CHAPTER I
INTRODUCTION

This chapter discusses several fundamental aspects underlying the research. The discussion includes the background of the study, which explains the significance of the research and provides an overview of the methods employed. In addition, this chapter presents the research problems, research objectives, research benefits, and scope limitations to clarify the focus and scope of the study.

1.1 Background

Japan is a country with strong global appeal, not only through its tourism sector and traditional culture but also through the influence of popular culture, such as anime, manga, J-pop music, and live-action movies. Popular culture plays an important role in increasing worldwide interest in learning the Japanese language. Among various forms of popular culture, anime and manga are considered the most influential media in promoting the learning of Japanese language and culture [1], and they are positively associated with learners' motivation to study Japanese [2]. This phenomenon is also evident in Indonesia, where public enthusiasm for Japanese-themed activities and festivals remains high.

However, the growing interest in learning Japanese in Indonesia is not solely driven by popular culture but also by academic and career demands. According to a survey report published by The Japan Foundation (2024), Indonesia ranks second in the world after China in terms of the number of Japanese language learners, with a total of 732,914 active learners across various educational levels. Indonesia also has 3,103 institutions offering Japanese language education, making it the country with the largest number of such institutions worldwide, surpassing China and South Korea [3]. Furthermore, employment cooperation programs between Indonesia and Japan, such as the Specified Skilled Worker (SSW) program, industrial internship programs, and educational collaborations, have increased the demand for workers with Japanese language proficiency. These

conditions indicate that learning Japanese has become not only a matter of interest but also a competency requirement for education and career development.

With the increasing interest in the Japanese language, understanding its writing system has become an essential part of the learning process. The Japanese writing system evolved from the adaptation of Chinese characters, which later gave rise to Kanji and the syllabic scripts Hiragana and Katakana [4]. Hiragana is used for native Japanese words and grammatical elements, Katakana is used for foreign loanwords, scientific terms, and foreign names, while Kanji represents the meaning of words and is considered the most complex script [5]. Among these writing systems, Katakana plays an important role in representing foreign terms, making its mastery one of the fundamental competencies required for Japanese language learners [6]. However, Katakana poses considerable challenges because many characters share similar shapes, such as シ (shi) and ツ (tsu), or メ (me) and ナ (na), which often lead to recognition errors by both learners and automated systems. Therefore, an approach capable of accurately capturing visual details and stroke patterns is required to minimize recognition errors.

In the process of learning Japanese, difficulties in recognizing and writing Katakana characters are experienced not only by learners but also by instructors and developers of digital learning media. To support learning and assessment activities, a handwritten Katakana character recognition system capable of automatically and accurately identifying characters is needed. Such a system is expected to serve as an educational support tool for learners, instructors, and developers of Japanese language learning applications.

As computer technology continues to evolve, its computational power has been increasingly applied to image processing and pattern recognition tasks, including the recognition of handwritten characters. A widely used solution for these tasks is machine learning (ML), especially deep learning, which consistently delivers higher accuracy than traditional ML techniques [7]. Among the various deep learning models, Convolutional Neural Networks (CNN) have become a popular choice because they are specifically developed to analyze and classify image data. Due to the diversity of handwriting styles and the strong visual

resemblance between many Katakana characters, an approach that can effectively learn discriminative visual features is essential. CNNs are well suited for this purpose because they can automatically extract complex image features and build robust feature representations for accurate classification [8].

Based on a literature mapping of 22 studies on Japanese handwritten character recognition, it was found that research has primarily focused on Hiragana and Kanji. Specifically, 11 studies addressed Hiragana, four focused on Kanji, and four investigated a combination of Hiragana and Katakana, while only one study specifically examined Katakana, employing the conventional LeNet architecture [9]. These findings indicate that research on Katakana character recognition, particularly using modern CNN architectures such as ResNet-18, remains limited, thereby providing opportunities for further investigation.

Consistent with these findings, existing studies on Japanese character recognition have generally employed early CNN architectures, including LeNet, VGG-16, standard CNNs, and hybrid CNN–SVM models, which have achieved satisfactory accuracy [9], [10], [11], [12]. However, variations in performance among these architectures suggest that there is still room for improvement in selecting more stable and efficient models to enhance handwritten character recognition performance.

To address the challenges posed by the high visual similarity and variations in handwritten Katakana characters, this study employs the ResNet-18 architecture as an advanced CNN model. ResNet (Residual Network) incorporates residual connections that help stabilize the training process and alleviate the vanishing gradient problem. Among the various ResNet variants, ResNet-18 was selected because it offers a favorable balance between complexity and performance, making it suitable for image classification tasks involving relatively simple patterns and limited datasets [13]. In this study, ResNet-18 is implemented using a transfer learning approach, which utilizes pretrained weights to improve training efficiency. The selection of ResNet-18 is further supported by previous findings indicating that deeper architectures do not necessarily yield higher accuracy and may lead to overfitting when trained on limited datasets. For instance, Christiana Subaar et al.

[14] reported that ResNet-18 achieved an accuracy of 92%, outperforming ResNet-34, which achieved 86.7%. In addition, ResNet-18 has demonstrated effectiveness in various image recognition tasks, including handwritten Kanji recognition [5], Javanese script recognition [15], license plate detection, and medical image classification [16], [13].

Besides the choice of model architecture, the quality of the input images is another important factor influencing the performance of handwritten character recognition systems. Handwritten images often contain low contrast, uneven lighting conditions, and indistinct stroke boundaries, which can make it more difficult for the model to learn meaningful visual features. For this reason, an image preprocessing stage is necessary to improve image quality before feature extraction. One commonly adopted enhancement technique is Contrast Limited Adaptive Histogram Equalization (CLAHE), an adaptive histogram-based method designed to improve local image contrast while preserving essential image details [17]. Previous studies in medical imaging have also reported that applying CLAHE during preprocessing can enhance the classification and detection performance of deep learning models compared with using the original images without enhancement [18], [19]. Motivated by these findings, this study employs CLAHE in the preprocessing pipeline to improve the visual quality of handwritten Katakana images, thereby enabling the ResNet-18 model to learn more informative feature representations and achieve better classification performance.

Accordingly, this study aims to contribute to the development of a more accurate and efficient handwritten Katakana character recognition system by combining the ResNet-18 architecture with CLAHE-based image enhancement.

1.2 Research Problem

In accordance with the research background presented in the previous section, this study addresses the following research questions:

1. To what extent can a ResNet-18 model utilizing transfer learning accurately classify handwritten Katakana characters?
2. What influence does the implementation of the CLAHE preprocessing

technique have on the classification performance of the ResNet-18 model for handwritten Katakana characters?

3. What differences can be observed in the classification performance of the ResNet-18 model before and after incorporating CLAHE into the preprocessing stage?

1.3 Research Objectives

Referring to the research problems formulated above, this study aims to achieve the following objectives:

1. To evaluate the classification capability of a transfer learning-enabled ResNet-18 model for handwritten Katakana characters.
2. To investigate the impact of applying the CLAHE preprocessing technique on the classification capability of the ResNet-18 model.
3. To examine the differences in the model's classification results before and after the implementation of CLAHE in order to assess the effectiveness of image enhancement for handwritten Katakana character recognition.

1.4 Research Benefits

The findings of this study are expected to offer the following contributions:

1. To support the advancement of handwritten Katakana character recognition by demonstrating the application of the ResNet-18 deep learning architecture.
2. To provide a better understanding of how CLAHE-based image enhancement contributes to improving input image quality for handwritten character recognition.
3. To provide a foundation for future research involving the integration of contemporary CNN architectures with image preprocessing techniques for handwritten character recognition.

1.5 Scope and Limitations

To maintain the focus of this study and ensure that it remains aligned with the research objectives, the following limitations are defined:

1. The classification task is limited to the 46 basic Katakana characters and does not include characters with dakuten, handakuten, or youon variations.
2. This study focuses solely on the recognition of individual Katakana characters and does not address the recognition of combined characters forming Japanese words or sentences.