State-of-the-art of Wearable EEG for Personalised Health Applications

Evangelia Balanou, Mark van Gils, Toni Vanhala
VTT Technical Research Centre of Finland

10th International Conference on Wearable Micro and Nano Technologies for Personalized Health, Tallinn, 2013
Wearable Sensors

‘Between 2012 and 2017, wearable health and fitness device shipments will increase by 552% [...]’

From these, 18.2m will be health sensors with a revenue of $16.3 billion.

From 100 wearable sensors analysed, [...] ‘over half are focused on self-management, prevention and general wellness.’

Wearable sensors

- widespread in sports and fitness
- an emerging market for healthcare
- mainly focusing on physiological and behavioural monitoring
- new opportunities for mental health
Motivation

• In 2010
  – in EU, 38% of the population is said to be affected by a mental disorder each year
  – total cost was estimated to be €798 billion

• Within the next 20 years
  – mental illnesses are expected to cause higher costs than cardiovascular diseases

• Mental health assessment has relied on subjective measures
Brain Monitoring

- Objective, real-time measure for the dynamic **mental states** of the brain.

- **EEG** (electroencephalography) is the *non-invasive* recording of the brain’s electrical activity with *high temporal resolution*.

- Well-established in **clinical** practice and **research**

### Golden Standard

- Uncomfortable
- Wet electrodes
- Constrictive
- Only a snapshot of the brain activity

### Challenges

- Time-consuming
- Cumbersome
- EXPENSIVE
- Expert's assistance
- Clinical/laboratory context

**What about applications beyond the clinical settings?**
"Now I want you to relax completely!"
Wearable EEG Systems

Increasing interest in wearable EEG devices that enable real-world applications.

Published Items in Each Year

Created June 7, 2013 from Web of Knowledge using (wearable EEG) OR (wearable electroencephalography*) in the topic in the advanced search options.
**Key attributes** of a wearable EEG device:

- Easy to wear
- Small, light, head-mounted device
- Wireless
- Dry or non-contact electrodes
- Intuitive / User-friendly
- Comfortable
- Software Development Kit
- Wider application areas
Commercial Systems

- Number of dry electrodes varies
- Integrated headsets
- Mostly fixed setup
- Many used in research
- Price varies
Non-commercial systems

- Not available or prototypes
- Specifications not available for all

Neurofocus – Mynd

Neurovigil - iBrain

Chi et al., “Wireless non-contact cardiac and neural monitoring,” WH 2010


Real-world Applications

**Affective**
- neuromarketing
- EEG Headband (physiological monitoring)

**Wellness**
- mental disorders
  - stroke patients
- sleep research, depression, autism
- Sleep management, wellness

**Physical Health**
- body area network, physiological monitoring
- game controller
- gaming, BCI

**Gaming**
- technology provider, consumer applications
- gaming, lifestyle, potential in assistive living
- focus
- focus
- cognitive, emotional training

**Mental Health Disorders**
- BCI
- brain research, BCI
- cognitive training, sleep research

**Mental State Monitoring**
- fatigue measurement in mining and heavy industry

**Lifestyle**
- cognitive states, military applications
- drowsiness detection
- military applications
Current Work

• Focus on the signal quality acquired by a commercial wearable EEG device and on whether the study can provide indications that EEG features are related to different levels of mental workload

• Working memory is a suitable indicator of mental workload in office scenarios

• Pilot study / 8 subjects
Challenges

- Technical challenges
- Design for functionality and appearance
- Compatibility with other sensors and integration into systems for multi-modal analysis and contextual interpretation
- Evaluation studies
- Algorithms
- Multi-disciplinary teams
- Move from technology to applications
Conclusions

- Wearable EEG systems have broken out of the laboratory into the wild
- The field will continue to expand quickly as new devices are introduced
- Wearable EEG devices open the way for scientific and clinical research in real-life settings and for self-tracking
- Wearable EEG devices may prove to be an integral part of future pervasive, ubiquitous and person-centered health care delivery.
Thank you