CHAPTER I
INTRODUCTION

1.1 BACKGROUND

The Balai Pengawasan dan Sertifikasi Benih Tanaman Pangan dan Hortikultura (BPSBTPH) in West Java Province, which operates as one of the Technical Implementation Units under the Food Crops and Horticulture Service Office of West Java Province, has the responsibility of certifying seeds, monitoring seed circulation, developing plans, promoting, and conducting evaluations, adaptation tests, or observations of food and horticultural crop varieties in West Java. Seed certification is a legal procedure involving field inspections, testing, supervision, and the fulfilment of all seed requirements and standards, resulting in the issuance of plant seed certificates [1]. The primary aim of certification is to uphold the purity and quality of superior varieties and ensure a consistent supply of seeds to farmers and seed producers [2].

Rice (Oryza sativa), one of the most fundamental food sources worldwide, holds a pivotal role in the food cultures of numerous countries [3]. In the certification process, the growth of rice seeds is monitored for germination at intervals ranging from 5 to a maximum of 14 days to determine the percentage of high-quality seed samples. If, within the observation period, more than 80% of the seed samples exhibit high quality, they will be certified as suitable for distribution to farmers. High-quality seeds are characterized by their capacity to support normal growth and their purity, which guards against contamination by dirt, other varieties, pests, and diseases. Rice seeds are classified into four categories: normal, abnormal, fresh, or dead seeds. The criteria for high-quality seeds are of paramount significance in boosting production and profitability [4].

The assessment process is still conducted conventionally, relying entirely on the observations and expertise of competent staff [5]. The current process is not only slow but also lacks efficiency, exhibits strong subjectivity, offers low accuracy, and lacks timeliness [6], [3]. If this problem can be resolved through an automated process based on a computer vision system, it would facilitate more accurate and consistent seed classification [3].

The advancement of technology in various sectors, including agriculture, is progressing rapidly, providing ample opportunities for innovation [3]. Classification and object detection are pivotal techniques within the field of computer vision.

Machine learning and deep learning are employed to enhance performance in tasks such as object classification, object detection, pattern recognition, and other related tasks [7], [8]. Furthermore, to enhance efficiency and reduce latency, computational offloading approaches [9], [10] can be employed to address hardware with limited computational resources, such as mobile phones, IoT devices, and so forth.

Enhancing the performance of the rice seed quality classification system will depend on the utilization of deep learning methods, which have been extensively employed in agriculture for automating and analyzing plant growth [11]–[13]. The application of deep learning has the potential to reduce workload and shorten identification times. Complex network structures and large data samples are among the primary attributes of deep learning [6]. The advent of deep learning technologies offers robust technical support for image recognition [11], [14]. As deep learning methods continue to advance alongside high-performance computing hardware, particularly CNNs for image classification and detection, more such methods are being proposed due to their demonstrated effectiveness with various plant species [8], [11].

Research [3] is focused on classifying five different rice species in Turkey using four distinct CNN architectures, namely VGGNet, ResNet, EfficientNet, and a custom architecture. The outcomes reveal that the VGGNet architecture yields the highest accuracy of 97%. However, this research does not expand the dataset by either increasing the number of images or employing balancing techniques.

In a recent research [15] diseases in tomato and grape plants were detected. Image feature extraction was performed using a deep learning method based on the VGGNet architecture to classify diseased and healthy leaves. In the experiments conducted in this proposed research, an accuracy of 98.40% for grapes and 95.71% for tomatoes was achieved. In the future, it is anticipated that the utilization of Inception or ResNet-based CNN architecture will enable a more in-depth analysis of crop images.

Another research [16] incorporated convolutional neural networks (CNNs) into the quality classification of maize seeds. The experiments demonstrated that the deep learning algorithm outperformed the machine learning algorithm, achieving an accuracy of 95% when using the GoogleNet architecture. The research employed a shallower network, specifically the VGG19 architecture, for transfer learning, which resulted in a stabilized testing accuracy of 88%. Because of the random placement, the orientation of the seeds was uncertain, necessitating the use of another technique to identify the seed characteristics.

Furthermore, in research [17] four varieties of sunflower seeds were identified using deep-learning methodologies and standard colour cameras. This research explored three deep learning architectures: AlexNet, GoogleNet, and ResNet, for sunflower seed identification. The GoogleNet architecture achieved the highest classification accuracy, reaching 95%.

Research [18] assesses the freshness of bananas using transfer learning and establishes the correlation between freshness and storage date. Banana image features are automatically extracted using the GoogleNet architecture and subsequently classified based on the classifier module. The results indicate that the architecture can detect the freshness of bananas with an accuracy of 98%. Nevertheless, the simulation duration was lengthy, as the training process extended to 4320 iterations to attain effective accuracy results.

Concerning the mentioned previous studies, the contributions of this research can be formulated as listed below:

1. Datasets for the training system, which are the rice seed growth dataset and rice seed quality dataset, are taken and labelled exclusively under the guidance of staff in the BPSBTPH West Java Province's laboratory.
2. This research uses a deep learning method based on the CNN architecture which modifications of the VGGNet and GoogleNet architectures, namely the VGG-GoogleNet architecture.
3. In order to verification of the proposed architecture based on the higher accuracy is compared with the accuracies of LeNet, AlexNet, ZFNet, VGGNet, and GoogleNet architectures using the best hyperparameter values.

1.2 PROBLEM IDENTIFICATION

Based on the background that has been described, the problem identification of this research is described in the following points:

1. The staff at Balai lack experience in processing data based on technology, and there are currently no datasets available for rice seeds.
2. Observations of rice seed quality are still conducted conventionally, relying on the experience of the staff, which is limited by human vision and inadequate technical support.
3. The outcomes of the system's architecture performance, which has been specifically developed for classifying rice seed quality, remain unknown.

1.3 RESEARCH OBJECTIVE

Referring to the identification of the problem that has been described, the objectives of this research are in the following points:

1. Collecting a dataset of rice seeds as input for an algorithm to train the system.
2. Designing an architecture to develop a system capable of classifying the quality of rice seeds such as normal, abnormal, fresh seeds, or dead seeds is essential for monitoring purposes.
3. Evaluating architecture performance involves adjusting hyperparameters to create a precise system for classification.

1.4 SCOPE OF WORK

To narrow the scope of discussion in this research, the problems are delineated as follows:

1. The dataset used for the processing system in this research consists of rice seeds of the Ciherang variety.
2. Dataset collection was obtained on the day the 3rd day, 5th day, 7th day and 14th day.
3. The classification process relies on a deep learning method using the CNN architecture.
4. The performance of the VGG-GoogleNet architecture will be assessed by comparing it with the LeNet, AlexNet, ZFNet, VGGNet, and GoogleNet architectures for validation.

1.5 HYPOTHESIS

In the process of designing a technology-based rice seed quality classification system, the method used is deep learning based on the CNN architecture for the design architecture. In research [19], [20] explore different architectural variations within the CNN framework, with each architecture offering its own set of advantages. VGGNet and GoogleNet represent architectures with the deepest layers among the CNN Spatial Exploitation architecture category, which includes LeNet, AlexNet, ZFNet, VGGNet, and GoogleNet. Deeper network processing is known to be more efficient than lower networks for handling complex operations [20].

VGGNet and GoogleNet exhibited superior performance in the ILSVRC-2014 competition, underscoring the idea that network depth is a crucial parameter influencing learning capabilities [21], [22]. VGGNet employs a small kernel and follows a uniform topology in CNN visualization to enhance comprehension of the feature extraction stages. In contrast, GoogleNet introduces the concept of branching within a layer, utilizing the inception module for the first time, thereby enabling the abstraction of features at various spatial scales [20].

The initial layers of a convolutional neural network are dedicated to extracting colour and corner features [23] while a smaller layer utilizes Inception for extracting these features. Hence, the first to third convolutional layers of VGGNet were retained, while the fourth and fifth convolutional layers were substituted with a two-layer GoogleNet architecture based on Inception modules. Instead of the fully connected layer following the Inception modules in both cases, an average global layer is employed, which is subsequently followed by the softmax classifier. Hence, a newly created network typically comprises two components: the first part serves as the pre-training module, functioning as the fundamental feature extractor, while the second part involves an extended layer responsible for extracting high-dimensional features and employing multi-scale feature maps for classification.

Therefore, drawing inspiration from its performance, this research proposes a novel architecture that combines the VGGNet architecture with GoogleNet, and subsequently, this combined architecture will be modified to create a new system for training. The VGGNet layer was modified in conjunction with the GoogleNet layer to enhance the feature extraction capabilities of the new architecture, known as the VGG-GoogleNet architecture. Through the proposed modification between the VGGNet and GoogleNet layers, a system with improved efficiency and performance for classifying the quality of rice seeds can be achieved.

1.6 METHODOLOGY

The deep learning algorithm is one of the algorithms that can be used to solve data problems, be it pattern analysis clustering, or classification. Deep learning is a learning process in machines by imitates the workings of the human brain network or what is commonly called a neural network. CNN algorithm is also one of the existing methods in deep learning. CNNs are deep learning methods consisting of convolutional, pooling and fully connected layers. The convolutional layers perform feature extractions, the pooling layers perform compression and fully connected layers are for classification.

In this research, the CNN algorithm employs a modified architecture based on the VGGNet and GoogleNet architectures for the training system. The VGGNet architecture incorporates 16 convolutional layers and 3 fully connected layers, resulting in a total of 19 layers. It contains convolution layers consisting of 3x3 filters.

In all convolution layers except the final one, the ReLU activation function is employed, while the softmax activation function is utilized in the last layer to distribute between classes.

The GoogleNet architecture features an Inception module comprising 22 layers. This module incorporates filters of varying sizes, including 1×1, 3×3, and 5×5. The 1×1 kernel is employed to reduce the dimensions of the layers, thereby increasing the model's depth. Various filter sizes are concurrently applied at the input of the Inception module, and the outcomes of these operations are aggregated to produce the final output. The parallel structure at multiple scales empowers the module to capture both smaller and larger features within the data pixels. The underlying concept is that convolution filters of varying sizes will more effectively address objects at multiple scales.

1.7 RESEARCH METHODOLOGY

Figure 1.1 Block Diagram in General.

The general block diagram in Figure 1.1 illustrates the flow of this research. The first stage of this research begins with literature research and a survey. The initial step holds significant importance, as it involves discussions with the staff about issues encountered in the field. These issues serve as a reference for this research. In the initial stages, a critical step is to conduct a literature review by gathering references related to the methods intended for problem resolution.

The second stage involves the collection of datasets. Deep learning necessitates datasets for use in the training and testing processes to develop a system. The objective is for the system to acquire the ability to discern the characteristics of an object to facilitate classification. The dataset utilized pertains to the growth of rice seeds, with data collected on the 3rd day, 5th day, 7th day and 14th day, each class containing a total of 50 images. Subsequently, following dataset acquisition, the images are cropped and labelled according to their respective objects.

The third stage involves the development of a system designed for classifying the quality of rice seeds. Following the cropping and labelling of the dataset, the subsequent step is to establish a system capable of assisting in the classification of rice seeds into categories such as normal, abnormal, fresh, or dead. The deep learning method employed draws inspiration from the human cognitive process used for predicting object attributes. The architecture is crafted through a fusion of the VGGNet and GoogleNet architectures, with subsequent modifications made to the layers in both architectures. This process results in the creation of a novel architecture known as the VGG-GoogleNet architecture. The VGG-GoogleNet architecture consists of 23 layers, encompassing 8 convolution layers, 14 inception layers, and 1 fully connected layer.

The fourth stage involves performing system simulation and analysis. Once the entire system has been developed, a simulation is conducted. The simulation comprises two types of datasets, with the primary objective of identifying weaknesses in the system that have been developed for subsequent improvement. The determination of hyperparameters used in the system is of utmost importance, including batch size, epochs, learning rate, and optimizer selection. To create a system with effective performance, it is imperative to receive support from well-designed hyperparameters and high-quality datasets utilized in the research. The final stage involves concluding.

1.7 RESEARCH TIMELINE

The research timeline helps organize, set deadlines, and progress monitoring. Table 1.1 shows the research project, from the initial idea to the final report.

Table 1.1 Research Timeline

Activity	**2022**		**2023**								
	Nov	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**
Literature Review											
Collect Dataset											
Pre-processing Dataset											
Creating System and Modified Architecture											
Writing Section I-III											
Training the Architecture and Scenario Testing											

Evaluation System and Analysis											
Report Writing Section IV-V											
Writing Paper											
Publish Paper, Review, Acceptance											
Finalization of Thesis											