Deciphering EEG Waves for Generation of Images

Department of Computer Science and Engineering
PES University, RR Campus, Bengaluru - 560085.

PROBLEM STATEMENT

- The project's goal is to enable a comprehensive representation of a human chain of thoughts in the form of images via text modality. The world is witnessing an increase in the number of neurological disorders, which could be genetic or as a result of age or accidents.

- The project entails the scope of assisting such subjects with seamless communication, allowing them to express their thoughts clearly. The project would have applications in neurolinguistics, which is a hotbed of research in the field of Brain Computer Interface.

BACKGROUND

The literature survey illustrates the limited nature of work pursued in this domain. Numerous attempts have been made on extraction of text from EEG signals pertaining to closed vocabulary. Several research on image reconstruction has also been done. However, the research on text generation using open vocabulary and image generation is still in its nascent stage.

DATASET AND FEATURES / PROJECT REQUIREMENTS/ PRODUCT FEATURES

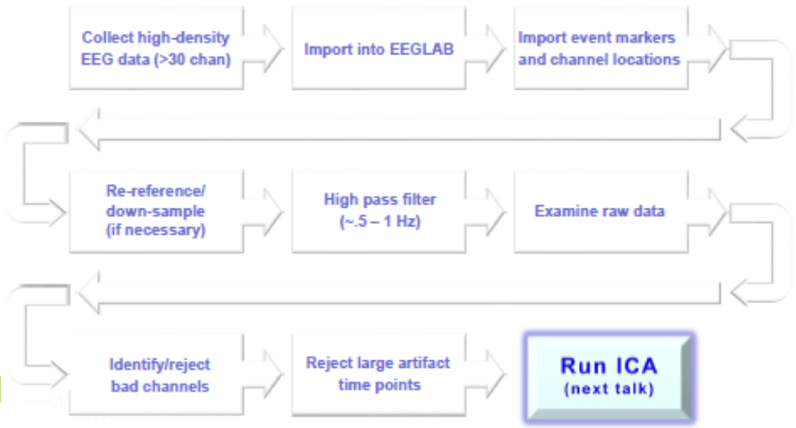
The use of the Zurich Cognitive Language Processing Corpus (popularly known as the ZuCO dataset) is to supplement natural language processing tasks with brain activity information. ZuCO is an openly available dataset that consists of simultaneous EEG and eye tracking from the subjects.

The subjects were given reading tasks which they are supposed to read sentence wise. While they read the sentences, their EEGs are recorded and they are entailed into MATLAB files. The project makes use of a really popular plugin for visualization of EEG signals viz. EEGLAB.

Since EEG signals are highly variable across gender, age, and mental situation of a person, it is tough to generalize EEG waves. Also, EEG waves are signals so it is necessary to have a good pre-processing strategy.

DESIGN APPROACH / METHODS

The project starts with the pre-processing of EEG signals to remove noise caused by blinking, unused high frequencies, muscular artefacts. This step follows a meticulously studied pipeline as follows:



Post pre-processing, the pre-processed files are integrated along with temporal mappings provided in the dataset across the tasks. Along with that, there is also a need for converting these MATLAB files into .pickle files to make the dataset python compatible and also to take care of the word-level and sentence-level data at the same time which is temporally mapped. Then, the EEG to Text conversion module is implemented by the use of LLMs like BERT and BART. BERT is used to generate embeddings and BART is used for training the model and decoding as well.

Once, the text is generated after testing phase, the predicted strings are plugged into Text to Image conversion module. This is implemented using a pre-trained model - Stable Diffusion v2.1 which is trained on a dataset of 5 billion image-text pairs.

Overall, this project attempts to generate images from EEG signals via text modality.

RESULTS AND DISCUSSION

Because of the application of LLMs, the evaluation metric is the BLEU score, a number between zero and one that measures the similarity of the machine-translated or generated text to a set of high-quality reference translations. A score of 0.34 was produced.

SUMMARY OF PROJECT OUTCOME

Original studies have shown a BLEU Score of 0.48 which indicates the need for improvement with the current implementation. Since the dataset was mostly based on political events, history, and biographies of eminent personalities, a need for considering keywords was imminent to improve the quality of text and also the semantics of the text to a particular extent. Thus, images are also generated using keywords from the predicted text.

Thus, the generated text is also subjected to keyBERT model, again a pre-trained large language model that generates suitable keywords.

CONCLUSION AND FUTURE WORK

In conclusion, the main goal of this project to generate images from EEG waves via the text modality is fulfilled. However, the results are anticipated to improve with further training for more epochs and hyperparameter tuning.

Future work entails the integration of these models into a large cohesive system with the possibility of having to acquire EEG data and generate text and images in a real-time environment using industry-grade equipment like headsets.

REFERENCES

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DIVIJA L.


GAURAV MAHAJAN


JEEVAN R.


P. DEEKSHITHA


DR. SURABHI NARAYAN