Chapter 6
Neural Patterns of Emotions in EEG and fMRI:
Emotions' Patterns in EEG Signals

Santhakumari Sadhasivam
School of Information Technology and Engineering, Vellore Institute of Technology, Vellore, India

Kamalakannan J.
School of Information Technology and Engineering, Vellore Institute of Technology, Vellore, India

ABSTRACT

Emotions have a vital role in human beings, and it is tough to define because of their intangible nature. Emotions vary over time and from person to person. Sometimes, emotions that sound good to people also may harm human beings. It depends upon one's health conditions and circumstances. Emotions are related to neurological, physiological, or cognitive processes. Though emotions are intangible, many invasive and non-invasive techniques are available to read the electrical activity in the brain to sense the different kinds of emotions. EEG is a non-invasive technique used in brain wave analyses. The main goal of this chapter is to give a brief introduction to EEG, characteristics of the brain waves, which part of the brain is responsible for emotions, the neurological structure of emotions, and lists of deep learning algorithms used to classify the various emotions. This chapter also contains data sets of emotions and a few key challenges in this field. For researchers with engineering backgrounds who are naive to this field, this chapter could be helpful.

INTRODUCTION

The human brain has billions of neurons that may fire in a particular brain area during the activity. The human brain generates various five signals, they are, Delta, Theta, Alpha, Beta, and Gamma. These signals have a unique frequency (Tangkraingkij, 2016). Beta signals have generated during emotions, which may be anger, aggression, happiness, sadness, upset, fear, confusion, pain, guilt, surprise, etc., More Emotions lead to various health issues like instability in BP, due to hypertension people may affect by

DOI: 10.4018/978-1-6684-5673-6.ch006

Table 1. Different brain lobes

S. No.	Name of the Lobe	Role
1	Frontal lobe	Controls cognition and memory. Speech and language
2	Temporal lobe	Hearing, recognizing the language, and forming memory.
3	Occipital lobe	Visual
4	Parietal lobe	Integrating sensory information, including touch, temperature, pressure, and pain

a disease called Hypertensive retinopathy, which is a type of retinal sickness (Chowdhary & Acharjya, 2017), abnormal Heart rate, and severe problems with brain disorders people. It is a possibility to mitigate those problems before getting into worsening. Recording brain signal accurately is more difficult due to the non-stationary behavior, noisy, and non-linear nature (Topic & Russo, 2021). EEG is used to read an electrical signal of the brain, which has a poor spatial resolution (Frey et al., 2013). Many researchers are facing the challenging task while capturing these signals. The fMRI is good in spatial resolution (Frey et al., 2013), so it is possible to get better accuracy in classifications if researchers consider both the EEG and fMRI together in analyses.

Parts of the Brain

The brain is a complex organ in a human. Mainly it has three parts. They are the Cerebrum which is the largest portion of the brain, the Cerebellum - its surface is called as cortex area and the third part is the Brain stem. The cerebrum is further divided into two hemispheres; the left and right hemispheres. Each hemisphere's responsibility to the body in the opposite direction; has four different lobes, namely the Temporal lobe, Frontal lobe, Parietal lobe, and occipital lobe. Each lobe has its responsibility. The role of the different brain lobes is shown in Table 1. (Jawabri & Sharma, 2021; Stuss & Benson, 2019).

Characteristics of Brain Wave

Two features are required to define any wave. These features are strength and frequency. The strength of the current or voltage range of neurons is from 0 to 200μv. The frequency ranges from 1 to 50 times/ Second. During any mental activity neurons will communicate with each other by electrochemical signals, these signals travel in entire brain areas with oscillation. This neuronal oscillation is called brain waves (Buskila et al., 2019). Based on the above mentioned two features the brain waves are divided into Delta (δ), Theta (θ), Alpha (α), Beta (β), and Gamma (γ) (Tangkraingkij, 2016). Each wave has its frequency. As per the brain states the particular wave has been generated. The Gamma wave is the fastest wave among all. And it is difficult to capture. Table 2 depicts the characteristics of the brain wave.

The delta is the slowest wave among all, the frequency of the delta wave is from 0.5 Hz to 4Hz; Walter introduced during the year 1936 the delta wave was introduced but announced it in 1963, generated during sleeping in the frontal brain region. Theta wave has a frequency between 4Hz to 8Hz was introduced by Wolter and Dovey in 1944; generated during a very relaxed mind in the brain region of the Parietal Lobe and Temporal Lobe. The frequency of an alpha wave is from 8Hz to 35Hz. Introduced by Berger in 1927; it is generated in the frontal and occipital lobes while the eyes are closed. Beta wave frequency between 12Hz to 35Hz, generated from the Frontal and Central lobes of the brain during awakened in