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Exploring the Potential of Electroencephalography (EEG) Signals for Diagnosing and Treating Neurological Illnesses: A Study Using Arc EEG Machine

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Abstract:- Electroencephalography EEG is an essential tool in healthcare, as it records and examines brain electrical activity. The Electroencephalography machine records and amplifies brain signals. Electroencephalography instruments are necessary for accurate diagnosis. The goal of Electroencephalography and innovative healthcare is to explore using Electroencephalography signals for diagnosing and treating neurological illnesses. The report aims to provide insights into using the Mosul Hospital Arc Electroencephalography machine. The primary goal is to investigate the potential of Electroencephalography signals in assisting with diagnosing and treating neurological illnesses such as epilepsy and Parkinson's disease. The report discusses various topics, such as electrode placement, channel configuration, and the use of conductive cream to improve the quality of Electroencephalography recordings. It also includes EEG recordings from two epileptic patients of varying ages and seizure statuses. An expert in Electroencephalography analysis analyzes these recordings, and the results are sent to the physician who requested the Electroencephalography recordings. In addition, the report states that the Hospital may conduct video EEG recordings if the physician has concerns about the patient's condition. The overarching goal is to provide helpful information on the use of Electroencephalography instruments and procedures in diagnosing and treating neurological illnesses and highlight potential future research and advancements in the field of Electroencephalography and healthcare.

Keywords:- *Electroencephalography, Epilepsy, Channel Arrangement, Electroencephalography Recording.*

I. INTRODUCTION

To provide cutting-edge healthcare services, the field of "smart healthcare" and the biomedical field merges healthcare with advanced technology like artificial intelligence (A.I.), machine learning (ML), and the Internet of Things (IoT). Electroencephalography (EEG) is one of the most intriguing uses of healthcare in diagnosing and treating neurological illnesses. EEG is a non-invasive method for capturing and analyzing brain electrical activity [1-4]. Several electrodes are positioned on the scalp to perform an EEG, which detects the electrical signals produced by the brain's neurons.

A graph of the brain's electrical activity over time is created using specialized equipment that amplifies and records these signals [5-7]. EEG is commonly used in neuroscience research and clinical settings to investigate how the brain works to identify neurological conditions, including epilepsy and sleep problems, and monitor brain activity during surgery or anesthesia [8-10]. Figure 1 presents an EEG recording system.

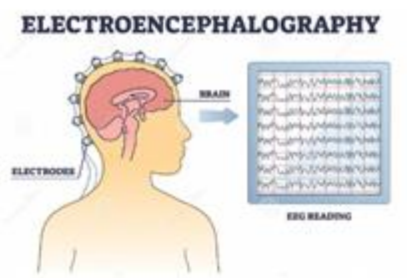

Fig. 1 EEG recording system
https://www.simplypsychology.org/what-is-an-eeg-test-and-what-is-it-used-for.html

Electroencephalography EEG has many applications in biomedical engineering [11-13]. To diagnose and track a variety of neurological problems, including epilepsy, sleep issues, and brain traumas, EEG is frequently utilized in clinical settings.

Electroencephalography (EEG) is a valuable tool in biomedical engineering and is widely used in scientific research for several reasons:

- Brain Activity Measurement: EEG is a non-invasive technique that measures the brain's electrical activity. It provides real-time information about the brain's electrical signals, allowing researchers to study brain functions, neural processes, and abnormalities. This data is crucial

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for understanding brain disorders and cognitive processes and developing treatments.

- Diagnostic and Clinical Applications: EEG is commonly used in clinical settings to diagnose and monitor neurological conditions such as epilepsy, sleep disorders, brain tumours, and brain injuries. Biomedical engineers play a vital role in developing advanced EEG technologies and algorithms to improve diagnosis and treatment accuracy, sensitivity, and reliability.
- Brain-Computer Interfaces (BCIs): EEG is instrumental in developing BCIs, which enable direct communication between the brain and external devices. BCIs have the potential to assist individuals with disabilities by translating their brain signals into control commands for prosthetic devices or computers. Biomedical engineers contribute to designing and implementing EEG-based BCIs to enhance their performance and usability.
- Cognitive and Neuroscientific Research: EEG is widely used in cognitive neuroscience to study various aspects of human cognition, such as attention, memory, language processing, and emotion. By analyzing EEG signals, researchers can investigate brain activity patterns associated with specific cognitive processes, gaining insights into the underlying mechanisms. This research contributes to our fundamental understanding of the brain and its functions. It is also employed in studies to examine how the brain responds to diverse stimuli and functions [14-15].

The Arc EEG Instrument is a sophisticated device for measuring and recording electrical activity in the brain. The Arc EEG Instrument is a user-friendly device with a compact design and a touchscreen interface. The device has sensors attached to the patient's scalp, measuring the brain's electrical activity. The sensors are connected to the device through cables, and the data is recorded and stored on a computer or other electronic device. Figure 2 shows the Arc EEG instrument.

One of the critical features of the Arc EEG Instrument is its ability to record data in real-time means that clinicians and researchers can monitor the brain's electrical activity as it occurs, which is particularly useful in diagnosing and treating neurological conditions. The device also can store data for later analysis, allowing clinicians and researchers to review the data later and identify any patterns or abnormalities. Another essential feature of the Arc EEG Instrument is its ability to analyze the data it collects. The device is equipped with sophisticated algorithms that can identify specific electrical activity patterns in the brain, allowing clinicians and researchers to identify abnormalities and patterns indicative of neurological conditions.

Fig. 2 Arc EEG

The Arc EEG Instrument is versatile and can be used in various settings. The device can be used in hospitals, clinics, and research laboratories and is suitable for use with both adults and children. The device is also ideal for patients with various neurological conditions, including epilepsy, sleep disorders. The small and lightweight device makes it easy to transport and use in multiple settings. The device is also very user-friendly, with a touchscreen interface that is easy to navigate and understand. The goal of research in Electroencephalography (EEG) with smart healthcare and biomedical may be to discover and create novel methods and apps that use EEG signals to enhance patient outcomes [16-22]. More specifically, the goal could be to:

- To monitor and diagnose neurological problems and create innovative techniques for properly and efficiently collecting EEG data in real-time, such as employing wearable EEG sensors.
- Examine how machine learning methods can analyze EEG readings and find patterns connected to neurological diseases.
- To identify and track the development of disorders like epilepsy, Parkinson's disease, and Alzheimer's disease, develop EEG-based biomarkers.
- Investigate using EEG signals in creating brain-computer interfaces (BCIs) that can help those with communication and motor problems.
- To create individualized treatment regimens, research the effects of EEG-based therapies, such as neurofeedback, on diverse neurological diseases.
- Ensure the technology is utilized safely and responsibly and assess the ethical and privacy issues of using EEG signals in healthcare.

II. METHOD

The following steps can be followed to use an EEG (Electroencephalography) instrument:

A. Preparation

The person undergoing the EEG procedure should be informed of the process and instructed to wash their hair the night before the test. The person should avoid caffeine, alcohol, and other stimulants for several hours before the test. The electrodes used in the test are attached to the person's scalp, so they should be clean and dry before the test.

B. Placement of electrodes

The technician will use a special paste to attach electrodes to the person's scalp. These electrodes are placed at specific locations to record the brain's electrical activity.

C. Recording

Once the electrodes are in place, the person will be asked to relax with their eyes closed or perform specific tasks while their brain activity is recorded. The EEG machine records the electrical signals produced by the neurons in the brain and amplifies these signals for analysis.

D. Interpretation

After the recording is complete, the EEG data is analyzed by a trained technician or physician. The results are compared to a database of normal brain activity to determine if there are any abnormalities in the person's brain activity.

E. Reporting

The results of the EEG test are reported to the physician or healthcare provider who ordered the test. The report may include a summary of the findings and further testing or treatment recommendations.

There is an arrangement of EEG electrodes as a table, commonly used in the 10-20 system, as shown in Table 1.

Table 1. Electrode arrangement according to 10-20 system

Electrodes Names	Placement
Fp1	**Frontal Pole 1**
Fp2	**Frontal Pole 2**
F7	**Left Frontal**
F3	**Frontal Left**
Fz	**Frontal Midline**
F4	**Frontal Right**
F8	**Right Frontal**
T3	**Left Temporal**
C3	**Left Central**
Cz	**Central Midline**
C4	**Right Central**
T4	**Right Temporal**
T5	**Left Parietal**
P3	**Left Parietal-Occipital**
Pz	**Parietal Midline**
P4	**Right Parietal-Occipital**
T6	**Right Parietal**
T5	**Left Parietal**

III. RESULT

The Hospital uses a standard technique for placing electrodes on the patient's scalp to obtain an EEG recording. The technician first measures the patient's head and then marks the scalp using a special pencil to ensure that the electrodes are placed in the correct positions according to the international 10-20 system for electrode placement. Certain areas of the scalp may be cleaned with a coarse cream to enhance the recording, which helps improve the conductivity between the electrodes and the scalp, leading to a more precise and accurate recording. The channel configuration used by the Hospital includes 16 channels, which are labeled according to the electrode positions on the scalp. These channels cover different brain areas and are arranged in pairs to record activity on either side of the brain. The configuration used by the Hospital includes channels that cover the frontal, central, parietal, and occipital regions of the brain. The Hospital provides an example of two EEG recordings taken from epileptic patients of different ages and seizure statuses. The EEG recording from the 9-year-old male epileptic patient shows seizure activity, as evidenced by the recording's high amplitude and irregular waves. The EEG recording from the 20-year-old female epileptic patient, who is not experiencing seizures at the time of the recording, shows normal brain activity with no signs of seizure activity. After the EEG recording is complete, an expert in EEG analysis interprets the recording and sends the findings to the physician who requested the EEG. The physician uses this information to diagnose and treat the patient's condition. When the physician doubts the patient's condition, they may request a video EEG to record the patient's behavior and movements during a seizure while recording their EEG activity to provide a complete picture of the patient's condition. They can aid in diagnosis and treatment planning. EEG is a non-invasive and low-cost technique that can provide important information about brain function. It can detect abnormalities in brain activity that may not be visible through other imaging techniques, such as Magnetic Resonance Imaging MRI or computerized tomography C.T. scans.

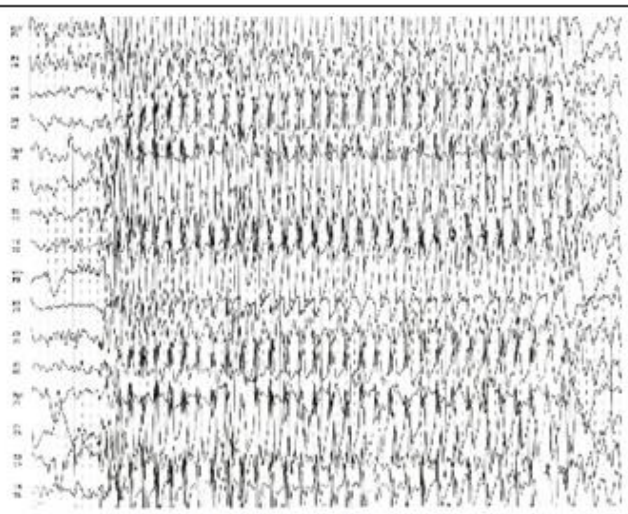

Fig. 3 EEG for epileptic patient

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A. Selecting a Template

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Fig. 4 EEG for normal state

EEG can also monitor brain activity in real-time during surgery or other medical procedures. In addition to clinical and research applications, EEG is used in cognitive neuroscience, psychology, and human-computer interaction. EEG can provide insights into how the brain processes information and how individuals respond to various stimuli by measuring brain activity.

IV. DISCUSSION

It's great to hear that the EEG recording system at Mosul Hospital is up-to-date and well-equipped with accessories to present data accurately. However, the challenge of time-consuming electrode placement can impact the efficiency and productivity of the technician and the Hospital. The suggestion to include an elastic cap with fitted electrodes can be a practical solution to address the challenge. The cap will simplify the registration process and reduce the time required to place electrodes on the patient's skull. It can also enhance the accuracy of electrode placement, leading to better-quality data collection.

Moreover, using an elastic cap can also improve patient comfort and satisfaction. The electrode placement process can be uncomfortable and stressful for patients with sensitive skin or a low pain threshold. The cap can reduce the physical discomfort associated with placement and minimize patient anxiety, leading to a positive patient experience. When discussing the technical challenges associated with the EEG recording system, consider the following points:

- Electrode Placement and Artifact Reduction: EEG recordings can be affected by various artifacts, such as eye movements, muscle activity, or environmental noise. One technical challenge is to ensure accurate electrode placement and minimize these artifacts.
- Patient Comfort and Compliance: EEG recordings often require patients to remain still for an extended period, which can be challenging, particularly for young children, individuals with movement disorders, or those experiencing discomfort.

Neurological illness diagnosis and treatment could be revolutionized by Electroencephalography (EEG) with smart healthcare and biomedical. Researchers are collecting and analyzing EEG data in novel and creative ways thanks to developments in wearable sensor technology and brain-computer interfaces, and the creation of EEG biomarkers is giving doctors new resources for identifying and monitoring neurological diseases. Additionally, EEG-based therapies, like neurofeedback training, are shown promise as a non-invasive and successful strategy for enhancing cognitive function and quality of life in individuals with neurological illnesses. However, EEG use for medical reasons raises ethical and privacy problems that must be thoroughly examined and handled. EEG with smart healthcare and biomedical represents an exciting area of research that could revolutionize how we comprehend and treat neurological illnesses. Although more study is required to realize EEG's potential in healthcare fully, the advancements that have already been made are encouraging and indicate that EEG-based techniques may become a more vital tool in the future for diagnosing, managing, and treating neurological illnesses. Incorporating an elastic cap with fitted electrodes into the EEG recording system can be a valuable investment for the Hospital. It can improve efficiency, accuracy, and patient experience, benefiting the Hospital and patients in the long run.

V. CONCLUSION

EEG is an essential instrument in smart health care and biomedical because it allows us to understand the brain and its functions better, diagnose and monitor neurological conditions, and develop new therapies and treatments for brain-related disorders; an example of EEG is the Arc Instrument, which is a sophisticated device that is useful for measuring and recording electrical activity in the brain. The device is portable, user-friendly, versatile, and suitable for clinical and research settings. The device's ability to record data in real-time and analyze the data it collects makes it a valuable tool in diagnosing and treating neurological conditions. Smart health care and biomedical with EEG instruments are two fields constantly evolving, and there are many exciting potential directions for future work in these areas. Here are a few possibilities in smart healthcare and biomedical with EEG for the future:

- BCIs (brain-computer interfaces) let people operate equipment or computers using their brainwaves. BCIs may eventually be used to operate wheelchairs, prosthetic limbs, and other devices, enabling disabled people to live more independently.
- EEG-based individualized diagnosis and therapy of neurological illnesses are now possible thanks to advancements in machine learning and artificial intelligence (A.I.), which may result in more precise and potent treatments for various ailments, ranging from epilepsy to Alzheimer's.

- Smart healthcare could use EEG data to diagnose and prevent neurological problems before they manifest. EEG-based predictive analytics can entail examining brainwave patterns for early indications of disorders like cognitive deterioration.
- Wearable EEG Technology: Outside of a clinical environment, wearable EEG technology may monitor brainwave activity and provide real-time information on brain health. As a result, neurological problems may be diagnosed earlier and treated more successfully.

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