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Mapping of Intellect Vision to Picture Pixels Using EEG Based Model

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Abstract-- In recent times, crime detection and investigation has seen major innovation largely due to the need to stay a step ahead of the perpetrators of the crime. An area that hasn't seen the light of the day is criminal identification. Criminal identification relies largely on the verbal description of witnesses and the interpretation of sketching artists, both of which can be erroneous. To address this need, we propose a thought-to-picture interpreter. It requires a person to visualize a picture in his mind while the same picture is mapped onto the screen. It consists of analysing datasets obtained from Electroencephalography (EEG) signals and mapping it to Red, Green, Blue (RGB) pixels of an image with the help of an algorithm. To collect the EEG data, an emotive headset will be used. A combination of basic colour grids is shown to the subject. The subject later visualizes the same grid in his mind and the EEG signals are recorded. This is correlated to the actual pixels in the image. This process is to be repeated to train the system and achieve the desired results. The system can be extended further, to produce any image that is envisioned, without necessitating the use of an existing database for matching. Further, portability of the device can be enhanced using wireless microcontrollers.

Keywords-- Crime detection, Electroencephalography, RGB, Machine learning, Artificial Intelligence, Emotive headset

I. INTRODUCTION

In today's times, with increasing crime rate, the onus of finding the criminal depends largely on the witnesses. Yet, the process of trying to find the criminal based on the description given by the witnesses is becoming increasingly difficult. Identifying the criminal largely depends on the interpretation of a sketch artist who needs to put to picture exactly what the witness says. This process is agreeably cumbersome and unwarranted. The mechanism that we propose vows to do away with oral descriptions and heard interpretations; it simply projects the picture if the witness visualizes the image of the criminal.

Also, the creative landscape is changing tremendously. With a device that can put to screen whatever we visualize, a creative explosion would occur. It would greatly benefit artists, photographers, directors, architects etc, both professional and amateur. It could provide more personalized services too.

In order to obtain information about brain activities, a variety of techniques can be used. The technologies relevant for our application are Electroencephalography (EEG) and Functional Magnetic Resonance Imaging (fMRI).

Electroencephalography (EEG) is a technology that is used to quantify and detect brain activity. It measures the voltage fluctuations that result from the ionic current between the neurons working in the brain. [5] It has electrodes placed along the scalp, thereby making it non-invasive in a majority of cases.

Functional Magnetic Resonance Imaging (fMRI) measures brain activity by detecting the changes associated with blood flow. The area of the brain currently in use, is identified based on the increased blood flow in that region. [1][3]

EEG signals are analog in nature. They have to be converted to digital signals for further processing. The scope of the proposed system also extends to the fields of image processing, artificial intelligence and machine learning.

It is essential to understand the perception of colours in the rain. It is universally known that any image consists of Red, Green and Blue (RGB) pixels only. However, the number of colours that an average person can identify is much higher than these three basic colours. This phenomenon occurs due to the fact that the brain's photoreceptors are limited to red, green and blue. Every other colour that a person perceives are educated guesses made by the brain, depending on the combination of these basic colours in a grid.

Hence, the objective is to build a comprehensive model that effectively maps EEG signals obtained from the brain to a known combination of colours, so as to produce and project a picture visualized in the mind.

II. BACKGROUND

In this section of the paper, the various technologies that have been used in this area of research are discussed. Subsequently, the paper elucidates on how the proposed idea is different and the advantages that the proposed solution has over the methods currently used.

In today's world everyone is looking forward to get the insights of the most powerful supercomputer known to man, i.e., human brain. This is the processor which processes enormous amount of data every second. The data comes from varied fields, such as science, politics, economics and spiritual science. In the quest to decode this mysterious organ, people have tried to combine the known form of computers with it to create a system called Brain Computer Interface (BCI). The few attempts already made in the field of BCI have been mentioned.

A. Reconstructing Visual Experiences from Brain Activity Evoked by Natural Movies [6]

This experiment has been carried out in The Gallant Lab at UC Berkley. The main aim of the experiment was to design an algorithm to decode the natural dynamic visual experiences from human visual cortex. In other words, the observer's brain activity was measured in order to reconstruct the natural movie clips seen by them.[6] The technology used in this experiment in order to measure the visual cortex activity is Functional Magnetic Resonance Imaging (fMRI). [9] This is done while the observer looks at several hours of movies. Later, computational models are developed to predict patterns in the activity of the brain induced by any random movie. Consequently, these computational models are used to process the brain activity to reconstruct the movies seen by the observer. This is the first demonstration that dynamic natural visual experiences can be recovered from very slow brain activity recorded by fMRI.

It is evident that modelling of human brain can provide crucial details about how the brain works. So far this has been executed using fMRI technique. However, the technology itself is quite expensive and time consuming.

B. Decoding spectrotemporal features of overt and covert speech from the human cortex [7]

It's not quite telepathy, but a group of scientists have successfully eavesdropped on our inner thoughts for the first time. Using a newly designed algorithm, it decoded what people sound in their heads. The idea behind this was to help individuals suffering from communication impairments i.e. the deaf, dumb and paralytic people. This was done using a technique called Electrocorticography, which involves measuring neuronal activity via electrodes placed on the surface of the brain. During the overt (reading aloud) task, the researchers mapped the neurons which got activated during specific aspects of speech, and used this to construct a decoder for each participant. After working out the firing patterns corresponded to particular words, the decoder was set to work on the participants' brain activity during silent reading. Remarkably, it was able to translate words that several of the volunteers were thinking, using only their neuronal firing patterns. [7]

C. Playing 20 Questions with the Mind: Collaborative Problem Solving by Humans Using a Brain-to-Brain Interface [8]

This work presents the demonstration of a new non-invasive brain to brain interface in humans. This involved participation of two individuals to play a 20 questions and answers game who were physically isolated. The two participants were kept in different buildings and the EEG data recorded from one person, "the respondent" was sent over internet to the other, "the inquirer" who had a magnetic coil positioned around their head. The technology used here is Electroencephalography (EEG) and Transcranial Magnetic Stimulation (TMS). The experiment was repeated over 20 rounds with an accuracy of around 72 percent. This experiment led to the conclusion that it is possible to decode a person's thoughts using non-invasive technology like EEG and TMS. [8]

From the above stated experiments, it is quite evident that it is fairly possible to decode human thoughts and vision. Since the dynamic natural visual experience has already been mapped to a video using fMRI, it is proposed to achieve the same for the static vision using the low cost EEG setup.

III. METHODOLOGY

The technique involves using an Emotive headset to collect Electroencephalography (EEG) signals while a subject visualizes a particular colour. The change in the signals while visualizing a colour as opposed to keeping the mind blank, will be recorded. The colours chosen for initial experimentationare white and black. The upcoming experiments aim at doing the same for a grayscale. Finally, colours such as red, green and blue will also be included.These colours are rather important as all images are invariably composed of a grid of Red, Green and Blue (RGB) pixels.

The obtained EEG signals are then converted to numerical data, and the noise is filtered. There are several techniques being used to filter noise in an EEG signal. Adaptive neuro-fuzzy inference system or adaptive network-based fuzzy inference system (ANFIS) is the most relevant technique that can be used for our system. [4] ANFIS combines the benefits of both neural networks and fuzzy logic in a single framework. It is predominantly implemented using MATLAB.

Next, the obtained data is classified into the corresponding colour. Subsequently, the subject is asked to visualize a grid containing a combination of these basic colours and the processed data is suitably correlated to the corresponding grid. The complexity of the grids continue to increase, thereby training the system to ultimately map complete images. Therefore, if the processed data obtained from signals in the brain has matching pixels in an image stored on the criminal database of the Police Department, then, the criminal can be identified.

Functional Magnetic Resonance Imaging (fMRI) can be used to record signals from the brain. However, the equipment is highly expensive and bulky. Hence, implementing the proposed design using an EEG model is recommended. The headset used for measurement is portable. However, it has to be connected to a computer in order to process the signals. This factor hinders the portability quotient. To enhance the portability of the system, a wireless microcontroller that is compatible to deal with EEG signals will be used. Tamas Hornos from the Department of Electronics and Electrical Engineering, University of Glasgow has proposed a Wireless ECG/EEG system built with the MSP430 Microcontroller. His design incorporates an ultra-low power wireless EEG and ECG monitoring device working at 868MHz frequency. [2] A similar design will be used to improve the portability of the proposed system.

IV. RESEARCH CHALLENGES

Electroencephalography (EEG) is the most studied potential non-invasive Brain Computer Interface, mainly due to its fine temporal resolution, ease of use, portability and low set-up cost. However, the technology is highly susceptible to noise. Another substantial barrier to using EEG as a brain–computer interface is the extensive training required before users can work the technology. Hence, the machine has to first filter the white noise using and train the machine on millions on samples and subjects.

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