A., Chernyshov, G., Kunze, K. and Dingler, T., 2019, April. Continuous Alertness Assessments: Using EOG Glasses to Unobtrusively Monitor Fatigue Levels In-The-Wild. In Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems. 2019 (p. 464-476).
2. Gupta A, Strivens FL, Tag B, Kunze K, Ward JA. Blink as you sync: uncovering eye and nod synchrony in conversation using wearable sensing. In Proceedings of the 23rd International Symposium on Wearable Computers 2019 (pp. 66-71).
3. Lee, J., Yeo, H.S., Dhuliawala, M., Akano, J., Shimizu, J., Starner, T., Quigley, A., Woo, W. and Kunze, K., r. Itchy nose: discreet gesture interaction using EOG sensors in smart eyewear. In Proceedings of the 2017 ACM International Symposium on Wearable Computers 2017 (pp. 94-97).
4. Zheng D, Chernyshov G, Kunze K. Electrodermal activity sensing using smart eyewear. In Proceedings of the ACM International Joint Conference on Pervasive and Ubiquitous Computing 2019 (pp. 653-656)
5. Zhengren F, Chernyshov G, Zheng D, Kunze K. Cognitive load assessment from facial temperature using smart eyewear. In Proceedings of the 2019 ACM International Joint Conference on Pervasive and Ubiquitous Computing. 2019. (pp. 657-660)

(2)特許出願

研究期間累積件数:0 件

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[2]https://www.theverge.com/circuitbreaker/2017/9/19/16332268/itchy-nose-smart-glasses-control-research

[3] https://dl.acm.org/citation.cfm?id=3210299&picked=prox

（3）その他の成果（主要な学会発表、受賞、著作物、プレスリリース等）

発表

1. Dagstuhl Seminar on Cognitive Augmentation accepted for next year: https://www.dagstuhl.de/20342
2. Dagstuhl Seminars are high ranked seminars on hot topics in informatics. The seminars, which are established after review and approval by the Scientific Directorate, bring together personally invited scientists considered experts in their field.
3. Dagstuhl Seminar on Beyond VR/AR held: **https://www.dagstuhl.de/17062**

報道

Keio Highlights Press Release: https://research-highlights.keio.ac.jp/2017/06/b.html

アウトリーチ

日本科学未来館 日本科サイエンティスト・クエストー「目は、こころの窓 ー最新のスマートなめがねが、私たちのふるまいについて教えてくれること」（2016 年 8 月 9 日）

以上