Brainwave Decoder: An EEG-based Art Generation System

Major Project

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Degree Scheme: Computer Science – G400
Module Code: CS39440
Date: 10/01/2025
Version: 1.8
Status: Release

Project Description

The proposed project is to create an art generation system which allows users to generate, display/listen to and save art that they create with brainwave data collected from an EEG (electroencephalogram) sensor. Ideally, users will be able to freely manipulate the generated pieces of art such as colours, patterns or different frequencies of sounds by actively recalling different emotions and memories. The objective is to explore the relationship between neuroscience and the creation of digital art by using an EEG sensor to allow users to artistically express themselves in a way unique to them.

With the development of brain scanning technology, we can now monitor people's brain activity safely. This technology was initially developed as a tool for medical purposes, such as diagnosing neurological disorders or identifying underlying issues that may not have been noticeable before, but as it becomes more accessible, it's starting to be considered as a potential tool for human comfort and communication. And, over the past couple of years, studies, personal projects and art exhibitions have started using this technology to control objects without physical contact or as a medium to create art. The aim is to finish with a project that advances this idea to include higher levels of responsivity and detail than what has been previously established.

This project will develop a piece of software that should be accessible to users with limited to no previous knowledge of EEG sensors. There will be a simple GUI (graphical user interface) that will allow users to upload data from previous sessions with an EEG sensor and access previously generated art.

The EEG sensor I will be using has 14 nodes and a sampling rate of 100+ Hz which means a major part of this project will be in managing large amounts of data, efficiently analysing the data and developing algorithms that can interpret and map brainwave patterns to artistic outputs, whilst minimising potential noise from irrelevant nodes and computational overlap.

The research for this project should include EEG signal processing for analysing raw data and generative algorithms for creating digital art. The final project should also make use of machine learning techniques to recognise patterns and changes from the processed data such as emotions. Additionally, the research could include biofeedback applications and HCI (human-computer interactions). Ethical and privacy conditions might also need to be considered when using someone's brain activity to generate art, raising concerns such as, authorship rights, data security of their brain activity and real-world applications.

Finally, for this project, I plan on using GitHub so that any work is stored online to prevent accidental loss of work and so that supervisors can have access to my work, Python is my language of choice due to the extensive libraries for visualisation and data analysis, as well as previous examples using the same language and a Scrum methodology to manage the different tasks I might need to finish before the project can be called complete.

Proposed Tasks

The following tasks will be performed on this project:

- **Investigate EEG Technology.** Research into EEG sensors and their applications in BCI's (brain-computer interface) will be necessary to fully incorporate them into the project, especially with no prior expertise. This will include investigating existing EEG-based art/analytical projects and methodologies to see what existing libraries and algorithms could be useful to me. This task will be finished after analysing emotion recognition techniques using EEG signals and how compatible they are to the project or how to make my own.
- **Setting Up Build and Version Control.** The language I'll be using is Python 3.11 and the IDE will be Spyder 6, and it will be necessary to download both for local development of the

project. I've also decided to use GitHub and will therefore need to set up a online git repository to serve as non-local backup of the project.

- **Development.** Development should be split into sections:
    - **A basic UI.** The basic UI will need to allow users to upload information, navigate through different sections and request data / results.
    - **EEG data analysis.** This will all be sub-surface and mostly inaccessible to the user and should be almost purely algorithmic and objective. This will be the main part of the developmental process and will need to implement EEG signal processing techniques. Developing a classification model to map brainwave patterns to emotions will also be necessary, as well as training the models.
    - **Art generation.** The final part of the developmental process would be to design generative algorithms that implement mappings of classified emotion patterns to visual or auditory parameters whilst optimising the responsiveness and quality.
- **Project Meetings and Project Diary.** Currently, the project will include at least one supervisor meeting per week and a project diary will be kept each week to keep track of what has been done on the project and when. The diary will be in the form of '.txt' files and will be saved in the repository of the project.
- **Preparation for Demonstrations.** The project is designed to have two demonstrations, one halfway through the course of the development and should show proof of several graphs of analysed EEG data, as well as the beginnings of either an emotion classification system or a generative system and the other will be after the project has been deemed as finished and should display a dynamic system of generating either sound or images from EEG data.

Project Deliverables

The following deliverables are expected.

- **Mid-Project Demonstration Notes.** A set of notes that sum upwhat was presented at the demonstration halfway through the course of the project and will be included as an appendix in my final report. A draft will be discussed with my supervisor beforehand.
- **Art Generative Algorithm.** One or more files which can be used to generate pieces of either visual or auditory media. All necessary files to create a piece of art will be included, including a set of 'test' information. This will form a noticeable portion of the submitted code.
- **EEG Signal Processing Software.** One or more files that take raw data from an EEG sensor and converts it into data that can be used to predict emotions and draw from. All necessary files to analyse a set of raw data will be included, as well as one set of raw data for testing purposes. This will serve a significant portion of the submitted code.
- **Emotion Recognition Model.** One or more files that convert cleaned EEG data into predictions for emotions. Should be trained before submitting and all necessary training data should be submitted. This will form a noticeable portion of the submitted code.
- **User Interface and Interactive Design.** A fully developed system will be provided that allows users to access all parts of the project. This will form a minor section of the submitted code.
- **Story Cards.** A document which will cover all stories generated during the project. This will form an appendix in the Final Report.
- **Final Report.** This will be the report and all associated appendices. This will discuss the work and acknowledge any 3rd party libraries, frameworks and tools used.
- **Final Demonstration.** No documentation will be produced for this demonstration, but it is still a deliverable.

Initial Annotated Bibliography

[1] Github, Inc., "GitHub homepage," 2025. [Online]. Available: http://github.com/. [Accessed 6 February 2025]

This is a free private repository for students and offers useful features.

[2] Hannia Barrera et al, Neurotech@Davis, 2021. [Online]. Available: https://medium.com/neurotech-davis/eeg-brainwave-art-giving-a-different-meaning-to-our-memories-202267dd2d55. [Accessed 6 February 2025]

[3] Neuroelectrics, Neuroelectrics, 2024. [Online]. Available: https://www.neuroelectrics.com/blog/eeg-art-exploration-beyond-the-canvas. [Accessed 6 February 2025]

[4] Reyansh Bahl, Medium, 2023. [Online]. Available: https://reybahl.medium.com/eeg-signal-analysis-with-python-fdd8b4cbd306. [Accessed 6 February 2025]

[5] AMIGOS dataset, 2018. [Online]. Available: https://www.eecs.qmul.ac.uk/mmv/datasets/amigos/readme.html#orig. [Accessed 6 February]

Dataset for potential use in trials