Work stream 1: Adaptive sensing and behavioural phenotyping

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Online signal processing

Wearable sensor node

Biological world

Brainwaves
Heart rate
Gait

Electronic world

Smartphones
PCs
Internet
Offline signal processing

mHealth
Big Data
Internet of Things

Signal conditioning

Interface / Electrode

Online signal processing

Wireless link

Feedback / treatment

Power delivery (Battery or energy harvesting)

Reduce system power.

[Chen et al., Wearable sensors, 2014]
Bio-degradable conformal electronics
EPSRC funded, £1.6M, 2017 - 2020

- Printed Graphene tracks and bio-degradable substrates for ease of disposal at end of life
- Roll-to-roll scale up manufacturing
- 3D pop-up antennas
- 30 µW power budget for 3m range RFID wireless powering
- Sensing: ECG, EMG, EEG, IMU, Temp, Strain, Pressure
Project 2: Contacting through hair

Personalised electrodes for better penetration through hair
MRC funded, £140k, 2018 - 2019

New materials: trying to match Ag/AgCl
New attachment methods: e.g. conformals
New manufacturing: personalisation, easier to put on
New electronics for active electrodes
Novel system design: getting information from hair-less regions
Novel signal processing: getting information from poorer quality connections
Project 3: Data based treatments

Closed loop wearables
MRC funded, £150k, 2017 - 2018

Current wearables just collect data. We want to create devices that analyse the data in real-time and release a very time targeted treatment.

- Signal processing is now power AND time constrained: for <10 ms accuracy don’t have time to send to an off-sensor-node computer.
Project 4: EHR integration

The wearable clinic
EPSRC funded, £2M, 2017 - 2020
1.1 Adaptive sampling

Key aim

Increase monitoring lifetime without degrading information utility from wearable
1.1 Adaptive sampling

Only turn on sensing when EHR indicates it is needed

Example:

- ✔ Sensor in sleep mode by default
- ☒ Appointment missed
- ✔ Pull data from wearable
- ✔ Supplement EHR with new information, despite no appointment
- ✔ Compare activities to usual profile
- ✔ Significant power savings due to discontinuous monitoring
- ✔ Allows very long term sensing

Variation on data driven adaptive sampling

- In addition to data from sensor itself, use time spare EHR as meta-data
- Mainly back-end processing rather than on-node
- A number of different variations are possible

Focus on accelerometry/activity monitoring
Five variations identified so far. Three examples:

One
Risk flag

Switch between:
High resolution data vs low resolution data
Accelerometer only or full IMU

Two
Continuous data
Classification accuracy
Dynamically turn on/off additional sensors

Three
Expected Information Value of packet
Impact on classification accuracy

Power cost of transmission: 5 – 50 nJ/bit

Model, based on Information theory

Care planning information
1.2 Behavioural phenotyping

Key aim

Unsupervised machine learning algorithms for discovering new, ‘computable behaviour phenotypes’
1.2 Behavioural phenotyping

On node processing to inform EHR

Example: bring forwards appointments based on wearable data

- Unsupervised machine learning (e.g. kNN)
- Validate using accelerometer data from Biobank
- Some pilot data collection
Tasks

1. **Systematic** literature review of wearable sensors in chronic kidney disease and serious mental illness

2. Set up wearable and link with ‘EHR’

3. Biobank data access

4. ‘Low hanging fruit’ adaptive sampling

5. Information theory based adaptive sampling model creation.

6. Creation of behaviour clustering algorithms

7. Porting of algorithms to run on the sensor device
Interactions

Overlaps with work stream 4 throughout
Challenges

- Grant written assuming WAX9
- Programmable, wireless, 9-axis IMU
- Not sold any more!

Alternatives

- Build ourselves
- Adds heart rate
- Fully customisable
- Schematics difficult to access
- Complex firmware
- Not CE marked
- Not optimized
- Not CE marked
Challenges

Need coordinated Biobank application

✔ First validation of behavioural phenotyping using Biobank data
✔ We want accelerometry data and EHRs
❌ Complex application with cost associated and 4 month lead time

Do other work packages want/need linked data?

We are currently talking to other investigators in Manchester who have applied to the Biobank previously
Wearable hardware and software

Task 1.1 is adaptive sampling

Task 1.2 is on-node grouping of behaviours