EEG Data Acquisition using the Muse 2 headband

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Abstract--The Muse 2 headband is a commercially available, research-grade, EEG device that passively senses brain activity. In this paper, we cover how researchers and practitioners are using the device and detail a method by which software developers can use in conjunction with modern programming tools.

1. INTRODUCTION AND BACKGROUND

The Muse 2 headband is the second generation of Interaxon's EEG sensing devices. Those devices are marketed to individuals interested in starting and improving the quality of their meditation practice.

The Muse 2 is a multi-sensor band capable of measuring EEG, Heart (using PPG + Pulse Oximetry), Body motion (using an accelerometer), and Breath motion (using PPG and Gyroscope). The device features a built-in Li-ion battery with a 5-hour continuous use rating. Connectivity with the device is via mobile phone and Bluetooth 5.0. [2]

The light-weight portability and reliance on dry-sensor technology have made the device ideal when compared to bulky devices and methods involving the use of gels. This has aided the utility of Muse devices in clinical and research studies.

2. USES IN RESEARCH STUDIES

In addition to consumer adoption, the Muse devices are also being used in research studies at MIT and Harvard, and at other research centers: [3]

- University of Toronto
- University of Memphis and IBM Watson Research Center
- Rotman Research Institute
- McMaster University
- University of Victoria
- University of British Columbia
- University of Victoria, in Canada

3. DATA ACQUISITION

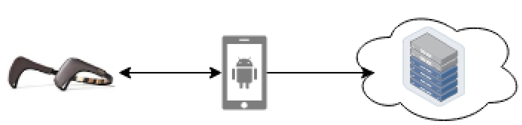
As purchased, the Muse 2 device pairs with a mobile phone application (provided by Interaxon) via BlueTooth. The mobile app is primarily used to aid in guided meditation sessions. Numerous third-party applications are also available for both iOS and Android. [4]

In this paper, we'll use the "Muse Monitor" application [5] which runs on an

Android device and is able to relay OSC Streaming data to cloud storage systems and remote servers.

In our use case, we'll leverage the steaming data capability and direct packets to a simple UDP server built using NodeJS. The full source code for the sample server is released as open-source software and hosted on Github under the name "Brainwave Tracker". [6] It should be noted that there are a number of ways in which to do the same using other documented open-source tools. [7]

Like related projects, Brainwave Tracker uses osc-min [8] to decode UDP packages. OSC (Open Sound Control) [9] is a communication protocol for controlling sound and systems. Muse Monitor connects to the Muse 2 headband and relays OSC encoded UDP packages to an IP address and Port on a network. The Brainwave Tracker server simply listens to incoming UDP packages and decodes them using the osc-min library.



The following sample code shows the processing of incoming UDP messages, decoding of OSC buffers, and setup of a simple server.

```
let main = async () => {
 const server =
dgram.createSocket('udp4');
 server.on('message', (msg, rinfo) =>
{
   const message =
oscmin.fromBuffer(msg);
   const type =
message.elements[0].address;
   if (type.includes('eeg') ||
type.includes('acc')) {
     // handle eeg or acc messages
   }
 });
 server.on('listening', () => {
   let address = server.address();
   console.log(`server listening
${address.address}:${address.port}`);
 });
 server.bind(43134);
};
```

For a more complete example see the BrainTracker sample project. [6]

4. CLOUD-BASED USAGE

An extension of the approach presented above would involve a custom application that connects to the muse device, identifies the device wearer, the possible context or activity, and sends messages to cloud-hosted server(s) using TCP/IP WebSocket messages rather than UDP. Doing so would improve the reliability of message transmission. Additionally, the use of UMF as a message format would increase the utility, route-ability, queuing, and scalable message handling. [10]

5. USE IN CONNECTED FITNESS

Outside of wellness and medical research use cases, the Muse device has uses in the connected fitness space where monitoring the effects of exercise on the brain can, when coupled with biometric sensors, aid in providing a holistic view of the effects of a particular physical training method. The use of biofeedback as input into 3D body simulation and modeling can enhance and illuminate the effects.

6. ACKNOWLEDGEMENTS

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7. REFERENCES

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[2] Muse 2 device specs https://choosemuse.com/muse-2/
[3] Research projects involving Muse https://choosemuse.com/muse-research/
[4] Muse third party apps in the Google Play Store https://play.google.com/store/search?q=muse%202&c=apps
[5] Muse Monitor https://musemonitor.com/
[6] Brainwave Tracker https://github.com/cjus/brain-wave-tracker
[7] muse-lsl: Python script to stream EEG data from the muse 2016 headset https://github.com/alexandrebarachant/muse-lsl
[8] osc-min: simple utilities for open sound control in node.js https://www.npmjs.com/package/osc-min
[9] OSC (Open Sound Control) http://opensoundcontrol.org/introduction-osc
[10] UMF (Universal Messaging Format) https://github.com/cjus/umf/blob/master/umf.md