Chapter 33
EEG Analysis of Imagined Speech

Sadaf Iqbal
Aligarh Muslim University, India

Muhammed Shanir P.P.
Aligarh Muslim University, India

Yusuf Uzzaman Khan
Aligarh Muslim University, India

Omar Farooq
Aligarh Muslim University, India

ABSTRACT

Scalp electroencephalogram (EEG) is one of the most commonly used methods to acquire EEG data for brain-computer interfaces (BCIs). Worldwide a large number of people suffer from disabilities which impair normal communication. Communication BCIs are an excellent tool which helps the affected patients communicate with others. In this paper scalp EEG data is analysed to discriminate between the imagined vowel sounds /a/, /u/ and no action or rest as control state. Mean absolute deviation (MAD) and Arithmetic mean are used as features to classify data into one of the classes /a/, /u/ or rest. With high classification accuracies of 87.5-100% for two class problem and 78.33-96.67% for three class problem that have been obtained in this work, this algorithm can be used in communication BCIs, to develop speech prosthesis and in synthetic telepathy systems.

INTRODUCTION

The human brain is a complex organ. The brain is divided into different areas with each area performing a specialized function. The different lobes and structures of the brain are frontal lobe, parietal lobe, occipital lobe, temporal lobe, cerebellum limbic system and brain stem. The brain is made up of cells called neurons. These work by sending electrical signals among themselves which is responsible for

DOI: 10.4018/978-1-5225-9273-0.ch033

generation of brain waves. Brain waves or brain rhythms are divided into bandwidths to describe their functions. The different brain rhythms are as follows:

1. **Delta Wave:** (0.5 – 3 Hz) Delta brainwaves have the least frequency but highest amplitude. They are generated in dreamless sleep and deepest meditation. Delta waves occur when external awareness is suspended. Regeneration and healing takes place in this state and this is why it is often said that deep restorative sleep is so essential to the healing process;
2. **Theta Wave:** (3- 8 Hz) Theta brainwaves also occur in sleep but are also dominant in the deep meditation. It acts as gateway to learning and memory. It is that state which is normally experienced fleetingly as one wakes up or drifts off to sleep. Theta is a state of intuition, vivid imagery and information beyond one's normal conscious awareness;
3. **Alpha Wave:** (8 – 13 Hz) Alpha waves occur during quietly flowing thoughts, but not quite meditation. Alpha is the brain's resting state. Alpha waves aid overall, calmness, alertness, mental coordination, mind/body integration and learning;
4. **Beta Wave:** (13 – 30 Hz) Beta brainwaves are present in one's normal waking state of consciousness when attention is focussed towards cognitive tasks and the outside world. Beta is a 'fast' activity, present when a person is attentive, alert, engaged in problem solving, judgment, decision making or engaged in focused mental activity. Beta brainwaves can further be divided into three bands namely Low Beta (Beta1, 12-15Hz), Beta (aka.Beta2, 15-22Hz) and Hi-Beta (Beta3, 22-38Hz);
5. **Gamma Wave:** (30-80Hz) Gamma brainwaves are the highest frequency brain waves and are associated with simultaneous processing of information from different brain areas. It passes information rapidly. Earlier gamma waves were more often dismissed as 'spare brain noise' until researchers discovered it was highly active when in states of universal love, altruism, and the 'higher virtues'. Gamma rhythms modulate perception and consciousness and are found to disappear under anaesthesia. Gamma is observed to be above the neuronal firing frequency, so how it is generated remains a mystery and continues to arouse a great interest in the minds of scientists.

These brain waves are recorded by using electroencephalogram (EEG). EEG can be recorded in different forms depending on its use. Scalp EEG recording is the most common and preferred way to acquire EEG data because it involves placing elecrodes on scalp and hence it is non-invasive and easy to acquire. But in case when an epileptic patient has to undergo surgery, it becomes necessary to locate the exact epileptogenic focus. In such cases scalp EEG may not serve the entire purpose because it doesn't give exact information of the deep cortical layers of the brain. This is due to the fact that cerebrospinal fluid, skull and scalp also provide their own hindrance to the EEG signal originating in the deeper layers. Therefore neurosurgeons implant strip and grid electrodes in the dura mater. The recording in such cases is called electrocorticography (ECoG), subdural EEG (sdEEG) or intracranial EEG (icEEG). But this is an invasive procedure and requires trained neurosurgeons and is risky too. So scalp EEG is a preferred method to collect neuronal information. Long and continuous EEG recording which may extend for several hours or days is called iEEG. iEEG generates a lot of data which may be difficult to analyse by epileptologists so now-a-days automatic seizure detection systems are being developed to analyse such recordings.

Recording of EEG is done according to the standard international procedure so as to ensure uniform procedure of recording throughout the world. In scalp EEG, the skin is prepared by light abrasion to