Electronically linked Brain to Brain communication in Humans Using Non-Invasive Technologies

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Abstract

In this paper we will discuss on how electronically linked Brain to Computer Interface(BCI) and Computer to Brain Interface(CBI) can be used to develop Brain to Brain Interface(BBI). In this system, non-invasive technology is deployed to achieve conscious Brain to Brain(B2B) communication. At BCI site, data is transmitted using ElectroEncephaloGraphy (EEG) a non-invasive method to record electrical activity of the brain along the scalp. At CBI site Transcranial Magnetic Stimulation (TMS) or Transcranial direct current stimulation (tDCS) again a non-invasive method used to stimulate small regions of the brain is used to receive the data. From the proposed system, it allows information transfer between brains to do away with language or can send thoughts from one brain to another brain in a way not represented by sounds or words. Connecting brains with computers as well as other brains is profoundly important as it will change human society in future communication technology.

Key words:
Brain to Computer Interface(BCI), Computer to Brain Interface(CBI), Brain to Brain(B2B), ElectroEncephaloGraphy (EEG), Transcranial Magnetic Stimulation (TMS),

1. Introduction

Physiologically, the function of the brain is to exert centralized control over the other organs of the body. The brain[1] acts on the rest of the body both by generating patterns of muscle activity and by driving the secretion of chemicals called hormones. The existing system[2]-[8] for communicating information between brains uses invasive technology which has limited practical application. Instead, our proposed system prefers non invasive direct brain to brain communication using well developed BCI technology and emerging CBI technology.
The functions carried out by brain is shown in figure 1. At BCI site, motor imagery in which individual rehearses or mentally simulates a given action. This type of phenomenal experience implies that the subject feels herself/himself performing the action. This stimulations which generates brain waves are detected by electroencephalography (EEG) as shown in figure 2.

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The data recorded by EEG are encoded and transmitted via internet to CBI site[9].

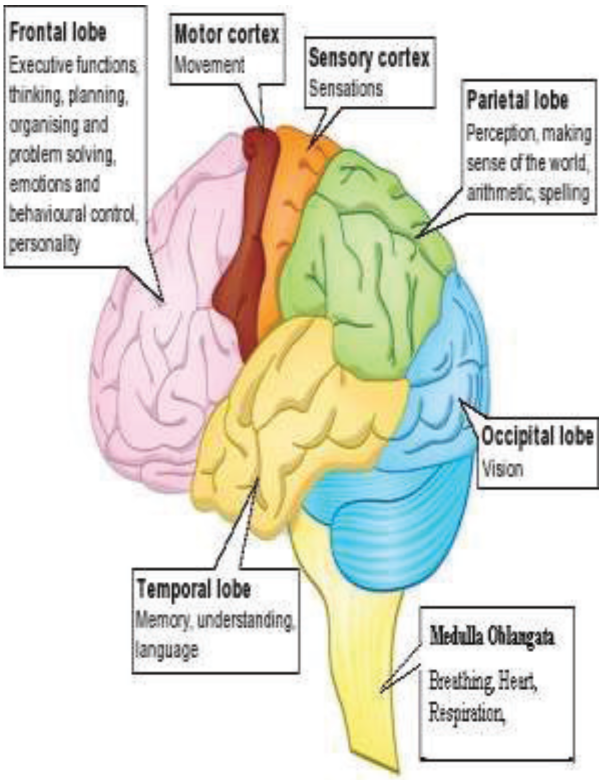

Figure 1: Brain functions
(courtesy eLearning portal http://www.ilmoamal.org/)

Figure 2: EEG cap with interfacing

At CBI site, non invasive TMS or Transcranial direct current stimulation (tDCS) technology is used to stimulate small regions of the brain. During a TMS procedure, a magnetic field generator, or "coil" is placed near the head of the person receiving the data. The coil produces small electric currents in the region of the brain just under the coil via electromagnetic induction. The coil is connected to a pulse generator, or stimulator, that delivers electric current to the coil as shown in below figure 3.

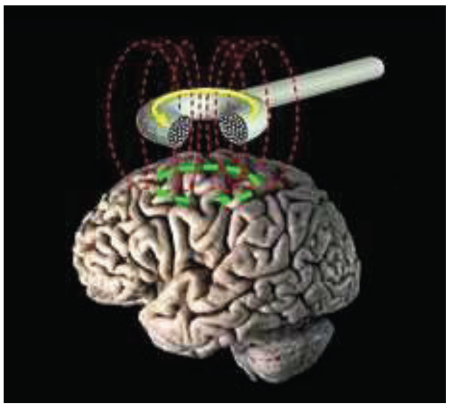

Figure 3: TMS stimulation(courtesy Wikipedia)

Using EEG and TMS technology, mental telepathy will be implemented based on existing internet system as shown in below figure 4.

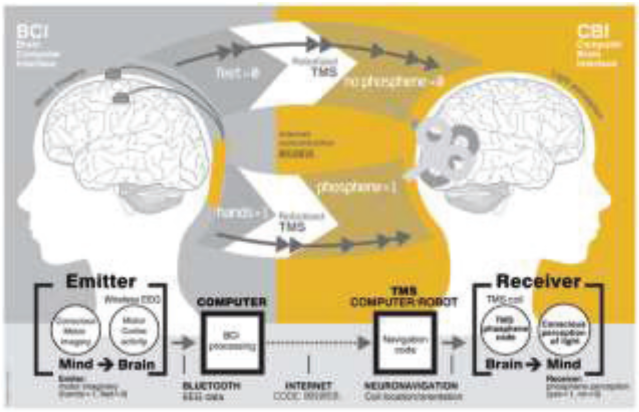

Figure 4: B2B communication (courtesy PLOS one)

2. Implementation

In the proposed implementation, the EEG systems are used for data acquisition from human subject 1 at BCI site.EEG measures voltage fluctuations resulting from ionic current within the neurons of the brain. In clinical contexts, EEG refers to the recording of the brain's spontaneous electrical activity over a period of time, as recorded from multiple electrodes placed on the scalp. Despite limited spatial resolution, EEG continues to be a valuable tool for research and diagnosis, especially when millisecond-range temporal resolution (not possible with magnetic resonance imaging (MRI) and computed tomography (CT)) is required. Below figure 5 shows EEG waveform which can be processed using freely available EEG software such as EEGLAB.

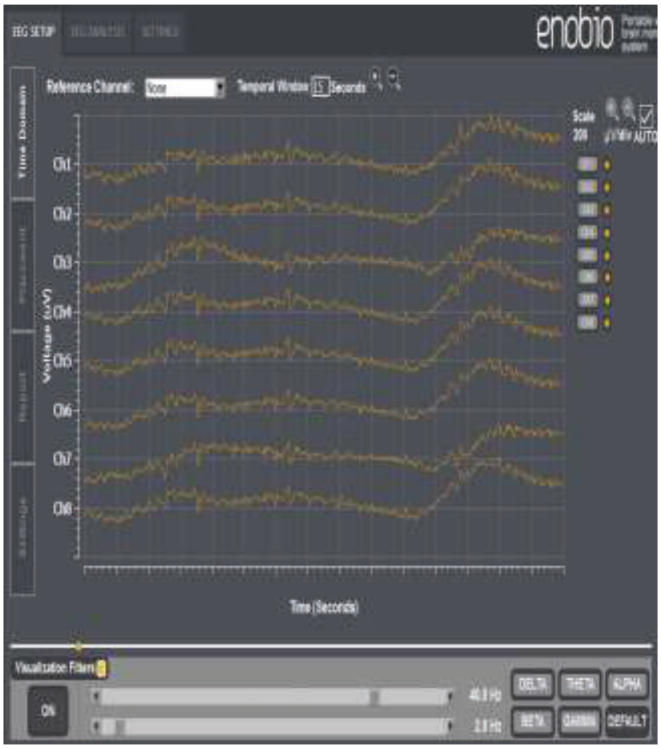

Figure 5: EEG waveform(Illustration -For Right Hand Move)

At the CBI site, TMS is used to stimulate small regions of the brain. During a TMS procedure, a magnetic field generator, or "coil" is placed near the head of the person receiving the treatment. The coil produces small electric currents in the region of the brain just under the coil via electromagnetic induction. The coil is connected to a pulse generator, or stimulator, that delivers electric current to the coil. Here, TMS pulses are produced at specific occipital lobe which is one of the four major lobes of the cerebral cortex in the brain of mammals. The occipital lobe is the visual processing center of the mammalian brain containing most of the anatomical region of the visual cortex.

The intensity of pulses was adjusted for each subject so

that one particular orientation of the TMS induced electric field produced phosphenes a phenomenon characterized by the experience of seeing light without light actually entering the eye. This is represented as the "active direction" and coding the bit value "1" and the orthogonal direction did not produce phosphenes which is represented as the "silent direction" and coding the bit value "0".

Subjects at CBI site reports verbally whether or not they perceived phosphenes on stimulation. The subject acted as emitter of information using a BCI system based on motor imagery (of moving feet or hands) to select two kinds of states in EEG spectral power in the motor cortex (coding for the bit values of "0" and "1").

2.1 Brain Computer Interface

In the BCI system, the user's intention is conveyed by brain signals which is recorded by EEG. Electroencephalography (EEG) is the most studied potential non-invasive interface, mainly due to its fine temporal resolution, ease of use, portability and low set-up cost. The technology is highly susceptible to noise. However another substantial barrier to using EEG as a brain–computer interface is the extensive training required before users can work the technology. Motor imagery involves the imagination of the movement of various body parts resulting in sensorimotor cortex activation, which modulates sensorimotor oscillations in the EEG. This can be detected by the BCI to infer a user's intent.
The 10–20 system or International 10–20 system is an internationally recognized method to describe and apply the location of scalp electrodes in the context of an EEG test or experiment. This method was developed to ensure standardized reproducibility so that a subject's studies could be compared over time and subjects could be compared to each other. This system is based on the relationship between the location of an electrode and the underlying area of cerebral cortex. The "10" and "20" refer to the fact that the actual distances between adjacent electrodes are either 10% or 20% of the total front–back or right–left distance of the skull.Each site has a letter to identify the lobe and a number to identify the hemisphere location. The letters F, T, C, P and O stand for frontal, temporal, central, parietal, and occipital lobes, respectively.Even numbers (2,4,6,8) refer to electrode positions on the right hemisphere, whereas odd numbers (1,3,5,7) refer to those on the left hemisphere as shown in below figure 6.

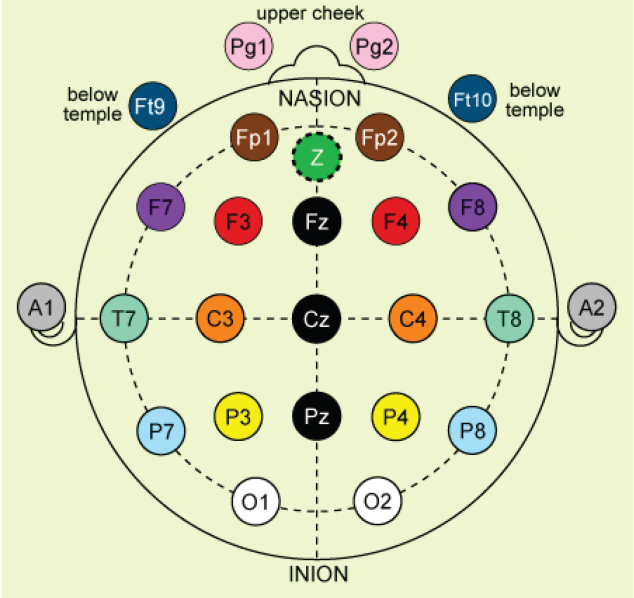

Figure 6: Electrode Position of EEG(courtesy learningcentral.health.unm.edu)

The captured signals are processed in the system using BCI 2000- software suite for brain-computer interface. It is commonly used for data acquisition, stimulus presentation, and brain monitoring applications. BCI2000 supports a variety of data acquisition systems, brain signals, and study/feedback paradigms. During operation, BCI2000 stores data in a common format (BCI2000 native or GDF), along with all relevant event markers and information about system configuration.
Brain pattern in motor imaginary for Binary Number 1 and 0 is stored from BCI site to CBI site via e-mail.

2.2 Computer Brain Interface

In the CBI system, TMS or tDCS a non invasive method can be used to decode the received message.TMS pulses are induced into receiver subject at right visual occipital cortex which produces phosphenes(light flashes-Bit1, No light flashes- Bit 0). Below figure7 depicts right visual occipital cortex.The subject was blocked visual contact by wearing an eye mask to avoid external inputs.The above experiment needs to be conducted after getting Ethical approval from the Research Ethics Committee, All India Institute of Speech and Hearing, University of Mysore, India.

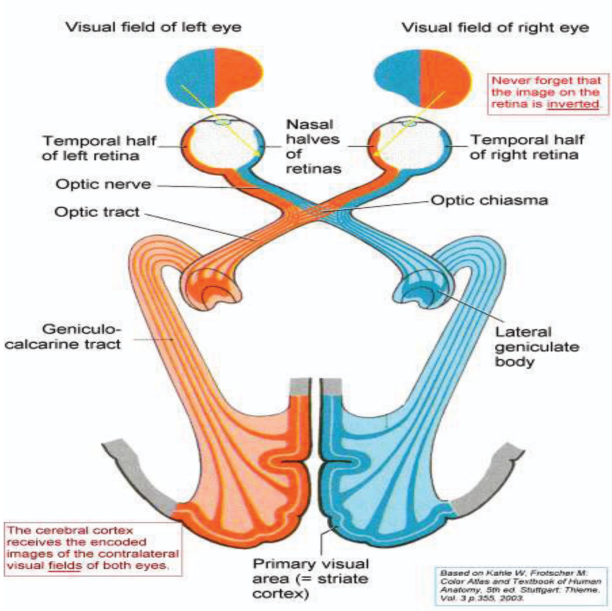

Figure7: Right visual occipital cortex
(courtesy medicinembbs.blogspot.in)

3. Result

Using B2B, an innovative way of non-invasive communication is established. At BCI site, the subject will be wearing EEG cap which follows 10-20 system for experiments. Additional electrodes in EEG can be used for higher special resolution. Usually healthy adult human generates EEG signal about 10 µV to 100 µV.
The BCI2000 software which is open source software provides required tools to record the brain activities.
The dataflow for EEG is shown below.

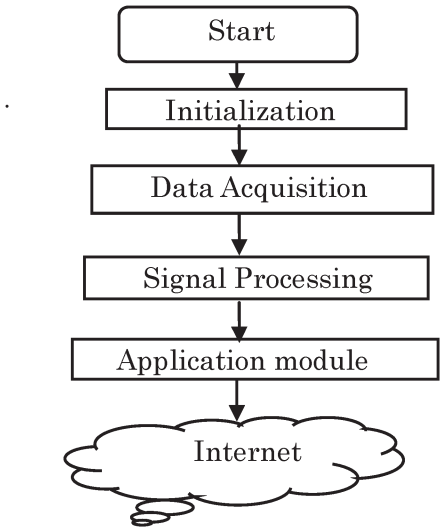

Figure 8: Flowchart for EEG data at BCI site

The hand motion and leg motion combination or Right hand motion and left hand motion can be used to encode data as 1's and 0's.After training period of subject for encoding data, the binary numbers for particular character can be sent to the destination.

For example for letter 'A' its ASCII value 41h(1000001b) can be sent. The existing internet provides communication between far places. The TMS provides the decoding facility by producing phosphenes.

By using BCI setup alone following function can be achieved.
-Google search through brain
-Provide disable with communication.
-Provides control of devices
-Additional control in comp game
-Mental type writer

4. Conclusion

Our objective is to work on the communication between brains without involvement of of sensory or motor systems in the exchange of information. Internet communication performed almost flawlessly data transfer from EEG sensors to remote area. Even communication can be made wireless based. With the proposed setup data can be successfully transmitted between brains. It can be further extended for various area of application like health monitoring system, Home security system, Vehicle Security system etc. Using tDCS duplex system can be accomplished from the existing one way communication in TMS system[9].

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