SCIENCE AND TECHNOLOGY RESEARCH CENTRE
UNIVERSITAS PGRI SEMARANG - INDONESIA

ISSN: 2715-4211

Journal ASSET

Advance Sustainable Science, Engineering and Technology

Volume 5, Number 3 (2023): August-October

URL LINK: http://journal.upgris.ac.id/index.php/asset

Advance Sustainable Science, Engineering and Technology

e-ISSN: 2715-4211

Volume 5 Number 3 October 2023

Science and Technology Research Centre, Universitas PGRI Semarang, Indonesia

Advance Sustainable Science, Engineering and Technology (ASSET) is a peer-reviewed open-access international scientific journal dedicated to the latest advancements in sciences, applied sciences and engineering, as well as relating sustainable technology. This journal aims to provide a platform for scientists and academicians all over the world to promote, share, and discuss various new issues and developments in different areas of sciences, engineering, and technology.

ASSET papers will be published twice a year by Universitas PGRI Semarang, Central Java, Indonesia.

Advance Sustainable Science, Engineering and Technology
e-ISSN: 2715-4211
Volume 5 Number 3 October 2023
Science and Technology Research Centre, Universitas PGRI Semarang, Indonesia

Editorial Preface

Advance Sustainable Science, Engineering and Technology (ASSET)
Volume 5 Number 3 October 2023

We are delighted to present the October 2023 issue of Advance Sustainable Science, Engineering and Technology (ASSET), Volume 5 Number 3. This edition features a diverse collection of research articles that showcase the impactful contributions made by scholars across various fields, shedding light on crucial topics in science, engineering, and technology.

The issue begins with an in-depth analysis titled "Analysis of Listen Before Talk Protocol Implementation in Terrestrial Network Using Multi-Node LoRa Communication" by Shafiatullaily Mahmud, exploring the implementation of the Listen Before Talk protocol in a terrestrial network employing multi-node LoRa communication. Next, "A Good Performance of Convolutional Neural Network Based on AlexNet in Domestic Indonesian Car Types Classification" by Ervira Aliya Nabila, Christy Atika Sari, Eko Hari Rachmawanto, and Mohamed Doheir, presents an effective application of convolutional neural networks (CNN) based on AlexNet for classifying domestic Indonesian car types. The study "Optimizing Electrical Efficiency and Thermal Performance of AMD Ryzen 3 2200G Processor through Undervolting in Synthetic Benchmarks and Gaming Scenarios" by Rizqi Sukma Kharisma and Ibnu Herlambang Wicaksono explores the optimization of electrical efficiency and thermal performance of the AMD Ryzen 3 2200G processor through undervolting in synthetic benchmarks and gaming scenarios. "Milkfish Freshness Classification Using Convolutional Neural Networks Based on Resnet50 Architecture" by Maulana Malik Ibrahim Al-Ghiffary, Christy Atika Sari, Eko Hari Rachmawanto, Noorayisahbe Mohd Yacoob, Nur Ryan Dwi Cahyo, and Rabei Raad Ali introduces a method for classifying milkfish freshness using CNN based on the Resnet50 architecture. "Ivan Stepheng, Christy Atika Sari, Eko Hari Rachmawanto, Folasade Olubusola Isinkaye" explores the security of images through a combination of Vigenere Cipher and Advanced Encryption Standard. The study "Effect of Chitosan Variation in Starch and Cellulose Based Biofoam" by Ayu Lintang Cahyani, Vidrika Linda, Dody Guntama, Mubarokah N Dewi, and Lukmanul Hakim investigates the effect of chitosan variation in starch and cellulose-based biofoam. "Analysis of Chemical Inventory Control in the GGCP Unit Using Forecasting and EOQ Methods at PT. XYZ" by Hisyam Aziz Aditya, Moch. Nuruddin, and Yanuar Pandu Negoro delves into the analysis of chemical inventory control using forecasting and EOQ methods. "Allieffa Salsabilla Pradisthi, Joko Aryanto" presents a Monitoring and Automation System for Bird Feeding and Drinking based on the Internet of Things using ESP32. "Analysis of the Effectiveness of Automatic Lathes Using the OEE and FMEA Methods" (Muhammad Bagus Maulana, Dzakiyah Widyaningrum) evaluates the effectiveness of automatic lathes using OEE and FMEA methods. "Innovatif Engineering Strategies for Revenue Growth: a SWOT and QSPM Analysis of UD AMJ Jaya Teknik" (Alif Putra Awanda, Elly Ismiyah, Akhmad Wasiur Rizqi) focuses on innovative engineering strategies for revenue growth. "Mangrove Tree Species Classification Based on Leaf, Stem, and Seed Characteristics Using Convolutional Neural Networks with K-Folds Cross Validation Optimization" by Fadillah Farhan, Christy Atika Sari, Eko Hari Rachmawanto, and Nur Ryan Dwi Cahyo explores the classification of mangrove tree species based on leaf, stem, and seed characteristics using CNN with K-Folds Cross Validation

optimization. The study "Identification of the Snail Oncomelania hupensis Lindoensis as Schistosomiasis Host Using CNN" by Muh Alif Alghifari, Hajra Rasmita Ngemba, Junus Widjaja, Syaiful Hendra, Muhammad Yazdi, and Yuri Yudhaswana Joefrie focuses on the identification of the snail Oncomelania hupensis Lindoensis as a host for schistosomiasis using CNN. "Integrated Web-based Palu City Blood Donor Service Application Model Using ReactJS and ExpressJS" by Muhammad Jindan, Hajra Rasmita Ngemba, Syaiful Hendra, Rahmah Laila, and Syahrullah Syahrullah presents an integrated web-based Palu City Blood Donor Service application model using ReactJS and ExpressJS. "Analysis of Inventory Control of Perishable Goods with Capital Constraints and Warehouse Capacity Using the Lagrange EOQ Method (Case Study UD. XYZ)" by Ahmad Taufiqur Rahman and Dzakiyah Widyaningrum analyzes inventory control of perishable goods with capital constraints and warehouse capacity using the Lagrange EOQ. The study "Review and Bibliometric Analysis of Biogas Power Plants in Indonesia" by Dhasa Ikrar Setyanansyach, Muji Setiyo, and Thirunavukkarasu Raja conducts a comprehensive review and bibliometric analysis of biogas power plants in Indonesia, contributing valuable insights to the field.

We extend our sincere gratitude to the 43 authors who have dedicated their expertise to enriching this issue with their research contributions. Their commitment has been pivotal in making this publication possible.

Furthermore, we acknowledge the institutions that have played a significant role in fostering this research. These include Politeknik Negeri Sriwijaya, University of Dian Nuswantoro, Universitas Amikom Yogyakarta, Universitas Muhammadiyah Gresik, Universitas Teknologi Yogyakarta, Jayabaya University, Tadulako University, Universitas Muhammadiyah Magelang, University Technical Malaysia Melacca (Malaysia), Ekiti State University (Nigeria), and P.S.V College of Engineering and Technology (India).

We look forward to the valuable insights and contributions that the future editions of ASSET will bring to the forefront of sustainable science, engineering, and technology.

October 2023
Assoc. Prof. Mega Novita
Asst. Prof. Rizky Muliani Dwi Ujianti

Advance Sustainable Science, Engineering and Technology
e-ISSN: 2715-4211
Volume 5 Number 3 October 2023
Science and Technology Research Centre, Universitas PGRI Semarang, Indonesia

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e-ISSN: 2715-4211
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Science and Technology Research Centre, Universitas PGRI Semarang, Indonesia

Advance Sustainable Science, Engineering and Technology (ASSET)
Vol. 5, No.3, October 2023, pp. 0230301-01 ~ 0230301-09
ISSN: 2715-4211 DOI: https://doi.org/10.26877/asset.v5i3.16520

Analysis of Listen Before Talk Protocol Implementation in Terrestrial Network Using Multi-Node LoRa Communication

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Abstract. This research implements wireless communication technology using Listen Before Talk (LBT) method and Long Range (LoRa) technology that enables efficient long-distance communication. The LBT protocol allows devices to listen to the communication channel before sending data, while the LoRa technology provides long-range communication capabilities with low power consumption. Both of these have significant implications in addressing transmission quality and distance challenges in wireless communications, especially in complex terrestrial environments. Test results show that LBT effectively reduces collisions at distances of 10 to 50 meters, Data transmission efficiency is also improved by using the LBT method with 90% efficiency from the previous 82% without LBT. This shows that LBT helps maximize data transmission by reducing data packet loss, so that the data received is closer to the amount of data sent, thus showing the positive potential of the LBT protocol in maintaining data transmission integrity in terrestrial environments.

Keywords: Listen Before Talk, LoRa, Wireless, Delay, Collision Data

(Received 2023-08-07, Accepted 2023-09-05, Available Online by 2023-09-29)

1. Introduction

Rapid advancements in communication technology have driven the development of increasingly complex and sophisticated wireless networks. In this context, terrestrial connectivity has become a crucial aspect to support data exchange between devices in vast and diverse environments. LoRa (Long Range) technology has emerged as a promising solution to address connectivity challenges in terrestrial regions involving long distances and diverse topologies[1]. While LoRa enables efficient long-range communication with low power consumption, issues of frequency overlap and collisions need to be tackled. The "Listen Before Talk" (LBT) protocol has emerged as a common solution with the principle of listening before transmitting[2]. Listen Before Talk (LBT) is a mechanism for fair channel usage, requiring other users to wait until the channel is available. Listen Before Talk (LBT) is a communication protocol to avoid collisions on the LoRa multinode communication channel[3].

LoRa (Long Range) is a wireless communication technology designed specifically for long-range

connectivity. Chirp Spread Spectrum (CSS) modulation is used by LoRa to transmit signals. In CSS, the signal frequency changes sequentially, creating a recognizable pattern for the receiver. This enables LoRa to communicate over long distances with low power usage[4].The use of Pure ALOHA by LoRa becomes relevant as Pure ALOHA allows devices to transmit data without needing to coordinate with other devices. Although there is a risk of data collisions, this approach is simple and allows devices to immediately send data when the channel is available. In the case of LoRa, the use of Pure ALOHA aligns with the long-range transmission and low-power consumption characteristics of LoRa[5].

Previous research has developed LoRa connectivity through various methods. The use of the CSMA/CA protocol helps avoid data collisions[6], while the TDMA protocol eliminates collision risks and improves packet delivery ratio[7]. In tackling these challenges, in the study "A Slotted Transmission with Collision Avoidance for LoRa Networks," the receiver only demodulates the strongest signal. Each node is allowed to transmit data in specific time slots and applies LBT to avoid collisions. LBT proves effective and reliable in addressing varying traffic loads[8].A recent study implemented the LBT protocol while considering collision rates and delivery delays. While LBT reduces collisions, packet delivery time increases as each node waits for an available channel. Devices continuously monitor the channel before data transmission through Clear Channel Assessment (CCA)[9].

The LBT protocol has proven effective in avoiding collisions and enhancing communication quality under varying traffic loads. Therefore, in this study, the "Listen Before Talk" protocol is implemented in a terrestrial network using LoRa technology. By combining the LBT mechanism and the Pure ALOHA approach, LoRa can optimize channel efficiency and maintain communication quality, especially in terrestrial environments prone to interference and disturbances.

2. Methods

2.1. Device Design

In this research, the method carried out has a design stage which is divided into two main parts, namely hardware and software design. Hardware design begins with developing an overall system block diagram. In designing a device, making a block diagram is a very important component. Through the block diagram, the workflow of the entire circuit can be understood. Therefore, the overall block diagram of the circuit will form the basis of a system that can operate effectively, as shown in Figure 1.

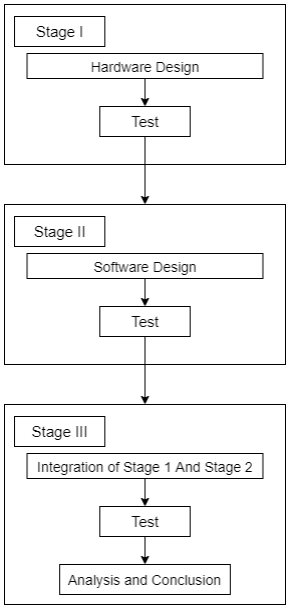


Figure 1. Stages of the Overall Research Methodology

The hardware design process involves planning and manufacturing the physical components that will be used. Hardware systems consist of several key components that interact with each other to form a functioning LoRa network. In this context, there are two crucial entities that become important points in the LoRa network, namely Node A and Node B. These two nodes act as data receivers in the network. These two nodes act as data receivers in the network. Not only that, the LoRa Gateway is also present as a communication center that connects and manages the data flow between Node A, Node B, and the Cloud Server device.

Arduino has a role in regulating the switching of data transmission modes from nodes to the gateway, by setting the transmission mode alternately between Node A and Node B. The LoRa component serves as a means to transmit data to the gateway. The LoRa operating frequency used is 915MHz. The application of the LBT (Listen Before Talk) protocol ensures that both LoRa nodes will send data at the same frequency in turn, so that the data sent is maintained in integrity. The final part of the circuit is the power supply which ensures there is enough power to carry out the LoRa transmission. Node A and Node B have a similar structure, with LoRa A sending data to "..." and LoRa B sending data to "..." continuously. The hardware block diagram is shown in Figure 2.

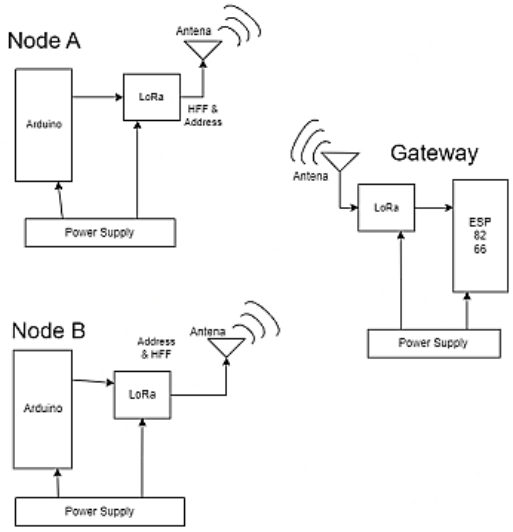
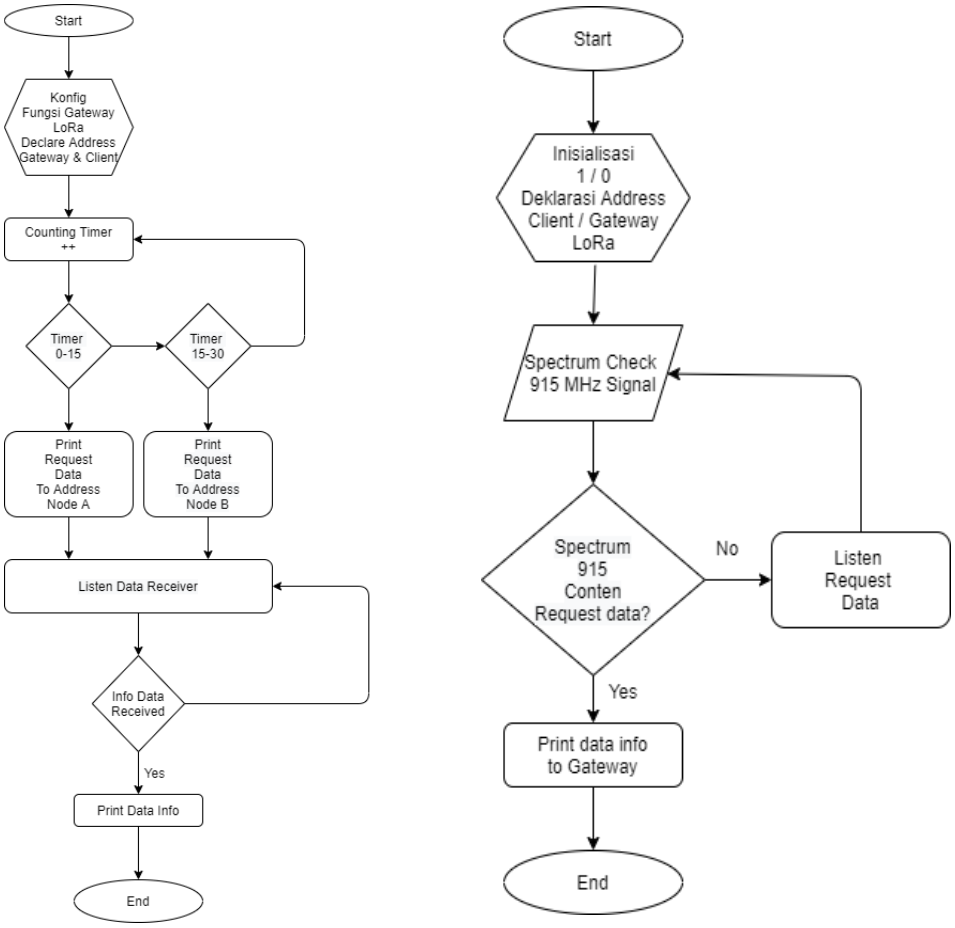


Figure 2. Hardware Design

The software design is described through flowcharts displayed on the gateway and the client. In the gateway flowchart, the process starts with the "Start" step to initialize the program. Then, the configuration of the LoRa gateway function is done by setting the LoRa device address for each node and the LoRa gateway. After that, the timing stage is performed to set the timer interval that controls the turn of the data transmission request cycle from the node to the gateway. In the timer range of 0-15, the gateway will request data delivery from node A. While in the 15-30 timer range, the gateway will request data transmission from node B. The gateway, as the center in the LoRa network, listens to the information data received from the gateway. If the data is interrupted or unsuccessfully received, the process will be repeated to try listening to the data again. Successfully received data will be displayed as success information, and this process will be terminated.

Furthermore, in the Client Flowchart, the process starts with "Start" to initiate the program. The next step is the preparation of input and output initialization, as well as address declaration for each client and gateway. The node will then check the 915 Mhz spectrum to look for data transmission requests from the gateway. If there is no data request, the system will repeat to continue listening for requests. However, if there is a request for data transmission, the node will send data information about the count to the gateway, and the process will end with "Done". The gateway and client flowcharts are shown in Figure 3.



(a) (b)

Figure 3. (a) Hardware Flowchart (b) Software Flowchart

2.2. Listen Before Talk Design

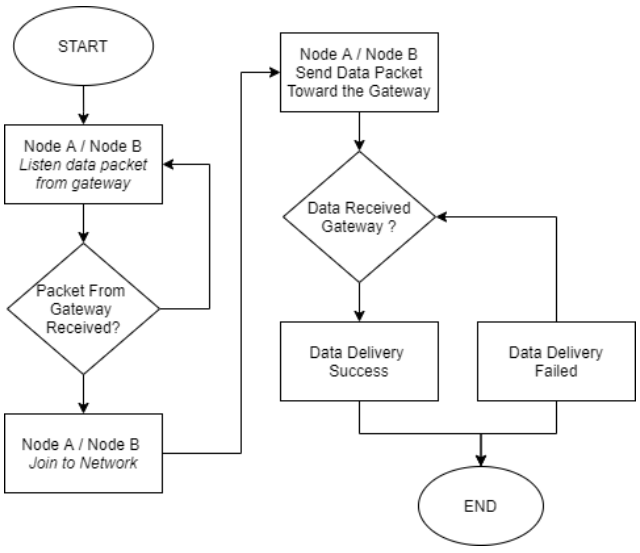


Figure 4. Listen Before Talk Process

Figure 4 illustrates the workflow or communication process in the LoRa network between Node A, Node B, and the Gateway. The process starts with Node A and Node B listening for data packets from the Gateway, ready to receive data sent by the Gateway. They wait to receive data packets from the Gateway and can join the network at the same time. After that, if there is data that needs to be sent to the Gateway, Node A and Node B will send data packets towards the Gateway. The Gateway then receives and processes the data sent by Node A or Node B, checking whether the data was successfully received. If the data is successfully received, it indicates that the communication between Node A/Node B and the Gateway is running smoothly, and the communication process ends, but if the data fails to be received, it will be taken back to the data sent from the gateway until the data is successfully sent. This diagram provides an overview of how communication in a LoRa network occurs, illustrating the important steps in the process.

2.3 Data Test

In this stage of Data Testing, the main attention will be focused on testing parameters that have a critical impact, namely the collusion rate and the delay. The collusion rate parameter measures the frequency of data collisions in the context of a wireless communication network. Data collisions occur when two or more devices attempt to transmit information simultaneously, resulting in data interference or "collisions" in the air medium. This causes the data to be received incorrectly by the receiver. The collusion rate formula can be calculated with the following equation :

$$\textit{Collusion Rate (\%)} = \frac{\textit{Transmission Count}}{\textit{Number of Collisions}} \cdot \mathbf{x\ 100\%} \tag{1}$$

Meanwhile, the concept of delay in the framework of network communication refers to the time interval required from when data is transmitted from the source until it is finally received by the receiver. It reflects the time required for data to pass through a communication channel or network, and reach its final destination. The delay formula can be calculated with the following equation :

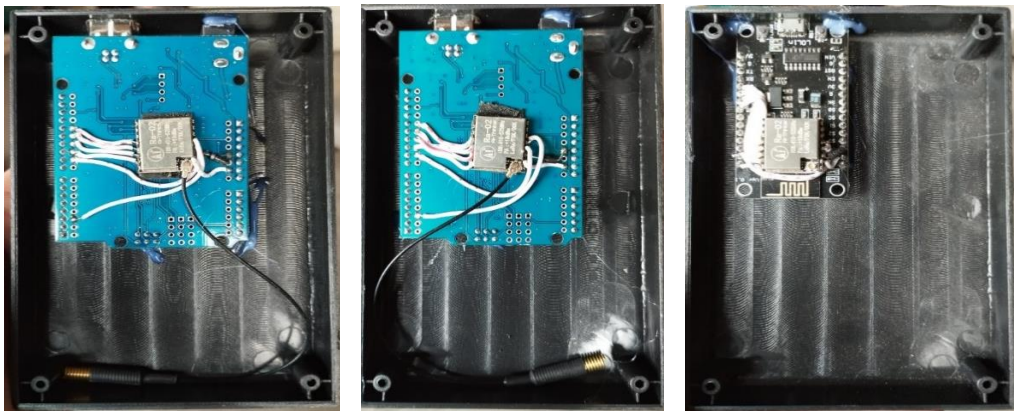
$$\textit{Delay} = \textit{Time Received} - \textit{Time Sent} \tag{2}$$

3. Results and Discussion

This implementation stage will present the hardware design results in detail. These results include concrete implementations of a previously prepared design consisting of two Node devices, namely Node A and Node B, and one Gateway. Node A and Node B will function as entities in the multi-node LoRa network to be tested. At the same time, Gateway will serve as a communication center to connect and manage communication between these nodes.

Carefully assembled devices will be placed in a specially designed case. This casing protects the device from external environmental conditions and ensures long-term operational safety and reliability. In addition, the casing can also help arrange the placement of the device in formations that match the proposed network topology design.

Through this process, the hardware will become more responsive to the tested environment and enable further implementation of the Listen Before Talk protocol on terrestrial networks through multi-node LoRa communication. With all the hardware components installed in the appropriate casing, this implementation stage is a key step in bringing theoretical design into the real world. The results of making this research device are shown in Figure 5.



(a) (b) (c)

Figure 5. (a) Node A (b) Node B (c) Gateway

3.1. Collusion Rate Testing Data

Table 1 shows the collusion rate data test results from the measurements taken and the results are calculated through the delay formula in equation (1).

Table 1. Collusion Rate Testing Data

No	Distance (meter)	Protocol LBT	Transmission Count	Number of Collisions	Collusion Rate (%)
1.	10	No LBT	100	8	8
		With LBT	100	0	0
2.	20	No LBT	100	12	12
		With LBT	100	0	0
3.	30	No LBT	100	16	16
		With LBT	100	0	0
4.	40	No LBT	100	20	20
		With LBT	100	0	0
5.	50	No LBT	100	24	24
		With LBT	100	0	0

The Collusion Rate test results in table 1 above provide an important understanding of the role of the Listen Before Talk (LBT) protocol in dealing with data collision challenges in LoRa Multi Node networks. This research includes a series of tests at various distances, ranging from 10 to 50 meters, by implementing two types of protocols, namely Without LBT and With LBT. The test results show that at each test distance, the use of the LBT protocol successfully prevents data collisions, as evidenced by the zero percent (0%) collision rate. Meanwhile, in tests without LBT, there is a clear relationship between the number of collisions and the number of transmissions performed. For example, at a distance of 10 meters, using the protocol without LBT resulted in a collusion rate of 8%, while using LBT reduced it to 0%. The same applies to other distances, where the use of LBT always successfully eliminates the risk of data collisions. In contrast, in tests without LBT, the data collision rate can reach 24% at a distance of 50 meters.

3.2. Delay Testing Data

Table 2 shows the test results of the delay data from the measurements taken and the results are calculated through the delay formula in equation (2).

Table 2. Delay Testing Data

No	Distance (meter)	Protocol LBT	Time Posted(s)	Time Accepted(s)	Delay(s)
1.	10	No LBT	30	42	12
		With LBT	30	48	18
2.	20	No LBT	30	48	18
		With LBT	30	55	25
3.	30	No LBT	30	54	24
		With LBT	30	62	32
4.	40	No LBT	30	60	30
		With LBT	30	68	38
5.	50	No LBT	30	65	35
		With LBT	30	72	42

Table 2 illustrates the results of delay testing in LoRa Multi Node networks with and without the Listen Before Talk (LBT) protocol at various distances. The data in the table identifies the impact of using LBT on delay parameters. At a distance of 10 meters, it can be seen that the use of LBT causes an increase in delay compared to the use without LBT, with the difference reaching 6 seconds. This indicates that with LBT, each node has to wait longer before it can transmit data, in accordance with the main purpose of LBT to avoid data collisions that can affect data transmission time. A similar trend is seen at other distances, namely 20, 30, 40, and 50 meters, where the use of LBT also results in an increase in delay. This time difference indicates that the LBT protocol provides additional time for each node to monitor the communication channel before performing data transmission. Despite causing an increase in delay in data transmission, the use of LBT is expected to reduce the risk of data collisions and improve the overall communication quality.

3.3. Efficiency Level Testing

Table 3. Efficiency Testing

No	Distance (meters)	No LBT			With LBT		
		Data Sent	Data Received	Efficiency (%)	Data Sent	Data Received	Efficiency (%)
1.	10	100	90	90	100	97	97
2.	20	100	88	88	100	94	94
3.	30	100	82	82	100	90	90
4.	40	100	76	76	100	88	88
5.	50	100	70	70	100	84	84

In table 3 above, this data efficiency level analysis compares the efficiency of data transmission with and without the Listen Before Talk (LBT) protocol in the LoRa Multi Node network. Efficiency is

measured by comparing the amount of data that is successfully sent with the amount of data that should be sent. The analysis focuses on the efficiency of using LBT at various distances. The test results from the previous table were used to calculate the efficiency under each condition, giving an idea of the advantages of using the LBT protocol in improving data delivery. At each test distance, the efficiency of data delivery with LBT (With LBT) is always higher than without LBT (Without LBT). For example, at a distance of 10 meters, the data efficiency without LBT is 90%, while with LBT it increases to 97%. This shows that LBT successfully increases the efficiency of data transmission. The same pattern is seen at other distances. At a distance of 20 meters, the data efficiency with LBT reaches 94%, higher than without LBT which is only 88%. The same applies at longer distances such as 30, 40, and 50 meters, where the data efficiency with LBT is always higher than without LBT.

4. Conclusion

Collusion rate test results highlight the significant benefits of using the Listen Before Talk (LBT) protocol in reducing data collisions. At a distance of 10 meters, the data collision rate with LBT is 3%, while without LBT it reaches 8%. Even at a distance of 50 meters, LBT managed to reduce the collision rate to 6%, while without LBT it reached 24%. This indicates a considerable reduction in data collision risk with LBT in a LoRa Multi Node network. Although the use of LBT increases the delay time in data transmission, this is proportional to its benefits in avoiding data collisions. At a distance of 20 meters, the delay time with LBT is 25 seconds, while without LBT is 18 seconds. The increase in delay time is acceptable considering the significant decrease in collision rate with the use of LBT. Data transmission efficiency also increases with LBT in a LoRa Multi Node network. At a distance of 30 meters, the data efficiency with LBT reaches 90%, while without LBT it is only 82%. This shows that LBT helps maximize data delivery by reducing data packet loss, so that the data received is closer to the amount of data sent.

Acknowledgements

I am very grateful to Prodi Telecommunications Engineering Polytechnic State of Sriwijaya for the outstanding facilities and support during this study. The facilities they provide play a crucial role in the success of this research. The guidance and cooperation provided by the lecturer Prodi Telecommunications Engineering contributed significantly to conducting this research smoothly.

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Advance Sustainable Science, Engineering and Technology (ASSET)
Vol. 5, No.3, October 2023, pp. 0230302-01 ~ 0230302-08
ISSN: 2715-4211 DOI: https://doi.org/10.26877/asset.v5i3.16854

A Good Performance of Convolutional Neural Network Based on AlexNet in Domestic Indonesian Car Types Classification

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Abstract.

Classification of car vehicle types has been carried out using CNN. There are weaknesses in the CNN algorithm so that it can be continued in the research we propose. This study aims to improve the previous accuracy by using the Alexnet architecture. To improve the results of the data set used we use threshold and brightness adjustment and data augmentation techniques for Reflection, Rotation, and Translation. Sample images with a resolution of 227x227x3 totaling 840 images used to represent 8 class types of cars, including Avanza, Fortuner, Freed, Inova, Pajero, Terios, Xenia, and Xpander. Alexnet with 10 epochs consisting of a total of 760 iterations, and validation is carried out every 30 iterations, the test results show that the use of the "sgdm" optimization function achieves a training accuracy of 99.74%, while the use of the "adam" optimization function produces an accuracy of 96.85%. This experiment shows the model's ability to classify the types of trainers after a success rate of 100%.

Keywords: *Alexnet, Classification, Cars, CNN, Image Processing, Car*

(Received 2023-08-29, Accepted 2023-09-05, Available Online by 2023-09-30)

1. Introduction

With the development of technology, human life has been greatly helped by the presence of machine vision. Recognition of vehicle types has always been a hot topic in the field of object detection, especially cars [1]. In 2023, cars will become increasingly popular and have an important role in supporting the development of the automotive and technology industries. Apart from that, it is impossible to find information directly from one person to another to find out the type of car used. This type of car recognition system can help identify and analyze car usage trends [2] and consumer preferences which can help classify car types based on market demand and it is hoped that the results of this research can help car manufacturers plan their marketing and products. strategy development. Data taken from Gaikindo [3] regarding the top 10 retail car sales in 2023, Avanza and its sibling Veloz appeared as Toyota's best-selling vehicles at the 2023 Gaikindo Indonesia International Auto Show (GIIAS) which took place from 10-20 August 2023. These two cars topped sales with a total difference in orders of more than 1,000 units through Vehicle Purchase Orders (VPO) of 1,213 units (20.9%).

Proving that in Indonesia the majority of people choose Toyota for their cars [4]. With this data, a car model recognition system is needed to classify the types of car vehicles in Indonesia using digital image processing. The Convolutional Neural Network (CNN) algorithm is an important algorithm that helps many machine vision tasks in image classification, semantic segmentation, and object detection and is often used for car model recognition [5]. Previous research has utilized CNNs to recognize distinctive features in car images, thereby enabling more precise classification. Some approaches have used data augmentation techniques, such as rotation, reflection, and brightness adjustment, to increase variation in the training data set, while others have considered various CNN architectures, such as AlexNet. Nonetheless, there is still room for further development in improving the accuracy and efficiency of car type classification. In this context, this paper contributes by introducing a method that combines data augmentation techniques with the AlexNet architecture, which is expected to open up new opportunities to significantly improve the accuracy of car type classification [6].

Data augmentation is a technique commonly used in machine learning to increase variety in a training data set by making small variations on existing images, such as rotating, mirroring, or panning them [7]. This helps machine learning models become more robust and able to recognize a wider variety of patterns. This study investigates the use of the AlexNet architecture on the CNN network [8]. The main focus of this research is centered on two main problem aspects as follows:

a. Found a method of implementing data augmentation on the AlexNet architecture which aims to identify car models.
b. Make a comparison between the Alexnet architecture and the implementation of data augmentation techniques such as Reflection, Rotation, and Translation.

This research begins with the collection of a dataset that includes various types of cars from various points of view. This car-type dataset is then pre-processed to ensure image quality and consistency. CNN Alexnet is proposed as the main model for performing automatic feature extraction from car images. There are weaknesses in the CNN algorithm [9] that can be continued in the research we propose. This study aims to improve the previous accuracy by using the Alexnet architecture. The research that has been built focuses on the use of data augmentation techniques, such as reflection, rotation, and translation, along with image segmentation using thresholding, brightness adjustment, and CNN Alexnet. This approach can provide greater variation in the training dataset, which in turn can improve classification performance and help increase the accuracy of car type recognition and produce good accuracy. After this training was completed, it resulted in an accuracy of 99.74% and proved to help recognize the type of car.

2. Methods

2.1. Data Collection

The dataset used in this training is a private dataset taken in real time on roads around Semarang by taking pictures of passing vehicles. Car images with dimensions of 227x227 pixels total 840 data sets of car types which are categorized into two different data sets, namely training data and test data which includes 8 classes of car type images consisting of 108 Avanza, 100 Fortuner, 100 Freed, 125 Inova, 108 Pajero, 102 Terios, 103 Xenia, 100 Xpander. The training data is used to understand the model for each type of car that needs to be categorized, while the test data is used to evaluate the effectiveness of the proposed method in accurately identifying the desired car type category.

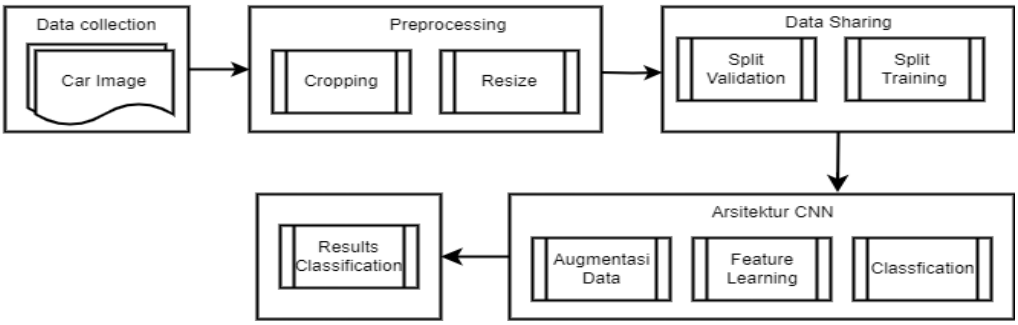

Figure 1. Our Proposed Method

2.2. Preprocessing

The initial data processing (preprocessing) of the vehicle image dataset is carried out to obtain a better image so that the results of the process to be carried out next have better results. The following steps are performed for pre-proccessing

1. Cropping the RGB image to adjust the center of the object so that the image on the car dataset can be more focused and uniform. This cutting process is done manually.
2. Resize the RGB image to 227x227 pixels. This is necessary so that the image of the car can be processed in practice. The car model dataset must be resized according to the input dimensions specified by the CNN AlexNet network, namely 227x227x3. Figure 3 shows the three RGB color channels namely Red (R), Green (G), and Blue (B). The image resizing process is done automatically using Matlab R2022a.

The preprocessing process of car image segmentation is carried out with 2 techniques, namely Thresholding brightness adjustment to help clarify objects [10] in the image so that the model can focus more on recognizing relevant features and classifying car types better. Divide the collected data into two parts: training data and test data[11]. Each vehicle is labeled to distinguish these two data, for each data is divided into 90% training data and 10% test data.

In car classification with CNN AlexNet, a rich and comprehensive feature extraction process occurs. This algorithm identifies complex visual patterns and statistically significant features that characterize car types. Feature extraction includes Mean, Variance, Kurtosis, Minimum Value, Maximum Value, Standard Deviation, Entropy, Skewness [12] as in (1) until (8). Calculations in finding the Mean value use the formula (1), where n is the number of elements in the dataset, x_i is the value of the to-i in the dataset. Calculations in finding the standard deviation value use the formula (2), where n is the number of elements in the dataset, x_i is the value of the to-i dalam dataset, m is the average value of the dataset. Calculations in finding the Kurtosis value use the formula (3), where n is the number of elements in the dataset and t, x_i is the value of the to-i dalam dataset, m is the average value of the dataset, std dataset standard deviation. Calculations in finding the Variance value use the formula (4), where n is the number of elements in the dataset, x_i is the value of the to-i dalam dataset, m is the average value of the dataset. Calculations in finding the Skewness value use the formula (5), where n is the amount of data in the sample, X_i adalah nilai data pada posisi to-i, $\overline{X}$ is the average of the data, S is is the standard deviation of the data. Calculations in finding the Entropy value use the formula (6), where N is the number of possible distinct values in the data set, x_i is the intensity value of the pixel value at position to-i, px_i is the probability of occurrence of the value x_i in the dataset. Calculations in finding the Minimum value use the formula (7), where n is the number of elements in the dataset, x_i is the value of the to-i in the dataset. Calculations in finding the Maximum value use the formula (8), where n is the number of elements in the dataset, x_i is the value of the to-i in the dataset.

$$Mean = \frac{\sum_{i=1}^{n} x_i}{n} \quad (1)$$

$$SD = \sqrt{\frac{\sum_{i=1}^{n}(x_i - Mean)^2}{n}} \quad (2)$$

$$the\ k = \frac{\sum_{i=1}^{n}(x_i - Mean)^4}{n \times SD^4} \quad (3)$$

$$v = \frac{\sum_{i=1}^{n}(x_i - Mean)^2}{n} \quad (4)$$

$$Skewness = \frac{\sum_{i=1}^{n}(X_i - \bar{X})^3}{n \cdot SD^3} \quad (5)$$

$$-\sum_{i=1}^{N} p(x_i) \,.\, log_2(p(x_i)) \quad (6)$$

$$Min = \min(x_1, x_2, \ldots, x_n) \quad (7)$$

$$Max = \max(x_1, x_2, \ldots, x_n) \quad (8)$$

2.3. Dataset and Data Augmentation

The dataset collected is images of different types of cars as many as 840 images divided into 8 classes. Each class has the same size of 227 x 227 pixels. Used for car samples separated into 2 different sets of 90% or 760 images for training data and 10% or 120 images for test data, with equal distribution, and all images are given .jpg image format and include RGB colors. Furthermore, preprocessing, namely cropping and resizing, is applied to the image, after which segmentation is carried out using thresholding and brightness adjustment, and data augmentation techniques that have various functions and parameters. The results of segmented imagery are illustrated in Figure 2. Data augmentation is an approach that allows professionals to significantly increase the variety of data available for training models, without the need to collect new data [13]. This data augmentation technique is useful for increasing variety in a training dataset by making small variations on existing images, such as rotating, mirroring, or panning images as illustrated in Figure 3.

(a) (b) (c)

Figure 2. Example of Raw Dataset: (a) Terios, (b) Fortuner, (c) Avanza

(a) (b) (c) (d)

Figure 3. Example of the results of the Data Augmentation process: (a) original image, (b) brightness adjustment, (c) flip horizontal, (d) rotation using 30^0

The parameters used in this study are:

1. 'RandXReflection', true: This option indicates whether to perform a random horizontal mirror (create a mirrored version of the image). With the value true, the image will be mirrored horizontally randomly.

2. 'RandRotation', [-10, 10]: This option indicates the range of random rotation to be applied to the image. [-10, 10] range means that the image can be randomly rotated between -10 degrees to 10 degrees.
3. 'RandXTranslation', [-10, 10]: This option shows a random range of horizontal shifts applied to the image. This [-10, 10] range means the image can be shifted randomly between -10 pixels to 10 pixels in the horizontal direction.
4. 'RandYTranslation', [-10, 10]: This option shows the random vertical shift range applied to the image. This [-10, 10] range means the image can be shifted randomly between -10 pixels to 10 pixels in the vertical direction.

2.4. Classification with CNN Alexnet

The AlexNet architecture approach is used for the classification of car types in the context of visual pattern recognition. In this task, a collection of input images with a resolution of 227 x 227 pixels and 3 color channels (RGB) is needed and pays attention to the structure of the alexnet architecture and the parameters used. AlexNet has layers such as convolution, ReLU, and pooling. Convolution layers take features from the image through filters. ReLU adds non-linearity, while pooling reduces the dimensionality of features. This process is repeated with subsequent layers to recognize increasingly complex features. Finally, a fully connected layer connects these features to classification classes via a softmax layer. In the image above, Alexnet connects Alexnet features to the car-class imagery used for the training and testing process of this study. Accuracy is a measure used to measure the extent to which a model or system can provide correct results or conform to expected data. In the context of pattern recognition or classification, accuracy aims to measure how well the model can correctly identify and classify data based on the labels or categories it should be.

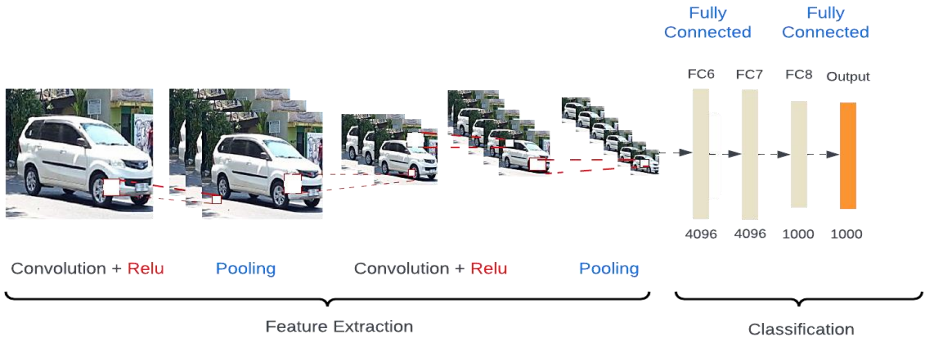

Figure 4. Proposed Structure of AlexNet CNN

3. Results and Discussion

Transfer learning techniques are used in building this type of car recognition model which utilizes a pre-trained model for use in classifying a new data set that undergoes a testing process using the Alexnet architecture to increase accuracy. The dataset collected is in the form of images of various types of cars totaling 840 images which are divided into 8 classes. Each class has the same size, namely 227 x 227 pixels. Used for car samples separated into 2 different sets of 90% or 760 images for training data and 10% or 120 images for test data, with even distribution and all images are rendered in .jpg image format and include RGB colors. In this image processing, there are limitations because some image datasets are taken in real-time on the highway, so the images have to go through a cropping process because there are objects other than cars. There are also some blurry pictures because the car pictures were taken while the car was passing by. Therefore, preprocessing is carried out, namely cropping and resizing the image, after which segmentation is carried out using thresholds and brightness adjustments, as well as data

augmentation techniques that have various functions and parameters. The results of the segmented image can be seen in Figure 4.

(a) Original Image (b) Brightness (c) Thresholding

Figure 5. Testing Process

Based on the image above, the next step after preprocessing and segmentation is classification using data augmentation techniques and CNN to classify car types. Data augmentation techniques to increase variation in the training process [14] [15]. The classification process is carried out with an enhanced AlexNet using several variables that are hyperparameters as a result; the optimation function is based on sgdm and adam; the hardware resource uses a single CPU; MaxEpochs is 10; Validation frequency is 30; and the MiniBatch is 10. In this stage, the classification process succeeded in issuing the appropriate results from the input image class. In running this dataset training using the Matlab2022a tool and for training options. Several features a more concise numerical form that reflects the important characteristics of the image. Table 1 shows accuracy and validation visualize the graph and plot the accuracy of the number of iterations. After undergoing training, the model using the 'sgdm' optimization function obtained 99.74% cursive results in Figure 6 and Figure 7. An experiment using the 'Adam' optimization function yielded an accuracy of 96.85%.

Table 1. Extraction Features

Car Type Name	Mean	Standard Deviation	Kurtosis	Skewness	Variance	Entropy	Min	Max
Avanza	143.981	79.6451	1.55745	0.0660755	6343.34	7.71607	1	255
Fortuner	99.7077	58.7835	2.55044	0.317762	3455.5	7.72498	0	255
Freed	105.944	57.8812	2.77128	0.65611	3350.23	7.51721	0	255
Inova	109.519	71.5589	2.22396	0.672527	5120.67	7.57052	0	255
Pajero	113.833	83.9327	1.73023	0.245698	7044.7	7.79173	0	255
Terios	107.178	63.7941	2.51832	0.388208	4069.68	7.76622	1	255
Xenia	107.19	69.4404	2.29854	0.704991	4821.97	7.56934	1	255
Xpander	69.9937	52.9429	4.32262	1.27483	2802.95	7.27868	1	255

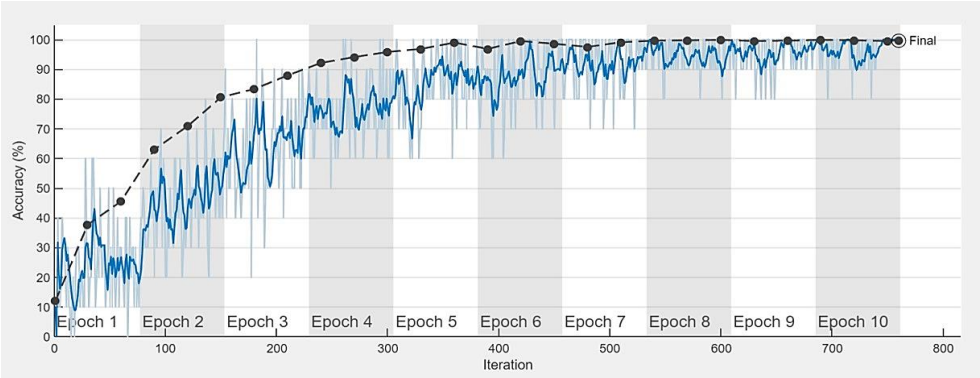

Figure 6. Training accuracy progress

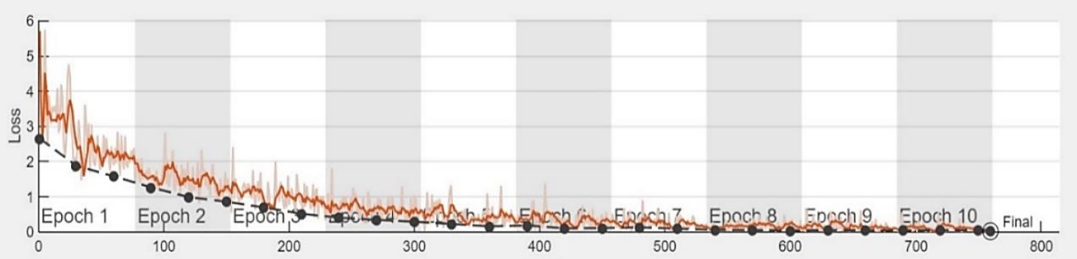

Figure 7. Training loss progress

Based on the results of training and testing, researchers managed to achieve high-accuracy validation and were able to optimize and minimize the value of the loss function in classifying the image of car types. Based on Table 3, the classification of car type classes using CNN Alexnet and data augmentation techniques produces excellent accuracy. All samples that passed the test were classified correctly, resulting in a training accuracy of 99.74%. In 18 experimental attempts per class with 2 samples each, the test results consistently indicated very high accuracy, reaching 100%. In this research, we also conducted experiments using the Deep Convulsive Neural Network (DCNN) method with the same number of datasets and training options but did not use the augmentation technique and AlexNet architecture, resulting in an accuracy of 35.71% with 'Adam' and 22.62% with 'sgdm'. With these results, it can be proven that the CNN method processed through data augmentation techniques using the Alexnet architecture can produce better accuracy.

Table 3. Classification Of Car Types

Image file.jpg	Car Type Class	Car classification	True or False
5.jpg	Avanza	Mobil_Avanza	T
21.jpg	Avanza	Mobil_Avanza	T
1.jpg	Fortuner	Mobil_Fortuner	T
16.jpg	Fortuner	Mobil_Fortuner	T
23.jpg	Freed	Mobil_Freed	T
20.jpg	Freed	Mobil_Freed	T
22.jpg	Inova	Mobil_Inova	T
44.jpg	Inova	Mobil_Avanza	T
17.jpg	Pajero	Mobil_Pajero	T
70.jpg	Pajero	Mobil_Pajero	T
26.jpg	Terios	Mobil_Terios	T
49.jpg	Terios	Mobil_Terios	T
9.jpg	Xenia	Mobil_Xenia	T
42.jpg	Xenia	Mobil_Xenia	T
2.jpg	Xpander	Mobil_Xpander	T
21.jpg	Xpander	Mobil_Xpander	T

4. Conclusion

This study uses the AlexNet architecture to improve the accuracy of car vehicle classification by applying data augmentation techniques. The results of the research achieved a training accuracy of 99.74%. The main finding of this research is to provide valuable insights regarding the use of machine vision technology in identifying car types, which is relevant to automotive industry trends and consumer analysis. Gaikindo's data showing the popularity of Toyota cars in Indonesia reinforces the value of this research contribution for car manufacturers, enabling them to understand market trends and preferences in greater depth. In addition, the implementation of a car model recognition system in the technology field can help the automotive industry develop better solutions for identifying and analyzing trends in

car usage. The implications of this research can be used as a basis for further development in optimizing the use of machine vision technology in the automotive industry and related sectors.

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Advance Sustainable Science, Engineering and Technology (ASSET)
Vol. 5, No.3, October 2023, pp. 0230303-01 ~ 0230303-08
ISSN: 2715-4211 DOI: https://doi.org/10.26877/asset.v5i3.16869

Optimizing Electrical Efficiency and Thermal Performance of AMD Ryzen 3 2200G Processor through Undervolting in Synthetic Benchmarks and Gaming Scenarios

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Abstract. Undervolt is a term that refers to a way to make a computer device run on lower electrical power than the manufacturer's provisions. To do undervolting requires a good experience for user and computer devices that are good or specialized for undervolt purposes such as processors. This study aims to find the optimal minimum voltage that the processor can use without causing performance degradation or instability, and temperature drops that the processor produces while it is running. In this study, the author tested a processor device with the type of AMD Ryzen that already supports the undervolting process from the factory. AMD Ryzen 3 2200G processor is one of the processors with 14nm fabrication, where this processor promises significant performance with the number of cores, memory chace capacity, and power efficiency. On this day, many games demand the use of an aggressive processor. Of course, this will consume power on a larger processor. The author conducted several test scenarios to get the best performance. It was found that the scenario with undervolt at 1.25V showed the best performance.

Keywords: undervolt, processor, AMD, game

(Received 2023-08-30, Accepted 2023-09-09, Available Online by 2023-09-31)

1. Introduction

The promotion of Green Energy and Green Computing has been gaining momentum due to their interconnected nature in addressing the environmental impact of energy consumption. These two initiatives share a common objective of promoting environmental responsibility and sustainability. By working together, they contribute to broader efforts to curb greenhouse gas emissions, conserve natural

resources, and combat climate change. The synergy between green computing and green energy lies in their commitment to reducing IT operations' environmental footprint and energy usage. By integrating these approaches, a more sustainable and eco-friendly future can be envisioned for information technology and energy production. Green computing is the behavior of using computing resources efficiently, by maximizing energy, extending hardware life, minimizing paper usage, and several other technical matters[1], [2]. The main targets of green computing are the earth, people, and profits [3]. Undervolt is one of the methods for implementing green computing. Undervolt is the process of reducing the voltage on the CPU, intending to maximize the use of voltage power [4]–[6]. With this voltage drop, it is expected to reduce electricity consumption without significantly reducing CPU performance [7].

According to developer Valve Steam Store, as of July 2022, 33% of users are AMD Central Processing Unit (CPU), with 32.05% using a 4-core CPU configuration and 0.92% using an Acceleration Processing Unit (APU) Vega 8 [8]. Based on this data, the writer can conclude that there are still quite a lot of Ryzen 3 2200G CPU users.

In this study, the authors conducted research to analyze the effect of undervolt on the AMD Ryzen 3-2200G processor. This study examines the impact of undervolt on electrical efficiency and temperature tested using Synthetic Benchmarks and several Games. The author will undervolt the processor to find a better power efficiency point than the factory specifications of this processor. This analysis will be adjusted to the user's computer usage scenario.

Anja Rabich wrote research in her journal entitled "Software-based Undervolting Faults in AMD Zen Processors". This study examines whether Zen processors are vulnerable to hardware errors used in power management that allow voltage and or frequency manipulation and exploit these hardware errors [9].

Anja Rabich's research has similarities with the author's research in the form of an analysis of the effect of undervolting on the stability of processors used on a software basis to manipulate voltages. The difference from this study is that undervolting is carried out on the processor using the Dynamic Voltage and Frequency Scaling (DVFS) mechanism, namely manipulating the voltage without changing the clock frequency on the processor.

Adam Muc, Tomasz Muchowski, Marcin Kluczyk, Adam Szeleziński (2020), wrote research in his journal entitled "Analysis of the Use of Undervolting to Reduce Electricity Consumption and Environmental Impact of Computers". This study discusses the analysis of the effect of undervolt on the Intel Core i5-6600 desktop processor found in the programming laboratory and the Intel i7-7700HQ mobile processor found on the laptop along with the analysis of accessories connected to the computer [10].

This research has something in common with the author, namely undervolting analysis which is carried out to reduce electricity consumption and temperature performance of computer-generated processors. The difference in this study is the processor used and the undervolting method used is voltage manipulation in the BIOS while the author uses AMD Ryzen Master software.

The author uses AMD Ryzen Master because by using the software, the voltage manipulation process can be carried out more easily because it is supported by an easy-to-understand user interface and there are scenario presets that can be set according to user needs. In addition, by using software, users can apply settings without having to restart the PC, whereas through the BIOS, the voltage manipulation process is carried out during the boot process and enters BOIS mode.

2. Methods

In this test, it is necessary to prepare the hardware and software that will be used and carry out the default test to analyze the scenario that will be used in the undervolt test.

2.1. Hardware

Personal Computer in the form of a desktop for research and supporting devices. The following are the specifications:

- Operating System : Windows 10 Pro
- Processor : AMD Ryzen 3 2200G
- Memory : VENGEANCE LPX 16GB (2 x 8GB)
- SSD : VGen NVME Hyper 256 GB
  VGen SSD 2.5" SATA
- GPU : Vega 8 Graphics onboard
- PSU : Infinity 450W 80+ Bronze
- Motherboard : GigaByte B450M Gaming
- Cooling : PC Cooler S83V2 HSF
- Thermal Paste : Deepcool Z3
- Case : mATX Infinity + Triple Fan RGB
- Power meter : Watt Meter

2.2. Software

• Ryzen Master is used for voltage manipulation on the processor
• Cinebench R20 is used as a CPU test
• Hwinfo64 to detect and analyze hardware information on computer systems.
• Unigine is used as a CPU and GPU test when undervolting
• MSI Afterburner is used to monitor clock frequency, voltage, and frame rate in playing games.
• GTA V and Genshin Impact are used to benchmark CPU-based and GPU-intensive games.

2.3. Undervolting Scenario

The Speed (Mhz) and Voltage Control (V) settings in the Ryzen Master program are modified to undervolt the AMD Ryzen 3-2200G processor. The average core voltage value is 1.316 Volts and the maximum is 1.320 Volts based on the parameters at the default testing stage. The maximum Core Clock is 3.693 GHz, and the average Core Clock is 3.441 GHz. Table 1 shows Undervoltage scenarios.

Table 1. Undervoltage scenarios

No	Voltage Core	Core Clock
1	1.3 V	3600 Mhz
2	1.275 V	3600 Mhz
3	1,25 V	3600 Mhz
4	1,225 V	3600 Mhz

In these researchers need parameters that will be used as the basis for the analysis of the use of undervolting on the processor. In the first stage, testing is carried out on the system using the initial device of the system.

This test is carried out by running the Cinebench R20 software which is used as a CPU test and will be run 10 times. The second is testing the APU by running the Unigine Valley software which is run 10 times. The third test is to run the GTA V benchmark contained in the game and play Genshin Impact, GTA V, Need For Speed Pay Back, PUBG PC games for 20 minutes.

During testing, a Watt Meter installed in the system is intended to monitor the power used in the PC. Hwinfo64 software is used for hardware performance monitoring and MSI Afterburner is used to display game FPS. The room temperature during testing was 27.8 Celsius.

3. Results and Discussion

At this stage, the authors conducted initial testing using the default settings. This is used as an initial standard reference which will then be compared with the four predetermined scenarios. This initial test was carried out by running the computer 10 times.

3.1. Default Tests

Cinebench R20 and Unigine Valley synthetic benchmark tests on the default system can be seen in the Figure 1 until figure 2 and table 2 until table 5.

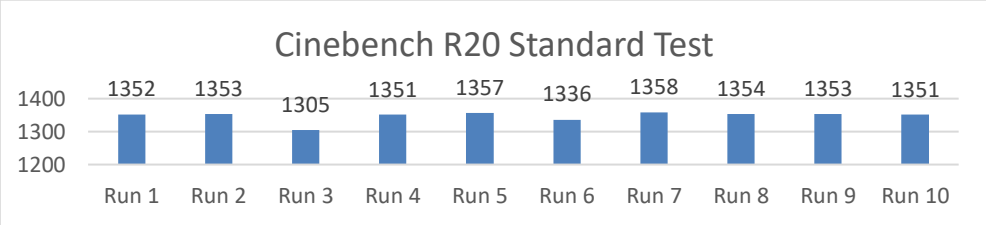

Figure 1. Cinebench R20 Standard Test Chart

Table 2. Cinebench CPU Voltage Performance

Average CPU Voltage (V)										
	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8	Run 9	Run 10
Min	0,856	0,852	0,850	0,850	0,850	0,850	0,850	0,856	0,853	0,850
Avg	1,320	1,316	1,317	1,318	1,311	1,309	1,318	1,315	1,316	1,320
Max	1,364	1,381	1,352	1,394	1,366	1,369	1,372	1,366	1,345	1,347

Table 3. Cinebench CPU Core clock

Average Core Clock (Hz)										
	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8	Run 9	Run 10
Min	1569	2540	2538	1597	1597	1597	1597	1597	2360	1597
Avg	3464	3451	3442	3434	3420	3429	3438	3442	3455	3441
Max	3565	3562	3569	3544	3550	3569	3569	3562	3562	3693

Table 4. Cinebench CPU temperature

Cinebench CPU temperature (°C)										
	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8	Run 9	Run 10
Min	37,1	37,1	37	39,8	38,9	37	39,6	38,7	38,3	37,7
Avg	63,68	63,83	63,74	65,81	61,83	59,44	63,64	63,59	64	69,3
Max	68,3	68,5	68,6	69,1	69,1	68,7	69,1	69,2	69	64,93

During the Cinebench R20 test, was repeated 10 times, each run read by the watt meter consumed 0.008 kWh of power for 5 minutes, and the average consumption of electric power was 96.39 Watts on a system with a maximum load of 104.8 Watts and a minimum of 40 watts.

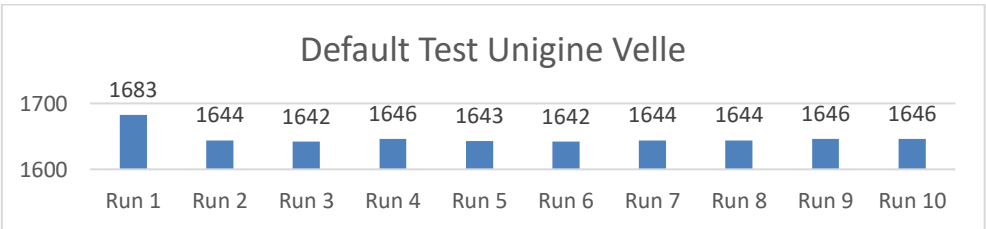

Figure 2. Diagram Default Test Unigine Velley

Table 5. Unigine Velley Temperature Standard

Unigine Valley CPU Temperature (°C)										
	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8	Run 9	Run 10

Min	41,4	46,1	46,3	44,5	42,3	43,9	43	44,7	44,6	44
Avg	50,11	50,39	50,28	50,04	48,82	49,7	49,64	49,92	49,75	49,77
Max	53,9	52,6	52,7	52,6	52,4	52,4	52,4	52,3	52,2	52,3

During the Valley test, was repeated 10 times, each run that was read by the watt meter consumed 0.008 kWh of power for 5 minutes, and the average consumption of electric power was 96.39 Watts on a system with a maximum load of 104.4 Watts and a minimum of 40 Watts.

The next test is the Genshin Impact game, with the game graphic setting being the default High and a scenario of playing the game for 20 minutes.

Table 6. Genshin Impact test data

Parameter	Min	Max	Avg
FPS	18	59,7	38,6
Watt Meter	88,3	107,8	105,01
CPU Temperature (°C)	47,5	66,25	51,36

The next test is the GTA V game with the game graphics setting set to high, the default game benchmark running for 3 minutes and 20 seconds, and playing casually for 20 minutes.

Table 7. GTA V benchmark test data

Parameter	GTA V Benchmark			GTA V Test		
	Min	Max	Avg	Min	Max	Avg
FPS	7,6	269,5	99,2	39,4	98,1	54,7
Watt Meter (W)	71,3	112,4	109,09	96,2	114,6	111,01
CPU Temperature(°C)	39,25	61,25	55,03	50,5	57	55,42

The next test is the game Need For Speed Payback, with the game graphic setting set to Very High with the default game benchmark, and playing it casually for 20 minutes.

Table 8. NFS payback test data

Parameter	Min	Max	Avg
FPS	17,5	60,7	32
Watt Meter (W)	89,2	123	114,9
CPU Temperature (°C)	55,75	71,75	57,72

The last test is playing the PUBG PC game casually for 20 minutes while the graphics are set to Very Low.

Table 9. PUBG PC test data

Parameter	Min	Max	Avg
FPS	3,3	61,7	44,4
Watt Meter (W)	73,7	114	105
CPU Temperature (°C)	51,75	64	54,79

3.2. Test Findings

The percentage data acquired in comparison to the default data is as follows based on the aforementioned scenario.

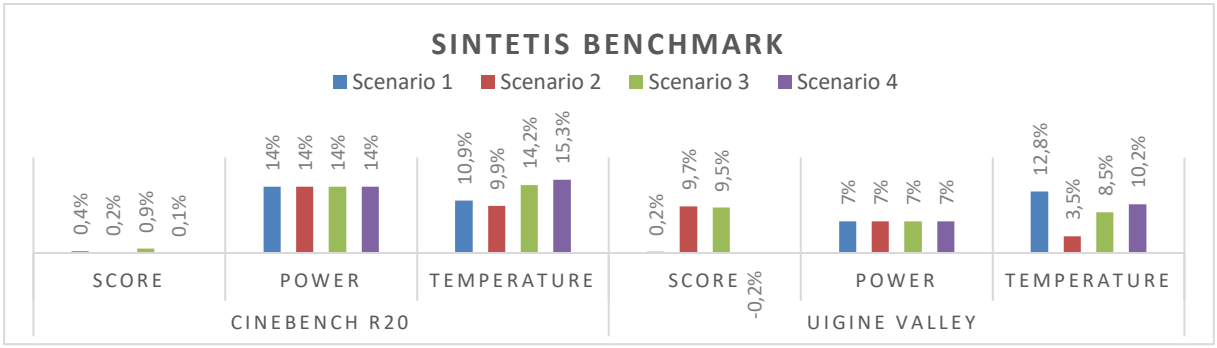

Figure 3. A percentage chart for Cinebench R20

Based on Figure 3, we can see that the third scenario had a greater average score rise with a value of 0.9%, and the fourth scenario had the best temperature decrease value with a value of 15.3%, according to the Cinebench R20 simulated test findings.

Also based on Figure 3, we can see that the second scenario had a greater average score rise with a value of 9.7%, and the first scenario had the best temperature decrease value with a value of 12.8%, according to the results of the Unigine Valley synthetic test.

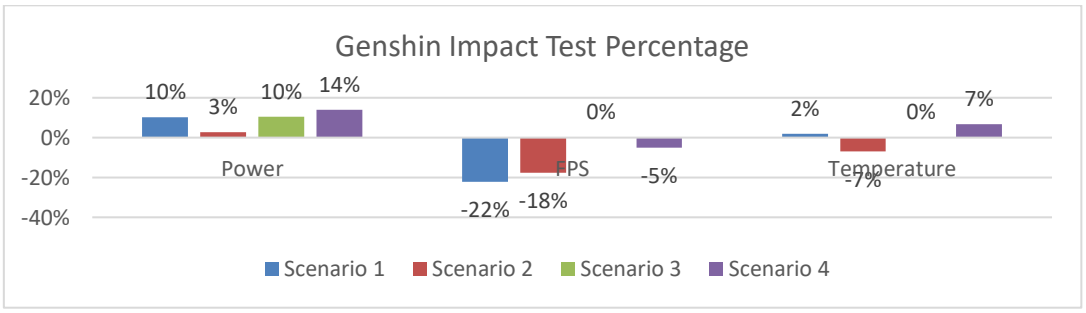

Figure 4. Percentage Diagram for Genshine Impact

Figure 4 shows that Genshine Impact was tested for 20 minutes, and the results showed that the fourth scenario had a higher average decrease in power consumption with a value of 14%. The third scenario could operate optimally without a reduction in FPS and temperature.

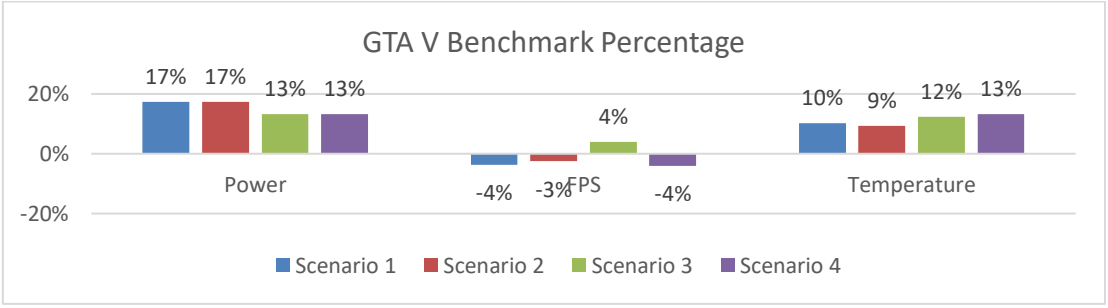

Figure 5. Benchmark Percentage Chart for GTA V

Figure 5 shows that the first and second scenarios had a larger average drop in power consumption with a value of 17%, while the third scenario had a higher average rise in FPS, according to the results of the GTA V Benchmark test, which lasted for 3 minutes and 20 seconds. Better with a value of 4%, and the best temperature reduction value is in the fourth scenario with a value of 13%.

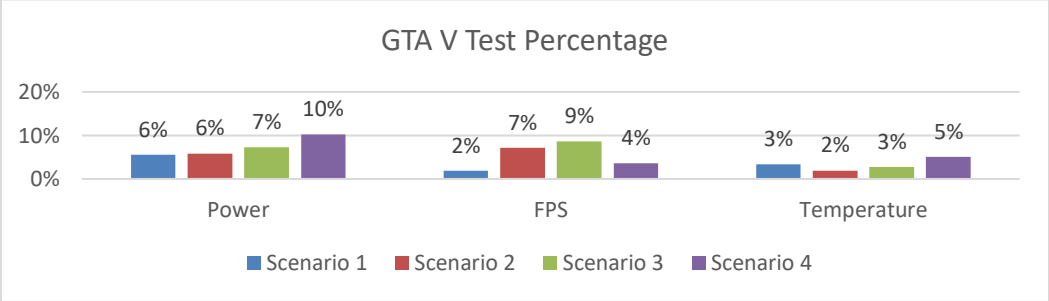

Figure 6. A percentage chart for GTA V

The fourth scenario has a higher average decrease in power consumption with a value of 10%, the third scenario has a better average FPS increase with a value of 9%, and the fourth scenario has a temperature reduction value of 5%, according to the results of testing the GTA V game, which lasts for 20 minutes, as shown in figure 6.

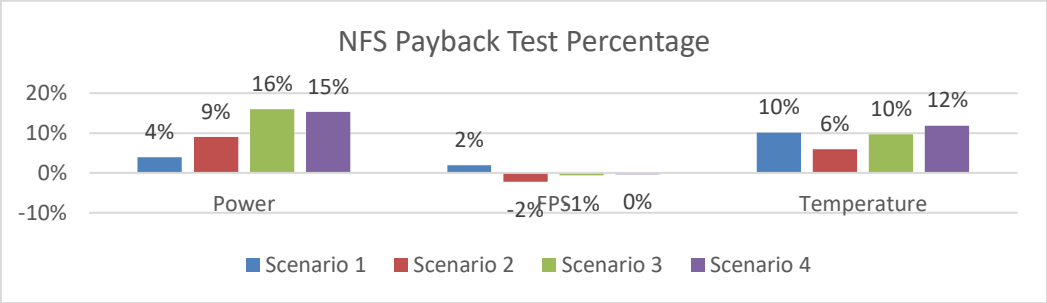

Figure 7. Diagram of the NFS Payback Percentage

The third scenario has a higher average power consumption decrease with a value of 16%, the first scenario has a better average FPS increase with a value of 2%, and the fourth scenario has an average temperature decrease of 12%, according to the results of testing the game Need For Speed Pay Back, which lasts for 20 minutes, as shown in figure 7.

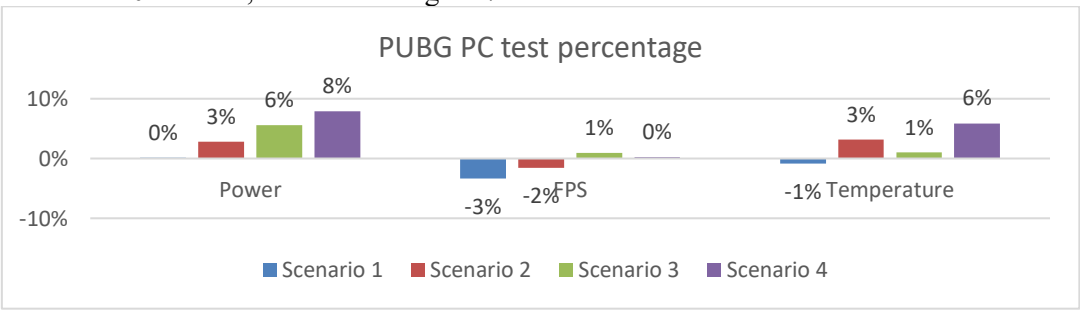

Figure 8. A percentage chart for PUBG PC.

According to the results of 20 minutes of testing the PUBG PC game, the 4th scenario had an average decrease in power consumption of 8%, the 1st scenario had an average decrease in FPS of 3%, and the 4th scenario had an average decrease in temperature of 6%, as shown in figure 8.

4. Conclusion

Based on the configuration results of the 4 test scenarios that the researchers have discussed, the researchers draw the following conclusions: Scenario 1's undervolting configuration has a low percentage value in several tests and the lowest result shows a performance decrease of -22% when testing the Genshine Impact game. Scenario 3 undervolting configuration has a high presentation value in each test when compared to the default test and the other three scenarios which have the best efficiency value of 16% and a decrease in processor working temperature at 14.2%. Scenario 3 undervolting configuration is a configuration that can affect the best processor performance compared to the other three scenarios because in all comparisons scenario 3 shows a stable and high percentage in each test.

Acknowledgements

Thank you to all those who have helped and supported this research. Especially to those who provide computers and hardware used throughout this research.

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Advance Sustainable Science, Engineering and Technology (ASSET)
Vol. 5, No.3, October 2023, pp. 0230304-01 ~ 0230304-09
ISSN: 2715-4211 DOI: https://doi.org/10.26877/asset.v5i3.17017

Milkfish Freshness Classification Using Convolutional Neural Networks Based on Resnet50 Architecture

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Abstract. Milkfish (Chanos chanos) had become the main commodity in three major cities in Indonesia, contributed at least 77 thousand tons of aquaculture production in 2021. The quality of fish is determined based on the level of freshness carried out in the sorting process, the sorting process is generally done by evaluating physical characteristics of the fish. However, this method is still considered less efficient and economical because the ability to classify the freshness level of fish can vary for each individual. In this study, by utilizing deep learning, a classification method for milkfish freshness level classification with ResNet50 architecture is proposed, the proposed method is purposed to overcome the previously stated problems, thus creating an efficient and economical system. By creating an efficient system, milkfish sorting process can be carried out quicker and more accurately. Using personal dataset divided into four different classes, the proposed method produces excellent result.

Keywords: milkfish, CNN, ResNet50, Adam Optimizer

(Received 2023-09-17, Accepted 2023-09-30, Available Online by 2023-10-23)

1. Introduction

Milkfish is considered as one of Indonesia's main food commodities, this is shown based on data provided by Badan Pusat Statistik Indonesia, in 2021 Indonesia had produced a total of 14.648.360 tons of farmed fish from multiple kind [1], at the same year, milkfish had become one of five fisheries production with counting at least 77 thousand tons [2], while on the other hand Indonesia had sold at least 2.527.632 tons of marine fish (from various sources) at the fish auction site [3]. Based on the provided data this conclude that milkfish plays important role and has significant part in contribution to Indonesia's food commodity, therefore this resource needs to be utilized as well as possible. A fish quality and economical value can be determined by its freshness, sensory evaluation is one of the methods of assessing fish freshness by observing the fish's characteristics such as appearance, color,

and odor [4]. Overtime, fish's color will change due to spoilage process, this affects the chemical substances in the fish therefore it changes the physical appearance of the fish, mainly its color on eyes, skin, and gills [5]. However, not many people have the ability and rigor in sorting fresh fish [6], in addition, this method of determining fish freshness is considered not time efficient and not easy [4]. Recently, computer science in the field of deep learning technology by utilizing CNN algorithm has been used in the process of classifying fish freshness level [6], CNN method is considered as a quick, economical, and environment friendly solution for classifying fish freshness [7]. There are various researches that was conducted previously about the use of CNN for fish freshness level classification, and as addition, other algorithm such as Support Vector Machine (SVM), is also provided in this literature study. The author has provided a list of previous research regarding to this study as in following table 1.

Table 1. Literature Study of Related Work

Authors	Year	Proposed Algorithm	Result or Findings
Kaladevi, Perumal, Priya [6]	2021	Deep Convolution Neural Network	Reached the score of accuracy, sensitivity, specificity, and F1-Score of 99,5%, 96,2%, 92,3%, and 94% respectively.
Prasetyo, Purbaningtyas, Adityo [7]	2020	Comparison of CNN algorithm based on MobileNet, ResNet, DenseNet, and NasNet architecture	Reached accuracy score of 77%, 35%, 73%, and 75% for MobileNet, ResNet, DenseNet, and NasNet respectively.
Hanifa, Ramadhan, Husna, Widiyono, et al [8]	2023	CNN algorithm with MobileNetV2 architecture	Testing accuracy of 97%, 94%, and 93% for tuna, milkfish, and mackerel respectively.
Janakidevi, Parasad, Udayaraju [9]	2021	Comparison of (Shallow Deep CNN), CNN, and SVM (Support Vector Machine)	Reached training accuracy of 71,87%, 83,75%, 85% for SVM, DCNN, and SDCNN respectively.
Lalabadi, Sadeghi, Mireei [10]	2020	Artificial Neural Network (ANN) and SVM (Support Vector Machine)	Reached testing accuracy for classification based on eye images of 84% for ANN algorithm and of 68% for SVM algorithm.

Based on the provided literature study, it is possible to utilize Convolution Neural Network (CNN) and other machine learning algorithm such as SVM (Support Vector Machine) for classifying fish freshness level, it is also considered that CNN can be used for integrated feature extraction and classification in one system [7], therefore it is also can be concluded that the use of CNN for classification purpose is still relevant to this date. This research is build based on existing methods and algorithm, yet this research tried to improve of what prior works has obtained, for example compared to [6] this research classifies fish freshness into four classes instead of two classes, and compared to [7] this research focused on ResNet50 architecture while using private dataset with larger quantity image instead of using combination of transfer learning method and smaller quantity image dataset.

This research specifically aims to create milkfish freshness classification system using CNN algorithm with ResNet50 architecture and Adam optimizer. The classification is divided into four class consisting of fresh, less fresh, starting to rot, and rotten class, dataset used in this research is private dataset consisting of 1803 images of milkfish taken in 16 hours of time. The purpose of the proposed

model of milkfish freshness classification is to overcome challenges in milkfish freshness classification process such as inefficiency due to misclassification or human error, and uneconomical factors due to excessive man-power needed to perform large-scale work load. It is also aimed that by eliminating these challenges, this research can help various individuals in working with milkfish freshness classification (for example, milkfish seller who needs to classify the fishes based on its freshness in a largescale unit or capacity, or a human individual who doesn't have the ability to classify or determine fresh milkfish, will be helped by this system in determining fresh milkfish.)

2. Methodology

2.1 Dataset

Dataset used in this research is a private dataset containing 1804 images of milkfish taken in 16 hours of time, the images were taken with Canon 800D DSLR camera with the resolution of 1980 x 1980 pixels. Each milkfish was taken fourteen times within interval of one hour and total duration of 16 hours, while the milkfish itself was purchased randomly from several different fish seller in Sayung Market, Demak Regency, Indonesia. Currently this dataset is not available to the public and considered to be the author's private archive. The sample images taken from the dataset is shown in the following figure.

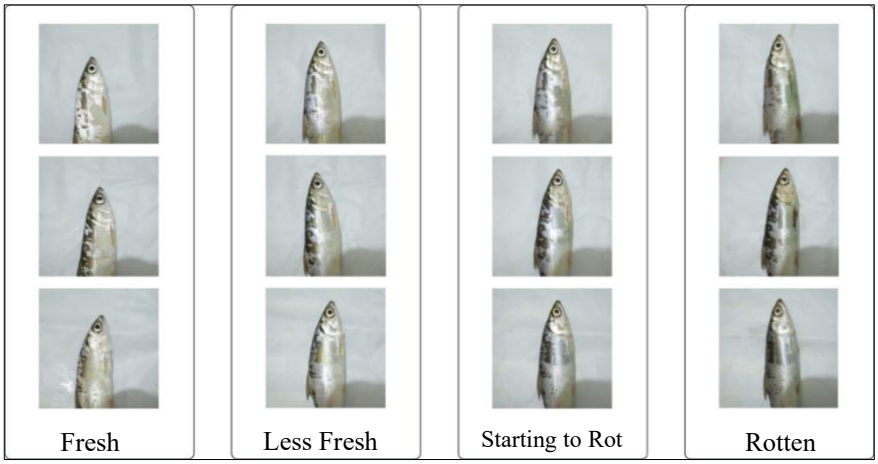

Figure 1. Dataset Sample from Each Class

During the 1st through 4th hour the milkfish is classified into fresh class, during the 5th through 8th hour it is classified into less fresh class, during the 9th through 12th hour it is classified into starting to rot class, and lastly during the 13th through 16th hour it is classified into rotten class. This is based on the changes of physical appearance of the fish as the time goes by, there are sign of rotting such as the eye membrane that is turning murky, the body turning into pale color, and bleeding mouth.

2.2 Convolution Neural Network (CNN)

CNN is a more advanced development of Artificial Neural Network that consisted of neural network that carries out the weight, bias, and activation function, furthermore, most common layers in CNN is convolution, pooling, and fully connected [11]. In the convolution layer, features of the image is extracted by utilizing specific Kernel, then activation process is performed by mapping negative value into 0 value and preserving positive value in order to achieve fast and effective training process. In pooling layer, feature map reduction is performed resulting in reduced parameter that needs to be learn by the network. Lastly the fully connected layer is performed resulting in vector with K dimension where K is the number of classes that can be predicted [11], [12].

2.3 CNN Layer with ResNet50 Architecture

There are several architectures in CNN algorithm in the case of computer vision field, one of them is ResNet50 (Residual Network), this architecture relies on large dataset for its training process with various category of class [13]. In this research, ResNet50 architecture is used because it's considered effective to work with large dataset with various class in it. Previous work done in [7]had done similar

research using ResNet50 research, however the dataset used is relatively small (234 images with three classes) compared to this research (1803 images with four classes). Further explanation of ResNet50 architecture used in this research is explained in the following figure and table.

Table 2. ResNet50 Architecture Layer

Layer	Description
Conv1	Output 125 × 125, residual block size of 7 × 7, 64 with stride size of 2.
Conv2	Output 63 × 63, residual block size of 1 × 1, 32 and 64 with stride size of 1. Residual block size of 3 × 3, 32 with stride size of 1.
Conv3	Output 32 × 32, residual block size of 1 × 1, 32 with stride size of 1 and 2. Residual block size of 3 × 3, 32 with stride size of 1.
Conv4	Output 16 × 16, residual block size of 1 × 1, 32 with stride size of 1 and 2. Residual block size of 1 × 1, 64 with stride size of 1. Residual block size of 3 × 3, 32 and 64 with stride size of 1.
Conv5	Output 8 × 8, residual block size of 1 × 1, 64 with stride size of 1 and 2. Residual block size 3 × 3, 64 with stride size of 1.

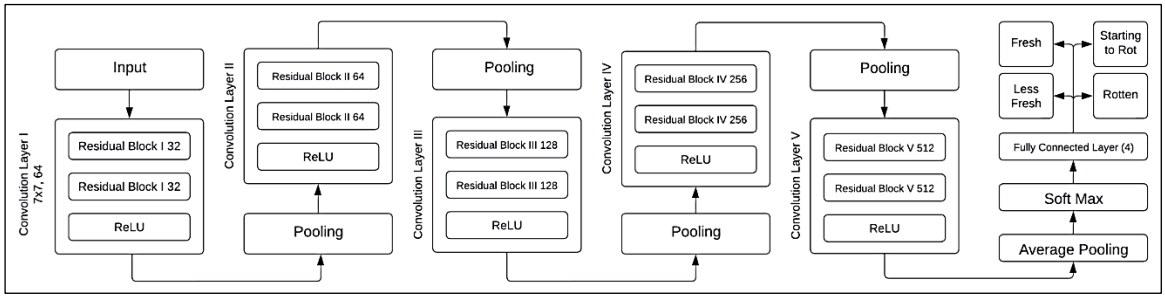

Figure 2. ResNet50 Architecture

2.4 Research Workflow

In this research, tool used is Matlab R2020a to develop and running the code for this research, the steps in this research are shown in figure 3 and explained as follows,

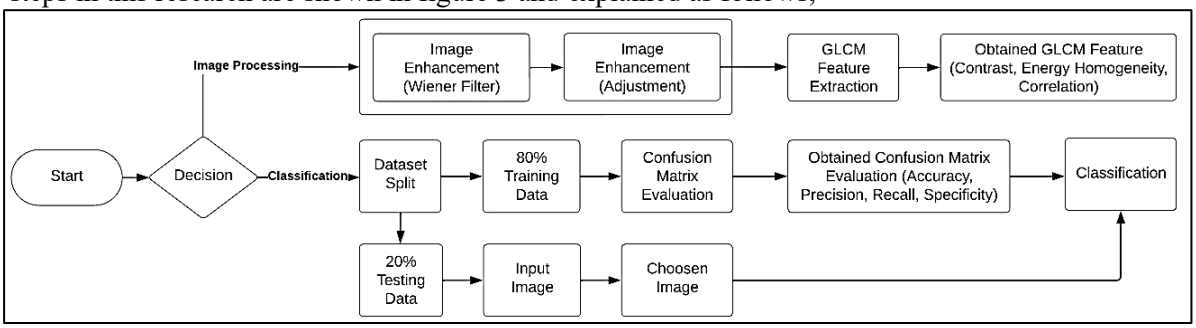

Figure 3. Research Workflow

2.4.1 Image Preprocessing

In order to improve the quality of the image it is needed to perform image preprocessing, enhancement used in this step is firstly applying Wiener Filter with the purpose of filter existing signal noises using spectral properties from the existing signal and noises, by considering both of them as a stochastic process with linear property [14]. The use of Wiener Filter is because some of the images in the dataset appears to be blurry due to external factors such as the camera shaking while taking the pictures, by applying Wiener Filter it appears to reduce the blur thus enhancing the image quality.

Second enhancement is image adjustment function from Matlab to fix the brightness and contrast of the image. The use of image adjustment is because the background used has almost the same colors of the milkfish body color appearance, in order to distinguish the background and the object (milkfish) image adjustment is performed, it appears that the milkfish's body after the preprocessing appears to be darker than the background thus making the milkfish more distinctive than the background. The enhancement result is shown in figure 4.

2.4.2 GLCM Feature Extraction

GLCM or Gray Level Co-occurrence Matrix is a statistic method used to obtain texture feature by obtaining the correlation value of two pixel in a specific range and angle [15]. The extracted features in this research are contrast, energy, homogeneity, and correlation as described in the following equation 1, 2, 3, and 4, the result of GLCM feature extraction from sample dataset is provided in Table 3. Contrast is a parameter that measure the contrast value of a pixel with other adjacent pixels [16]. Energy is a feature that represent the number of square elements in a GLCM matrix through a homogenous area to inhomogeneous area [16]. Homogeneity refers to a similarity between pixel where the value of GLCM matrix of a homogenous picture is 1 [16]. Correlation is used to measure linear dependency of a grayscale color in an image [16].

$$Contrast = \sum_{i,j}(i-j)^2 p_{(i,j)} \quad (1)$$

$$Energy = \sum_{i,j} p(i,j)^2 \quad (2)$$

$$Homogeneity = \sum_{i,j} \frac{p(i,j)}{1+|i-j|} \quad (3)$$

$$Correlation = \sum_{i,j} \frac{(i-\mu i)(j-\mu j)p(i,j)}{\sigma i\, \sigma j} \quad (4)$$

The variable p (i,j) represents the value of the matrix elements in a row (i) and column (j); μi,μj represents the average value of the elements in the matrix row and column; σi σj represents the standard deviation value in the matrix row and column [17]. In this research, GLCM feature extraction is used to obtain GLCM features from each class in order to know the differences of GLCM features value of each class, for example based on table 3 it is shown that the contrast and energy value of sample from fresh class is significantly lower than sample from rotten class, while on the other hand the homogeneity value of sample from fresh class is significantly higher than sample from rotten class, while for the correlation value it appears that the value is decreasing from fresh all the way to rotten class. Based on the obtained value of GLCM features, it can be concluded that the image from each class had different characteristics, therefore the dataset in this research can be used in milkfish freshness classification. Furthermore, based on the research workflow in figure 3, although GLCM features extraction in this research doesn't directly contribute to the classification process, it contributed indirectly by indicating that each class had different and variative value of GLCM features.

Table 3. Feature Extraction Result from Sample Dataset

No.	Class	Contrast	Energy	Homogeneity	Correlation
1	Fresh	10733.85	1.7952e-05	0.035	-0.084
2	Less fresh	11073.02	1.8857e-05	0.033	-0.108
3	Starting to rot	47822.07	4.5972e-06	0.018	-0.119
4	Rotten	49325.42	4.9558e-06	0.017	-0.162

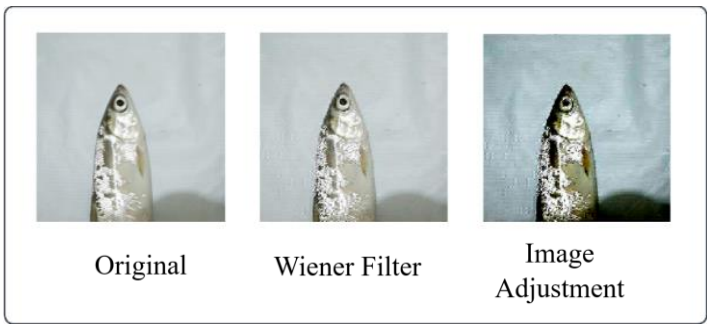

Figure 4. Image Preprocessing Result

2.4.3 Training Data and Confusion Matrix

In this research, dataset used contained 1803 images of milkfish classified into four classes being fresh, less fresh, starting to rot, and rotten class, furthermore, the training data portion for the training process is 80%. In the training process, there are three optimizers used being Adam, SGDM (Stochastic Gradient Descent with Momentum), and RMSProp (Root Mean Square Propagation). Adam optimizer is considered to work well even with small resources thus considered effective and can replace traditional stochastic gradient algorithm [18]. In this research, three of the optimizers is compared with at least three times training run in order to find the best optimizer to be used, additional training options used are epoch number of 16, mini batch size of 32, validation frequency of 30, and false verbose value. The training result is shown in table 4 as well as figure 5 shows the accuracy and loss graphics for the last training run of Adam optimizer.

Table 4. Training Run Result

No.	Optimizer	1st Training	2nd Training	3rd Training	Average
1	Adam	98,61%	100%	99.44%	99,35%
2	SGDM	98,89	97,22%	91,39%	95.83%
3	RMSProp	95,83%	97,50%	85,83%	93,05%

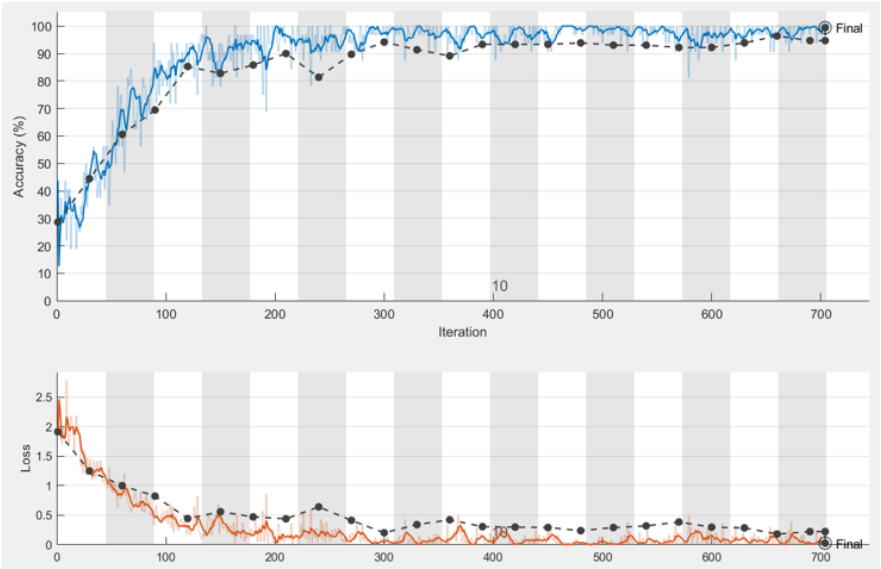

Figure 5. Accuracy and Loss Graphic

In this research, confusion matrix is used as an evaluation parameter, this matrix contains accuracy, precision, recall, and specificity. This confusion matrix is involving TP, TN, FP, and FN, TP and TN are a condition where model is able to classify positive and negative class correctly, while on the other hand FP and FN is a condition where model is mistakenly classified negative class into positive class and vice versa [19]. The equation for accuracy, precision, recall, and specificity is described in the following equation 5, 6, 7, and 8.

$$Accuracy = \frac{TP+TN}{TP+TN+FP+FN} \quad (5)$$

$$Precision = \frac{TP}{TP+FP} \quad (6)$$

$$Recall = \frac{TP}{TP+FN} \quad (7)$$

$$Specificity = \frac{TN}{TN+FP} \quad (8)$$

2.4.4 Classification Using Convolution Neural Network

Classification was done using CNN using dataset and training optimizer explained previously. The testing is done by taking random images from each class being fresh, less fresh, starting to rot, and rotten class. The result is discussed in result and discussion section.

3. Result and Discussion

In this classification part, three sample images taken randomly from each class is then classified by the model, the result of the classification is shown in table 6. Based on the result obtained, the model is able to classify each image into correct class, therefore the obtained accuracy score is 100%.

Table 5. Testing Classification Result

File Name	Milkfish Freshness Level Classification		
	Real Class	**Predicted Class**	**Result**
fresh_33	Fresh	Fresh	True
fresh_219	Fresh	Fresh	True
fresh_414	Fresh	Fresh	True
lessfresh_78	Less fresh	Less fresh	True
lessfresh_224	Less fresh	Less fresh	True
lessfresh_400	Less fresh	Less fresh	True
startingtorot_57	Starting to rot	Starting to rot	True
startingtorot_232	Starting to rot	Starting to rot	True
startingtorot_317	Starting to rot	Starting to rot	True
rotten_42	Rotten	Rotten	True
rotten_162	Rotten	Rotten	True
rotten_248	Rotten	Rotten	True

Based on the obtained result, the training accuracy score for this proposed method scored at 99,35% while the testing accuracy scored at 100%, compared to some previous works for example although research [6] achieved higher accuracy score (99,5%) compared to this research (99,35%), this research successfully classified milkfish freshness into four different classes, compared to only two classes from research [6]. On the other hand, compared to research [7]–[9] this research achieved higher accuracy score by around 2% to 22% compared to those researches. With this excellent result, it is possible for further development that this proposed method can be deployed into practical use, for example by developing the model into a mobile phone application where user can use the mobile phone's camera to take pictures of milkfish and then classify it into four different classes with the proposed method, however this research aim is to proposed a method of classifying

milkfish freshness based on CNN algorithm therefore this research can be used as a proof of concept. Furthermore, although this research is focused and limited in classifying milkfish freshness, it's still possible for the further development of the proposed method to be used into similar cases for example Tilapia freshness classification, or Seabass freshness classification etc.

4. Conclusion

In this research a classification of milkfish freshness level was done using Convolution Neural Network (CNN). In this research a dataset containing 1803 milkfish images taken within 16 hours of time and divided into four classes being fresh, less fresh, starting to rot, and rotten class. In this research the CNN architecture used is ResNet50 with image size of 250 x 250 x 3 and utilizing Adam optimizer with 16 epochs, moreover image preprocessing technique such as applying Wiener Filter and image adjustment is also performed in order to enhance the quality of the images. The result obtained for training accuracy is 99,35% of accuracy score from at least three training runs. The result obtained for testing accuracy is 100% of accuracy score from at least three testing runs, with the model being able to correctly classified images into its class. With the conclusions obtained from this research, it is hope that this research can overcome challenges in milkfish freshness classification process such as inefficiency and uneconomical factors It is also hoped that by eliminating these challenges, this research can help various individuals in working with milkfish freshness classification.

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Advance Sustainable Science, Engineering and Technology (ASSET)
Vol. 5, No.3, October 2023, pp. 0230305-01 ~ 0230305-08
ISSN: 2715-4211 DOI: https://doi.org/10.26877/asset.v5i3.17150

A Combination of Vigenere Cipher and Advanced Encryption Standard for Image Security

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Abstract. In an era where digital information security is paramount, this research addresses the pressing need for robust encryption methods. We propose a novel approach that combines the Vigenere Cipher and the Advanced Encryption Standard (AES) for secure digital image transmission. Our study recognizes the research gap in secure image transmission methods and aims to bridge it with a powerful encryption solution. We implement this hybrid encryption approach using the Vigenere Cipher in C++ and the AES algorithm in MATLAB. Our experiments validate the effectiveness of our program in concealing and restoring digital images during transmission. This hybrid encryption technique has promising applications in healthcare, military, and confidential business operations, bolstering image security in real-life scenarios. By enhancing image security, our research can contributed to safeguarding sensitive information in the digital age.

Keywords: *Vigenere Cipher, Advanced Encryption Standard, Encryption, Decryption*

(Received 2023-10-06, Accepted 2023-10-13, Available Online by 2023-10-24)

1. Introduction

Along with the development of today's technology, it is now commonplace for people in the digital era to send messages/data. With the activity of sending messages/data between people via the internet, it is necessary to have a level of data security so that the data sent is not opened by unauthorized parties and privacy is maintained [1]. Computer technology made it easier for society to communicate. However, with the development of this technology, it is also necessary to pay attention to the level of security of the information. The internet is one of the infrastructures to facilitate communication so it is widely used by the public. Therefore, there is a high possibility of wiretapping and data manipulation, therefore the security of data/information sent and received is very important [2]. Data cannot be separated from issues of data confidentiality and security. Big data analysis can be carried out with third parties so that

it can be processed in a manner that avoids problems properly to protect sensitive data and ensure its security, because they of course entrust experts or other tools to analyze data, which can increase the potential for security hazards. Security and privacy are sensitive issues that are often compromised by technological advances. Personal data requires protection. For example, the banking and telecommunications sectors receive personal data directly from customers, which can be misused by other parties [3]. One of the randomization techniques with a key so that the information is unknown is usually called a cryptographic technique. In cryptography, it is further classified into symmetric and asymmetric cryptography. Symmetric methods such as AES are relatively fast in carrying out the encryption and decryption process. [5] Advance Encryption Standard (AES) is a cryptographic technique that has the ability to encrypt and decrypt keys with lengths of 128 bits, 192 bits, and also 256 bits. The use of this key will later affect the round calculations carried out in the Advance Encryption Standard (AES) algorithm [6].

Based on the problems in this research, we will try to combine the Advance Encryption Standard (AES) algorithm and the Vigenere Cipher algorithm. It is hoped that using a combination of these two algorithms can increase the security of the encrypted data. The purpose of using the Vigenere Cipher algorithm is to encrypt the key used in AES. The Vigenere Cipher algorithm is an encryption technique in cryptography that is often used to encrypt data in the form of text. Encoding this algorithm requires a key. One of the advantages of using the Vigenere Cipher algorithm is that this algorithm is one of the algorithms that is not easily vulnerable to password cracking methods [7].

Implementation of the AES-128 algorithm for file security at Imelda Medan Public Hospital, the implementation is carried out using a website with a login page before carrying out the encryption and decryption process, the advantage of the implementation is that it improves radiological test results at the RSU, but the disadvantage is that it can only process files with .jpg and .png format extensions, outside these formats it will automatically be rejected by the system [8]. The AES-128 algorithm for Document Encryption at Gunung Geulis Elok Abadi company, the implementation is carried out using a website with a login page before carrying out the encryption and decryption process. The implementation of the AES algorithm is aimed at text document files, the implementation of this algorithm is only carried out using one algorithm, namely the AES Algorithm. The author's statement says that using just 1 algorithm is considered less secure in the file encryption and decryption process, so the author suggests using 2 algorithms to make it safer [9]. Application of the AES-128 Algorithm in Securing Population Data at the Pematangsiantar City office of demographic affairs, implemented by Java programming language to carry out encryption and decryption on files with the extension .doc, .xls, .ppt, .pdf, .jpg, and .png whose encryption results in the form of text for all file types, both images and text. The decryption process will display the same results as before encryption if the same key is used [10]. Implementation of the AES Algorithm for Securing Login and Customer Data in Web-Based E-Commerce, this implementation uses a website to encrypt the text, namely the password used by users when logging in to the website they own. So the use of the AES – 128 algorithm aims to encrypt data in the form of text which will later be stored in the existing database. By implementing the AES algorithm on an e-commerce website, the author states that it can provide security when logging in and guarantee the security of customer data [11]. Implementation of the AES Algorithm on the QR CODE for Ticket Verification Security, the implementation of the AES algorithm on the QR Code uses a smartphone device, so that the encryption and decryption process is carried out when the user orders a ticket so that the identity of the user/ticket order cannot be accessed by anyone. To check the tickets ordered, the counter staff only scans the existing barcode and then automatically checks the database using an API which is used in real time using the internet. This implementation aims to ensure that the system can secure ticket identities from ticket resale and manipulation of ticket data from unauthorized parties [12].

In this research, the author aims to address the challenge of securing digital image data during transmission. Specifically, it proposes a solution that combines the Vigenere Cipher and the Advanced Encryption Standard (AES) to enhance the security of digital image communication. The study intends to demonstrate that this hybrid encryption approach effectively conceals and restores digital images,

ensuring their confidentiality and integrity during transmission. To achieve this, the research will employ the Vigenere Cipher implemented in C++ for one layer of encryption and the AES algorithm implemented in MATLAB for another layer. The combination of these two encryption methods aims to provide a robust and layered approach to image security, mitigating potential threats in digital image communication.

2. Methods

For this research, the author used Code::blocks V20.03 software for the Vigenere Cipher algorithm with C++ and the MATLAB R2021A application to run the AES algorithm. For hardware, the author uses an AMD Ryzen 5 5600G processor, 16GB 3200 Mhz Dual Channel RAM and 1TB SSD. Algorithms are the steps to do a job, in choosing the algorithm used it must be correct. In selecting an algorithm there are considerations that must be assessed, including: how good the results provided by the algorithm are, the efficiency provided by the algorithm both in terms of time and memory [13]. Cryptography is the science of maintaining the security of messages sent so that they can be safely received by the recipient of the message. This word encoding technique is carried out by hiding the original data so that the information is not known by unauthorized / unrelated parties [14]. According to Bruce Schneider, cryptography is the art or science of maintaining the confidentiality of data so that it is not known by unauthorized parties. Experts in cryptography are cryptographers, and cryptanalysis is the opposite of the cryptographic process [15]. Meanwhile, according to Sadikin, cryptography is not a science that studies message hiding techniques alone, but cryptography also includes data security techniques such as data integrity, confidentiality, authentication, and so on [16]. According to Sentot Kromodimoeljo, cryptography is a science that discusses encryption techniques using keys so that the data is difficult to read by people who do not have the key to the data [17].

The Vigenere cipher algorithm is a cryptographic algorithm which is a development of the polyalphabetic substitution cipher [18]. This algorithm can be done in 2 ways [19], namely using the manual method using the Tabula Recta table in Figure 1 or using a formula (1) and (2).

KEYWORD LETTERS \ PLAINTEXT LETTERS	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
A	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
B	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A
C	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B
D	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C
E	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D
F	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E
G	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F
H	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G
I	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H
J	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I
K	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J
L	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K
M	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L
N	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M
O	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N
P	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Q	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
R	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
S	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
T	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
U	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
V	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
W	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
X	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
Y	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
Z	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y

Figure 1. Vigenere Tabula Recta

$$Ci = (Pi + Ki)\ mod\ 26 \qquad (1)$$

$$Pi = (Ci - Ki)\ mod\ 26 \qquad (2)$$

Where, *Ci* is decimal value of the i-th ciphertext character, *Pi* is decimal value of the i^{th} plaintext character and *Ki* is decimal value of i^{th} the key character. The Rijndael Algorithm / AES Algorithm is a safe cryptographic algorithm to protect confidential data / information. In the AES algorithm there are several key lengths consisting of 128 bits, 192 bits and 256 bits. The difference in key lengths affects the rounds carried out by the AES algorithm in carrying out the encryption process. The longer the key,

the more rounds it takes [20], as shown in Figure 2. There are three different types of rounds in the AES algorithm as shown in Table 1. Based on Table 1, this research uses a 128 bit key with 10 rounds of encryption. The key used is a random letter, this is an example of the key used in this research key = "Halokamudisana" with a calculation of 8 bits per letter so that there are 16 characters which, if multiplied by 8 bits, = 128 bits.

Table 1. AES Key Type [20]

Type	Key Length	Block Length	Rounds Number
AES – 128	128 bit	128 bit	10
AES – 192	192 bit	128 bit	12
AES – 256	256 bit	128 bit	14

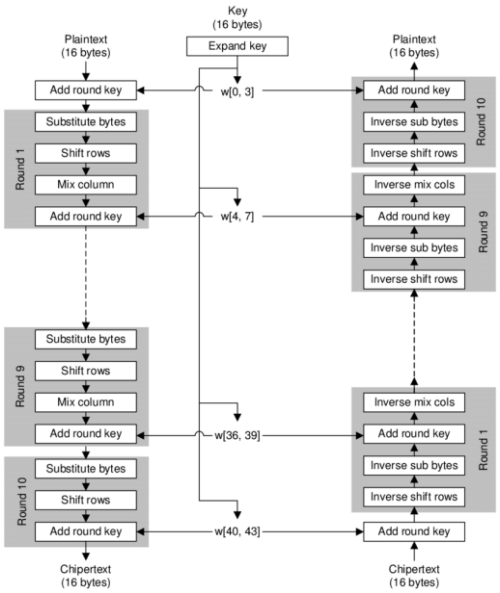


Figure 2. AES General Process

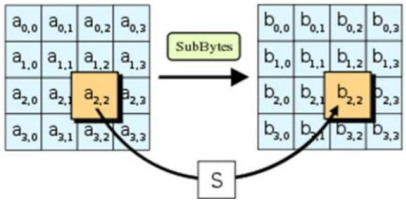
Generaly [21], AES algorithm has 4 main processes for encryption and decryption as in the Figure 3, include:

1) AddRoundKey, to combine state array and round key for illustration.
2) Sub – Bytes, it is a process to exchange the contents of Bytes in each state with an existing substitution table (S-Box),
3) ShiftRows, this is the process of shifting the leftmost bit to the right on each row in the state array, for illustration.
4) MixColumn as in figure 6, it is a multiplication process between a block cipher and a predetermined matrix, to randomize each state array using (3).

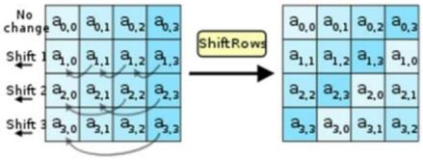
Meanwhile, for decryption process include :

1) AddRoundKey, to combine state array and round key for illustration.
2) InvShiftRows, this is the opposite process to ShiftRows in the encryption process, in this process the bits of each row are shifted from right to left.
3) InvSubBytes, this is the opposite process to SubBytes, in this process the elements in the state are mapped to the existing inverse S-Box table, for inverse S-BOX.
4) InvMixColumn, this is the process of multiplying the state column with the AES matrix.

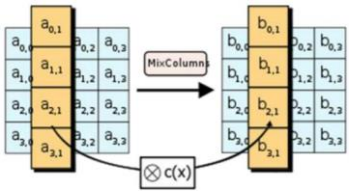
$$A(x) = \{03\}x^2 + \{01\}x^2 + \{01\}x + \{02\} \qquad (3)$$



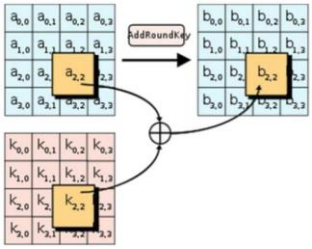
(a) Sub byte



(b) Shift Row



(c) Mix Column



(d) Add Round Key

Figure 3. AES Common Stages

3. Results and Discussion

Here, program testing is carried out in several stages, including:

1) Use a normal / unencrypted key, namely= Halokamudisanasa as the main key;
2) Carry out the encryption and decryption process using the AES algorithm, to get the test results;
3) Encrypt the key = Halokamudisanasa using the Vigenere Cipher algorithm;
4) Use a key that has been encrypted using the Vigenere Cipher algorithm, namely = Pplbspmhlxsnvpsn as the main key;
5) Carry out the encryption and decryption process using the AES algorithm, to get the test results;
6) Test and compare the results between keys that have been encrypted using the Vigenere Cipher algorithm and keys that have not been encrypted using any algorithm.

In this test, 10 image samples were used, consisting of 5 color images and 5 grayscale images with .jpeg and .jpg file formats. using key = "Halokamudisanasa" which will be detailed in Table 2.

Table 2. Data Collection for Encryption

Number	Height (px)	Width (px)	Size (kb)	Type
1	210	240	6	Grayscale
2	285	177	9	Colored
3	667	1000	118	Colored
4	167	301	4	Colored
5	350	300	21	Colored
6	540	360	25	Colored
7	408	612	16	Grayscale
8	375	500	20	Grayscale
9	395	600	38	Grayscale
10	300	332	14	Grayscale

The encryption results will produce a file called encrypt and the decryption results will produce a file called decrypt. Where in this experiment the encryption and decryption process will be carried out directly in the existing program, table 3 will display the results of the tests carried out. In this second test, 10 image samples has been used, consisting of 5 color images and 5 grayscale images with .jpeg and .jpg file formats. using key = "Pplbspmhlxsnvpsn" which detailed in Table 2, Key calculations has been done using manual calculations or using programs such as those in Figure 4 and Figure 5.

Table 1. AES Encryption Test Results

No.	Size Original (kb)	Size Decrypted (kb)	Time (sec)	Bit Error Rate (BER)	UACI	NPCR	Entropy Original	Entropy Decrypt
1	6	43	10.54	0	33.00%	100.00%	7.6445	7.6445
2	9	89	6.73	0.000010738	33.19%	99.28%	7.7374	7.7372
3	118	929	764.35	0.00000049975	33.01%	98.06%	7.8269	7.8269
4	4	85	4.94	0.000009118	32.44%	99.30%	7.5878	7.5879
5	21	100	26.72	0.0000031746	38.98%	97.94%	7.2345	7.2345
6	25	103	69.07	0	34.18%	99.56%	6.8013	6.8013
7	16	83	113.90	0	48.26%	99.01%	6.1985	6.198
8	20	154	65.02	0.0000026667	44.27%	98.95%	7.6389	7.6390
9	38	205	101.15	0.0000014065	36.88%	99.36%	7.6396	7.6397
10	14	84	20.60	0	38.67%	98.44%	7.4534	7.4534

```
Masukkan teks yang akan dienkripsi: Halokamudisanasa
Masukkan kunci enkripsi: ipan
Teks terenkripsi: Pplbspmhlxsnvpsn

Process returned 0 (0x0)   execution time : 7.145 s
Press any key to continue.
```

Figure 4. Key Encryption using Program

The encryption results will produce a file called encrypt and the decryption results will produce a file called decrypt. Where in this second experiment the encryption and decryption process will be carried out directly in the existing program, table 4 will display the results of the tests carried out. The UACI and NPCR graphic display of the experimental results shown in Figure 7.

Teks =	H	a	l	o	k	a	m	u	d	i	s	a	n	a	s	a
Key =	i	p	a	n	i	p	a	n	i	p	a	n	i	p	a	n
Urutan Abjad pada Teks =	7	0	11	14	10	0	12	20	3	8	18	0	13	0	18	0
Urutan Abjad pada key =	8	15	0	13	8	15	0	13	8	15	0	13	8	15	0	13
Total Teks + Key =	15	15	11	27	18	15	12	33	11	23	18	13	21	15	18	13
Mod 26	15	15	11	1	18	15	12	7	11	23	18	13	21	15	18	13
Konversi Ke Abjad	P	p	l	b	s	p	m	h	l	x	s	n	v	p	s	n

Figure 6. Key Encryption using manual calculation

Table 2. AES Key Encrypted Encryption

No.	Size Original (kb)	Size Decrypted (kb)	Time (sec)	Bit Error Rate (BER)	UACI	NPCR	Entropy Original	Entropy Decrypt
1	6	43	11.54	0	33.00%	100.00%	7.6445	7.6445
2	9	89	65.73	0.000010738	33.19%	99.28%	7.7374	7.7372
3	118	929	760.35	0.00000049975	33.01%	98.06%	7.8269	7.8269
4	4	85	7.94	0.000009118	32.44%	99.30%	7.5878	7.5879
5	21	100	23.72	0.0000031746	38.98%	97.94%	7.2345	7.2345
6	25	103	67.07	0	34.18%	99.56%	6.8013	6.8013
7	16	83	108.90	0	48.26%	99.01%	6.1985	6.198
8	20	154	61.02	0.0000026667	44.27%	98.95%	7.6389	7.6390
9	38	205	98.15	0.0000014065	36.88%	99.36%	7.6396	7.6397
10	14	84	25.60	0	38.67%	98.44%	7.4534	7.4534

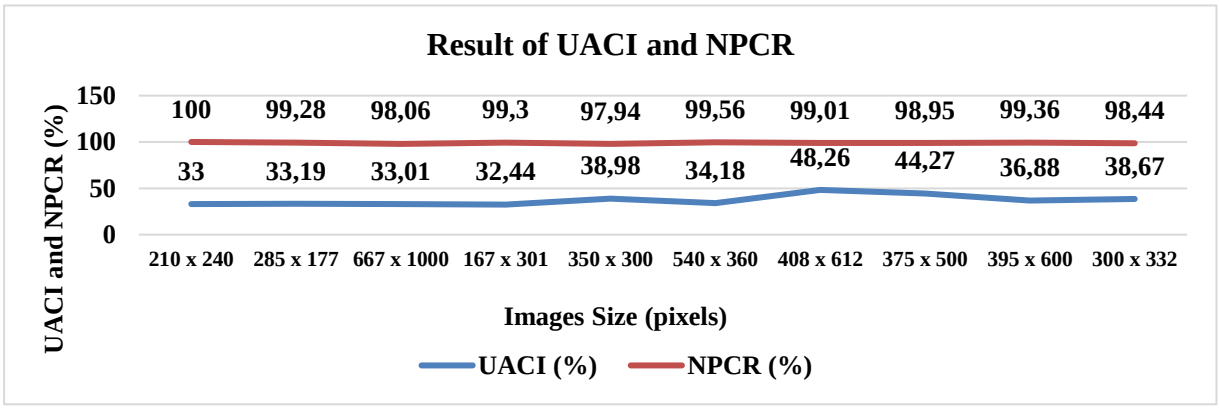


Figure 7. Result of UACI and NPCR

From the experimental results above, it can be concluded that, encrypted and unencrypted keys actually give the same results because they have the same 128 bits and the AES algorithm only runs 10x rounds. AES – 128 algorithm has been used as an alternative for securing data in the form of digital images. The size of the digital image/image affects the time of the encryption and decryption process carried out by the system. In accordance with the research objective, namely to make digital images safe so that they can be used in various institutions and aspects of research results: based on the UACI and NPCR graphs above, it can be seen that the average NPCR value is close to 100%, which means the original image is identical to the decrypted image, the same Likewise, the UACI is getting closer to 50%, indicating an inconspicuous change between the original image and the encrypted image, thus indicating that the resulting encryption has a fairly balanced level of security. The entropy result shown to be close to 10 means that the resulting encrypted image is random enough so it is considered safe in securing data. From the research results, it is proven that the initial image that has undergone the encryption and decryption process will return to the original image and remain unchanged.

4. Conclusion

This research still has many shortcomings and limitations, including being quite complex, it cannot be said to be perfect in carrying out encryption, it takes quite a long time if the image size is large. This research can be used to secure digital images so that they are not easily identified by other people as long as the key is not given. For further development, this research will continue to develop encryption and decryption of digital images using a combination of AES and k-order based on Fibonacci due to enhance key security and get the best results of imperceptibility.

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Advance Sustainable Science, Engineering and Technology (ASSET)
Vol. 5, No.3, October 2023, pp. 0230306-01 ~ 0230306-09
ISSN: 2715-4211 DOI: https://doi.org/10.26877/asset.v5i3.17126

Effect of Chitosan Variation in Starch and Cellulose Based Biofoam

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Abstract. Styrofoam's using as packaging is increasing. Styrofoam is difficult to decompose so alternatives such as biofoam are needed. This study explores the creation of eco-friendly packaging material by varying cellulose (0%, 3%, 5%, and 7%) and chitosan concentrations (0%, 2%, 4%, 6%, 8%, and 10%) in biofoam, aiming to replace non-biodegradable Styrofoam. Production is carried out by delignifying sugarcane bagasse and corn cobs with 10% NaOH, making tofu pulp starch and biofoam. The research focuses on tensile strength, absorption capacity, biodegradation, and morphology of the biofoam. Results indicate that chitosan concentration affects water absorption and biodegradation, while cellulose impacts tensile strength. The findings highlight the potential of biofoam made from tofu dregs, corn cobs, and sugar cane bagasse, offering a promising alternative to Styrofoam

Keywords: Styrofoam, bagasse, corn cobs, and biofoam.

(Received 2023-10-06, Accepted 2023-10-22, Available Online by 2023-10-26)

1. Introduction

The use of Styrofoam as food and drink packaging has become a practical part of human lifestyle in recent years. The application of styrofoam as a packaging material is because styrofoam has the advantages of being practical, light and economical. Based on information provided by the Ministry of the Environment and Forestry (KLHK) on the website karet6.com published on February 16 2021, the increase in packaging material waste, especially plastic and styrofoam, jumped to 27-36% during the pandemic to the new normal era. The increase in the number of Styrofoam users is caused by people's new habits of preferring to buy food and take it home to avoid the spread of the covid-19 virus.

An increase in the amount of styrofoam waste will cause many problems for the environment due to the nature of styrofoam which is difficult to decompose naturally and if burned it will produce dioxin compounds which are carcinogens [1]. One alternative that can be used as a substitute for styrofoam is biodegradable foam (biofoam). Biodegradable foam is an alternative packaging material that can be made from starch and cellulose [2]. One of the studies on biofoam was carried out by Nanik who used

sago starch with the addition of chitosan. Research shows that the addition of chitosan can provide biofoam characteristics that are stronger and do not easily absorb water. This is because chitosan has amine, primary, and secondary hydroxyl functional groups [2]. Apart from that, research on biofoam has been carried out by Bangkit using tea dregs waste. This research shows that the addition of pulp fiber causes an increase in tensile strength and an increase in water absorption capacity. This is caused by individual fibers and fiber length in the composition of biofoam [3].

Biodegradable foam (Biofoam) is an alternative replacement for Styrofoam packaging using the main raw material in the form of starch so that the alternative packaging can decompose naturally [4]. The main ingredient that is widely used in making biodegradable foam is starch. The use of starch as an alternative main ingredient for making biofoam is because starch has several advantages, namely that it can be renewed, is an abundant raw material in nature and is easily degraded. Starch also has special properties such as the ability to expand and is easily modified. However, biofoam made from pure starch still has shortcomings, namely that it is brittle and easily absorbs water. To increase the strength and flexibility of starch-based biofoam, additives can be added including plasticizers, modified starch, synthetic polymers, and fibers [5].

The process of making biofoam can be done using several methods, including using thermopressing technology and a baking process where starch, fiber and other additives are mixed with a certain composition. Biofoam can be made with a main mixture of starch and fiber. Starch is used in its manufacture because it is cheap and easy to obtain, low in toxicity and easily decomposed. However, the use of starch alone will greatly reduce the strength value of the product produced and has a very low resistance value to water absorption so to increase the strength and flexibility properties of the product, fiber is added to improve its mechanical properties [3].

2. Methods

2.1. Design Process for Making Biofoam

The design process for making biofoam, it begins with making cellulose, followed by making starch and then the stage of making the biofoam itself. Cellulose was prepared from sugar cane bagasse and corn cobs. Tofu dregs were used for starch. Biofoam was made with varying cellulose (0%, 1%, 3%, 5%, 7%) and chitosan (0%, 2%, 4%, 6%, 8%, 10%) concentrations. Testing included tensile strength, absorption capacity, biodegradation, and SEM analysis.

2.1.1. Materials

In the process of preparing the materials and making the biofoam, the main ingredients were tofu dregs obtained from the tofu production center in the Kelapa Dua area of Depok, sugar cane dregs obtained from the Tumpah Pesona Square market, Depok, and corn cobs. The material used to make starch is distilled water. The materials used to make cellulose are Sodium Hydroxide (NaOH), Aquadest, and Hydrochloric Acid (HCl). The material used to make biofoam is Polyvinyl Alcohol (PVA); Magnesiumstearate and chitosan

2.1.2. The Process of Making Cellulose

In the process of making cellulose, the dried sugar cane bagasse and corn cobs are then chopped to reduce the fiber surface. The bagasse and corn cobs that had been chopped and dried were each weighed at 1 Kg and carried out a delignification process with 1 L of 10% Natrum Hydroxide (NaOH) and heated at a temperature of 121^{o}C while stirring for 15 minutes. The resulting cellulose is then washed with distilled water until it is clean and neutral. The cellulose was then dried in an oven at 100^{o}C for 5 hours [6].

2.1.3. Starch Manufacturing Process

In making starch, tofu dregs obtained from tofu production centers are cleaned. Tofu dregs are added with water 1:1. The tofu dregs that have been added to water are then filtered using a filter cloth to take

the filtrate. Then leave the tofu dregs filtrate for 24 hours until a starch precipitate forms which is then separated from the filtrate. The tofu dregs are then dried and mashed [7].

2.1.4. Process of Making Biofoam

In the process of making biofoam, the prepared cellulose is then weighed according to variations of 0%, 1%, 3%, 5% and 7%. Starch is added as much as 85% of the total weight of the dough assuming the total weight of the dough is 100 grams. The starch and cellulose mixture was weighed and 5% of the weight of the dough was added with magnesium stearate. Polyvinyl Alcohol (PVA) is added as much as 10% by weight of the total mixture. Aquadest is added to as much as 40% of the total dough weight. Chitosan was added according to variations of 0%, 2%, 4%, 6%, 8%, and 10% of the dough weight. After obtaining the perfect mixture of ingredients, stir until the dough expands. The finished dough is then molded and heated in the oven at 120 ^{o}C for 1 hour jam [2]. The following is a flow diagram of the biofoam making process.

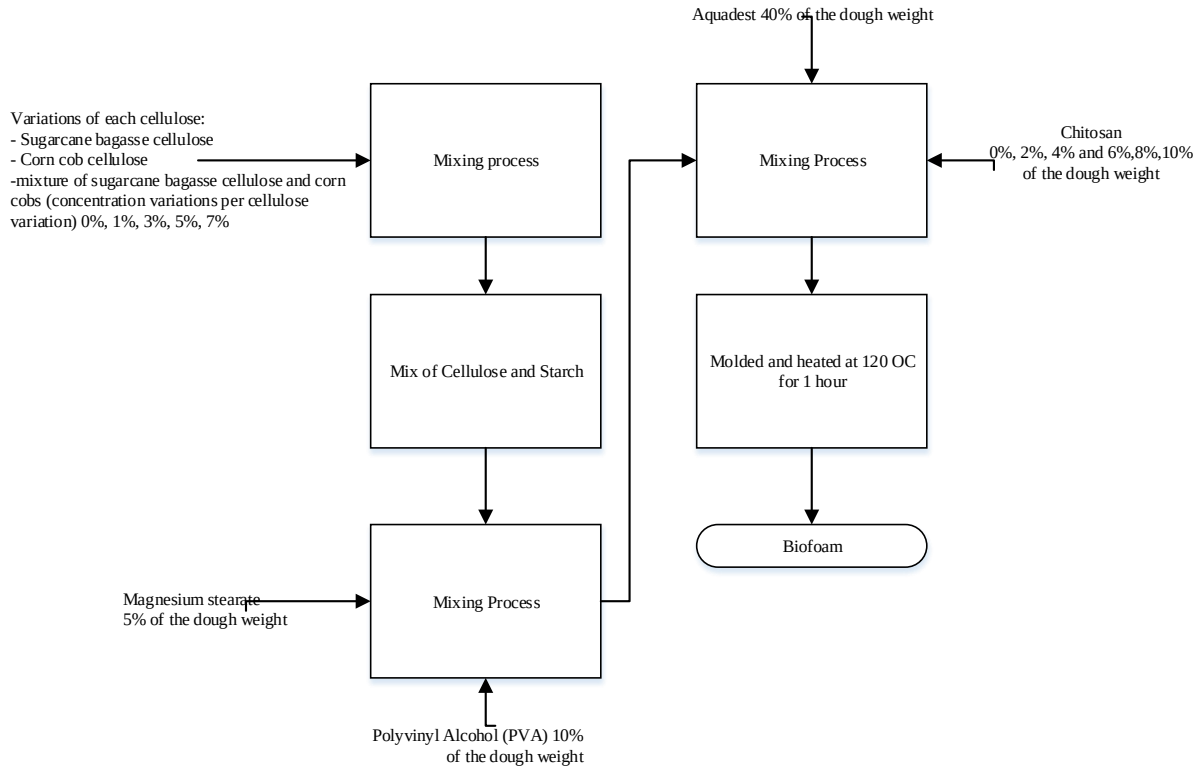


Figure 1 Research Metodology

2.2. Sample Testing Procedure

2.2.1. Tensile Strength Test

The biofoam to be tested is adjusted to size. The size of the biofoam is adjusted to the standard size that will be used. Standard ASTM D-638 size type 1 with a maximum length of 16 cm and thickness < 7 mm. The customized biofoam sample is then clamped at both ends to the grip. The biofoam sample was then tested by pulling it until it broke with a tensile strength tool. The test results in the form of maximum break were recorded as the tensile strength of the biofoam [6].

2.2.2. Absorption Test

The biofoam that was tested was adjusted to a size of 2.5 cm x 5 cm. The biofoam was then dried in the oven for 5 minutes at a temperature of 40-50 °C. Biofoam is weighed as an initial weight. The 500 mL glass cup that has been prepared is then filled with distilled water to ¼ volume. The biofoam to be tested for absorption is placed in a glass cup filled with water for 1 minute. After one minute, remove the biofoam and dry the surface a little. The dried biofoam is then weighed as the final weight [6].

2.2.3. Biodegradation Rate Test

The Biofoam to be tested is adjusted to a size of 2.5x5 cm. The biofoam that has been adjusted to size is then weighed as the initial weight. The biofoam samples were then planted in the soil for 21 days. Checks are carried out every 7 days by weighing the biofoam to determine the level of degradation. After 21 days the sample was then removed and cleaned then weighed again as the final weight [6].

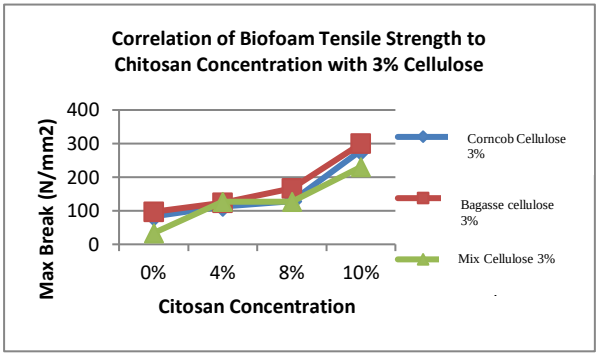
2.2.4. Biofoam Morphology Test using SEM

The Biofoam to be tested is adjusted to a size of 3x3 cm. Biofoam that has been adjusted to size is then placed in the sample compartment. Biofoam was read using Prisma E SEM ThermoFisher Scientific at 100x and 1000x magnification.

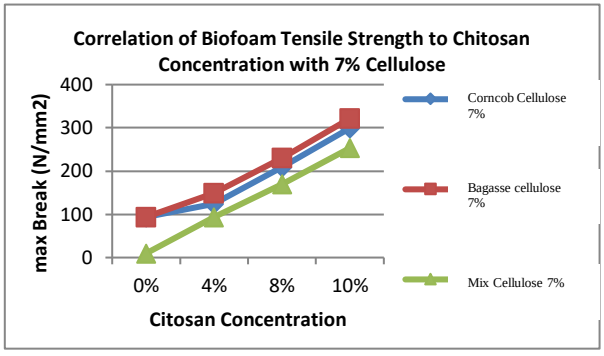
3. Results and Discussion

3.1. Tensile Strength Test

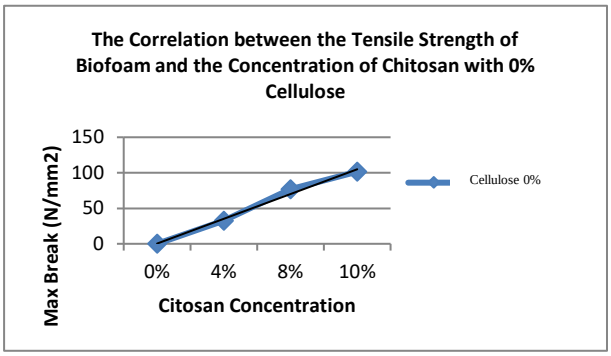
Tensile strength testing was carried out on biofoam both with the addition of cellulose from bagasse, corn, mixtures and without the addition of cellulose. The greater the tensile strength value of a material means a greater force is needed to pull the material. The effect of the composition ratio of cellulose and chitosan on the tensile strength of biofoam as in Figure



(a)



(b)



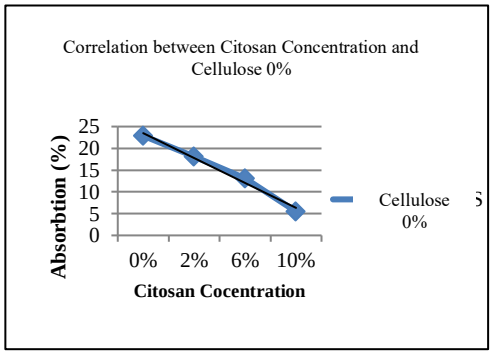
(c)

Figure 2. Graph of the correlation between the tensile strength of biofoam and the concentration of chitosan (a) The correlation between the tensile strength of biofoam and the concentration of chitosan with 3% cellulose (b) The correlation between the tensile strength of biofoam and the concentration of chitosan with cellulose 7% (c) The correlation between the tensile strength of biofoam and concentration chitosan with 0% cellulose

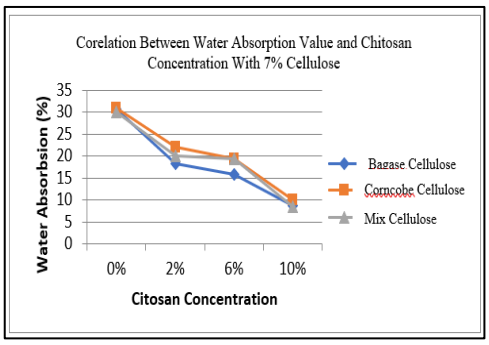
The graph shows biofoam's strength increased with higher sellulose. Cellulose concentration was tested at concentrations of 0%, 3%, and 7%. The increasing amount of cellulose will increase the strength between the phases of biofoam. The strength between these phases provides a biofoam effect that can withstand tension so that the tensile strength increases [3]. This increase in tensile strength value is in accordance with research conducted by Nanik Hendrawati (2017) that increasing the amount of chitosan will increase the tensile strength of biofoam [4].
The graph shows that biofoam's strength increased with higher cellulose concentrations, with bagasse cellulose showing superior results (graph with orange line). The tensile strength value of bagasse cellulose is caused by the crude fiber component that dominates bagasse cellulose, which is 36.75% [8]. Long fiber size as a filler will increase the biofoam's resistance strength which will make the tensile strength value greater [3].
Based on data from Prodcut Information Commercial regarding the mechanical properties of styrofoam, the mechanical strength of styrofoam is 0.1 Mpa or 1 N/mm2. Based on the results obtained from this research, the tensile strength value was obtained at a value of more than 0.1 MPa [3]. Based on this data, the biofoam produced from the application of tofu dregs, sugar cane bagasse and corn cobs meets the tensile standards of commercial Styrofoam.

3.2. Water Absorption Test

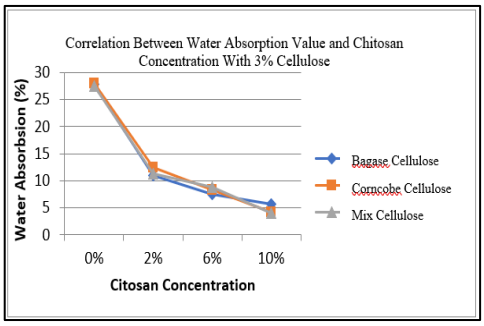
Water absorption capacity is the ability of a material to absorb water. The water absorption test is an important parameter to find out whether biofoam can easily absorb water or not. This parameter can be used as an indication of the suitability of biofoam in its application as a food packaging material. The following is Figure 3 which presents the corelation between variations in biofoam concentration and the ability of biofoam to absorb water with 0% cellulose.



(a)



(b)



(c)

Figure 3. (a) Graphic image of the correlation between water absorption values and the concentration of chitosan with 0% cellulose. (b) Graphic image of the correlation between water absorption values and the concentration of chitosan with 7% cellulose. (c) Graphic image of the correlation between water absorption values and chitosan concentration with a cellulose concentration of 3%

The graph above shows the effect of chitosan concentration on the ability of biofoam to absorb water. Based on the graphs presented in Figure 3 it appears that chitosan reduced water absorption, especially at higher concentrations. Corn cobs displayed high water absorption due to their hydrophilic nature. The large amount of cellulose in corn cobs 41%, is one of the reasons why corn cobs can absorb more water [9].

Based on the data presented in Figure 3 regarding the comparison graph between cellulose concentration and chitosan concentration, the percentage of water absorption decreases with an increase in the amount of chitosan concentration. The decrease in the amount of water absorbed is caused by the hydrogen bonds formed by chitosan so that it is more hydrophobic. Hydrogen bonds in chitosan are formed due to the presence of amine groups and hydroxy groups. The amine group (NH^{2-}) in chitosan will be protonized to become NH^{3+} which will form hydrogen bonds with OH^{-}, making the biofoam bond stronger and not easily absorbing water [4].

3.3. Biodegradation Test

Biodegradation testing of biofoam produced from research, both with and without the addition of chitosan, aims to find out how much biofoam can decompose naturally when compared to packaging that is widely used, such as styrofoam or plastic. The effect of the comparison of cellulose composition from corn cobs, sugar cane bagasse, and the mixture on the biodegradation value can be seen in the following graph.

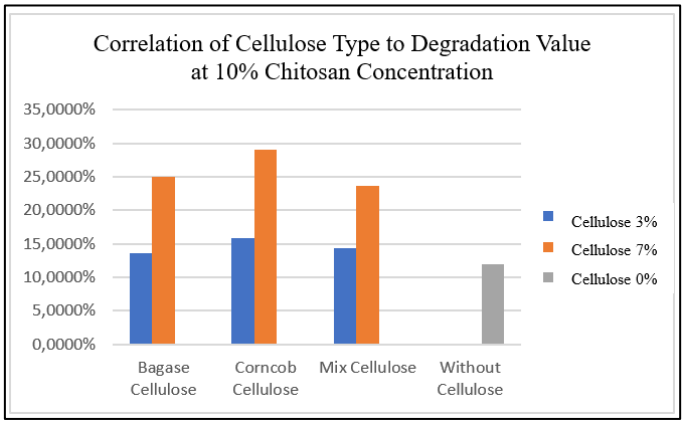


Figure 4. Graph of the correlation between cellulose type and biofoam degradation value

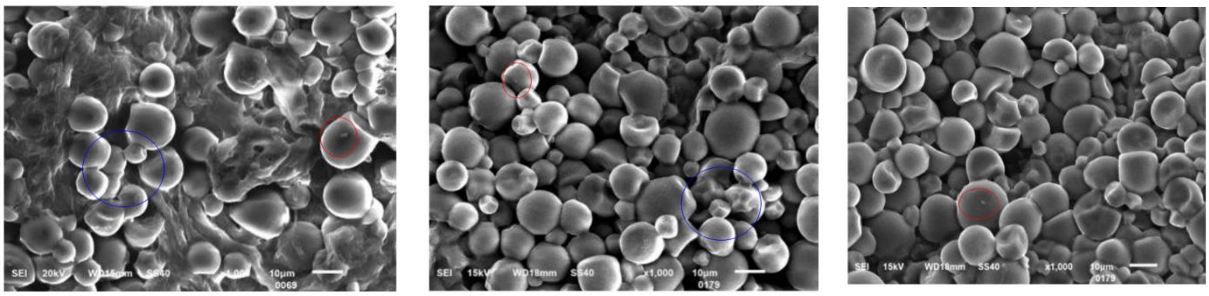
Figure 4. above shows a graph of the correlation between cellulose type and degradation value at a chitosan concentration of 10%. In the graph it can be seen that corn has the highest degradation value among other types of cellulose with a percentage of 15.8820% at a cellulose concentration of 3% and a percentage of 28.9818% at a concentration of 7% under conditions where the chitosan concentration for both is 10%. Corn cellulose exhibited the highest biodegradation rates. Increasing chitosan hindered biodegradation, making the biofoam more resistant. The high biodegradation value of corn cobs is because corn cob cellulose has a fairly high water content of 5.39% [10]. The biodegradation test was carried out under aerobic conditions with the help of microorganisms in the soil using the soil burial test method [13]. The water content in the supporting specimen will increase the ability of bacteria to decompose the specimen. Thus, the biodegradation value of corn cobs is higher than the value of other cellulose.

In this research, chitosan was used as an additive to increase the strength of biofoam and as a coating to reduce the ability of biofoam to absorb water in its environment [4]. The degradation value decreased along with increasing chitosan concentration. A decrease in biodegradation value indicates that biofoam will be increasingly difficult to decompose. The addition of chitosan causes the formation of hydrogen bonds between NH^{3+} from chitosan and OH from starch. The NH^{3+} value will increase with the addition of chitosan and make the biofoam stronger and not easily degraded. Apart from increasing the strength of biofoam, the addition of chitosan can also act as an anti-microbial agent [12].

Based on biodegradation results data, it refers to the Synbra Technology biofoam standard which degrades in less than 48 days. The results obtained in the biodegradation test process for 21 days were in the highest range of 40% - 57%. The biodegradation value will continue to increase if continued until the 48^{th} day. Based on SNI, the biodegradation standard is 89.8% - 90% for less than 180 days. Thus, based on the test reduction interval of 21 days, the biofoam based on tofu dregs, corn cobs, sugar cane bagasse with chitosan as an additive meets the established standards.

3.4. Biofoam Morphology Test with Scanning Electron Microscope (SEM)

Characterization using a scanning electron microscope (SEM) aims to see the morphological structure and determine the interactions that occur between the filler material and the biofoam matrix. Characterization of biofoam with a composition without chitosan, plus 4% chitosan, and 6% chitosan with 5% mixed cellulose can be seen in the following picture



(a) (b) (c)

Figure 5. 10. Morphological characteristics of biofoam (a) Composition 0% chitosan 5% cellulose mixture (b) Composition 4% chitosan 5% cellulose mixture (c) Composition 10% chitosan 5% cellulose mixture

SEM analysis indicated denser biofoam with increased chitosan, showcasing improved interfacial bonding. Figure 5 (a) shows the morphology of biofoam with a composition of 0% chitosan 5% cellulose mixture at 1000x magnification. You can see a rough, dense surface with fibers that dominate and don't look perfectly distributed. In Figure 5 (b) and (c) you can see the density between the starch bound by chitosan. In Figure 5 (a), the interaction of uniformly distributed cellulose in the matrix can improve mechanical properties, but the higher the cellulose concentration, the easier it will be for the biofoam to absorb water. The nature of cellulose which tends to be hydrophilic or prefers water causes cellulose to absorb water from its environment. This will have an effect on microbial activity in biofoam.

Figures 5 (b) and (c) show the morphology of biofoam with concentrations of 4% chitosan and 5% mixed cellulose and 10% chitosan and 5% mixed cellulose, respectively. Figures 5 (b) and (c) show that there has been good inter-phase bonding between chitosan, starch, PVA and cellulose. In picture (b) there are still voids which cause the biofoam to be less impermeable to water. Figure 5 (c) shows the morphology of the denser biofoam. The tighter the bonds between chitosan, the more impermeable the chitosan is to water. The OH bonds formed between chitosan and acetate make the biofoam stronger and does not absorb water.

Magnesium stearate is used as a demolding agent which aims to make the biofoam less sticky when released from the mold. Magnesium stearate is a magnesium compound with a mixture of solid organic acids obtained from fat, its physical form is smooth, shiny white and does not easily dissolve in water so it remains in the form of lumps [11] . In the image above, the morphology of magnesium stearate can be seen in the area marked with a red circle.

4. Conclusion

This study highlights the significant impact of chitosan and cellulose concentrations on biofoam properties. Low chitosan concentrations enhance biodegradation, while higher concentrations improve water resistance. Bagasse cellulose strengthens biofoam, offering promising alternatives to non-biodegradable packaging materials. Further research could explore optimizing these variables for diverse applications, contributing to eco-friendly packaging solutions.

Acknowledgements

The author thank to the Faculty of Industrial Technology, Jayabaya University for the fund has been given

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Advance Sustainable Science, Engineering and Technology (ASSET)
Vol. 5, No.3, October 2023, pp. 0230307-01 ~ 0230307-010
ISSN: 2715-4211 DOI: https://doi.org/10.26877/asset.v5i3.17205

Analysis of Chemical Inventory Control in the GGCP Unit Using Forecasting and EOQ Methods at PT. XYZ

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Abstract. PT. XYZ is a company operating in the energy producing industry. Which has 2 types of products, steam power and electricity. Steam in GGCP contains 3 chemicals, namely Amine, phosphate, oxygen scavenger. However, this company experienced an accumulation of excessive chemical stocks and reduced chemical consumption. This research aims to determine the number of company orders and determine overall inventory costs using forecasting methods and economical order quantities. In calculating the Total Inventory Cost (TIC) results, there is a significant calculation where TIC EOQ has an economical cost for Amine chemicals of IDR. 15,879,937 while the company's TIC is IDR. 36,226,539. with forecast results for Amine chemicals of 4148/ltr, phosphate of 3061/ltr, and scavenger oxygen of 5450/ltr. Meanwhile, the EOQ calculation results obtained a value for Amine chemicals of 1361/ltr, phosphate of 1164/ltr and 1554/ltr for oxygen scavenger chemicals.

Keywords: Inventory Control, Forecasting, EOQ, Chemicals

(Received 2023-10-16, Accepted 2023-10-22, Available Online by 2023-10-22)

1. Introduction

In the current era of development, more and more industries are developing in Indonesia which require support or encouragement from disciplined management to be able to compete in the industrial world. Where many factors become a reference in a business, one of which is a warehouse layout that is less effective and efficient[1]. A warehouse is a temporary storage place for raw materials, process materials and finished materials[2]. If you just arrange it without designing a good warehouse layout, you will experience difficulties in the operational process of an industry. Good warehouse management can minimize costs, time and energy. Every business organization has an inventory planning and management system. Banks have measures in place to manage their cash inventories. Hospitals have ways to manage blood and medication supplies. Authorities, schools, and of course almost everyone. Manufacturing and production organizations handle inventory planning and management[3].

Inventory control is a very important managerial function, because inventory involves the largest rupiah investment in current assets. Apart from that, if there is excessive inventory in the warehouse, it

will cause the risk of loss and damage to goods to be greater. However, if the company does not have sufficient inventory, it can result in increased costs caused by a shortage of raw materials[4]. Raw materials are a top priority and very vital for an industry in its production process[5]. This makes many companies use various methods to manage raw material inventories[6]. The function of inventory for a company is to be able to provide products optimally, smooth production and also minimize or avoid shortages of raw materials[7]. Forecasting isthe process of forecasting a variable (event) in the future based on variable data in the previous period[8].

PT. XZY is a company operating in the energy producing industry. This company has 2 types of products, namely steam and electric power. Steam in GGCP with chemicals Amine, phosphate, oxygen scavenger is pressurized water vapor intended for cooling the ammonia reformer and driving the generator turbine while electric power is electrical energy that is generated or produced from electric power generation facilities for internal and external purposes, in the form of gas turbines. Generator (GTG). However, there are several chemicals that experience a buildup of chemical stocks due to excessive purchasing and lack of chemical consumption, lack of chemical stocks, and difficult to predict.future production numbers. This condition will result in the company being unable to maintain product quality and the company's costs will only focus on storing chemical materials.

Given these conditions, companies need appropriate raw material inventory management with more efficient inventory costs[9]. The methods used to help control raw materials are Forecasting which is a forecasting method to find out future values based on past data and Economic Order Quantity is a method which can minimize total inventory costs and optimal purchases. This method was chosen because this company experienced a buildup of stock caused by excessive purchases where forecasting was also needed to determine the amount of raw materials that needed to be ordered in the next period. So this research aims to determine the number of company orders and determine minimal overall inventory costs.

2. Methods

Data collection was carried out by observation and direct interviews with raw material control management. The data used are storage cost data, ordering cost data, chemical consumption data, and chemical stock availability data. There are 3 chemicals taken, namely Amine, phosphate, and oxygen scavenger. By using 2 methods, namely forecasting with processing predictions calculating single exponential smoothing and doblue exponential smoothing and EOQ.

2.1. Forecasting

It is a prediction of some event or many events that will come. Forecasting or forecasting is also called a very efficient and effective tool[10]. Or interpreted as a form of effort to predict future conditions through testing in the past. This method helps to determine the number of future sales of goods[11].

2.2. Single Exponential Smoothing

Used as a short distance estimate. The model assumes that the data fluctuates around a fairly stable average range[12]. The following is the formula for the single exponential smoothing method[13] that is :

$$Y't+1=\alpha .Tt+(1-\alpha).Y't \quad (1)$$

Information :

Nr = demand data in period t
α = smoothing factor/ constant
Y't+1 = forecast for period t

2.3. Double Exponential Smoothing

This method is used when the data shows a trend. Exponential smoothing with a trend is like simple smoothing except that two components must be updated every period – the level and the trend. Levels are smoothed estimates of the data values at the end of each period. Trend is a smoothed estimate of average growth at the end of each period[14].

2.4. Economic Order Quantity

It is a method of inventory management with efficient inventory purchasing control techniques by minimizing the total cost of ordering and storage costs[15]. The formula used in solving problems using the EOQ method is:[16]that is :

- Calculation of the optimal order level

$$Q = \sqrt{\frac{2.D.S}{H}} \quad (2)$$

- Safety stock calculation

$$SS = Z\ x\ \alpha \quad (3)$$

- Calculation of purchase frequency

$$F = \frac{D}{Q} \quad (4)$$

- Re-order point calculation

$$ROP = (D\ x\ L) + SS \quad (5)$$

- Calculation of total inventory costs

$$TIC = (+ (\frac{D}{Q}\ x\ S)\frac{Q}{2}\ x\ H) \quad (6)$$

Information :

Q = Optimum number of units per order (EOQ)
D = Number of requests for a period
S = Ordering costfor each order
H = Storage costs per unit per year
SS = is a safety stock.
Z = is the normal standard deviation (standard level).
A = is the standard deviation of the level of need
ROP =is the reorder point
L = is the lead time or waiting time.

3. Results and Discussion

Data collection

The data collection process was carried out by means of interviews and direct observation, the following data were obtained:

a. Chemical demand data for 1 year

Table 1. Chemical demand 1 year

Month	Demand (Liters)		
	Amine	***Phosphates***	***Oxygen scavenger***
Jan	225	225	225
Feb	375	375	375
Mar	450	450	450
Apr	675	675	675

May	450	450	450
Jun	400	400	400
Jul	250	250	250
Aug	500	500	500
Sept	125	125	125
Oct	425	425	425
Nov	350	350	350
DES	675	675	675
Total	**4900**	**3450**	**5700**

(Source: Company data)

b. Lead time data

*Lead time*is the time interval between ordering a product until the product is received. This data is used to determine the right time to place an order for the product so that the product arrives at the right time.

Table 2. Chemical lead time data

No.	**Chemical material**	***Lead time*(Sunday)**
1	Amine	**3**
2	Phosphate	**3**
3	**Oxygen Scavanger**	**3**

(Source: Company data)

c. Holding cost data

Carrying costs are the costs incurred by a company to store a product for a certain time before the product is released due to demand.

Table 3. Holding costs

Electricity cost		**Total**
air conditioning	Rp. 311,904	Rp. 500,201
Lamps (3)	Rp. 124,761	
Computer	Rp. 63,536	
Labor costs		
Warehouse staff	Rp. 6,750,000	Rp. 11,350,000
Security guard	Rp. 4,600,000	
Maintenance costs		
Maintenance costs	Rp. 490,000	Rp. 490,000
Total costs in 1 month		**Rp. 12,340,201**
Total costs in 1 year (12 months)		**Rp. 148,082,412**

(Source: Company data)

Because there is only 1 chemical supplier, the calculation of holding cost per liter is directly based on each chemical. Holding cost/chemical formula = (Total cost x percentage (chemical))/D.

Example of Amine holding costs

= (RP. 148,082,412 x 32.96%)/4184

= RP. 48,804,790/yr

For further chemicals, see the following table.

Table 4. Chemical holding cost data

Chemical material	***Demand* Chemicals 1 year (Liter)**	***Percentage***	***Holding costs* (Rupiah)**
Amine	4184	32.96%	Rp. 11,664
Phosphate	3061	24.11%	
Oxygen scavenger	5450	42.93%	
Total	**12695**	**100%**	

(Source: Company data)

d. Message cost data
These costs are costs incurred for goods ordering activities, starting from ordering until the goods are available.

Table 5. Message fees

Electricity cost		**Total**
air conditioning	Rp. 311,904	Rp. 375,440
Computer	Rp. 63,536	
Labor costs		
Warehouse staff	Rp. 6,750,000	Rp. 6,750,000
Internet costs		
Internet costs 100 mbps	Rp. 625,000	Rp. 625,000
Total costs in 1 month		**Rp. 7,750,440**

(Source: Company data)

Because the chemical supplier only has 1 partner, the ordering cost calculation directly looks for each jerry can. The ordering cost formula for each jerrycan = total cost / amount of chemicals
= Rp. 7,750,440/3
= Rp. 2,583,480/ltr

Data processing

Forecasting calculations

This experimental method is used to determine the demand for chemicals in the next year. Where forecasting techniques are used to determine the size of demand which is very close to the actual value. This research uses two methods, namely single exponential smoothing (Single Exponential Smoothing) and double exponential smoothing (Double Exponential Smoothing). The following is the processing of requests for chemicals (Amine, phosphate, oxygen scavenger) using the Single Exponential Smoothing method $\alpha = 0.3$.

Table 6. Calculation of Amine error using the Single Exponential Smoothing method

Period	***Demand***	***Single exponential smoothing***				
		Forcast	***Error***	**|e|**	**(e^2)**	**|e/At|x100%**
1	225					
2	375	4	-371	150.00	22500.00	40.00%
3	450	-107.3	-557.3	105.00	11025.00	23.33%
4	675	-274.49	-949.49	246.00	60516.00	36.44%
5	450	-559,337	-1009.34	175.80	30905.64	39.07%

6	400	-862.138	-1262.14	85.16	7252.23	21.29%
7	250	-1240.78	-1490.78	167.03	27899.69	66.81%
8	500	-1688.01	-2188.01	216.59	46912.79	43.32%
9	125	-2344.42	-2469.42	331.68	110012.47	265.35%
10	425	-3085.24	-3510.24	233.66	54598.75	54.98%
11	350	-4138.32	-4488.32	28.27	799.04	8.08%
12	675	-5484.81	-6159.81	319.35	101982.22	47.31%
Total	4900	-19780.8	-24455.8	2058.54	474403.82	**645.98%**
			89.50193	20626.25		28.09%
			MAD	**MSE**		**MAPE**

Table 7. Calculation of Amine error using the Double Exponential Smoothing method

Period	***Demand***	***Double exponential smoothing***						
		ICE	***Trends***	***Forcast***	***Error***	**|e|**	**(e^²)**	**|e/At|x100%**
1	225							
2	375	225	0	225	150	150	22500	40.00%
3	450	270	9	279	171	171	29241	38.00%
4	675	330.3	17.46	347.76	327.24	327.24	107086	48.48%
5	450	445,932	33.6024	479.5344	-29.5344	29.5344	872.2808	6.56%
6	400	470.6741	25.10986	495.7839	-95.7839	95.78394	9174.562	23.95%
7	250	467.0488	14.34085	481.3896	-231.39	231.3896	53541.15	92.56%
8	500	411.9727	-2.4107	409,562	90.43797	90.43797	8179.027	18.09%
9	125	436.6934	3.497721	440.1911	-315,191	315.1911	99345.45	252.15%
10	425	345.6338	-16.1133	329.5205	95.47949	95.47949	9116.334	22.47%
11	350	358.1644	-7.16186	351.0025	-1.00249	1.00249	1.004986	0.29%
12	675	350.7017	-5.78964	344.9121	330.0879	330.0879	108958	48.90%
Total	4900	4112.121	71.53533	4183.656	491.3438	1837.147	448014.8	**591.44%**
					44.67	167.01		53.77%
					MAD	**MSE**		**MAPE**

Table 8. Calculation of MAD, MSE, MAPE for Phosphate chemicals

METHOD	**MAD**	**MSE**	**MAPE**
SINGLE ES	57.43	9441.33	23.13%
DOUBLE ES	14.90	106.34	46.78%

Table 9. MAD, MSE, MAPE results for oxygen scavenger chemicals

METHOD	**MAD**	**MSE**	**MAPE**
SINGLE ES	81.37	20295.02	26.88%
DOUBLE ES	-20.45	151.32	50.74%

Based on the calculations in tables 6, 7, 8, and 9, it can be concluded that the forecasting results using the double exponential smoothing method are better than the single exponential smoothing method. This is proven by the MAD value of the double exponential smoothing method being smaller than the single exponential smoothing method. Where the MAD value of double exponential smoothing for Amine chemicals is 44.67, phosphate is 14.90, and oxygen scavenger is -20.45. Meanwhile, single exponential smoothing for Amine chemicals was 89.50, phosphate was 57.43, and oxygen scavenger was 81.37. So companies can use the double exponential smoothing method to be able to predict demand for three chemicals in the future.

EOQ (Economic Order Quantity) Calculation

After forecasting demand, the next stage in this research is calculating the optimal order quantity using the EOQ method. The following is the data needed for this calculation, namely:
D = Demand Amine = 4184, phosphate = 3061, oxygen scavenger = 5450
S = Order Cost Rp. 2,583,480
H = Storage costs Rp. 11,664
L = Lead time 3 weeks
So the settlement of chemicals based on the EOQ method can be completed as follows:

$$Q\ Amine = = \sqrt{\frac{2.D.S}{H}}\sqrt{\frac{2x4184x2.583.480}{11.664}}1361$$

$$Q\ phosphate = = \sqrt{\frac{2.D.S}{H}}\sqrt{\frac{2x3061x2.583.480}{11.664}}1164$$

$$Q\ oxygen\ scavenger = = \sqrt{\frac{2.D.S}{H}}\sqrt{\frac{2x5450x2.583.480}{11.664}}1554$$

So ,The optimal frequency of ordering chemicals that needs to be made by the company based on the EOQ calculation for one Amine order is 1361/ltr, phosphate is 1164/ltr, and oxygen scavenger is 1554/ltr.

Safety Stock Calculation

*Safety stock*is the company's ability to create inventory conditions that are always safe or full of security with the hope that the company will never experience a shortage of inventory. The following is a calculation of safety stock for chemicals. The following is the calculation:

Amine chemicals	SS = zxσ = 1645 x 1107 = 1821 ltr
Phosphate chemicals	SS = zxσ = 1645 x 810 = 1332 ltr
Oxygen scavenger chemicals	SS = zxσ = 1645 x 1442 = 2372 ltr

So,with a standard deviation of 1645, the chemical safety stock that the company needs to have is Amine of 1821/ltr, phosphate 1332/ltr, and oxygen scavenger of 2372/ltr.

Purchase Frequency Calculation

The optimal frequency of purchasing chemicals can be solved by calculating as follows:

Amine chemicals $F = = \frac{D}{Q}\frac{4184}{1361} = 3{,}07 \approx 3$

Phosphate chemicals $F = = \frac{D}{Q}\frac{3061}{1164} = 2{,}62 \approx 3$

Oxygen scavenger chemicals $F = = \frac{D}{Q}\frac{5450}{1554} = 3{,}50 \approx 4$

So,The optimal frequency of chemical purchases that companies need to make is Amine 3 times, phosphate 3 times, while oxygen scavenger 4 times a year.

Re-Order Point Calculation

If it is assumed that the company has 52 weeks to work, then to obtain an accurate reorder point size it can be completed as follows:

a. Calculating average monthly demand:

Amine $= d = \frac{D}{n} = \frac{4184}{12} = 348{,}66 \approx 349$

Phosphates $= d = \frac{D}{n} = \frac{3061}{12} = 255{,}08 \approx 255$

Oxygen scavenger $= d = \frac{D}{n} = \frac{5450}{12} = 454{,}16 \approx 454$

b. *Lead time*booking: 3 weeks

c. Calculating ROP

Amine = ROP = d x L + SS = 349 x 3 + 1821 = 2867

Phosphates = ROP = *d x L* +SS = 255 x 3 + 1332 = 2098

Oxygen scavenger = ROP = d x L + SS = 454 x 3 + 2372 = 3735

So,Based on the results of the ROP calculation, the company needs to reorder chemicals if the inventory has reached an Amine inventory quantity of 2867/ltr, phosphate of 2098/ltr, oxygen scavenger of 3735/ltr.

Calculation of Total Inventory Cost (TIC)

TIC here aims to prove that if there is an optimal amount of raw material purchases, which is calculated using the EOQ method, it will be achieved if the total cost of raw material inventory is minimal. The following is the TIC calculation for chemicals as follows:

TIC EOQ Amine $= \left(\frac{D}{Q}\ x\ S\right) + \left(\frac{Q}{2}\ x\ H\right)$

$= \left(\frac{4184}{1361}\ x\ 2.583.480\right) + \left(\frac{1361}{2}\ x\ 11.664\right)$

= Rp. 15,879,937

Phosphates = Rp. 13,582,653

Oxygen scavenger = Rp. 18,123,880

Total =**Rp. 47,586,478**

So, The TIC from the EOQ calculation that must be paid by the Amine chemical company is IDR. 15,879,937, phosphaste of Rp. 13,582,653, and oxygen scavenger Rp. 18,123,880/year. With a total of Rp. 47,586,478/year. Meanwhile, TIC issued based on company policy can be calculated as follows:

TIC Amine company = 5,224,780 + (2,583,480 x 12)

=Rp. 36,226,539

Phosphates = Rp. 34,476,846

Oxygen scavenger = Rp. 37,247,194

Total =**Rp. 107,950,579**

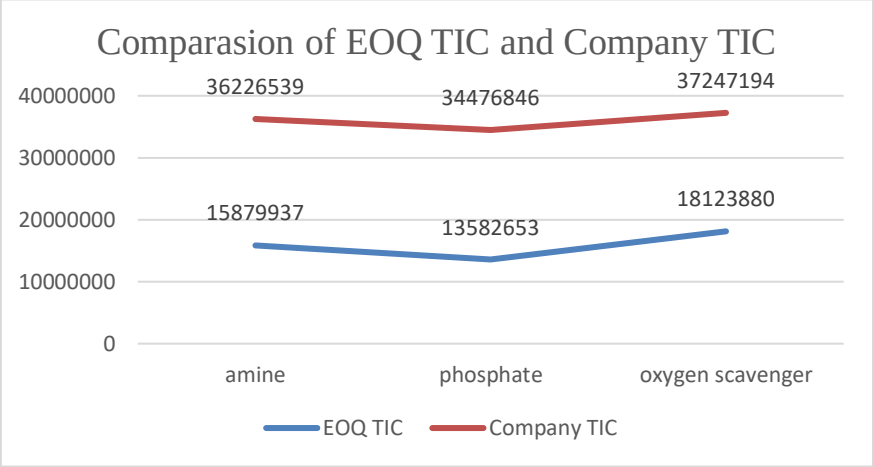

Figure 1. Comparasion TIC

So, based on company policy where chemical orders are made every month, the costs that will be incurred are Rp. 36,226,539, phosphate Rp. 34,476,846, and oxygen scavenger Rp. 37,247,194/year. With a total of Rp. 107,950,579.

4. Conclusion

Based on the results of research using the forecasting and EOQ methods, it was concluded that the forecasting and EOQ methods were more precise and optimal than the company's. This research has forecast results for demand for Amine chemicals of 4184/ltr with the best MAD test result of 44.67. The optimal purchase frequency is 1361/ltr with 3 purchases a year. Orders can be made if the Amine inventory level has reached ROP at 2867/ltr. ltr, and the company gets a safety stock size of 1821/ltr. After that, the phosphate chemical has a forecasting result of 3061/ltr, with the best MAD test result of 14.90. The optimal purchase frequency is 1361/ltr with 3 purchases a year. Orders can be made if the phosphate inventory level has reached the ROP in 2098. /ltr, and the company gets a safety stock size of 1332/ltr. And the chemical oxygen scavenger is 5450/ltr with the best MAD test result of -20.45. The optimal purchase frequency is 1554/ltr with 4 purchases a year. Orders can be made if the oxygen scavenger inventory level has reached ROP at 3735/ltr. and the company got a safety stock size of 2372/ltr. The TIC calculation also produces results for 3 chemicals where the TIC EOQ gets a value ofRp. 47,586,478/year Meanwhile, the TIC issued based on company policy is IDR. 107,950,579. So that an economic value is obtained when calculating TIC using the EOQ method.

This research has limitations in the methods taken, because both methods have the same similarities and shortcomings. In future research, it is hoped that the data samples will be taken over one year and can represent the data needed. Apart from that, further research can use or choose other methods to determine accurate total inventory costs

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Advance Sustainable Science, Engineering and Technology (ASSET)
Vol. 5, No.3, October 2023, pp. 0230308-01 ~ 0230308-09
ISSN: 2715-4211 DOI: https://doi.org/10.26877/asset.v5i3.17182

Monitoring and Automation System for Bird Feeding and Drinking Based on Internet of Things Using ESP32

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Abstract. Birds are vertebrate animals characterized by feathers and wings. Their melodious sounds and colorful plumage make them a popular choice for bird breeders, which presents a promising business opportunity. Manual feeding and drinking requires farmers to feed and drink every day, which often results in delayed feeding and drinking or inconsistent dosing, causing birds to become susceptible to disease and death. Therefore, this study is intended to create an automated system for monitoring feed and drink at predetermined times utilizing the Internet of Things (IoT) concept. The system's schedule can be remotely accessed and monitored through a website, and it operates in real-time without requiring manual intervention. This allows farmers to monitor and provide birds with food and water even from a distance. The Internet of Things (IoT) system utilized in this research employs an ESP32 microcontroller as the primary controller, which connects to a Wi-Fi network. It features a servo motor designed to refill bird feeders and drinkers. Further, a mini pump is used to replenish water in the drinker based on the owner's predetermined schedule set via the application. The research concludes that the tool functions based on the input time on the website. The system sends notifications to the breeder's smartphone regarding successful feeding and drinking, with an error rate of less than 20% in system testing and over 80% accuracy in system functioning. The outcome is in the form of a tool dispensing feed and drink daily, in accordance with the breeder's specified hours.

Keywords: Monitoring, Internet of Things, Website, ESP32, Sensor

(Received 2023-10-10, Accepted 2023-10-22, Available Online by 2023-10-29)

1. Introduction

With the development of technology today, many activities require technology to facilitate daily work and business. One of them is the Internet of Things (IoT) technology. IoT is a computing and communication model used in everyday objects that are connected to the internet [1]. IoT, or the Internet of Things, refers to objects that are able to exchange data with other objects over the internet. The IoT architecture consists of three layers: the physical layer, the transport layer, and the application layer. The physical layer is comprised of a range of devices, such as sensors and actuators, that can be controlled and manipulated remotely. The transport layer is responsible for the network layer used to transmit data

and connect to servers. While the hardware layer refers to the physical components of a system, the application layer encompasses software such as apps and websites which serve as user interfaces for obtaining information and remotely controlling devices [2]. With IoT, we can utilize applications that require data, automation, and control [3]. IoT has consistently influenced and changed our society, such as urban areas, agriculture, animal husbandry, transportation, residential environment, and health [4]. IoT plays a vital role in the real-time monitoring of livestock [5].

Birds belong to the class Aves, as determined by expert and scientific data. The global population of birds comprises approximately 9,700 species (~92% of all existing bird species) [6]. Birds that are kept can basically give satisfaction to their owners because they can produce melodious sounds and colors of bird feathers [7]. Many people have a hobby of breeding birds making it a promising business opportunity, ranging from small to large-scale operations [8]. Regularly providing proper nutrition, feeding, and hydration is crucial in maintaining bird husbandry [9]. Birds that lack of nutrients are susceptible to disease which can decrease the health state of birds and cause death [7]. To solve this problem, an IoT system that can monitor bird feeding and drinking automatically with a specified time using a website is needed so that birds do not experience hunger when left by the breeder.

ESP32 is a microcontroller introduced by Espressif System Company (Shanghai, China) which is the successor of the ESP8266 microcontroller. The ESP32 features a dual-core processor, Wi-Fi and Bluetooth connectivity, general-purpose input/output (GPIO) pins, and low power consumption. ESP32 is often recognized as a metal-cased module positioned on a larger board for the addition of other components [10]. The ESP32 microcontroller has gained popularity due to its technical characteristics, software support, and the ability to use multiple programming languages [11]. Usually, the ESP32 microcontroller serves as the core of a range of tools to support specific applications such as real-time audio processing or Internet of Things-based systems [12]. The microcontroller is affordable and includes a built-in module for WiFi and dual-mode Bluetooth, embedded within a small chip [13].

In the research conducted, the author found one farm that still feeds and drinks birds by hand. On this farm there are 2 types of cages, livestock cages and hanging cages. The livestock cage contains 2 birds and there are 2 sizes, namely 15 large cages with a size of 2m x 3m and 15 small cages with a size of 1m x 40cm, while the hanging cage contains 1 bird and there are 2 sizes, namely 7 round cages with a diameter of 60cm and 15 box cages with a size of 40cm x 40cm. The farmer manually feeds the birds every morning from 7:00 to 9:00 and supervises their feeding and drinking every afternoon at 4:00. Each bird requires 10g-15g of feed and 50ml-100ml of drinking water per day. Inconsistent dosage of food and water can lead to starvation or overfeeding of the birds, resulting in deaths that cost $10-15 million per bird.. Problems in nutrition management using manual techniques often result in human error and inconsistent feeding and drinking patterns, primarily caused by delays in managing bird feed and water[14].

In previous research [15] discussed the design of an automatic chicken farm monitoring system using Arduino Uno, this system can monitor temperature, humidity and calculate the average weight of chickens. The results of the study [15] are a circuit that is able to measure the temperature and humidity of the cage and the average weight of chickens in the cage and in this study using the Blynk application for cage control. In research [16] discusses the feed monitoring system in lovebird cages using the ESP8266 microcontroller. The system designed in research [16] can provide automatic feed remotely using the Blynk application. From research [15], [16] can be developed by adding features of automatic animal feeding and drinking and the system can be monitored using a website so that it can be opened using several devices to make it easier for farmers to monitor livestock.

To develop the system, Monitoring and Automation System for Bird Feeding and Drinking Based on Internet of Things using ESP32, was using ESP32 as the main controller. Bird owners can input the time of feeding and drinking using the website, which can be accessed by multiple devices facilitating monitoring of the coop. The data will be sent to the firebase database to be seen by the microcontroller and give commands to the servo motor which is the driving force to fill the bird feeders and in the bird drinking place. A mini pump has been provided to channel water from the water storage to the bird drinking container. The HC-SR04 ultrasonic sensor detects the availability of feed and water in the bird's

feed and water supplies. Additionally, a DHT22 sensor measures the temperature and humidity of the bird cage. The ESP32 microcontroller camera serves as a real-time camera sensor to monitor the bird's feed and drink place. This system must be connected via a Wi-Fi network to function properly. All schedules for bird feeding and drinking will be automatically uploaded to the Firebase database for display on the website.

2. Methods

In this research, there are research stages which are divided into several stages, namely identifying problems, literature study, observation and determination of case studies, data collection, system design, tool assembly, testing, and evaluation and conclusions.

2.1 System Block Diagram

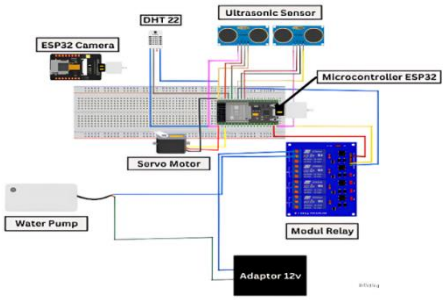

Figure 1. System Block Diagram

In Figure 1, the circuit can be explained as follows, the ESP32 microcontroller functions as the main control that can carry out pre-programmed instructions both in processing data, reading sensors, and moving sensors. The Servo Motor will open and close the bird feed container door. Ultrasonic Sensor serves to control the height of feed and water in the bird feed and drinking water supply. Relay module serves to connect electric current to the water pump so that the water pump can run. DC Water Pump will suck the water in the water supply and then flowed to the minimal place of the bird. DHT22 sensor serves to measure temperature and humidity in bird cages. ESP32 Camera functions as a camera that can monitor the condition of the bird cage directly and in real-time. The website is used for inputting and monitoring the bird's feed and drink schedule. Firebase serves for data storage on the system. 12V adapter serves to convert AC current into DC current.

2.2 Flowchart

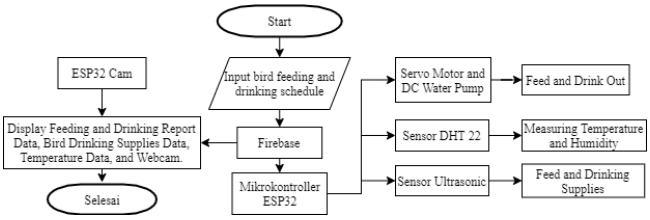

Figure 2. System Workflow Diagram

Figure 2 is the workflow of the monitoring system when the farmer (user) inputs a bird feeding and drinking schedule containing the dose and time of bird feeding and drinking. After the data is inputted and sent to firebase to be stored, it is displayed on the schedule input page and sent to the microcontroller. On the microcontroller there is a real-time clock API that will synchronize with the time that has been inputted on the website. The microcontroller also adjusts the feed and drink doses according to what is inputted, then sends a signal to the servo motor and water pump to remove the bird feed and drink. After removing the feed and drink, the sensor will send a data report to the microcontroller, continued to Firebase and then displayed on the website. In the feed and water supply, the ultrasonic sensor will measure the availability of bird feed and water and send it to the microcontroller, continued to Firebase and displayed on the website. In the camera sensor, a webcam will appear on the website and user's mobile phone the condition of the bird feed and drink directly and in real-time, and the temperature

sensor will calculate the temperature and humidity in the cage which will be stored on Firebase so that it can be displayed on the website.

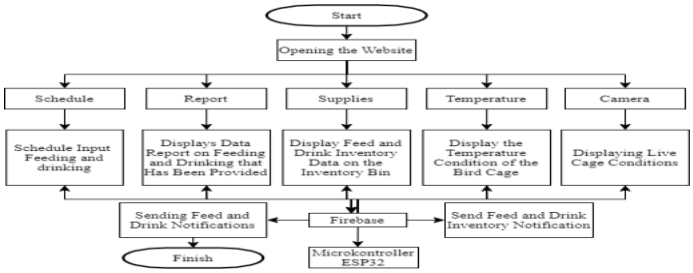

Figure 3. Website Workflow Diagram

Figure 3 displays a flowchart available on the website. Upon opening the website, several menus are visible, including schedule, report, inventory, temperature, and camera. The user can input the bird's feeding and drinking schedule, monitor the cage's condition, and receive notifications when successfully provided feed and drink. The website was created with the use of HTML and JavaScript through Visual Studio Code, a text editor created by Microsoft for use in multiplatform operating systems [17]. HTML is a markup language designed to manage the structure and content of web pages [18]. JavaScript adheres to the ECMAScript standard, a high-level programming language utilizing Just-In-Time (JIT) compilation to enable users to execute code as it runs. It is also classified as a multi-paradigm programming language due to its features [19]. The database used in this study is Firebase which can be stored in the Cloud in real-time [20]. The research data used in this investigation pertains to livestock farming, with two distinct types of cages. There are 30 livestock cages, measuring 2m x 3m and 1m x 40cm, containing two birds each, as well as 22 hanging cages that have a round shape of 60cm and a boxy shape of 40cm x 40cm, accommodating one bird each. The livestock cages hold 31 birds altogether, comprising Blackhoroat, Canary, Murai, and Cucakrowo. Among the hanging cages, there are 13 birds - canaries and magpies. A daily intake of 10g-15g of bird feed and 50ml-100ml of water was provided for each cage.

3. Results and Discussion

In this research, the results are obtained in the form of a series of tools and website displays described in the results section.

Figure 4. Implementation on Cage

Figure 5. Implementation on Website

3.1 Tool Set Results

The bird cage is made using bamboo wood with a size of 35cm long, 17cm wide, and 23cm high. The series of tools in the cage can be seen in Figure 4 which is made by arranging and connecting the components together so that they become a tool that can run with their respective roles, then there is a program using the Arduino IDE which is then compiled into a sketch and embedded into the ESP32 as a microcontroller system.

3.2 Schedule Input Page Result

This page is used to input the time of bird feeding and drinking and the amount of bird feed and drink that you want to issue to the bird feed and drink. The schedule input page contains a sentence of instructions for inputting the time of feeding and drinking birds and the dose of bird feed and drink, if so then click Submit. The inputted time and dose will be displayed on the website page, so that users

who use this website know the time and dose that has been inputted earlier. Figure 5 shows the schedule input page.

3.3 Feeding and Drinking Equipment Testing

In this report, there are results of tests carried out to test the feasibility and minimize failure or trouble on the website and the series of tools made, to find out whether the system made has been realized and in accordance with the design and meets functionally. This test includes testing the website, firebase, and the overall tool circuit.

Table 1. Testing Results of Feed and Drinking Equipment

No	Day	Time	Feed	Drink	Servo Condition	Pump Condition	Delay
1	Monday	01.36	10g	100ml	ON	ON	0s
2	Tuesday	01.36	10g	100ml	ON	ON	1s
3	Wednesday	01.36	10g	100ml	ON	ON	0s
4	Thursday	01.36	10g	100ml	OFF	OFF	Wifi off
5	Friday	01.36	10g	100ml	ON	ON	3s
6	Saturday	01.36	10g	100ml	ON	ON	0s
7	Sunday	01.36	10g	100ml	ON	ON	0s
8	Monday	09.00	15g	50ml	ON	ON	0s
9	Tuesday	09.00	15g	50ml	ON	ON	2s
10	Wednesday	09.00	15g	50ml	ON	ON	0s
11	Thursday	09.00	15g	50ml	OFF	OFF	Wifi off
12	Friday	09.00	15g	50ml	ON	ON	0s
13	Saturday	09.00	15g	50ml	ON	ON	0s
14	Sunday	09.00	15g	50ml	ON	ON	2s
15	Monday	12.00	10g	100ml	ON	ON	0s
16	Tuesday	12.00	10g	100ml	OFF	OFF	Wifi off
17	Wednesday	12.00	10g	100ml	ON	ON	0s
18	Thursday	12.00	10g	100ml	ON	ON	0s
19	Friday	12.00	10g	100ml	ON	ON	0s
20	Saturday	12.00	10g	100ml	ON	ON	0s
21	Sunday	12.00	10g	100ml	ON	ON	0s
22	Monday	12.00	15g	100ml	ON	ON	0s
23	Tuesday	12.00	15g	100ml	ON	ON	0s
24	Wednesday	12.00	15g	100ml	ON	ON	0s
25	Thursday	12.00	15g	100ml	ON	ON	0s

Testing the automation of bird feeding and drinking is the main stage that must be done. This test is carried out to see whether the servo motor and water pump can run according to the inputted time. The results obtained can be seen in table 1 when the time is inputted, namely 1:36 a.m. for 1 week the feed and drink equipment comes out in real-time and it can be concluded that the inputted time data can be received properly by ESP32 and the device can run properly, it's just that during system testing there is a delay of a few seconds which is the effect of the lack of network strength between the time inputted and the feed and drink equipment to come out. When the servo and water pump conditions are dead when the Wi-Fi network is dead, the system cannot run.

The calculation of the percentage error value in the study follows equation 1, where the amount of delay is divided by the number of trials performed and multiplied by 100.

$$\% \text{ Error Rate} = \frac{\text{Delay}}{\text{Number of Trials}} \times 100 \quad (1)$$

% Error Rate = (4/25) x 100

Error Rate = 16%

The calculation of the percentage value of success in the study follows equation 2, the number of successes divided by the number of trials conducted and multiplied by 100.

$$\% \text{ Success Rate} = \frac{\text{Success of Trials}}{\text{Number of Trials}} \times 100 \quad (2)$$

% Success Rate = (21/25) x 100
Success Rate = 84%

According to the data and manual calculations, the sensor accuracy is 84%. The system operates properly when the network is stable, and ceases operations when the Wi-Fi network is deactivated. The average error is 16%, in cases where network connections are unstable, device delays may occur, typically no longer than five seconds. Following the delay, the tool resumes normal function.

The data entered as shown in Figure 6 in the Firebase database contains bird data which is data inputted from the website and the data will be retrieved by the ESP32, the data is also real-time data. The data that has been inputted is also stored in the database to be displayed on the website, after the tool works the ESP32 will also send information data to the database and display it on the website page.

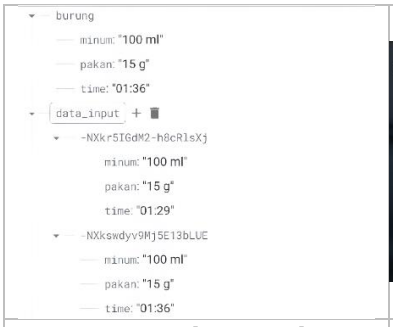

Figure 6. Database Firebase

Figure 7. Testing the Inputted Data Page

Figure 8. Tools Testing

The Input Data page as shown in Figure 6 is a page that contains data that has been inputted and there is a button that will go to Figure 7, which is a place to input data on bird feeding and drinking. As researchers enter hours and doses, the data enters the database and the ESP32 configures the entered time using the real-time API embedded in the ESP32. When the time is right, the servo motor starts to release the food and is continued by the water pump that sucks the water supply into the bird's drinker as shown in Figure 8.

3.4 Ultrasonic Sensor Testing

On ultrasonic sensors, testing of bird feed and drinking water supplies is carried out to find out whether sensor data can be read properly by system. On Monday at 01.36, the water in the inventory is fully filled and the status displayed is "Available" when the status is available then the notification will not appear on the breeder's smartphone and on Sunday at 09.00 the water in the inventory is reduced and the status issued is "Not Available", and a notification that the water supply has run out will be sent to the breeder's smartphone. Likewise, the feed storage is also tested when the feed has run out, there is also a status of "Not Available" and there is a notification on the farmer's smartphone, when the feed is still there, the status is "Available". The test data results can be seen in table 2.

Table 2. Ultrasonic Sensor Testing Results on Feed and Drink Supplies

Day	Time	Feed	Water	Sensor Condition	Delay	Notification
Monday	01.36	Full	Full	ON	0s	-
Tuesday	01.36	Full	Full	ON	0s	-
Wednesday	01.36	Full	Full	ON	0s	-
Thursday	01.36	Full	Exhausted	OFF	WiFi off	-
Friday	01.36	Full	Full	ON	0s	-
Saturday	01.36	Full	Full	ON	0s	-
Sunday	01.36	Full	Full	ON	0s	-
Monday	09.00	Exhausted	Exhausted	ON	0s	Send
Tuesday	09.00	Full	Full	ON	0s	-

Wednesday	09.00	Full	Full	ON	0s	-
Thursday	09.00	Full	Full	OFF	Wifi off	-
Friday	09.00	Full	Exhausted	ON	0s	Send
Saturday	09.00	Full	Full	ON	0s	-
Sunday	09.00	Full	Full	ON	0s	-
Monday	09.00	Full	Full	ON	0s	-
Tuesday	09.00	Exhausted	Full	OFF	Wifi off	Send
Wednesday	09.00	Full	Exhausted	ON	0s	Send
Thursday	09.00	Full	Full	ON	0s	-

Figure 9 shows the data in the database of bird feeding and drinking supplies read by the ultrasonic sensor to the microcontroller and the data is sent to the database so that it can be displayed on the website. In Figure 10 is a notification sent by Firebase to the farmer's smartphone, when the bird's feed and water supply has run out.

Figure 9. Feed and Drinking Supplies Database

Figure 10. Smartphone Notifications

In previous research [16] which is a bird feeding monitoring system using the Blynk application and the previous system has been developed in this study by making the bird cage monitoring system quite complex with the addition of bird drinking features, temperature monitoring using DHT22 sensors, cage monitoring using camera sensors on the ESP32 Camera, and ultrasonic sensors as sensors that detect bird feed and drink supplies and send notifications when supplies run out. In research [16] remote control can only be used in 1 device in the Blynk application, and in research Designing Monitoring Systems and Automation of Internet of Things-Based Bird Feeding and Drinking Using ESP32 the system can be opened using several devices by opening a web page so that it makes it easier for farmers to monitor bird cages.

4. Conclusion

Based on the results of testing the system, it can be concluded that this research can work well in accordance with the objectives of breeders can monitor the state of bird cages through the website and can provide feed and drink remotely with the accuracy of sensors that run which is 84% and presentation error 16%. Expected specifications such as the system being able to open and close feed and drinking water through control from the website and run automatically and send data on feeding and drinking on the report data page in real-time, it's just that in this study there is still a delay of a few seconds when feeding and drinking birds, and it is recommended to use a stable internet network so that the system can run well without any delay. All sensor systems such as ultrasonic sensors can read bird feed and drink supplies properly and in real-time, DHT22 sensors can read temperature conditions in cages and camera sensors that make it easier for farmers to remotely monitor the state of the cage. Future research should consider incorporating batteries as an alternative power source, as the current tool solely relies on electric power. Additionally, integrating tools such as RTC would enable the system to continue functioning even when the WiFi network is down. Improving the connectivity would facilitate real-time monitoring.

Acknowledgments

The authors would like to thank Yogyakarta University of Technology for supporting the implementation of this project.

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Advance Sustainable Science, Engineering and Technology (ASSET)
Vol. 5, No.3, October 2023, pp. 0230309-01 ~ 0230309-10
ISSN: 2715-4211 DOI: https://doi.org/10.26877/asset.v5i3.17214

Analysis of the Effectiveness of Automatic Lathes Using the OEE and FMEA Methods

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Abstract. UD AMJ Jaya Teknik is a manufacturing company that produces various kinds of construction products and spare parts, one of which is boshing products made using an automatic lathe. This research aims to identify the performance of automatic lathe machines to measure the productivity of automatic lathe machines using Overall Equipment Effectiveness and using the Failure Mode and Effect Analysis method. Based on the advantages of OEE, further analysis is carried out to calculate the six big losses. The results obtained from the OEE calculation of 68.22%, this value does not meet the standard ideal OEE value of 85.00%. Meanwhile, the results of the six big loss calculations obtained large values and influenced the effectiveness of the lathe to be minimized, namely process defect loss, reduce speed loss, idling and minor stoppages, and setup and adjustment loss. For the results of the FMEA analysis, the largest RPN value was obtained, namely 336 for the Man factor, with the failure mode that occurred being workers who lacked focus and lack of experience. From the research results of the above calculations, it can be seen that the effectiveness of the UD AMJ Jaya Teknik workshop still needs to be improved, where UD AMJ Jaya Teknik can find out and take corrective action in aspects of machine maintenance and workforce awareness.

Keywords: OEE, FMEA, Engine Performance, Six Big Losses, Lathe

(Received 2023-10-11, Accepted 2023-10-22, Available Online by 2023-10-30)

1. Introduction

In the current era of global competition in industry 4.0, technological developments are progressing very rapidly, especially in the manufacturing sector. Where the use of technology is something that is inevitable, seen from the many activities carried out conventionally that have shifted to automation with the use of machines or tools that provide effectiveness and efficiency in an activity thereby increasing productivity[1]. Due to the widespread use of machines, companies need to think about how to increase and carry out production activities smoothly[2]. The effectiveness of machines or equipment is one of the factors that must be considered and optimized so that the machine does not experience damage or problems which results in production activities stopping and the resulting product being defective. This can be prevented by thinking about ways to improve it in an effort to increase effectiveness so that

productivity can be sustainable, one of which is by carrying out maintenance on machines or equipment. In the future, it is possible that manufacturing technology will continue to develop, so that the manufacturing industry will be required to become a technology company.

UD Amj Jaya Teknik is a company engaged in the field of turning and manufacturing spare parts for factory machines which is currently developing. The company produces various products including: straight gears, oblique/helical gears, internal gears, boshings, worm gears, worm axles, filtering, pulleys, rolls, springs, knives and seals and chucks. This company produces various kinds of custom construction products (the company produces products according to customer requests). Based on the company's history in the last 3 months, boshing products have had the most demand for different diameters. In this way the production process will take place continuously. Production is carried out using an automatic lathe. In the boshing production process, several products experience defects caused by several factors, one of which is the machine factor. Among the causes of defects in boshing products are rusty grease, broken lathe blades, worn bearings, worn gearboxes, damaged lathe speed sensors and damaged lathe motors. Therefore, it is necessary to measure machine performance and evaluate in repairing or optimizing automatic lathe machines.

Based on the conditions described above, it is necessary to measure machine performance using the OEE (Overall Equipment Effectiveness) method. OEE is the value of the effectiveness of a machine/equipment[3]. In the OEE calculation there is an analysis of the six big losses to meet quality standards related to the OEE value. Six big losses are things that can cause losses due to inefficient use of machines or equipment such as Breakdown loss, Setup and Adjustment loss, Reduced Speed Loss, idling and minor stoppage loss, Process Defect Loss and Reduced Yield Loss[4]. After the effectiveness value is known, the machine performance will then be evaluated using the FMEA method[5]. FMEA (Failure Mode and Effects Analysis) is a method for knowing or observing the level of failure in a process which will later be analyzed so that failure can be properly anticipated.

2. Methods

The method used in this research is the OEE and FMEA method to calculate and evaluate machine performance to increase productivity at UD AMJ Jaya Teknik. This research uses data types including: ideal time data for automatic lathe machines, production results data, product damage data, details of machine working time (availability time), unplanned downtime data (production downtime data, maintenance downtime data) and planned downtime data (preventive maintenance data). Data collection in this research was carried out by observation and interviews. The data samples taken by researchers were the last 3 months March - May 2023, then data processing and analysis was carried out using Microsoft Excel, Microsoft Word and Visio software.

2.1. Overall Equipment Effectiveness (OEE)

It is a tool for measuring overall equipment performance that shows how effectively the equipment can do what it is supposed to do[6]. This method is also called the main part of the maintenance system which is widely used by several of the largest companies in Japan. Several improvements to increase the OEE percentage both in terms of available time (Availability), equipment usability (Performance), and quality (Quality)[7].The purpose of this method is to compare the performance lines across the company where it will show unimportant flows and be able to identify which machines have poor performance.[8]. The benefit of the OEE method is to identify productivity losses and increase OEE and Increase productivity[9].

To find the results of the OEE value, you can use 3 main ratios by calculating Availability, Performance and Quality Rate (journal) with the following formula:

OEE (%) = Availability X Performance X Quality Rate X 100% [1]

Table 1.OEE Ideal Value Standard

OEE Factor	***OEE Procented***
Availability	90.00%
Performance Efficiency	95.00%

Rate Of Quality Products	99.00%
Overall Equipment Effectiveness (OEE)	85.00%

(Nakajima, 1988)

The following are the components of OEE:

A. *Availability*

It is a ratio to find out the actual or actual time available for machine operational activities compared to the predetermined time[11].

$$Availability = \frac{Operation\ Time}{Loading\ Time} X\ 100\% \qquad [2]$$

*Loading time*is the available time (availability) per day or month minus the planned machine downtime. Operation time is the result of reducing loading time with machine downtime (non-operation time). So the mathematical formula is as follows:

- *Loading time* =Working hours — Planned downtime
- *Downtime = Breakdown time + Setup and Adjustment*
- *Operation time = Loading time – Downtime*production - Downtime Maintenance – setup and adjustment

B. *Performance Efficiency*

It is a ratio to show the quality of actual production output then multiplied by the ideal cycle time versus operation time[12].

$$Performance\text{Efficiency} = \frac{Processed\ Amount\ x\ Ideal\ Cycle\ time}{Operating\ Time}\ x\ 100\% \qquad [3]$$

*Process amount*is the total amount of production while the ideal cycle time is the ideal cycle time required in a product process.

C. *Rate of Product Quality*

This is a ratio to see the level of machine ability to produce quality products according to specifications[13].

$$Rate\ Of\ Quality\ Product = \frac{Process\ Amount - Defect\ Process}{Process\ Amout} X\ 100\% \qquad [4]$$

*Process defects*is the number of defective or failed products processed.

Six big losses

The definition of six big losses is as follows[14]:

Table 2. Six Big Losses

Six big losses	**Understanding**
Breakdown losses	Losses related to equipment failure or damage. Which results in time losses and guantity losses.
Setup and Adjustment of losses	Losses related to congestion that occur when there are changes to work systems such as during operation, changes in products and equipment.
Reduced Speed Loss	Losses related to actual operating speed which is lower than ideal operating speed.
idling and minor stoppage loss	Losses are related to small stoppages when the production process is interrupted by temporary damage or when the machine is idle.

Defect Loss Process	Time losses related to defects and process rework, financial losses related to reduced product quality, and loss of time needed to repair defective products to perfection. Which is caused by the malfunction of production equipment.
Reduced Yield Loss	Material losses related to insufficient input of material weight and weight of quality products.

$$Breakdown\ losses = \frac{\text{Total } Breakdown\ Time}{Loading\ Time} x100\% \quad [5]$$

$$Setup\ and\ adjustment\ loss = \frac{Set\ up\ and\ adjustment\ Time}{Loading\ Time} x100\% \quad [6]$$

$$Reduce\ Speed\ Loss = \frac{\boldsymbol{Operation\ Time - (\ Ideal\ Cycle\ Time\ x\ Processed\ Amount)}}{\boldsymbol{Loading\ Time}} x100 \quad [7]$$

$$Idling\ and\ minor\ stoppage\ loss = \frac{\boldsymbol{Doentime}\ \textbf{perpindahan}}{Loading\ \boldsymbol{Time}} x100\% \quad [8]$$

$$Defect\ Loss\ Process = \frac{Ideal\ Cycle\ Time\ x\ Defect}{Loading\ \boldsymbol{Time}} x100\% \quad [9]$$

$$Reduce\ Yield\ Loss = \frac{Ideal\ Cycle\ Time\ x\ Scrap}{Loading\ Time} x100\% \quad [10]$$

2.2. Failure Mode and Effect Analysis (FMEA)

It is a method used to determine the level of failure in a process that can be analyzed so that failure can be properly anticipated.[15]RPN is used to determine the priority of a failure and has no value or meaning with the following formula:

RPN = S x O x D.[16]

3. Results and Discussion

Data collection

The data needed in this research relates to manual lathes. So the data collected for this research is manual lathe machine ideal time data, production results data, product damage data, machine working time details (availability time), unplanned downtime data (production downtime data, maintenance downtime data) and planned downtime data (preventive maintenance data). The automatic lathe machine data used in this research was taken for the last 3 months March – May 2023 and is presented in Tables 3 and 4 as follows:

Table 3.Data collection

Month	Production target (Pcs)	Production/month (Pcs)	*Unplanned downtime* (O'clock)	*Planned downtime* (O'clock)	Product defects (Pcs)	*Set up* (O'clock)
March	155	98	3	0.25	19	1.25
April	109	72	2.5	0.25	11	0.83
May	113	61	2	0.16	9	1.67

Source: company data

Table 4.Data collection

Month	*Ideal cycle time* (O'clock)	*Downtime*		*Availability time* (O'clock)
		Production (Hours)	*Maintenance* (O'clock)	
March	0.25	0.5	-	28
April	0.25	-	0.383	21
May	0.25	-	0.33	21

Source: company data

The results of this quantitative data are used in OEE analysis, the determination of which is based on
in measuring three main ratios, including availability, performance efficiency, and rate of quality. Then proceed with qualitative data in FMEA analysis, the determination is based on severity, occurrence and detection. Then proceed with risk priority number analysis.

Data processing

The data collected for this research is data*ideal time*manual lathe machine, production results data, product damage data, detailed machine working time data (availability time), setup and adjustment data, unplanned downtime data (production downtime data, and maintenance downtime data) and planned downtime data (preventive maintenance data and data no delivery order). From this data, data processing is then carried out using calculations for each existing machine.

3.1 OEE calculation of automatic lathes

Overall Equipment Effectiveness (OEE) is a calculation and magnitude of the effectiveness of equipment. The steps for calculating the OEE value are:

3.1.1 Availability calculation

*Availability*is a ratio that describes the utilization of time available for machine or equipment operation activities [11]. After there is the necessary data using the formula in number [2], below is the calculation data*availability*automatic lathe.

Table 5.Availability value of automatic lathes for March – May 2023

Month	*Loading time* (O'clock)	*Operating time (*O'clock)	*Availability (%)*
March	27.75	26	93.69%
April	20.75	19.53	94.15%
May	20.84	18.84	90.40%
Average	23.11	21.45	92.74%

Example of calculation for March:

- *Loading time* =28 - 0.25 = 27.75
- *Operating time* =27.25 - 0.5 - 0 – 1.25 = 26
- $Availability = \frac{26}{27,75} X\ 100\% = 93,69\%$

DSee table 5. Each month's Availability Calculation has different results. The largest percentage value was in April with a value of 94.15% and the lowest percentage value was in May with a value of 90.40%. However, after calculating the overall average availability value of 92.74%, it already meets the ideal OEE availability standard value of 90.00% in table 1.

3.1.2 Calculation of performance efficiency

*Performance Efficiency*is a ratio to show the quality of actual production output then multiplied by the ideal cycle time versus operation time [12]. After there is the necessary data using the formula in number [3], below is the calculation data for the performance efficiency of an automatic lathe machine.

Table 6.Automatic lathe machine efficiency performance value for March – May 2023

Month	*Processed Amount* (Pcs)	*Ideal Cycle Time* (O'clock)	*Operation Time Availability*	Boshing Displaceme nt	*Operating Time*	*Performance Efficiency* (%)
March	98	0.25	26	1.25	24.75	98.99%
April	72	0.25	19.53	0.83	18.7	96.25%
May	61	0.25	18.84	1.67	17,17	88.81%
Average	77	0.25	21.45	1.25	20,20	94.68%

Example of calculation for March:

- *Operating time* =26 - 1.25 = 24.75
- *Performance Efficiency* $\frac{98\ x\ 0{,}25}{24{,}75} x\ 100\% = 98{,}99\%$

DSee table 6. Each month's Performance Efficiency Calculation has different results. The largest percentage value was in March with a value of 98.99% and the lowest percentage value was in May with a value of 88.81%. After calculating the average performance efficiency value, the result was 94.68%. This value does not meet the ideal OEE performance efficiency value standard, namely 95.00% in table 1. With a deficiency of 0.32%.

3.1.3 Calculation of rate of quality

Rate of Quality Product is a ratio to see the level of machine ability to produce quality products according to specifications [13]. Once there is what is needed using formula number [4], below is the data for calculating the rate of quality for automatic lathe machines.

***Table*7.**Rate of quality for automatic lathes for March – May 2023

Month	***Processed Amount* (pcs)**	***Defect Amound* (Pcs)**	***Quality Rate* (%)**
March	98	19	97.81%
April	72	11	71.85%
May	61	9	60.85%
Average	77	13	76.84%

Example of calculation for March:

- *Quality Rate*$=\frac{98-19}{98} X\ 100\% = 97{,}81\%$

Insee table 7. Each month's Rate of Quality calculation has different results. The highest percentage of scores was in March with a score of 97.81% and the lowest percentage of scores was in May with a score of 60.85%. After calculating the average rate of quality value, which is 76.84%, it does not meet the standard OEE ideal rate of quality value, namely 99.00% in table 1. With a deficiency of 22.16%.

3.1.4 Calculation of OEE value

After obtaining the availability, performance efficiency and quality rate of the manual lathe, the OEE value can be calculated to determine the effectiveness of the automatic lathe using formula number [1.]

***Table*8.**OEE value of automatic lathes for March – May 2023

Month	***Availability (%)***	***performance efficiency* (%)**	***Quality Rate* (%)**	**OEE Value (%)**
March	93.69%	98.99%	97.81%	90.71%
April	94.15%	96.25%	71.85%	65.11%
May	90.40%	88.81%	60.85%	48.85%

Average	92.74%	94.68%	76.84%	68.22%

Example of calculation for March:

- MarkOEE (%) =93.69% X98.99% X97.81% X 100% =90.71%

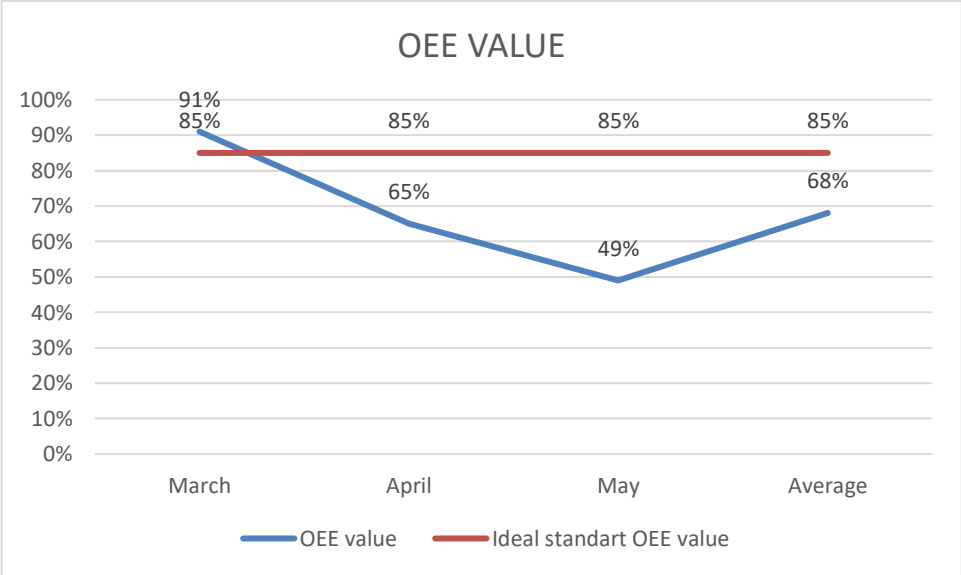

Figure 2. **OEE value**

Figure 1 above shows the results of different OEE values every month. The largest percentage value occurred in March at 90.71% and the lowest was in May at 48.85%. With an average OEE value of 68.22%, this value does not meet the ideal OEE value standard, namely 85.00% in table 1. With a deficiency of 16.78%. Meanwhile, if you look at the OEE value each month, only March does not need to be repaired

3.1.5 Calculation of the value of six big losses

From the comparison of the OEE value of manual lathe machines with the standard ideal OEE value, the company needs to take corrective action to increase the OEE value of the machine, therefore it is necessary to calculate the six big losses. From the data collection that has been carried out, there are five losses from the six big losses that occur on manual lathes, namely equipment failure (breakdown loss), setup and adjustment, idling and minor stoppages, reduced speed loss, and process defect loss.

***Table* 9.**Value of six big losses for automatic lathes for March – May 2023

Six big losses	***Percentage (%)***	***Cumulative percentage (%)***
Breakdown losses	1.74%	5.2%
Setup and Adjustment Losses	5.50%	16.4%
Reduce Speed Loss	7.07%	21.10%
Idling and Minor Stoppage Loss	5.50%	16.4%
Defect Loss Process	13.71%	40.90%
Reduce Yield Loss	0 %	0 %
Total	33.52%	100%

Seen in Table 9, the average percentage of the six big losses for 3 months. It can be concluded that there are 5 loss factors that influence machine performance, namely Process Defect Loss, Reduce Speed Loss, Idling and Minor Stoppage Loss, Setup and Adjustment Loss and Breakdown loss. The largest

percentage in this calculation is Process Defect Loss of 40.90%, and the lowest is Breakdown loss of 5.2%. For the Reduce Yield Loss calculation, no symptoms were found on the automatic lathe. It can be concluded that based on the percentage for the Defect Loss Process category, more intensive maintenance is needed for automatic machines and to maintain raw materials to meet standards in order to produce a product according to the Company's wishes. For the next step, for a more detailed explanation, a Fishbone diagram was created to find out what factors caused the product to lose.

Fishbone diagram

*Fishbone diagram*is identifying multiple potential causes of a single effect or problem. After identifying the Losses of boshing products, it is determined that in this fishbone there are 5 main causal factors that influence quality, namely people, methods, machines, materials, environment. However, from the results of observations there are only 4 factors that cause losses. Below is a picture to see several factors of losses on automatic lathe machines.

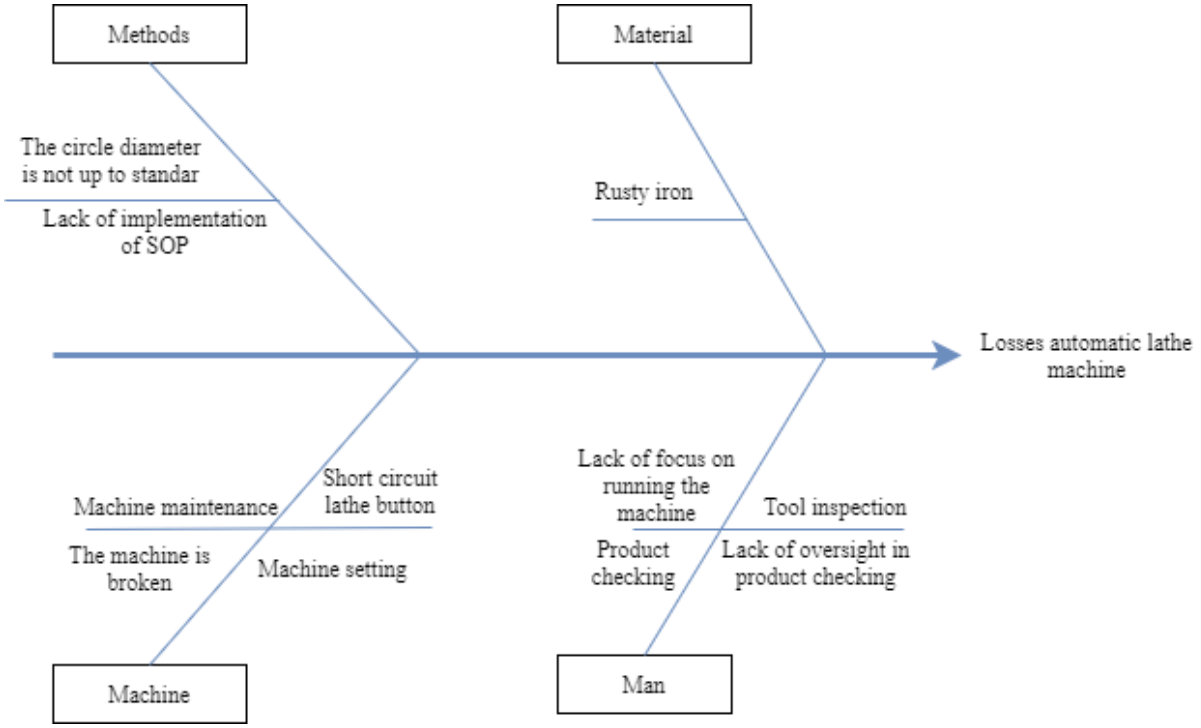

Figure 2. Cause and effect diagram of boshing defects on automatic lathe machines

From the diagram above, it can be concluded that product defects are divided into four parts, namely methods, materials, humans and machines. Next, an analysis of each factor will be carried out in the explanation in FMEA Analysis

FMEA analysis

FMEA has several components that were obtained when conducting field studies with interviews and the results of identifying defects in the boshing turning process using an automatic lathe obtained the following results:

1. Man Factor: There are some workers who lack focus in doing their work because they are sleepy when running the machine and have too much mental stress, workers do not have experience in running the machine due to lack of training.
2. Machine Factors: There are several defective products due to less than optimal machine performance due to lack of machine maintenance, damaged machines and errors in machine settings.
3. Material Factor: High rate of product failure due to errors or errors in the material ordering process

from suppliers.

4. Methods Factor: There are several machines that experience problems or even damage due to a lack of updates to the SOPs implemented.

Table 10.Determination of SOD and RPN

Factor	S (severity)	O (Occurrence)	D (detection)	RPN	*RPN Percentage (%)*	*Cumulative percentage (%)*
Man	8	7	6	336	45.40%	45.4%
Machines	8	7	4	224	30.27%	75.67%
Material	5	4	6	120	16.21%	91.88%
Methods	4	5	3	60	8.10%	100%
Total				**740**	**100%**	**100%**

Seen in table 10, there is the highest RPN value for the man factor for the failure mode, namely workers who lack focus and do not have experience. With an RPN value of 336, while the lowest RPN value in the Methods factor for the failure mode is because the work does not comply with the SOP with an RPN value of 60. So for the solution that is implemented, it is hoped that workers will be more careful in carrying out their work and provide training so that workers are not careless.

4. Conclusion

Based on the calculations above, it can be concluded that the average value of availability within 3 months of an automatic lathe is 92.74%. Where it has met the ideal OEE standard value of 90.00%, while the average performance efficiency value has a value of 94.68% and the rate of quality has a value of 76.48%, where both values still do not meet the ideal standard value of 95.00% and 99.00% with deficiencies of 0.32% and 22.16% respectively. With the final result, the average Overall Equipment Effectiveness value for automatic lathes in 3 months was 68.22%, this value does not meet the ideal standard Overall Equipment Effectiveness value of 85.00% with a deficiency of 16.78%. Looking at table 9, it can be concluded that there are 4 loss factors that influence machine performance, namely Defect Loss Process, Reduce Speed Loss, Idling and Minor Stoppage Loss and Setup and Adjustment Loss. Therefore, it is necessary to improve so that machine performance increases by minimizing the value of losses and the causes of defects. From the results of the RPN calculation, it was obtained that the largest value was found in the Man factor with a value of 336 with the failure mode that occurred namely workers who lacked focus and lack of experience. From the research results of the above calculations, it can be seen that the effectiveness of the UD AMJ Jaya Teknik workshop still needs to be improved, where UD AMJ Jaya Teknik can find out and take corrective action in aspects of machine maintenance and workforce awareness.

This research still has shortcomings, because the object observed is only one product out of several products produced. In future research, it is hoped that the objects observed will have a wide coverage or the entire object, the number of production samples can be increased so that the research is more complete and accurate. Apart from that, you can also use other methods to add methods and references for further research

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Advance Sustainable Science, Engineering and Technology (ASSET)
Vol. 5, No.3, October 2023, pp. 02303010-01 ~ 02303010-10
ISSN: 2715-4211 DOI: https://doi.org/10.26877/asset.v5i3.17253

Innovatif Engineering Strategies for Revenue Growth : a SWOT and QSPM Analysis of UD AMJ Jaya Teknik

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Abstract. Business competition in the current era of globalization is very rapid, so it is increasing competition between companies which is getting higher and tighter. UD AMJ Jaya Teknik is a company in the field of turning and manufacturing spare parts. As long as the business run by UD AMJ Jaya Teknik experiences a decline in income, good and appropriate strategic management is needed for UD AMJ Jaya Teknik. The methods used in this research are the SWOT and QSPM methods. The aim of this research is to provide strategy suggestions for companies to experience increasingly rapid increases in income. The four stages carried out are the stage of looking for internal and external company factors, the IFE and EFE matrix stage, the SWOT matrix matching stage, the stage of determining the main strategy with the largest total attractive score using QSPM. There are 7 proposed marketing strategies for UD AMJ Jaya Teknik. Improving the quality of the products produced and innovating the products produced is the strategy with the highest TAS score of 5.95.

Keywords: SWOT, QSPM, Marketing Strategy, Increasing Revenue

(Received 2023-10-12, Accepted 2023-10-26, Available Online by 2023-10-31)

1. Introduction

Business competition in the current era of globalization is very tight, where with increasing competition between companies which is getting higher and tighter, companies must also always innovate and collaborate with fellow competitors. This situation causes the company to strive to maintain survival, develop the company for the better, obtain optimal profits and try to strengthen its position in facing business competition. To achieve these goals cannot be separated from marketing efforts which must be thought about and planned before creating a product.[1]. Companies must make various efforts so that they can have a strong attraction that is embedded in the minds of consumers and ultimately can achieve a wide market share, so that they are able to compete with other competitors.[2]. The company's ability to excel against competitors will determine which companies remain the market choice and which ones go bankrupt. This kind of very dynamic and complex internal and external business environment requires the right business strategy to maintain the company's existence[3]. This causes the decision making process to become increasingly difficult and complicated[4]. For this reason, strategic management plays a central role. Every strategy always requires review and perhaps even changes in the future[5]. One of the main reasons why this is the case is because the conditions faced by companies,

both internal and external, are always changing. Strategy analysis and selection is one of the important steps in strategic management[6].

UD AMJ Jaya Teknik is a small and medium business that operates in the field of turning services and spare part manufacturing. The products produced by this company are very popular with customers, but in mid-2020, in the era of the Covid-19 pandemic, UD AMJ Jaya Teknik experienced a decline in income and minimal orders received until now. With this happening, UD AMJ Jaya Teknik had to carry out a strategy to be able to compete with other competitors, thus requiring the company to carry out or implement a more appropriate marketing strategy so that revenue would increase. Marketing strategy is a tool fora tool to achieve marketing goals which is a way for a company to capture customer mind share[7]. The methods used to prioritize marketing strategies are SWOT (Strength, Weakness, Opportunity, Threat) and QSPM (Quantitative Strategic Planning Matrix). The advantage of using the QSPM matrix is that strategies can be examined sequentially and simultaneously, and there is no limit to the number of strategies which is a marketing mindset that will be used by a business unit to achieve its goals.[8]. The aim of this research is to implement or provide new strategies to companies so that they experience increasingly rapid increases in income.

2. Methods

This research was conducted at UD AMJ Jaya Teknik which is located on Jalan Lingsir, Slempit, Kedamean District, Gresik Regency. The types of data used in this research include order income data andUD AMJ Jaya Teknik has never experienced complaints regarding the products produced. Data collection was carried out by observing and interviewing. This research uses 2 methods to provide marketing strategies, namely the SWOT and QSPM methods.The stages carried out in this research were as follows:

1. Early stage
   Carrying out field studies and literature studies in the Company, after that identifying problems, the problems taken in this research.
2. Second stage
   Collecting data obtained from companies through observations and interviews with business owners.
3. Third phase
   Data processing and analysis determines the company's internal and external factors which then calculate the weights, ratings and scores to determine the company's position on the IE matrix. After that, a SWOT analysis was carried out using the SWOT matrix. The results of the SWOT analysis will be processed again using the QSPM method to obtain alternative strategies that are suitable for marketing strategies as an effort to increase revenue at UD AMJ Jaya Teknik.
4. Fourth stage
   Conclusions for research conducted by researchers.

2.1. *SWOT Identification*

It is a strategic planning method that aims to determine the environmental conditions found in a company. This method is used to evaluate strengths, weaknesses, opportunities and threats in an effort to run a business. From these four factors, the acronym SWOT was formed[9]. Which can be explained as follows:

a) Strength (*Strength)*
   These are various kinds of advantages that a company has, which, if used properly, will play a big role in the company and can enable the company to achieve its goals.[10].
b) Weakness
   It is a characteristic that is related to the company's weaknesses compared to competitors, but if the company can successfully overcome or minimize it, it will play a big role for the company.
c) Opportunities
   It is a positive factor faced by a company, where if this opportunity can be utilized properly and

correctly it will have a big influence on a company and can achieve its goals.

d) Threats
It is a negative factor faced by a company, where if the company succeeds in overcoming all forms of threats from outside and inside, it can be overcome, it will play a big role in a company.[11].

2.2. *IFE Matrix*

The IFE (Internal Factor Evaluation) matrix is used to analyze the company's internal environment. The factors that will be used in the process of preparing the IFE matrix are the company's internal environmental factors. These internal company factors are in the form of strengths and weaknesses possessed by a company[12]. According to[13]There are 5 steps taken for the EFE and IFE matrices to be developed, namely:
Make a list of 10-20 internal factors that indicate specific strengths and weaknesses of the organization (percentages, ratios, or comparative figures, literature studies) ; Giving each factor a weight ranging from 0.0 (not important) to 1.0 (all important). Weights indicate the relative significance of a particular factor to a company's industry success. Factors that are considered to have the greatest influence on organizational performance are given the highest weight, regardless of whether the main factor is an internal weakness or strength. The sum of all weights must equal 1.0. ; Give each factor a rating of 1 to 4 to indicate the factor is very weak (rank 1), weak (rank 2), strong (rank 3), (very strong (rank 4). Weaknesses get a rank of 1 or 2, while strengths get a ranking 3 or 4. So the ranking is company based, while the weighting is industry based. ; Multiplying the weight of each factor by its ranking to determine a weight score for each variable. ; Add up the weight scores for each variable to obtain the organization's total weight score.

2.3. Matrix *EFE*

It is a tool used to examine a company's external environment and to identify existing opportunities and threats. According to[14]There are 5 stages to complete the EFE matrix, namely:
List the external factors as identified in the external audit process. List several factors that include opportunities and threats that affect the company and its industry. Write opportunities first and then threats. Be as specific as possible, using percentages, ratios and comparative figures. ; Give a weight ranging from 0.0 (not important) to 1.0 (very important) for each factor. opportunities are often given a higher weight than threats, but threats can also be given a high weight if they are very serious or extremely threatening. The sum of all weights must equal 1.0. ; Give a rating of 1 to 4 for each factor to indicate how effective the company's current strategy is in responding to that factor, 4 = superior company response, 3 = above average company response, 2 = average company response, and 1 = bad company response. It is important to note that threats and opportunities can be rated 1,2,3, or 4. ; Multiply each factor weight by the ranking to determine the weighted average for each variable ; Add up the weighted averages for each variable to determine the total weighted average for the organization.

2.4. *SWOT Matrix*

The SWOT Matrix is an important matching tool that helps managers develop four types of strategies: SO Strategy (strengths-opportunities), WO Strategy (weaknesses-opportunities), ST Strategy (strengths-threats), and WT Strategy (weaknesses-threats).

2.5. *QSPM analysis*

It is a technique that can identify an alternative strategy that suits the company's conditions[15]. This method has advantages such as a series of strategies that can be observed sequentially or simultaneously, preparers who need a strategy to integrate relevant internal and external factors in the decision-making process, highlighting important relationships to influence strategic decisions, increasing the probability

of the final strategic decision results are good for the company[16]. According to[10]The steps that must be considered in the QSPM analysis are:

1. Prepare a key list of external factors in the form of opportunities and threats as well as a list of key internal factors in the form of company strengths and weaknesses in the left column of the QSPM. Then this information will be obtained from EFE and IFE.
2. Give a weight to each critical internal and external success factor, this value is the same as the weight for EFE and IFE.
3. Identify and determine strategic alternatives that can be implemented by the company, and write them on the first line of the QSPM.
4. Determine Attractiveness Scores (AS) as a numerical value that can indicate the relative attractiveness value of each alternative strategy. Attractiveness Scores (AS) are determined by calculating each key internal and external factor at one time.
5. Calculate the total Attractiveness Scores (AS) value by multiplying each weight by each Attractiveness Scores (AS) value.
6. Calculate the average Total Attractiveness Scores, by entering the TAS value in each strategy column. The average TAS value can indicate the best strategy to use. The alternative strategy with the highest TAS value indicates that this strategy is the best strategy to use, where the external opportunities are large enough to be exploited using the company's current strengths and weaknesses.

3. Results and Discussion

3.1. *SWOT Identification*

Before calculating the weights, ratings and scores on the IFE and EFE matrices, SWOT identification is first carried out. Where researchers will brainstorm the company's internal and external factors with several respondents. These results can be seen in Table 1.1. After obtaining the results from determining the Company's internal factors and internal factors, weights, ratings and scores will be calculated.

3.2. Matrix*IFE and EFE*

The table below is the IFE and EFE Matrix, in this matrix the score value for each strategic factor is calculated, after that the total score is used to determine the company's strategy in the IE Matrix. Determination of the significant value and weight of this research was obtained from the results of brainstorming by 3 participants, namely , business owners, workers, and researchers. This is because there are only 2 workers in the business. The formula for finding the Score value = Weight value X Rating. Example of calculation in finding a score: S1 = 0.06 x 4 = 0.23.

Table 1.IFE Matrix calculation results

No.	Internal Strategic Factors	Weight	Ratings	Score
	Strength :			
S1	UD AMJ Jaya Teknik has competent workers in the turning field	0.06	4.0	0.23
S2	The products produced are very good and there are almost no failures in production	0.06	4.0	0.26
S3	The method used in turning techniques is according to SOP	0.05	3.0	0.15
S4	Turning processing time is relatively fast	0.06	3.0	0.17
S5	The machines used comply with Indonesian National Standards (SNI)	0.05	3.0	0.15
S6	Can handle various types of turning (according to customer wishes)	0.06	3.0	0.17
S7	Carrying out the mandate and being responsible for product requests received (good relationship with consumers)	0.05	4.0	0.20
S8	Have a permanent supplyer and quality materials	0.06	4.0	0.26
S9	Have your own workshop (no rent)	0.05	3.0	0.15

S10	Can negotiate prices on submitted offers	0.05	3.0	0.15
	Weakness :			
W1	Lack of capital to increase company productivity	0.04	2.0	0.09
W2	Not having a particular machine that can do special turning	0.04	1.0	0.04
W3	The owner is still the main decision-making power	0.04	1.0	0.04
W4	Machines still depend on humans	0.04	1.0	0.04
W5	Does not have permanent employees	0.05	2.0	0.10
W6	Promotional strategies are less varied	0.06	2.5	0.14
W7	The owner still goes straight to the sale	0.04	1.0	0.04
W8	The profits obtained are not optimal	0.05	2.0	0.10
W9	The organizational structure is still weak	0.05	2.0	0.10
W10	Not having adequate operational transportation	0.04	1.0	0.04
	TOTAL	**1.00**		**2.60**

From the analysis of the IFE matrix in table 1, it shows that the highest strength score with a value of 0.26 was obtained for the factorThe products produced are very good and have almost no failures in production and have a permanent supplyer and quality materials. Meanwhile, the highest weakness score with a value of 0.14 was obtained in the less varied promotional strategy factor.

Table 2.EFE Matrix Calculation Results

No.	External Strategic Factors	Weight	Ratings	Score
	Opportunity :			
O1	Have collaborative partners with other workshops that have more complete machines	0.09	4.0	0.31
O2	Strategic location of the workshop (close to human resources, raw materials, consumers)	0.10	4.0	0.40
O3	Technological advances that are currently developing	0.08	3.0	0.24
O4	Have a good relationship with the surrounding environment	0.09	3.0	0.27
O5	Market share is quite high	0.09	4.0	0.36
O6	Good relationship with suppliers	0.09	4.0	0.36
	Threat :			
T1	Global economic crisis (a phenomenon or disease outbreak such as Covid-19)	0.09	3.0	0.22
T2	Rise in fuel prices	0.07	1.0	0.07
T3	There are more and more similar lathe companies in the city of Gresik	0.07	1.0	0.07
T4	The development of product quality in relation to current consumer needs still needs to be considered	0.08	1.0	0.12
T5	Increase in raw material prices	0.08	1.0	0.12
T6	Competitive price competition with competitors.	0.08	2.0	0.16
	TOTAL	**1.00**		**2.70**

From the analysis of the EFE matrix in table 2, it shows that the highest opportunity score with a value of 0.40 was obtained for the factorstrategic location of the workshop (close to human resources, raw materials, consumers). Meanwhile, the highest threat score with a value of 0.22 was obtained from the global economic crisis factor (the presence of a disease phenomenon or outbreak such as Covid-19).

The weighting and rating process in tables 1 and 2, the weight values are obtained from internal and external factors, so it can be seen which factors are not important to which are important, which are likely to have an impact on strategic factors. Meanwhile, the rating value given is between 1 and 4. This factor influences the condition of the company.

The following are the rating values obtained from the questionnaire as follows: From the IFE and EFE matrix calculations it can be seen:

a. Total IFE weight score = 2.60
b. Total EFE weight score = 2.70

3.3. *IE Matrix*

In this matrix, the IFE and EFE matrix scores regarding company strength are combined based on the organization's internal and external conditions. Based on the results, the total IFE weight score is 2.60 while the EFE is 2.70.

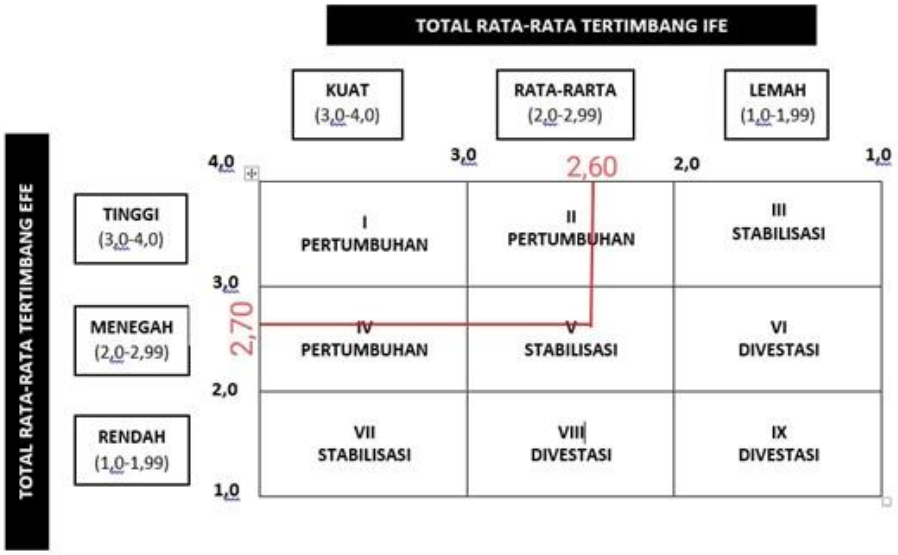

Figure 1. IE Matrix

3.4. SWOT Matrix

The SWOT matrix is obtained by using factors that include strengths and opportunities for the SO strategy, weaknesses and threats for the WO strategy, strengths and threats for the ST strategy, and weaknesses and threats for the WT strategy.[5].

Table 3.SWOT analysis

	Strength :	**Weakness :**
	• **UD AMJ Jaya Teknik has competent workers in the turning field** • **The products produced are very good and there are almost no failures in the production process** • **The method used in turning techniques meets the SOP** • **Turning processing time is relatively fast** • **The machine used meets Indonesian National Standards (SNI)**	• **Lack of capital to increase company productivity** • **It does not have a special machine that can perform special turning operations** • **The owner still has the main power in making decisions** • **Machines still depend on humans** • **Does not have permanent employees** • **Promotional strategies are less diverse** • **The owner still goes straight**

	• **Various types of turning can be done (according to customer wishes)** • **Practically carry out tasks and be responsible for the product requirements received (good relationship with consumers)** • **Have permanent suppliers and quality materials** • **Have your own workshop (no rent)** • **S10. Can negotiate prices on submitted offers**	**to sales, taking a direct sales approach** • **Profit is less than optimal** • **The organizational structure is still weak** • **Operational transportation is not enough of an option**
Opportunity : • **Have collaborative partners with other workshops with more complete machines** • **Strategic location of the workshop (close to human resources, raw materials and consumers)** • **Technological advances that are currently developing** • **Have a good relationship with the surrounding environment** • **Market share is quite high** • **Good relationship with suppliers**	**Strengths and opportunities:** • Collaborating with other workshops with more complete machines with a profit sharing system (S1, S2, S3, S4, S5, S6+O3) • Apply for a discount on raw material prices (S8+O5,O6)	**Weaknesses and opportunities:** • Collaboration with workshops that have complete machines with a profit sharing system (W1, W2+O1) • Increase cooperation with other factories (Consumers) and improve promotional strategies (W6, W7, W8+O3, O4, O5) • Create online media to make it easier to search for orders and deliveries (W10+O3)
Threat : • **Global economic crisis (a phenomenon or disease outbreak such as Covid-19)** • **Rise in fuel prices** • **The increasing number of similar lathe machine companies in the city of Gresik** • **Developing product quality based on customer needs is currently still in the high demand stage** • **rising raw material prices** • **Competitive price competition with competitors.**	**Strengths and threats:** Improving the quality of the products produced and innovating the products produced (S1, S2, S3, S4, S5+T3) Make attractive price offers by making price discounts (S1, S2, S3, S4, S5+T6) Asking for discounts from raw material suppliers (S8+T5)	**Weaknesses and threats:** • Carrying out promotions and negotiating prices with consumers • Adding the latest product variations to meet customer standards (W3,W7+T6)

3.5. QSPM analysis

Based on SWOT matrix analysis and IE matrix. Several alternative marketing strategies can be generated. The following are the results of the strategy and calculation of TAS values:

Table 4. Calculation of TAS value

Factor	Weight	Strategy													
		1		2		3		4		5		6		7	
		AS	TAS	AS	TAS	AS	TAS	AS	TAS	AS	TAS	AS	TAS	AS	TAS
S1	0.06	2	0.12	1	0.06	4	0.24	2	0.12	2	0.12	2	0.12	4	0.24
S2	0.06	2	0.12	2	0.12	4	0.24	3	0.18	3	0.18	1	0.06	4	0.24
S3	0.05	2	0.1	2	0.1	4	0.2	3	0.15	3	0.15	3	0.15	3	0.15
S4	0.06	2	0.12	2	0.12	4	0.24	3	0.18	3	0.18	3	0.18	4	0.24
S5	0.05	1	0.05	2	0.1	4	0.2	2	0.1	2	0.1	3	0.15	1	0.05
S6	0.06	1	0.06	2	0.12	4	0.24	3	0.18	3	0.18	4	0.24	3	0.18
S7	0.05	2	0.1	2	0.1	4	0.2	4	0.2	4	0.2	4	0.2	4	0.2
S8	0.06	2	0.12	4	0.24	2	0.12	3	0.18	3	0.18	3	0.18	4	0.24
S9	0.05	1	0.05	1	0.05	2	0.1	2	0.1	2	0.1	3	0.15	3	0.15
S10	0.05	2	0.1	3	0.15	3	0.15	4	0.2	4	0.2	3	0.15	4	0.2
W1	0.04	4	0.16	4	0.16	2	0.08	2	0.08	3	0.12	4	0.16	2	0.08
W2	0.04	4	0.16	2	0.08	2	0.08	2	0.08	3	0.12	2	0.08	1	0.04
W3	0.04	3	0.12	4	0.16	3	0.12	4	0.16	3	0.12	4	0.16	4	0.16
W4	0.04	2	0.08	1	0.04	1	0.04	1	0.04	1	0.04	2	0.08	1	0.04
W5	0.05	4	0.2	1	0.05	2	0.1	3	0.15	1	0.05	3	0.15	1	0.05
W6	0.06	2	0.12	2	0.12	4	0.24	3	0.18	4	0.24	4	0.24	3	0.18
W7	0.04	4	0.16	4	0.16	3	0.12	4	0.16	3	0.12	3	0.12	4	0.16
W8	0.05	3	0.15	3	0.15	4	0.2	4	0.2	3	0.15	3	0.15	4	0.2
W9	0.05	2	0.1	2	0.1	3	0.15	1	0.05	1	0.05	1	0.05	1	0.05
W10	0.04	2	0.08	2	0.08	3	0.12	1	0.04	1	0.04	2	0.08	1	0.04
O1	0.09	4	0.36	1	0.09	4	0.36	2	0.18	3	0.27	2	0.18	2	0.18
O2	0.1	4	0.4	4	0.4	2	0.2	3	0.3	4	0.4	2	0.2	2	0.2
O3	0.08	3	0.24	3	0.24	4	0.32	2	0.16	2	0.16	4	0.32	1	0.08
O4	0.09	4	0.36	3	0.27	3	0.27	4	0.36	4	0.36	3	0.27	4	0.36
O5	0.09	4	0.36	4	0.36	4	0.36	3	0.27	3	0.27	4	0.36	3	0.27
O6	0.09	2	0.18	4	0.36	1	0.09	2	0.18	4	0.36	2	0.18	1	0.09

T1	0.09	3	0.27	3	0.27	2	0.18	3	0.27	2	0.18	4	0.36	2	0.18
T2	0.07	1	0.07	3	0.21	1	0.07	2	0.14	2	0.14	2	0.14	2	0.14
T3	0.07	3	0.21	1	0.07	4	0.28	4	0.28	4	0.28	4	0.28	4	0.28
T4	0.08	3	0.24	3	0.24	3	0.24	2	0.16	2	0.16	2	0.16	2	0.16
T5	0.08	2	0.16	4	0.32	2	0.16	1	0.08	1	0.08	2	0.16	1	0.08
T6	0.08	3	0.24	3	0.24	3	0.24	4	0.32	4	0.32	3	0.24	4	0.32
Total value			**5.36**		**5.33**		**5.93**		**5.43**		**5.62**		**5.70**		**5.23**

The method for calculating TAS is as follows: weight x AS (0.06 x 2 = 0.12). The AS (Attractiveness Score) value was obtained from the brainstorming results of 3 participants, namely business owners, workers and researchers.

Table 5.QSPM Matrix

Strategy Alternatives	Strategy Description	TAS value	Ranking
Strategy 1	Collaborating with other workshops with more complete machines with a profit sharing system	5.36	5
Strategy 2	Proposing discounts on raw material prices to suppliers	5.33	6
Strategy 3	Improving the quality of the products produced and innovating the products produced	5.95	1
Strategy 4	Make attractive price offers by making price discounts	5.43	4
Strategy 5	Increase cooperation with other factories (Consumers) and improve promotional strategies	5.62	3
Strategy 6	Create online media to make it easier to find orders and deliveries	5.70	2
Strategy 7	Carrying out promotions and negotiating prices with consumers	5.23	7

Based on the ranking results in table 4, the strategy that is the main priority to be implemented by company management is improving product quality where this strategy aims to increase revenue and add consumers to the company.

4. Conclusion

Based on the results of the discussion and data processing that has been carried out, it can be concluded that the strategy is a combination of strengths and opportunities, namely improving relationships with colleagues to increase the amount of product productivity and expanding the market by becoming a supplier to retail businesses. Meanwhile, suggestions are obtained from a combination of shortcomings and threats, namely re-structuring business management so that work can be more optimal, being braver in taking risks that are profitable for the future and maintaining product quality so that it is not affected by price competition. From the results of the research discussion above, it can be seen that UD AMJ Jaya Teknik still needs to increase the number of product productivity and expand the market and maintain product quality so that customers do not look for other suppliers.

This research has shortcomings in that the discussion only refers to marketing and calculations that are less than optimal. In future research, it is hoped that the objects observed will have a wide scope so that they can be observed well so that the research is more complete and accurate. Apart from that, further research can use other methods.

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Advance Sustainable Science, Engineering and Technology (ASSET)
Vol. 5, No.3, October 2023, pp. 02303011-01 ~ 02303011-08
ISSN: 2715-4211 DOI: https://doi.org/10.26877/asset.v5i3.17188

Mangrove Tree Species Classification Based on Leaf, Stem, and Seed Characteristics Using Convolutional Neural Networks with K-Folds Cross Validation Optimalization

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Abstract. *Mangrove classification plays a pivotal role in environmental monitoring and conservation efforts. In this study, our meticulously curated dataset comprised diverse mangrove tree images standardized to 250 x 250 pixels, capturing the nuances of various species. Employing advanced deep learning techniques, our models demonstrated exceptional accuracy, reaching 99.23% without K-Folds and a slightly enhanced 99.78% with K-Folds. These models exhibited outstanding consistency, showcasing recall, precision, and F1-Score metrics all surpassing 99%. Through rigorous testing in 10 experiments, both K-Folds and non-K-Folds methods consistently achieved 100% accuracy, evidenced by the presence of True Positives in every classification scenario. This remarkable performance underscores the robustness of our algorithms in precisely classifying mangrove species, offering a valuable tool for ecological research and conservation initiatives. The practical implications of our findings are profound, providing an invaluable resource for environmentalists, conservationists, and policymakers engaged in mangrove preservation. Accurate species classification is pivotal in understanding biodiversity, aiding in targeted conservation efforts, and ultimately promoting the sustainable management of these vital coastal ecosystems.*

Keywords: Mangrove, Image Classification, CNN, K-Folds

(Received 2023-10-13, Accepted 2023-10-23, Available Online by 2023-10-31)

1. Introduction

The classification of mangrove tree species based on image analysis, a field known as digital plant taxonomy, has become integral to ecological research, contributing significantly to biodiversity conservation and sustainable environmental management [1]. This process involves extracting meaningful information from images, enabling the identification of plant species through computational methods. Traditional methods of species identification, reliant on manual observation and expertise, are often time-consuming and prone to errors [2]. In response to these challenges, the integration of

advanced technologies has become imperative in the field of botanical taxonomy. With the advent of computer vision and machine learning, the landscape of species classification has undergone a transformative evolution, enabling the development of highly efficient and accurate automated identification systems [3].

Contemporary technologies used for species classification primarily encompass image processing algorithms and machine learning models. These technologies leverage features such as leaf shape, texture, and color to differentiate between plant species. However, the limitations of these methods are apparent when dealing with intricate botanical characteristics, necessitating the exploration of more sophisticated approaches. One such groundbreaking technology is Convolutional Neural Networks (CNN), a class of deep learning algorithms specifically designed for image recognition tasks [4]. CNNs have demonstrated unparalleled proficiency in pattern recognition, allowing them to discern complex patterns within images and make highly accurate classifications [4], [5]. This methodology holds immense promise in revolutionizing the classification of mangrove tree species, addressing the limitations of traditional techniques and significantly enhancing the precision and efficiency of species identification efforts [6].

In this research, the primary research objective is to investigate how these distinct features can be effectively utilized to differentiate between various mangrove species. Additionally, the study endeavors to optimize the performance of the CNN model using K-Folds cross-validation, ensuring robustness and minimizing overfitting.. By harnessing the capabilities of deep learning, this study aims to create a robust and reliable system capable of accurately identifying mangrove species based on their distinct leaf, stem, and seed characteristics. The utilization of CNN not only represents a significant advancement in botanical research but also opens new avenues for ecological studies, conservation initiatives, and sustainable environmental practices. Through this research, we strive to contribute to the ongoing efforts in preserving the invaluable biodiversity of mangrove ecosystems, emphasizing the critical role of cutting-edge technology in shaping the future of ecological studies and environmental conservation. This study will include a detailed analysis of specific cases, showcasing the effectiveness of CNN in resolving intricate botanical classification challenges and providing valuable insights into the applicability of this technology in real-world ecological contexts. The results derived from the fulfillment of these research objectives will be comprehensively detailed and discussed in the "Results and Discussion" section of the research paper.

2. Methods

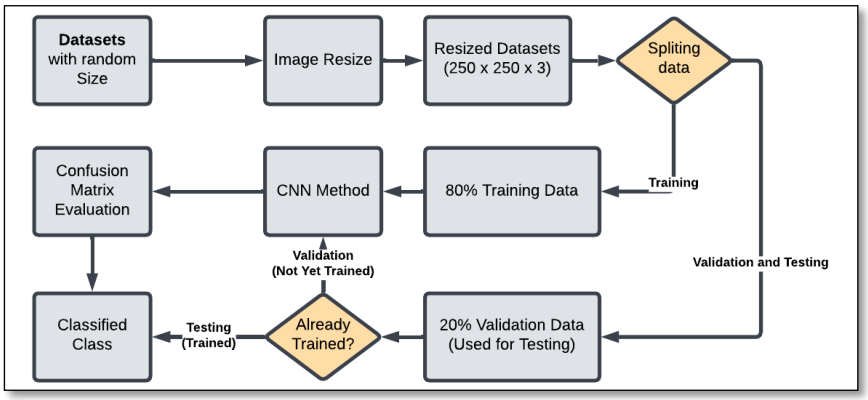


Figure 1. Research Methodology

Figure 1 represent proposed workflow, the study begins by acquiring diverse datasets containing images of mangrove tree species with varying sizes. To ensure uniformity and consistency in the analysis, the images undergo a resizing process, standardizing them to a resolution of 250 x 250 pixels

and maintaining the RGB color channels. This step ensures that all images are of the same dimensions, allowing for seamless processing within the neural network. The dataset is then split into two subsets: 80% of the data is allocated for training the Convolutional Neural Network (CNN) model, enabling it to learn and recognize patterns from the images, while the remaining 20% serves as validation data for testing the trained model's accuracy and performance. During the training phase, the CNN method is employed to process the training dataset, allowing the model to analyze and extract intricate features from the resized images. This training process involves iteratively adjusting the network's parameters to minimize errors and enhance accuracy. The model's performance is continuously evaluated using the 20% validation data, which acts as a benchmark for its classification capabilities. The confusion matrix, a powerful tool for evaluating classification models, is utilized to assess the CNN's accuracy, providing a detailed breakdown of the model's predictions against the actual classes. Following the training and validation phases, the model is tested using the 20% validation data to assess its real-world performance.

2.1. Datasets

In this study, our dataset comprised a comprehensive collection of mangrove tree images, capturing the diverse array of sizes and complexities inherent to different species. To ensure consistency and facilitate effective analysis, the images underwent meticulous resizing, all standardized to a uniform dimension of 250 x 250 pixels. This careful standardization process was paramount as it preserved the essential visual intricacies of mangrove stems, leaves, and seeds, allowing for precise computational analysis. The dataset, thoughtfully curated into eight distinct classes, represented a variety of mangrove species, including Avicennia marina (146 samples), Avicennia officinalis (149 samples), Avicennia rumphiana (116 samples), Rhizophora mucronata (120 samples), and Sonneratia alba (120 samples). Based on sample image, can be seen in **Figure 2**. For the purpose of this study, 80% of the total dataset, meticulously organized into these distinct classes, was allocated for the training phase. The remaining 20% of the dataset was dedicated to testing and validation, serving as a robust benchmark for evaluating the trained CNN accuracy and performance. By segregating the dataset in this manner, we ensured a rigorous evaluation process, enabling us to validate the model's proficiency in classifying mangrove species accurately and reliably.

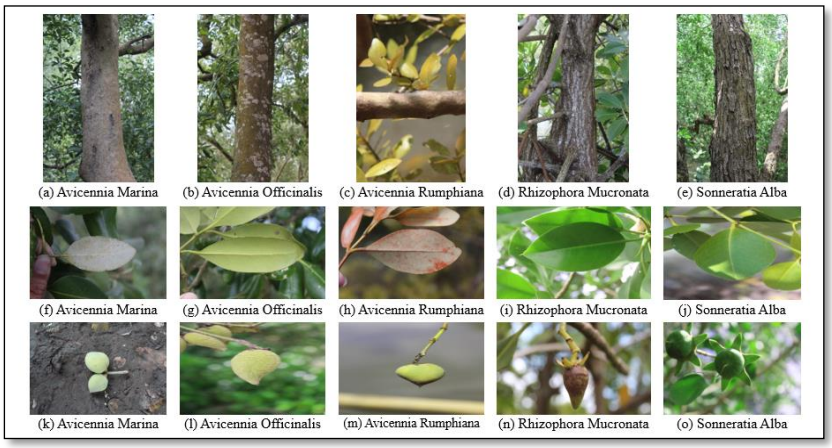


Figure 2. (a) – (e) represents Stems, (f) – (j) represents Leaf, (k) – (o) represents seed.

2.2. Convolutional Neural Netwrks (CNN) Classification

CNN stand as a pioneering force in the realm of artificial intelligence, revolutionizing the field of image recognition and classification [7]. Rooted in deep learning, CNN are intricately designed neural networks inspired by the visual processing capabilities of the human brain. What distinguishes CNN from traditional neural networks is their ability to automatically learn and extract intricate features from images through convolutional layers [4]. By employing filters that slide across the input image, CNN

can identify patterns such as edges, textures, and complex shapes, enabling them to comprehend visual data in a manner akin to human perception. This powerful methodology has found profound applications in diverse domains, ranging from facial recognition systems and autonomous vehicles to medical image analysis and natural language processing. The adaptability and accuracy of CNN have propelled them to the forefront of cutting-edge technology, cementing their status as a cornerstone in the evolution of machine learning and computer vision [4], [6].

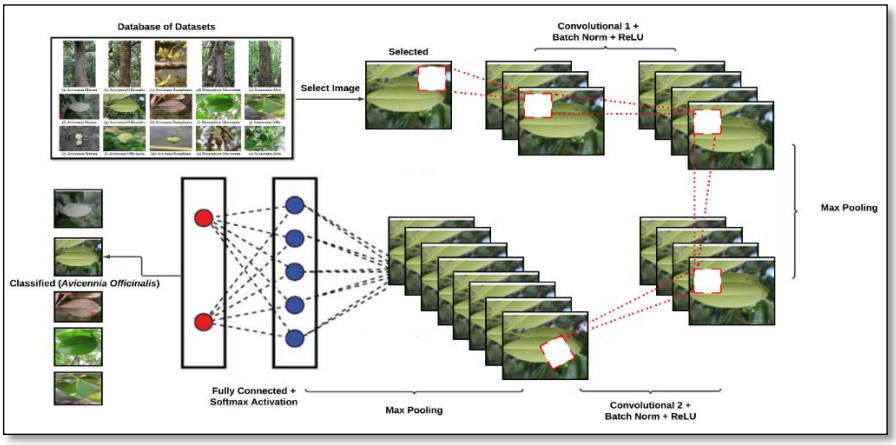


Figure 3. CNN Classification Layers Based on Proposed Method.

2.3. Confusion Matrix Evaluation

Confusion matrix is a fundamental tool in the realm of classification tasks, offering a clear and comprehensive snapshot of a model's performance across multiple classes [8]. The confusion matrix [9] serves as a foundational step in the evaluation process, enabling data scientists and machine learning practitioners to gauge the efficacy of classification models and make informed decisions to enhance their predictive capabilities. Following the Confusion Matrix Equation, can be seen below, where, True Positive (TP) values lie along the diagonal, indicating correct predictions, while off-diagonal elements represent misclassifications. False Positive (FP) signifies instances wrongly classified as positive, and False Negative (FN) represents instances incorrectly labeled as negative. True Negative (TN) values denote correct rejections.

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN} \quad (1)$$

$$Precision = \frac{TP}{TP + FP} \quad (2)$$

$$Recall = \frac{TP}{TP + FN} \quad (3)$$

$$F1 - Score = \frac{2 \times Precision \times Recall}{Precision \times Recall} \quad (4)$$

2.4. K-Folds Cross Validation Optimalization

K-Fold Cross-Validation stands as a critical strategy for refining the performance of CNN [10]. With the challenge of classifying five distinct mangrove species, employing K-Fold Cross-Validation becomes indispensable. This technique involves dividing the dataset into k subsets and iteratively training the CNN on $K - 1$ folds while validating on the remaining fold. By systematically cycling through the data, each subset is used for both training and validation, ensuring a comprehensive assessment of the model's ability to discern intricate features specific to each mangrove class [11]. The iterative nature of K-Fold Cross-Validation minimizes the risk of overfitting and provides a more accurate estimation of the CNN's performance across diverse instances of mangrove species [12]. This

rigorous validation methodology not only optimizes the network's architecture and hyperparameters but also fosters a model that exhibits robustness and reliability in classifying the intricate variations within the mangrove ecosystem. Through K-Fold Cross-Validation, CNN-based mangrove classification achieves a level of precision essential for ecological studies and biodiversity conservation efforts [13]. For example, when employing K-Fold Cross-Validation with $K = 5$, the dataset is divided into five subsets, enabling the Convolutional Neural Network to be trained and validated iteratively on distinct portions of the data, ensuring a robust evaluation of its performance. **Figure 4** represents new flow with previous study with addition of K-Folds Cross Validation Optimization parameters. K-Folds cross-validation technique was employed with a value of K set at 5. This means that the dataset, which consisted of approximately 3200 iterations in the pre-processing phase of the Convolutional Neural Network (CNN), was divided into five subsets or folds. The training and validation process was then repeated five times, each time utilizing a different subset as the validation data and the remaining four subsets for training. This approach effectively resulted in 5 iterations, with each iteration serving as both the validation and training set once. The purpose of this meticulous division was to ensure comprehensive model assessment and avoid biases that might arise from a singular split of the data. The choice to employ K-Folds cross-validation over other techniques stems from its ability to address the crucial concern of overfitting in machine learning models. Overfitting occurs when a model learns the training data too well, capturing noise and irrelevant patterns instead of generalizing to new, unseen data. K-Folds cross-validation mitigates this risk by rigorously evaluating the model's performance across multiple subsets of the data [14].

Figure 4. Addition of K-Folds Cross Validation Optimization parameters

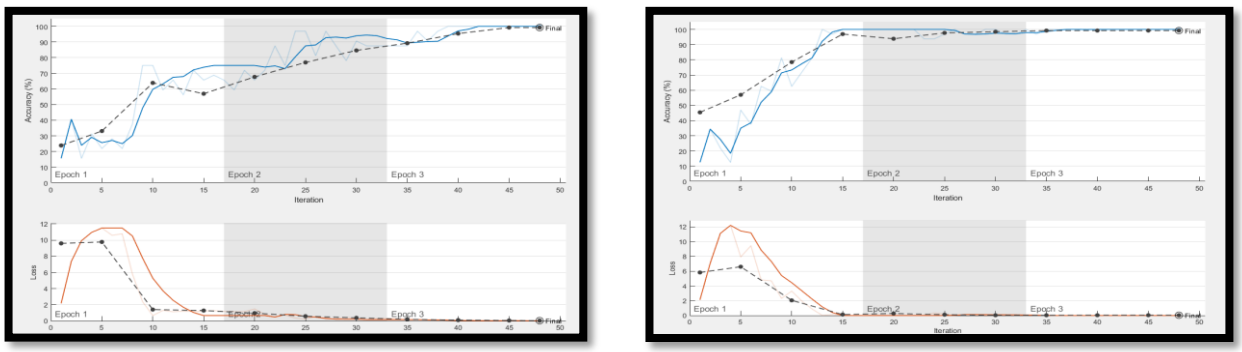
3. Results and Discussion

Based on the proposed method, the results and discussion are intricately intertwined with the two algorithmic approaches described below. The first algorithm, employing an 80-20 training-validation split, utilized a neural network architecture with convolutional layers, batch normalization, ReLU activation, and max-pooling, culminating in a multi-class classification model. The second approach focused on the analysis of specific performance metrics such as accuracy, precision, and recall through confusion matrix evaluation. Notably, the intricate interplay between these algorithms illuminates the nuanced intricacies of the proposed methodology, showcasing its robustness in handling complex classification tasks. Based on the pseudocode algorithm provided in **Table 1**, an evaluation graph has been generated, reflecting the precision and performance of the designed model. This graph, as depicted in the image below, illustrates the progress of both loss and accuracy throughout the training process. The graph becomes a valuable window, allowing an in-depth understanding and assessment of the model's convergence. The Graph can be seen below. In **Figures 5**, the generated graphs led to the production of the following confusion matrix. This matrix encapsulates the classification outcomes, providing a clear and detailed overview of the model's performance in categorizing various mangrove

species. The values within the confusion matrix serve as a quantitative reflection of the model's accuracy and effectiveness, essential for a comprehensive evaluation of its classification capabilities. The results of confusion matrix evaluation, can be seen in **Table 2**.

Table 1. Pseudocode Algorithm Based on Proposed Method

CNN With and Without K-Folds
Initialize the training data split ratio: $numTrainFiles = 0.80$
Split the dataset into training and validation sets using splitEachLabel function (**Without K-Folds):** $[imdsTrain, imdsValidation] = splitEachLabel(imds, numTrainFiles, 'randomize')$ **Split** the dataset into training and validation sets using splitEachLabel function (**With K-Folds**): $[imdsTrain, imdsValidation] = splitEachLabel(imds, numTrainFiles, 'Kfold', 5)$
Input layer: imageInputLayer with size [250 250 3] **Convolutional layers:** • 2D Convolutional layer with 8 $filters, 3x3$ $kernel\ size, and\ 'Padding'$ set to 1 • Batch normalization layer • ReLU activation layer • 2D Max-pooling layer with $2x2$ $pool\ size\ and\ 'Stride'$ set to 2 • Repeat the above convolutional block with 16 and 32 $filters$ respectively • Fully connected layer with 5 $output$ nodes • Softmax layer for classification • Classification layer
Define training options: • Use stochastic gradient descent with momentum $(sgdm) optimizer$ • Set GPU as the execution environment • Maximum number of epochs: 3 • Mini-batch size: 32 • Validation data: $imdsValidation$ • Validation frequency: $every$ 5 $iterations$ • Disable verbose mode during training
Confusion Matrix Evaluation



(a) Training and Loss Progress without K-Folds (b) Training and Loss Progress with K-Folds

Figure 5. Training and Loss Progres with and without K-Folds

Table 2. Confusion Matrix Evaluation

Evaluation	**Without K-Folds**	**With K-Folds**
Accuracy	99,23%	99,78%
Recall	99,13%	99,17%
Precision	100%	100%
F1-Score	99,56%	99,58%

Table 3. Classification Testing with and without K-Folds

Input Image	Classification Testing Without K-Folds			Classification Testing With K-Folds		
	Actual Class	Predicted Class	Result	Actual Class	Predicted Class	Result
Avicennia Marina1.jpg	Avicennia Marina	Avicennia Marina	TP	Avicennia Marina	Avicennia Marina	TP
Avicennia Marina32.jpg	Avicennia Marina	Avicennia Marina	TP	Avicennia Marina	Avicennia Marina	TP
Avicennia Officinalis2.jpg	Avicennia Officinalis	Avicennia Officinalis	TP	Avicennia Officinalis	Avicennia Officinalis	TP
Avicennia Officinalis48.jpg	Avicennia Officinalis	Avicennia Officinalis	TP	Avicennia Officinalis	Avicennia Officinalis	TP
Avicennia Rumphiana3.jpg	Avicennia Rumphiana	Avicennia Rumphiana	TP	Avicennia Rumphiana	Avicennia Rumphiana	TP
Avicennia Rumphiana66.jpg	Avicennia Rumphiana	Avicennia Rumphiana	TP	Avicennia Rumphiana	Avicennia Rumphiana	TP
Rhizophora Mucronata4.jpg	Rhizophora Mucronata	Rhizophora Mucronata	TP	Rhizophora Mucronata	Rhizophora Mucronata	TP
Rhizophora Mucronata6.jpg	Rhizophora Mucronata	Rhizophora Mucronata	TP	Rhizophora Mucronata	Rhizophora Mucronata	TP
Sonneratia Alba7.jpg	Sonneratia Alba	Sonneratia Alba	TP	Sonneratia Alba	Sonneratia Alba	TP
Sonneratia Alba21.jpg	Sonneratia Alba	Sonneratia Alba	TP	Sonneratia Alba	Sonneratia Alba	TP

For future research, an intriguing avenue to explore would be integrating image segmentation techniques to identify specific regions within whole mangrove ecosystems. This segmentation approach could distinguish between different mangrove species, such as Mangrove A or Mangrove B, within a single image. By employing advanced image analysis methods, researchers can delve deeper into the intricate structures and ecological patterns of various mangrove species, enhancing our understanding of their distinct characteristics and contributions to the ecosystem**.**

4. Conclusion

In conclusion, the evaluation results depicted in **Table 2** demonstrate exceptional performance for both models, with an accuracy of 99.23% for the approach without K-Folds and a slightly improved accuracy of 99.78% for the K-Folds methodology. Notably, both models exhibited remarkable consistency across key metrics, showcasing high recall, precision, and F1-Score, all exceeding 99%. Analyzing the detailed classification outcomes in **Table 3**, it is evident that in all 10 experiments (testing), both the K-Folds and non-K-Folds approaches consistently achieved 100% success rates. This is evidenced by the presence of True Positives (TP) exclusively in the "Result" column for each classification scenario, signifying accurate predictions for every mangrove species tested. This outstanding achievement underscores the robustness of the models, regardless of the utilization of K-Folds. Therefore, the application of both methods yielded flawless results, reaffirming the effectiveness of the developed algorithms in precisely classifying mangrove species within the dataset. Furthermore, the robustness of the developed algorithms ensures their efficacy in real-time field applications, enabling scientists, researchers, and conservationists to make informed decisions for the preservation and restoration of mangrove ecosystems worldwide. The successful application of these models underscores

their potential to revolutionize how we understand and protect delicate ecological environments, making a tangible impact on the preservation of biodiversity and the overall health of our planet.

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Advance Sustainable Science, Engineering and Technology (ASSET)
Vol. 5, No.3, October 2023, pp. 02303012-01 ~ 02303012-09
ISSN: 2715-4211 DOI: https://doi.org/10.26877/asset.v5i3.17195

Identification of the Snail Oncomelania hupensis Lindoensis as Schistotomiasis Host Using CNN

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Abstract. *The World Health Organization reports schistosomiasis as a neglected tropical disease. In Indonesia, schistosomiasis is endemic in 3 regions of Central Sulawesi. In 2023, the prevalence rate of schistosomiasis in humans in Indonesia was 0.43%. Efforts are needed to achieve the government target of 0% prevalence in humans, snails, and mammals in 2025. Survey officers who do not recognize specific O. hupensis lindoensis snails need to ask officers who know. The identification system was made using the CNN (Convolutional Neural Network) algorithm with MobileNet architecture. With four classes and 1200 image data, the training accuracy is 93%, and the validation accuracy is 87%. The training loss function is 0.17, and the validation loss is 0.33. This research uses the Black Box testing method to test the functionality of the system with a result of 90% and Confusion Matrix testing precision with a result of 0.87. The results of this study can speed up, facilitate, and reduce the cost of snail prevalence surveys for officers and are useful for ordinary people to recognize this snail as the cause of schistosomiasis disease.*

Keywords: World Health Organization, Schistosomiasis, Endemic, O.hupensis lindoensis, CNN

(Received 2023-10-14, Accepted 2023-10-26, Available Online by 2023-10-31)

1. Introduction

The World Health Organization (WHO) released its second *road map* to address the problem of *Neglected Tropical Disease* (NTD). The new *road map* continues the 2010 *road map* that ended in 2020. The new *road map* has a period of 2021-2030 and sets targets and measures to prevent, control, eliminate, or eradicate 20 diseases in the NTD group. One of the diseases included in NTDs is

schistosomiasis. The WHO report stated that *schistosomiasis* caused 236 million people to need treatment in 2019 and was responsible for 24,000 deaths in 2016 [1]. Muller and Tesch first discovered schistosomiasis in Indonesia in a 35-year-old male patient from Tomado village in Lindu Valley in 1973. Tomado village was later designated as a *schistosomiasis* endemic area by Brug and Tesch in the same year [2]. In Indonesia, *schistosomiasis is* endemic in 3 areas of Central Sulawesi, namely the Lindu Plateau, Napu Plateau, and Bada Plateau [3]. These three areas are included in 2 districts, namely Sigi District with five endemic villages (Anca, Tomado, Olu, Puroo, and Langko villages) and Poso District with 23 endemic villages (Banyusari Village, Sedoa, Kaduwoa, Alitupu, Tamadue, Mekarsari, Maholo, Winowanga, Dodolo, Torire, Watutau, Wuasa, Wanga, Siliwanga, Betue, Kalemango, Watumaeta, Kageroa, Tomehipi, Lengkeka, Tuare, Koloni, Leleo). [4].

Schistosomiasis in Indonesia is caused by the *Schistosoma japonicum* worm, hereafter referred to as S. japonicum [5]. This worm has two stages of development in its life cycle. The asexual development stage requires the intermediate *host* snail *Oncomelania hupensis lindoensis, hereinafter* referred to as O.hupensis lindoensis. The sexual development stage in the main host body is humans and mammals [6]. In 2019, the prevalence of *schistosomiasis* in humans in Indonesia was suppressed and dropped significantly to reach 0.1% compared to 2018, which was 0.5%. In 2020, there was no significant change from the previous year, which amounted to 0.11%. However, in 2021 and 2022, there was an increase in the prevalence rate of 0.22% and 1.44%, respectively. However, the 2023 survey showed that the prevalence rate could be reduced to 0.43% [7].

Although efforts to prevent *schistosomiasis* transmission have been made since 1974 [8], the infection still continues to occur [3][9][10]. To solve this problem, the Indonesian government, through Bappenas in 2017, issued a *schistosomiasis* elimination *road map* for 2018-2025. Then, it was strengthened by Permenkes Number 19 of 2018 with a target of 0% prevalence in humans, snails, and animals in 2025 [4]. The snail *O.hupensis lindoensis* hosts *schistosomiasis* before attacking humans and mammals. The *cercariae* phase of the *S. japonicum* worm inside the *O. hupensis lindoensis* snail at a certain time comes out looking for a new host and enters through the skin of humans or mammals as a place for further development into adult worms. *Cercariae* can only survive within 48 hours in the search for a new host. If it does not find a host, then this worm will die [11]. The position of the snail *O.hupensis lindoensis in* the *schistosomiasis* disease cycle is very important because it contains *cercariae* that can infect humans or mammals. Therefore, it is necessary to suppress or eliminate *O.hupensis lindoensis* snails. So that transmission of *schistosomiasis* to humans or mammals can be interrupted [11].

O.hupensis lindoensis snails act as *intermediate* hosts and are amphibious [12]. Therefore, they are often found on the banks of irrigation channels, drainage channels, or rivers. Several environmental conditions affect the survival of these snails, such as water temperature, water flow velocity, and vegetation cover. Other things that also affect are the type of vegetation, soil type, and water that is sufficient for the development of snails and *cercariae* in the *host-seeking* stage [13]. To find out the location of the *O.hupensis lindoensis* snail, a survey of snail locations or habitats was conducted [10][14]. In 2021, Nurwidayanti et al. [14] conducted a survey of 25 snail habitats in Anca and Tomado Villages, Lindu District, Sigi Regency. It was found that there were still snails containing *S.japonicum* cercariae.

Morphologically, the O. hupensis lindoensis snail has a shell size of 6 mm when mature, narrowed cone-shaped, smooth surface, stacked as many as 6.5 - 7.5, black, gray to brown, the size of the hole where the snail's body exits are 2.38 x 1.75 mm, and the inside of the shell (*inner lip*) is light yellow to orange yellow [5]. Currently, when conducting snail site surveys, officers use their experience to identify and distinguish *O. hupensis lindoensis* among other snails. So, officers who are first-timers or have yet to gain experience in identifying *O.hupensis lindoensis* need to ask officers who know better. This slows down the survey process. A system that can identify *O.hupensis lindoensis* among snails in schistosomiasis endemic areas can speed up the identification process and reduce survey costs. Addressing *schistosomiasis* requires cross-sectoral cooperation [1][4]. Thus, the technology sector is needed to help identify *O. hupensis lindoensis* among snails in the same habitat in *schistosomiasis* endemic areas.

Technological developments in the field of health have been widely utilized and proven to benefit humans [15][16][17][18]. Some of them are *AI chatbots* that provide health recommendations under

expert supervision, sleep monitoring tools developed by *Google*, and breast cancer diagnosis through *x-ray* scan images [15]. This research aims to create a system that can identify *O.hupensis lindoensis* among other snails in the same habitat using the *Convolutional Neural Network (CNN)* algorithm. The selection of the CNN algorithm in this identification system is based on the evidence of CNN to classify or identify image data with good results. Research by Zhang et al. [16] used CNN to classify breast cancer. Artificial Neural Network as the basis of CNN is used by Utari et al. [19] to classify materials that enter the body with Ultrasonography. CNN has also been applied in brain tumor diagnosis by Wu et al. [17]. Souid et al. [18] utilized CNN with MobileNet to classify and predict lung diseases. The purpose of this research is to provide convenience to the community to recognize the *O.hupensis lindoensis snail* as the cause of *schistosomiasis*, especially for officers in conducting snail habitat surveys by utilizing the *O.hupensis lindoensis snail* identification system using CNN. This research hypothesizes that the identification system of *O.hupensis lindoensis* using CNN can help and facilitate officers in conducting snail habitat surveys so as to speed up the process, reduce survey costs, and make it easier for people in *schistosomiasis* endemic areas to recognize *O.hupensis lindoensis snails* as hosts of this disease.

2. Methods

2.1. Flowchart

System development is divided into three main parts, namely data *pre-processing*, CNN model building, and CNN model evaluation [14].

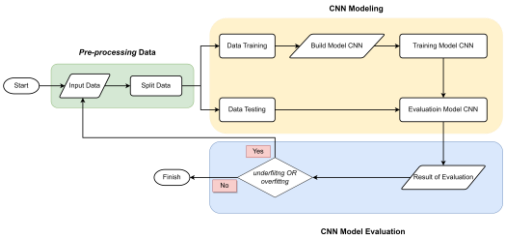


Figure 1. Flowchart

The data *pre-processing* stage begins by inputting data from the *Google Drive* folder that has been collected into the Goole Colab notebook jupyter. The data is then divided by 60% for *training data* and 40% for *validation* data. Then, augmentation is done to increase the amount of data with various variations [20]. Data that has been divided into two is included in the CNN model as model training material. The final results of model training are the accuracy rate and the loss rate or classification error. These final results can show whether the model formed is in an overfitting, underfitting, or fit condition. The ideal condition is that the model formed has a *fit* condition [20][21].

2.2. Datasets

The dataset in this study is in the form of snail image data obtained from various sources. Researchers collected data from the Central Sulawesi Provincial Health Office, Donggala LITBANGKES Center, and researchers who deal with *schistosomiasis* disease in Central Sulawesi. In addition, researchers also went to the field in Winowanga village, Lore Lindu sub-district, Poso district. The collected snails are divided into four types, namely *O.hupensis lindoensis*, *Sulawesidrobia sp*, *Thiara sp*, and *Brotia sp*. The habitats of these snails are in *schistosomiasis* endemic areas [5][22]. The snails were placed on white paper and then photographed using a *handphone* camera. Collected each type of 300 image data so that the overall dataset is 1200 images. The system created will recognize four types of snails in the dataset.

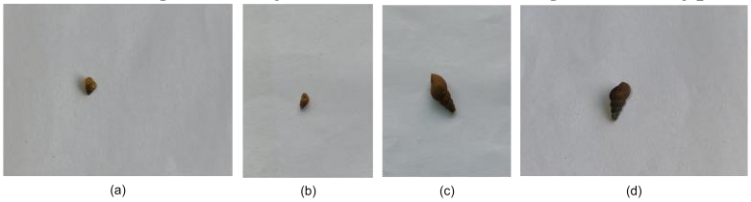


Figure 2. Images of Conch Dataset: (a) Sulawesidrobia sp (b) O. hupensis lindoensis (c) Thiara sp (d) Brotia sp

2.3. CNN

Convolutional Neural Network or CNN algorithm is a classification algorithm that is widely applied to image analysis [15][16][17][18]. CNN algorithm itself is part of *deep learning* [20]. In this study, the model formed was added to the *pre-training* layer of the *MobileNet* model. *MobileNet* is one of the development architectures of the CNN algorithm [23].

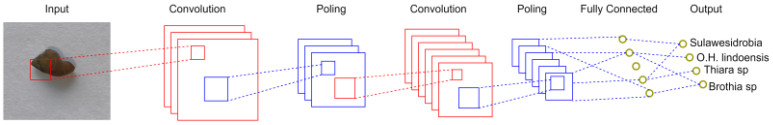


Figure 3. CNN Architectures

In general, *deep learning* has three layers, namely the *input layer*, *hidden layer*, and *output* layer. The *hidden layer* in *deep learning* aims to find the features of an object. The basic structure of the CNN hidden layer consists of *a convolutional layer, a pooling layer,* and a *fully connected layer* [20]. The convolutional layer is where most of the computation of the CNN architecture takes place, so it is called the core layer of the CNN. Each convolutional layer has a layer of neurons connected to a small area of the input image of a certain size called the receptive field. The size of this receptive field is expressed as a *convolutional layer* filter. The number of filters can be more than one [24]. This filter will trace the entire area of the input image and shift by a given *stride*, generally of size 1. The output of this process is the *dot product of the* filter and the receptive field of the input image [20]. Sometimes, the size of the input value and the size of the output value want to be equalized in height and width. Then, a *zero padding* can be added to the input value size [20][24]. There is a formula to determine the amount of padding, namely:

$$P = \frac{(F-1)}{2}$$

Description:
P = padding size; F = receptive field or filter size

Pooling layers are used to decrease or reduce the output size of the convolution layer. With this technique, the data becomes smaller, easier to manage, and easier to control overfitting [24]. Each result of the dot product between the filter and the receptive field will be polled. There are two types of *pooling*, namely, *max pooling* and *average pooling*. But the most commonly used is *max pooling*, taking the maximum value of the *dot product* result area [20].

$$f(x) = \max(0, x)$$

Description:
f(x) = *max pooling* result*; max* = take maximal data or 0 x = maximal data

Fully connected layers have the same form as Multi-Layer Perceptron or MLP. MLP itself is the basis of artificial neural networks. The way it works is the same as MLP, which is matrix multiplication with a bias value [20][24].

$$y = f(\sum_i x_i w_i + b)$$

Description:
y = output; f = activation function x = input; w = weights; b = bias

The output layer is the layer that produces the classification value. The classification result of the *output* layer or *output value* will be compared with the actual value or *target value of* the input data. The error distance between the *output value* and the *target value* will be calculated with a *loss function*. In this research, the *sparse categorical cross-entropy function is* used. Optimization is carried out with the optimizer function to minimize the *loss function* value while improving the CNN model. This research uses the *Adam optimizer* function.

2.4. Model created

The CNN model consists of the input layer, the pre-trained layer of the MobileNet architecture model, a trained layer, and an output layer.

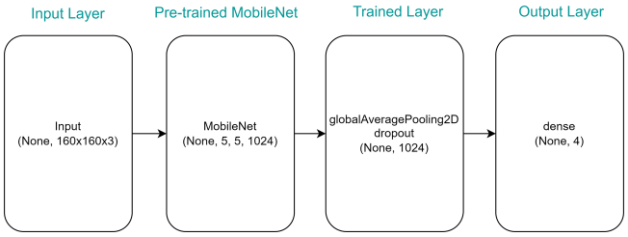


Figure 4. Layer Model Created with Output Shape of Each Layer

The input layer will receive image data with a size of (160x160x3). For this reason, each input image needs to be processed in the form of resizing the image to 160x160x3. The CNN model uses the pre-trained architecture of the MobileNet model. MobileNet itself is available in the tensorflow framework. To use the pre-trained MobileNet model, simply call the tf.keras.application. Mobile net.MobileNet function. The MobileNet pre-trained model architecture was chosen because it can provide the ability of the model to learn quickly and get good results with a small model size. Models with good results and small sizes can be used in further system development applied to mobile devices with low computational capabilities [18][23]. To adjust the model with the data used, researchers added a layer after pre-trained MobileNet. This addition is done to reduce the overfitting of the CNN model to the data. The added layer is a pooling layer, namely AveragePooling, and a dropout layer. The output layer will produce an array with a length of 4. Each value will have a range from 0.0 to 1.0. The final result is selected based on the highest value among the four output array values.

3. Results and Discussion

3.1. CNN Model Training Result

The convolutional Neural Network model is built with *the Tensorflow framework*. *Tensorflow is* run on *Google Collab,* which is an *open-source jupyter notebook* that has installed *libraries* to support the development of AI systems. The CNN architecture used is *MobileNet,* with the novelty of adjusting the dataset used and adding *global average-pooling* and *dropout* layers. The model *output* layer is 4, following the number of snail species found in *schistosomiasis* endemic areas. The 1200 datasets were divided into 60% or 720 data for training and 40% or 480 data for validation. Each group of data is augmented. The techniques performed are rescaling, random flip (horizontal and vertical), random contrast, random rotation, random brightness, random height, and random width on training data. In contrast, the validation data is only performed augmentation techniques in the form of rescaling. The augmentation process is done with a size of 64 batches.

The creation process undergoes some fine-tuning in the form of optimizer selection, input layer resizing selection, and augmentation batch size, as well as the batch size during the model training process. The suitable optimizer is the Adam optimizer. The data size for the input layer is 160x160x3, The batch size used is 64. In the process of training models on Google Colab, out-of-memory usually occurs. This is due to large data, so that the computational process is also large. To handle this problem, Google Collab was upgraded to pro and obtained a 16 GB V-100 GPU system. The CNN model trained for 100 *epochs* produced an accuracy of 93% with a validation accuracy of 87%. The *loss* value on training data is 0.16, while the *loss* value on validation data is 0.32.

Figure 5. Visualization of CNN Model Training Results

CNN model training visualization results show an increase in Accuracy in *training* data up to the 100th *epoch*. In validation data, the Accuracy increases up to the 40th *epoch*. In visualizing the *loss* value, up to the 100th *epoch*, *training loss* continues to decrease. While *validation loss* only decreased until the 40th *epoch*.

3.2. Confusion Matrix

The data used in confusion matrix testing is validation data, namely 480 data. The confusion matrix shows the system's shortcomings in identifying the *Sulawesidrobia sp* class, which is 30 times judged as the *O.hupensis lindoensis* class. This is because the *Sulawesidrobia sp* snail has similarities with *O.hupensis lindoensis* [6]. From the confusion matrix multiclass classification, a table can be made that relates the values of True Positives (TP), False Positives (FP), and False Negative (FN) [25].

Table 1. Confusion Matrix

	Sulawesidrobia sp (1)	***O.hupensis lindoensis (2)***	***Thiara sp (3)***	***Brothia sp (4)***	**Total**
TP	*84*	*110*	*114*	*110*	*418*
FP	*31*	*16*	*1*	*14*	*62*
FN	*12*	*39*	*9*	*2*	*62*

From the table above, we can calculate Accuracy for the ability of the system to identify all data and calculate Precision on the *O.hupensis lindoensis* class because this class is the focus of research and the cause of *schistosomiasis* disease. Knowing the Precision value of the *O.hupensis lindoensis class* can provide an overview of the system identifying this class.

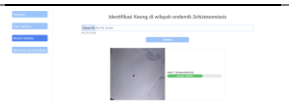
$$Accuracy = \frac{TP}{All\ data} = \frac{418}{480} = 0.87 \qquad Precision(2) = \frac{TP(2)}{TP2+FP2} = \frac{110}{110+16} = 0.87$$

Accuracy results of 0.87 or 87% were obtained, as shown in **Figure 7,** visualization of model training results. The Precision value of *O.hupensis lindoensis* was obtained as 0.87. In this study, the Precision value of the *O.hupensis lindoensis* class is more emphasized due to consideration of the system's ability to recognize O.hupensis lindoensis snails by reducing False positives. If *O.hupensis lindoensis is* identified as another snail, it can be dangerous for officers and the public.

3.3. Black Box Testing

The model that has been generated is stored in the form of a file. Then, it is loaded into a web-based system created using the Flask framework. The website can receive input in the form of images and return identification results in the form of the name of the snail class and the Accuracy of the class assessment. The system is then tested with Black Box testing.

Table 2. Black Box Testing

No.	Testing	Input	Output	Description
[1]		O.hupensis lindoensis	O.hupensis lindoensis	Valid
[2]		O.hupensis lindoensis	O.hupensis lindoensis	Valid
[3]		Sulawesidrobia sp	Sulawesidrobia sp	Valid
[4]		Thiara sp	Thiara sp	Valid
[5]		Brotia sp	Brotia sp	Valid
[6]		Brotia sp	Sulawesidrobia sp	Not Valid

Black Box testing uses six new image data that are not used in the model *training* process. Of the 6 data, 1 data was correctly identified by the system, and only one data was answered incorrectly, namely *Brotia sp* data identified as *Sulawesidrobia sp*. From this test, the system can provide 90% correctness. The prediction error of the 10th Black Box Testing data is caused by the position of taking pictures that do not show the striking shape of the snail, thus reducing the system's ability to identify. With the wrong answer, the value of confidence to assess the data is only 53%, which shows that the system needs to be more confident in the assessment given.

4. Conclusion

From the results of research on the identification of *O.hupensis lindoensis snails* among snails in *schistosomiasis* endemic areas using the MobileNet architecture CNN method, with adjustments to the addition of layer pooling and dropout and the number of data classes used, namely four classes with 1200 image data, the results obtained training accuracy of 93% and validation accuracy of 87%. The training *loss function is* 0.17, and the validation *loss is* 0.33. The ability of the system to precisely determine the class of *O. hupensis lindoensis*, which is a temporary host of schistosomiasis, is 0.87. In the black box test of 10 new data, the system can answer 9 data correctly and only one wrong. This model can be applied to help *O. hupensis lindoensis snail* habitat survey officers speed up their tasks. However, for communities in endemic areas, efforts need to be made to disseminate and introduce the system so that they can easily identify the snails that cause schistosomiasis. Although the system has achieved 93% training accuracy, it needs improvement in the form of increasing the number of datasets and data variations. This improvement is to reduce errors, as shown in Black Box testing, and increase the Precision of the *O.hupensis lindoensis* class in Confusion Matrix testing. This system is also still implemented on the website. It needs development so that this system can be applied to Mobile Devices.

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Advance Sustainable Science, Engineering and Technology (ASSET)
Vol. 5, No.3, October 2023, pp. 02303013-01 ~ 02303013-08
ISSN: 2715-4211 DOI: https://doi.org/10.26877/asset.v5i3.17196

Integrated Web-based Palu City Blood Donor Service Application Model Using ReactJS and ExpressJS

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Abstract. *Blood donation is an important activity in the medical world that requires efficient coordination between donors and recipients to fulfill the need for blood. However, the blood donation process is often still constrained by the lack of donors and the difficulty of blood recipients to find donors. Based on this problem, researchers designed and developed a web application that utilizes ReactJS as a frontend Library, ExpressJS as a backend framework. This application will allow donors to register, make donor appointments, and access information related to blood donor activities. In addition, Admin can use this application to manage information on the application and send notifications to donors. The development method used in this research includes requirements analysis, system design, application implementation, and testing and evaluation. This research uses two tests, namely blackbox and questionnaire. In testing the questionnaire using the end-user computing satisfaction (EUCS) measurement model with a quantitative approach and data distribution involving 31 respondents with 32 questions. The results obtained are EUCS variables (content, accuracy, format, ease of use, and timeliness) get results with a Mean value of 4.123. The result of this research is an application system named Badonordarah that can improve the efficiency and effectiveness of the blood donor service process in Palu City, and make it easier for blood donors and recipients to interact.*

Keywords: Blood Donation, ReactJS, ExpressJS, Website, Palu City

(Received 2023-10-15, Accepted 2023-10-26, Available Online by 2023-10-31)

1. Introduction

Blood donation services are an important aspect of a city's health system. Blood donation is the act of taking blood from individuals voluntarily, then stored in a blood bank for later use in the blood transfusion process. Blood transfusion is basically the delivery of blood from a healthy donor to a recipient who needs it [1], [2]. Therefore, management in the blood donation process needs to be organized and improved efficiently and effectively. Palu City, as one of the cities located in Central Sulawesi province, also needs a blood donor service system that can support the community's need for adequate blood supply. In the era of growing digitalization, the use of information technology is an appropriate solution in improving the efficiency and quality of blood donor services. Web-based applications have become an effective tool to facilitate various social activities, including blood donation[3]. Therefore, this research aims to design and build a web-based blood donor service application that will facilitate donors and parties involved in the blood donation process in Palu City.

According to the Data Center of the PMI Blood Transfusion Unit of Central Sulawesi Province, currently developed countries need transfusion blood above 5% of their population, while in Indonesia it is estimated that the national need for transfusion blood is in the range of 4%. In Central Sulawesi, the need for transfused blood is still below 2%, while Palu City and its surroundings are still at 1.8% or around 1,000 bags per month[4]. Although blood donation efforts have been in place for many years in Palu City, the current state of the process is fragmented, and the required information is often scattered across different platforms and entities. This can result in uncertainty in blood availability, delays in response in emergency situations, and difficulties for individuals who wish to participate in blood donation. The designed application will use ReactJS technology to develop an interactive and responsive user interface, and ExpressJS as a server that will manage data and function as a link between the application and the database. ReactJs is an open source JavaScript library that can make the process of developing interactive user interfaces easier [5]-[7]. ExpressJs is a framework built on NodeJs[8], [9]. This framework provides a simplified Application Programming Interface (API) for some core NodeJs functions[10]. In addition, researchers will also implement JSON Web Token (JWT) technology to improve security in user access and authentication [11].

Through this research, it is expected to obtain a blood donor service application that is adequate, easy to use, and safe for its users. This application is expected to increase community participation in blood donation activities, facilitate the management of blood stocks, and provide accurate and up-to-date information about blood donor services in Palu City.

2. Methods

2.1. Type of Research

The research used is descriptive research. Descriptive research is a type of research that aims to explain or describe phenomena or events in a specific, transparent, and in-depth manner regarding the circumstances observed in the field [12].

2.2. *System development*

Application system development is carried out using the Prototype method. In the development process, the Javascript programming language is used, MySQL is used as a database because MySQL is one of the fast and reliable relational database management systems, especially the need to store and manage complex data, while ReactJS and ExpressJS are used as frameworks because javascript flexibility is a very flexible programming language, easy to find resources or documentation because it has a large community, and ease of integration is one of the factors why using ReactJS and ExpressJS. The purpose of using this method is to make it easier for programmers to develop.

3. Research and Discussion

The design of the Palu city blood donor application (Badonordarah) using ReactJS and ExpressJS that has been made is then tested using the Black Box and Questionnaire testing methods.

3.1. Planning

In this initial stage, there is an identification of problems that occur in the people of the city of Palu, namely the people of the city of Palu still seem to have difficulty in finding blood donors to donate to people who are in need of blood, therefore researchers are working with the Galang Bersama Kami foundation, a foundation engaged in the humanitarian field to create an application that can help donors and blood recipients to exchange information in order to communicate with each other and quickly get donors who can donate their blood.

3.2. Analysis

In this analysis stage, the author analyzes what features are needed for the application later through observations and interviews with members of the Galang Bersama Kami foundation what is needed to help foundation members operate the application.

3.3. System design

A context diagram is a visual representation used to show how an information system interacts with its environment in which it operates [13]-[15]. Data Flow Diagram is a visual representation that utilizes symbols to illustrate the movement of data in the system. Its use is very useful in understanding the system in a logical, structured, and easy-to-understand way [16]-[18].

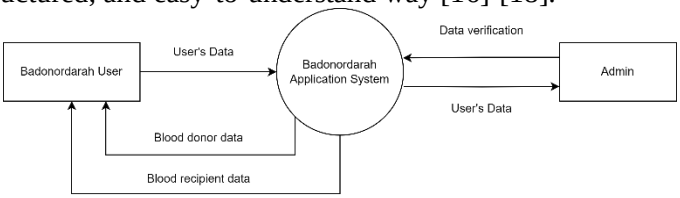


Figure 1. Data Flow Diagram

A use case is a visual representation that describes the relationship between actors and use cases[19]-[21].

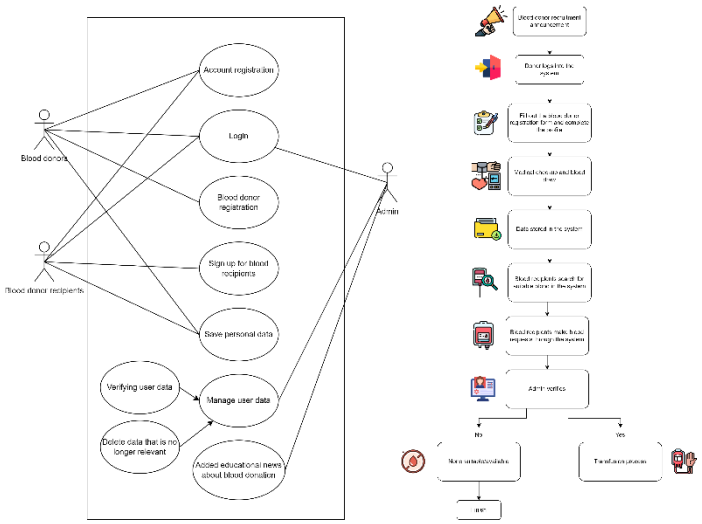


Figure 2. Use Case Diagram and User Flow

Activity diagram is a graphical representation that visualizes the concept of data flow or control, structured action, and good design in the system [19], [22].

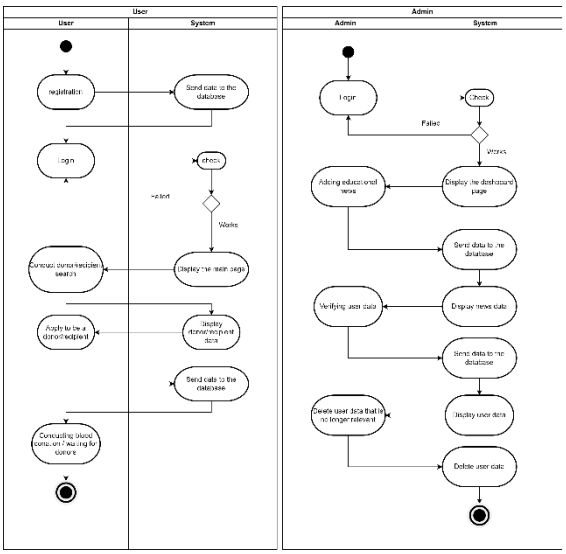


Figure 3. Activity Diagram User and Admin

3.4. Prototype

The prototype stage aims to build a user interface that shows the process or flow of the application and will later be implemented in the application. prototyping using the Figma application.

3.5. Implementation

At this stage the system will be built, which uses javascript programming language and MySQL database. javascript is divided into 2, there is a client side and a server side which are both developed using NodeJS [23]. on the client side using ReactJS to create a user interface and on the server side using ExpressJS to build the Enpoints API and routing system. The account registration process includes filling in your full name, email address, password, blood type and Rhesus factor. On the homepage, users can view statistics of registered users, a list of blood applicants, and educational news about the importance of blood donation. The following is a comparison between the application (left) and the prototype (right) in Figure 4:

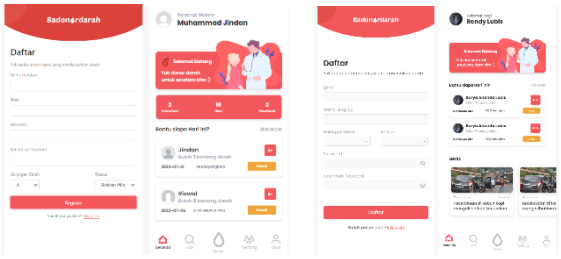


Figure 4. User Registration and User Home

On the Blood Recipient Details page, users can view blood recipient info including name, age, blood type, amount of blood needed, location, status (completed or not), and an "I want to donate" button that directs to the WhatsApp messaging service. On the Education News Detail page, users can get education about blood donation, blood types, and more. The following is a comparison between the application (left) and the prototype (right) in Figure 5:

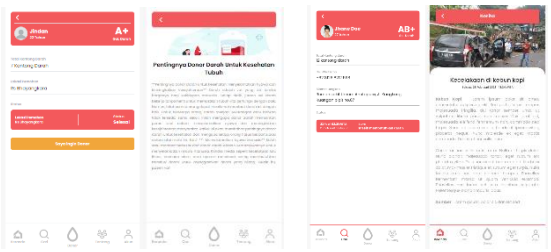


Figure 5. User Blood Recipient Details and Education News Details

On the Search page, users can search for blood donors or recipients based on blood type. Blood recipients need to fill in complete data, including name, WhatsApp number, amount of blood needed, transfusion location, blood type, rhesus, and date of birth. The following is a comparison between the application (left) and the prototype (right) in Figure 6:

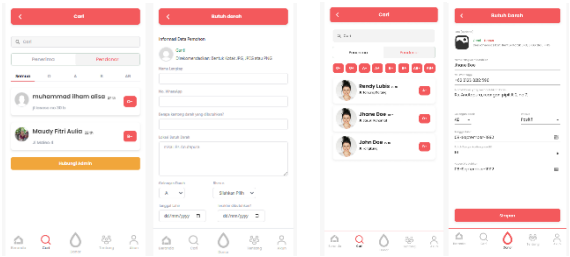


Figure 6. User Search and Register Form

On this admin dashboard page, the admin can see data such as total donors, total donor applications, and total educational news articles. The following is a comparison between the application (left) and the prototype (right) in Figure 7:

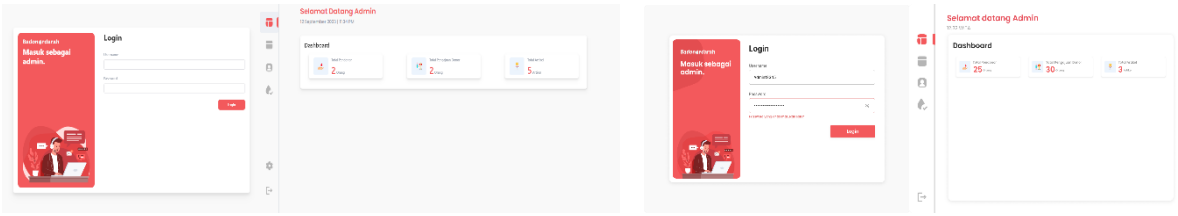


Figure 7. Admin Login and Admin Dashboard

On the Educational News page, the admin sees a table of educational news with photos, titles, content, and content sources. Admins can edit or delete content with the action button. On the Account Verification page, the admin decides whether the account is spam or not, can reject or verify suspicious accounts before verification. The following is a comparison between the application (left) and the prototype (right) in Figure 8:

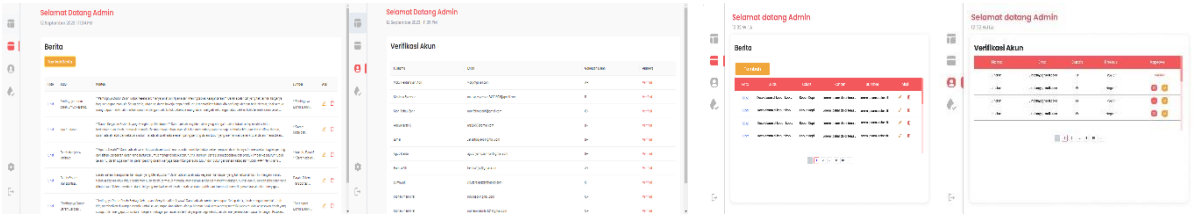


Figure 8. Admin Education and Account Verification News Table

In the recipient table, the admin sees the photo data, name, address, blood type, amount of blood needed, and can contact or delete the user. The admin can also approve the request with the "Agree" button or mark it as "Verified". In the donor table, the admin sees data on name, date of birth, address, blood type, blood donor history, and can contact or delete users. The following is a comparison between the application (left) and the prototype (right) in Figure 9:

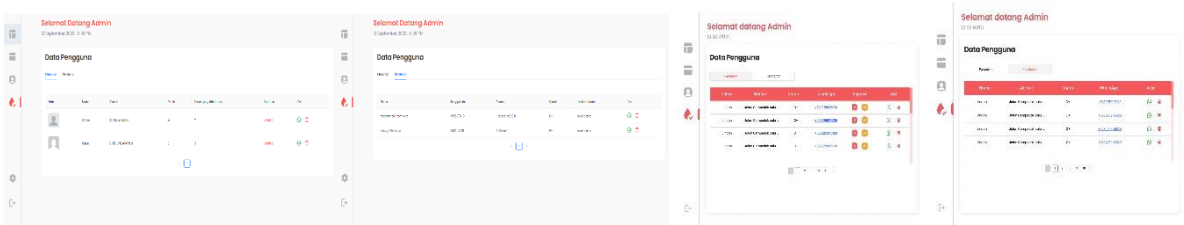


Figure 9. Blood Recipients and Blood Donors Table Admin

The challenges faced during development are data security because there is some sensitive data that needs to be encrypted and limited access, and the way to overcome it is to do Authentication using JWT (JSON Web Token). Another challenge is Testing and Debugging and how to overcome it by testing application functions using Postman.

3.6. System Testing

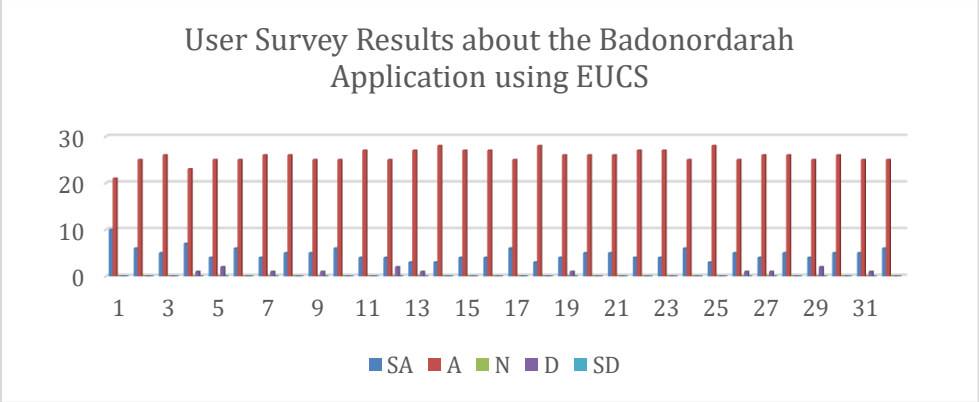
At this stage, system testing will be carried out which is carried out using the BlackBox method which is needed to find out the functions of the system running properly and reduce errors in the system. The challenge faced during blackbox testing is browser and device compatibility because it must ensure that the application works properly on various web browsers such as chrome, firefox, and safari and then check the application's performance on various devices, including computers, tablets, and cell

phones. The following are the results of system testing using the Blackbox method on the Badonordarah Application System can be seen in Table 1.

Table 1. System Testing Results

Features	Feature Funtion	Results
Registration (User)	Register an account to log in	Valid
Login (User)	User login to access other features in the app	Valid
Blood donor and recipient search (User)	Perform searches to make it easier for users to find blood donors or recipients	Valid
Filling in the Registration Form (User)	Fill out the registration form to register as a blood recipient	Valid
Complete Profile Data (User)	Completing profile data to be able to donate blood needs to complete profile data	Valid
Login (Admin)	Admin login so that not just anyone can access admin features	Valid
Add, Edit and Delete Education News data (Admin)	This feature is useful so that Educational News can appear on the user's home page	Valid
Verifying Account (Admin)	Account verification to avoid spam accounts	Valid
Verifying Blood Recipients (Admin)	Recipient verification so that donors can help targeted blood recipients	Valid
Delete Recipient and Donor Data (Admin)	Delete data if there is data that is no longer relevant then the admin can delete the data	Valid
Change Password (Admin)	Change passwords to improve information security	Valid

Questionnaire testing was carried out by distributing online and offline questionnaires totaling 31 respondents. The questionnaire given to users (PMI employees, prospective donors, and prospective donor recipients) uses EUCS satisfaction measurements. This needs to be done to find out whether this system is classified as a successful system or not. The purpose of this study is to measure the level of end-user (fundraiser) satisfaction with the Badonordarah application based on content, accuracy, format, ease of use, and timeliness variables. The measurement model used by researchers is end-user computing satisfaction (EUCS) with a quantitative approach and dissemination of data. The questionnaire is conducted online to obtain the required data. The results obtained, namely the EUCS variable (content, accuracy, format, ease of use, and timeliness) get results with a Mean value of 4.123, which means that the majority of users agree that the Badonordarah application has good content, accuracy, format, ease of use and timeliness. The following are the results of system testing using the EUCS Model on the Badonordarah Application System can be seen in Table 2 and Figure 18.



Noted : (SA) strongly agree; agree (A), neutral (N), disagree (D) and strongly disagree (DS)

Figure 18. User Survei

Based on the graphic image of the survey results, it can be seen that the average respondent said they agreed with the statement that the Badonordarah Application provides accurate information and is in accordance with user needs, provides complete reports and the application really helps you in completing blood donations. Apart from that, from the format dimension, the average respondent agrees that the badonordarah application has an orderly menu structure, is easy to understand and understand. This also applies to the accuracy dimension, where respondents agree that the badonordarah application produces information that is reliable, trustworthy, precise and correct. The majority of respondents also agreed that it does not take a long time to learn the badonordarah application, and it is very easy to interact with the application.

4. Conclusion

Based on the results of testing and discussion, it can be concluded that the application runs well which can help users to find donors and find blood recipients who are in need of blood. In this application system, users can register an account if they don't have an account, login if they already have an account, search for donors and recipients of blood donors who need blood, fill out the registration form so that they can be registered as blood recipients, and complete profile data to be able to donate blood, for admins can login, manage educational news in order to educate users about the importance of blood donation, verify user accounts so that no accounts are indicated as spam, verify blood recipients so that donors can help blood recipients according to targets, delete recipient and donor data if the recipient or donor is no longer relevant, and change the admin password to increase information security.

This Badonordarah application has limitations, namely if you want to communicate with users or admins, you need to do it via whatsapp because there is no chat feature in this application. This Badonordarah application has the potential to be sustainable in the long term, especially if good maintenance and development planning is implemented and can enable easier collaboration between various parties involved in blood donor services, such as hospitals, medical staff, and donors.

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Advance Sustainable Science, Engineering and Technology (ASSET)
Vol. 5, No.3, October 2023, pp. 02303014-01 ~ 02303014-11
ISSN: 2715-4211 DOI: https://doi.org/10.26877/asset.v5i3.17225

Analysis of Inventory Control of Perishable Goods with Capital Constraints and Warehouse Capacity Using the Lagrange EOQ Method (Case Study: UD. XYZ)

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Abstract. *Inventory control is a company policy in managing goods in order to optimize the number of orders and minimize inventory costs. The object of this research is PT XYZ in Gresik city which produces tempeh and tofu. Several raw materials are needed in the production process, one of which is soybeans. As the main raw material for making tempeh and tofu, soybeans are perishable goods. Previously, the company used a method based on past usage data in controlling its inventory, resulting in bloated inventory costs and a buildup of raw materials in the warehouse. Therefore, researchers need a method that is economical and takes into account the limitations of the company. The Lagrange EOQ method is a model that measures the order quantity by looking at one or more restrictions. The results of the Lagrange EOQ method get an order quantity of 20 sacks of soybeans with an order frequency of 27 times a year, a total inventory cost of Rp. 665,575, an ROP of 12 sacks and a safety stock of 10 sacks.*

Keywords: Lagrange's EOQ, Inventory Control, Perishable Goods, Soybeans

(Received 2023-10-16, Accepted 2023-10-27, Available Online by 2023-10-31)

1. Introduction

Every company must maintain sufficient raw material inventory to meet production needs so that the company can run smoothly [1]. Companies must manage an efficient production system by creating excellent planning and control, starting from raw material inventory management to the final product of value [2]. Control and handling of raw materials are important factors that affect the smooth running of the production process in order to achieve the desired goals [3]. Ideal stock can lessen organization costs, like the expense of requesting and putting away unrefined components. Consequently, the executives approaches connected with stock will be key in aiding the organization.

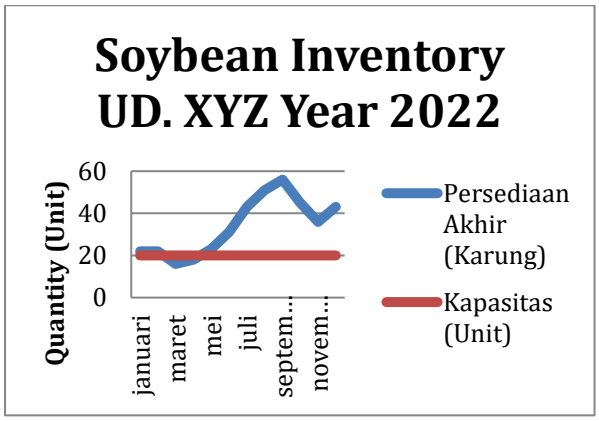
According to [4] Stock control is a framework that covers all parts of business stock administration, including buying, delivering, getting, following, warehousing, putting away, supplanting, and repurchasing. Stock control strategies assist with diminishing dangers in business production network the board. Stock decrease is a significant part of functional administration [5]. On the other hand, if the company tries to reduce inventory, the company will face difficulties. The problem of running out of inventory disrupts the smooth or continuous production process of the company. Business people must be able to plan inventory control carefully, raw materials are not too large and not too small. One of the control activities is especially the stage of supplying raw materials.

UD.XYZ is a Home Industry participated in the food area, to be specific creating tempeh and tofu.

This business can possibly be grown further, on the grounds that this item is a regular Indonesian food that is generally utilized as a side dish consistently by individuals from different circles. In making tempeh and tofu, several raw materials are needed including soybeans, yeast, plastic, vinegar and so on, but the main concern is the supply of soybeans because soybeans are the main staple for making tempeh and tofu, besides that soybeans are perishable *goods* which means that the material is easily damaged and cannot be stored for a long period of time, Therefore, companies need to calculate soybean inventory control so that spoilage does not occur which will affect inventory costs and can be detrimental to the company. It is known that UD. XYZ is a small-scale company that has several limitations in controlling availability, counting capital restrictions that can spend Rp. 10,000,000 for each soybean buy and the stockroom region claimed is 53 M², where the soybean stockpiling region is just 13 M² with a distribution center level of ± 2.5 M. Whenever loaded up with soybeans, it can store a limit of 13 M² with a level of ± 2.5 M. When loaded up with soybeans, it can store a limit of 20 sacks.

Previously, the company carried out inventory management based on experience, so that the procurement of raw materials was often late which could later hamper the production process and there was often a buildup of raw materials in the warehouse which resulted in bloated inventory costs. The following is soybean inventory data for 2022.

Tabel 1 Soybean inventory with warehouse capacity at UD. XYZ



(Sumber : UD. XYZ)

Based on Table 1, the soybean inventory exceeds the capacity of the warehouse, which is only enough to hold 20 sacks of soybeans, and often the company owner's house is used as temporary storage. Therefore, an economical inventory control model is needed and can adjust to the company's capabilities.

To determine the optimal order size for each item and reduce ordering and shipping costs, namely by performing EOQ calculations [6]. However, sometimes the results of the EOQ calculation do not match the limitations of the company. According to [7] The EOQ Lagrange method is a method used to optimize production costs based on existing inventory constraints. Based on the problems obtained, this research aims to find out and analyze the results of calculating the most economical soybean inventory control based on the company's capabilities.

2. Methods

2.1 Observation

This research was conducted at UD. XYZ which is one of the MSMEs in Gresik city. The observation results obtained will later be reviewed with literature that is in accordance with the problems that exist in the company.

2.2 Data collection

The information assortment strategy was completed by meeting and gathering organization information in 2022. The data used in this study are data on the purchase and use of UD raw materials. XYZ for one year. According to [8] the cost of raw material inventory includes holding costs and procurement costs. In addition, the data needed to complete the research are order lead *time* data, *service light,* warehouse capacity and maximum investment costs incurred by the company.

2.3 Raw Material Purchasing Analysis

Company Method

The calculation for purchasing raw materials using the company's method [9]is as follows:

$$Company\ Method = Soybean\ needs/frequency \quad (1)$$

Economic *Order Quantity* (EOQ) *Method*

According to [10] the EOQ method is the quantity of inventory purchases made efficiently so that the total cost of inventory is as low as possible. Based on [11] the EOQ calculation can be formulated as follows:

$$EOQ = \sqrt{\frac{2.S.D}{H}} \quad (2)$$

Where:

EOQ economical purchase quantity
S procurement cost
D forecasted demand at a given time
H cost

After knowing the optimal amount of raw material orders, the frequency of new orders can be calculated [12]. According to [11] it can be formulated as follows:

$$I = \frac{D}{EOQ} \quad (3)$$

Details:

I frequency of purchase within a certain time
D forecasted demand at a given time
EOQ economical purchase quantity

Lagrange EOQ Method

According to [13] *EOQ Lagrange* is a method used to optimize inventory costs by considering various constraints faced in the warehouse. The calculation of the lagrange *method* uses maximum and minimum limits. There are several calculations that need to be done using the *Lagrange method* [14] including the following:

$$Q * Li = \sqrt{\frac{2.A_i D_i}{C_i.(a+2)}} \quad (4)$$

While the constraint value (λ) can be obtained with the following calculation:

$$\lambda = \frac{1}{2}\left(\frac{1}{B}\sum\sqrt{2.A_i.D_i.C_i}\right)^2 \quad (5)$$

Then to calculate the total investment from the *Lagrange* calculation is as follows:

$$\sum_{i=1}^{n} C_i.Q^*Li \leq B \quad (6)$$

Information:

Ci : product price (Rp/Unit)
Ai : ordering cost (Rp)

Di : total demand (Unit/Year)
Q*Li : Lagrange optimal order quantity (Unit)
l : Lagrange multiplier factor
a : storage cost (percentage)
B : maximum investment value spent by the company (Rp)

2.4 Total Inventory Cost Analysis

The total inventory cost is the sum of the purchase cost, inventory cost and ordering cost [15] which can be formulated as follows:

$$TC = \frac{A_i D_i}{Q^*} + \frac{Q^*(aCi)}{2} \quad (7)$$

Meanwhile, according to [16] the calculation of the company's total inventory cost is as follows:

$$Company\ TIC = (Frequency\ of\ messages\ x\ cost\ of\ one\ message) + (average\ raw\ material\ usage\ x\ holding\ cost\ per\ unit) \quad (8)$$

2.5 Reorder Point

Reorder Point is a certain condition or delay that requires the company to reorder raw materials, so that the arrival of raw materials coincides with the exhaustion of previously purchased raw material inventory . ROP can be formulated as follows:

$$ROP = (d.Lt) + SS \quad (9)$$

Where is :
ROP : reorder point
D : average use of raw materials per day
SS : safety stock (Safety Stock)
Lt : waiting time (Lead Time)

According to [17] the purpose of safety stock is to minimize stock-out situations and reduce the cost of additional inventory and the total cost due to stock-outs. Storage costs here will increase with the reorder coming from the reorder point due to safety stock. The Safety *Stock* formula can be formulated as follows:

$$SS = SDxZ \quad (10)$$

Information:
SS : safety stock
SD : standard deviation
Z : service level (adjusted for company capabilities)

Meanwhile, the standard deviation formula is as follows:

$$SD = \sqrt{\sum \frac{(x-\bar{x})^2}{n}} \quad (11)$$

Information:
SD : standard deviation
x : number of raw materials used each period
$\bar{x}$: average quantity of raw materials used
n : amount of data

3. Results and Discussion

3.1 Soybean Usage

UD. XYZ in controlling soybean inventory only relies on sales forecasting in the previous period, so there is often a shortage of materials (*Stockout)* or excess materials (*Overstock).* To find out the optimal amount of raw material orders, you must first know the amount of raw material requirements needed each month. The amount of soybean usage per month during 2022 is as follows:

Table 2 Soybean use in 2022

Month	Quantity
January	45
February	50
March	54
April	57
May	45
June	47
July	40
August	37
September	40
October	44
November	39
December	35
Total	**533**
Average	**44.4**

(Source: UD. XYZ)

3.2 Soybean Reservation

UD. XYZ purchases soybeans 3 times a month with different order quantities. The following is soybean order data at UD. XYZ during the year 2022.

Table 3Soybean orders for 2022

month	Frequency (Times)	Order quantity (Sacks)
January	3	55
February	3	50
March	3	48
april	3	59
with	3	50
June	3	55
July	3	52
August	3	45
September	3	45
October	3	33
November	3	30
December	3	42
Total	**36**	**564**
Tariffs	**3**	**47**

(Source: UD. XYZ)

3.3 Inventory Cost

Procurement cost (S)

Procurement costs are all costs incurred during the procurement process. Based on data obtained from the company, procurement costs include:

Table 4 breakdown of the company's procurement costs in 2022

Needs	Cost (Rp) / Frequency
Shipping cost	15,000
Credit	500
Total	**15,500**

(Source: UD. XYZ)

Storage cost

Storage costs are costs associated with inventory and inventory maintenance. Based on the observations obtained, the company's storage costs include the following:

Table 5 Company ownership cost breakdown for 2022

Needs	Cost (Rp) / Year
Electricity	1,117,200
Maintenance and Safety	12,000,000
Tax	341,220
Total	**13,458,420**
Total / Unit	**25,250**
Percentage	**5%**

(Source: UD. XYZ)

Based on table 5, storage costs are obtained from electricity bills, maintenance and security and taxes with a total storage cost per year of Rp. 13,208,724 and a total storage cost per unit of Rp. 25,250 with a percentage of 5% of the product price per unit.

3.4 Company Limitations

In running the company, the owner of UD. XYZ has limitations in purchasing and storage capacity of raw materials, including the following:

Table 6 Company limitations

Warehouse		Investment Cost (IDR)
area (M^2)	Capacity (Unit)	
13	20	10,000,000

(Source: UD. XYZ)

Based on table 6, the maximum investment cost that the company can spend is Rp. 10,000,000 and the warehouse capacity can only store 20 units with an area of 13 M². Furthermore, in determining the reorder point, supporting data is needed to complete the calculation, including: *Lead Time* (waiting time) for 1 day, *service level of* 25% and average use of raw materials per day is 2 units.

3.5 Raw Material Purchasing Analysis

Company method

The requirement for soybeans during 2022 is 533 sacks with a recurrence of requesting in one year of multiple times, so the acquisition of unrefined components as per the organization's technique is as per the following:

$$Company\ Method = Soybean\ needs\ for\ one\ year/Frequency \quad (12)$$

$$Company\ Method = \frac{533}{36} = 15\ Sacks \quad (13)$$

The results of the calculation for purchasing raw materials using the company's method show that the number of orders is 15 sacks with a frequency of ordering 36 times.

Economic *Order Quantity* (EOQ) *Method*

Soybean purchases using the EOQ method can be formulated as follows:

$$EOQ = \sqrt{\frac{2.S.D}{H}} \quad (14)$$

$$Q^* = \sqrt{\frac{2.15500.533}{25250}} = 25.58 \approx 26\ Sacks \quad (15)$$

The calculation of the order frequency using the EOQ method is as follows:

$$I = \frac{D}{Q} \quad (16)$$

$$I = \frac{533}{25{,}58} = 20.83 \approx 21\ Times \quad (17)$$

The results of the calculation of purchasing raw materials using the EOQ method show that the quantity per order is 26 units with a frequency of ordering 21 times a year. The result is that the order quantity exceeds the warehouse capacity and exceeds the company's maximum investment cost, which is Rp. 13,130,000, so the next step will be the calculation of the *EOQ lagrange* method.

Lagrange EOQ Method

Based on the observation results, supporting data is obtained to complete the *Lagrange* EOQ calculation *as* follows:

Total demand (Di) = 533 Units
Pre-set storage fees (a) = 5%
Product Price (Ci = Rp. 505,000
Message fee (Ai) = Rp. 15,500
Maximum investment value (B) = Rp. 10,000,000

Before calculating the quantity per order using *Lagrange's* EOQ method can be done, first calculate the value of λ. The calculation of λ value is as follows:

$$\lambda = \frac{1}{2}\left(\frac{1}{B}\sum\sqrt{2.Aj.Dj.Cj}\right)^2 - \frac{a}{2} \quad (18)$$

$$\lambda = \frac{1}{2}\left(\frac{1}{10000000}\sum\sqrt{2.15500.533.50500}\right)^2 - \frac{0{,}05}{2} \quad (19)$$

$$\lambda = 0{,}017 \quad (20)$$

Based on the above calculation, the value of λ is 0.017, so after that the optimal number with restrictions will be calculated, the calculation is as follows:

$$Q^*That = \sqrt{\frac{2.A_j.D_j}{C_j.(a+2\lambda)}} \quad (21)$$

$$Q^{*}That = \sqrt{\frac{2.15500.533}{505000.(0,05+2.0,017))}} \quad (22)$$

$$Q^{*}Li = 19.8 \approx 20\ Units \quad (23)$$

To figure out the recurrence of orders set in one year, the complete interest for one year is partitioned by the aftereffects of the EOQ Lagrange computation, the estimation is as per the following:

$$I = \frac{Dj}{Q^{*}That} \quad (24)$$

$$I = \frac{533}{19,8} = 26.91 \approx 27\ Times \quad (25)$$

In view of the Lagrange EOQ computation, it is observed that the ideal request amount is 20 units with a request recurrence for one year of multiple times. Where the complete expense doesn't surpass the organization's most extreme venture cost of Rp. 9,999,000 and the quantity of orders doesn't surpass the stockroom limit.

3.6 Total Inventory Cost Analysis

Inventory control cannot be separated from the costs incurred, so the company must know how much it costs to control soybean inventory. Total inventory costs can be calculated using the formula:

$$Company\ TC = (Frequency\ of\ messages\ x\ Cost\ of\ one\ message) + (average\ soybean\ usage\ x\ storage\ cost\ per\ unit) \quad (26)$$

$$Company\ TC = (3\ x\ 15500) + (44,4\ x\ 24,782) = Rp.\ 1,147,227 \quad (27)$$

Meanwhile, the total inventory cost for the EOQ method is as follows:

$$TC\ EOQ = \frac{A_j D_j}{Q^{*}} + \frac{Q^{*}(aC_j)}{2} \quad (28)$$

$$TC\ EOQ = \frac{15500.533}{26} + \frac{26.(5\%.505000)}{2} = Rp.\ 646,000 \quad (29)$$

And for the total cost of inventory using the *Lagrange* EOQ method as follows:

$$TC\ Q^{*}That = \frac{A_j D_J}{Q^{*}That} + \frac{Q^{*}Li(aC_j)}{2} \quad (30)$$

$$TC\ Q^{*}That = \frac{15500.533}{20} + \frac{20(5\%.505000)}{2} = Rp.\ 665,575 \quad (31)$$

The total inventory cost from the calculation of the EOQ method results in more economical inventory costs compared to the company method and the *Lagrange* EOQ method. However, in terms of the number of orders, the EOQ method exceeds the capacity of the warehouse which can only accommodate 20 units.

3.7 Comparison of calculation results of Inventory control methods

Carry out calculations for controlling soybean supplies at UD. XYZ needs to consider several aspects starting from the number of orders, warehouse capacity, and inventory costs. From the results of inventory control calculations using several methods, several differences were obtained, including the following:

Table 7 Perbandingan hasil perhitungan metode pengendalian persediaan

Need	EOQ Method	Lagrange EOQ method	Company method
Number of messages (Units)	26	20	15
Frequency (Times)	21	27	36
TC (Rp)	665.575	646.000	1.147.227

(Source : Data proccesed)

Based on table 7, the EOQ method obtains a total inventory cost of at least Rp. 665,775, but the number of orders exceeded the warehouse capacity limit, which means the EOQ method is not suitable for controlling soybean supplies at UD. XYZ, while controlling soybean inventory using the EOQ Lagrange calculation, the number of orders is 20 units, which means it does not exceed the warehouse capacity, but the total inventory cost is greater than with the EOQ method, namely a difference of Rp. 19,575.

Therefore, the EOQ method only emphasizes inventory costs, not the values that are the company's limitations, so it is the most suitable method to use to control soybean inventory at UD. XYZ is the EOQ Lagrange method even though it has greater inventory costs than the EOQ method. After determining the order quantity, reorder points will be calculated to avoid soybean shortages and delays in the production process.

3.8 Reorder Point

Safety stock

The safety *stock calculation* aims to minimize the shortage of raw materials when product demand has increased significantly, the Safety *Stock* calculation is as follows:

Table 8. Calculation of Deviation of soybean usage in 2022

Month	**x**	$\bar{x}$	**x-$\bar{x}$**	**(x-$\bar{x}$)²**
January	45	44.4	0.6	0.34
February	50	44.4	5.6	31.17
March	54	44.4	9.6	91.84
April	57	44.4	12.6	158.34
May	45	44.4	0.6	0.34
June	47	44.4	2.6	6.67
July	40	44.4	-4.4	19.51
August	37	44.4	-7.4	55.01
September	40	44.4	-4.4	19.51
October	44	44.4	-0.4	0.17
November	39	44.4	-5.4	29.34
December	35	44.4	-9.4	88.67
Total	**533**	**533.0**	**0.0**	**500.92**
Tariffs	**44.4**			

(Source: Data processed)

$$St.Deviasi = \sqrt{\sum \frac{(x-\bar{x})^2}{n}} \quad (32)$$

$$St.Deviasi = \sqrt{\sum \frac{500{,}92}{12}} = 41{,}74 \quad (33)$$

Based on the results of the standard deviation calculation and it is known that the service level for soybean raw materials is 25%, the safety *stock* calculation is as follows:

$$SS = SDxZ \quad (34)$$

$$SS = 41.74\ x\ 0.25 = 10.44 \approx 10\ Sacks \quad (35)$$

The Safety *Stock* calculation gets a total of 10.44 which is rounded up to 10 sacks.

Reorder Point (ROP)

It is known that the Lead *Time* or waiting time for product orders to be received is 1 day, and the number of working days in a year is 312 days, so the average use of raw materials per day is 2 units and the results of the safety *stock* calculation obtained are 10 units so that the ROP can be calculated as follows:

$$ROP = (d\ x\ LT) + SS \quad (36)$$

$$ROP = (2\ x\ 1) + 10 = 12\ Sacks \quad (37)$$

From the results of the above calculations, the reorder point will be made when the stock in the warehouse remains 12 sacks.

4. Conclusion

In solving problems at UD. XYZ researchers analyzed several inventory control methods including the EOQ method and the EOQ Lagrange method. The EOQ method is a model for determining lot/order size to minimize inventory costs. However, the problem is not just the size of the order, but the company also has limited capital and warehouse capacity. The EOQ Lagrange method is a calculation to determine the number of lot sizes by considering one or two constraints. Based on the results of this research, it was found that controlling the inventory of soybeans which is a perishable item using the Economic Order Quantity (EOQ) method resulted in a total inventory cost that was less than the method used by the company and the EOQ Lagrange method, namely with a total inventory cost of IDR. 646,000 with an order quantity of 26 units, but the order quantity exceeds UD's warehouse capacity. XYZ can only accommodate 20 units, so the most optimal method for the company's conditions is to use the EOQ Lagrange method even though the total cost is greater than the EOQ method, namely IDR. 665,575 but the number of orders does not exceed the warehouse capacity, namely 20 units with an order frequency of 27 times and reorders will be made when the stock in the warehouse reaches 12 sacks.

Further research can also be carried out on inventory control on raw materials for tempeh and other tofu, so that the calculation results can help companies control inventory more economically. And the results of the research can be used as a reference for future researchers to solve the same problem.

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Advance Sustainable Science, Engineering and Technology (ASSET)
Vol. 5, No.3, October 2023, pp. 02303015-01 ~ 02303015-12
ISSN: 2715-4211 DOI: https://doi.org/10.26877/asset.v5i3.16806

Review and Bibliometric Analysis of Biogas Power Plants in Indonesia

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Abstract. *The demand for energy is increasing due to population growth, technological advancements, and a growing need for sustainable energy sources. Indonesia, which faces an energy deficit, is exploring alternatives to fossil fuels. Biogas, produced through the anaerobic fermentation of organic matter, offers a clean and sustainable energy option while addressing waste disposal issues. Therefore, this literature review examines various aspects of a biogas power plant, including a feasibility study that encompasses technical and economic analyses, generator design, trials, implementation, and post-implementation evaluation. In this review, we gathered scientific papers from Google Scholar using the keywords "pembangkit listrik biogas" between 2019 and 2022, with a focus on recent content. Patents and citations were excluded from the Google Scholar searches to ensure article relevance. Out of a total of 40 articles, 30 were rejected because they did not originate from scientific journals. The collected articles are categorized based on the materials used for biogas generation in power plants. This systematic approach yielded 10 relevant articles. Consequently, the literature reveals that various raw materials, such as palm oil mill waste (POME), livestock manure, and organic waste, hold the potential for biogas production. The results emphasize the economic feasibility of specific biogas projects, the environmental challenges they pose, and the positive impact they have on community well-being.*

Keywords: Biogas, Power plants, Feasibility studies, Renewable energy

(Received 2023-10-16, Accepted 2023-10-29, Available Online by 2023-10-29)

1. Introduction

Population growth and technological developments increase energy demand and have an impact globally, including in Indonesia [1]–[3]. In the last decade, Indonesia has experienced an energy deficit due to an imbalance between demand and supply [4]. According to the 2019 Indonesia Energy Outlook, the need

for electrical energy from 2019 to 2050 is projected to increase by up to 9 times from the 254.6 TWh electricity demand in 2018. In addition, future electricity demand is also predicted to experience a shift from the household sector to industry, including the agricultural, paper, fertilizer, steel, and other industries [5].

In the last few decades, Indonesia's energy supply has been dominated by fossil sources, such as oil, gas, and coal [6]. Oil and coal are non-renewable energy sources because they originate from fossil deposits and accumulated plant remains, which take millions of years to form. While new and renewable energy power plants are rapidly increasing worldwide, the International Energy Agency (IEA) reported that in 2000, only 18.7% of such plants were used as a source of electrical energy. By 2018, this proportion had increased to 25.6%, and it is expected to reach 30% by 2024 [7].

Several alternative sources of electrical energy have been developed in Indonesia, including water, wind, solar energy, and more. However, these alternative energy sources still come with several disadvantages [8]–[10]. Hydroelectric power plants require a large investment. Wind power plants require large areas of land. Solar power plants are constrained by high initial costs because solar panels are made of expensive materials. Even with price reductions that occur almost every year, they still feel expensive [11], [12]. Therefore, other alternative energy sources are needed that are economical, sustainable, and environmentally friendly [13].

The use of biomass for biogas is an alternative that has attracted worldwide attention as a clean and sustainable energy source in recent years [14], [15]. In addition, biogas production also serves to reduce the problem of inefficient disposal of municipal waste, which causes uncontrolled methane emissions [16]. Biogas is a gas produced by microbes when organic matter undergoes a fermentation process in an appropriate anaerobic condition, in terms of temperature, humidity, and acidity [17]. Biogas has great potential as a renewable energy source because it is obtained from the decomposition of organic matter (such as animal waste, human waste, and plants waste) by methanogenic bacteria. Most of the biogas produced consists of 50 - 70% methane (CH4), 30 - 40% carbon dioxide (CO_2), and small amounts of other gases [3]. As is known, methane has only one carbon in each chain. Thus, burning methane allows for more environmentally friendly emissions compared to long carbon chain fuels, such as butane (C_4H_{10}) or gasoline (C_8H_{18}). In addition, the amount of CO_2 produced from burning low carbon fuels tends to be lower. The high methane content in biogas can help reduce the role of LPG and gasoline. The chemical composition of biogas is presented in Table 1.

Table 1. Composition of biogas [18]

Element	Formula	Concentration (% volume)
Methane	CH_4	50-75
Carbon dioxide	CO_2	25-45
Water vapor	H_2O	2-7
Oxygen	O_2	<2
Nitrogen	N_2	<2
Hydrogen sulfide	H_2S	<2
Ammonia	NH_3	<1
Hydrogen	H_2	<1

Based on the raw material filling method, the biogas production system consists of two primary methods: bulk filling and continuous filling. The bulk filling system is implemented when biogas production has stopped, involving the removal of the remaining material from the processing tank and the subsequent addition of new raw materials. In contrast, the continuous filling system involves placing raw materials into the processing tank, and it continues uninterrupted for approximately four weeks from the initial filling time. The processed material does not require removal from the tank [17]. Up until the writing of this article, the most common method for converting biogas into electricity was the digester system, illustrated in Figure 1.

While various methods and raw materials for generating biogas have been explored in the literature, there remains a significant lack of comprehensive studies on biogas power plants. Therefore, this review aims to identify and analyze feasibility studies, generator designs, generator testing, implementation strategies, and evaluations. Furthermore, we also investigate global biogas research trends, as documented in Wizdom.ai, to better understand current and future opportunities.

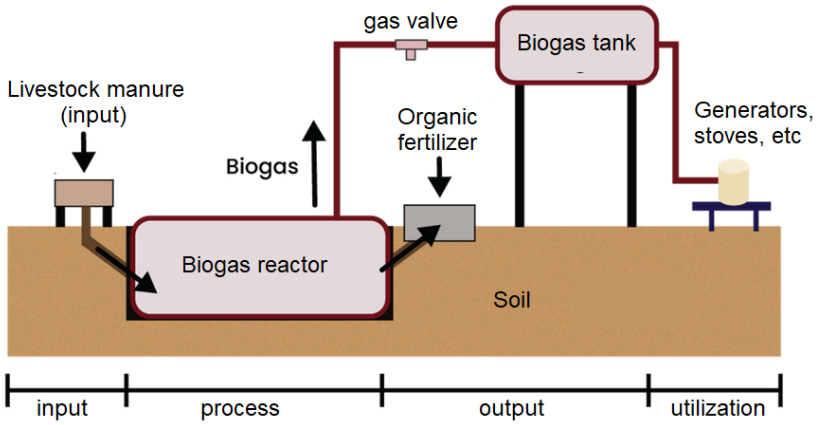

Figure 1. Schematic of biogas plants from livestock manure [4]

2. Methods

In this study, we collected scientific articles from Google Scholar with the keyword "pembangkit listrik tenaga biogas" in the period 2019–2022. This timeframe was chosen to get the most recent articles. From the search mechanism in Google Scholar, we do not include patents and citations to get the appropriate article. We found 40 articles on Google Scholar related to the keyword. However, of the 40 articles, 30 were not included because they were not from scientific journals. The collected articles are then classified based on the type of material used to produce biogas in power plants. From the structured search, 10 relevant articles were collected. The article filtering mechanism is presented in Figure 2.

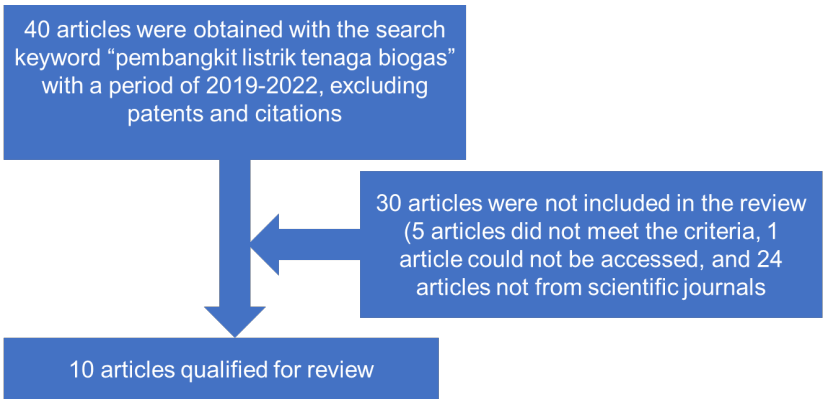

Figure 2. Mechanism for selecting reviewed articles

3. Results and Discussion

3.1 Result

As described in the Methods section, we identified 10 journal articles on Google Scholar discussing biogas. The identification of raw materials, methods, variables studied, results, and measured parameters is presented in Table 2. Furthermore, the articles are classified based on the type of raw materials, as shown in Table 3. We found that 60% of the total reported biogas raw materials were palm oil liquid waste, specifically called Palm Oil Mill Effluent (POME), followed by livestock manure at 30%, and organic waste at 10%.

Table 2. Raw materials, methods, and results

No	Materials	Objective	Results
1.	POME [19]	Economic analysis of the construction of a biogas power plant with a capacity of 700 kW using a continuous stirred tank reactor (CSTR) biodigester.	The results of economic calculations show that the investment costs reach IDR 26.3 billion with a 70% loan scheme from banks and the remaining 30% with their own capital. Operation and maintenance costs reach IDR 2.3 billion/year. The construction of a biogas power plant is feasible with an IRR value of 11.44%, a payback period of 7 years and 11 months, and an NPV of IDR 1.1 billion.
2.	POME [16]	Converting POME into biogas for electrical energy while reducing the impact of climate change from the palm oil production process.	The results of this study show that the POME flow rate is 146,880 m^3/year. With this potential, a power plant of 4.5 MWe can be designed and has the potential to generate 42.34 kWh of electricity/year.
3.	Organic waste [20]	Analysing the installation of a biogas power plant on the social, economic, and environmental aspects of the community in residential areas in Manado.	This research proves that the installation of a biogas power plant has a significant influence on the social, economic, and environmental aspects of the community in Manado.
4.	Livestock manure [17]	Identify the potential for livestock manure to be developed into a biogas power plant in the Province of Bali.	Based on the results of the analysis conducted, it is known that biogas can produce as much as 246,130.81 m^3, which is equivalent to 1,156,814.81 kWh/day or around 1.16 GWh/day.
5.	POME [7]	Simulating the connection of a biogas power plant to a commercial power grid and investigating the requirements stipulated in S.K/DIR/0357/2014.	The result of connecting the biogas power plant to the commercial electricity network meets the requirements.
6.	Livestock manure [21]	Utilizing cow dung to produce electrical energy that can meet electricity needs technically and economically.	The results of the analysis show that methane production per day is 1.22 m^3 and generates 1.22 kWh of electricity. With four maintenance times per year, the electrical energy that can be generated is 1.90 kWh × 362 days = 686 kWh/year.
7.	POME [22]	Analyzing the connection of a biogas power plant from POME with a 20 kV distribution network using ETAP simulations.	The connection of the biogas power plant improves the voltage profile so that it does not drop more than 10%. Total power losses decreased by 6.42% during WBP.
8.	POME [23]	Implementing a PLC-based instrumentation and control system to support the operation of a biogas power plant.	The inlet pressure in the gas engine during the two hours of commissioning trials complied with the requirements of the gas engine, while the methane concentration proved to be stable during operation.
9.	Livestock manure [24]	Assessing the potential utilization of cattle ranch waste in livestock areas as raw material for biogas power plants and assessing the carbon value that can be reduced if proposed as a Clean Development Mechanism (CDM) project.	Based on the data obtained, the production of cow dung of 400 kg/day has the potential to generate 4.89 kW of electrical energy.
10.	POME [5]	Analyzing the technical and economic aspects of the Solar PV Biogas power plant.	Based on technical and economic analysis it can be concluded that this hybrid power system can be developed.

Table 3. Classification of raw materials for biogas

Raw material	References	Articles	%
POME	[19], [16], [7], [22], [23], [5]	6	60%
Livestock manure	[17], [21], [24]	3	30%
Organic waste	[20]	1	10%
Total		10	100%

Based on the data presented in Table 2 and Table 3, the articles are classified based on the type of raw material. Furthermore, Table 4 presents the classification based on the feasibility study, generator design, generator trials, implementation, and evaluation. The data is then presented in Figure 3.

Table 4. Parameters discussed in the reviewed articles

No	Raw material and references	Parameter discussed				
		Feasibility study	Generator design	Generator trials	Implemen-tation	Evaluation
1.	POME [19]	√	×	×	×	×
2.	POME [16]	√	√	×	×	×
3.	Organic waste [20]	×	×	×	×	√
4.	Livestock manure [17]	√	×	×	×	×
5.	POME [7]	×	×	√	×	×
6.	Livestock manure [21]	√	√	√	×	×
7.	POME [22]	×	×	×	√	√
8.	POME [23]	×	×	×	√	×
9.	Livestock manure [24]	×	×	√	×	×
10.	POME [5]	√	×	×	×	×

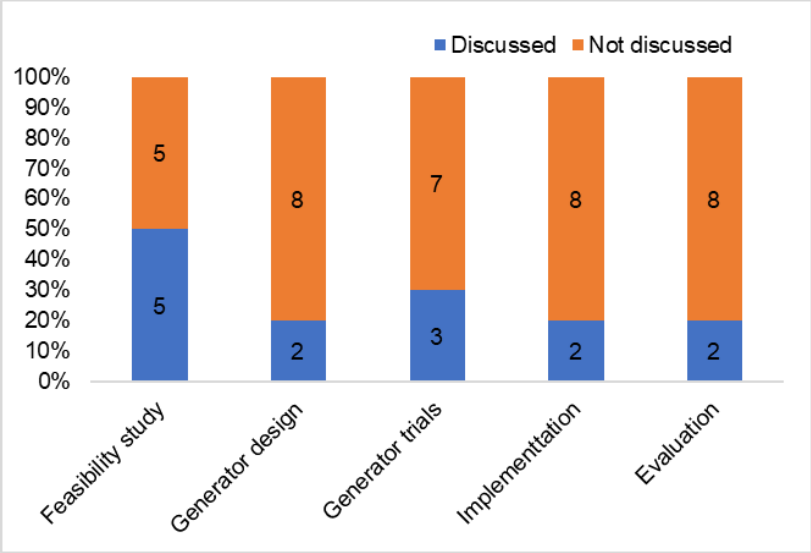

Figure 3. Parameter map discussed in the reviewed articles

3.2 Discussion

Feasibility study - The feasibility study of a biogas power plant generally assesses two key aspects: the feasibility of electricity generation and the economic viability. The feasibility of electricity generation has been examined by several researchers, including Firdausi [16] and Santoso [17]. Meanwhile, economic analysis was reported by Sugiyono et al. [19], Pasaribu et al. [21], and Putra [5].

Firdausi [16] conducted a study at PT Trimitra Lestari, West Tanjung Jabung Regency, Jambi Province. From the available data, POME production of 414,720 tons/year produces 80% of liquid waste. The liquid waste is channeled into a holding pond which produces methane. Further analysis explains that there is a potential for electricity production of 42,336 kWh/year from the POME waste. Considering the continuity of POME production at PT Trimitra Lestari and the electricity potential that may be generated, the construction of a biogas power plant at PT Trimitra Lestari is feasible to proceed to the technical feasibility study stage. Meanwhile, Santoso [17] conducted a study to estimate the potential of biogas from livestock manure for electricity in the province of Bali. Data from the Directorate General of Livestock and Animal Health states that there are 19,183,779 potential animals in Bali, consisting of cows, buffaloes, horses, goats, sheep, pigs, chickens, and ducks. Of this amount, the potential for biogas in Bali Province is 246,130.81 m^3/day and can be converted to 1.16 GWh/day.

From an economic feasibility perspective, Sugiyono et al. [19] calculated the feasibility of building a biogas power plant from POME with a continuous stirred tank reactor (CSTR). According to them, the biogas power plant is feasible to build with an IRR value of 11.44%, a payback period of 7 years and 11 months, and an NPV of IDR 1.1 billion. However, POME-based biogas power plants can pollute the air, water, and sound. Air pollution, such as odors, pollutants, and dust, must be anticipated and mitigated by installing equipment to protect the environment. Water contamination is possible from sewage contaminating the surface or groundwater, so a separate drainage system can be used to prevent this contamination. Meanwhile, noise pollution arises due to noise from the biogas power plant. Different results were reported by Pasaribu et al. [21] who conducted an economic analysis of the potential for a biogas power plant on a cattle farm with a biogas capacity of 3.90m^3/day in a 6000-liter digester. From the available data, the biogas power plant produces 686 kWh of electricity/year. Economic feasibility is calculated through simulation with REETscreen software. From the simulation results, a financial feasibility analysis is obtained in the form of a Cash-in-flow (CF) calculation of IDR 988,320, a Net Present Value (NPV) of IDR -6,316,305.03 <0, and a Payback Period (PBP) of 15.4 years which indicates an analysis this is not economically feasible.

Finally, Putra [5] claims that the PVBiogas solar hybrid generation system has great potential to be implemented. In their research, the Solar PVBiogas off-grid system hybrid power plant is technically capable of serving loads continuously for 20 years of the project life. Until the end of the 20th year of the planned project life, production from the off-grid Solar PV-Biogas system hybrid power plant still has an excess of energy of 2,283,787kWh/year or 15.9% of total production which can be used to serve the energy needs of next year. Based on the results of the feasibility calculation of the economic aspect with 3 parameters, it shows: that the NPV is positive, the PBP is smaller than the project life, and the IRR is greater than the bank's interest.

Generator design and trial - Firdausi [16], in his research, explains several important things which are the basis for consideration for carrying out a biogas power plant process, such as collecting data for the source of raw material for biodigester feed, determining the process design, and determining specifications on generator capacity. In another study, Pasaribu et al. [21] modified an oil-fired generator set to a biogas generator set. The digester is designed by considering the potential of available raw materials, determining the digester model, designing the storage tank, and ending with determining the location.

Pasaribu [21]reports on a biogas power plant with a continuous filling digester system, which initially fills only 80% of the volume of the digester tank. After production, organic matter filling is carried out continuously every day with a daily filling volume of 1/60 of the initial filling volume. In another study, to increase biogas production, Setiawan [24] experimented to prove that there was a difference before

and after adding Green Phoskko (GP-7) to a household-scale biogas power plant with cow dung as the main raw material. As a result, the sample gas production rate after the addition of GP-7 was 0.2209 m^3/kg, while the sample gas production rate before the addition of GP-7 was 0.2162 m^3/kg.

In a distinct scenario concerning the operationalization of biogas-generated electricity, Ramadhan and Abidin [7]established a linkage between a biogas power facility and a switching substation within the Sanggau district. This investigative endeavor offers valuable insights for contemplating the integration of a biogas power unit into a 20 kV distribution framework. Furthermore, this study's potential extends to an in-depth exploration of power system safeguards through the analysis of simulations involving short-circuit currents.

Implementation - In the literature studied, several electricity generators from biogas have been successfully implemented, as reported by Rizal dan Gianto [22] and Adiprabowo [23]. Rizal dan Gianto [22], undertook an investigation in Sanggau Regency, wherein the integration of a biogas power plant with a 20 kV substation demonstrated compliance with the SK/DIR/0357/2014 standards. Noteworthy is their preliminary step of employing ETAP simulation software to meticulously blueprint and evaluate the electrical power framework before the biogas-generated electricity was incorporated into the 20 kV distribution grid. This use of ETAP was integral to mimicking real-world conditions and providing a comprehensive platform for pre-implementation system analysis. ETAP, recognized as a sophisticated tool for electrical power system planning and simulation, served as an indispensable asset in these endeavors.

In a separate investigation, Adiprabowo [23] effectively executed the deployment of a monitoring system designed to oversee the initial operation of a biogas power plant. This involved the measurement of pivotal parameters including pressure, engine gas power, biogas emission, and methane concentration. The method employed a programmable logic controller (PLC)-centered instrumentation and control framework, strategically integrated to facilitate the functioning of the biogas power plant. This innovative system holds particular significance in the precise regulation of vital procedures, thereby leading to enhanced operational efficiency and performance of the biogas power plant.

Evaluation - As reported by Florence [20], biogas power plants are not only beneficial for the community but also expand and increase public knowledge. On the economic aspect, the biogas power plant plays a very significant role in improving people's lives, and on the environmental aspect, the biogas power plant functions as a solution to the problem of waste management and environmental cleanliness in the city of Manado. They analyzed the data using the analytical technique of the T-test (one sample t-test) to analyze whether there is a significant difference produced by the biogas power plant on social and environmental aspects after 1 to 2 years of implementation. On the other hand, the economic aspect is calculated using income assumptions. Meanwhile, Rizal & Gianto [22] have provided the fact that the connection to the biogas power plant has improved the voltage profile so that it does not drop more than 10%.

3.3 Research Trends on Biogas

To illustrate research trends, we used data from Wizdom.ai [25], as depicted in Figure 4, showcasing the trend in the number of biogas-related publications from 2004 to 2023. Our analysis reveals an upward trajectory in biogas-related publications from 2004 to 2021, encompassing all publication categories, including closed, bronze, hybrid, gold, and green publishers. However, there is a projected decline in biogas-related publications for the years 2022 and 2023 (ongoing). From 2004 to 2023, a total of 26,784 articles were related to biogas, with the following distribution: 1,273 articles in green publishers, 7,317 in gold publishers, 1,721 in hybrid publishers, 1,609 in bronze publishers, and 14,864 in closed publishers. These articles also exhibit a growing scientific impact, as evidenced by the citation trend illustrated in Figure 5. The solid blue and red curves in Figure 5 represent the citation trend and citation ratio, respectively. Finally, Table 5 presents the top 20 rankings of journals and proceedings that publish articles on biogas.

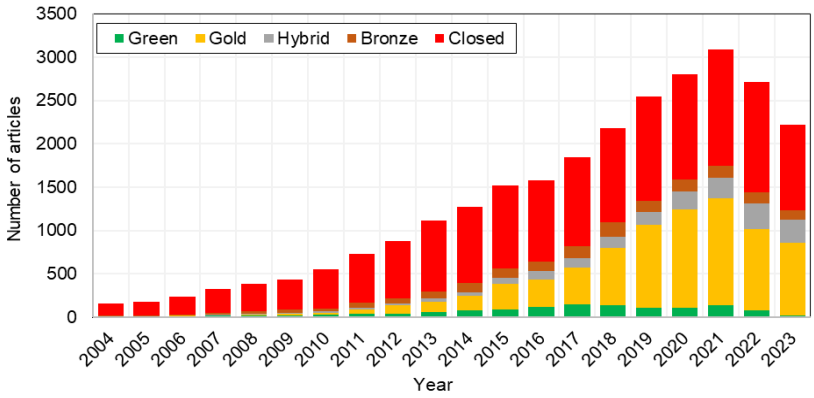

Figure 4. Number of publications about biogas in 2004-2023 recorded on Wizdom.ai [accessed: 27/10/2023]

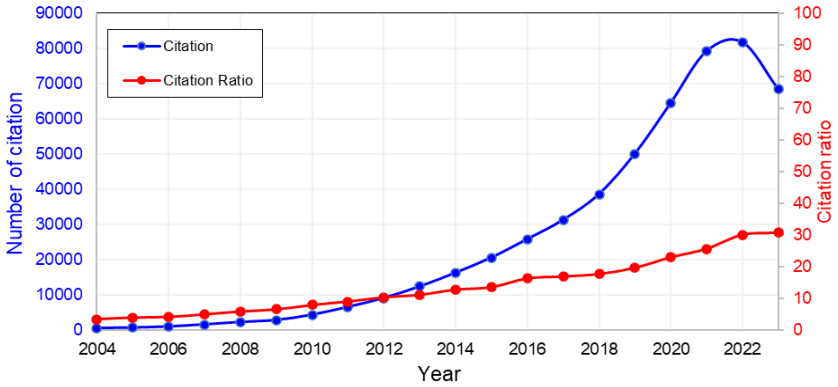

Figure 5. Trends in citations and citation ratios of articles about biogas recorded on Wizdom.ai [accessed: 27/10/2023]

Table 5. Top source title of articles about biogas recorded on Wizdom.ai [accessed: 27/10/2023]

Nr.	Source title	Articles	Percentage
1.	Bioresource Technology	1910	23.1%
2.	Water Science & Technology	665	8.1%
3.	Waste Management	588	7.1%
4.	Energies	584	7.1%
5.	The Science of The Total Environment	436	5.3%
6.	Journal of Environmental Management	409	5.0%
7.	IOP Conference Series Earth and Environmental Science	360	4.4%
8.	Renewable Energy	311	3.8%
9.	Sustainability	306	3.7%
10.	Water Research	302	3.7%
11.	Journal of Cleaner Production	299	3.6%
12.	International Journal of Hydrogen Energy	291	3.5%
13.	Environmental Technology	281	3.4%
14.	Environmental Science and Pollution Research	266	3.2%
15.	Renewable and Sustainable Energy Reviews	236	2.9%
16.	Fuel	219	2.7%
17.	Energy	211	2.6%
18.	Proceedings of the Water Environment Federation	205	2.5%
19.	E3S Web of Conferences	194	2.4%
20.	Published by EDP Sciences	179	2.2%
Total		8252	100%

3.4 Limitation

This study may not be able to fully represent the development of biogas power plant research in Indonesia because the search keywords are too narrow and use Bahasa Indonesia. As a further comparison, besides searching on Wizdom.ai, we used Scopus as another search database. With the keyword "biogas power plant", we found 12 publications in journals indexed by Scopus in 2014-2023. We restricted the country to Indonesia and articles in journals, not including articles and proceedings and book chapters. Of the 12 articles, they discuss utilization of cow dung for biogas [26], assessment, protection and monitoring system in biogas power plants [27]–[29], evaluation of the techno-economic and environmental impacts of biogas power plants from POME [30], [31], regulation of biogas power plants from palm oil mill waste [32], enhancing methane production from dairy cow manure [33], removal of H_2S from biogas with bioscrubber [34], chemical pretreatment for biogas production from water hyacinth [35], potential for electrical energy from livestock waste in a selected area in South Sulawesi [36], and utilization of fruit waste as feed for biogas plants [37].

4. Conclusion and Recommendation

A review of various studies on biogas power generation has highlighted its potential as a clean and sustainable energy source. Indonesia's energy needs are soaring due to population growth and technological advances, giving rise to an energy deficit. Fossil fuels that dominate Indonesia's energy supply are non-renewable and detrimental to the environment. Alternative energy sources such as hydroelectric power, wind, and solar face limitations in terms of cost and feasibility. However, biogas, produced through anaerobic fermentation of organic materials, is a promising alternative. In particular, palm oil mill liquid waste (POME), livestock manure, and organic waste are the main raw materials for biogas plants. The feasibility, economic feasibility, generator design, implementation, and evaluation of a biogas power plant have been explored. Comprehensive feasibility studies, technical designs, and economic analyses have demonstrated the potential success of biogas power projects.

Based on these findings, several recommendations emerge. First, policymakers and energy planners must prioritize the integration of biogas power plants into the national energy mix. Further research should look for ways to increase the efficiency of biogas production and reduce potential environmental impacts. Collaboration between the public and private sectors is essential to provide the necessary funding and expertise. In addition, a comprehensive feasibility study must be carried out for each potential biogas project, considering not only technical aspects but also economic and environmental factors. Additionally, investment in monitoring systems and control frameworks is critical to optimizing operational efficiency. Finally, public awareness campaigns can educate the public about the benefits of biogas power plants, encourage support, and speed up implementation. By making biogas a viable renewable energy source, Indonesia can overcome the energy deficit while contributing to sustainable development and environmental protection. Because this study is limited to the scientific literature studied, a detailed review involving more articles in various databases is needed to produce a more comprehensive future direction regarding research and implementation of biogas power plants.

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ISSN: 2715-4211