Eyewear Computing

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Eyewear Computing

Overview

- Personal Background
- **Activity Recognition**
- **System Development**
  - MEME
  - Own Smart Glasses Designs
- **Augmented**
  - HCI Studies and Beyond
- Outlook

My Background

Professor (2018)	Graduate School of Media Design, Keio University
Research Assistant Professor (2012)	Osaka Prefecture University
Visiting Researcher at MIT Media Lab	MIT, Cambridge, USA
PhD in Ubiquitous/Wearable Computing (2011)	University Passau, Germany
Collaborations with PARC, SUN, Deutsche Börse ...	Palo Alto, Grenoble, Frankfurt,Innsbruck

Activity Recognition

With the computers surrounding us in everyday life, worn on our bodies, the performance bottle neck is

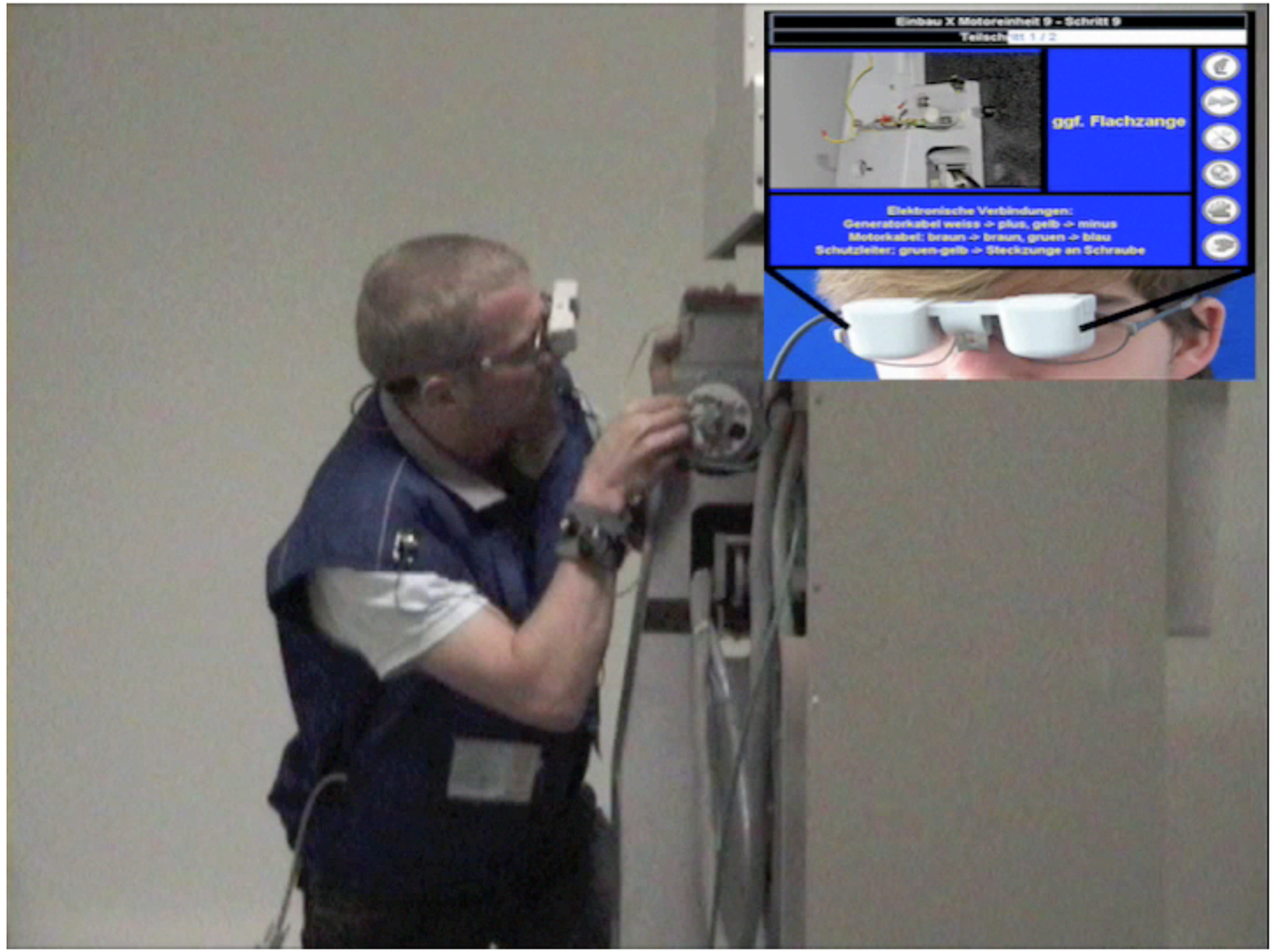
Human Attention.

Key challenge: intuitive cooperation between humans and computers

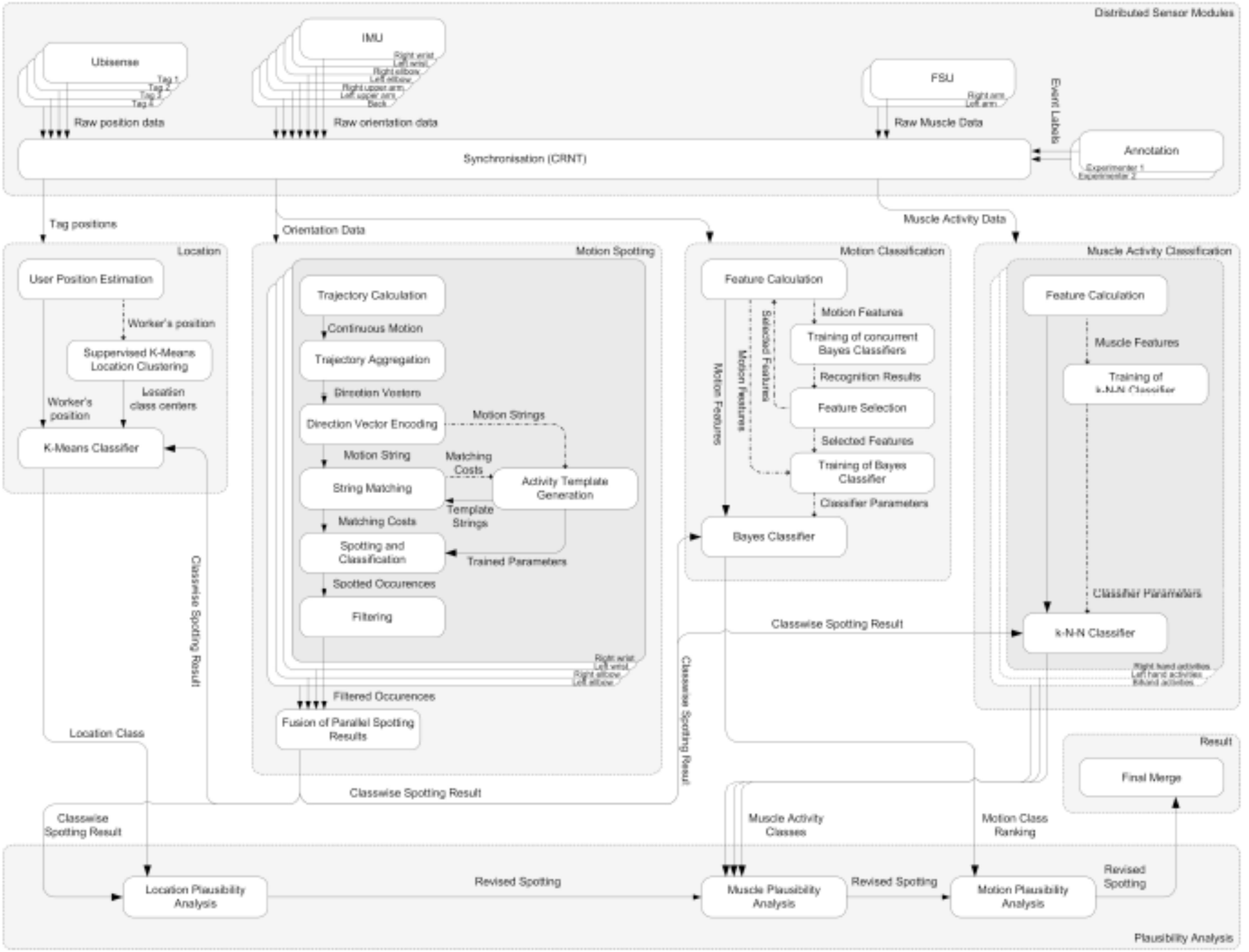
Activity Recognition, Context-Aware Systems
Using a Combination of Sensors, Signal Processing, Applied Machine Learning to Support Users in Everyday Situations

Wearable Computing around 2007

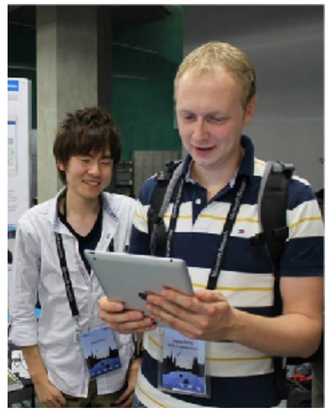
Maintenance Scenario, Collaboration with University Bremen and Zeiss.



Kunze, Kai, et al. "Does context matter?-a quantitative evaluation in a real world maintenance scenario." *Pervasive Computing: 7th International Conference, 2009*.

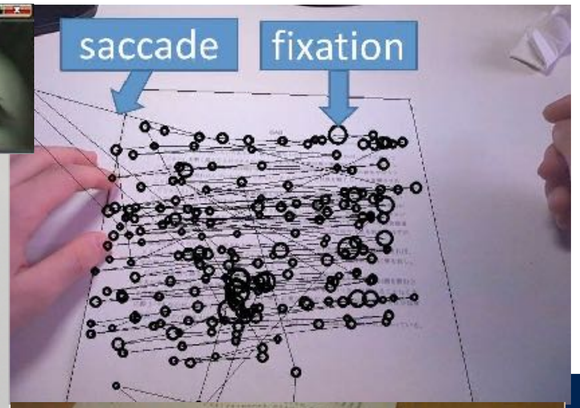

Distributed Sensor Modules
Ubisense
Tag 1
Tag 2
Tag 3
Tag 4
IMU
Right wrist
Left wrist
Right elbow
Left elbow
Right upper arm
Left upper arm
Back
FSU
Right arm
Left arm
Raw position data
Raw orientation data
Raw Muscle Data
Event Labels
Annotation
Experimenter 1
Experimenter 2
Synchronisation (CRNT)
Tag positions
Orientation Data
Muscle Activity Data
Location
User Position Estimation
Worker's position
Suppervised K-Means Location Clustering
Worker's position
Location class centers
K-Means Classifier
Classwise Spotting Result
Location Class
Motion Spotting
Trajectory Calculation
Continuous Motion
Trajectory Aggregation
Direction Vectors
Direction Vector Encoding
Motion Strings
Motion String
Matching Costs
String Matching
Activity Template Generation
Template Strings
Matching Costs
Spotting and Classification
Trained Parameters
Spotted Occurences
Filtering
Filtered Occurences
Fusion of Parallel Spotting Results
Classwise Spotting Result
Motion Classification
Feature Calculation
Motion Features
Training of concurrent Bayes Classifiers
Recognition Results
Feature Selection
Selected Features
Training of Bayes Classifier
Classifier Parameters
Bayes Classifier
Motion Features
Selected Features
Classwise Spotting Result
Muscle Activity Classification
Feature Calculation
Muscle Features
Training of k-N-N Classifier
Classifier Parameters
k-N-N Classifier
Classwise Spotting Result
Result
Final Merge
Classwise Spotting Result
Location Plausibility Analysis
Revised Spotting
Muscle Activity Classes
Muscle Plausibility Analysis
Revised Spotting
Motion Class Ranking
Motion Plausibility Analysis
Revised Spotting
Plausibility Analysis

Wearable Computing — Activity Recognition becomes Mainstream



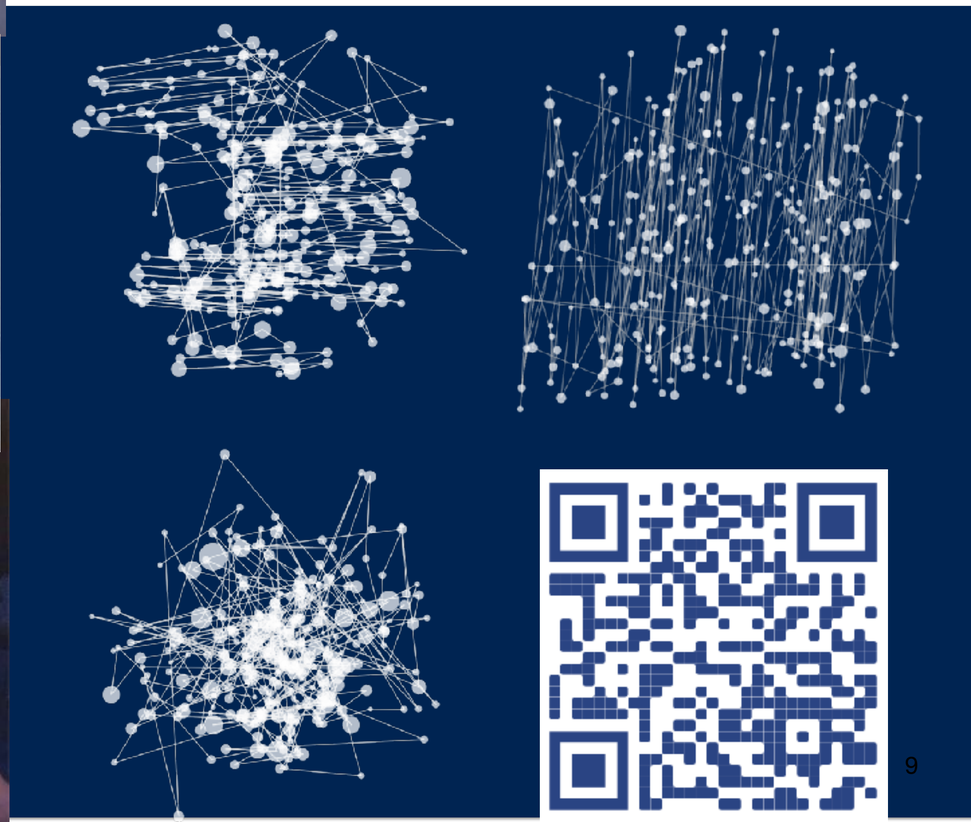
Kunze Kai. Compensating for On-Body Placement Effects in Activity Recognition, 2011.

Tracking Cognitive Tasks— Reading Habits



Where to start?

Ubiquitous learning activity: reading



Kai Kunze, Yuzuko Utsumi, Yuki Shiga, Koichi Kise, and Andreas Bulling. 2013. I know what you are reading: recognition of document types using mobile eye tracking. ISWC '13

System Development

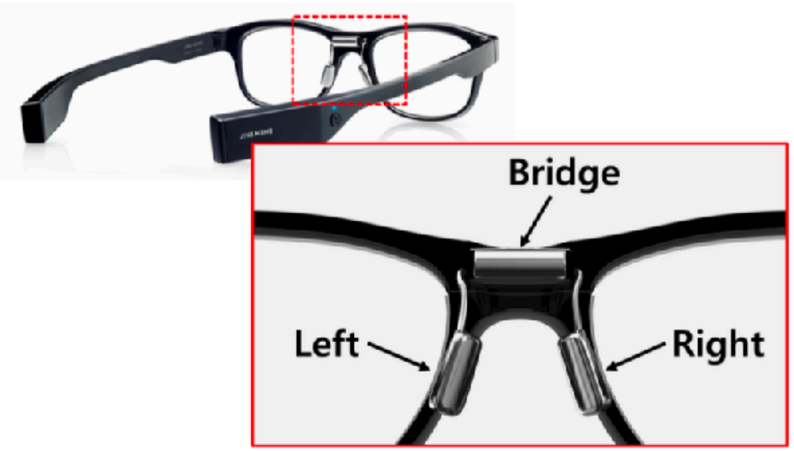
J!NS MEME and more

Is this how our brains work when we interact with the world?

https://www.sciencedirect.com/science/article/pii/S1053811918306505

Cognitive Activity Tracking in Everyday Life

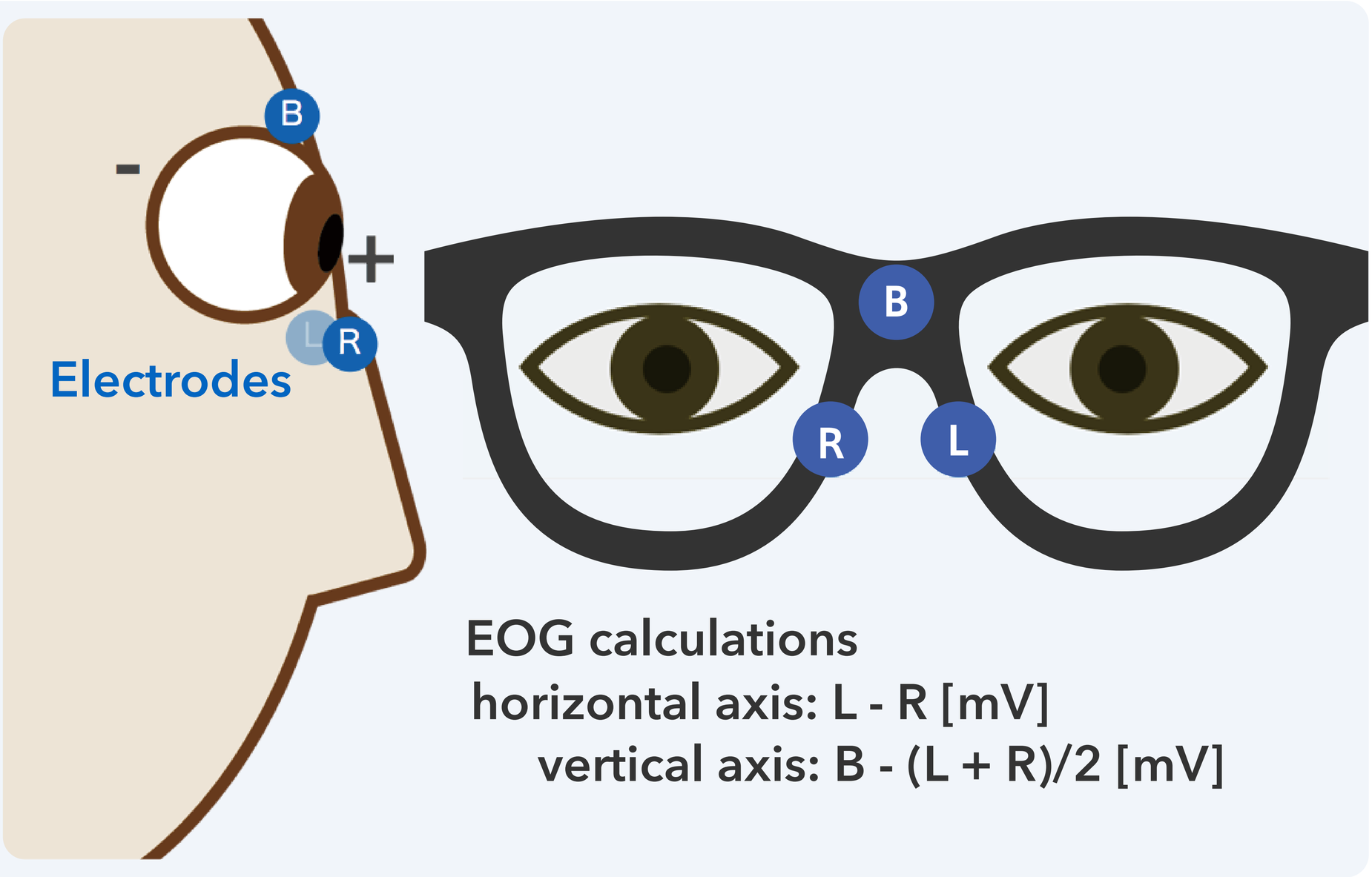
Overview of J!NS MEME



J!NS MEME

3-axis accelerometer
3-axis gyroscope
2-axis EOG

J!NS MEME - Electrooculography



EOG calculations

horizontal axis: L - R [mV]

vertical axis: B - (L + R)/2 [mV]

Meme Academic Collaborations

Used by over 100 research institutes (just the most prominent ones are highlighted)

mit media lab

University of Glasgow

Universität Stuttgart

UNIVERSITÄT PASSAU

Universität Bremen

UCL

German Research Center for Artificial Intelligence

KIT Karlsruher Institut für Technologie

UNIVERSITÄT SIEGEN

MAX-PLANCK-GESELLSCHAFT

Royal College of Art
Postgraduate Art and Design

RPTU Rheinland-Pfälzische Technische Universität Kaiserslautern Landau

LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN LMU

Goldsmiths UNIVERSITY OF LONDON

University of San Diego

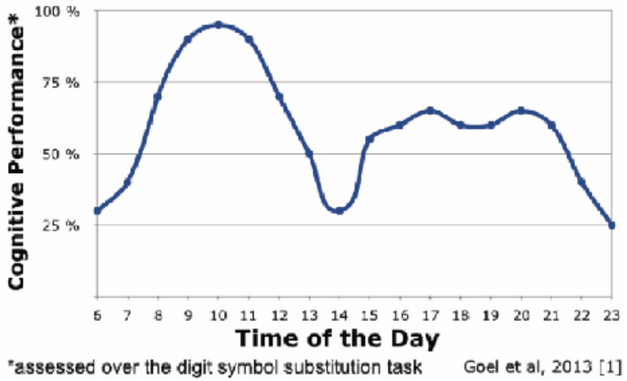
Georgia Tech

THE UNIVERSITY OF SYDNEY

University of South Australia

KAIST

Cognitive Fluctuation Studies



Cognitive load, Circadian Rhythm, **Fatigue/Alterness**

20 participants, 3 weeks

At least 10 hours a day:

Electrooculography + Motion Sensors

“Groundtruth” every 2 hours:

Standard Cognitive Tests

Karolinska Sleepiness Scale

Psychomotor Vigilance Task (PVT)

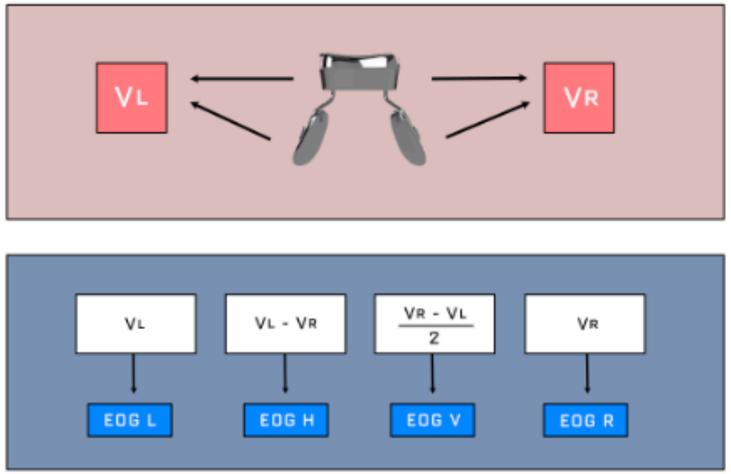
Stroop Test

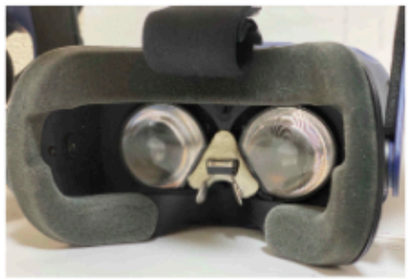
Log Caffein intake and Naps

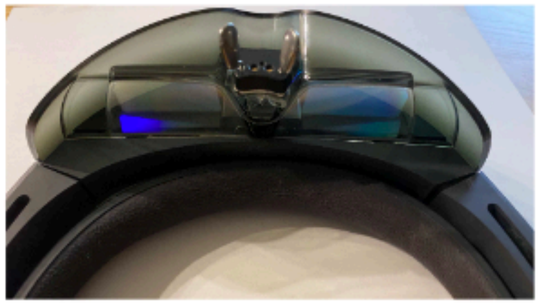
Sessions in the lab with FNIRS

Tag, Benjamin et all. "Continuous Alertness **II 2019** Assessments: Using EOG Glasses to Unobtrusively Monitor Fatigue Levels In-The-Wild." *CHI*, 2019.

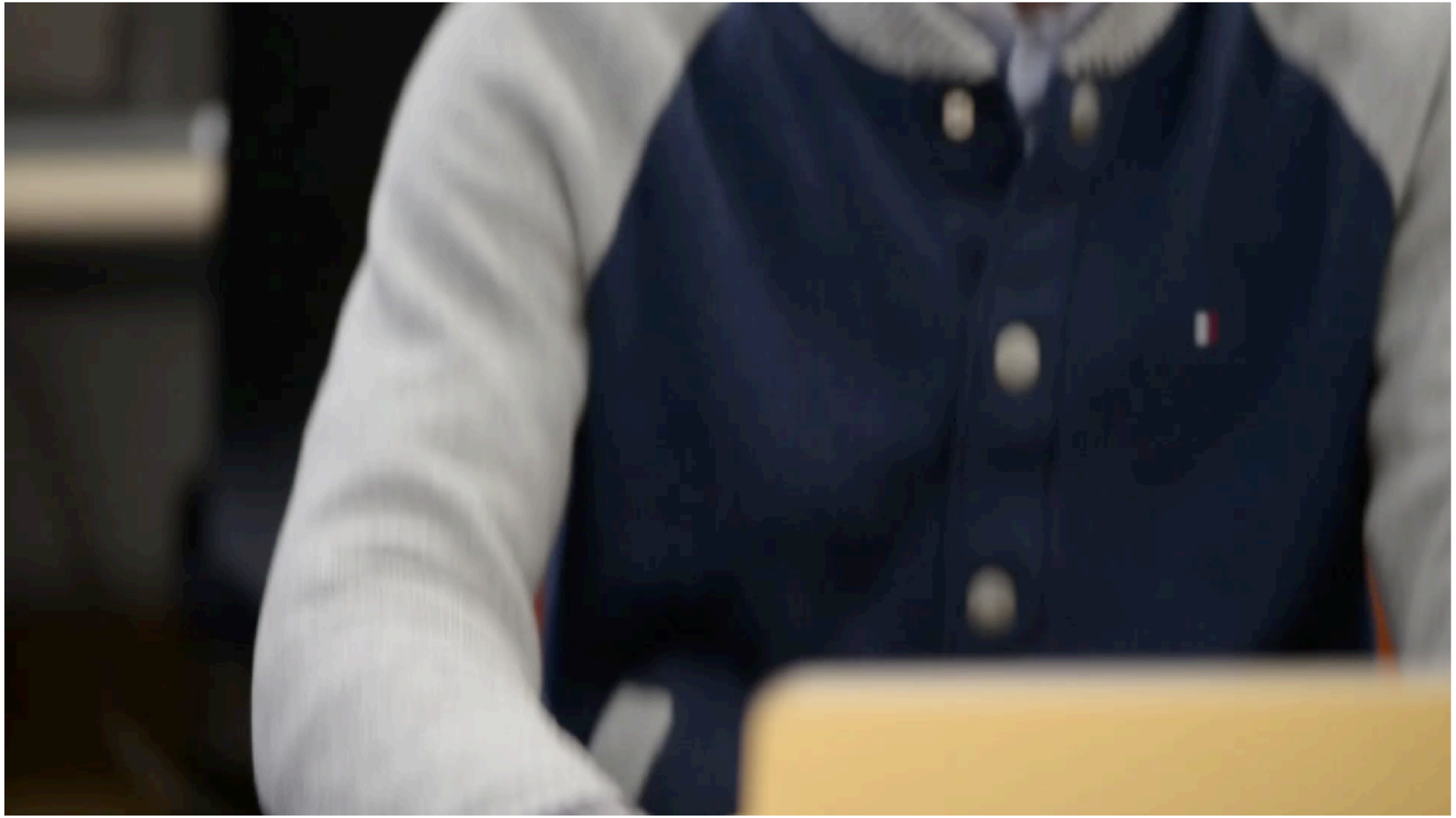
MEME 3.0





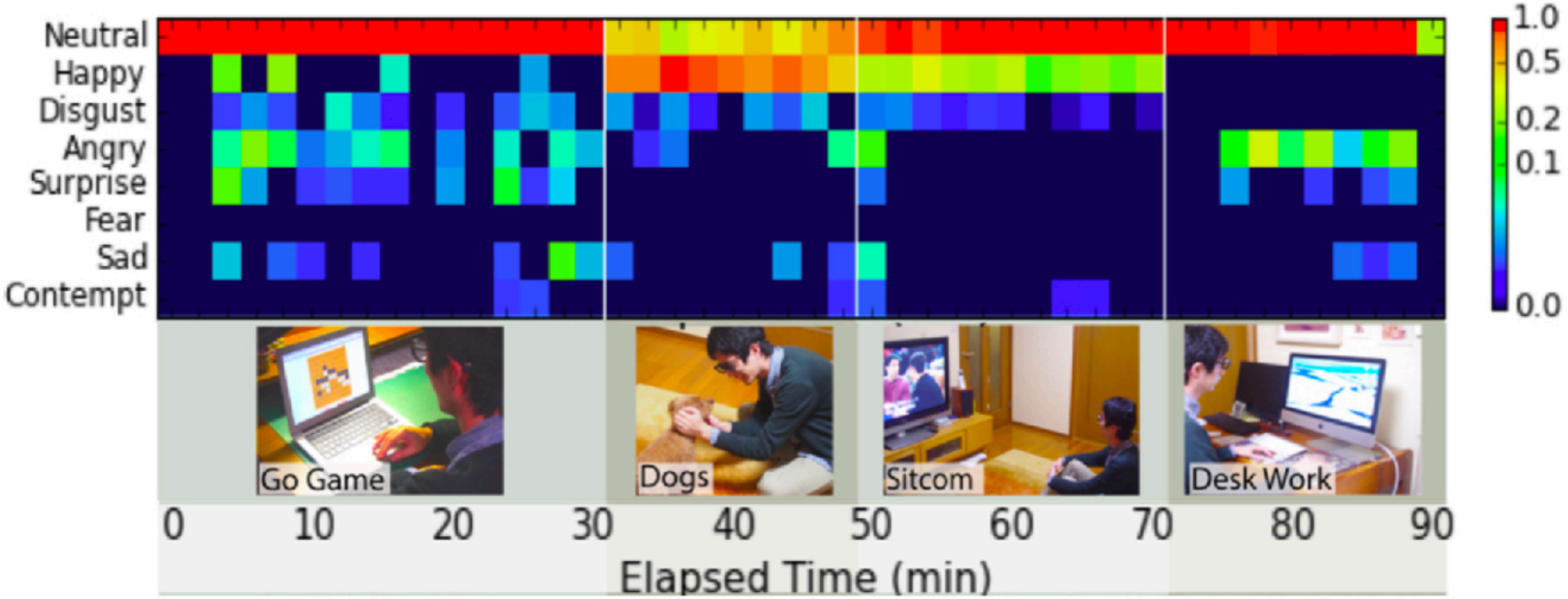


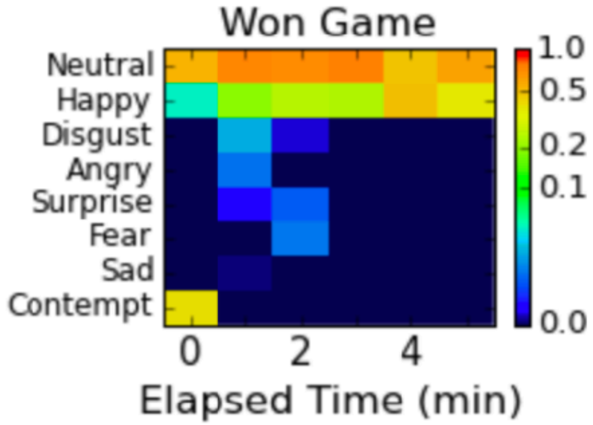
Smart Glasses to detect Facial Expression

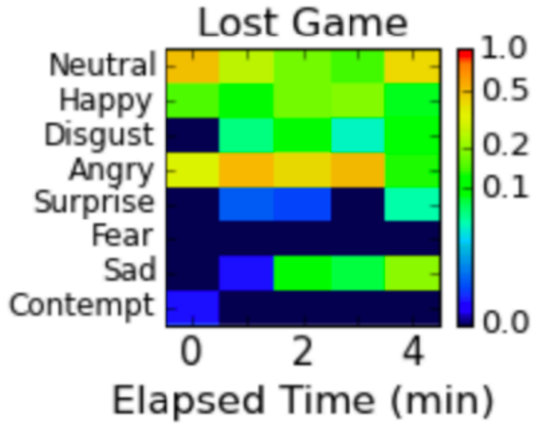


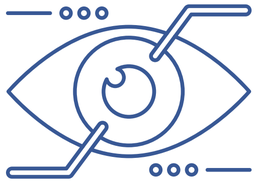
Evaluation of Facial Expression Recognition by A Smart Eyewear, ACM Transactions on Interactive Intelligent Systems, 2017.

Facial Expressions Change Depending on Activities





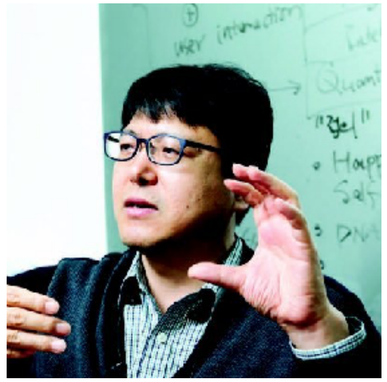




Augmented

HCI Studies and beyond

Subtle Interactions with Smart Eyewear

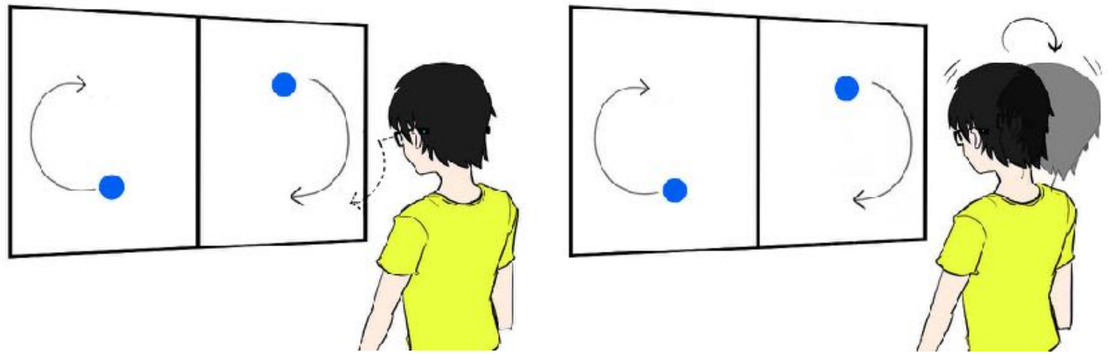


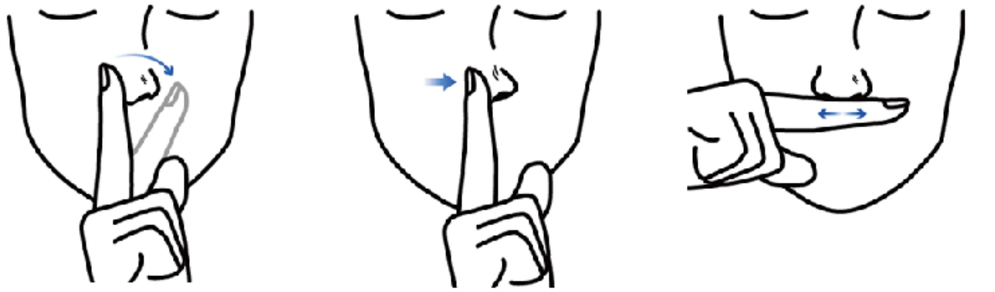
Collaboration with Woontack Woo,

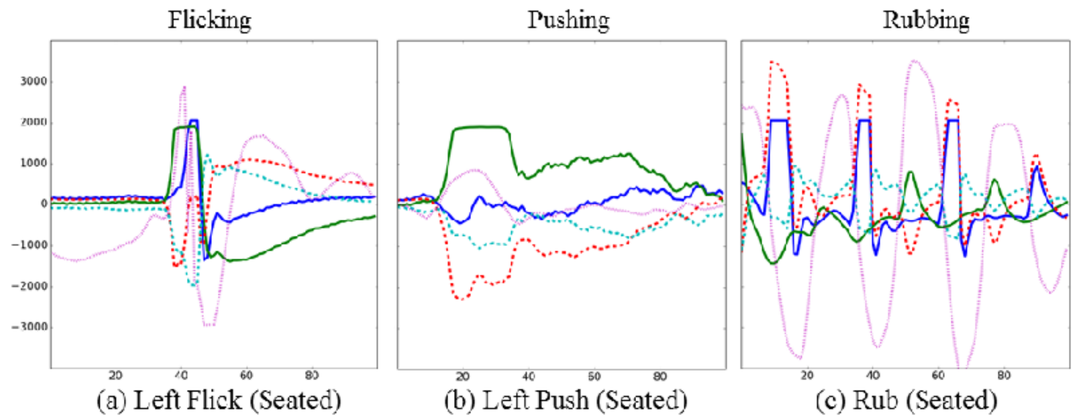
Thad Starner, Aaron Quigley

KAIST

Georgia Tech

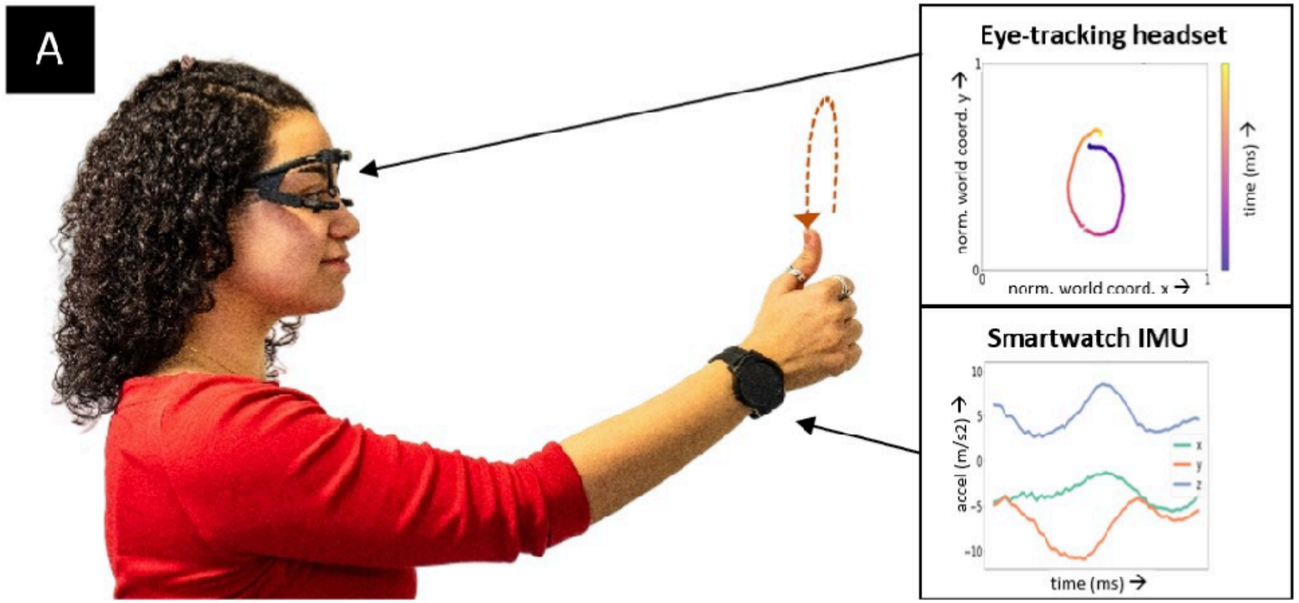


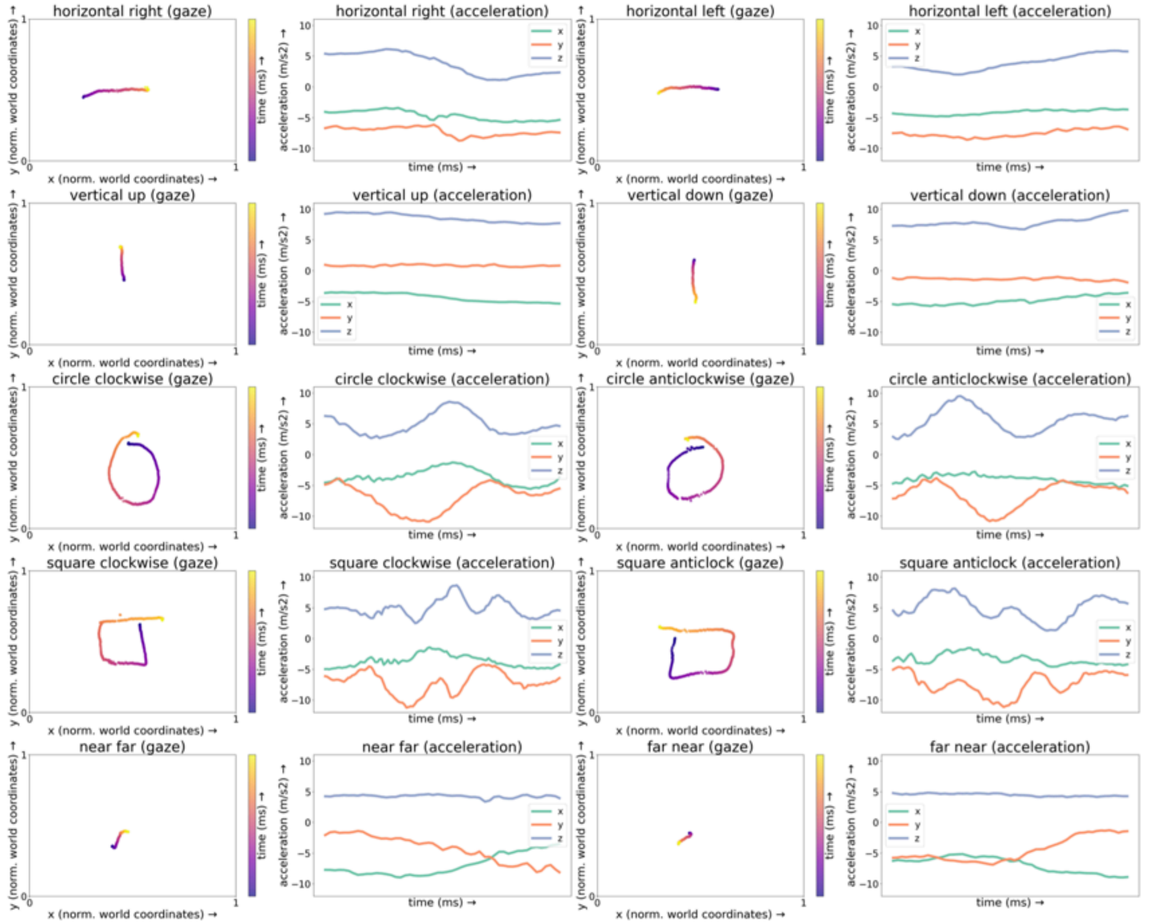




(a) Left Flick (Seated) (b) Left Push (Seated) (c) Rub (Seated)

BodyPursuits: Exploring Smooth Pursuit Gaze Interaction Based on Body Motion Targets





Hansen, Anja, et al. "BodyPursuits: Exploring Smooth Pursuit Gaze Interaction Based on Body Motion Targets." Proceedings of the 2025 Symposium on Eye Tracking Research and Applications. 2025.

ISWC 2017
Sept. 11-15, Maui, Hawaii

Itchy Nose

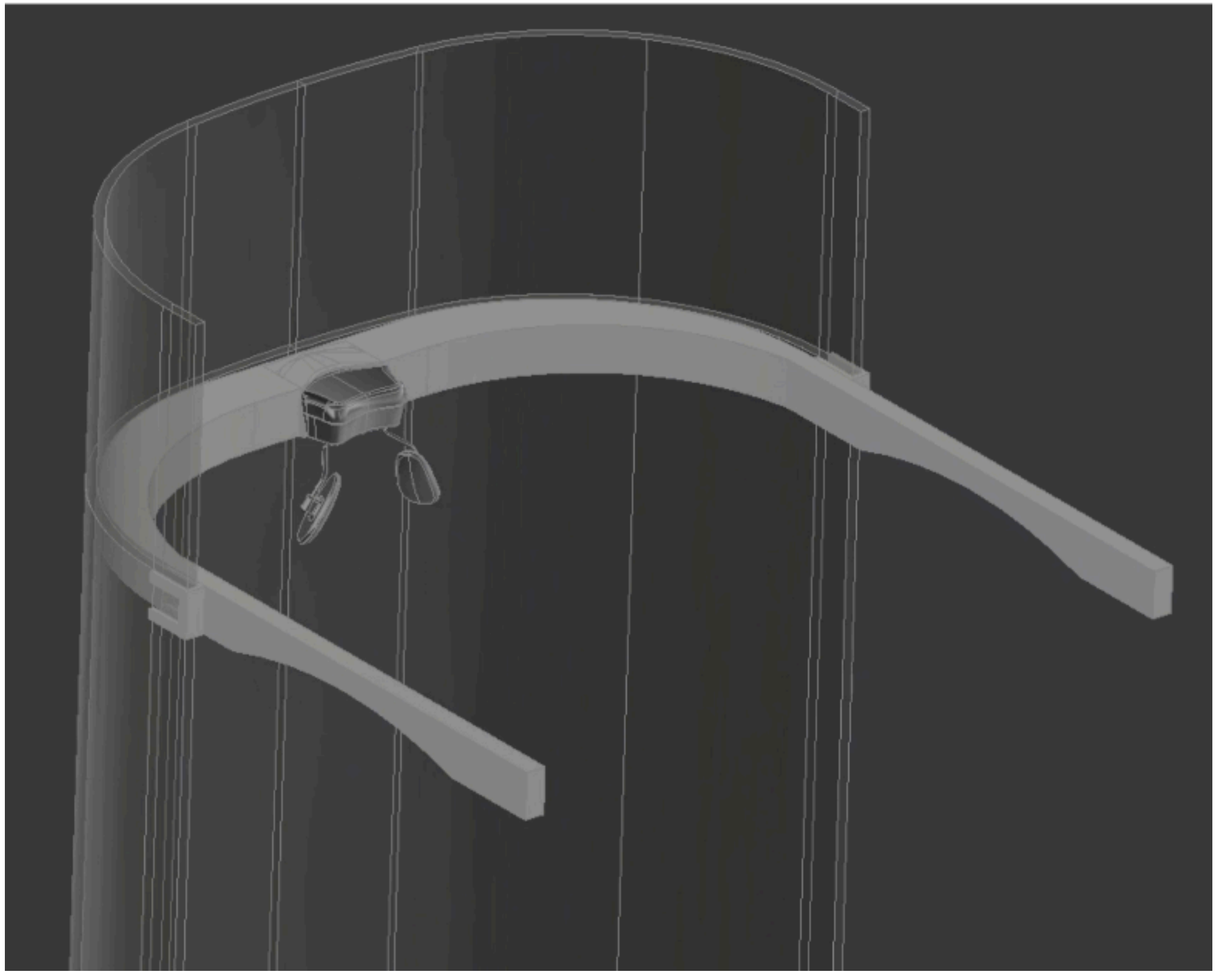
Discreet Gesture Interaction using EOG Sensors in Smart Eyewear

Juyoung Lee[1] , Hui-Shyong Yeo[2], Murtaza Dhuliawala[3], Jedidiah Akano[3], Junichi Shimizu[4],
Thad Starner[3], Aaron Quigley[2], Woontack Woo[1], Kai Kunze[4]

[1]KAIST, [2]University of St.Andrews, [3]Georgia Institute of Technology, [4]Keio University

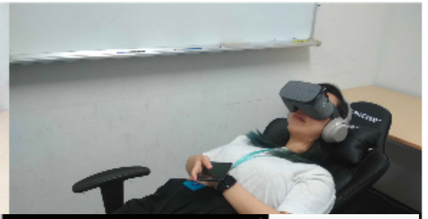
"Royalty Free Music from Bensound

Integration into a face-shield to detect Mouth/nose touch events



How can we sleep better?

Nap Assistant in Virtual Reality



user study (n= 20) comparing different sleep conditions

no devices, sleeping mask, VR environment of the study room preferred VR environment by the participant.

Recorded the electrooculography (EOG) signal and sleep onset time using a finger tapping task (FTT).

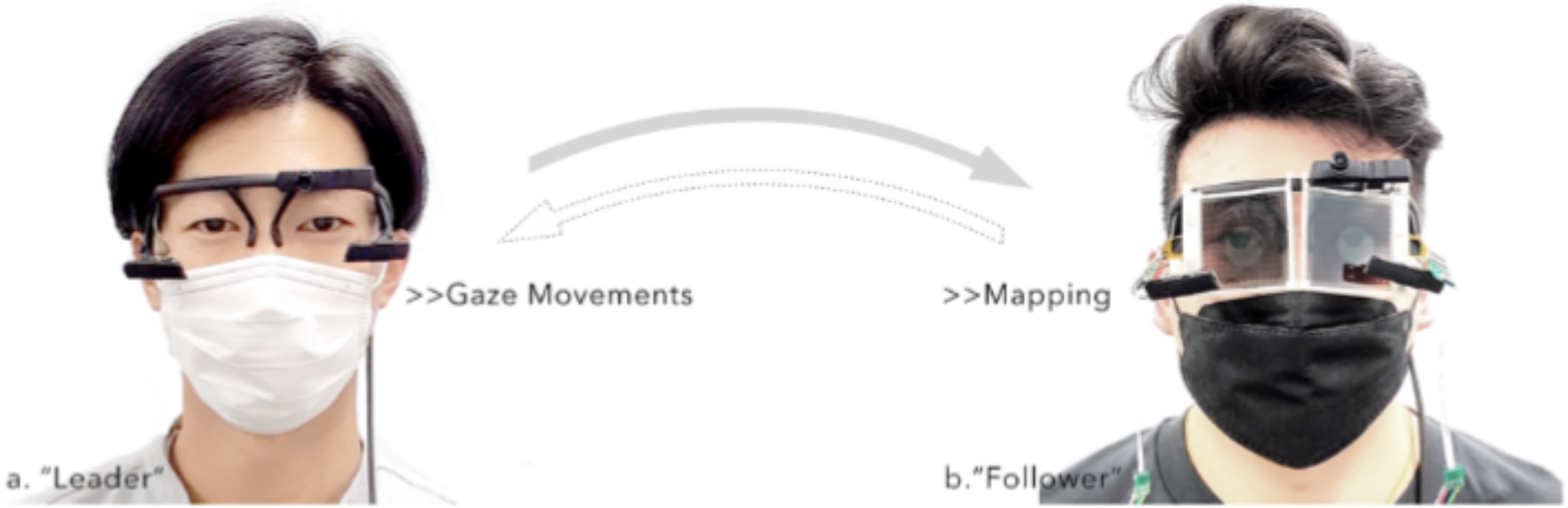
NapWell: An EOG-based Sleep Assistant Exploring the Effects of Virtual Reality on Sleep Onset

Yun Suen Pai,Marsel L. Bait, Juyoung Lee,Jingjing Xu,Roshan L Peiris,Woontack Woo,Mark Billinghurst &Kai Kunze

Virtual Reality (2021)

Can we share our visual perception with others?

GazeSync (IUI 2022)

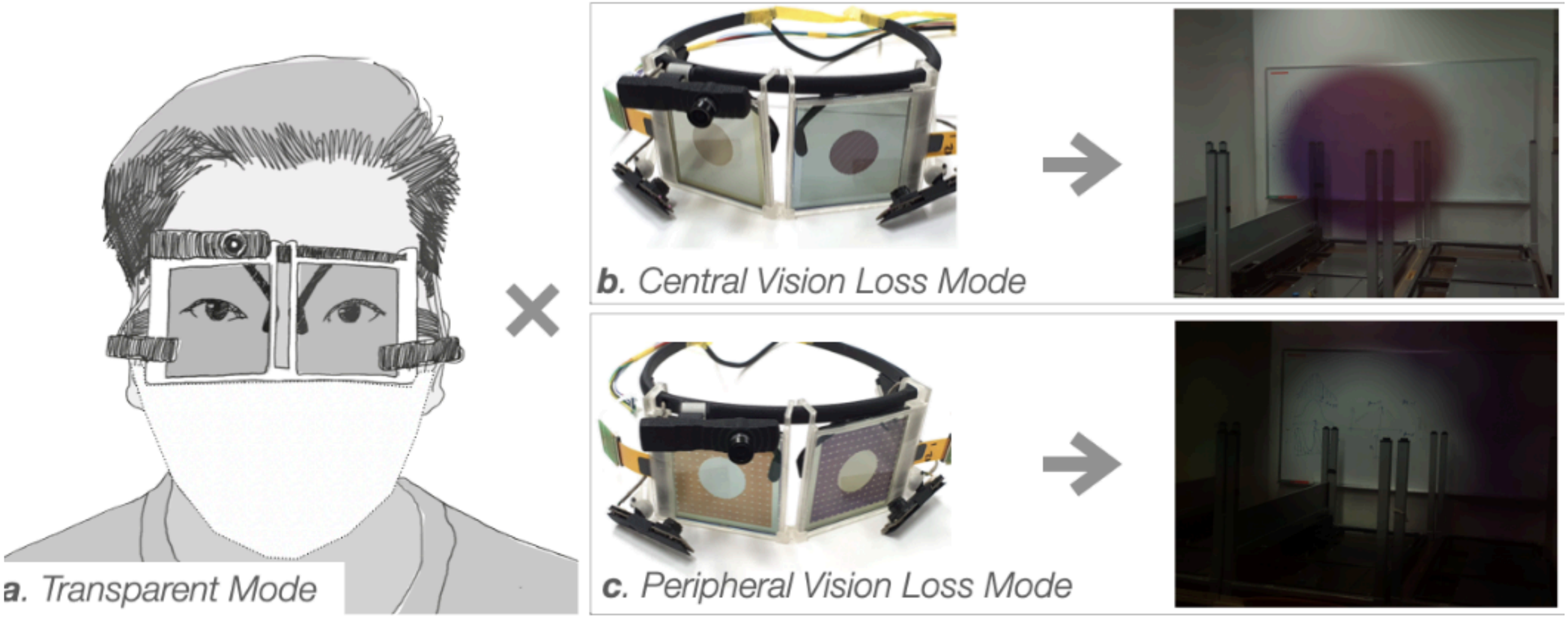


GazeSync: Eye Movement Transfer using an Optical Eye Tracker and Monochrome Liquid Crystal Displays. IUI 2022.

Eye movement mapping ⇨

Visual Impairment Simulation

Seeing our Blind Spots: Smart Glasses-based Simulation to Increase Design Students' Awareness of Visual Impairment



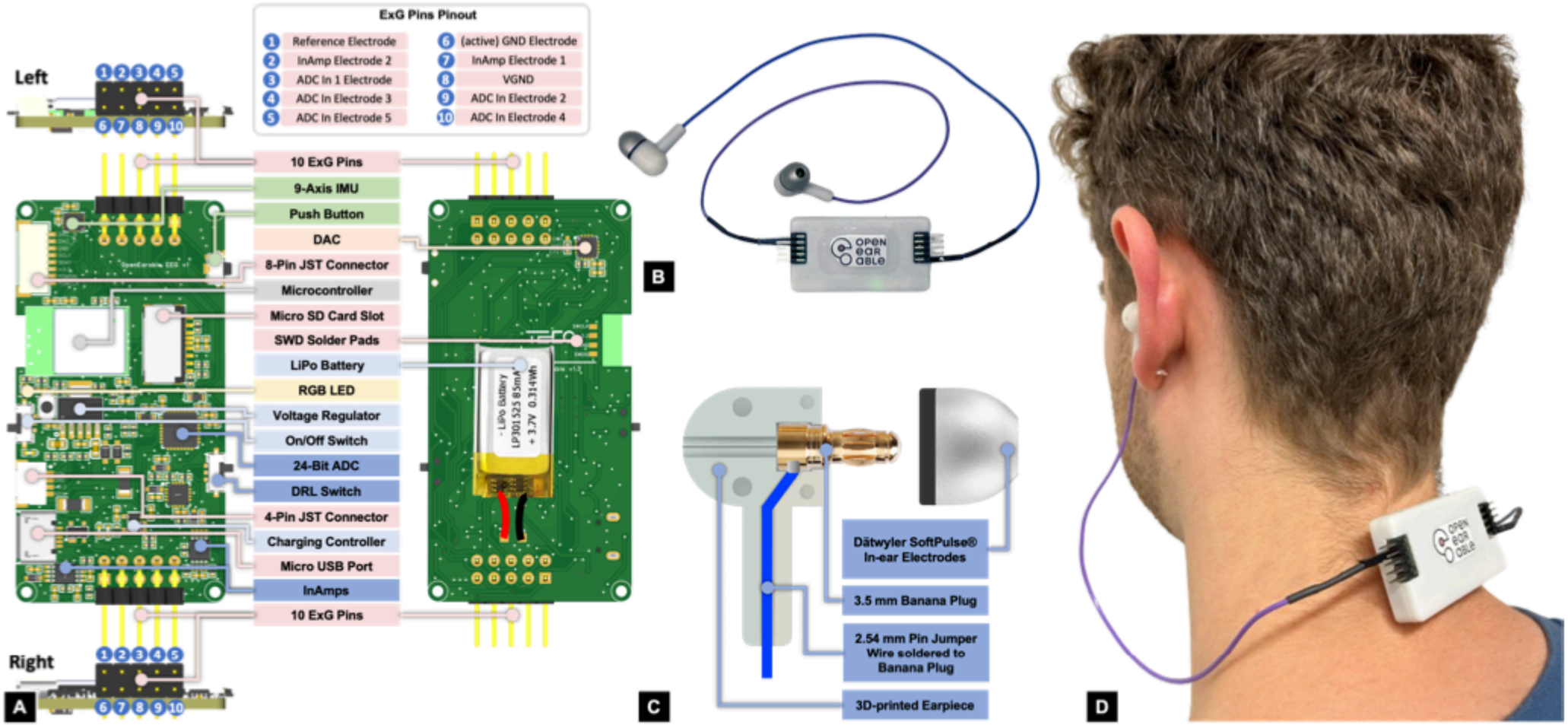
Zhang, Qing, et al. "Seeing our Blind Spots: Smart Glasses-based Simulation to Increase Design Students' Awareness of Visual Impairment." UIST 2022.

Seeing our Blind Spots:

Smart Glasses-based Simulation to Increase Design Students' Awareness of Visual Impairment

OpenEarable ExG

Open-Source Hardware for Ear-Based Biopotential Sensing Applications



Philipp Lepold, Tobias Röddiger, Tobias King, Kai Kunze, Christoph Maurer, and Michael Beigl. 2024. OpenEarable ExG: Open-Source Hardware for Ear-Based Biopotential Sensing Applications. In Companion of the 2024 on ACM International Joint Conference on Pervasive and Ubiquitous Computing (UbiComp '24). Association for Computing Machinery, New York, NY, USA, 916–920. https://doi.org/10.1145/3675094.3678480

Questions,Remarks, Violent Dissent?

http://augmented-humans.org/

Full/Short Paper/ Submission Deadline

November 18th, 2025

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