# A Methodology to Extract Information from the Brain Waves in a Multi-Core Environment

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***Abstract*— Brain Computer Interface (BCI) is one of the most dynamic fields in the world of Artificial Intelligence. It involves a direct neural interface between the subject and the machine, and the information is extracted from the brain in the form of waves. This raw brain-wave needs to be classified, de-noised, translated and suitably stored. These steps involve the use of a number of techniques like, the de-noising involves the use of Discrete Wavelet Transform (DWT) [1] or Recurrent Quantum Neural Network (RQNN) [2]. The translation involves the combined use of Fast Fourier Transform and Feed Forward Backpropogation algorithm [1][3]. After translation, the data is stored in a Parse Tree database for faster access [4].This paper proposes a hybrid methodology by bringing together various techniques in order to perform the task of saving the extracted brain-waves in a human-understandable form.**

**Keyword- Brain Computer Interface, Discrete Wavelet Transform, Parse Tree Database, Feed Forward Backpropogation**

## I. INTRODUCTION

Brain Computer Interface (BCI) involves the direct communication between the Brain and the Machine. BCI has tremendous amount of applications since it can be used for understanding the needs of the disabled people. BCI involves the use of a head-gear for extracting the brain waves. This is called as Electroencephalography (EEG) [5] as shown in Fig 1. Brain is made up of billions of neurons. It exchanges information by discharging ions thereby conducting electrical impulses. EEG involves the use of conducting electrodes which are positioned at particular points on the scalp. Then a conducting Gel or Paste is applied on the scalp and the electrodes are held in contact with this gel. The procedure is given in great detail in [7]. Any electrical impulse is captured by the gel and is transmitted to the electrodes. The complete set of electrode position has been given in Fig. 1 to the International 10-20 system [5]. Here the letters T, F, P, O and C represents Temporal, Frontal, Parietal, Occipital and Central Lobes respectively. The anatomical landmarks in the head include the "nasion" which is the point between the nose and forehead and the "inion" which is the central lowermost region at the back of head where the skull ends. This is mentioned in the Figure 1. [5][6]. These brain-waves are classified, de-noised, translated and then stored in a database. The procedure how this is performed is being explained in detail in the paper.

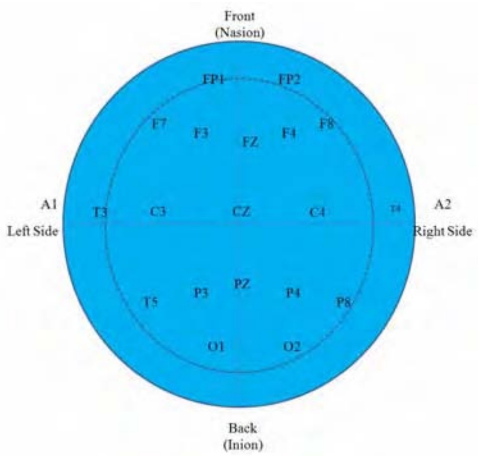


Fig 1: International 10-20 System

## II. CONCEPT

The brain contains neurons and these neurons communicate with each other using electrical impulses. These impulses need to be captured and decoded to obtain what the user thinks at the given point of time. After the data is decoded, they need to be stored using a technique from which retrieval becomes simple. The information about the brain-waves can be obtained using Electroencephalogram [3] and raw brain impulses can be captured. This information contains a lot of unwanted data and thereby needs to be de-noised[1][2][3][8][9]. After this, the de-noised signals must be translated into a form that can be understood by humans[3]. This can be done by using a feed forward back-propagation technique by which, using neural networks, the signals can be decoded [3]. This de-noised and decoded information is then stored in such a way that, information can be retrieved efficiently [4] [10].

### *A. **Electroencephalogram***

The detailed method about how to use the EEG has been explained by Atul Gaidhani et. al. in [5] and by R. Sudirman et. al. in [1]. K Revert et. al. in [11], we have emphasized that, brain communication occurs through electrical impulses. But understanding what these impulses represent can only be done using device which is capable of recording the brain-related activities. Brain activities can be recorded using Magneto-encephalo-graphy (MEG), functional Magnetic Resonance Imaging (fMRI) and electro-encephalo-graphy (EEG). Owing to advanced hardware, portability and detailed information gathering, EEG is widely used for practical applications [3][11][12].

### *B. **Using Signal Data***

Once the data from EEG has been captured, decoding the data starts. The EEG signal in general has a lot of noise in it [1][2][3][8][9]. Noise may be any undesirable data which needs to be discarded from the actual set of signal. For eg; if the subject is been asked to listen to a particular sound and the brain response is to be captured, the brain waves will contain certain signals which would have occurred due to wavering of his concentration, such as capturing the information what he sees at that time [1][8][9]. For removing such unwanted signals, we can use some de-noising techniques.

According to [3], we can perform it using Principle Component Analysis (PCA). It involves generation of principle components (new set of variables) which is the linear combination of original variables and is orthogonal to each other. But in [5], a different technique called RQNN (Recurrent Quantum Neural Networks) is used. In this technique, the EEG signals are sent to a neural lattice. Here, a quantum object mediates the collective response of the neural lattice. Similar technique has also been mentioned in [13]. In [8] and [9], Discrete Wavelet Transforms (DWT) is used for achieving the same purpose. On applying DWT, the signal gives an approximate signal and the detailed signal [8][9][13] which can be used processed using Mean Square Error method (MSE) [8][9][14] from the original to obtain the de-noised signal.

In [3], it defines the use of an algorithm called Feed Forward Back Propagation algorithm, in order to decode the signals. The algorithm employs the technique of propagating errors in order to ensure the errors are obtained. The explanation can be seen in Fig 2 and the discussion below.

Fig. 2 shows a basic 2 layer neural network. The input layer provides the input of the EEG signals and the processing is done in the hidden layers and the output is being provided in the output layer. Now, there will be errors in the neural network. But, the errors are reflected only in the output layers hence, it’s not taken into consideration while processing. Therefore, these outputs are again back-propagated to the hidden layers to ensure these errors are taken care of; hence the name; “Back Propagation Algorithm”. This paper deals with a 21 layer neural network as opposed to the 2 layer network shown here, thereby giving extensive precision.

In [1] too, DWT is used to obtain the same thing. Here, the signal is analyzed at various frequency bands in order to obtain approximate, but detailed information. Here, high-pass and low-pass filters are used consecutively in order to decompose the signal simultaneously. This can be done using the dwt function in MATLAB [1]. The advantages of DWT have been further elaborated in [8][9][14]. DWT has the ability to capture the transient features and can be localized in both frequency and time domains accurately. In [14], the author has discussed about the lifting scheme, a technique which has been proved more computationally efficient for constructing bi-orthogonal wavelets. [14]. In [15], for decoding purposes, Kalman filter is used which is a real time processing algorithm.

In [16], the different types of waveforms that can be possibly encountered during an EEG (while checking the condition of an epileptic patient) has been populated and a comparative case-study has been presented for all the feature extraction algorithms, viz. Tarassenko’s Algorithm, Webber’s Algorithm, Kalayci’s Algorithm and Ozdamar’s Algorithm. A comparison has been presented in accordance to the various Artificial Neural Networks (ANN) specified parameters and has been presented in the paper. In [14] too, classification of EEG signals is done based on ANN while another technique called Logistic Regression (LR) is also considered.

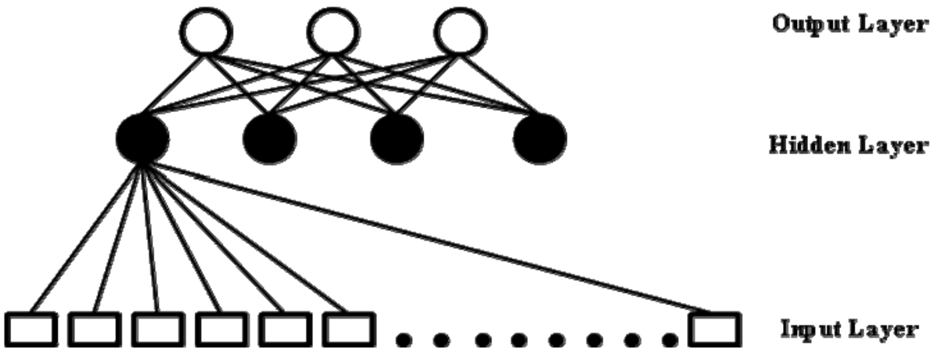


Fig 2: Basic Neural Network (2 Layers)

### C. *Information Storage and Extraction*

Now that we have the decoded information, we should judiciously store this information with good techniques for fast and efficient retrieval. In [6], A technique called Combining Tag and Value Similarity is being presented. This technique segments the data it into Query Result Records (QRR) in the query result pages. It then automatically extracts the data from the query result pages. The aligned QRR is then segmented into a table. A new alignment record algorithm has been described, which is selected pair-wise then holistically [10]. This technique has certain drawbacks which are enumerated as follows:

- Optional attribute which appears in start node acts as auxiliary information.
- It requires atleast two QRRs in the query result page.
- It can't handle cases where multiple data values are clustered together in a single leaf of the node.

In [4], the author has discussed about a new technique which facilitates the information extraction. Information Extraction (IE) has been implemented as a pipeline for special purpose modules such as, sentence splitters, optimizers, tokenizers and syntactic parsers and extraction is done on the basis of collection of patterns. This paper proposes a new technique for IE. Intermediate Output for each text processing component is stored. Extraction is performed by taking into consideration, both the previously processed data and the unprocessed data. Such an approach is called Incremental Information Extraction. This technique too, has certain drawbacks which are enumerated as follows:

- Presently, intermediate processed data like parse trees can't be managed efficiently. Hence, computation of the entire corpus can be computationally expensive
- Intermediate parse trees needs to be stored in the database which would result in an increase in space complexity
- Parse Tree Query Language (PTQL) lacks support for common features like Regular Expression

## III. METHODOLOGY

The system that is been proposed is a hybrid model. It encompasses the techniques aforementioned to develop a system which is capable of extracting the brain waves, decode it and store it in such a way that retrieving is simple and efficient.

As mentioned in the system, the system has six phases in all. They are:

*A.* Signal Acquistion
*B.* Brain Signal Isolation
*C.* Brain Signal Translation
*D.* Data Arranging
*E.* Facilitating parallel approach
*F.* Creating a Buffer Database

### A. *Signal Acquistion*

It involves the use of Electroencephalogram (EEG) in order to capture the brain waves from the humans. These brain waves are recorded in ensure further processing. [1][2][3][5][8][9][17][18][20]

### B. *Brain Signal Isolation*

This step involves de-noising the existing signals. [1][2][3] De-noising the signals is very important because this removes all the unnecessary glitches and provides the part of signal which is useful. De-noising a signal saves a lot of processing time and enhances the quality of the decoded signal. This is done using RQNN (Recurrent Quantum Neural Network) [2] which uses an array of neurons to process the signal and feed it to the

Neural Lattice. The output of this RQNN then undergoes feature extraction and classification to enhance the quality of the isolated de-noised information.

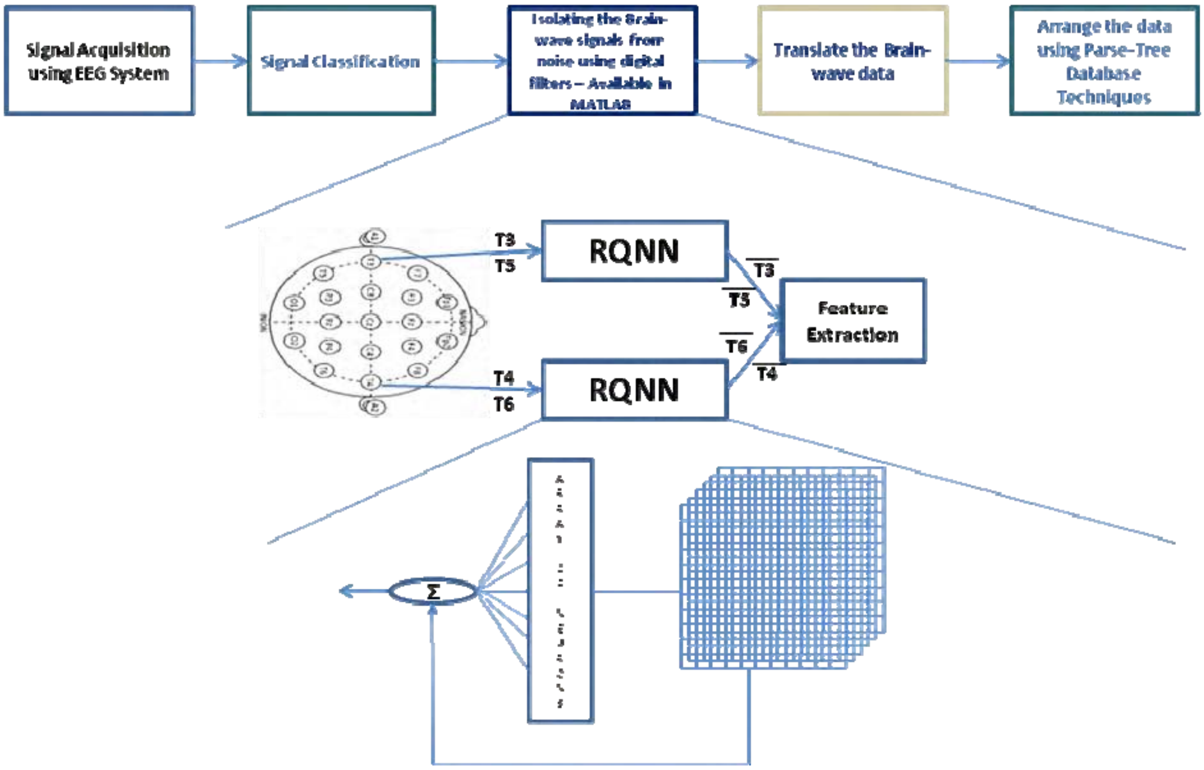


Fig 3: System Design Model [2]

### C. *Brain Signal Translation*

In this phase, the de-noised brain signals are translated from "waves" to "human understandable languages". This is done using Fast Fourier Transformations and Natural Language Processing based techniques [1]. The Back-Propagation algorithm plays an important role in this phase. [3]

### D. *Data Arranging*

This involves properly arranging the data in order to enable speedy information searching. The data is arranged using the Combined Tag Value Similarity technique which is explained in great detail in [10].

### E. *Facilitating parallel approach*

The data is made compatible for parallel data extraction using multi-threading technique. This is especially important to improve the overall performance of the system. The Combined Tag Value Similarity Technique [10] coupled with Parallel Approach greatly enhances the performance.

### F. *Creating a Buffer Database*

Once information is searched, it is added to a separate parse-tree database which acts as a buffer. The most frequently used data is inserted inside this parse-tree database so that; hit ratio of the searched information is as high as possible. The detailed information about the construction, working and efficiency of a parse-tree database is provided in [4].

TABLE I
Comparing the Techniques of each Paper

| Paper | Noise Isolation | Signal Decoding | Signal Storage | Signal Storage |
|---|---|---|---|---|
| [1] | PCA | DWT | - | - |
| [2] | RQNN | - | - | - |
| [3] | - | FFT | - | - |
| [4] | - | - | Parse Tree Database | Parse Tree Database |
| [8] | - | DWT | - | - |
| [9] | - | DWT | - | - |
| [10] | - | - | Tag Value Similarity | Tag Value Similarity |
| [13] | - | DWT | - | - |
| [15] | - | Kalman Smoother | - | - |

## IV. SUMMARY

Table I gives a comprehensive comparative study between the various techniques that is used in various papers for the particular domains that has been mentioned in the paper. This paper involves the use of four domains viz. Noise Isolation, Signal Decoding, Signal Storage and Information Extraction. Papers [1] and [3] deal with Noise Isolation (also called de-noising) and use Principle Component Analysis (PCA) and Recurrent Quantum Neural Networks (RQNN) respectively. Papers [1], [15] and [16] deal with signal decoding which uses Digital Wavelet Transform (DWT), Fast Fourier Transforms (FFT) and Kalman Smoother respectively. [8], [9] and [13] also uses DWT for Signal decoding. Signal Storage and Information Extraction and hand-in-hand techniques, which has been explained in papers [10] and [4] which uses “Tag and Value Similarity” and “Parse Tree Database” respectively.

## V. CONCLUSION AND FUTURE WORK

This paper gives an overview about the various steps that are presently being used for decoding the brain-waves. All techniques and algorithms used by the respective steps have been mentioned and a comparative study has been presented in order to simplify it. In addition to it, a hybrid model has been proposed that is in process of being implemented, which involves categorically subdividing the entire process into four major sub-parts as aforementioned. Currently, efforts are being made to perform the de-noising of the waves using DWT and RQNN separately and using parallelization techniques, in order to improve the performance. This technique is extremely useful when a huge repository of brain-waves needs to be decoded into human understandable form and certain information needs to be extracted from this huge repository of information.

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