CHAPTER I
INTRODUCTION

1.1 Background

Games are a form of entertainment favoured by people of all ages to relieve stress. Online games, in particular, have become a popular choice due to their features that offer unlimited competitive experiences, complex narratives and characters, and opportunities to socialize with other players through internet connections [1]. Interest in online games has been steadily increasing yearly. According to the Digital 2024 report, Indonesia ranks first worldwide in the percentage of online gamers aged 16-64, with a share of 96.5% [2]. This rise has positively impacted the economy. In 2024, the video game market in Indonesia is projected to generate revenues of USD 1.232 million, with an annual growth rate of 7.32% until 2027 [3]. The increasing availability of affordable internet access and widespread use of hardware have made Indonesia one of the largest and most promising video game markets in Southeast Asia, with the number of gamers estimated to reach 53.8 million by 2027 [3].

However, this growth in online gaming has also posed challenges, one of which is the increase in players excessively using the internet, leading to problematic gaming behavior. Research by Lopez-Fernandez et al. [4] shows that Indonesia has a problematic internet usage rate of 4.7%, the highest among fifteen countries from Europe, America, and Asia. Specifically, problematic gaming-related internet usage in Indonesia stands at 4%. According to Shi et al. [5] , individuals who repeatedly and persistently play video games not just for enjoyment but as a vital means of coping with life stress are characteristic of those vulnerable to becoming problematic gamers. Problematic gaming behaviors can trigger various risks, such as addiction, increased tolerance for gaming, and reduced interest in other activities. Zajac et al. [6] and Kashif et al. [7] confirmed that gaming addiction is linked to several psychological issues, including sleep disturbances, decreased daily performance, and Attention Deficit Hyperactivity Disorder (ADHD). In some cases, these conditions can even lead to severe consequences, such as seizures or death triggered by gaming activities. This addiction, referred to as behavioral Addiction, makes individuals susceptible to various factors such as psychological conditions, stress, environment, and easy access to

games, ultimately forming self-destructive gaming patterns [1]. These findings highlight the importance of monitoring and managing gaming behavior, which can be achieved using Electroencephalography (EEG) to track the neurophysiological impact of problematic gaming.

Neurophysiological studies on problematic gaming, particularly in Internet Gaming Disorder (IGD) and Internet Addiction Disorder (IAD), provide insights into the neurocognitive mechanisms underlying the risks faced by problematic players. The use of EEG has been widely employed to investigate addictive behaviors, offering advantages such as accessibility, low cost, and excellent temporal resolution [8]. One technique that aids in EEG analysis is Event-Related Potential (ERP). ERP can provide direct measurements of neural activity that occur rapidly following stimuli, responses, or other events. Various ERP components have been identified and validated as measures of sensory, cognitive, affective, and motor processes [9]. ERP P300 is the most widely analyzed component in cognitive research and serves as an objective measure to detect changes in cognitive performance [10]. It can be used to understand how problematic gaming behavior affects the brain, particularly in cognitive and affective aspects.

To obtain more relevant and accurate information from ERP, it is essential to apply feature extraction techniques on EEG signals to identify patterns or critical information in brain activity. However, given the numerous features that can be extracted from EEG signals, it is crucial to select a subset of features efficiently to focus on the most informative ones [11]. According to Torres et al. [12], feature selection plays a vital role in enhancing model quality by eliminating redundant or irrelevant features, thereby reducing the risk of overfitting and avoiding noise-based predictions. This approach contributes to higher classification accuracy by focusing the data on the most relevant features.

However, in the context of analyzing problematic gamers, the feature selection process from complex EEG signals still presents challenges. Current approaches in studies, such as those by Jeong et al [13], Kim et al. [14], Park et al. [15], and Azhari et al. [16], could be improved through effective feature selection for analyzing problematic gamers. Without feature selection, the high dimensionality of features can hinder the development of effective models. This increased complexity may obstruct the identification of relevant patterns and reduce the model's ability to generalize data

[17]. Using filter-based feature selection methods tends to result in models with lower predictive performance because these methods do not account for feature interactions when selecting the best features and only rely on individual statistics of each feature, which may not always form the best feature combination [18]. Wrapper methods rely on the performance of the selected classifier to choose the best feature subset, but the chosen features may not be optimal if a different classifier is used [18]. Therefore, developing an effective feature selection approach to address these challenges is necessary.

One promising approach to solving the feature selection problem is using metaheuristic algorithms [19]. This approach has proven effective in enhancing accuracy in other studies involving EEG signals, such as Ivaylov's [20] use of the Genetic Algorithm (GA) for Brain-Computer Interface (BCI) classification, Houssein et al.'s [21] application of the enhanced Coati Optimization Algorithm (COA) for emotion recognition classification, Puri et al.'s [22] identification of Alzheimer's disease using seven metaheuristic algorithms, Saif et al.'s [23] use of Enhanced Ant Colony Optimization for Depressive Disorder classification, Xiao et al.'s [24] classification of spontaneous brain activity states in Pediatric Emergence Delirium (PED) patients using the Marine Predator Algorithm (MPA). Applying these metaheuristic techniques provides opportunities to overcome challenges in feature selection for analyzing problematic gamers.

1.2 Problem Identification and Objective

The aforementioned studies demonstrate that using metaheuristic approaches in EEG signal analysis is effective for feature selection. However, in the context of problematic gamers, the application of metaheuristics for feature selection remains limited. A major challenge lies in selecting the most informative subset of features from the extensive range of features that can be extracted from EEG signals using efficient feature selection methods [19]. The large number of features in EEG signals complicates the development of efficient models, as many features may be extracted, and without proper feature selection, the increased complexity can hinder the model's ability to identify relevant information, ultimately reducing its performance [11], [17].

While filter-based feature selection methods are common, they have limitations as they rely solely on individual feature statistics and fail to consider the relationships between features, often leading to suboptimal feature subsets [18]. Alternatively,

wrapper-based methods evaluate the feature subset using the performance of the selected classifier algorithm, but their effectiveness is dependent on the classifier used, making it uncertain whether the chosen features will remain optimal when applied to a different classifier [18].

The implementation of hybrid metaheuristics, which combines two metaheuristic algorithms to optimize exploration and exploitation, shows potential for achieving more optimal results in feature selection [19]. This opens opportunities for determining optimal features in the context of problematic gamers, facilitating more accurate classification and analysis. The primary contribution of this thesis is to implement feature selection using metaheuristic algorithms and hybrid metaheuristics to produce an optimal feature subset, with the following objectives:

1. Evaluate the classification performance using feature subsets generated by metaheuristic and hybrid metaheuristic algorithms.
2. Assess the number of feature subsets selected by metaheuristic and hybrid metaheuristic algorithms.
3. Analyze classification computation time using feature subsets from metaheuristic and hybrid metaheuristic approaches.

1.3 Scope of Work

The scope of the research is carried out in several stages, including:

1. Data collection, which involves the respondent recruitment phase and EEG signal recording.
2. Data processing of the recorded EEG signals.
3. Feature selection using Genetic Algorithms (GA), Particle Swarm Optimization (PSO), and Ant Colony Optimization (ACO).
4. Comparison of the classification performance based on the feature subsets generated by the three metaheuristic algorithms and determining the best algorithm.
5. Implementation of hybridization on the best metaheuristic algorithm using Binary Stochastic Fractal Search (B-SFS).

1.4 Research Methodology

In the research and system development, several processes are carried out, including:

1. Literature Study

The purpose of the literature study is to gain further understanding of EEG signals and ERP, particularly in online gamers, feature selection, and the workings of metaheuristic algorithms. The literature is sourced from papers, journals, and books related to EEG signal processing and metaheuristic algorithms, with a publication range of no more than 5 years.

2. Data Recording

   The data used is primary EEG signal data. EEG signals are recorded with participants who meet the predetermined criteria, in collaboration with the Faculty of Psychology, Universitas Islam Bandung (UNISBA).

3. Data Processing

   The recorded EEG signals are processed through decomposition using Independent Component Analysis (ICA) and filtering to reduce noise or artifacts. Then, segmentation and class labeling are performed for "ERP" and "No ERP" based on the peak amplitude determined at the time of 200-500ms.

4. System Model Development

   A system model is designed for feature selection and classification. Before feature selection, the data undergoes feature extraction. The extracted features are then selected and classified using two scenarios: feature selection using metaheuristic algorithms and feature selection using the hybrid implementation of the best metaheuristic algorithm from the first scenario.

5. Metaheuristic Performance Evaluation

   Analysis of the system model is based on three testing scenarios: classification without feature selection, classification using feature subsets from metaheuristic algorithm feature selection, and feature subsets from the hybrid metaheuristic algorithm for feature selection. The evaluation focuses on the effect of the hybrid metaheuristic algorithm on the feature subset results and classification performance.

1.5 Hypothesis

Metaheuristic algorithms are alternative methods for feature selection due to their iterative search process to determine the optimal feature subset [25]. However, when faced with datasets containing a large number of features, these algorithms become computationally less effective and struggle to balance exploration and exploitation. Therefore, a hybrid implementation approach is needed to address this issue [26].

According to research by Alyasiri et al. [19] and Battacharyya et al. [27] , hybrid implementations have successfully outperformed conventional metaheuristic algorithms, improving classification performance with fewer features and faster computation times. Based on these references, this thesis proposes three hypotheses:

1. ERP classification on problematic gamers using feature subsets from the hybrid implementation will result in higher accuracy compared to metaheuristic algorithms.
2. The number of features selected by the hybrid metaheuristic algorithm will be fewer than those selected by the metaheuristic algorithms.
3. Using the feature subsets from the hybrid metaheuristic algorithm will reduce the ERP classification computation time on problematic gamers.

1.6 Structure of The Thesis

The rest of this thesis will be constructed as follows. Chapter II focuses on a deeper discussion of previous research and explains the fundamental concepts used in this thesis. The basic concepts discussed in this chapter include EEG signals, ERP, feature selection, metaheuristic algorithms, and classification models. Chapter III describes the process of collecting EEG signal data, including the explanation of respondents, data collection procedures, and the resulting dataset. It also presents the proposed system model, explaining the processing of the dataset to generate data for analysis. Additionally, the research design is outlined to clarify the testing scenarios for the created system model. Chapter IV presents the results of the research conducted in this thesis. The study is tested and analyzed across three scenarios, performed within subjects. The performance evaluation is carried out by assessing the accuracy, the number of features selected, and the classification time. Finally, Chapter V provides the conclusions of this thesis and outlines the limitations and directions for future research.