Team 17 – Initial Architecture Document

Members:
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Project Name:
Soundfield

Project Synopsis:
Software application that inputs EEG data of emotions while listening to music and outputs a corresponding piece of art.

Architecture:

Our goal in this project is to record and interpret our emotions as we listen to our favorite songs using generative art. We chose this approach because it has such a huge audience. Everyone has a favorite song, whether it allows them to escape from their day, remember a loved one, or make them break out in dance. Their reasons for why those songs are their favorite though are deeply rooted in emotions and having the chance to capture them visually is something I bet most people would like to participate in.

Now our first problem when it came to planning this project was how and what are we going to use to record our emotions, and we decided upon using an EEG headset. When it comes to neurological imaging there are four main techniques: PET, fMRI, EEG, and MEG. PET and fMRI are both hemodynamic methods, meaning they actually process and record different components of blood flow in the brain rather than neuronal activity. They both can create images of brain activity that have spatial resolution down to the millimeter, creating amazing structural images of the brain, but they have incredibly bad temporal resolution of at best six to eight seconds. This temporal resolution made us immediately take PET and fMRI off of our scope because of how fast emotions can pass during a song. We want to be able to record down to at least a tenth of a second. Not to mention, PET scans include injecting radioisotopes into your patients, fMRI scans are extremely loud, and both cost a tremendous amount of money for each session.

This led us to choosing between EEG and MEG recording methods. Both of these methods can record down to the millisecond depending on the machine you buy, which is just the temporal resolution that we were looking for. However, MEG machines cost around two million dollars and also are very expensive to run. There is one at KU Medical Center, but we doubted they would let us take as many recordings as we were wanting. This left us with getting an EEG headset, which is in our price range and commercially available for only a couple thousand dollars.

What exactly are EEG headsets though and what are we actually recording? EEG stands for electroencephalography which is a method to record digital electrograms of electrical activity at the scalp of the head. This means we are actually recording the electrical activity of neurons, but mostly in cortical structures that are closer to the skull. Which in our case is great news, because a lot emotional tracking research is done using EEG headsets while looking at some of these important cortical structures. In addition, as you can see from Figure 2, there are electrodes placed all around the head that are each recording their own electrograms, meaning there isn't just one central recording device and we can choose the granularity we are wanting at different regions of the brain. The way these electrodes work is that there are small holes in the center of them, and during recording will be filled with electrolytic jell to create a connection between the scalp and the electrode. The electrical activity of the neurons is then conducted through the electrodes into an amplifier (because of how small these electrical changes actually are) and are then recorded into a file or computer.

The next step we need to figure out though before we can even use the EEG data for the generative art is how we are going to filter and preprocess the data. One of the biggest cons when it comes to working with EEG headsets is that they record a lot of noise. It makes sense though. You are recording very sensitive changes of electrical activity when there is technology all around us. Sitting to close a computer, having in earbuds, having your phone on you, etc. will all create noise in the readings that need to be filtered out or mitigated during recordings. In addition, other normal bodily functions and processes can also create a lot of noise that we are not wanting to record as you can see in Figure 3. Funny enough, blinking creates huge spikes of electrical activity along the scalp, as well as looking around, and even your heart rate. Luckily for us, a lot of researchers in the past have dealt with these troubles and there are plenty of signal processing libraries that will help in this cleanup during preprocessing.

Once the data has been cleaned up our code becomes a little less tedious. As you can see in the flowchart in Figure 4, we'll take the EEG time series data and average it into 24 frames per second. We'll then start with a blank canvas and for each "frame" we decode what emotion is being portrayed, generate that emotion onto the canvas, save an image of the canvas and move to the next frame until you've gone through all the data. We'll save a "complete still" at the end, and then compile a video of the art being generated using the song that they listened to as the audio. Outputting both the still and the video to the user.

We then decided to host this art generation on a web service as depicted in Figure 1. We wanted to allow people to upload their own EEG data and audio to our service in order to reach the biggest audience we could, as well as easily compile all of the EEG data that's been uploaded into the site using a database. Our future goals would be to implement machine learning models onto this huge EEG dataset for further research.

We also decided to split the web service into two separate frontend and backend servers. This will allow us to easily test sections of our code, by separating art generation logic (Figure 4) from the front end portion.

We'll be using docker images to build the frontend, backend, and database servers separately to host on GCP or AWS. Using docker compose to create a cross platform testing environment for everyone on the team. This will mitigate any dependency problems from anyone's different computers and allow us to test in the exact same environment that would be in production.

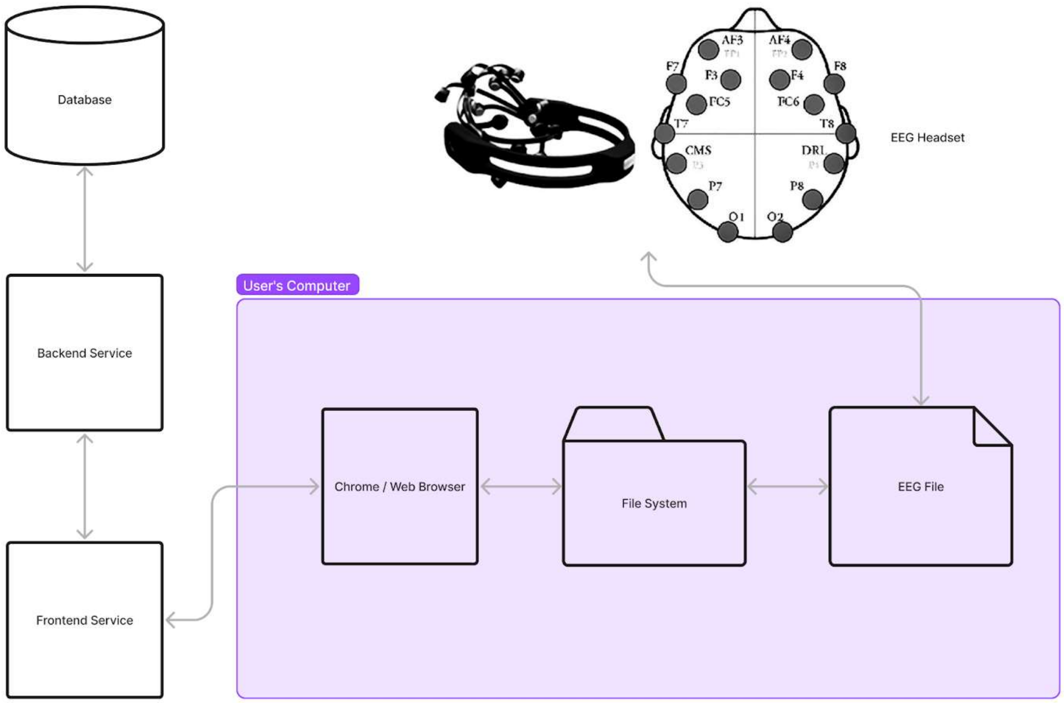

Figure 1:

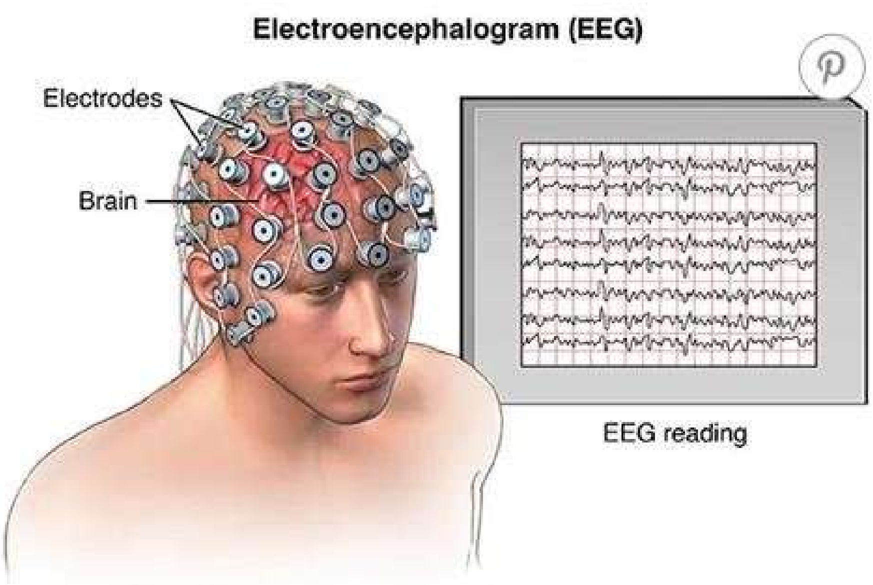

Figure 2: https://www.brightbraincentre.co.uk/electroencephalogram-eeg-brainwaves/

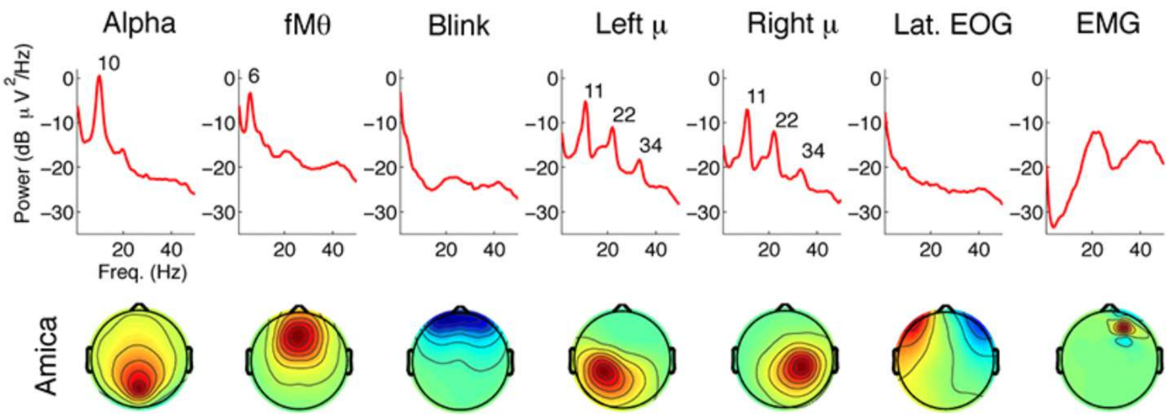

Figure 3: https://eeglab.org/tutorials

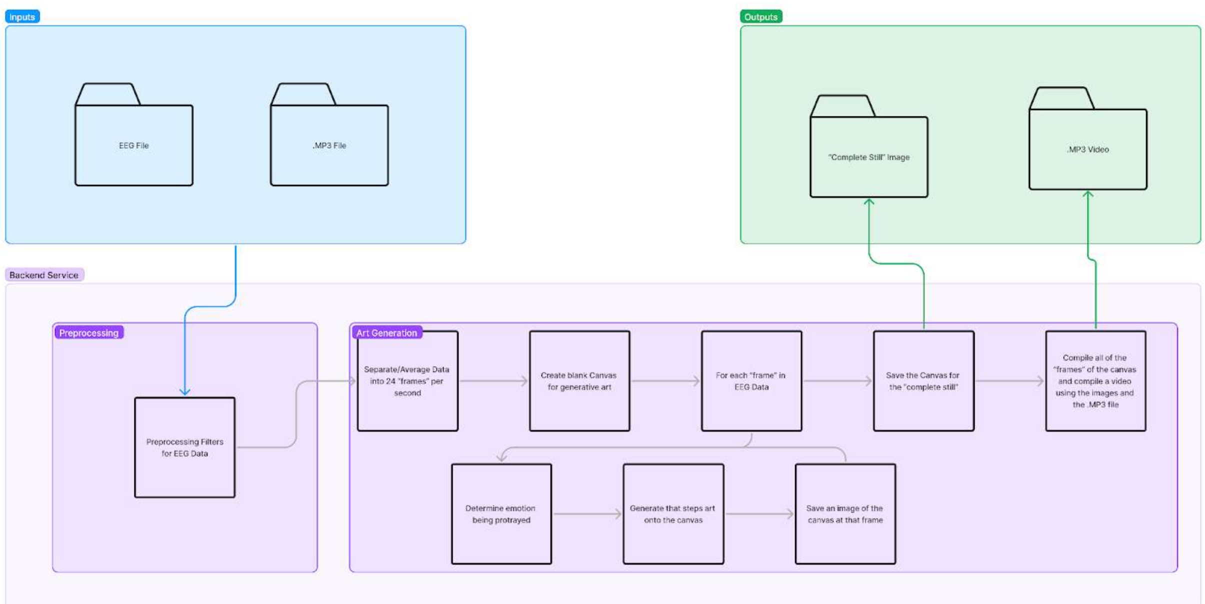

Figure 4