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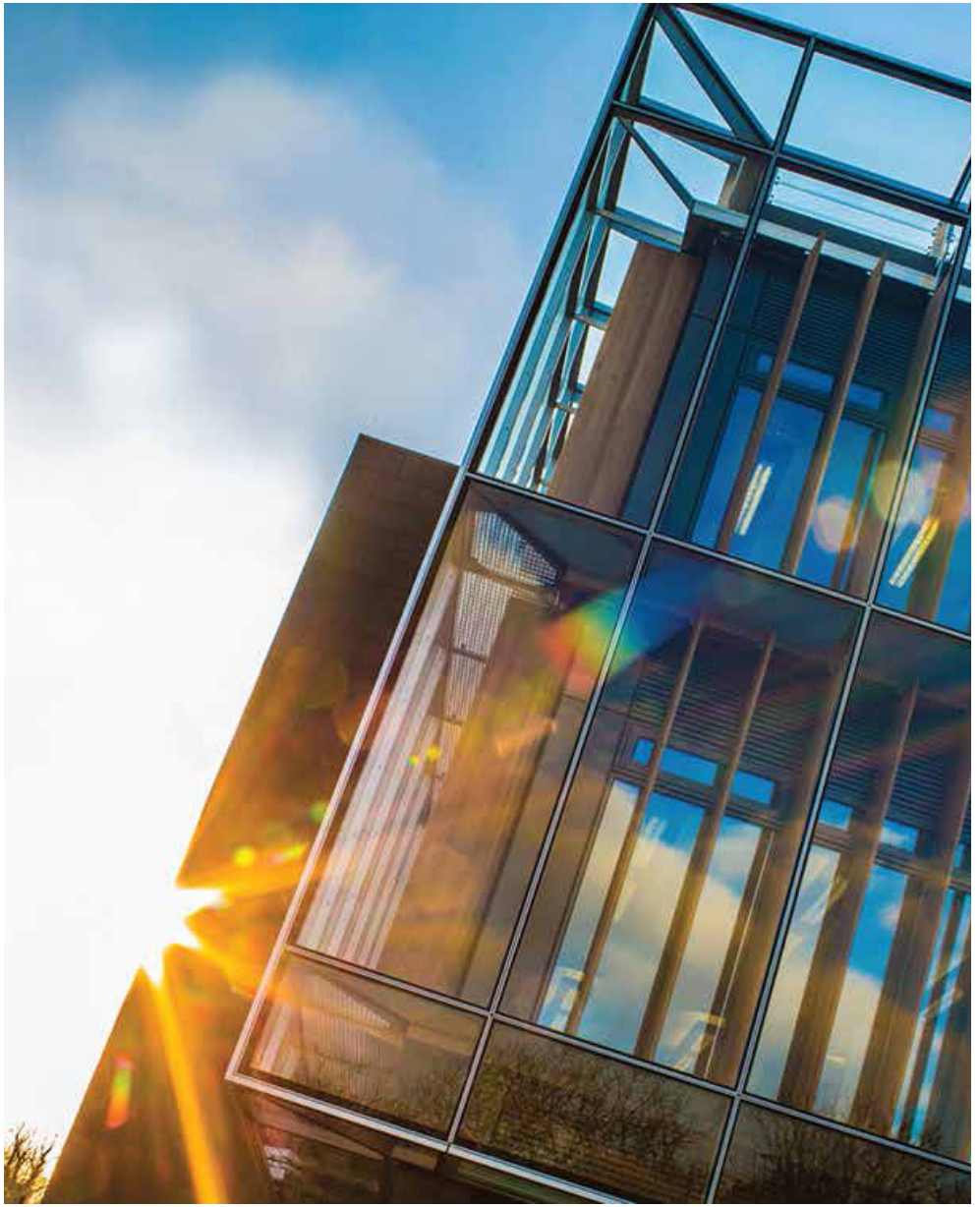
BeatHealth: Considerations When Moving Technology from the Lab to the Wider World



The Beathealth Project: Considerations When Moving Technology from the Lab to the Wider World

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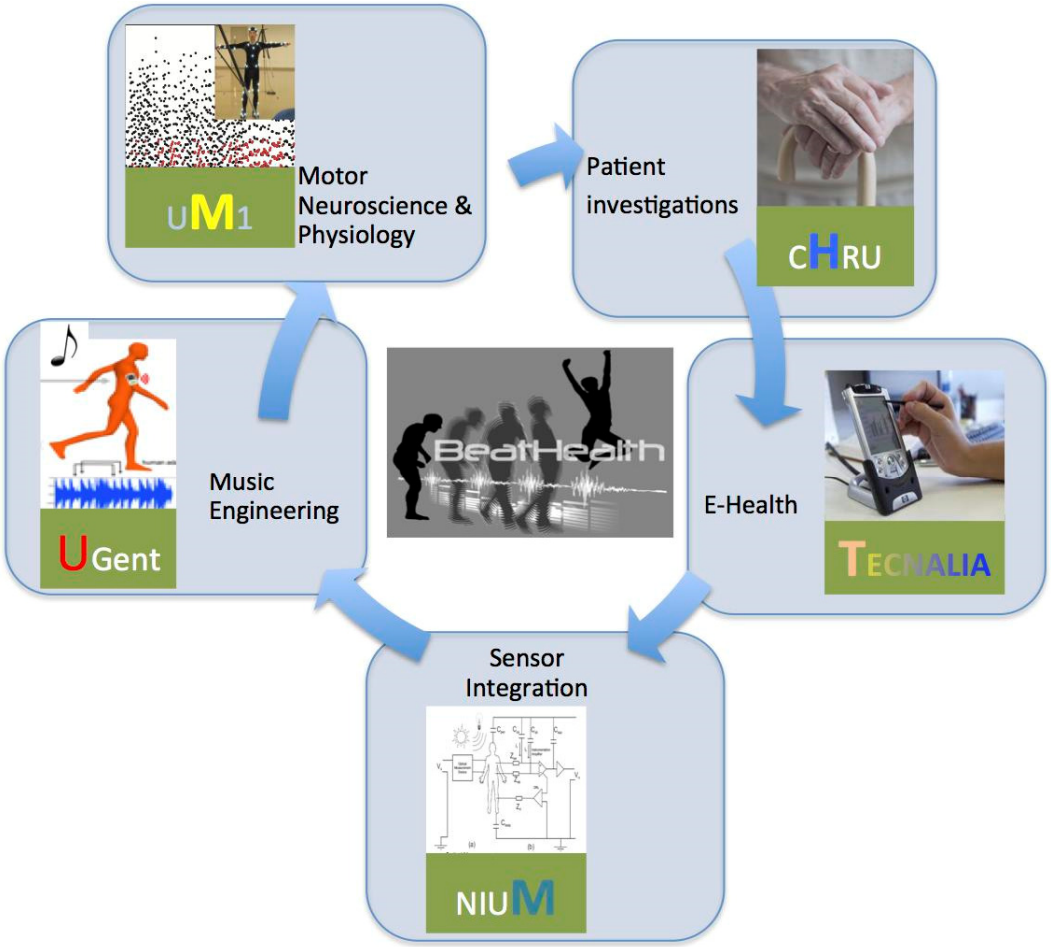
Introduction

- Background to the BeatHealth Project
- The theory and science of BeatHealth
- Organisation of the BeatHealth Project
- Technical Challenges
- Conclusion

Motivation

- In recent times scientists have begun to seriously investigate how using rhythm and music can be harnessed as a drug-free way of simulating health
- Music works on our autonomic nervous system, thus stimulating our sensations of wellbeing at a subconscious level
- Can this lead to a whole new set of therapeutic tools?

Consortium Expertise



Objective

- The objective of the project is to create a new method for improving health and wellness based on rhythmic stimulation

- To achieve this requires an age-friendly, portable system that has the capability to invigorate the user through musical playlists and then simultaneously record their movements (i.e., during walking or running) and physiological activity via advanced sensors.

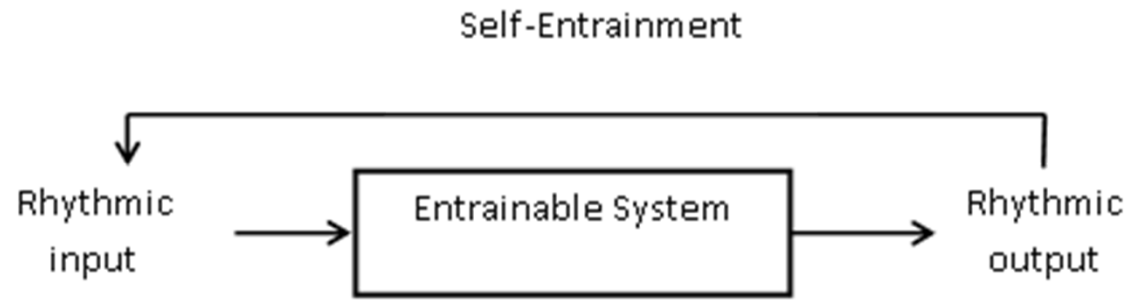
Entrainment

- This link between an external rhythm and the human body's movement response is a phenomenon known as *entrainment* (Clayton, Sager, and Will, 2004). This theory describes the synchronicity of two or more independent rhythmic processes.

- The Dynamic Attending Theory (DAT) model proposes that rhythmic processes endogenous to the listener entrain to cues in the musical sound

Self-Entrainment

- 'Self-entrainment' describes the case where two or more of the body's oscillatory systems, such as respiration and heart rhythm patterns, become synchronized (Phillips-Silver, Aktipis, and Bryant, 2010).



Self-Entrainment

- Complex-bodied humans and animals typically exhibit self-entrainment in their physical activity, that is, a gesture by one part of the body tends to entrain gestures by other parts of the body

- For example, the locking of step and inhalation cycles when jogging

Stimulating Health

- The fundamental idea is that by stimulating an entrainment between auditory rhythmical cues and spontaneous or deliberate movement, it boosts individual performance and leads to enhancements in health and wellness.

- For healthy people, this means that they should synchronize their movement with the beat of an external music source when dancing or when performing physical and sport activities such as running or cycling.

Stimulating Health

- This should lead to (i) better coupling between breathing and running, (ii) a reduction of energy expenditure, and (iii) a general increase in endurance and (iv) a desire to run

Stimulating Health – Motor Disorders

- Entrainment has a role in a therapeutic context where movement is constrained by a motor disease.

- One study reported how it been integrated into a rehabilitation therapy in patients with motor disorders where external rhythmical cues were found to help patients' regularize their gait

Consumer Technologies

- Yamaha released BODiBeat in 2007 (Yamaha, 2007) followed by Philips Activa (Philips, 2010) in 2010.

- Applications are now appearing for mobile devices.

- No similar commercial products are available for people with movement disorders.

Three BeatHealth Challenges

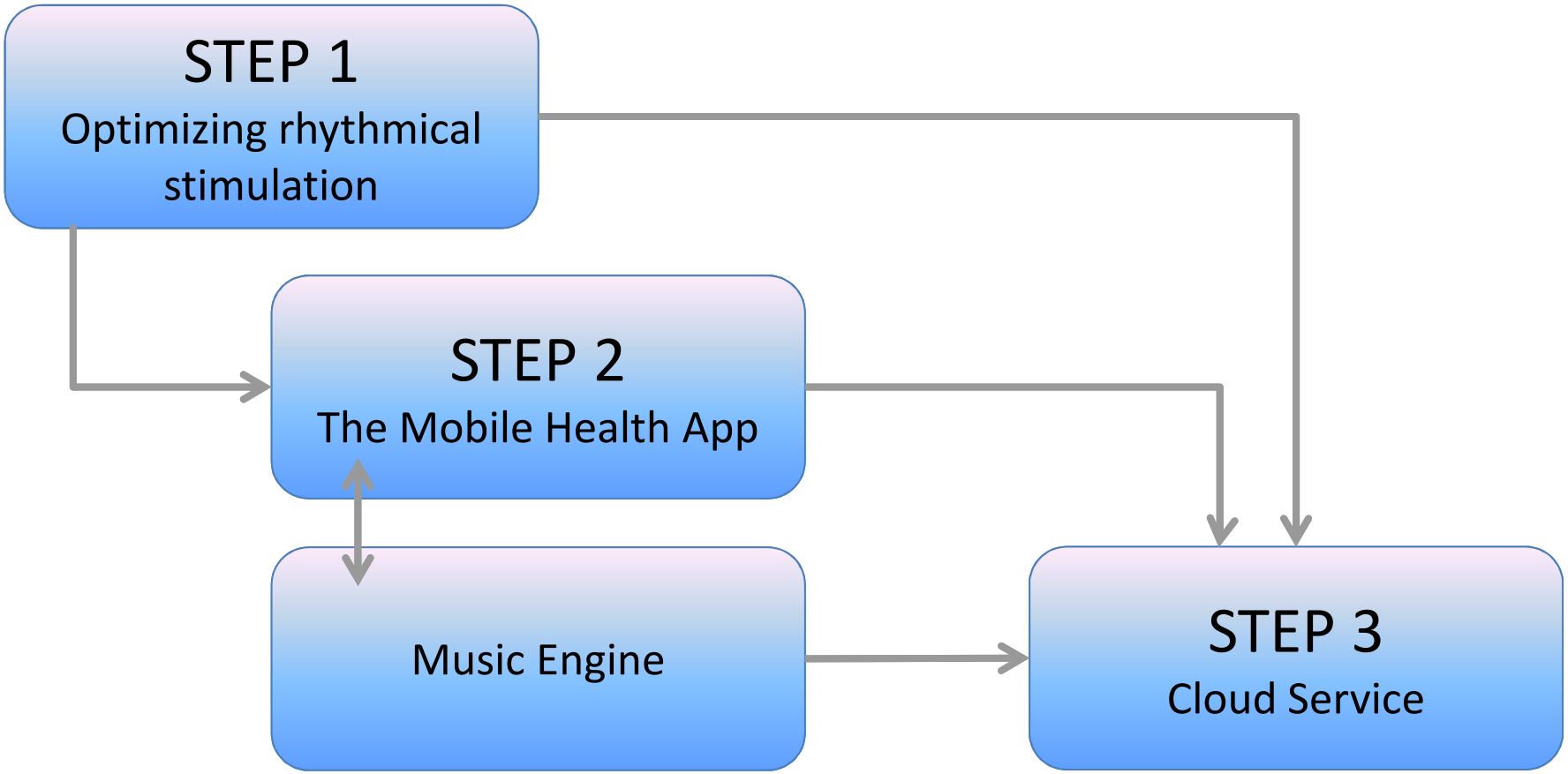
- (i) fundamental research aimed at improving information parameters for maximizing the beneficial effects of rhythmic stimulation on movement kinematics and physiology,

- (ii) technological development to a achieve state-of-the-art implementation platform to deliver the rhythmical stimulation that has attributes of portability, flexibility and reliability,

Three BeatHealth Challenges

- (iii) the creation of a new IT service in the form of a network-based application for collecting on the fly kinematic data and sharing them with online with others such as medical doctors, family, and trainers.

BeatHealth in Three steps



Rhythmical Stimulation

- Aims to boost motor performance
- Finds best auditory stimulation parameters for entrainment movement
- Found for both health people and those with motor disorders

Audio Material

- For the audio stimuli, attention will be devoted to understanding which type of stimulus (i.e. existing music or artificially generated signals) best fits the particular individual preferences and functionalities in relation to the motivational effort.

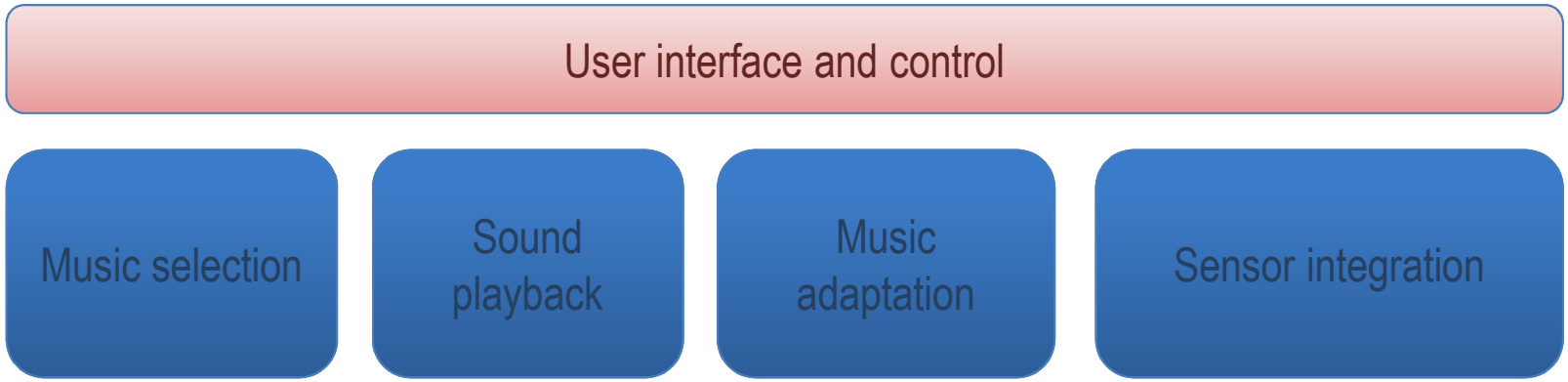
Mobile Application

- The structure is that a sensor or sensors detect bodily movement and complimentary physiological responses, and these sensor responses are transmitted to a mobile device that is carried by the user
- App will have a playlist of auditory stimuli
- Synchronization algorithms will align music with kinematic activity

Mobile Application

- Runs on a cost-effective smartphone
- For example, the motorola moto-g
- Uses the Android operating system

Application Architecture



Off-the-shelf sensors

MetaWatch

IMEC ECG Patch

iRhythm Zio

Zen / Lumafit

Polar Hx series

Zephyr HxM

Sensors

Communication Technologies

- The principal communication technologies compatible with Android mobile devices are WiFi, Bluetooth 2.1, Bluetooth 4, and ANT+. All of these technologies operate using the 2.4 GHz ISM band.

Communication Technologies

- WiFi: The power consumption of WiFi is high. Relies on access to a router making it less suitable for outdoor use
- Bluetooth 2.1 is a well established protocol that is widely supported on most mobile devices. It is a short range communications scheme—the most common devices have a range of about 10 m.
- Bluetooth 4 is an enhanced version. Bluetooth Low Energy (BLE) is a subset optimized for applications such as sensing. Support for Bluetooth 4 was added in Android 4.3
- ANT is currently only supported by a limited set of Android devices

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Communication Technologies - Issues

- using off-the-shelf Bluetooth modules for the sensors the buffer delays are unknown
- sensor samples are received in bursts rather than a steady stream and
- some packets (samples) may be lost when using Bluetooth 4

Signals and Synchronisation

- Ultimately the purpose of physiological signal feature extraction in BeatHealth is to identify the features and events which drive the music adaptation process.

- A very important aspect of this is ensuring that the music is adapted to synchronise with motion events (for example, steps when running).

Latency

- This problem is complicated by various sources of latency which occur in the system.
- For example, the communication latency between sensor and client
- Initial results suggest that the total latency is between 200 and 300 ms indicating that some form of compensation is needed to achieve synchronisation

Comment

- Fusion of data from different sensors is of particular interest
- Kalman filter type algorithms are normally used
- Must be efficient enough to work on the mobile phone

Conclusion

- Discussed the scientific background to the Beathealth project, mentioning entrainment, and particularly self-entrainment.
- It then explained the organization and components of the Beathealth application itself.
- The issues with sensors, communications and sensor signals were discussed

Any Questions?

- Thanks for Listening!!!