Union of Brain Computer Interface and Internet of Things: An Integrated Platform to Enhance Cognitive Interaction in Real-time

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Abstract

Brain Computer Interface (BCI) is a platform which receives brain signals, measures and analyses them, providing a pathway for the human brain to interact with external utilities in real-time. It is entirely independent of the normal output of peripheral nerves and muscles. On the other hand, with the exposure of Internet of Things, the concept of connectivity of devices has evolved. The number of connected devices is expected to grow phenomenally across multiple industries, thereby boosting productivity and efficiency in coming years. This paper elaborates the procedure of developing a system merging Brain Computer interface and internet of things, the possible applications of human-thing cognitive interactivity and the challenges we face while working with it.

Key words*: Brain-Computer Interface, Internet of Things, cognitive, interactivity.*

INTRODUCTION

According to the statistical records, in the last decade around 50 million devices have been connected to the Internet. The number of interconnected devices exceeded our population back in 2008. With the revolution of Internet of Things, people can interact and control a number of devices through a wide range of applications available on our smartphones, laptops, etc. The global worth of IoT devices is projected at $6.2 trillion by 2025. On the other hand, the popularity of Brain-Controlled Interface is growing in recent years which allows establishment of a direct communication pathway between the human brain and any external device in real-time. In recent years, the world has seen the ability of BCI to decode the thinking capabilities of man and using the relevant information obtained to control external devices. Some common examples being, mind-controlled robotic hand (underneuro-prosthetics), mind-controlled wheelchair and other IoT based appliances. To establish human-cognitive interactivity, BCI proves to be advantageous as it has the inherent privacy setup. This is because brain activity is invisible in nature. Another advantage of BCI is that the received data is real-time in nature as a person just need to think about the interaction instead of performing any physical task.

While working on BCI platform we face a number of challenges as it is time consuming and not completely efficient. The environmental factors are also a major factor for decreased efficiency.

In this paper we are highlighting the working principle of the integrated platform of BCI, IoT and the problems we face while working with BCI, the possible applications and the current works on human-thing cognitive interaction.

The Integrated System: Working Principle

Internet of Things is a platform of interrelated electronic devices, machineries, objects etc, which are having a unique identification and are capable of interacting and exchanging data via Internet without any human-human interaction, thereby executing the practical applications with utmost efficiency in real-time.

The standpoint of integration of Brain Computer Interface with the Internet of Things, the correlation of BCI and IoT is given below:

Fig 1: Correlation among BCI and IOT

SENSORS/DEVICES

Brain cells communicate with each other by transmission of small electrical signals. Under normal conditions, to perform a particular task, these signals are sent to the muscles via the central nervous system. Brain Computer Interface is a platform which creates an alternative pathway to interact with external utilities in real-time without normal output of peripheral nerves and muscles. For execution of the following process, the initial requirement is collection of brain

signals. A number of technologies can be used to collect these signals, the most common being Electroencephalography (EEG). There are other popular technologies like Magneto-encephalography (MEG) and Functional Near-Infrared Spectroscopy (fNIR) for the collection of brain signals. As they involve the use of expensive machineries, they are not suitable for household application. The most common way of collection of brain signals is by placing electrodes on the scalp of a person, or by implanting electrodes inside the brain by surgical method which is commonly termed as implantable BCI. These electrodes sense the small electrical signals and amplify them to detect the active regions of the brain.

CONNECTIVITY

Connectivity is an important segment of Internet of Things. There are a number of communication portals available for execution of the same, for example, WiFi, Bluetooth, Satellite, Cellular, RFID, NFC, LPWAN and Ethernet. The sensors can be connected to any of these communication portals based on the desired range and thereby facilitate to send the received signal data from the brain to the cloud. For the organizations it will be difficult to store the massive amount of data produced by the devices in the coming years, as it involves a huge cost. Cloud is a platform which is designed to store the amount of data received from the sensors and process them for real-time applications. Selecting the most suitable connectivity portal is essential because an erroneous choice may lead to poor performance or increased cost which is not desirable. The technical, commercial and ecosystem requirements are to be analysed before selecting the suitable connectivity portal.

DATA PROCESSING

This is the core of the integrated system of BCI and IoT. In 2012, a team of IEEE members proposed a Deep Learning Framework. The cloud consists of this Deep Learning Framework to process the received data from the sensors. The processing of the data is a tri-level process.

- **Data Replication and Shuffling** Data replication allows copying of application database to a secondary clone database by capturing the small changes in data occurring from time to time. It ensures availability, increased parallelism, and security. The Data replication is not instantaneous as it involves increased cost. So it captures the data when the system is not in use. This causes a time delay, which is termed as latency. Now, EEG signals are arranged as one-dimensional vectors in practice. To use this data efficiently, we need to replicate it to a higher dimensional space. The massive amount of replicated data is then shuffled to improve the predictive performance and machine learning model quality.

- **Selective Attention Mechanism** As different categories of data signify different characteristics of the brain, it is difficult to specify the fragments with utmost relevant

information. Selective Attention Mechanism is designed to select the relevant information received from the brain signals and preferably process it while suppressing the redundant data. This increases the efficiency of the integrated system.

- **Weighted Average Spatial LSTM Classifier** Recurrent Neural Networks (RNN) is a class of neural networks which is expert in learning crucial information from sequential data. A section of RNN, which is applicable for practical use is, Long Short-Term Memory (LSTM). Now, in Weighted Average Spatial LSTM Classifier, the LSTM output is obtained by averaging the last two weighted outputs to enhance the stability of the neural network as it is continuously fluctuating.

USER INTERFACE

User Interface deals with the act of sending the relevant information obtained to the user end for executing the practical applications. The several ways by which a user can interact with the system are by receiving automatic notification, monitoring information proactively and control the system remotely. A significant example of Brain-Controlled Interface with Internet of Things being Smart Living Environmental Auto-adjustment Control System (BSLEACS). It monitors the mental state of the user and adapts the surrounding accordingly. Also the integration of smart house and healthcare is a recent approach of this model.

Problems we encounter while working in this platform

- BCI is primarily based on the emotional state of the user.
- Environmental factor is also a prime factor which affects BCI efficiency.
- It is incapable of detecting the complex signal control of the brain. So it is not suitable for practical purpose as it is not sufficiently efficient.
- Data pre-processing is time consuming and dependent upon the skill of the person.
- The most suitable area of the brain for decoding the signals is yet to be found.

CONCLUSION

This paper primarily deals with the working principle of BCI and IoT integrated field for human-thing cognitive interaction. Initially, we discussed about the suitable brain wave sensor for home application based on the cost effectiveness. Later, we gave a brief idea on the connectivity suitable for various conditions based on the range of control. We highlighted the data processing segment which was recently proposed. It uses a deep learning framework. The processed data was then sent to the user end for executing the IoT enabled appliances. We also elaborated the problems we face while working in this platform, thereby suggesting the fields which require improvement. The eradication of the mentioned problems will increase the efficiency of this platform, making practical use of this system possible.

REFERENCES:

[1]“Internet of Things Meets Brain-Computer Interface: A Unified Deep Learning Framework for Enabling Human-Thing Cognitive Interactivity” by Xiang Zhang, Lina Yao, Shuai Zhang, Salil Kanhere, Michael Sheng, Yunhao Liu.

[2]”How IoT works?” from www.leverege.com

[3]”The Pros and Cons of IoT Connectivity Options for Asset Tracking” from www.leverege.com

[4]”What is IoT Cloud (Salesforce IoT Cloud)?” from SearchSalesforce.com

[5]”What is Data Replication?” from **www.intricity.com**.