CHAPTER I
INTRODUCTION

1.1 Background

Currently, disabilities are not merely a problem. Globally, there are approximately 15% of the world's population with disabilities, with around 110-190 million people experiencing significant difficulties in performing daily activities [1]. In Indonesia, there are at least 10 million people with various forms of disabilities. This number represents 4.3% of the population based on the latest census. More than 8 million households, or 13.3% of the total, include individuals with disabilities [2]. One classification of individuals with disabilities is based on their type, which is physical disabilities that result in impairments of bodily functions. These disabilities consist of mobility impairments, vision impairments, hearing impairments, and speech impairments [3].

As time advances, there are increasingly more robots capable of making human life feel easier and more efficient. Devices and techniques that can read human brain signals have become one of the alternatives for controlling a robot. Brain-computer interface (BCI) is a system that can control external devices using recorded brain activity [4]. BCI systems with functions to interpret, manage, and recognize human brain activity are widely used by researchers. There are several types of inputs in BCI systems, with Electroencephalography (EEG) being the most commonly used system due to its non-invasive electrode characteristics and cost-effectiveness. The recorded brain signals during Motor Imagery (MI) tasks serve as an important input for BCI applications. Subsequently, channel selection algorithms are used to identify the optimal types of channels.

Motor Imagery (MI) involves several steps to achieve optimal performance in BCI systems. After recording the EEG signals, the signals are then extracted and classified according to their respective channels. EEG-based BCIs are used to assess the performance of MI, as desynchronization/synchronizations can be detected from the EEG signals during MI tasks [5]. Therefore, individuals with physical disabilities who can still imagine limb movements can use BCI to trigger signals corresponding to MI EEG signals. A study [6] identified the direction of hand movements executed from EEG signals. The signal-to-noise ratio, which depends on the movement direction, was used as a parameter to indicate the effectiveness of each temporal frequency bin in classifying movement directions. EEG signals produce frequency values that can determine the location or type of brain signals. In this paper, transient changes in EEG signals during motor imagery are explored to decode the direction of hand movements.

The purpose of our research is to develop an EEG-based BCI system that can decode the imagined direction of hand movements from non-invasive EEG signals in individuals with hand movement disabilities. The recorded brain signals will be processed to determine the appropriate type of signals to operate the system. The motor arm system can assist individuals with disabilities in moving their arms by imagining the desired direction. Finally, retrospective offline analysis is conducted to evaluate the potential performance improvements resulting from BCI-based training interventions.

1.2 Statement of Problem

The research problem in this study is formulated as follows:

1. How to determine the optimal EEG channels to be used.
2. How to transform EEG signals into energy distribution.
3. How for achieving Motor Imagery (MI) in the classification of right and left hand movement directions.

1.3 Objective

1. This thesis develops an EEG-based Brain-Computer Interface (BCI) system capable of decoding imagined hand movement directions from non-invasive EEG signals.
2. This thesis designs a system using frequency-based methods to control hand movements to the right and left.
3. This thesis designs EEG signal filtering techniques to operate the system without noise.

4. This thesis designs and analyzes suitable brain signal types to operate the system effectively.

1.4 Hipotesis

Study V. Scarapicchia et al., 2017 [7] validated the feasibility of using an MI-based BCI system combined with motor arm support for the neurorehabilitation of stroke patients. The study's results projected the discriminative ability of Phase Locking Value (PLV) features extracted from the most significant electrode pairs within the frequency band [8-30 Hz]. The estimated performance of this system reached an accuracy of 76% when discriminating between right and left hand movements, recorded through EEG signals from multiple participants.

1.5 Research Method

In this thesis, several processes are undertaken to operate the system, starting with data acquisition by recording EEG signals from multiple participants. The research primarily focuses on collecting and analyzing numerical data, utilizing a quantitative method that employs statistical approaches to generalize results from EEG signals. The outcomes of the statistical analysis will be subjected to binary classification to identify brain signal patterns, and subsequently, the system will control the movement of the hand either to the right or to the left.