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Aspects and Perspectives of Electrophysological Electroencephalography Patterns

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Abstract

Electroencephalography (EEG) is an electrophysiological monitoring method to record electrical activity of the brain. It is typically noninvasive, with the electrodes placed along the scalp, although invasive electrodes are sometimes used such as in electrocorticography. EEG measures voltage fluctuations resulting from ionic current within the neurons of the brain. In clinical contexts, EEG refers to the recording of the brain's spontaneous electrical activity over a period of time, as recorded from multiple electrodes placed on the scalp. Diagnostic applications generally focus either on event-related potentials or on the spectral content of EEG. The former investigates potential fluctuations time locked to an event like stimulus onset or button press. The latter analyses the type of neural oscillations (popularly called "brain waves") that can be observed in EEG signals in the frequency domain. EEG is most often used to diagnose epilepsy, which causes abnormalities in EEG readings. It is also used to diagnose sleep disorders, depth of anesthesia, coma, encephalopathies, and brain death. EEG used to be a first-line method of diagnosis for tumors, stroke and other focal brain disorders, but this use has decreased with the advent of high-resolution anatomical imaging techniques such as magnetic resonance imaging (MRI) and computed tomography (CT). Despite limited spatial resolution, EEG continues to be a valuable tool for research and diagnosis. It is one of the few mobile techniques available and offers millisecond-range temporal resolution which is not possible with CT, PET or MRI. Keywords: Electroencephalographic Evaluation, Nano Particles, Deep Learning

Introduction

Derivatives of the EEG technique include evoked potentials (EP), which involves averaging the EEG activity time-locked to the presentation of a stimulus of some sort (visual, somatosensory, or auditory). Event-related potentials (ERPs) refer to averaged EEG responses that are time-locked to more complex processing of stimuli; this technique is used in cognitive science, cognitive psychology, and psychophysiological research.

The history of EEG is detailed by Barbara E. Swartz in Electroencephalography and Clinical Neurophysiology.In 1875, Richard Caton (1842–1926), a physician practicing in Liverpool, presented his findings about electrical phenomena of the exposed cerebral hemispheres of rabbits and monkeys in the British Medical Journal. In 1890, Polish physiologist Adolf Beck published an investigation of spontaneous electrical activity of the brain of rabbits and dogs that included rhythmic oscillations altered by light. Beck started experiments on the electrical brain activity of animals. Beck placed electrodes directly on the surface of brain to test for sensory stimulation. His observation of fluctuating brain activity led to the conclusion of brain waves.

In 1912, Ukrainian physiologist Vladimir Vladimirovich Pravdich-Neminsky published the first animal EEG and the evoked potential of the mammalian (dog). In 1914, Napoleon Cybulski and Jelenska-Macieszyna photographed EEG recordings of experimentally induced seizures.

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German physiologist and psychiatrist Hans Berger (1873–1941) recorded the first human EEG in 1924. Expanding on work previously conducted on animals by Richard Caton and others, Berger also invented the electroencephalogram (giving the device its name), an invention described "as one of the most surprising, remarkable, and momentous developments in the history of clinical neurology". His discoveries were first confirmed by British scientists Edgar Douglas Adrian and B. H. C. Matthews in 1934 and developed by them.

In 1934, Fisher and Lowenback first demonstrated epileptiform spikes. In 1935, Gibbs, Davis and Lennox described interictal spike waves and the three cycles/s pattern of clinical absence seizures, which began the field of clinical electroencephalography. Subsequently, in 1936 Gibbs and Jasper reported the interictal spike as the focal signature of epilepsy. The same year, the first EEG laboratory opened at Massachusetts General Hospital.

Franklin Offner (1911–1999), professor of biophysics at Northwestern University developed a prototype of the EEG that incorporated a piezoelectric inkwriter called a Crystograph(the whole device was typically known as the Offner Dynograph).

In 1947, The American EEG Society was founded and the first International EEG congress was held. In 1953 Aserinsky and Kleitman described REM sleep.

In the 1950s, William Grey Walter developed an adjunct to EEG called EEG topography, which allowed for the mapping of electrical activity across the surface of the brain. This enjoyed a brief period of popularity in the 1980s and seemed especially promising for psychiatry. It was never accepted by neurologists and remains primarily a research tool.

In 1988, report was given on EEG control of a physical object, a robot.

In October 2018, scientists connected the brains of three people to experiment with the process of thoughts sharing. Five groups of three people participated in the experiment using EEG. The success rate of the experiment was 81%.

Sleep EEG Analysis in GNU Octave

Assorted signals are delivered to all parts of the body so that the other organs can communicate each other for specific or general purposes. One of the key signals in the human brain is Electroencephalography (EEG) which is generated from the brain including during

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the state of sleep and unconscious. Electroencephalography (EEG) signals comprise the brain waves which can be evaluated using GNU Octave. The analysis on sleeping disorders and various diseases can be done with EEG evaluation.

GNU Octave (https://www.gnu.org/software/octave/) is one the powerful and multifunctional tool for engineering and scientific applications of research. The simulations related to engineering as well as medical can be implemented with the assorted toolboxes and functions in Octave. It is used as an effective alternate to MATLAB under open source distribution. A number of toolboxes for different applications are available in GNU Octave which can be used for optimization and predictive analysis.

The Wave Form Database (WFDB) Package can be integrated with GNU Octave. This package is equipped with the functions and modules for EEG and Brain Signal evaluations. Similar process is followed in case of Brain Mapping or Brain Fingerprinting for criminal investigation in their unconscious state. There are assorted stages of sleep or unconscious states which can be analyzed from EEG signals after recording from the electrodes. This process assists in the forensic analysis of the person while in unconscious state. By this evaluation, the medical disorders can also be detected using WFDB package in Octave. Following are the excerpts of Benchmark Sleep Stages which can be evaluated using WFDB package in GNU Octave so that the overall nervous system can be predicted along with the brain disorders.

Stage 1 : Tiredness / Drowsiness / Pre-Sleep / Lethargy

- Eye Activities
- Rolling Eye Movement
- Sharp Transients

Stage 2 : Normal Night Sleep

- Mix of Spindles
- Slow Eye Movement

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Sleep 3: Delta Sleep or Slow Wave Sleep

- Sleep Time of 6.5 Hours

With the following instruction, the demonstration of WFDB toolbox can be viewed in Octave.

>> wfdbdemo

Following instructions can be executed to read and plot the ECG Signal from the dataset repository of PhysioBank

[time,signal]=rdsamp('mitdb/100',1);
plot(time,signal);

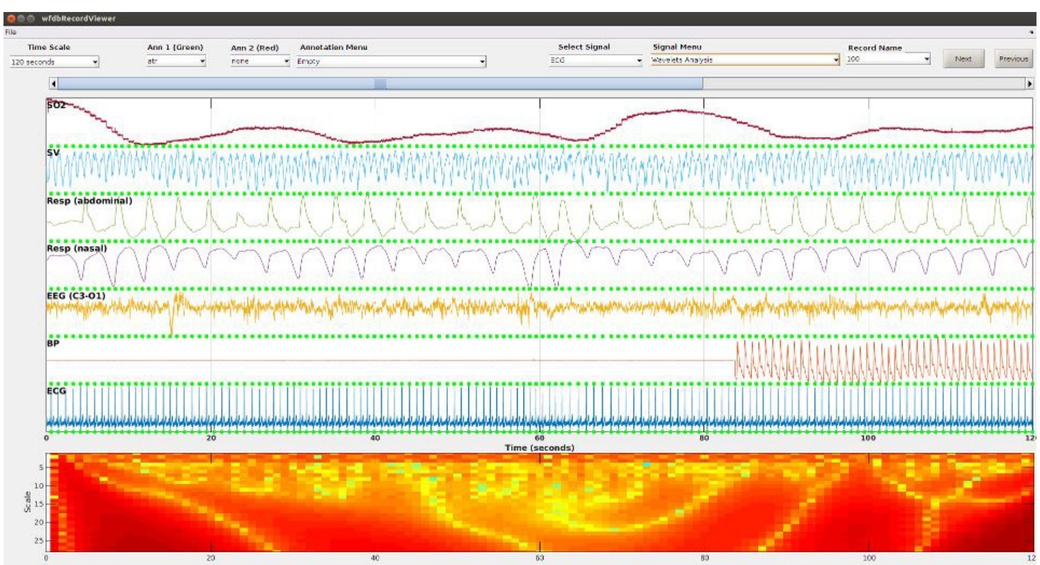

Figure 1: Viewing EEG Signals in WFDB Toolbox

(Source: https://www.physionet.org/physiotools/matlab/wfdb-app-matlab/)

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In similar methodology, the Waveform of Arterial Blood Pressure (ABP) can be analyzed using wabp function.

Conclusion

The EEG has been used for many purposes besides the conventional uses of clinical diagnosis and conventional cognitive neuroscience. An early use was during World War II by the U.S. Army Air Corps to screen out pilots in danger of having seizures; long-term EEG recordings in epilepsy patients are still used today for seizure prediction. Neurofeedback remains an important extension, and in its most advanced form is also attempted as the basis of brain computer interfaces. The EEG is also used quite extensively in the field of neuromarketing. The EEG is altered by drugs that affect brain functions, the chemicals that are the basis for psychopharmacology. Berger's early experiments recorded the effects of drugs on EEG. The science of pharmaco-electroencephalography has developed methods to identify substances that systematically alter brain functions for therapeutic and recreational use. Honda is attempting to develop a system to enable an operator to control its Asimo robot using EEG, a technology it eventually hopes to incorporate into its automobiles. EEGs have been used as evidence in criminal trials in the Indian state of Maharashtra. A lot of research is currently being carried out in order to make EEG devices smaller, more portable and easier to use. So called "Wearable EEG" is based upon creating low power wireless collection electronics and ‘dry’ electrodes which do not require a conductive gel to be used. Wearable EEG aims to provide small EEG devices which are present only on the head and which can record EEG for days, weeks, or months at a time, as ear-EEG. Such prolonged and easy-to-use monitoring could make a step change in the diagnosis of chronic conditions such as epilepsy, and greatly improve the end-user acceptance of BCI systems. Research is also being carried out on identifying specific solutions to increase the battery lifetime of Wearable EEG devices through the use of the data reduction approach. For example, in the context of epilepsy diagnosis, data reduction has been used to extend the battery lifetime of Wearable EEG devices by intelligently selecting, and only transmitting, diagnostically relevant EEG data. EEG signals from musical performers were used to create instant compositions and one

CD by the Brainwave Music Project, run at the Computer Music Center at Columbia University by Brad Garton and Dave Soldier.

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