Audio Output from EEG Data

A Way to Turn Brainwaves into Music

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ABSTRACT

Our project uses EEG equipment Emotiv Insight to detect and record the user's brainwaves in 5 channels. After mapping the EEG data with music frequencies, users can create midi files of their brainwave and play the audio with different instruments they select. We found that while using our brainwaves is a viable way to create music, the ability to alter the music to our thoughts is not possible to the capacity we imagined.

INTRODUCTION

Making music is difficult. Professional musicians spend years of theoretical education and practices to master composing but everybody has some melody in their head. If that melody can be reflected through people's thought processes, everybody can communicate their thoughts through music. The target group of our project is people who want to try new equipment and explore new experiences. This is also an application for people to generate music easily. Users can manipulate the wave of the music with their brains and assign each channel to the instruments of their choice. The purpose of the project is to explore the possibilities and the interaction between brainwaves frequencies and music scale frequencies. The purpose of this project is to help users learn more about their brain and how they can manipulate their brainwave frequencies and create music.

RELATED WORK

Due to the nature of our project and difficulties in obtaining equipment, we used many different technologies in making this project. In the end, we only used a small handful of tools in the final design.

What we used in the final product:

Emotiv Insight:

https://www.emotiv.com/insight/
This is the final headset used in our project. The Emotiv Insight has 5 channels and outputs EEG data in various formats. For our project, we outputted EEG data in CSV format

MIDI sequencer:
https://onlinesequencer.net/import
Online MIDI Sequencer we used to output brainwave MIDI files. This can be replaced with any other MIDI sequencer of one's choosing

MIDIUtil:
https://pypi.org/project/MIDIUtil/
A python module that generates MIDI files with the desired number of tracks and channels and allows control over the tempo, volume, and notes in the MIDI file.

Midi To mp3 converter:
https://audio.online-convert.com/convert/midi-to-mp3
Online service that converts MIDI file to mp3 format for easier access to the created music for consumers.

EEG Logger:
https://github.com/Emotiv/cortex-v2-example
Cortex API to receive EEG data and write to an output CSV file.

Other resources we used (not in the final project):

OpenVibe: http://openvibe.inria.fr/
Open Source software allowing users to design, test, and use BCIs (Brain-Computer Interfaces) used with MindWave Mobile

MindWave Mobile (link is for Mobile 2, we used Mobile 1):
https://store.neurosky.com/pages/mindwave
Headset used before the arrival of Emotiv Insight. Only capable of one channel.

Insight2OSC:
https://www.nime.org/proceedings/2017/nime2017_paper0055.pdf
Software converting Emotiv Insight messages to OSC messages

DESIGN CONSIDERATIONS

The scope of the project was limited mainly due to financial factors and the limited time-frame at hand. High-end equipment required for recording EEG waves and analyzing them in-depth required hardware that exceeded acceptable cost for a project that would only last for one quarter. Due to limited access to suitable equipment, we shifted our goal from analyzing and classifying brain waves to mapping brain wave frequencies to MIDI values to generate music. The number of musical instruments in the produced composition was limited by the number of nodes in our hardware (Emotiv Insight). Readings from each node relate to one musical instrument and the frequencies map to notes in the MIDI file. Hardware with more nodes would correspond to more instruments in the generated audio file.

A viable product would be an app that would be able to connect to the EEG hardware through Bluetooth and retrieve the EEG stream in CSV format and would have a UI that would allow the user to select the number and type of instruments they would like to have in their output while they are generating the music. The frontend would also include the option to view the EEG waves as the music is being generated, as well as the musical notes sequenced as a result in the same window. The app would include in its backend an EEG format CSV to MIDI file generator and a sequencer to edit the MIDI file as it is being generated and a MIDI to mp3 converter that would allow the user to store the file to the desired location when they are done.

DESCRIPTION OF THE SOLUTION

The user wears the headset and ensures a strong connection to get usable readings from the hardware. This is done inside the Emotiv app, ensuring above a 95% connection quality. Afterward, the user records their brain waves using the Emotiv app for the length of time they desire, experimenting with different thoughts, emotions, and facial movements, to manipulate the readings from the headset. A couple of examples of these actions could be and are not limited to extreme focus, meditation, deliberate blinking, clenching of the jaw, or no movement or focus at all.

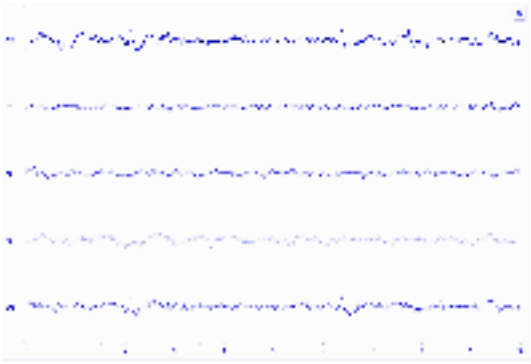

Fig.1 All 5 channel readings from Emotiv Insight

The user takes the recording from the Emotiv app and outputs it to a CSV file.

title:Nothing	headset type:INSIGHT	headset serial:A1D2068CFA	headset firmware:930	subject name:Corey	channels:31
Timestamp	EEG.AF3	EEG.T7	EEG.Pz	EEG.T8	EEG.AF4
1583521669.067160	4298.461426	4278.974121	4101.538574	4150.256348	4132.820313
1583521669.075050	4311.282227	4278.974121	4100.512695	4170.769043	4127.179688
1583521669.082750	4306.666504	4278.974121	4100.512695	4173.846191	4129.230957
1583521669.090640	4305.641113	4272.820313	4103.077148	4169.743652	4138.461426
1583521669.098340	4311.794922	4270.769043	4099.487305	4182.563965	4132.820313
1583521669.106240	4315.897461	4281.025879	4091.281982	4196.410156	4123.589844
1583521669.114140	4308.205078	4270.769043	4082.051270	4197.948730	4113.333496
1583521669.122030	4295.384766	4252.307617	4066.666748	4183.589844	4109.230957
1583521669.129730	4285.128418	4252.307617	4060.000000	4186.666504	4102.563965
1583521669.137430	4297.948730	4272.820313	4071.794922	4218.461426	4108.717773
1583521669.145120	4297.948730	4266.666504	4076.410156	4231.794922	4102.051270
1583521669.152820	4294.358887	4256.410156	4066.666748	4221.538574	4083.589844
1583521669.160520	4294.358887	4250.256348	4053.846191	4218.974121	4078.974365
1583521669.168410	4295.384766	4248.205078	4057.435791	4225.641113	4092.820557
1583521669.176110	4303.077148	4254.358887	4066.153809	4230.769043	4095.384521
1583521669.184010	4325.128418	4260.512695	4065.128174	4251.282227	4099.487305
1583521669.191910	4321.538574	4256.410156	4051.281982	4253.333496	4100.512695
1583521669.199800	4303.077148	4248.205078	4048.205078	4248.205078	4089.230713
1583521669.207500	4302.051270	4244.102539	4052.307617	4260.000000	4087.179443
1583521669.215400	4304.102539	4244.102539	4060.512939	4269.230957	4090.769287
1583521669.223100	4309.743652	4252.307617	4064.615479	4266.666504	4093.333252

Fig.2 All 5 channel readings from Emotiv Insight in CSV format

The CSV file displays time stamps and frequency band data. The **Timestamp** column contains the timestamp of the sample in seconds. The **AF3_THETA** to **AF4_GAMMA** columns contain the frequency band data for each channel.

Using Python, the user then runs our program, csvToMidi.py, to translate the brain recordings to a MIDI file that can be used by a sequencer. The user then uses a sequencer of their choosing to modify the instruments used by the five different

waves to create music. This is then converted to an MP3 file for the final track.

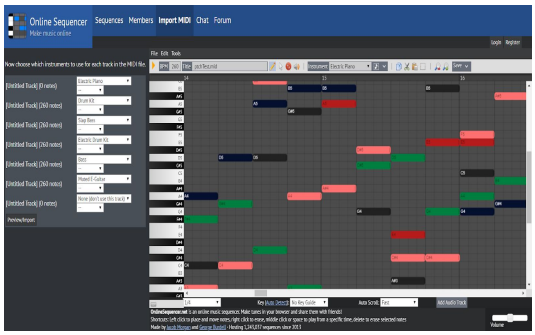

Fig.3 Midi File Sequence Generated

We found the connection between EEG data and sound data through frequencies. We studied the different frequencies bounds among the 5 channels and mapped each channel to an individual track in the MIDI file. We averaged a range of frequencies (roughly in intervals of 30) to one value that maps to a single note in a track at 360 BPM (beats per minute) in order to match the length of each track to the length of the EEG recording. Using different instruments for each track allows the user to create fairly interesting music from the MIDI file.

CONCLUSION

Even though we were able to create music using data from brainwaves, we found that this doesn't necessarily create a unique sound. Recordings from the same person tend to be similar, despite the mental state and physical action the person is doing. What we can determine from this is that the recordings we got were not unique enough to create a high variance in sounds. This could be limited by our headset, or it is also possible that brain waves do not vary enough with mental changes to create a meaningful difference. Denoising the data could possibly produce more unique sounds but does not isolate the actions and mental states we want to capture.

GITHUB & YOUTUBE

https://github.com/Crystor9/Brainwave2Music

https://www.youtube.com/watch?v=oVCC_tT416Q&feature=youtu.be