Chapter 4
Real-Time Brain Mapping Using Wireless Technology for the Future

Sujatha K.
Dr. MGR Educational and Research Institute, India

Karthiga G.
Dr. MGR Educational and Research Institute, India

Bhavani N. P. G.
Saveetha School of Engineering, India

Kalaivani A.
Saveetha School of Engineering, SIMATS, India

N. Janaki
Vels Institute of Science and Advanced Studies, India

ABSTRACT

As it is known that different brain regions have specific functions, and before performing any surgery on the brain, including surgery for the treatment of epilepsy, the surgeon seeks to understand the functions of the areas affected by the seizures or of the lesion. The attempt to specify in as much detail as possible the location of function in the human brain is called brain mapping. In this paper the authors produced real time brain mapping from digitized EEG data recordings. And the authors developed this software to obtain continuous movie map and spectral slide. Nowadays, monitoring various signals from human body is an active area of research and development. Increasingly, monitoring devices are becoming wireless to allow patient mobility. For this aim the authors made it possible to be wireless.

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INTRODUCTION

The recording and use of electroencephalograms (EEG) to visualize "what the brain is doing" has been practiced since 1928 when Hans Berger first attached two electrodes to a scalp surface and recorded the first EEG on a cathode ray tube. The evolution of EEG technology has since improved substantially; including multi-channel recording, but the basic use of the EEG systems remains the same to record changes in potential between various locations on the scalp surface (Tyagi et al., 2020).

It is very well known that different brain regions perform specific functions. And also before performing any surgery on the brain, including surgery for the treatment of epilepsy, the surgeon seeks to understand the functions of the areas affected by the seizures or of the lesion. All of the surgical planning is done to preserve important functions such as speech, comprehension, sight, movement, or sensation, and to lessen the risk of loss of function from the surgery (Goyal et al., 2020).

While recognizing the vital role EEG plays in clinical diagnoses, it must be emphasized that the output of multipage row waveforms is rather difficult to interpret, especially for someone without long experience in EEG. The task of identifying the function of different regions of the brain is called brain mapping. The first aim of this project is to generate a brain map from digitized EEG recordings and the development of its software to obtain continuous movie map (animation movie) and slides. Which help the physicians to seek the area more carefully and compare the slides to find out what is the exact function of the human brain? The second aim of our work is making it real time. So that it is more possible to study how electrical activity evolves and changes overtime in a manner that is clear to even the casual observer. And our last aim is preparing a system for wireless electrical brain mapping (Madhav and Tyagi, 2022).

The greatest advantage of this wireless system is practically unlimited movement of the patients. The users can carry such EEG devices not only in their house, but also while working or sleeping. Also, the computer system allows the selection of the number of the electrodes, the interpolation method, the display mode, and also the number of spectral slides and the exact interval of EEG (Mishra and Tyagi, 2022).

High resolution structural magnetic resonance imaging (MRI) and Diffusion Weighted Imaging (DWI) images provide an unprecedented view of the human brain in vivo. Structural MRI images show a detailed grayscale three-dimensional picture of tissue organization, containing tens of millions of voxels. DWI builds on this information by capturing the diffusion of water molecules in tissue. It samples the diffusion strength in multiple directions at each point in the brain to generate a profile diffusion. This information furnishes a macro scopic view of the brain's tissue, which restricts diffusion because of interactions with axons, cell membranes and vascular structures. In subjects, these images along with the genome sequence, cognitive tests, age, and sex comprise a detailed picture of the human condition for the study of disease, genetic effects, developmental changes, and aging (Nair et al., 2021).

Researchers have designed methods that capture and interpret medical images using tools from computer science, statistics, and mathematics. They used an array of techniques to register MRI images into the same space such as the discrete cosine transform with Leven berg- Marquardt optimization or a Eulerian velocity framework with a multi-grid method. Others have tackled brain segmentation with a trained Markov random field model, a machine learning feature based discriminative model combined with a generative model, and recently a geodesic curvature flow on the cortical surface using level sets. In DWI, scientists first captured the diffusion information using a tensor and then introduced the orientation distribution function (ODF), a parameterization rich with information designed for high angular resolution diffusion imaging (HARDI). The knowledge represented by these models was used by investigators to generate a representative set of fibers for pathways of white matter tissue in the brain, a process referred to as tractography. Research initially defined tractography as fibers following the direction of highest local diffusion, a method referred to as streamlines, but more recently introduced methods such as a global probabilistic method that searches all possible fibers to find and optimize the core function. The fibers from tractography give a way to quantify the connectivity between regions and there has been a plethora of research on how to represent and understand connectivity. In addition to standard image processing problems, scientists have created disease classification methods of image features based on support vector machines or nearest neighbor classification with a self-smoothing operator. The availability of quick and affordable genome sequencing give researches the ability to perform genome-wide association studies in tens of thousands of subjects to discover relationships between our brain structure and our genetic code (Tyagi et al., 2020).

In this dissertation, a collection of methods is presented to understand the structure of the human brain and compare this information across a group of subjects. Our first method addresses brain segmentation with a deformable organism framework paired with a machine learning error identification algorithm. We then present a method that compactly represents white matter tissue in the brain and uses this representation to understand differences in a cohort of subjects. The latter part of this dissertation presents various methods that can capture and define connectivity in the human brain. An optimized tractography algorithm, a flow-based connectivity metric, a connectivity-based classification function and a framework to define the architecture of connectivity was discussed.

Brain segmentation involves delineating the brain in full head MRI images, the process removes extraneous material such as the skin, cerebrospinal fluid (CSF), eyes, and nose from the image and is referred to as skull-stripping. The segmented brain is an important pre-processing step in most neuroimaging studies, necessary for registration algorithms, cortical analysis, segmentation methods, and in homogeneity correction. The resulting masks are also applied to DWI images to focus subsequent analysis on exclusively brain tissue. Skull- stripping was traditionally done manually by trained experts who went through each slice and traced the boundary of the brain, a process that is prone to error and has difficulties with repeatability. In addition, manual tracing can take up to one week per subject, making it intractable for large studies with thousands of images. There has been a wide array of proposed automatic skull-stripping methods that can quickly and consistently identify the brain. Some of the most widely used methods use a deformable model expanding from the center of the image, the watershed algorithm in combination with a template, and edge detection combined with morphological operations. However, depending on the input data, these algorithms may be deficient and require manual clean-up, a process taking hours per subject. We proposed a segmentation method that allows the user to specify a high-level plan unique to their data. Our algorithm draws from the principals of artificial life and deformable models to created formable organisms that cooperatively work together to segment the brain. Segmenting brain from non-brain tissue within magnetic resonance (MR) images of the human head, also known as skull-stripping, is a critical processing step in the analysis of neuro-imaging data. Though many algorithms have been developed to address this problem, challenges remain.

In this paper, the "deformable organism" is applied as a framework to the skull- stripping problem. Within this framework, deformable models are equipped with higher- level control mechanisms based on the principles of artificial life, including sensing, reactive behavior, knowledge representation, and proactive planning. Our new deformable organisms are governed by a high-level plan aimed at the fully-automated segmentation of various parts of the head in MR imagery, and they are able to cooperate in computing a robust and accurate segmentation. We applied our segmentation approach to a test set of human MRI data using manual delineations of the data as a reference "gold standard." We compare these results with results from three widely used methods using set-similarity metric. Segmentation methods for medical images may not generalize well to different data sets or tasks, hampering their utility. We attempt to remedy these issues using deformable organisms to create an easily customizable segmentation plan.

This plan is developed by borrowing ideas from artificial life to govern a set of deformable models that use control processes such as sensing, proactive planning, reactive behavior, and knowledge representation to segment an image. The image may have landmarks and features specific to that dataset; these may be easily incorporated into the plan. We validate this framework by creating a plan to locate the brain in 3D magnetic resonance images of the head (skull-stripping). This is important for surgical planning, understanding how diseases affect the brain, conducting longitudinal studies, registering brain data, and creating cortical surface models. Our plan dictates how deformable organisms find features in head images and cooperatively work to segment the brain. In addition, a method used is based on Adaboost to learn and correct errors in our segmentation. This method is tested on 630T1-weighted images from healthy young adults, evaluating results using distance and overlap error metrics based on expert gold standard segmentations. We compare our segmentations with and without the error correction step; we also compare our results to three others widely used methods: BSE, BET, and the Hybrid Watershed algorithm. Our method had the least distance to expert segmentations on this dataset but included slightly more non-brain voxels (false positives). Our framework captures diverse categories of information needed for skull-stripping and produces competitive segmentations.

The white matter of the central nervous system (CNS) is difficult to represent in anatomy because it is located predominantly "between" other anatomical entities. In a classic presentation, like a cross section of a brain segment, white matter is present and can be labeled adequately. Several appearances of the same entity are feasible on successive cross section views. The problem is the absence of a global view on long tracts, and more generally, the lack of a comprehensive classification of white matter pathways. Following the recent revision of the Terminologia Anatomica, in particular the chapter on the nervous system, resulting in the Terminologia Neuroanatomica, the authors have developed a new schema for the representation of white matter. In this approach, white matter is directly attached to the CNS, and no longer considered as part of the brain segments. Such a move does not affect the content but redistributes the anatomical entities in a more natural fashion. This paper gives an overall description of this new schema of representation and emphasizes its benefits. The new classification of white matter tracts is developed, selecting the origin as the primary criterion and the type of tract as the secondary criterion.

The connectivity between areas of the cortex is often quantified as their intersection with tractography fibers, with these measures commonly organized into a connectivity matrix. The connectivity matrix is a type of adjacency matrix where each element represents the number of fibers connecting two regions. These matrices have been used to understand differences in connectivity depending on hemisphere, sex, age, disease, heritability, and our genes. Conventionally, research have relied on streamline tractography to generate fibers for connectivity analysis, but streamlines may compound noise in DWI images. In response to these issues our work focused on generating fibers using a global probabilistic tractography algorithm based on the Hough transform, that optimized a measure of FA along with a probability based on diffusion. Due to the added complexity and lengthy running time of the Hough transform method, we introduced an optimization based on an ODF lookup table and random traversal of the parameter space. In addition, we explored the relationship of fiber density or count on measures of connectivity between healthy elderly controls versus Alzheimer's disease patients. Our optimization of the tractography make it practical for research to use as an alternative to streamlines and our work stresses the importance that additional fibers may have to connectivity analysis.

The traditional fiber count-based measure was expanded by introducing a flow based measure of connectivity between regions. Our method modeled the DWI image space as a graph (a set of nodes and edges), where the edge weight was the diffusion strength and represented the capacity between two nodes. A modified maximum flow algorithm was executed which incorporated the biologically viable pathways from tractography between two nodes to quantify the connectivity and compared it with the standard fiber count method to differentiate Alzheimer's disease. Our name for the method was evaluating maximum flow across tracts indicating connectivity (EMFATIC).

Scientists have developed many graph measures derived from connectivity matrices in hopes to provide scalar measures that assess and describe networks. These measures are often used to understand how the connect some reflects the effects of disease, aging, or difference in hemisphere. We use these measures as features in a machine learning framework based on support vector machines to classify Alzheimer's disease. Our framework computes hundreds of thousands of these features, reduces their dimension using principal components analysis, and feeds them into a 10-fold cross-validated design to evaluate the information contained in the features based on the accuracy, specificity, and sensitivity. It is found that classification based on connectivity is a useful addition to current framework for identifying Alzheimer's disease that rely on MRI measures of volume, CSF biomarkers, genotype, age, sex, body mass index, and diagnostic tests.

In most cases the regions of the cortex or nodes in the connectivity matrix are based on an automatic segmentation into functional areas. A few researchers have explored how the size, shape, and location of these nodes affect the connectivity matrix. To address this issue by introducing a Bayesian statistical framework that finds the optimal segmentation of the cortex so that the resulting connectivity matrix optimizes an objective function, a method we brand evolving partitions to improve connectomics (EPIC). We accomplish this by posing the problem as a partition of a set of small random patches on the cortex and sample it based on probability dictated by an objective function using Markov chain. In our experiments we defined our objective function as the accuracy of a classification of Alzheimer's disease based on graph measures derived from the connectivity matrix. This method is compared with a matrix following the standard functional segmentation of the cortex and a matrix based on the small random patches. Our method allows researchers to choose the nodes or architecture of a connectivity matrix to best capture connectivity information for any purpose whether that be the disease, aging, or genetics. Brain connectivity declines in Alzheimer's disease (AD), both functionally and structurally. Connectivity maps and networks derived from diffusion-based tractography offer new ways to track disease progression and to understand how AD affects the brain. Here it is identified that

1. which fiber network measures show greatest differences between AD patients and controls, and
2. in what way these effects depend on the density of fibers extracted by the tractography algorithm.

The brain networks are computed from diffusion-weighted images (DWI) of the brain, in 110 subjects. It is derived that the connectivity matrices and network topology measures, for each subject, from whole brain tractography and cortical parcellations.

An ODF lookup table is used to speed up fiber extraction, and to exploit the full information in the orientation distribution function (ODF). This made it feasible to compute high density connectivity maps. We used accelerated tractography to computer a large number of fibers to understand what effect fiber density has on network measures and in distinguishing different disease groups in our data. We focused on global efficiency, transitivity, path length, mean degree, density, modularity, small world, and as a part of sorting the relevant measures computed from weighted and binary undirected connectivity matrices. Of all these measures, the mean nodal degree best distinguished diagnostic groups. High-density fiber matrices were most helpful for picking up the more subtle clinical differences, e.g. between MCI and normal, or for distinguishing subtypes of MCI (early versus late). Care is needed in clinical analyses of brain connectivity, as the density of extracted fibers may affect how well a network measure can pick up differences between patients and controls.

It is presented that a new flow-based method for modeling brain structural connectivity. The method uses a modified maximum-flow algorithm that is robust to noise in the diffusion data and guided by biologically viable pathways and structure of the brain. A flow network is first created using a lattice graph by connecting all lattice points (voxel centers) to all their neighbors by edges. Edge weights are based on the orientation distribution function (ODF) value in the direction of the edge. The maximum-flow is computed based on this flow graph using the flow or the capacity between each region of interest (ROI) pair by following the connected tractography fibers projected onto the flow graph edges. Network measures such as global efficiency, transitivity, path length, mean degree, density, modularity, small world and the sorted values are computed from the flow connectivity matrix.

It is shown that the benefits and differences of using different types of connected features to distinguish diseased states in Alzheimer's disease. Our features come from connectivity matrices constructed from tractography fiber density between regions and using a flow-based connectivity method. In addition, we compute 28 network measures from the connectivity matrices. We reduce the dimensionality of these features using principal components analysis (PCA) and incorporate them into a 10- fold cross-validation using support vector machines (SVMs), a supervised learning algorithm. Measures of accuracy, sensitivity, and specificity show the differences between feature sets in discriminating between normal healthy controls, early- and late-stage mild cognitive impairment, and Alzheimer's disease in 110 subjects.

Researchers have proposed a method for choosing nodes in a connectivity matrix of the brain that optimizes feature-based classification performance for disease. Given 'N' cortical regions, the network measures are stored in a $N \times N$ matrix that represents the pair wise connectivity between those regions. The problem is formulated by sampling over the space of possible partitions of a random set of cortical patches. These partitions are assigned a value using a support vector machine (SVM) classifier of disease, based on graph measures derived from the connectivity matrix specified for a group of subjects. We characterize the resulting high dimensional optimization problem using Markov Chain Monte Carlo (MCMC), which provides information on the optimal partition for classification accuracy and a sample variance to understand the distribution. Ultimately, the method yields a quantitative connectivity measurement to determine the importance of selecting the optimal network architecture for classification. The demonstration of the proposed method is done on the ADNI-2 dataset, where an optimal output is obtained for the cortex corresponding to an efficiency of 80%.

LITERATURE SURVEY

Normal binaural hearing allows the auditory system to determine the direction and distance of sound sources and to detect certain sounds at much lower intensity levels. Different stimuli may have different impact on binaural processing and may generate different brain responses (Azam et al., 2017). The mechanism by which this occurs is poorly understood. Time averaged EEG responses of normal hearing subjects to repeat stimuli were analyzed. The stimuli, 500 Hz Blackman windowed pure tones, were presented as homo-phase or anti-phase and were also mixed with various noise conditions. Auditory evoked potentials (AEP) were obtained by averaging 500 trials of in-phase and 500 trials of out- phase of each EEG epoch. The results show that the amplitude of the dominant frequency component in the 20-50 Hz range of the middle latency response of the AEP was larger for the anti-phase condition than for the homo-phase condition. The normalized amplitude differences were larger when the stimuli were embedded in noise resulting in a higher mean value of the normalized amplitude difference than for noise free stimuli. These results are likely to relate to binaural masking level difference which finds that the detection of a signal in a background noise is easier when the signal has a different inter-anural phase difference than the noise (González and Eblen-Zajjur, 2018).

One of the most powerful functional evaluations of the electrical activity of the brain is the EEG imaging, but wide clinical use is limited by its costs. It is also of clinical, academic and scientific interest to obtain brain electrical maps from old paper/ink, patient recordings. The aim of the present study was the development of a computer system designed to obtain bi dimensional and tridimensional maps, continuous movie map display and mosaic presentation from conventional paper/ink EEG recordings. The wave amplitude was manually measured with a translucent template from conventional 8- to 16-channel EEG paper recordings using 10–20 mono-polar montage for one or both hemispheres. The computer system allows the selection of the number and location of electrodes, input of amplitude values, and the map display mode. The electrical brain field was generated from amplitude measurements by a spherical spline interpolation algorithm on a conventional Pentium based computer. The interpolated surface was represented on a semi- sphere modeled skull. The EEG maps displayed with pseudo-color or gray scales can be rotated, zoomed in or zoomed out and/or printed for clinical reports. Movie animation or mosaic display of space-temporal EEG voltage changes were generated by processing sequential amplitude measurements. This system represents a cost-effective method for EEG mapping from conventional paper/Ink EEG Equipment (Piangerelli et al., 2018).

In order to retrieve the communicative processes in people with hearing loss or auditory processing disorders, sometimes the use of hearing aids is not enough. Additionally, it may be necessary to fit other technological systems to optimize the amplification, including interconnectivity between different electronic devices. The intention is to design and propose a protocol for the fitting of Hearing Assistive Technology Systems (HATS), from the level of satisfaction of a user group of these hearing aids and analysis of medical records. Is reviewed the literature and scientific evidence related to the adaptation of HATS. Medical records of nineteen patients HATS users treated between August 2011 and February 2015 are analyzed, subsequently the level of satisfaction is evaluated with Client Oriented Scale of Improvement COSI. It suggests and designs a fitting protocol of HATS. The results show that the FM system is used for all types and degrees of hearing loss, except for minor losses, resulting in a total of 11 subjects 19, further evidenced that can be adapted to all types of hearing aids. For Bluetooth systems are evident that is only used by users with air conduction hearing aid, for mild, moderate and severe loss with a total of 8 subjects. The achievement is about designing and proposing a protocol for the adaptation of HATS, from the level of satisfaction of 19 users and analysis of medical records. Through the study of communicative and psychosocial variables, is observed besides considering hearing status should be taken into account age, occupation, cognitive level, family support, daily environment and expectations (Hoshi, 2003).

The increasing adoption of the Internet-of-Things (IoT), the wireless sensors network (WSN), as an underlying application of IoT, has attracted the increasing attention of the medical experts. Topology, with the working structure is used to observe WSN, the most instinctive form in troubleshooting and has great significance to WSN management and safety. To this end, it is imperative to recover WSN topology for the purpose of network management and non-cooperative network detection. Traditional network topology recovery mainly relies on the monitoring modules installed in nodes, or an extra network attached. However, these two approaches have several limitations, such as high energy consumption for monitoring nodes, time synchronization problems: reuse failure, limitation to specific targeted networks and high cost. In this paper, we present a new approach to recover the topology of WSN that adopts location-based routing protocols, based on movable platforms. Our observation is that the network topology is consistent with the node routing, as the nodes choose the next hop according to the geological position of neighbor nodes. Hence, we calculate the cost parameters of choosing routing nodes for the targeted network according to the partial connection of the nodes. Based on those cost parameters, we can determine the topology of the whole network. More specifically, by collecting the geological position and data packets of the nodes from movable platforms, we are able to infer the topology of the WSN according to the recovered partial connection of nodes. Our approach can be easily adapted to many scenarios, especially for non- cooperative large-scale networks (Lin et al., 2010).

Health care applications are considered as a promising field for wireless sensor networks, where patients can be monitored using wireless medical sensor networks. Current WMSN healthcare research trends focus on patient reliable communication, patient mobility, and energy-efficient routing, as a few examples. However, deploying a new technology in health care applications without considering security makes patient privacy vulnerable. Moreover, the physiological data of an individual are highly sensitive. Therefore, security is a paramount requirement of healthcare applications, especially in the case of patient privacy, if the patient has an embarrassing disease. This paper discusses the security and privacy issues in healthcare application using WMSNs. We highlight some popular healthcare projects using wireless medical sensor networks and discuss their security. Our aim is to instigate discussion on these critical issues since the success of healthcare application depends directly on patient security and privacy, for ethical as well as legal reasons. In addition, we discuss the issues with existing security mechanisms, and sketch out the important security requirements for such applications. In addition, the paper reviews existing schemes that have been recently proposed to provide security solutions in wireless healthcare scenarios. Finally, the paper ends up with a summary of open security research issues that need to be explored for future healthcare applications using WMSNs (Lee et al., 2018).

Although near-infrared spectroscopy (NIRS) was developed as a tool for clinical monitoring of tissue oxygenation, it also has potential for neuroimaging. A wide range of different NIRS instruments have been developed, and instruments for continuous intensity measurements with fixed spacing [continuous wave (CW)-type instruments], which are most readily available commercially, allow us to see dynamic changes in regional cerebral blood flow in real time. However, quantification, which is necessary for imaging of brain functions, is impossible with these CW-type instruments. Over the past 20 years, many different approaches to quantification have been tried, and several multichannel times resolved and frequency-domain instruments are now in common use for imaging. Although there are still many problems with this technique, such as incomplete knowledge of how light propagates through the head, NIRS will not only open a window on brain physiology for subjects who have rarely been examined until now, but also provide a new direction for functional mapping studies (Yoshimitsu et al., 2011).

A real-time wireless electroencephalogram (EEG) based brain-computer interface (BCI) system for drowsiness detection has been proposed. Drowsy driving has been implicated as a causal factor in many accidents. Therefore, real-time drowsiness monitoring can prevent traffic accidents effectively. However, current BCI systems are usually large and have to transmit an EEG signal to a back end personal computer to process the EEG signal. In this study, a novel BCI system was developed to monitor the human cognitive state and provided a bio-feed back to the driver when a drowsy state occurs. The proposed system consists of a wireless physiological signal acquisition module and an embedded signal-processing module. Here, the physiological signal acquisition module and embedded signal processing module were designed for long-term EEG monitoring and real-time drowsiness detection, respectively. The advantages of low owner consumption and small volume of the proposed system are suitable for medical applications. Moreover, a real time drowsiness detection algorithm was also developed and implemented in this system. The experiment results demonstrated the feasibility of our proposed BCI system in a practical driving application (Paola et al., 2018).

The scientists have introduced optimized elastomeric conductive electrodes using a mixture of silver nano wires (AgNWs) with carbon nanotubes/poly dimethyl siloxane (CNTs/PDMS), to build a portable earphone type of wearable system that is designed to enable recording electrophysiological activities as well as listening to music at the same time. A custom- built, plastic frame integrated with soft, deformable fabric-based memory foam of earmuffs facilitates essential electronic components, such as conductive elastomers, metal strips, signal transducers and a speaker. Such a platform incorporates with accessory cables to attain wireless, real-time monitoring of electrical potentials whose information can be displayed on a cell phone during outdoor activities and music appreciation. Careful evaluations on experimental results reveal that the performance of fabricated dry electrodes is comparable to that of commercial wet electrodes, and position-dependent signal behaviors provide a route toward accomplishing maximized signal quality. This research offers a facile approach for a wearable healthcare monitor via integration of soft electronic constituents with personal belongings (Li et al., 2020).

The dedicated intra operative examination monitor for a wake surgery (IEMAS) was originally developed by us to facilitate the process of brain mapping during a wake craniotomy and successfully used in 186 neurosurgical procedures. This information sharing device provides the opportunity for all members of the surgical team to visualize a wide spectrum of the integrated intra-operative information related to the condition of the patient, nuances of the surgical procedure, and details of the cortical mapping, practically without interruption of the surgical manipulations. The wide set of both anatomical and functional parameters, such as view of the patient's mimic and face movements while answering the specific questions, type of the examination test, position of the surgical instruments, parameters of the bi-spectral index monitor, and general view of the surgical field through the operating microscope, is presented compactly in one screen with several displays. However, the initially designed IEMAS system was occasionally affected by interruption or detachment of the connecting cables, which sometimes interfered with its effective clinical use. Therefore, a new modification of the device was developed. The specific feature is installation of wireless information transmitting technology using audio-visual transmitters and receivers for transfer of images and verbal information. The modified IEMAS system is very convenient to use in the narrow space of the operating room (Sweekat et al., 2018).

Wireless transmission of cortical signals is an essential step to improve the safety of epilepsy procedures requiring seizure focus localization and to provide chronic recording of brain activity for Brain Computer Interface (BCI) applications. Our group developed a fully implantable and externally rechargeable device, able to provide wireless electrocordiograph (ECoG) recording and cortical stimulation (CS).

The first prototype of a wireless multi-channel very low power ECoG system was custom designed to be implanted on non-human primates. The device, named, is housed in a compact hermetically sealed Polyetherether ketone (PEEK) enclosure, allowing seamless battery recharge. ECOGIW-16E is recharged in a wireless fashion using a special cage designed to facilitate the recharge process in monkeys and developed in accordance with guidelines for accommodation of animals by Council of Europe. The inductively recharging cage is made up of nylon and provides a thoroughly novel experimental setting on freely moving animals. The combination of wireless cable-free ECoG and external seamless battery recharge solves the problems and shortcomings caused by the presence of cables leaving the skull, providing a safer and easier way to monitor patients and to perform ECoG recording on primates. Data transmission exploits the newly available Medical Implant Communication Service band (MICS): 402–405 MHz. ECOGIW-16E was implanted over the left sensor motor cortex to assess the feasibility of wireless ECoG monitoring and brain mapping through CS. With this device, it is possible to record the everyday life ECoG signal from a monkey and to deliver focal brain stimulation with movement elicitation (Nair and Tyagi, 2021).

METHODOLOGY

Existing Method

The EEG is a recording of the brain's electrical activity, in most cases made from electrodes over the surface of the scalp. It may also consist of electrodes placed over the surface of the brain or from needle electrodes inserted into the brain. The recordings are the summation of volume conductor fields produced by millions of interconnecting neurons. The architecture of the brain is not uniform but varies with different locations. Thus, the EEG can vary depending on the location of the recording electrodes. Recordings made from an electrode on the surface of the scalp, using a distance reference electrode, are the resultant field potential at the boundary of a large volume conductor containing many neurons. Action potentials in axons contribute little to scalp surface records as they are asynchronous, and the axons run in many different directions. Surface records are the net effect of local postsynaptic potentials of cortical cells.

Proposed Method

For obtaining basic brain patterns of individuals, subjects are instructed to close their eyes and relax. Brain patterns from wave shapes that are commonly sinusoidal. Usually, they are measured from peak to peak and normally range from 0.5 to 100 µV in amplitude, which is about 100 times lower than EEG signals. By means of Fourier transform power spectrum from the row EEG signal is derived. In power spectrum contribution of sine waves with different frequencies are visible. Although the spectrum is continuous, ranging from 0 Hz up to one half of sampling frequency, the brain state of the individual may make certain frequencies more dominate. Brain waves have been categorized into four basic groups (Figure1.1): - Beta (>13 Hz), - Alpha (8-13 Hz), - Theta (4-8 Hz), - Delta (0.5-4Hz). The internationally standardized10-20 system is usually employed to record the spontaneous EEG. In this system 21 electrodes as in Figure 2 are located on the surface of the scalp, as shown in Figure 1. The positions are determined, and the reference are the nasal points, which is at the top of the nose, level with the eyes; and which is the bony lump at the base of the skull on the midline at the back of the head. From these points, the skull perimeters are measured in the transverse and median planes. Electrode locations are determined by dividing these perimeters into 10% and 20% intervals. Three other electrodes are placed on each side equidistant from the neighboring points.

Figure 1. Brain Waves

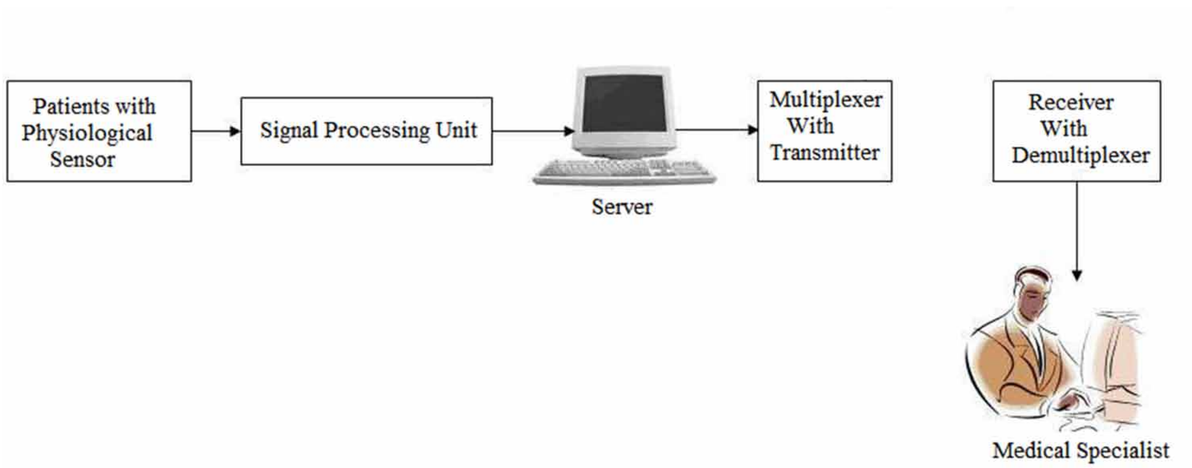
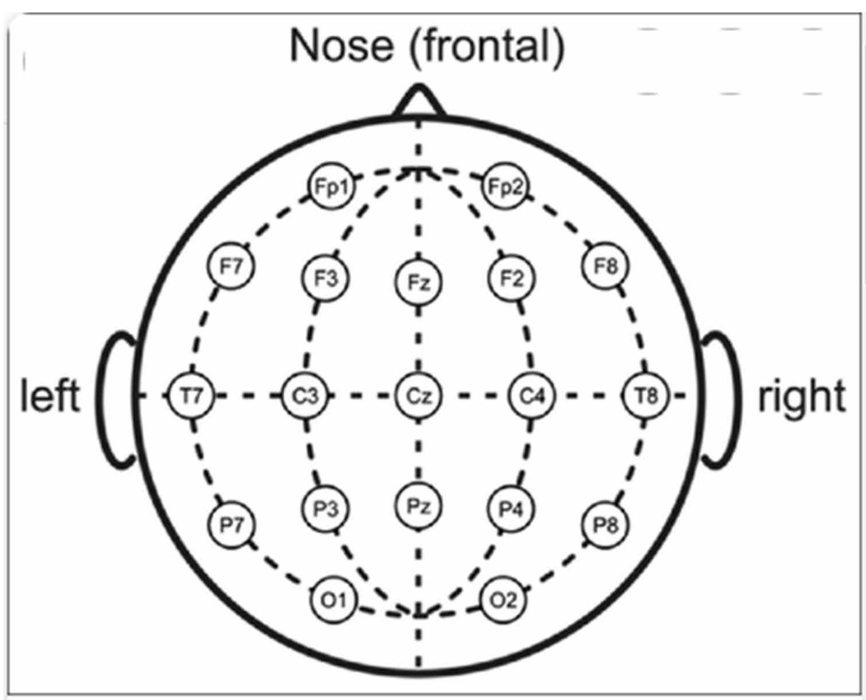
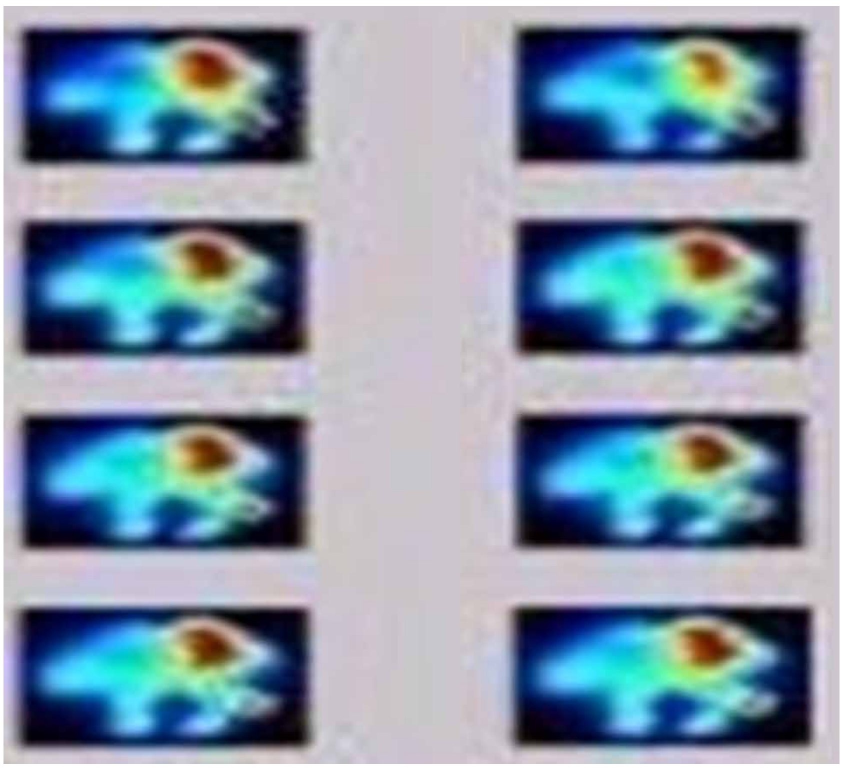


Figure 2. Positioning of Electrodes on the Scalp



Monitoring various signals from human body is presently an active area of research and development. Increasingly, monitoring devices are becoming wireless to allow patient mobility. Wireless EEGs are currently being used to wireless transmission of the data from brain sensors to a computer and they carry a huge potential for many future medical applications. Another trend is to connect monitoring devices into a network using wireless sensor nodes. Wireless sensor nodes called "motes" consist of different types of sensors such as pulse oximeter, gyroscopes, accelerometers, an 8-bit processor and a wireless component. The processor runs a simple operating system called Tiny OS as in Figure 3.

Figure 3. Quality of Slides



RESULTS AND DISCUSSION

In order to use the superior power and flexibility of the computer to store and to analyze the EEG and other bio signals, an invention was of fundamental importance: the so-called analog to digital converter. Sampling is performed at a high speed, and the resulting numbers are stored in the computer disk. Each channel of EEG has its own separate DAC process, in parallel with the others, and this proceeds in real time. The format of EEG recordings which is to use was unknown, so the first step was the rereading of the data set. Next step was interpolation. For this step the cubic spline interpolation is applied. However, one of the software's options is about choosing the interpolation method. The points for interpolation are chosen from the standard 10 to 20 electrodes placement. The final generated brain map is shown in Figure 4. The Matlab Software does all the process. Finally, by using Matlab GUI as in Figure 5, the spectral slides are produced and animation movie and also made it real time. The number of slides and also the special time period of EEG can be chosen by the operator or neurologists.

Figure 4. Output Signal

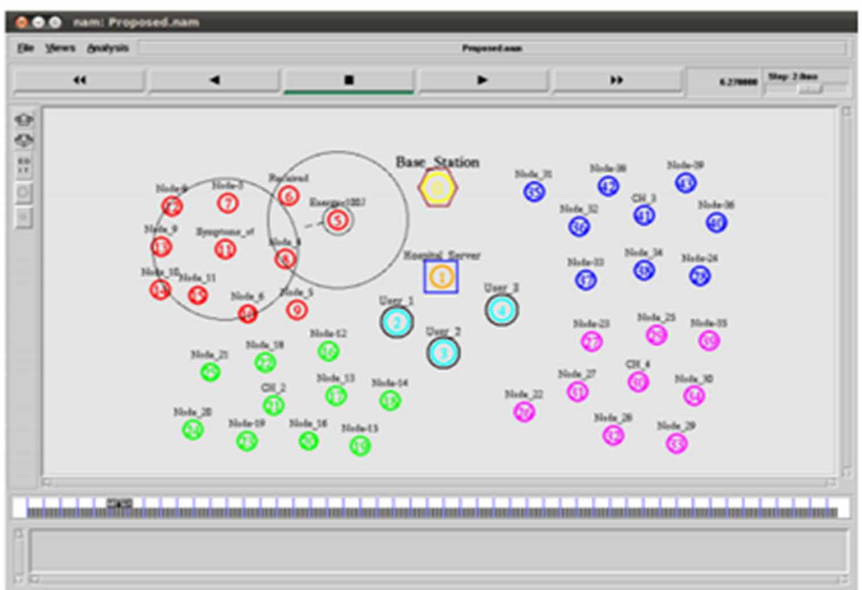
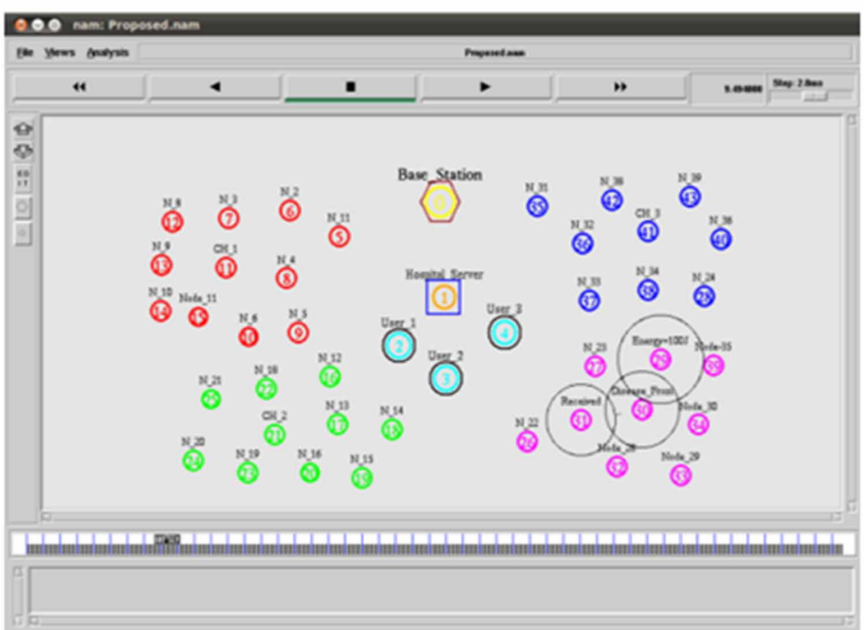


Figure 5. Frequency Wave of Each EEG Record



CONCLUSION

The wireless EEG transmitting consists of EEG sensors, electrodes, digitizing equipment with wireless interface providing connection to a personal computer or a PDA. The modes have been designed to operate using Tiny OS. EEG sensors are connected to well defined parts of the human scalp to collect brain signals. Brain signals from each sensor (channel) are digitized at 250 Hz with 16 bits implying a data rate of 4 kbps per channel. We assume a combined software and hardware platform for medical sensor networks such as the Code Blue. The Code Blue provides several features that are useful for EEGs in location tracking, publish/subscribe routing layer and query interface. RF based location tracking in Code Blue allows mobility to the patients with EEG sensors in their scalp. The Code Blue query interface (CBQ) is how the end user devices in the medical sensor network express their data requirements from the EEG sensors. Wireless link in mote-based EEG scan be implemented using Bluetooth, i.e., IEEE sensors designed with Bluetooth radio running Tiny OS have been reported in the literature. Blue tooth wireless interface is used to transmit the EEG signals to computer for create a brain mapping. Bluetooth supports minimum data rate of 115.2 kbps and a maximum data rate of 921.6 kbps. With the minimum data rate, all 24 channels of EEG data can be transferred using Bluetooth. For several EEG sensors in the patient's scalp, the data from each sensor node need to be synchronized at the base station. For this purpose the data are time stamped. There is a similar synchronization problem when motion analysis sensors are used on scalp. A patient will wear several 'T' motes outfitted with motion analysis sensors and the data from these sensors arriving at the base station. Topographical mapping of brain electrical activity presents temporal and spatial information From EEGs in direct and cleaner manner. Presenting these maps in a manner that we described in this paper help physicians to find out the functions of the area affected by seizures or of the lesion more carefully

REFERENCES

Azam, S., Jonkman, M., & De Boer, F. (2017). A New Approach Correlating Binaural Hearing and the Brain's Response. *Engineering Journal (New York)*, *21*(7), 403–413. doi:10.4186/ej.2017.21.7.403

González, I., & Eblen-Zajjur, A. (2004). Tridimensional animated brain mapping from conventional paper-ink EEG recordings. *Computers in Biology and Medicine*, *34*(7), 591–600. doi:10.1016/j.compbiomed.2003.06.002 PMID:15369710

Goyal, D., & Tyagi, A. K. (2020). A Look at Top 35 Problems in the Computer Science Field for the Next Decade. In *ICT for Competitive Strategies,* (pp. 379–396). CRC Press.

Hoshi, Y. (2003). Functional near-infrared optical imaging: Utility and limitations in human brain mapping. *Psychophysiology*, *40*(4), 511–520. doi:10.1111/1469-8986.00053 PMID:14570159

Lee, J. H., Hwang, J. Y., Zhu, J., Hwang, H. R., Lee, S. M., Cheng, H., Lee, S.-H., & Hwang, S. W. (2018). Flexible conductive composite integrated with personal earphone for wireless, real-time monitoring of electrophysiological signs. *ACS Applied Materials & Interfaces*, *10*(25), 21184–21190. doi:10.1021/acsami.8b06484 PMID:29869498

Li, R., Wang, J., & Chen, J. (2020). Movable Platform-Based Topology Detection for a Geographic Routing Wireless Sensor Network. *Sensors (Basel)*, *20*(13), 3726. doi:10.339020133726 PMID:32635280

Lin, C. T., Chang, C. J., Lin, B. S., Hung, S. H., Chao, C. F., & Wang, I. J. (2010). A real-time wireless brain–computer interface system for drowsiness detection. *IEEE Transactions on Biomedical Circuits and Systems*, *4*(4), 214–222. doi:10.1109/TBCAS.2010.2046415 PMID:23853367

Madhav, A. V., & Tyagi, A. K. (2022). The world with future technologies (Post-COVID-19): open issues, challenges, and the road ahead. In *Intelligent Interactive Multimedia Systems for e-Healthcare Applications,* (pp. 411–452). Springer.

Mishra, S., & Tyagi, A. K. (2022). The role of machine learning techniques in internet of things-based cloud applications. In *Artificial Intelligence-based Internet of Things Systems,* (pp. 105–135). Springer.

Nair, M. M., & Tyagi, A. K. (2021). Privacy: History, Statistics, Policy, Laws, Preservation and Threat Analysis. *Journal of Information Assurance & Security*, *16*(1).

Nair, M. M., Tyagi, A. K., & Sreenath, N. (2021, January). The future with industry 4.0 at the core of society 5.0: open issues, future opportunities and challenges. In *2021 International Conference on Computer Communication and Informatics (ICCCI),* (pp. 1-7). IEEE. 10.1109/ICCCI50826.2021.9402498

Paola, A., Páez, T., Pinilla, A., & Cruz, P. (2018). *Communicative process in Audio processing*.

Piangerelli, M., Ciavarro, M., Paris, A., Marchetti, S., Cristiani, P., Puttilli, C., Torres, N., Benabid, A. L., & Romanelli, P. (2014). A fully integrated wireless system for intracranial direct cortical stimulation, real-time electrocorticography data transmission, and smart cage for wireless battery recharge. *Frontiers in Neurology*, *5*, 156. doi:10.3389/fneur.2014.00156 PMID:25202300

Sweekat, K., Zarka, F., Maala, B., & Ahmad, A. S. (2018). A New Secure Wireless Body Sensor Network Architecture. *management, 12*(13).

Tyagi, A. K., Fernandez, T. F., Mishra, S., & Kumari, S. (2020, December). Intelligent automation systems at the core of industry 4.0. In *International Conference on Intelligent Systems Design and Applications,* (pp. 1-18). Springer, Cham.

Tyagi, A. K., Nair, M. M., Niladhuri, S., & Abraham, A. (2020). Security, privacy research issues in various computing platforms: A survey and the road ahead. *Journal of Information Assurance & Security*, *15*(1).

Yoshimitsu, K., Maruyama, T., Muragaki, Y., Suzuki, T., Saito, T., Nitta, M., Tanaka, M., Chernov, M., Tamura, M., Ikuta, S., Okamoto, J., Okada, Y., & Iseki, H. (2011). Wireless Modification of the Intraoperative Examination Monitor for Awake Surgery—Technical Note. *Neurologia Medico-Chirurgica*, *51*(6), 472–476. doi:10.2176/nmc.51.472 PMID:21701117