CHAPTER I
INTRODUCTION

This chapter provides a brief overview of the research. Consist of five sections; the explanation starts with background, problem identification and objective, scope of work, and research methodology.

1.1 Background

Online games are games played through the internet and are currently popular due to content development and the exciting adrenaline experience they offer players [1]. In 2024, as much as 66.5% of Indonesia's total population used the internet, placing Indonesia first in the world for the number of online gamers aged 16-64 years, with a percentage of 96.5% [2]. Internet addiction, also known as Internet Addiction Disorder (IAD), indicates that internet users cannot control their usage of the internet [3]. One of the disorders under IAD is Internet Gaming Disorder (IGD) or gaming addiction. Study by Lopez-Fernandez et al. [4] revealed that the problematic internet usage rate in Indonesia was 4.7%, with problematic gamers accounting for 4% considered high among the countries studied.

Psychologically vulnerable gamers are at risk of problematic gaming behavior or even gaming addiction [1]. They tend to be unable to stop or control their gaming behavior, which leads to problematic outcomes, particularly psychological stress, brain response failure, and self-control dysfunction [5], [6], [7]. In online gamers, cognitive bias affects how players interpret information, make decisions, and respond to stimuli reflected in their brain activity. This psychological, behavioral phenomenon is usually investigated through neuropsychological studies using Electroencephalography (EEG) as a non-invasive tool to analyze the brain's dynamic electrical activity [8]. In the case of online gamers, EEG signals are used to objectively quantify behavioral responses, observable from the recorded EEG signal output [9].

Various studies have observed signs associated with gaming disorders or addiction. Research by Lee et al. [10] demonstrated that specific brain regions reflect the impact of gaming addiction. Patients with gaming disorders exhibit high alpha coherence in the right brain and increased theta, alpha, and beta connectivity between the orbitofrontal cortex and parietal regions [11]. Delta and theta activity have also increased in the mid-to-high frequency range [12]. Rabadanova et al. [13] observed irregular EEG patterns that could be interpreted as anxiety symptoms, with more pronounced beta rhythm patterns. These diverse findings highlight the complexity of understanding gaming disorder characteristics and emphasize the need for further research to understand this phenomenon comprehensively.

Based on the observed studies, many attributes of EEG signals have been identified, including wave patterns, frequencies, and brain regions used to analyze brain activity. Event-Related Potential (ERP) can be utilized to analyze the brain's cognitive processes. ERP is a technique used to monitor brain responses to specific stimuli, which is particularly useful for understanding brain reactions to relevant stimuli, such as video games [14]. In studies on gaming disorders, ERP can be employed to identify more detailed brain activity patterns related to addiction [15]. ERP is identified based on the amplitude peak of signals within specific time ranges on central channels [16], [17], [18]. Therefore, a channel selection process must identify which channels are most relevant to ERP components in problematic gamers.

Several approaches to brain channel selection have been conducted in studies, including methods using metaheuristic algorithms. Chang et al. [19] applied the Genetic Algorithm for channel selection in BCI motor imageries. Jana et al. [20] used Particle Swarm Optimization for seizure detection. Zhang et al. [21] employed the Ant Colony System for emotion recognition. Alyasseri et al. [22] utilized binary GWO with SVM for person identification. Additionally, Eid et al. [23] applied the Whale Optimization Algorithm for channel selection. However, these baseline methods also have limitations such as premature convergence, long computational time, and a focus on local solutions [19], [24], [25]. Another approach, the hybrid metaheuristic algorithm, can address these shortcomings by combining two metaheuristic algorithms to achieve more optimal solutions [26]. A Hybrid Metaheuristic algorithms have been applied in several studies to assist the channel selection process, Alyasseri et a. [27] used a hybrid optimization technique based on the Binary Flower Pollination Algorithm (FPA) and β-hill climbing (referred to as FPAβ-hc). Additionally, Eid et al. [23] conducted hybrid metaheuristics using Binary Stochastic Fractal Search with the Whale Optimization Algorithm, proving that this hybrid algorithm outperformed other baseline algorithms.

The aforementioned studies have proven the use of metaheuristics in channel selection effective for evaluating the most representative channel combinations. Therefore, this study will develop an EEG signal channel selection system using a Hybrid Metaheuristic Algorithm. This process will explore the relationship between brain activity patterns through ERP components in problematic gamers.

1.2 Problem Identification and Objective

Event Related Potential (ERP) is the brain's electrical response that occurs in a coordinated and time-locked manner as a reaction to a given stimulus, particularly in the form of a cognitive task [14]. In this study, ERP is used to observe and measure the response speed of problematic gamers to a given stimulus. In EEG signal processing, particularly for Event-Related Potential (ERP) classification, channel selection is crucial to improve model accuracy and computational efficiency [28], [29]. EEG signals with high dimensions and various noise require effective channel selection algorithms. However, conventional methods often fail to provide optimal results, especially for data with complex structures.

Metaheuristic algorithms such as Genetic Algorithm (GA) [19], Particle Swarm Optimization (PSO) [20], Ant Colony Optimization (ACO) [21], Grey Wolf Optimizer (GWO) [22], and Whale Optimization Algorithm (WOA) [30] are known to handle channel selection optimization problems effectively. Moreover, hybrid algorithms, such as Binary Stochastic Fractal Search (BSFS) [30], offer a more adaptive and precise approach to selecting relevant channel subsets.

The primary objectives of this research are:

1. Evaluate the performance of baseline metaheuristic algorithms (GA, PSO, ACO, GWO, and WOA) in EEG channel selection for ERP classification.
2. Evaluate the performance of hybrid algorithms (BSFS) in EEG channel selection compared to baseline metaheuristic algorithms.
3. Determine the most dominant EEG channels in representing ERP P300 in problematic online gamers after channel selection.

The results of this study are expected to significantly contribute to the development of efficient EEG channel selection methods, particularly for ERP classification applications.

1.3 Scope of Work

Based on the explanation, this thesis is limited to:

1. Conducting data collection with psychologists using visual stimuli.
2. Collecting data using a 16-channel EEG device.
3. Performing data preprocessing from recorded signals.

4. Using baseline metaheuristic algorithms such as GA, PSO, ACO, GWO, and WOA for EEG channel selection.

5. Developing a hybrid algorithm with BSFS for EEG channel selection.

6. Performing feature extraction of Maxpeak and Power on the selected channels.

7. Applying classification algorithms using Logistic Regression and Voting Classifier.

8. Measuring classification performance using metrics such as accuracy, specificity, sensitivity, and computational time.

1.4 Research Methodology

The research methodology carried out in the preparation of this thesis is designed in several stages as follows:

1. Literature Review
   Understanding the basic concepts of EEG theory, ERP, and various metaheuristic algorithms applied in EEG signal channel selection through related references such as books, articles, and journals that support the thesis.

2. System Design
   Designing the EEG signal recording scheme for participants, including the necessary hardware and software.

3. Data Collection
   Collecting EEG signal data from 19 participants who are problematic online gamers for use in the analysis process.

4. Data Processing
   Processing the collected EEG signal data, including:

   - ICA: Cleaning the data from eye artifact disturbances.
   - Filtering: Cleaning the data from noise.
   - Channel Selection: Selecting the most relevant channels for further analysis using metaheuristic algorithms.

5. Analysis
   Analyzing the data to obtain the best channels from the processed data, then classifying the EEG signals into two classes, namely ERP and NO ERP.

6. Report Preparation
   Compiling the research report based on the previous stages in the format of a thesis report.

1.5 Structure of The Thesis

The thesis is structured into several chapters to ensure a comprehensive understanding of the research. Chapter II: Literature Review and Basic Concept discusses related studies relevant to the topic and provides an in-depth explanation of the theoretical foundations, including EEG, ERP, metaheuristic algorithms, and machine learning. Chapter III: System Model and the Proposed Design outlines the system to be developed, detailing the materials and testing scenarios used for system evaluation. Chapter IV: Performance Evaluation presents the results of the testing scenarios and provides a thorough analysis of the system's performance. Finally, Chapter V: Conclusion and Future Work summarizes the study's key findings and contributions, discusses its limitations, and offers recommendations for future research and development.

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