ISSN No:-2456-2165

Systemic Study of Devices Processing Electromagnetic Waves Application to Brain Waves and Emotions

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Abstract:- This article studies electromagnetic signal processing devices and in particular, brain signals. There are two of them, the EEG and the MEG. They transform the detected waves into curves. We describe the procedure for performing medical screenings with these devices. The second part of the article presents a systemic analysis of three technical systems that can process brain waves other than in the form of curves, taking into account that emotions are an electro-chemical activity originating in the brain. The article concludes with a direct application of one of these devices to cognitive science for children. Specially, in learning emotions to young children. It is important to carry out a systemic analysis of the devices. Indeed, the analysis carried out according to the interdisciplinary principles of the systemic, study of complex objects by their exchanges, whether living beings, social organizations, or technical objects; makes it possible to adapt technologies to modern needs and to improve human life.

Keywords:- *Systemic Analysis, Electrical Scheme, EEG, MEG, Radio Wave, Emotion, EEG Plot, Cognitive Science.*

I. INTRODUCTION

Modern neurologists have proven that emotions are an electro-chemical signals that originates in the brain and drives reactions in the body. This arouses the interest of developing new devices that use this electrical character. Indeed, it is well known that any electrical activity generates a magnetic field. Thus, for more than a century, scientists and engineers have been manufacturing brainwave processing machines such as the EEG and the MEG. What if emotions could be deciphered in a brain wave. A systemic analysis of simple devices for educational use is presented for the use of such a discovery.

II. EEG AND MEG

Several machines record brain waves. They allow scientists and other users to use these recordings in the form of plots in their professional activities. Among these machines, the electroencephalogram and the magneto encephalogram are the two functional machines. They are used in several scientific, medical, marketing fields and even in modern educational games. This trend is described in the article [1]. The electroencephalogram EEG and the magneto encephalogram MEG are brain wave detection machines. Researchers and scientists as well as doctors also use imaging machines in their work. Among these machines, there are those that indirectly measure the activity of the brain by metabolic imaging such as positron emission tomography PET (late 1940s), tomography by single photon emissions TSEP (early 1960s) and functional magnetic resonance imaging fMRI (1990s). See article [10].

A. EEG

The first EEG recordings date back to the end of the 19^{th} century. In 1875, the British doctor Richard Caton documented in animals that the electrical activity generated by the brain corresponded to mental activity. Nowadays, researchers and scientist use the EEG in their works like studying emotions in the article [2]. An EEG is an automated system. Its functional structure is illustrated in the figure 1. The control part is managed by a computer. The operative part is carried out thanks to the EEG headset. In EEG headset, sensors detect brain activity. They are called sensor or electrodes. For conventional medical headsets, there are three types of sensors. Patch sensor, cupule sensor and needle sensors. Recently, a new company has manufactured a new generation of sensors called "Biosensor".

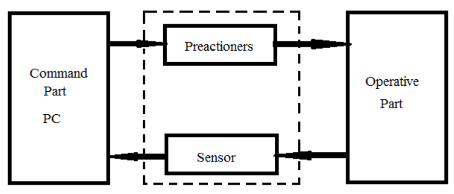

FIG 1 – Functional structure of an EEG system

Medical observations of the human brain could lead to a description of the brain. It is subdivided into 2 hemispheres by a longitudinal split, each hemisphere containing 6 distinct lobes according to the apparent furrows : the frontal lobe, the occipital lobe, the temporal lobe, the insular lobe and the limbic lobe, see figure 2. The distribution of the electrodes of an EEG helmet is associated with this observation. The number of electrodes in EEG headset vary. Their distribution

ISSN No:-2456-2165

on the scalp follows a perfect symmetry. The location of the electrodes is from front to back and from right to left. There is an International Standard nomenclature called 10/20 for 21 electrodes headset. Each Electrode has a specific name. This is made up of letters and numbers. The letters indicate the precise location of the Scalp (FP : fronto-polar; F : frontal; T : temporal; C : central; P : parietal; O : occipital). The even numbers mean the right side of the scalp and the odd number means the left side of the scalp. There are headset for medical use and others for commercial use. Headset for medical are used to identify diseases such as epilepsy. Headsets for commercial use are presented for children and adults for games and applications that allow the management of emotions and the well-being of the individual. The outlet of an EEG are curves. For medical use, a preparation must be made. Thus the scalp must be stripped with a conductive paste such as Katz paste or a gel.

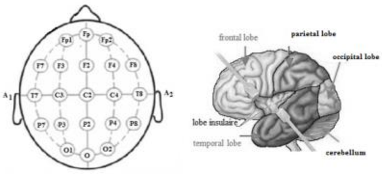

FIG 2 – The lobes of the brain and the distribution of the electrodes on the scalp.[11]

- *Setting up*

After putting on the headset, an electrolytic gel is used. Gels for EEG (electroencephalography) and ECG (electrocardiography) are very often the same. Their necessity is identical : They improve the conductivity. During an EEG examination, the electrical activity of the heart muscles is plotted on a graph thanks to an ECG sensor.

- *Conduct of an EEG session*

After the electrodes have been installed, the actual recording of a standard EEG lasts 20 to 30 minutes. The patient is comfortably installed in an armchair, in a quiet room, with little light, in order to promote relaxation. The EEG is first recorded at rest, eyes closed, then eye openings of a few seconds are requested, to test the reactivity of the plot. Then two activation tests are carried out to raise awareness of the occurrence of possible anomalies :

1. **hyperpnea**, consists of inhaling slowly and widely, eyes closed, for 3 to 6 minutes.
2. **intermittent light stimulation**, or SLI, consists of sending series of light flashes, at variable frequencies. During this test, the witness opens and closes his eyes for a few seconds.

The objectives of these tests

1. **hyperpnea** : try to trigger a seizure by making the patient breathe very quickly and very deeply that is to say to induce an increase in the amplitude of respiratory movements.
2. **intermittent light stimulation**, or SLI, : studying photosensitivity and seizures visually induced corresponding to all the reflexive epileptic seizures, caused by visual stimuli of different natures.

III. RESULT

The outlet of an EEG device consists of curves resembling seismic curves. This curve corresponds to the traces of a helmet sensor Each sheet represents a recording of a brain activity that lasts 20 seconds. In the curves, the first 18 lines correspond to the recordings of the 18 sensors of the EEG headset. Line 19 corresponds to the recording of the ECG sensor. Finally, the last line SLI, presents the curve of the intermittent light stimulation (SLI). It is an activation technique performed routinely in the standard EEG. This examination makes it possible to diagnose certain diseases such as epilepsy. During he SLI, a white light of increasing and decreasing frequency 0 - 50 Hz is emitted. Photosensitivity or photo-paroxysmal response (RPP) corresponds to a genetic trait and is characterized by the occurrence of spikes and wave spikes on the electroencephalogram (EEG) during particular light stimuli reproduced in the laboratory by intermittent light stimulation (SLI). In the article [2], the five types of brain waves are resented. The detection of the type of wave on an EEG tracing is done by counting the frequency in one second.

A. MEG

It was in 1968 that Dr. Cohen, considered the inventor of the MEG system, realized the first magneto encephalogram Magnetoencephalography is a medical examination for measuring magnetic fields induced by the electrical activity of neurons in the brain. The MEG is an automated system more complex than the EEG. Its functional structure is the same as for an EEG, see diagram 1. The sensors of the MEG are magnetometers called Squid (Superconducting Quantum Interference Device). They are distributed in such a way as to cover the lobes of the cortex. The outlet of MEG are precise plots to the nearest thousandth of a second in relation to brain activity.

IV. DETECTION OF EMOTIONS IN BRAIN WAVES

A. *New uses of brain devices*

When the electrical activity of the brain was discovered, the EEG was tested directly on the patient. It took until the development of computer science to use brain waves in real time and transform them into curves. In the last decade, the appearance of brain-machine interfaces (BMIs) has allowed several scientists to use brain waves differently, see figure 3. Indeed, several attempts by researchers around the world illustrate the considerable efforts made in this field. For example, in the article [5], a groupe of researchers G. Rashkov and al. have been able to decipher images from brain waves. If the decryption of the emotions is not yet announced, the decryption of the sensation has been revealed. In 2020, the Japanese professor H. Miyashita makes a machine that share taste.

ISSN No:-2456-2165

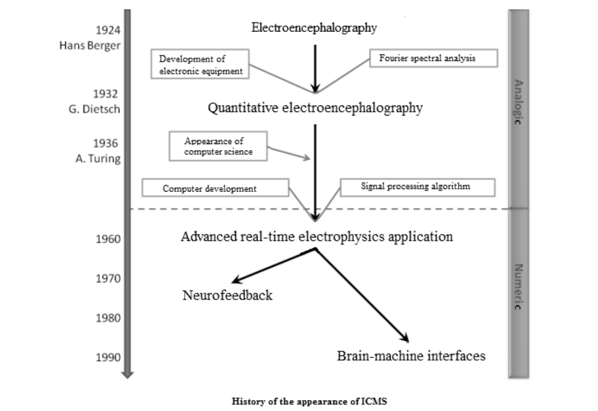

FIG 3 – Evolution of the electroencephalography examination. [9].

The psychological impact of these machines on people in their daily lives, has not been the object of a psychological study. However, it is better to anticipate the impact of the use of these devices in human life. The usual devices on the world market do not yet contain a function to manipulate brain waves and even emotions, because the psychological impact is still unknown. Some are even skeptical and pessimistic. There are many devices for processing electromagnetic waves in everyday life. A radio receiver transforms them into sound, television transforms them into images, microwaves into heat and submarines into oceanographic obstacle detectors. The brain magnetic fields are very small but they are just as manipulable.

B. Systemic analysis of technical systems

This paragraph relates technical needs and objectives. The need to manipulate emotions exists in the applications of the article [2]. The technical objects that can satisfy these needs can come in three forms. As explained in the figure 4, an emotion device can have three functions : emotion detection, recording of emotions, and finally emitting of emotions. The figure 5, presents a diagram modeling an appliance which detect emotions from brain waves. The constraints can be energy or in the configuration of the computer software. An EEG headset may be necessary to transmit brain signals to the computer. All the work therefore lies in the design of a computer software for calibrating the signals and the identification of the emotion or its classification in simple or compound. The figure 6, presents a diagram modeling an appliance which record emotions from brain waves. The brain waves representing the incoming artwork material can be raw or processed by an electronic or computer filter. The control data are the same as before. The figure 7, presents a diagram modeling an appliance that emits emotions from a recording. In this device, emotions are recorded as an electrical signal in an integrated circuit. It is enough to press a trigger button to feel the emotion. ll devices work thanks to electricity. Therefore, in the three actigrams the heat appears as a secondary outlet. In addition, an information light signal can be used to describe the operation of the device to the user.

C. Simplified electronic wave transmitter and receiver circuits

As mentioned earlier, there are multiple devices processing electromagnetic signals. This paragraph, studies the radio as a device that can detect these signals or transmit them. A resentation of some electronic components processing electromagnetic signals are exposed in the article [3]. Electronic components are classified into passive and active components. Passive components store energy as a resistor, capacitor and coil. The active components influence the power of a signal, whether it is a voltage, a current, or both. They can reduce it by joule effect or increase it. For example, the semiconductors are active components, such as the transistor or the integrated circuit. Radio is an example of devices for processing electromagnetic waves. It can detect waves and transform them into audible form through a speaker. It’s a signal receiver. A radio transmitter detects the voice via a microphone and processes the electromagnetic signal by broadcasting it via an antenna or recording it on a memory medium. It is a signal transmitter. An example of a simplified electronic circuit of a radio transmitter and a radio receiver are illustrated in the diagram 8. Indeed, two electronic components are illustrated, the coils and the transistors. However, the processing of any signal goes through several steps. A transformer, consisting of two or more coils, transforms a voltage and current system into another voltage and current system and generates different values, but at the same frequency. The current intensity control is carried out thanks to the resistors. Capacitors smooth and stabilize power supplies. Finally, the transistor is a semiconductor electronic component making it possible to control or amplify electrical voltages and currents. All these components are listed on the board of a radio. The microphone, the speaker and the antenna are transducer components.

V. APPLICATION : LEARNING EMOTIONS TO YOUNG CHILDREN

In modern educational systems, the teaching of emotions begins in an early age : 4 - 6 years old. At this age, the child begins to become aware of his basic emotions : joy, sadness, disgust, fear, anger and surprise. These emotions have been extensively studied by Dr. Ekman, as in his article [4]. The educational programs include emotion recognition sessions on children’s faces, or even exercises such as : expressing their emotion verbally. These sessions can be consolidated by the manufacture of devices like the one illustrated in the figure 9. This is the same device from the diagram 7. The case must be unbreakable and the buttons in colors representing the emotions. In the figure, red represents anger, green joy and yellow sadness. On each button, faces representing the emotion can appear. The integration of technologies has been very studied by researchers in educational science as in the article [12]. Thus, emotion recordings can be used for educational and cognitive purposes : teaching emotions to young children.

VI. CONCLUSION

This article presents two tools for measuring brain electromagnetic activity. As well as some perspectives on the manufacture of new devices in this same directive. The added value of these devices is the different processing of the signals picked up by the electrodes of an EEG headset. The article also highlights the importance of a psychological study on the impact of these devices on users.

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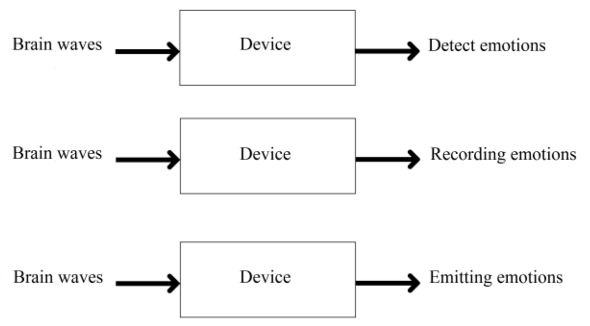

FIGURE 4 – Modeling of new devices using brain waves.

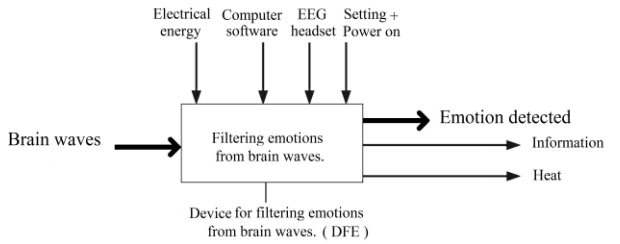

FIGURE 5 – Modeling of new devices detecting emotions from brain waves.

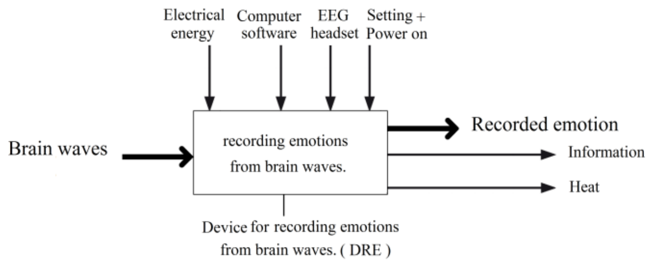

FIGURE 6 – Modeling of a device recording of emotions.

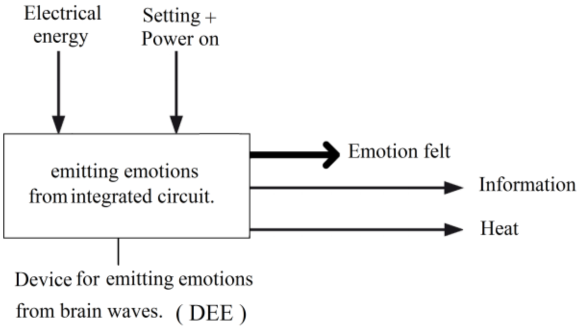

FIGURE 7 – Modeling of a device that emits emotions from a recording.

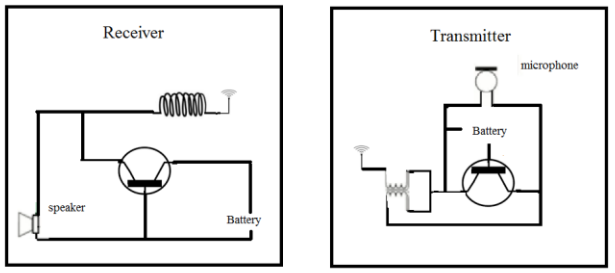

FIGURE 8 – Very simplified electrical circuit of a radio transmitter and a radio receiver.

FIGURE 9 – Device to learn emotions to young children.