A Survey on usage of FMRI technique in BCI

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ABSTRACT- This paper mainly focuses on how Functional Magnetic Resonance Imaging (FMRI) technique will helps in the brain computer interface (BCI). Since BCI uses the neurophysiologic signals originating in the brain to communicate with the devices or computer, FMRI records noninvasively activity of entire brain with a high spatial resolution. Finally, FMRI-BCI provides a novel approach for studying the brain regions, which in turn helps the communication. Technological advancement in higher field Magnetic Resonance Imaging (MRI) scanners, fast data acquisition sequences, preprocessing algorithms, and robust statistical analysis are anticipated to make FMRI-BCI more widely available and applicable.

Keywords: FMRI (Functional Magnetic Resonance Imaging), BCI (Brain Computer Interface), EEG (Electro Encephalograph), BOLD (Blood Oxygen level dependent).

I. INTRODUCTION

TheăfirstăBCIăwasădescribedăbyăDr.ăGreyăWalterăină1964.ă Ironically,ă thisă wasă shortlyă beforeă theă firstă Stară Trekă episode aired. Dr. Walter connected electrodes directly to **theă motorăareasă ofă aă patient'să brain.ă (Theă patientă wasă** undergoing surgery for other reasons.) The patient was asked to press a button to advance a slide projector while Dr. Walter recorded the relevant brain activity. Then, Dr. Walter connected the system to the slide projector so that **theăslideăprojectorăadvancedăwheneverătheăpatient'săbrai**n activity indicated that he wanted to press the button. Interestingly, Dr. Walter found that he had to introduce a delay from the detection of the brain activity until the slide projector advanced because the slide projector would otherwise advance before the patient pressed the button! Control before the actual movement happens, that is, control without movement – **theă firstă BCI!ă** Unfortunately, Dr. Walter did not publish this major breakthrough. He only presented a talk about it to a group called the Ostler Society in London [1].Today many research is going on in this field, where FMRI is the one technology which is associated with the BCI in this paper. BCI also called as MCI (Mina- machine interface) is a direct communication pathway between an enhanced or wired brain and an external device. Based on the functional neuroimaging recordings obtained through FMRI, we can easily observe the effects on behavior. In the rest of the paper, we will compare the MRI with FMRI technologies and the working methodology of FMRI with respect to BCI. The development of FMRI in the 1990s, generally credited to Seiji Ogawa and Ken Kwong, is the latest in long line of innovations, including positron emission tomography (PET) and near infrared spectroscopy (NIRS), which use blood flow and oxygen metabolism to infer brain activity [3].Functional magnetic resonance imaging, or FMRI, is a technique for measuring brain activity. It works by detecting the changes in blood oxygenation and flow that occur in response to neural activity – when a brain area is more active it consumes more oxygen and to meet this increased demand blood flow increases to the active area. FMRI can be used to produce activation maps showing which parts of the brain are involved in a particular mental process.

The fact that the magnetic state of hemoglobin changes with its state of oxygenation was discovered in 1936 by Pauling and Coryell, before the discovery of nuclear magnetic resonance (NMR) itself [2].

II. MRI VS. FMRI

Magnetic resonance imaging, or MRI, is a machine used for brain structure imaging. MRI, or magnetic resonance imaging, is the technique widely used in modern medicine to diagnose soft tissues of the human body. The most important application of MRI is in the investigation of the human brain.

FMRI, or functional magnetic resonance imaging, is the technique which utilizes magnetic fields to create the image of what is going inside the human brain. The focus of FMRI is on the processes in the human brain as they will develop in time. FMRI functions through blood flow or blood oxygen level measurements to achieve the **brain'să functională image.ă Ită isă primarilyă usedă toă gatheră** relevant data as to the consumption of oxygen by the tissues. Through its modernization, fMRI sequences will view a picture of th**eăbrain'săactiveăregionăbyăpickingăupă** the excess blood supply called Blood Oxygen Level Dependence (BOLD) [4].

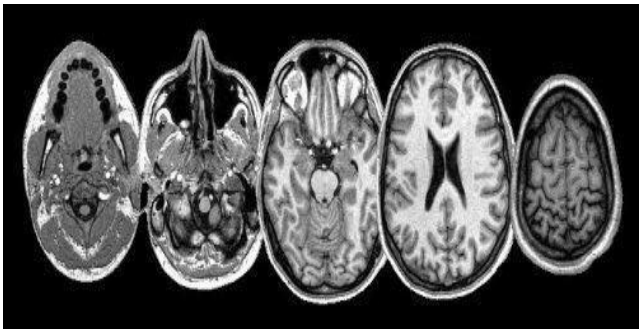

Fig 1: Image obtained through MRI

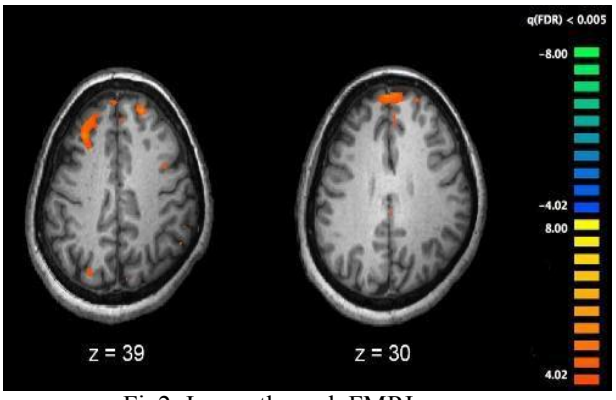

Fig2: Image through FMRI

A high spatial resolution MRI image is used to map the changes in oxygenated and deoxygenated blood ratio which is measured by a series of low spatial resolution fMRI scans, although scans can be adjusted to incorporated higher temporal resolutions at the cost of a lower spatial resolution

FMRI has advantages of other methods of neurological activity as it does not require radioactive tracers to be injected. Finally MRI is both a structural and functional imaging technique, it can provide a range of differently contrasted high spatial resolution images, or alternatively it can provide a series of low spatial resolution at a relatively high temporal resolution to map neurological functionality due to the levels of oxygen within the blood[5].

III. ARCHITECTURE OF FMRI-BCI

An FMRI-BCI system shown in Fig. 1 is a closed-loop system with the following major subsystems: signal acquisition, signal preprocessing, signal analysis, and signal feedback [6].

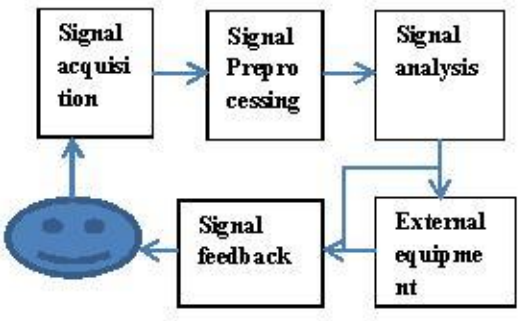

Fig3: Architecture of FMRI-BCI

An echo planar imagining is used to acquire whole brain images from experimental subjects, then the three dimensional brain is divided into a specified number of two dimensional slices. More slices gives better resolution. For the real time achievement of FMRI-BCI requires to acquire once the images have been produced for repetition. Pattern based methods can be used to identify the patterns of activation in the images and then these patterns are used to control the feedback. After specific pattern to be identified is used as a feedback, further processing is conducted to produce a brain activity in the form of functional maps, curves, waves,etc.,

IV. WORKING METHODOLOGY

A human head is equipped with electrocap which helps in the detection of signals of brain. The BCI works in the following steps.

1. Signal production

For a BCI, brain signals need to be produced by human and this can be generated by placing an eletrocap on his/her head. Once the signal is generated from the brain, he will get control over the stimuli.

2. Signal detection

Many signals will be generated from the brain, but most well known are: EEG and FMRI[4]. EEG measures the electrical activity of the brain and FMRI measures the blood-flow in the brain.

3. Signal processing

One of the problem we find in dealing with brain waves is that, it contains lots of noise. This noise needs to be filtered out. The data can now be used for detecting actual signals. The signals which are removed from noise will help for better achievement.

4. Signal transduction

When we have detected the interesting signals, we can use that in interfacing. In our paper, we are using the signals of EEG and FMRI to communicate with the external devices or computer.

EEG records electrical patterns of the brain. The billions of nerve cells in the brain produce very small electrical signals that form patterns called brainwaves. The electrodes in the electro cap detect brain waves and EEG machine amplifies the signals and records them in a wave pattern on graph paper or a computer screens. The following figure shows the capture of EEG wave patterns.

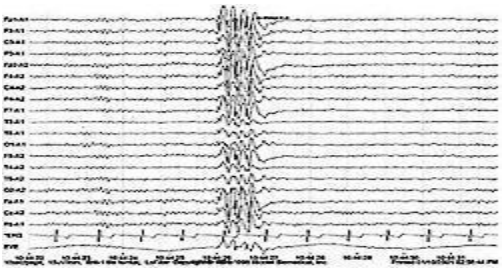

Fig4: A sample EEG recording showing a focal spike typical of a seizure.

FMRI measures the oxygen, which is delivered to neurons by hemoglobin in capillary red blood cells. When neuronal activity increases, there is an increased demand for oxygen and that region of neural activity. Due to this blood oxygenation variation of neuron activity, we can use it to detect the brain activity. FMRI mainly captures the blood- oxygen level dependent (BOLD) regions. The following figure shows the capture of BOLD regions from fMRI.

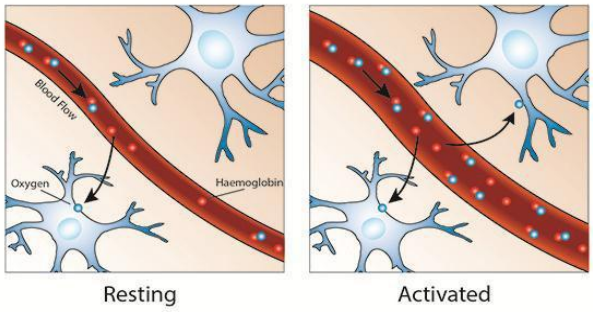

Fig5: FMRI measures the oxygen level in the regions of the brain.

V. CONCLUSION

Brain computer interface based on FMRI enable real – time feedback of brain regions to learn volitional regulation of those regions. FMRI-BCI can be widely applicable due to usage of advanced MRI scanners and faster feedback technologies. Since FMRI identifies the BOLD responses, which will tell us the activity to be performed by the brain, and that can be used to communicate with the external devices by blind people specially.

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