Controlling IoT devices with our brain, eyes, and facial muscles.

Project Description

This project envisions a future where all smart devices in our homes and offices are controlled via thoughts, eye movements, and facial expressions. It aims to take a step toward making this vision a reality. Though this sounds like science fiction, the motivation behind making it a reality is to provide greater access to technology for disabled people. Often, technology assumes that you have full use of your limbs or assumes that you are comfortable standing up and walking to the device, but this isn't the case for many people. For example, the UK disability charity Scope estimates that one in every 400 children will be born with cerebral palsy[1], which can make mobility difficult.

The specific problem I will address is that of controlling the playback of music via our brain, eyes and facial muscles. Controlling the playback of music with a computer or Bluetooth headset requires the use of your hands and arms, and though some smart speakers like the Amazon Echo allow you to control playback with vocal commands, I have found in my own experience that this is difficult to do when music is playing at loud volumes. Additionally, some disabilities such as cerebral palsy can make speech difficult or even impossible to understand. Thus, my solution to this problem will allow users to skip to the previous or next track on a playlist by detecting whether they have looked left or right. It will allow users to pause and resume playback by clenching their jaw. Additionally, it will detect the user's current mental state, whether they are feeling frustrated or relaxed, feeling positive or negative, or whether they are feeling drowsy or alert, and will play a song which matches this mood. This will be achieved using a device called the ANT Neuro EEGO-Sport, a cap worn by the user. Using EEG (Electroencephalogram) and other biosensors, it can detect when the wearer moves their eyes from side to side, clenches their jaw, and experiences brainwave patterns associated with different emotions. The data that the EEGO-Sport detects will be streamed to a computer which will analyse the signals, calculate what the user is trying to do, and will act accordingly, playing music through a connected speaker.

This problem presents a sufficient challenge for the module. I have not worked with an EEG device like the EEGO-Sport before, and I also have not received formal education on how brain waves such as alpha, beta and theta waves work. Learning about this topic is a significant undertaking. Additionally, though I have worked with IoT devices before, and have sent data wirelessly from a peripheral to a computer via Bluetooth, I predict that this will be challenging for me.

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[1] https://www.scope.org.uk/advice-and-support/cerebral-palsy-introduction

Aims and objectives

In essence, the aim of this project is to design a system which will allow the user to control the playback of music using their eye movements, facial expressions, and brain waves. The user will be able to skip to the previous track by looking left, skip to the next track by looking right, they will be able to pause and resume playback by clenching their jaw, and depending on their mental state, different songs will play which matches the user's mood. This will be achieved through the EEGO-Sport, which will be able to detect these changes in brain waves using EEG sensors and by detecting other physiological data.

There are three tasks involved in this project:

1. Set up the biosensing system to capture brain, eye and muscle biosignals,
2. Design a scenario to automatically control the IoT "smart speaker",
3. Implement an algorithm to process the biosignals and control the devices following the designed scenario.

The greatest risk to the project, particularly with tasks one and three, is that the EEGO-Sport breaks. The later in the project this happens, the greater the impact this would have on development. The Physical Sensing Lab in the Abacws building has other biosensing technologies such as OpenBCI Cyton and Ganglion platforms if the worst should happen, however it is unlikely that they would work in the same way the EEGO-Sport would, and thus breakage remains a large risk.

I do not foresee any significant risks associated with the second task. I am able to provide speakers and computers, including microcomputers such as a Raspberry Pi, to the project.

Feasibility

I will be seeking ethical approval to test the system on people other than myself. This is so that I can be assured that the system works. The EEGO-Sport cap is almost entirely safe; however, it has been reported that on rare occasions that if a person has epilepsy, they could suffer a seizure whilst an EEG test is carried out. This could affect my chances of receiving ethical approval, and so while it would be helpful to test the system on other people, it is not necessary. I have been assured by my project supervisor that as long as I perform testing on only myself and other people doing similar projects to me working under the same supervisor, I would not need ethical approval.

Additionally, I will need to carefully consider copyright laws when selecting music for the project. It is possible that I could use small portions of copyrighted music rather than a whole track, however it would be more simple to attempt to use music that is in the public domain. Archives such as the "Open Music Archive" provide a collection of songs in the public domain. Alternatively, I could find "royalty free" music, though this may not be feasible if the initial licensing fee is too great.

Work Plan

Week 1 and 2:

Tasks:

- Initial plan preparation (this document)
- First meeting with supervisor
- Background reading into how EEG and other biosensors work
- Background reading into brain waves and what each kind of wave indicates
- Background reading into the EEGO-Sport and how it interfaces with other devices, how it communicates. Reading into how the computer attached to the speaker will receive data and in what format.
- Background reading into playback of tracks, deciding how exactly this will be achieved. Decide if a GUI is necessary? If not, can this be achieved with Python?

Background reading will commence during this period but will likely continue throughout the project.

Deliverables:

- Initial plan document

Week 3:

Tasks:

- Meet with Loic Lorente Lemoine, who has volunteered to help introduce me to the EEGO-Sport.
- Once I have been familiarised with the technology, start to capture data with the cap

Week 4 and 5:

Tasks:

- Start working on the music playback algorithm, at this stage playback should be controlled via the terminal rather than by the EEGO-Sport
- Capture data from myself using the cap, noting when I am feeling frustrated/looking in a specific direction (stressful/ relaxed moods can be triggered using stimulus like attempting to complete difficult puzzles and meditating. Fatigue can be triggered by getting poor sleep)
- Send data from the cap to the computer, ready for analysis

Week 6:

Tasks:

- Finish capturing data from the cap
- Note when captured biosignals correlate with eye movements/ facial expressions/ mental states

Milestones:

- Data capturing from myself should have now been completed.

Week 7 and 8:

Tasks:

- Ensure that once data is sent from the cap to the computer, it is able to differentiate between inputs, eg. It can tell when the user is looking left rather than right

Milestones:

- The computer should now know when the user is looking in specific directions, and should understand the brain waves the user is feeling

Week 9 and 10:

Tasks:

- Input from the cap should now control the music playback algorithm

Week 11 and 12:

Tasks:

- Finish writing the final report. (Note the final report will be worked on throughout the semester, but the last two weeks will be focused on finishing and refining it)

Deliverables:

- Final report

References

1. https://www.scope.org.uk/advice-and-support/cerebral-palsy-introduction
   Scope's Cerebral Palsy information page.