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ECoG Based Brain Computer System

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***Abstract* — Brain–computer interfaces (BCIs) allow people with severe neurological impairment and without ability to control their muscles to regain some control over environment. The BCI user performs a mental task to regulate brain activity that is measured and translated into commands controlling some external device. The sensor modalities that have most commonly been used in BCI have been electroencephalographic (EEG) recordings from the scalp and single neuron recordings from within the cortex. In few decades, a growing number of studies have examined the use of electrocorticographic (ECoG) activity recorded from the surface of the brain. The technical characteristics should support robust and chronic implementations of BCI systems in individuals. In proposed method, chronically implanted ECoG-based Brain Computer Interface system would consist of either an epidural or subdural array that contains wireless/amplification/digitization amplification electronics, which is powered by a battery, and is permanently fixed through a small burr hole in the skull. This method shows ECOG based BCI system. This technique shows how integration process actually works.**

***Keywords* — Brain Computer Interfaces, Electrocorticographic, Electroencephalography**

I. INTRODUCTION

The concept of BCI concerns technologies creating direct communication channels between a computer and other devices with the brain. The goal is to achieve real-time decoding of brain activity with sufficient reliability for paralyzed people to use devices in their daily life. There are two essential defining components in a BCI system are the mental control tasks used for regulating activities and the modality used for gaining brain signals. The ECoG is achieved by placing electrodes beneath the skull, either below (subdural) the dura mater or above (epidural), but not within the brain parenchyma itself. Compared to signals achieved from the scalp (EEG) and intraparenchymal single neuronal recordings, ECoG recordings have characteristics which make them mainly suited for basic neuroscience research and resulting translational opportunities [3]. These characteristics include signal fidelity and high spatial resolution, substantial robustness, and resistance to noise over long recording periods. The ECoG recordings appear to strike an ideal balance between clinical and fidelity practicality [3]. Individuals with tetraplegia or paraplegia due to spinal cord injury (SCI) are unable to walk and most are wheelchair bound. Reduced physical activity related with prolonged wheelchair use leads to a wide range of co-morbidities such as heart disease, metabolic derangements, pressure ulcers and osteoporosis.

In proposed method, chronically implanted ECoG-based Brain Computer Interface system would consist of either an epidural or subdural array that contains wireless/amplification/digitization amplification electronics, which is powered by a battery, and is permanently fixed through a small burr hole in the skull. This method shows ECOG based BCI system. This technique shows how integration process actually works.

II. BACKGROUND

The combination of functional electrical stimulation (FES) electrodes and an invasive brain signal acquisition system and implantable can potentially act as a permanent BCI prosthesis [1]. While, for safety reasons, the feasibility of brain-controlled ambulation must be established first using noninvasive systems. Surface cortical potentials were first recorded from animals and humans in the late 19th century [1]. Recently, in few decades there has been a renewed scientific interest in ECoG signals in a variety of animal studies (mostly in rabbits, rats, pigs and cats) [3]. Because placement of ECoG electrodes requires an intracranial surgery, research experience in humans has been more limited [3]. Mental control tasks have mainly been based on brain functions which involve strong signals, like the motor potential and the P300 oddball response, because these can be detected well from the scalp using EEG [2]. The advanced signal quality of intracranial technologies permits testing brain functions not earlier used for BCI. Modern studies indicate the potential of a new approach using top–down regulation of the sensory cortices via attention. Attention can change brain activity even in the absence of exogenous [5]. Attending to a region of the peripheral visual field, keeping the gaze fixed generates neural responses in the parts of the cortex processing visual information from this region [5]. BCI technology has matured to the extent that it is available for home use. Most BCI technology was developed for medical applications. There are identifying 7 non-medical applications including device control, user state monitoring and gaming [4].

III. PREVIOUS WORK DONE

Patrik Andersson et al. [1] have proposed navigation of a robot in real time is feasible with COVISA brain computer interface. Given that the center video display did not interfere with the generation of movement instructions for the robot, covert shifting of attention to the periphery can be achieved without interfering with processing of information in the center of the field. Besides being inherently dependent on external visual stimulation, there are growing evidences that SSVEP BCI and visual P300 systems are more or less dependent on gaze control that yields better results if subjects direct their gaze to the target as opposed to fixating gaze somewhere else. Real-time fMRI can consequently facilitate BCI training and the activation pattern is likely to indicate the most reliable implant sites and make it possible to limit the cortical area that needs to be covered with electrodes for decoding. An H Do et al. [2] have proposed one able-bodied subject and one subject with paraplegia due to SCI underwent electroencephalogram (EEG) recordings while engaged in alternating epochs of idling and walking KMI (kinesthetic motor imagery). These data were analyzed to generate an EEG prediction model for online BCI operation. A commercial robotic gait orthosis (RoGO) system was interfaced with the BCI computer to allow for computerized control. The subjects were then tasked to perform five, five-min-long online sessions where they ambulated using the BCI-RoGO system as prompted by computerized cues. The performance of this system was assessed with cross-correlation analysis, and omission and false alarm rates. Gerwin Schalk et al. [3] have proposed clinical implementation of ECoG-based brain computer interface system. A chronically implanted ECoG-based BCI system would consist of a subdural or epidural array that consists of wireless / amplification / digitization electronics is powered by a battery and is permanently implanted through a small burr hole in the skull. In this paper, ECoG based system is implemented by four simple steps which are localization, coregistration, implementation, integration. The ECoG based systems are appropriate for chronic use must be wholly implanted and capable of performing reliability. Jan B. F et al. [4] discussed concern area like the lack of standardization and provide ten recommendations to push the field forward. This paper provide look specifically at novel applications and at the technological challenges that consider them to be the main drivers of near future developments. The device control application is beneficial especially for the patients who lack full control of their limbs access to devices and communication. Non-medical applications require a clear picture of the target group of users, the added value a BCI can bring and the minimal requirements to be met. If these requirements are not met, users will simply abandon the BCI because there are better alternatives to this system. Min Chen et al. [5] has proposed new man-machine interactive mode, BCI to construct brain-controlled spelling devices, single recognition of communication carrier signals must be realized. SVM is a non-linear classifier, as its optimization procedure is completed only by its support vectors. Moreover, it is fast and has good generalization ability, and is especially applicable to the classification of EEG signals with some non-linear behaviors. This algorithm is very sensitive to parameters ν and γ; thus, it must be carefully determined. These results create a good foundation for increasing the overall communication speed of the brain computer interface.

In proposed method, chronically implanted ECoG-based Brain Computer Interface system would consist of either an epidural or subdural array that contains wireless/amplification/digitization amplification electronics, which is powered by a battery, and is permanently fixed through a small burr hole in the skull. This method shows ECOG based BCI system. This technique shows how integration process actually works.

IV. Existing Methodology

A) Navigation of a Telepresence Robot via Covert Visuospatial Attention and Real-Time fMRI

In Covert Visuospatial Attention [1] method author test the hypothesis that people can navigate a robot in real time by merely shifting the visuospatial attention, with no moving the eyes and without the need for exogenous stimuli. Subjects were commanded to navigate the robot through a path containing targets that were to be reached in a given order. The robot is equipped with a camera and images are sent as response to the user. An ultrahigh field MRI scanner (7 Tesla) is used to obtain an fMRI BOLD i.e. blood oxygen level dependent signal that is tough enough for real-time decoding. BOLD activity is well correlated spatially with modifications in the higher frequencies of electrophysiological signals; the performance with fMRI is an indirect signal of the feasibility of a BCI with electrode implants.

B) BCI controlled robotic gait orthosis(RoGO)

One able-bodied subject and one subject with paraplegia due to SCI underwent EEG recordings while engaged in alternating epochs of idling and walking kinesthetic motor imagery. These data were analyzed to produce an EEG prediction model for online BCI operation. A commercial robotic gait orthosis system was interfaced with the BCI computer to allow for computerized control. The subjects were then tasked to execute five, five-min-long online sessions where they ambulated using the BCI-RoGO system as prompted by computerized indications. The performance of this system was assessed with cross-correlation analysis and omission and false alarm rates [2].

C) Enabling Fast Brain-Computer Interaction by Single-Trial Extraction of Visual Evoked Potentials

The figure 2 illustrates a general architecture of a BAN-based wireless BCI system. EEG sensors with other sensors, such as electromyography (EMG), electrocardiography (ECG), blood pressure sensors and motion sensors, send data to nearby personal server devices. After that, through a WLAN /Bluetooth connection, these data are streamed remotely to a backend system, where data analysis unit are deployed to generate the up-to-date service directives. Afterward, the interpreted action commands to the service response system which performs the desired tasks according to the user's expectation [5].

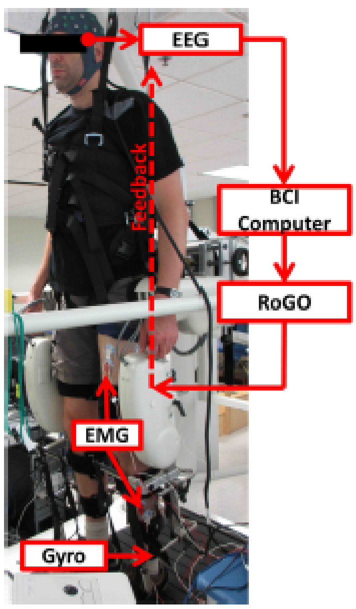

Fig.1.The experimental setup showing a subject suspended in the RoGO, while surface EMG electrodes, a gyroscope and donning an EEG cap on the left leg. A monitor, placed in front of the subject at eye-level, presented instructional cues.

V. Analysis And Discussion

1) The results of Covert Visuospatial Attention and Real-Time fMRI show that real time robot navigation can be accomplished. Since the magnitude of the fMRI signal has been shown to correlate well with the magnitude of spectral power changes in the gamma frequency band in signals measured by intracranial electrodes. The offline accuracy of the EEG prediction model averaged 86.30% across both subjects (chance: 50%).

2) The results of controlled robotic gait orthosis show cross-correlation between instructional cues and the BCI-RoGO walking epochs averaged across all subjects and all sessions was 0.812 ± 0.048 (p-value $< 10^{-4}$). Furthermore, there were on average 0.8 false alarms per session and no omissions.

3) The new man-machine interactive mode, BCI to construct brain-controlled spelling devices, single recognition of communication carrier signals must be recognized. SVM is a non-linear classifier, since its optimization procedure is completed only by its support vectors. Higher dimensions of characteristic quantity did

VII. Possible Outcome And Results

Despite the many practical difficulties of such studies, the results are promising. ECoG-based BCIs might provide control comparable or even superior to that reported for EEG-based. The extensive work needed to develop the complete systems and to validate them first in animals and then in humans has just begun. Its successful completion, combined with resolution of the other issues, could lead to ECoG-based BCI systems of great value to people with disabilities.

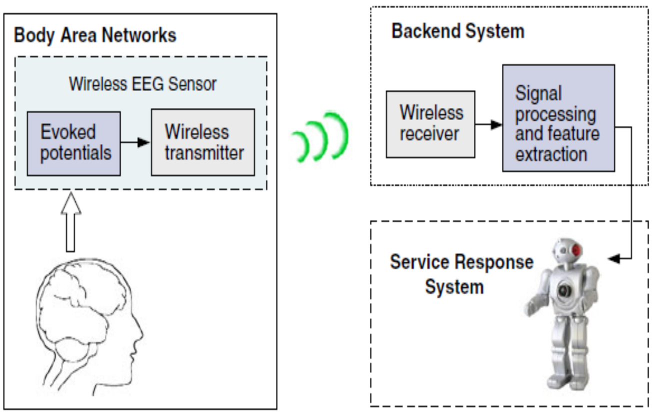

Fig.2. Architecture of a BAN based wireless BCI system

not mean higher classification accuracy; therefore, the significance level of characteristic quantity and the stability of each selection operation were decisive. In order to accelerate classification and reduce the amount of results, the feature dimensions were as low as possible.

VI. Proposed Methodology

In proposed method, chronically implanted ECoG-based Brain Computer Interface system would consist of an epidural or subdural array that contains wireless/amplification/digitization amplification electronics, which is powered by a battery, and is permanently fixed through a small burr hole in the skull. This method shows ECOG based BCI system. This technique shows how integration process actually works.

There are four steps that are starts from localization to integration. The purpose of the localization step is the identification of cortical areas that represent the best substrate for BCI control and so will identify the target location for subsequent grid implantation. The purpose of the second coregistration step is to relate the target location that was identified by the first step to the physical position on the target brain. This step can readily be achieved using conventional stereotactic navigation systems. The purpose of implantation step is to place the ECoG sensing/transmission device over the identified location and to secure it to the skull. This method may also entail placement of a battery at a remote site and installation of related cabling. The purpose of integration step is to configure the BCI system such that it properly identifies and detects relevant brain signals and relates them to the output function desired by the user. There are 3 divisions in integration process receiving signals, decoder and then command. The signals are received by ECoG electrodes then they are decoded by decoder and at last the decoded signals are used for commanding the devices. In this way the integration process completed. The following fig 3 shows the block diagram of ECoG based BCI system.

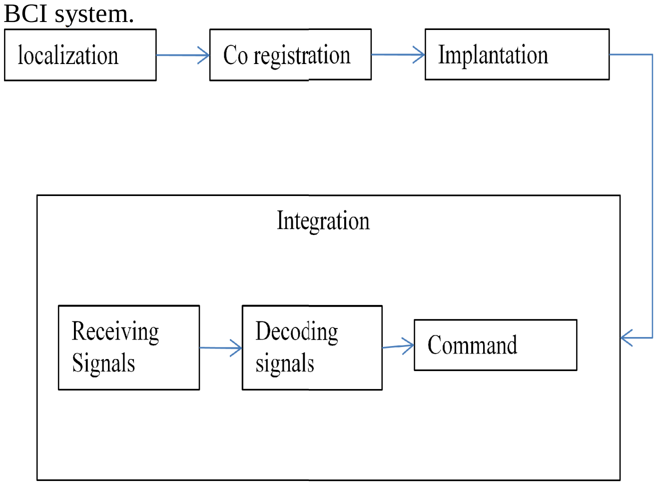

Fig.3. block diagram of ECoG technology

Conclusion

ECoG is generating strong and growing excitement for its potential to support basic neuro scientific investigations and powerful and clinically practical BCI systems. ECoG has higher topographical resolution, greater amplitude and a much wider frequency range than scalp-recorded EEG, and is less susceptible to artifacts. Simultaneously, ECoG is likely to have, and will possibly continue to have, greater long-term stability than do intracortically recorded signals. In addition, the technical requirements for ECoG-based systems are much lower than those for intracortical systems; therefore, they should be more amenable to chronic implantation.

ECoG-based BCI systems suitable for chronic use must be wholly implantable and capable of performing reliably. The extensive work needed to develop the complete systems and to validate them first in animals and then in humans has just begun. Its successful completion, combined with resolution of the other issues, could lead to ECoG-based BCI systems of great value to people with disabilities.

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AUTHOR'S PROFILE

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He has exhibited meritorious performance in his studentship. He has more than 27 years of experience in teaching and research. Throughout his teaching career he has taught more than 50 subjects at various UG and PG level courses. He has done his PhD in area of robotics, AI and computer architecture. 5 candidates have completed PhD under his supervision and more than 8 are perusing the PhD at national and international level. His area of research is Computer Architectures, AI and IT. He has completed one UGC research project on "Development of ES for control of 4 legged robot device model.". One UGC research project is ongoing under innovative scheme. At PG level also he has guided more than 300 projects/discretion. He has published more than 150 papers in International & National level Journals and also International Conferences and National level Conferences. He has also successfully completed the Software Development & Computerization of Finance, Library, Exam, Admission Process, Revaluation Process of Amravati University. Also completed the Consultancy work for election data processing . He has also worked as member of Academic Council, selection Committee member of various Other University and parent university, Member of faculty of Engineering & Science, BOS (Comp. Sci.), Member of IT Committee, Member of Networking Committee, Member of UGC, AICTE, NAAC, BUTR, ASU, DRC, RRC, SEC, CAS, NSD etc committees. . He has also worked chairman of many committees like BOS, Monitoring and Control, New Installations, Curriculum design and developments etc. He has organised more than 50 Summer schools / STTP/ Conferences / Seminar /Symposia / Workshop /Orientation Program/Training/Program / Refresher Courses. He is member and fellow of Learned Societies like Institute of Engineers, Indian Society of Technical Education ISTE, Computer Society of India CSI, etc. He has delivered more than More than 70 Keynote addresses and Invited talks delivered in India and abroad at the occasion of International & National level Technical/social events, International Conferences and National level Conferences, and also acted as session chairs many times. 3 times he has received National Level excellent paper award at National Conference, Gwalior and at other places. He has also received UGC fellowship and a major UGC project.