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Generating SQL Command Syntax Using MySQL Based on Typing Command Sentence

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Abstract— Information retrieval system is a system that is widely used to retrieve information. This research will discuss how the system finds back the information stored in database tables. Tables in the database are arranged to store all forms of data entered by database users so that later the stored data can be used again. Re-accessing the database's information must go through a mechanism known as a database management system (DBMS). One of the most widely used DBMS is MySQL. By using a DBMS, information and data can be manipulated according to user needs. Data manipulation in the database is done in a special language, namely SQL (Structure Query Language). Mastery of SQL commands is an obligation for database users so that the manipulated data can produce the required information. However, many database users still do not understand how the actual SQL command syntax manages and manipulates data into information. This is, of course, very risky if the solution is not immediately sought because it will hinder the process of retrieving information from the data stored in the database. For this problem to be resolved, it is necessary to design a system that can help database users translate their wishes into SQL command syntax. This paper will discuss how a command in Indonesian can be translated into SQL command syntax. The method used to solve this research problem is rule-based. There are two stages in the main process: the pre-processing stage, which consists of a word tokenization process, and a translation stage, including a keyword grouping process. This keyword grouping process consists of the keyword group analysis phase, table and column analysis, identification of SQL commands, and mapping of SQL commands. From all stages that have been passed and testing of 7 scenarios with ten (10) commands for each scenario, the accuracy is 81.42%. The inaccuracy in the testing process is more a problem of displaying data from two or more tables, for example, using the join table command. This problem can be addressed by adding new rules for the use of table joins.

Keywords— Database, DBMS, MySQL, SQL, Command Sentence.

I. INTRODUCTION

The database collects organized, organized and managed, and appropriately stored data in computer storage media. The data stored in the database can be processed or manipulated using application software to become useful information. The database collects information stored systematically to simplify and speed up the information retrieval process [1]. According to Connoly [2], a database is a collection of data designed logically to complement an organization's information needs. For the information stored in the database to be conveyed to database users, the data must be managed or manipulated using a unique system mechanism. The system is a Database Management System. Some database systems have metadata that is part of systematic data management in a DBMS (Database Management System) [3].

DBMS is a software system that allows users to define, create, maintain, and control access to databases [2]. Laudon [4] explains that DBMS is software that enables an organization to centralize data, manage data, and provide access to data stored by application programs. According to Indra [5], DBMS is software used to control the creation of maintenance, processing, and use of large databases. DBMS is also designed in such a way to make it easier to manipulate data. DBMS had become a significant role or key and standard part in supporting a company. By using a DBMS, database users can manipulate data into useful information. There are many DBMSs, one of which is MySQL. MySQL is one of the most well-known DBMS. MySQL functions as a Relational Database Management System (RDBMS) and is open so that MySQL is considered suitable for demonstrating the database replication process [6]. In a relational database, there is the term constraint. In this case, Constraints are significant to pay attention to because if they are not, then the resulting data will not be valid and cannot fulfill the elements as data for testing [7]. The process of manipulating data in a database requires special tools recognized by the DBMS in use. This tool is known as SQL (Structured Query Language).

SQL is a structured language used to access data stored in databases. SQL is also a standard language that can be applied in various existing databases to be easier to use even though it is easy to move between databases, even though moving from one database to another [8]. According to Junus [9], SQL is a standard language for interacting with databases by operating common commands in the database. Based on its function, SQL is classified into three types, namely DDL (*Data Definition Language*), DML (*Data Manipulation Language*), and DCL (*Data Control Language*). In the context of its use in database management, the CRUD (Create, Read, Update and Delete) concept of the three SQL groups is used to describe the function of a data storage area [10]. SQL commands (or commonly referred to as SQL statements) are issued to the DBMS, which will then run the SQL command and will display the results (if any) [11]. However, many database users cannot use SQL commands to get certain information from the data stored in database tables. This is due to a lack of understanding and the user's ability to use SQL. Sometimes,

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user confusion is also caused by determining what SQL commands should be used to get the expected information.

This study aims to help database users get the expected information even though their understanding of SQL is still lacking. Also, another goal of this research is how database users can quickly generate commands typed in Indonesian into SQL command syntax form. According to Khalek [12], to promptly generate or get SQL command syntax, you can use a query creation framework called the Random Query Generator (RQG). The working concept is to use SQL grammar as the basis for generating queries.

However, to achieve the stated objectives in this study, an application was created that could translate user commands into SQL command syntax. In this application, users can type the command in Indonesian, and then the application will display the actual SQL command syntax. Suppose a user wants to display married employees. In this application, the user can type the command in Indonesian, and then the application will display the actual SQL command syntax. For example, a user wants to display married employees. Then in the application, the user will simply type the command: Show employees whose marital status is Married. The application will automatically display the following SQL command syntax from this command: Select * from tbl_karyawan where *stskawin* = 'Married'.

II. Research Methodology

The research method is generally defined as a scientific way to obtain data with specific purposes and uses [13]. In this sub-section, the methods used in this research will be explained.

A. Action Research Method

In conducting this research, the method used is a case study. The case study research method is one type of research that can provide answers to several main ideas about a particular event. The case study research method allows the investigation of certain events, circumstances, or social conditions [14].

The steps of the researcher in the case study method are shown in Figure 1. The steps taken by the researcher in this case study can be described as follows:

- Determining Research Topic: Researchers carry out selecting topics by considering specific objectives according to the case to be researched and a solution sought. In this case, the case to be investigated is how to create a system that can help database users use SQL commands based on typing command sentences in Indonesian.
- Determining and Defining Questions: At this stage, the researcher arranges questions on the problem under study and the ultimate goal of this research. This research's main problem is that there are still many database users who do not understand SQL. The question is formulated about a solution to make it easier for database users to write SQL command syntax. From the questions that have been formulated, then the researcher analyzes these questions and looks for answers about what methods are used to answer questions and implement them into the system.
- Determining Research Design: At this stage, the researcher will evaluate the design and instruments used in the unit's study or subject under study. The researcher will evaluate a situation that must be resolved by determining whether to use a single or multiple-case design in the research and selecting the appropriate instrument with the research question.
- Collecting Research Data: At this stage, the collection of data relevant to the topic under study and the formulation of questions that have been made is carried out. Researchers used data collection methods through observation and literature study in scientific journals, books that discuss similar cases, and other references.
- Data Analysis and Validation: In this step, from the data collected, the researcher will sort out which data is most suitable and can be tested into the system to be built.
- Creating Documentation: The final step in this case study method is to generate documentation. Documentation is made by the researcher in a written report on the research's overall implementation.

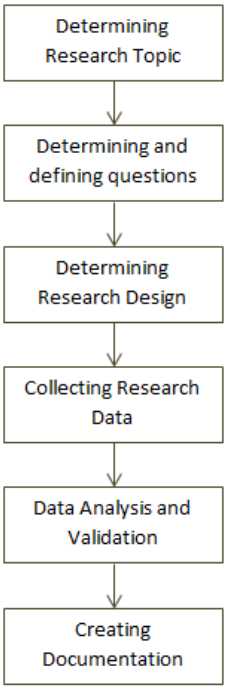

Figure 1. Action research steps

B. Collecting Data Method

Data collection methods are techniques or methods used to collect data. The method refers to how its use can be demonstrated through questionnaires, interviews, observations, tests, documentation, etc. According to Subarsimi [15], data collection methods are defined as researchers' procedures in collecting research data. Data collection methods are the main thing in research activities because the research aims to get data.

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In this research, data collection was carried out secondarily, namely through literature study. A literature study is carried out by studying scientific work results from previous researchers, both from journals and proceedings that have themes relevant to current research. In addition to scientific literature, researchers also studied books that discuss the Query language and SQL generator techniques. From the results of this literature review, it is hoped that researchers will gain in-depth knowledge of methods for making SQL generators effectively based on users' commands to reduce the level of difficulty of users in using SQL commands.

C. Analysis Data Method

The data analysis method is part of the implementation of research activities where the data that has been collected by the researcher is processed and used as an answer to the identification or formulation of the problems obtained.

The data analysis method used in the implementation of this research is qualitative analysis. The qualitative analysis method is a procedure intended to understand the symptoms or problems faced by research subjects, including behavior, actions, and research subjects' perceptions.

In this method, the researcher can formulate several issues: the inaccuracy of using SQL commands to execute what the user wants. This inaccuracy is since the user does not even master SQL command forms in displaying the required information.

D. Research Flow

The research flow is designed so that the research implementation stages are more focused so that the results will be as expected. The flow of research activities is shown in Figure 2.

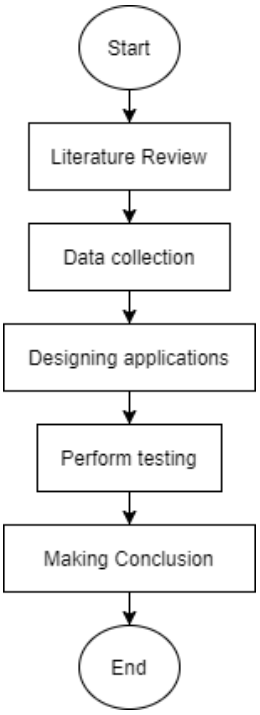

Figure 2. Research flow

Based on Figure 2 above, the system flow can be described as follows :

Start

- Literature review: the researchers looking for research that discusses SQL syntax and looking for a study that examines text processing
- Data collection: the researchers search for the dictionary table, formulate keyword groups and formulate SQL syntax pattern phrases for displaying data. Including look for examples of Indonesian command sentences to display data
- Designing application: the researchers decide the SQL syntax pattern rules for displaying data then implementing a programming language
- Perform testing: The researchers tested the application with examples of Indonesian command sentences from previous data collection results. Then, make adjustments to the application until the results are close to the designed SQL syntax pattern rules, including Record test results.
- Concluding: the researchers determine conclusions from the test results regarding the suitability of the system in the application with the expected results

III. Result and Discussion

This section describes the system's flow, pre-processing text analysis, tokenizing process analysis, and keyword grouping process up to the application implementation stage.

A. System Flow

The resulting system from this research is focused on displaying the SQL command syntax using MySQL based on typing the command sentence by the user. In general, the running of the system is shown in Figure 3.

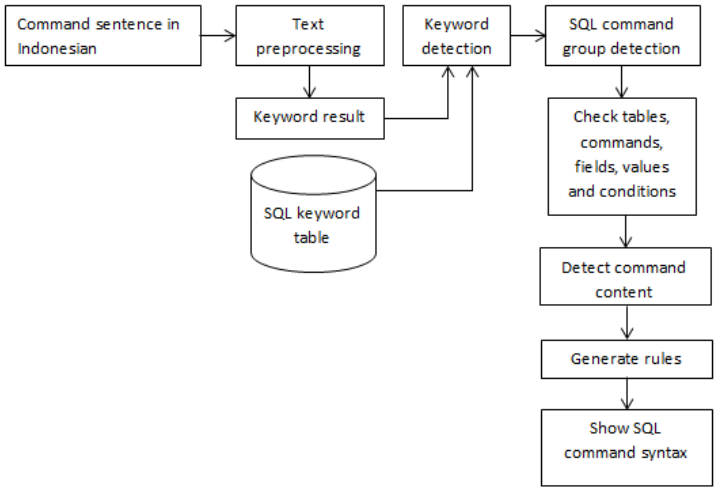

Figure 3. System flow

Based on Figure 3 above, the system flow can be described as follows :

- The user types the command using Indonesian.
- After the command is typed, the next step is the pre-processing text.

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- From the pre-processing text process, the result is a list of keywords.
- The keyword list is then detected to match with the SQL keyword table.
- The matched keyword is used to define SQL commands, whether it belongs to the DDL or DML group.
- After getting the group from the SQL command, the next process is to check whether it is included in the table, command, field, value, or condition category.
- The next step after the command is detected to check the contents of the user's command and match it with the SQL command group.
- In the last stage, the system will display the SQL command syntax

B. *Pre-processing Text*

Pre-processing text is the first step in preparing input data, namely command sentences in Indonesian. This input is carried out the first time before the translation activities are carried out. Pre-processing text is a necessary process that needs to be done to obtain excellent accuracy results [9]. The pre-processing text generally consists of the case folding, filtering, word tokenizing, stemming, and stopword removal stages. The pre-processing text stages are shown in Figure 4.

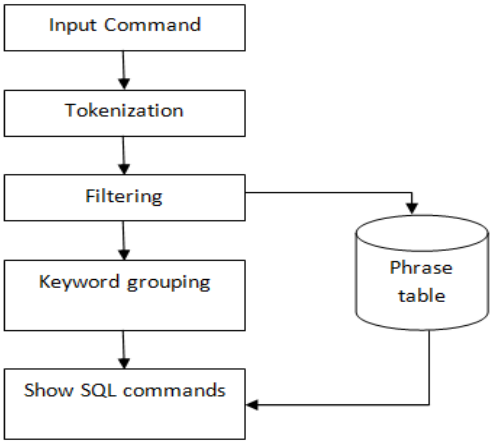

Figure 4. Pre-processing text flow

The pre-processing text stage based on Figure 4 above can be explained as follows :

- Commands in Indonesian are entered into the system.
- From the entered command, the tokenization process is carried out where this process is a process where a long command sentence is cut into words.
- Furthermore, the filter process is carried out from the tokenization results. This filtering process is used to compare words with the existing table of phrases. Its purpose is to find out whether the words have a special symbol. For example, the same as being a sign (=), less than being a sign (<), and so on.
- After the filtering process, then proceed with the keyword grouping process. This process aims to determine whether the command entered belongs to the DDL or DML group, whether it also includes a condition, clause, or condition value.
- The final step is to display the SQL command syntax based on typing the command sentence in Indonesian.

C. *The Tokenizing Process*

Tokenizing is defined as a process of dividing a sentence into words (tokens) using a separator parameter, namely a blank space ('). With the parameters, a sentence can be used to collect words (tokens), which can be in numbers or words [16]. The resulting words will be processed at a later stage.

The tokenizing process is also applied in the research results system this time. This process is intended to analyze each word that has been separated from the command sentence entered by the user. An example of the result of the tokenizing process in Table I.

TABLE I
EXAMPLE OF THE TOKENIZING PROCESS

Command sentence	The result of the tokenizing process	
	Word index order	The word
Show all students who have a male gender	0	Show
	1	All
	2	Students
	3	Who
	4	Have
	5	Male
	6	Gender

D. *Keyword Grouping Process*

In this keyword grouping process, the word tokenizing results are detected into what SQL command group and translated into SQL command syntax form according to the SQL command group. This keyword grouping is divided into four processes: keyword group analysis, table and column analysis, SQL command analysis, and SQL command syntax mapping.

1) Keyword group analysis: Each root word resulting from the pre-processing process, namely tokenizing, will be analyzed to determine the type of root word included in the type of command, value, condition, or other types. An overview of the keyword group analysis is shown in Figure 5.

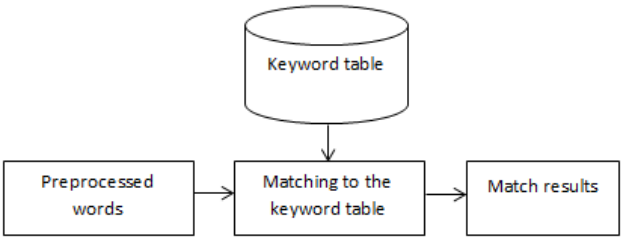

Figure 5. Keyword group analysis process

A group of keywords is generated from the process of keyword analysis, as in Table II.

TABLE II.
KEYWORD ANALYSIS RESULTS

Basic word	Keyword group
Show	
All	Command
Student	
Have	Value

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Basic word	Keyword group
Male Gender	 Condition

2) Analyze tables and columns: Each base word that is not a keyword will be used in the table and column analysis process. Its function is to automatically know each word's type so that it can be used for the next process. The flow of the table and column analysis process is shown in Figure 6 below, and the results of the table and column analysis process are shown in Table III.

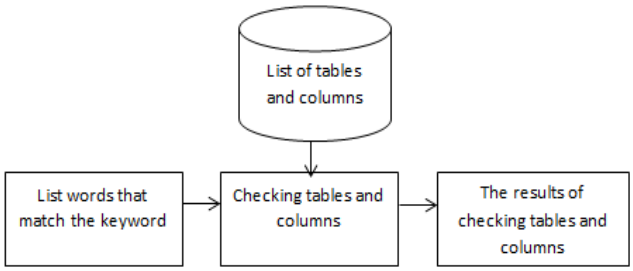

Figure 6. Table and column analysis process.

TABLE III.
RESULTS OF THE TABLE AND COLUMN ANALYSIS

Basic word	Keyword group
Show All	Command
Student	Table
Have	Condition
Male	Value
Gender	Column

3) Identify SQL commands: This identification process is carried out to determine whether the user's command is included in the DDL or DML group. After knowing the SQL language group, it is continued to identify each word of the command with the SQL command keyword. Does it include: tables, fields, commands, conditions, or values. If everything is known correctly, the command sentence that is typed is compared with the data in the database so that the SQL command can be known [17]. The identification process flow is shown in Figure 7, and examples of the identification process results in Table IV.

TABLE IV.
AN EXAMPLE OF THE RESULTS OF THE IDENTIFICATION PROCESS

Basic word	Keyword group	SQL command identify
Show	**Command**	**Select**
All		
Student	Table	*Mahasiswa*
Have	Condition	Where
Male	Value	*Kelamin*
Gender	Column	*Pria*

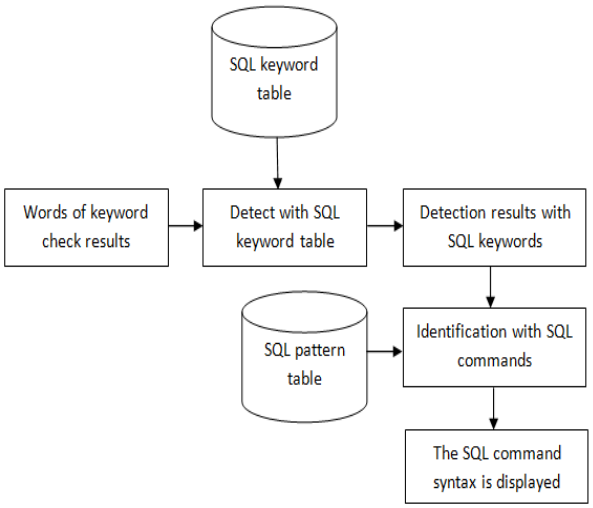

Figure 7. Identification process flow

4) SQL command syntax mapping: At this stage, mapping the SQL command syntax is based on identifying the SQL command. From this process, the SQL command syntax will be obtained according to the user's commands. An example of the results of this process in Table V.

TABLE V.
EXAMPLES OF SQL COMMAND SYNTAX MAPPING RESULTS

Basic word	SQL command identify	Keyword group	SQL command syntax
Show All	Select	Command	Select * from *mahasiswa* where *kelamin*='*Pria*'
Student	*Mahasiswa*	Table	
Have	*Where*	Condition	
Male	*Kelamin*	Value	
Gender	*Pria*	Column	

E. System Testing Analysis

This section will explain the test scenario to determine the level of accuracy of the system being built. There are 7 test scenarios, with each scenario having 10 commands in Indonesian, which will be tested for the SQL command syntax accuracy. Examples of test scenarios, input commands, and expected SQL syntax results are shown in Table VI.

TABLE VI.
EXAMPLE OF THE TESTING PROCESS

Scenario number	Scenario name	Example input command	Expected SQL syntax results
1	Mention the table name directly	show student data	SELECT * FROM t_student
2	Mention the name of the table accompanied by a column, amounting to one column	show a list of student names	SELECT t_student.name FROM t_student

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Scenario number	Scenario name	Example input command	Expected SQL syntax results
3	State the name of the table accompanied by a column of two or more columns	show student number and student name	SELECT t_student.studentnumber, t_student.name FROM t_student
4	Mention the name of the table with the filter, the number of one filter	show the data of students whose college status has passed	SELECT * FROM t_student WHERE collegestatus = ‘passed‘
5	Specifies the name of the table with the filter, two or more filters	show the data of information system study program students who graduated in 2019	SELECT * FROM t_student WHERE studyprograme = ‘information system’ AND graduatedin = ‘2019’
6	Mention table name along with columns and filters	show a list of names of students from the information systems study program	SELECT t_student.name FROM t_student WHERE studyprograme = ’information system’
7	State the names of two different tables	show a list of students and lecturers of the information system study program	SELECT * FROM t_student, t_lecturers WHERE studyprograme = ‘information system’

Table VI shows examples of tests in 7 scenarios for getting SQL command syntax. From the overall trials for all scenarios, the test results are obtained as in table VII. The total accuracy value in table VII is obtained from the number of correct divided by the total data multiplied by 100%. Judging from the test results as in table VII, in general, the system can perform its functions quite well in terms of the accuracy value obtained.

TABLE VII.
TEST RESULTS TABLE

Scenario Number	The number of commands tested	Total Correct	Total False	Accuracy (%)
1	10	10	0	100
2	10	10	0	100
3	10	10	0	100
4	10	8	2	80
5	10	8	2	80
6	10	7	3	70
7	10	4	6	40
Total	70	57	13	81,42

IV. CONCLUSION

Based on the results of the trials and accuracy tests that have been carried out. The system built in this study has a level of functionality that is already running properly. After being tested with several scenarios and commands in Indonesian, the system could translate user commands into SQL command syntax with a reasonably good accuracy value of 81.42%. The accuracy value is quite good, but there are still things that are not suitable, namely when the system is asked to display data from a different table, for example, a command that uses a join table.

The future work is the SQL command dictionary table in this application is still incomplete. If there is an input command that does not match the table, the results are not optimal. This requires the process of identifying commands and automatically recording them in the basic SQL command dictionary table. This application's system can still detect and repair if there are commands that emphasize a condition initially. For example: Show the highest score of student test results. We need to add more capabilities to detect and display SQL command syntax with any conditions. We need to add a special rule to handle commands that require the system to display data from different tables. as an example, command with table join

The application produced from this study functions to display the SQL command syntax based on the command sentence typed by the user. For further development, the application's deficiencies will be fixed to have a function that runs well in any condition. Also, the application will be developed using voice input commands.

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Optimization Economic and Emissions of Hydro and Thermal Power Plants in 150 kV Systems Using the Dragonfly Algorithm

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Abstract — Electricity is one of the energies required by daily living since the greater demand for electricity increases greenhouse emissions that create emission gases resulting in global climate change. The main portion of the output cost is fuel's cost to manufacture electrical energy in thermal turbines. The use of electrical energy is currently rising increasingly following the increasing population. The research aims to optimize hydro generation to minimize thermal generation expense and address economic problems and pollution from shipping. With 2016b using Matlab applications and the lambda iteration process, the analysis method uses the Dragonfly Algorithm method. The analysis found that the average cost of fuel consumption provided by the Dragonfly Algorithm method was IDR 151,164,418 per day with an emission of 917.40 tons per day, based on the simulation results the Dragonfly Algorithm in testing by considering the emission of 5 practical steps. Meanwhile, with the emission of 918,044 tonnes per day, the average cost of fuel consumption produced by the Lambda Iteration method is IDR 151,202,209 per day. Test results can enhance the fuel consumption cost of IDR 37,791 and emissions of 0.641 tons with the Dragonfly Algorithm process.

Keywords — Electricity, Economic and Emissions dispatch, Dragonfly Algorithm.

I. INTRODUCTION

Greenhouse emissions boost the demand for more oil, resulting in global climate change. The sustain economic development, energy is one of the fundamental elements. Electrical energy is one of the most vital for economic growth [1]. Due to the rising population and economy, Indonesia's need for electricity increases in one region, South Kalimantan.

In 2018, the Province of South Kalimantan consumed 4,058 GWh of electricity with a household sector dominated by demand per consumer sector of approximately 2,046 GWh (50%), a sector of approximately 1,172 GWh (29%), an industry sector of approximately 564 GWh (14%) and a public sector of approximately 275 GWh (7%)[2]. This allows the *PLN* (State Electricity Company) to safely and efficiently preserve electrical power delivery to the electrical grid and optimize the necessary load. Fuel costs are presently the primary portion of manufacturing costs, and electrical energy use is currently undergoing fast growth. PLN also aims to replace, by scheduling, costly fuels for economically viable fuels[3].

The generation units are not in the same setting as the load in an electrical power grid linked to the interconnection network. Furthermore, the cost of manufacturing these units is different. The generation system's capability is expected to be greater than the system's total load requirements and power losses during standard service. A sustainable energy system needs to pay attention to the economic sector and the reliability, but it also requires a system that recognizes environmental damage[1].

Optimizing the timing of hydrothermal generation in the electric power grid is a reasonably inexpensive way to satisfy consumer requirements. During the optimization time, the overall running cost is higher than the cost of thermal generation. Due to efficient running costs, hydro generation units are used to bear the baseload. The thermal generation units are also run with higher running costs to satisfy the remaining load specifications[3].

Thermal power stations are a significant cause of polluting atmospheric sulfur dioxide (SO2), nitrogen oxides (NOx), and carbon dioxide (CO2)[4]. In comparison, if production is improved, the energy efficiency and the volume of carbon emitted into the air from thermal power plants would significantly accelerate, thus reducing the resultant pollution emissions.

The optimization of short-term hydrothermal scheduling can be applied to reduce gas emissions resulting in recent environmental disruption. The prerequisite that a hybrid economic short-term hydrothermal emission scheduling is also created and minimizing the fuel cost of thermal power generation[5]. For the optimization problems of thermal, hydropower plants, there are many approaches used. These optimization techniques are divided into two, namely, the deterministic technique and the artificial intelligence technique.

Economic and Emissions Dispatch (EED), to fix economic and social aspects, has been the most important optimization in the operation of the power plant and control problems. Guanghui Yuan et al., respectively. Using the PSO and AFSA Algorithm Hybrid process, they have the objective of minimizing coal use, pollution emissions, and buying costs[4]. To minimize coal consumption and CO2 gas leakage emissions in thermal power plants, Ehab E. Elattar analyzed the optimization theme, namely economic dispatch and emissions, using the modified shuffle frog leaping (MSFLA) algorithm system [5]. Vinay Kumar Jadoun et al. Investigated

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using the Modulated Particle Swarm Optimization (MPSO) approach to solve the EED machine's thermal problem and evaluated the comparison for optimum optimization of many artificial intelligence methods[6]. To solve sending economic emissions consisting of Combined Heat and Power Economic Emission Dispatch (CHPEED) and Dynamic Economic Emission Dispatch (DEED). Hossein Nourianfar et al. investigated using Time-Varying Acceleration Coefficient-Particle Swarm Optimization combined (TVAC-PSO) with Exchange Market Algorithm (EMA)[7]. From M. Amiri et al. Examined using the floating search space swarm-based optimization approach, the proposed method will offer competitive solutions to problems in the distribution of economic pollution by increasing precision, reducing computational budgets, and achieving better performance[8].

The authors would apply the Dragonfly Algorithm in this analysis, based on the Dragonfly algorithm principle that begins statically as a starting point and energetic behavior of the dragonfly herd. At the two main stages of optimization via the heuristic meta-algorithm, this clustered action is used as a parable, namely inquiry and use[9]. The optimization strategy in meta-heuristic hybrids, DA (Dragonfly Algorithm), deals with optimization power flow problems in the study guide. The algorithm stated is applied to obtain the optimum value variable power system control and address OPF issues. It will minimize power loss, voltage profile variations and monitor fuel costs, which are the critical goals of the OPF problem[9]. There is, however, no study using the Dragonfly algorithm on economic optimization and pollution.

A comparatively recent algorithm is the Dragonfly algorithm. There have been some previous reports to deal with the OPF (optimal power flow) problem. Shilaja C et al. used the Dragonfly algorithm and analyzed the IEEE 30 bus system [9]. The Dragonfly algorithm was used by Sureshkumar et al. to mitigate device errors based on objective power flow control functions such as actual power and reactive power[6]. Ling-Ling Li and others, et al. To refine short-term projections for the wind power model [10], the Dragonfly algorithm was used. Jie Li et al. To optimize the Wind-Solar-Hydro power scheduling model [11].

As a guide, numerous experiments have attempted to maximize hydrothermal plants' economy and pollution using artificial intelligence techniques, claiming that thermal generation costs can be reduced. Based on this data, in the 150-kilovolt system in South and Central Kalimantan, the researchers conducted economically, and emission optimization for hydro and thermal power plants using the Dragonfly Algorithm method hydro generation the cost of thermal generation and solve economic problems and shipping pollution.

II. RESEARCH METHODOLOGY

The Dragonfly algorithm flowchart that the author did can be seen in Figure 1. The generating Flowchart from the Dragonfly algorithm, the system recognition process is a step taken to get the system's model outcomes. In this method of recognition, the steps include:

- Starting is a system-starting process.
- Input parameters are a data input method in the form of iteration values, the thermal generator load (PLTU).
- In thermal generators, iterations are obtained using lambda (PLTU).
- Calculate constants using polynomial regression of the second order.
- The Convergence Criterion is a criterion for estimation or software verification.
- Fitness feature evaluation is a function of the algorithm of the dragonfly.
- Updating the Dragonfly algorithm equation's value can be seen in equations (3) - (7).
- Dragonfly Algorithm calculates process and solution selection for economic optimization and emissions from thermal generation.

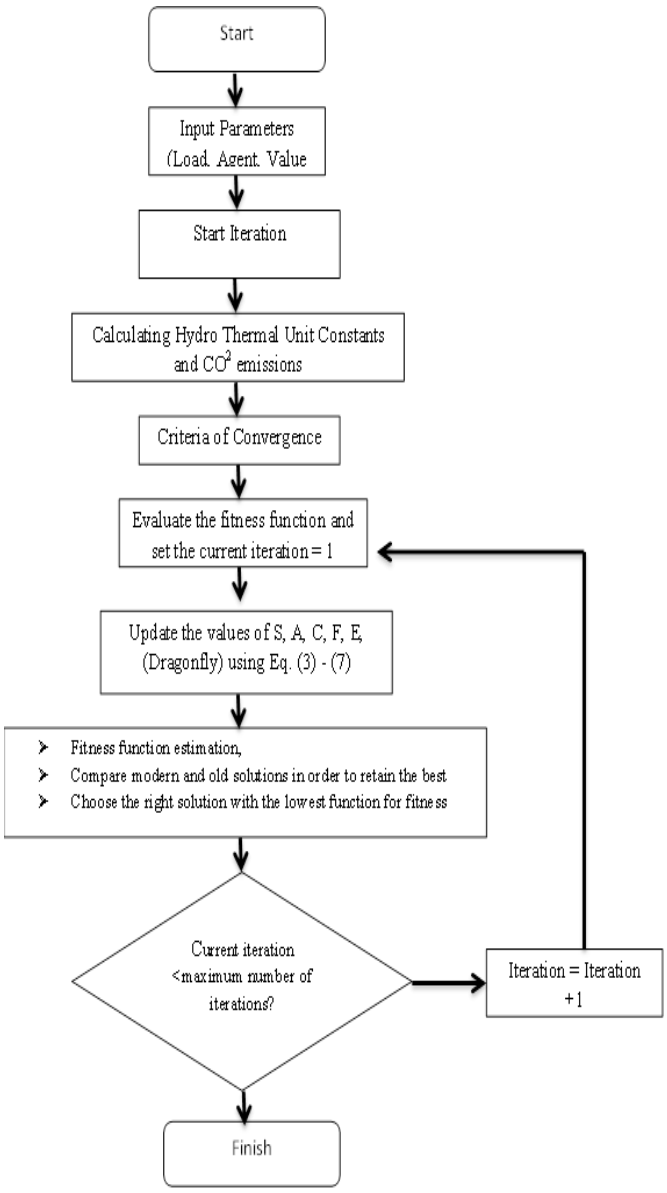

Figure 1. The Dragonfly algorithm

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A. Data Collection

Data sources were collected from the 150 kilovolts South Kalimantan power plant with the 50 MW *Asam Asam* Steam Power Plant (*PLTU*) unit 2, the 60 MW *PLTU Asam Asam* unit 3, and the 60 MW *PLTU* Asam Asam unit 4. Hydroelectric Power Plant *Riam Kanan* (*PLTA*) with a capacity of 30 MW and a 150 kilovolt Central Kalimantan Power Plant with a *PLTU Pulang Pisau* Unit design 1 with a capacity of 60 MW, *PLTU Pulang Pisau* Unit 2 with a capacity of 60 MW.

B. Power Plants Optimization

For the delivery of generator loads, the electric power grid's operation is necessary to achieve optimum function. Coordination of the loading of massive electric power produced by the central power plant units needs to be aligned to obtain cheap fuel consumption costs [11]

Economic distribution is one means of calculating the quantity of power generated by each generator unit to fulfill a given load by optimally separating the load on the generating units in the system to rationalize the cost of developing fuel consumption [12].

C. Combined Economic and Emission Dispatch

Economic and Emission Dispatch are optimized to fix ignored emission challenges in economic delivery, and fuel cost goals are not considered in emission delivery issues based on Equation (1) [13].

$$\text{Min } Objective = w1 \times F1(P_{si,m}) + w2 \times \text{PRm} \times F1(P_{si,m}) \quad (1)$$

where:
w1: Factor of weight for fuel cost
w2: Factor weighting for emissions costs
F1: Fuel cost objectives
F2: Emission Objectives
Psi, m: Thermal unit power output
PRm: Price penalty factor

D. Characteristics of Power Units

There are three types of generator types in the device: generation of simple load, generation of medium load, and peak load generation [3].

In this analysis, thermal generators' input-output characteristics are steam power plants per hour input to the generator unit in Btu. The generation expense is the multiplication of the cost (*IDR*) of the gasoline's calories, in this case, gas, with the generator's hourly calorie requirements (*Btu/h*). The power generated as a result is written as PG [14].

The characteristics create a correlation as a function of the generator output between the generator inputs with Equation (2). The input-output characteristic equation of the power plant defines the relationship between the amount of fuel (coal) needed in the binomial function method to generate a certain power in a power plant, namely [15]:

$$(F) = xP2 + yP + z \quad (2)$$

Where:
F = Fuel cost (Coal)
P = Generating power yield (MW)
x, y, z = Constant

E. Dragonfly Algorithm

The Dragonfly Algorithm is an algorithm for artificial intelligence that serves as an optimization for decision-making. The dragonfly algorithm began with static dragonfly actions as the starting point and enthusiastic crowds. In the two main optimization stages via the heuristic meta-algorithm, namely inquiry and consumption, the two swarming activities tend to be identical[9]. The following mathematical model using Equation (3)-(7).

- The Conduct of Separation:

$$S_i = \sum_{j=1}^{N} X - X_j \quad (3)$$

Where j = 1; 2;...; N, I = 1; 2;...; Np, N is the number of distinct classes of dragonflies and Np is the number of populations of dragonflies. The individual dragonfly's current location is indicated by X, Xj by the particular group's j-th position.

- Sustaining synchronized flight activity with groups of dragonflies:

$$A_i = \frac{\sum_{j=1}^{N} V_j}{N} \quad (4)$$

Where Vj reflects the velocity of the individual dragonfly group jth

- Conduct for each person to enter each other (Cohesion):

$$C_i = \frac{\sum_{j=1}^{N} X_j}{N} - X \quad (5)$$

- Conduct in foraging:

$$F_i = X^{+} - X \quad (6)$$

Where X + represents the current position of the human dragonfly with the optimum fitness score.

- Conduct of enemy avoidance:

$$E_i = X + X^{-} \quad (7)$$

Where X- represents, with the worst health score, the present location of the actual dragonfly.

F. Economical Operation Lambda Iteration Method

The value of λ is derived from the estimation results in an iterative solution methodology with an initial approximate price that has been calculated in advance and before the value of ΔPi is accurate using Equation (8)-(11)[16].

The number of load requests PR is proportional to all generators' combined capacity, while the transmission line's power losses are ignored[16].

$$\sum_{t=1}^{n} P_i = P_R \quad (8)$$

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A requirement for the optimum distribution from the ith generator of production costs is

$$\frac{\partial Fi}{\partial Pi} = \lambda \quad (9)$$

Where λ is a multiplier of the Lagrange or

$$2a_i + b_i \mathrm{P} = \lambda \quad (10)$$

Determining the value of Pi from the equation above is:

$$Pi(k) = \frac{\lambda(k) - bi}{2ai} \quad (11)$$

The equation above can be iteratively solved. The value of λ is obtained by replacing the value of Pi in equation 7 with equation 8, resulting in the following results:

$$\text{or} \quad \sum_i^n \frac{\lambda - b_i}{2a_i} = P_R \quad (12)$$

$$\lambda = \frac{PR + \sum_i^n = i \frac{bi}{2ai}}{\sum_i^n = i \frac{bi}{2ai}} \quad (13)$$

where:

Pi = The power produced by the ITH generator (MW)

N = number of generators within the system

PR = Complete load on the system (MW)

Fi = Function of Expense

A, b = Constancy

III. Result and Discussion

The testing process of the proposed method will be performed in this study. Compared with the economical lambda iteration scheduling method, the Dragonfly Algorithm method used will be used in Figure 2.

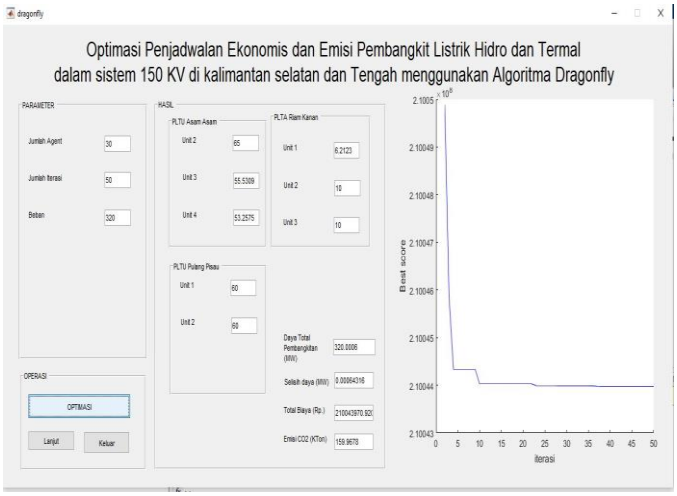

Figure 2. *Display Dragonfly Algorithm GUI in Matlab Software*

In the GIU Display, there is an Icon Parameter Number of Agents, Number of Iterations and Loads which will be used as input for optimization, the Result Icon in the Giu is the power optimization value of each of the *Asam-Asam PLTU, Pulang Pisau PLTU,* and *Riam Kanan PLTA* using Dragonfly Algorithm, The Total Power Plant Icon (MW) is the Optimization Value of the power determined by the Load on Parameters and the total of the power optimization value of each of the *Asam-Asam PLTU, Pulang Pisau PLTU and Riam Kanan PLTA*, Icon Total Cost (IDR) and Emissions CO2 is the result of the Dragonfly Algorithm, while the graph on Giu shows the iteration value of the total cost (IDR)

A. *Testing with Lambda Iteration*

Each generator unit's characteristic function is determined in the initial stage based on the average energy output to the power generated by the second-order polynomial regression. Then the function of each generator is obtained using equations 2 and 8:

PLTU Asam Unit 3, $C1=1{,}3846+2{,}55000(50)+0{,}0128(50)^2$
PLTU Asam Unit 4, $C1=0{,}6895+3{,}1445(61)-0{,}0034(61)^2$
PLTU Asam Unit 2, $C1=0{,}6155+0{,}4583(61)+0{,}0023(61)^2$
PLTU Pulpis Unit 1, $C1=4{,}8669+0{,}2975(59)+0{,}0056(60)^2$
PLTU Pulpis Unit 2, $C1=0{,}3330+0{,}9909(59)-0{,}0031(59)^2$

In the following research, the calculation method for economic planning with and without emissions is as follows:

- Enter the value of Power Demand.
- Determine the minimum and maximum requirements for generation limits
- Alpha, Beta, and Gamma are order 2 polynomial regressions obtained from a matrix using Matlab software.
- The CT consumption formula = Alpha + (Beta x Power P1) + (Gamma * Power PI^2)
- The formula for Fuel Cost Search = CT Fuel Consumption x Coal Price per Ton (Coal Price per Ton is derived from ESDM Data)

B. *Testing Dragonfly Algorithm Method*

The research consists of 3 *Asam-Asam* generator units and 2 *Pulang Pisau* generator units, checked without considering emissions and taking emissions into account. The experiment was performed in 5 phases using 320 MW of power from the generator load inputted into the Matlab program.

TABLE I
COST RESULTS COMPARISON OF THE 2 METHODS WITHOUT CONSIDERING EMISSIONS

NO	Dragonfly Algorithm	Iteration Lambda Method
1	IDR167.927.206	IDR167.969.188
2	IDR174.470.095	IDR174.513.713
3	IDR165.756.426	IDR165.797.865
4	IDR170.819.341	IDR170.862.046
5	IDR164.151.106	IDR164.192.144
Average	IDR168.624.835	IDR168.666.991

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The findings show that the total value of the cost of fuel consumption from the two strategies is not the same, based on the data in Table I. The average cost of fuel consumption is in the Dragonfly Algorithm process. After 5 measures, IDR 168,624,835, the cumulative cost of fuel consumption in the Lambda Iteration Process is From IDR 168,666,911. It can be shown that the Dragonfly Algorithm process carries out optimization. The total cost of producing consumption is IDR 41,856.

The experiment was carried out in 5 steps and used a load of 320 MW. Determined the weighting factor W1 = 1/2 and W2 = 1/2 for the test

TABLE II
COST RESULTS COMPARISON OF THE 2 METHODS BY CONSIDERING EMISSIONS

Dragonfly Algorithm		**Iteration Lambda Method**	
Fuel Consumption Costs with Emissions	**Emissions per ton**	**Fuel Consumption Costs with Emissions**	**Emissions per ton**
IDR 151.398.354	915,22	IDR 151.436.204	917,51
IDR 154.247.570	936,28	IDR 154.286.132	936,51
IDR 148.129.253	909,95	IDR 148.166.286	910,18
IDR 153.527.768	927,34	IDR 153.566.150	927,57
IDR 148.519.146	898,22	IDR 148.556.276	898,45
IDR 151.164.418	917,402	IDR 151.202.210	918,044

It is understood that the cost of fuel consumption from the two strategies is not the same, based on the data in Table II. Next, a 5-step experiment was performed, it was known that IDR151,164,418 per day with the emission of 917.40 tons per day was the average cost of fuel consumption produced by the Dragonfly Algorithm process. Meanwhile, with emission of 918,044 tonnes per day, the average cost produced by the Lambda Iteration method is IDR 151,202,209 per day. The findings show that the Dragonfly Algorithm approach will optimize the fuel consumption cost of IDR 37,791 and emission of 0.641 tons from the 2 forms of tests. The research's job restrictions are:

- To minimize the facility's running costs. The study uses heat rate equation data in thermal generators optimized for the performance of the plant.
- Emissions take only CO2 gas into account,
- Generating conditions are called natural conditions and are not taken into consideration when there is a system malfunction.

IV. CONCLUSION

The following findings are derived based on the outcomes of simulation and research in the study. For a 5-step trial, the average cost of fuel consumption in research without considering the Dragonfly Algorithm process's pollution is IDR 168.624.835. In contrast, the cumulative cost of fuel consumption in the Lambda Iteration Process is IDR 168.666.911. It can be shown that with an average of IDR 41.856, the Dragonfly Algorithm approach optimizes the cost of consumption generation. The average cost of fuel consumption provided by the Dragonfly Algorithm method is IDR 151,164,418 per day with an emission of 917.40 tonnes per day while measuring by considering the Dragonfly emission Algorithm method with a 5-step experiment. Meanwhile, with an emission of 918,044 tonnes per day, the average cost of fuel consumption produced by the Lambda Iteration system is IDR 151,202,209 per day. The findings show that the Dragonfly Algorithm approach will optimize the fuel consumption cost of IDR 37,791 and emission of 0.641 tons from the 2 forms of tests. The further research development, emission gases such as sulfur dioxide (SO2), nitrogen oxides (NOx) can be added to apply economic optimization and emissions in thermal power plants. You can combine or compare the dragonfly algorithm method with other artificial intelligence optimization methods to use economic and emission optimization in thermal power plants for research development.

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Real-Time Telemetry Data Monitoring System on Soil Movement of Railway Tracks

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Abstract— A telemetry data monitoring system is needed to monitor land shifting. This system consists of an ATMega328 microcontroller, a Linear Variable Differential Transformer (LVDT) and a rheostat, an accelerometer sensor, a rain gauge tipping bucket, and the HC-12 radio telemetry module. Normally, the LVDT reads the land shift in the 0-20 mm range, the Rheostat is capable of shifting up to 66 mm, the accelerometer sensor reads less than 20 deg of data, and the rain gauge tipping bucket sensor creates the amount of rainfall below 50 mm/hour which is then sending real-time data regularly for 24 hours. The buzzer installed in the field will sound if the LVDT reads land shift more than 30 mm, Rheostat more than 51 mm, and the accelerometer sensor reads data more than 45 deg; also, the rain gauge tipping bucket sensor reads more than 70 mm/hour. This test creates parameter data. So that shift data can be monitored.

Keywords— Monitoring, Telemetry, Real-Time, Land Shift.

I. INTRODUCTION

According to the BNBP Performance Report in 2019, the landslide disaster is the fourth most disaster in Indonesia [1]. Conditions such as slopes, volcanic activity, and even weathering can cause soil movement [2]. Soil movement can easily cause landslides [3]. According to *Azkin*, landslides' leading cause is the gravitational force that affects steep slopes such as soil movement and excess water due to high rainfall [4]. High rain causes changes in soil pressure, leading to structural changes and collapse [3].

On April 6th, 2014, the *Bandung-Malang Malabar* Train had an accident [5]. The train travels 20 meters while crossing unstable land [5]. Based on information from the BPBD of the *Tasikmalaya* Regency, three points of vulnerable areas, namely *Ciawi*, *Kadipaten*, and *Manonjaya*, often experience moderate to high soil movements [5].

Previous research about landslide early warning systems uses the same parameters, consisting of angular displacement, ground movement, and rainfall [6]. But the data transmission method uses a GSM module with the SMS feature that requires a fee for text delivery, and the GSM module depends on the internet [6]. The solve this research's weakness, data transmission uses the HC-12 module with the long-distance wireless transmission with a working FSK frequency of 433.3-473.0 MHz, up to 100 communication channels [7].

In areas prone to landslides, information and evacuation measures easily accessible to the public are needed. The Linear Variable Differential Transformer (LVDT) sensor can be used to measure the displacement of an object [8] [9] [10], which can be developed into a ground motion measurement [11]. Thus, a long-distance communication system is needed so that ground movement can be monitored in real-time. This system uses a telemetry system that transmits data with FSK modulation via analog radio [9]. The radio output then produces monitoring data, which is monitored continuously.

The telemetry system was created to remotely transducers and sensors that can detect ground movement at any time in vulnerable areas on the railroad.

II. RESEARCH METHODOLOGY

The experimental remote measurement system for soil displacement, soil slope, and rainfall determines the characteristics of the potential landslide warning system. References data were obtained at Resort 4.21 *Gundih* KM 60 + 7/8 and KM 67 + 0/1 on March 21st, 2020. This data is used as a reference for designing a telemetry system to warn of potential landslides and ground movement. The telemetry system design model has been tested in the Madiun PPI station laboratory from July to September 2020. A 10-meter displacement detector is installed, and the first sensor is installed 2.5 meters from the axle rail.

A. Method of Initial Testing on the System

Before the system is used to take data experiments, the system is tested to match the expected data results. The test was carried out in the Electronics Lab using supporting devices, namely, a digital multimeter and variac.

1) LVDT Sensor Tests: The LVDT sensor circuit is connected to a variac. For the maximum Shift to be known, the LVDT sensor's core is shifted to the right, then to the left until it reaches the maximum voltage. The voltage value is observed on a digital multimeter to determine the voltage linearity with the shift distance.

2) Rheostat Tests: The rheostat test uses the variac as the source voltage, and the Rheostat connects to a digital multimeter. Then, make observations on the resistance to determine the minimum and maximum limits of the Rheostat working.

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3) Accelerometer Sensor Tests: Accelerometer sensor testing is done by looking at the sensor output value for ground movement. From the reading of the sensor value, it can be known the set point on the sensor when conditions are perpendicular. So, value changes can be processed when the sensor is moved.

4) Tipping Bucket type Rain Gauge Sensor Tests: The sensor test is carried out using the calibration method. The calibration method is used to determine the reliability of the sensor.

5) Telemetry Radio Module Tests: The HC-12 telemetry module test by connecting the transmitter and receiver. The connection test is done by connecting the appropriate channel address. After the channel match, the module is ready for use.

B. Method of Collecting Data

Reference data for telemetry system design for landslide-prone area data were obtained from the DAOP 4 line unit and the DAOP 4 Semarang area bridge office. Then at the Central Statistics Agency (BPS) Purwodadi area, rainfall data were obtained. And 4.21 Gundih data from the entire resort area and cross-section images obtained through observations at the 4.21 Gundih Resort Line and Bridge Unit.

C. Method of Processing Data

After the sensor is tested, continue to test the landslide warning telemetry system's potential using reference data to measure the LVDT sensor, Rheostat, accelerometer sensor, and rain gauge tipping bucket sensor. This research includes calibration testing, ADC (analog to digital converter) conversion, and sensitivity.

Calibration testing is carried out on the acceleration sensor, rain gauge tipping bucket sensor, LVDT, and rheostats. The test is used to determine the system output value's closeness and the standard measuring instrument to understand system reliability [11].

The ADC conversion test is used for the rheostat and LVDT sensors. Voltage output data is analog data that can be converted into equations and processed as follows Equation (1) on a microcontroller [14].

$$BIT = 2^n \quad (1)$$

The ATMega 328p microcontroller support 10 bit ADC systems, which have a binary value of 2^{10} based on Equation (2).

$$Land\text{-}shift = (ADC+1) / 102{,}3 \quad (2)$$

Where:
ADC = source voltage on the sensor
102,3 = binary value for 10 bit
n = the number of bits

The LVDT and Rheostat sensors' sensitivity test in this research was determined based on the transfer function of the output voltage curve to the displacement distance. The transfer function is taken from the LVDT voltage curve and graphs the most linear data of the Rheostat relative to the distance in the linear direction. In this research, Microsoft Excel software can be used for calculations to determine the transfer function and sensor sensitivity [13]. The linearity of straight-line equations can also be seen from linear correlation (R2) [13], and the straight line equation used is the regression curve equation. The straighter the curve, the higher the linearity [14] based on Equation (3).

$$y = a + bx \text{ (linier)}$$
$$y = ae^{bx} \text{ (exponential)} \quad (3)$$

Information:

$b = \frac{\sum x_i y_i - (\sum x_i)(\sum y_i)/n}{\sum x_i^2 - (\sum x_i)^2/n} = \frac{n\sum x_i y_i - \sum x_i \sum y_i}{n\sum x_i^2 - (\sum x_i)^2}$

$a = \bar{y} - b\bar{x}$

y = land shift (mm)

x = LVDT sensor and rheostat voltage (mV)

After knowing the shape of the approximate curve, we can determine the constant of the Equation. If the value of x is known, the regression line $y = a + bx$ is used to estimate the value of y.

D. Data Analysis

Data analysis includes system design using hardware and software. The hardware consists of an ATMega 328p microcontroller, an LVDT sensor, a rheostat, a tipping bucket-type rainfall sensor, and an ADXL345 accelerometer sensor. Meanwhile, the software consists of Microsoft Visual Studio, Arduino IDE C Language, AVR Khazama, and XAMPP programmers. The landslide warning telemetry system uses the HC_12 wireless serial port communication module, USBASP as the transistor-transistor logic (TTL) serial sender, Microsoft Visual Studio software as a computer viewer, and phpMyAdmin as the database processor.

1) Soil Movement Measurement Design: In this research, ground motion measurement used a transducer rheostat, LVDT sensor, accelerometer, and tipping bucket type rainfall. Rheostats are used to determine the vertical movement of the ground on the surface. The Rheostat is mounted in a transverse direction, and the LVDT sensors are mounted longitudinally as far as 10 meters each. Both attachments are attached to nylon strings to spread them, which are attached by rods as in Figure 1.

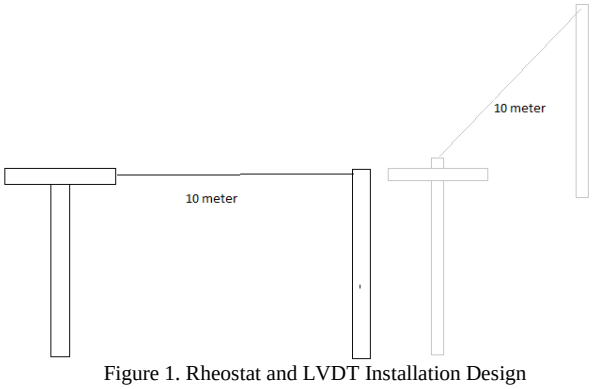

Figure 1. Rheostat and LVDT Installation Design

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On the accelerometer sensor that is mounted in the ground. This installation aims to determine the movement of the soil in the ground. Meanwhile, the tipping bucket type rainfall sensor is installed above the ground. Installation of a rainfall sensor is intended to determine the rainfall capacity experienced in the area.

2) *Hardware Circuit Design (Hardware):* The system's hardware includes an electronic circuit in the form of a power source as a power source and a minimum system circuit as a data processing center. The results of the circuit image route are shown in Figure 2.

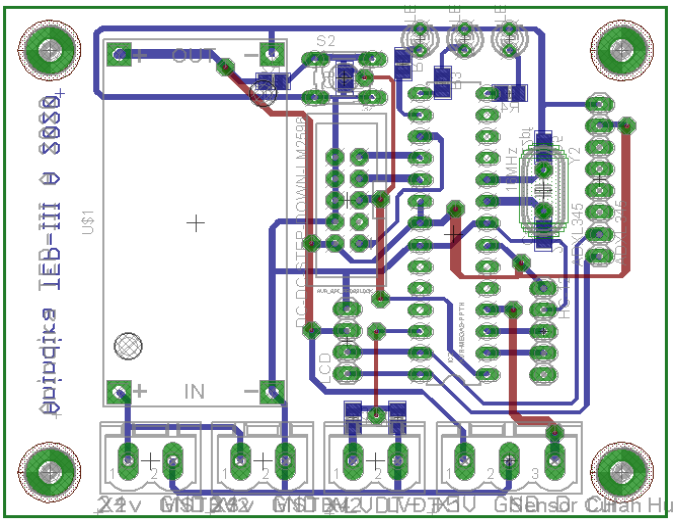

Figure 2. Circuit Board Design

3) *Software Design:* Programming in this tool is divided into two parts: using the Arduino IDE software to program each sensor and using Microsoft Visual Studio software to create a Graphical User Interface (GUI) on a PC. In the telemetry system, landslide potential warnings have a flow based on the flowchart description shown in Figure 3. The ATMega 328p minimum system initialization program consists of initializing the ADC, LCD, serial/ USART, and timer. The main program is a program that is used as a sub-routine to read shift data to send data and determine potential landslide warning signals. The process of sending data and determining potential landslide warning signals. The process of sending data is divided into three parts, namely, sending data to check the connection, sending routine data that will be sent every 1 minute, and sending data when an event occurs in 1 second. This means that the microcontroller system will instruct the HC-12 wireless communication module to send regular data continuously. So, the data that the user is known is always updated. Figure 4 shows an LVDT sensor, accelerometer, rain gauge, and Rheostat as inputs in the block diagram. The LVDT sensor is used to detect the vertical ground shear distance, and the Rheostat is used to detect the horizontal sheer distance. The ATMega 328p microcontroller runs this process. The process carried out is receiving data input from the sensor then process the sensor data. If there is a potentially dangerous "High" warning indicator, then the bell will light. If the level reaches "moderate" and "low" danger status, only a warning will appear on the interface.

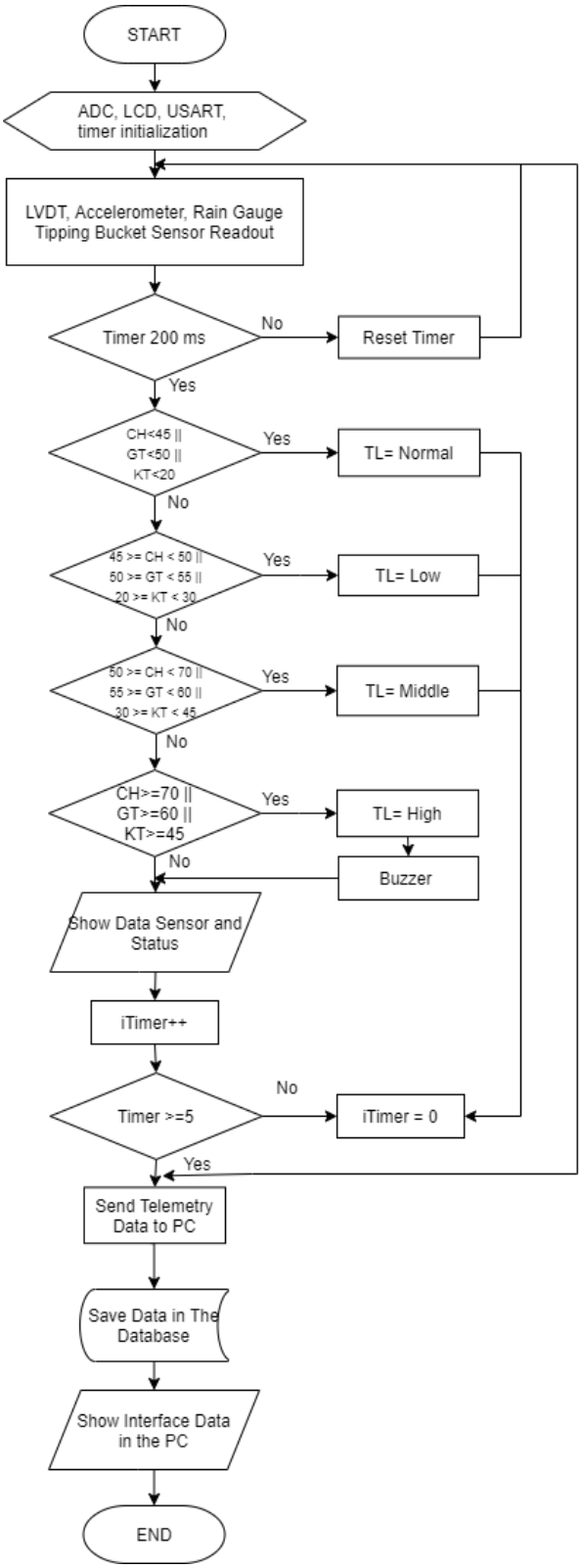

Figure 3. Flowchart Program

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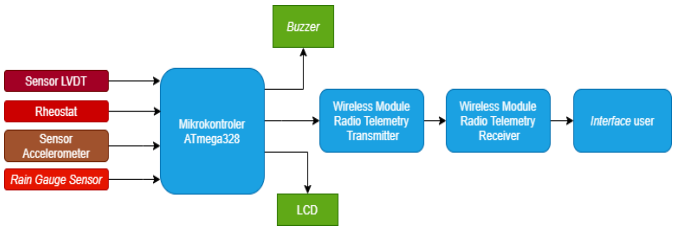


Figure 4. Telemetry System Block Diagram

At the same time, always updated data will be displayed in the LCD field and user interface. At the output end, the data is sent wirelessly via the HC-12 wireless serial port communication module, and then the data will be monitored on the user interface. Data transmission has been tested with one of the sensors to the test data transmission for 24 hours.

III. Result and Discussion

The hardware that has been made uses an ATMega 328p microcontroller, a rainfall sensor, an LVDT sensor, and an ADXL345 accelerometer. This system has supplied by 24 Volt AC power is shown in the following figure 5.

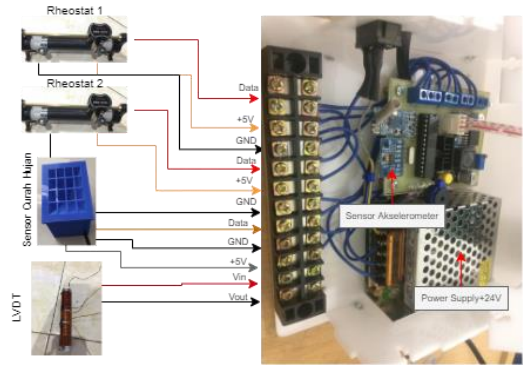


Figure 5. Circuit of Land shift Detection System

A. *LVDT Sensor Tests Results and Rheostat*

The LVDT sensor and Rheostat are applied at the location of the Indonesian Railway Polytechnic Laboratory. Testing of the LVDT sensor and Rheostat is done by connecting the circuit to the 5 Volt AC variac source. The output voltage in the form of secondary voltage is measured using a digital multimeter. The test is carried out at a distance of 0-41 mm with a shift to the right (positive) and left (negative) each 20mm. The measurement results in Table I (a) and (b).

TABLE I
TEST RESULTS OF LVDT SENSOR AND RHEOSTAT

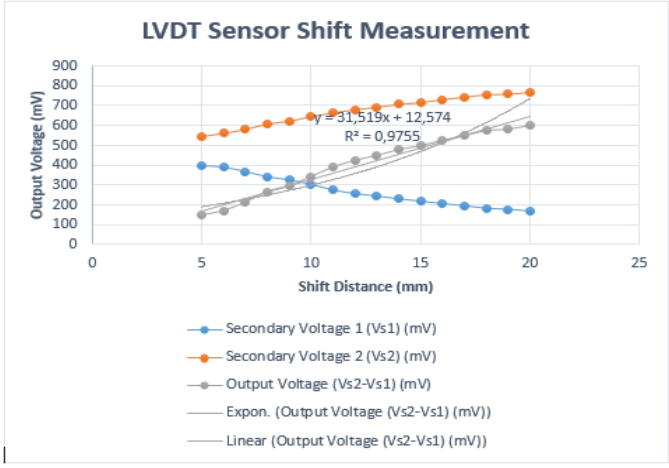
LVDT Sensor		
Shift Range (mm)	**Readable Shift (mm)**	**%Error**
1	2	0%
2	2	0%
3	3	0%
4	4	0%
5	5	0%
6	6	0%
7	7	0%
8	8	0%
9	9	0%
10	10	0%

(a)

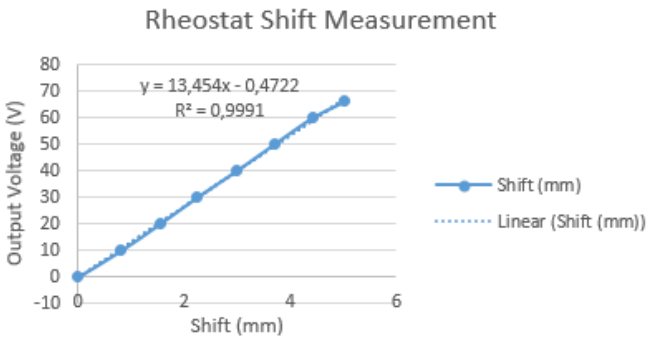
Rheostat			
Readable Shift			
Rheostat 1	**%Error**	**Rheostat 2**	**%Error**
0	0%	0	0%
9	10%	10	0%
20	20%	19	5%
30	0%	29	3,3%
41	2,5%	39	2,5%
50	0%	48	4%

(b)

Based on the results of using the LVDT and Rheostat sensors, after a 5 mm drop, the error percentage is getting smaller, even reaching 0%. Besides, after using the LVDT sensor and Rheostat 5 times, the error percentage is an average of 1.97%. This indicates that the LVDT sensor and Rheostat are accurate. Figure 6 shows the results of using the accuracy.



(a)



(b)

Figure 6. Graph LVDT Sensor Rest Results (a) and Rheostat (b)

The movement distance and output voltage are linear. Both are by the R-squared value, which results in a value of 0.9755 close to the value 1. The relationship between movement distance and the output voltage is linear. Based on the Equation obtained, it can be seen that the R-squared value obtained is 0.9991. The R-squared value is close to the value 1.

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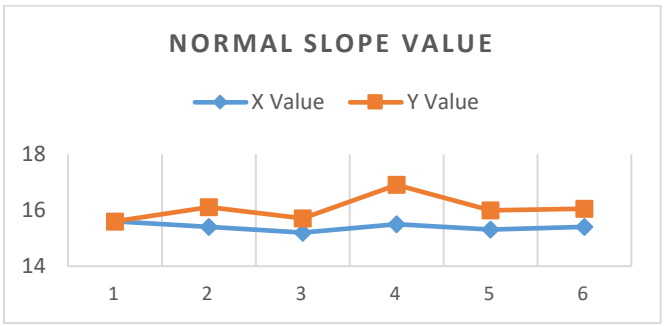
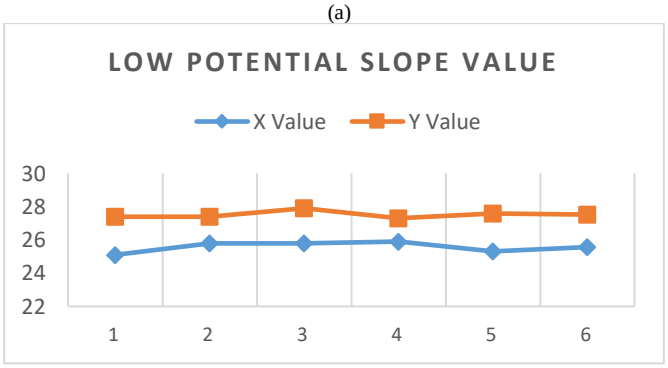
B. *Accelerometer Sensor Tests Results*

Accelerometer sensor testing is one by reading the sensor output value. Sensor accelerometer read the output value when the sensor is in a certain position so that the average range of the sensor readings to the Shift can be seen. The accelerometer sensor is made with a determined tolerance value when the slope value is <20 deg when in normal conditions. When the sensor at a slope of 20-30 deg indicates a low landslide potential, the LCD and software display a low hazard notification. The sensor at a slope of 30-45 deg indicates a moderate landslide potential, the LCD and software display a moderate hazard notification. Meanwhile, when the tool is at a slope of >45 deg, the buzzer lights up, software, and LCD high hazard notification.

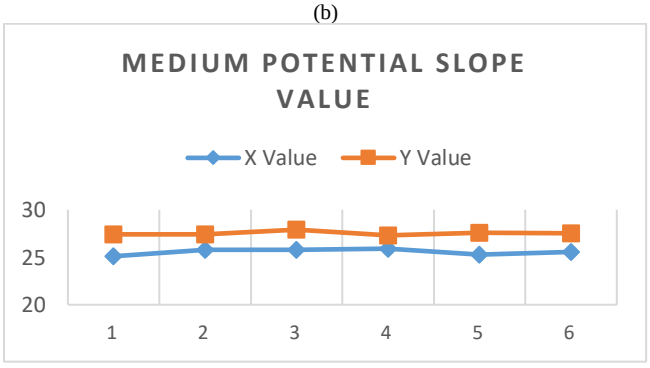
Figure 7 (a), (b), (c), and (d) show the acceleration sensor testing based on the ground moving forward, backward, upright, left, and right, which produces the following data.



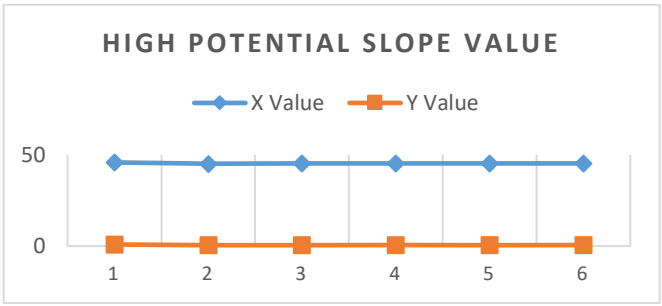
(a)



(b)



(c)



(d)

Figure 7. Slope Graphics

Based on the results in Figure 7 (a), (b), (c), and (d), it shows that when the sensor moves back and forth on the test soil, the mean values of X are 2.08 and 1.86, and the Y values were 15.44 and 15.28, respectively. When the sensor moves left and right, under normal conditions, the mean slope of X is 15.22 and 15.4 and Y is 3.02 and 0.66. When the sensor is installed vertically, the slope values of X and Y are 0.76 and 2.48, respectively.

C. *Tipping Bucket Rain Gauge Sensor Tests Results*

Tipping bucket type of rainfall sensor tests is carried out by conducting simulations in the field by dripping simulated rain-water within 2 hours to determine which conditions match the expected criteria. So that, after knowing the sensor's ability to accommodate rain, a calibration is carried out to provide a setpoint value.

The results of sensor testing based on rainfall intensity are based on three criteria, namely: 1) total rainfall less than 50 mm, 2) total rainfall 50 mm-70 mm, 3) total rainfall exceeding 70 mm. The test results are described in Table II.

TABLE II
POTENTIALS OF SOME CONVERSION OF RADIONUKLIDA

No.	Time (minutes)	Total Rainfall / mm	Shift (mm)
1.	0	3	1
2.	1	2	2
3.	2	0	3
4.	3	1	4
5.	4	2	5
6.	5	3	6
7.	6	2	7
8.	7	5	8
9.	8	1	9
10.	9	3	10
11.	10	4	11
12.	59	1	60

D. *Radio Telemetry Test Results in Observation of Delivery Distance*

The radio telemetry testing results are to observe the transmission distance based on the distance and standards that do not exceed the maximum limit in meters. The explanation of the test results is described in Figure 8 as follows. Figure 8 shows that the HC-12 communication module has successfully transmitted data up to a distance of 600 m. This is following the technical specifications on the HC-12 module.

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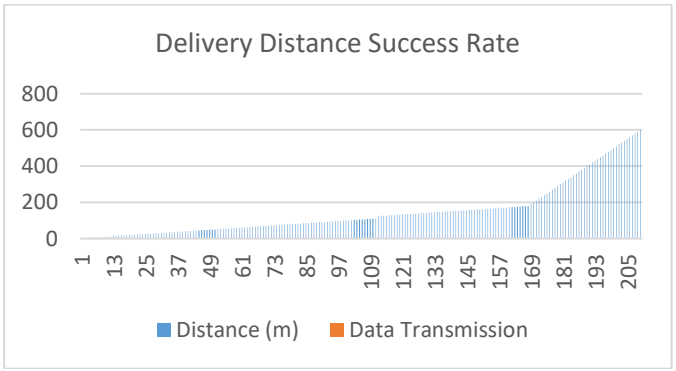

Figure 8. Delivery Success Rate Graphic

E. *Radio Telemetry Test Results in Observation of Delivery Distance*

The Telemetry System circuit in Figure 9 represents sending data is carried out using the HC-12 wireless serial port communication module displayed through the Graphical User Interface (GUI) in Microsoft Visual Studio. Then, the data is stored in the phpMyAdmin database.

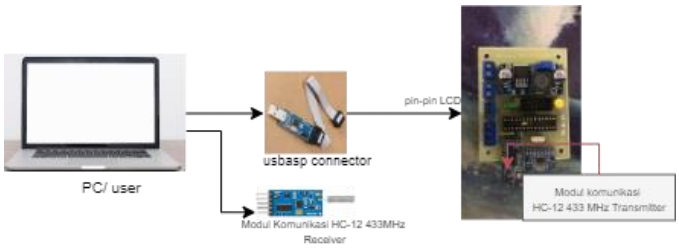

Figure 9. Circuit of Telemetry System

In this system, Microsoft Visual Studio is used to create a GUI. The script used is C # Visual Studio. The GUI displays data about rainfall (mm / hour), the Shift of the x-axis and y-axis (degrees), and ground movement (mm). The interface application test results produce the following simulation, and database tables are shown in Figures 10 and 11.

Based on Figures 10 and 11, the test is carried out by connecting the appropriate COM7 to the radio transmitter and receiver module. Then the application is connected to the database via the phpMyAdmin web.

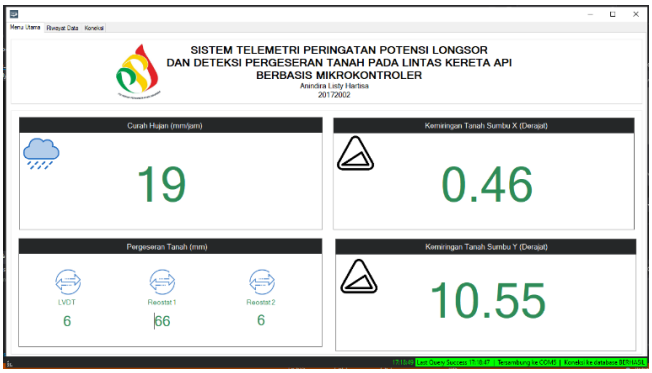

Figure 10. Application Interface

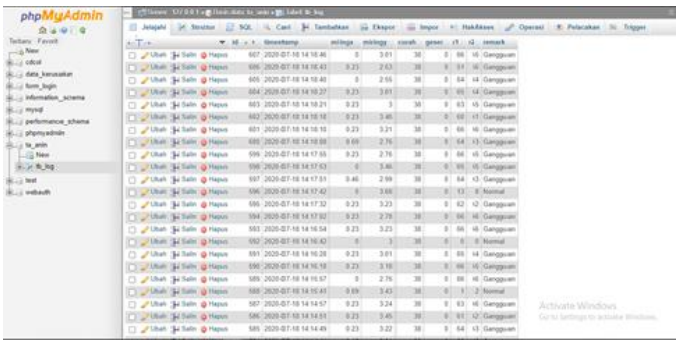

Figure 11. Database Testing Results

F. *Overall Test Results*

On the PPI Madiun Laboratory's left side, testing the entire telemetry data forecasting system is carried out. The ground motion detector installation distance is 10 meters. The LVDT sensor installation is placed from the axle rail to the LVDT sensor along 2.5 meters. Meanwhile, the LVDT sensors, rheostat 1, and rheostat 2 are installed with a distance of 3.3 meters each.

Based on the results of the tests carried out, the resulting data in a position where the x and y coordinate values are lower than 20 deg have normal conditions, while the data represented by a position where the x and y coordinate values are higher than 21 deg experience interference. The value of rainfall data (CH) under normal conditions is less than 45 deg. Meanwhile, the CH value is greater than 46 deg, thus indicating a potential disturbance. The Rheostat and LVDT sensors' movement is less than 50 mm, and it can be said that the movement is normal, and the movement of the sensor that is greater than 51 mm can be said to have the potential for interference. The results of testing the entire ground motion detector are described in Table III.

TABLE III
OVERALL TOOL TEST RESULTS

5' to	Date	Sb X (°)	Sb Y (°)	CH (mm / min)	GT (mm)	Rh1 (mm)	Rh2 (mm)	Info
1	07-18-2020 / 14:18	0	3.46	38	0	65	65	Distraction
2	07-18-2020 / 14:13	0.23	3.24	38	0	63	66	Distraction
3	18-07-2020 / 14: 09	0.46	2.96	29	0	59	63	Distraction
4	18-07-2020 / 14: 04	0	3.24	18	0	11	3	Normal
5	18-07-2020 / 13: 59	0	2.77	34	0	48	53	Distraction
6	18-07-2020 / 13: 54	0	3.01	29	0	1	10	Normal
7	07-18-2020 / 13: 49	5.92	35.14	0	15	65	43	Distraction

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IV. CONCLUSION

To view monitoring data in anticipation of potential landslides, it can conclude that the linearity coefficient of the LVDT sensor-shift distance of 0.975 and the rheostat shift distance of 0.9991. The accelerometer sensor's tilt angle calibration is moved forward and back with a high potential of landslides on average x, y (45.62, 45.46) degrees. Rainfall capacity calibration with a standard range of 0-45 mm, a middle range of 50-69 mm, and a high range of more than 70 mm. the maximum transmission distance of the HC-12 communication module is 600 m. Telemetry data transmission is 99.9% successful, but 1 time has a 1-minute delay.

The monitoring data through an interface application connected to the database can regularly send data. Then, reports can be appropriately delivered according to the level of risk of potential landslide disasters. This research needs to be further developed. Development can be done by widening the measurement range of the LVDT sensor. Radio telemetry coverage can also be extended, and the underground detection can be re-tested with water absorption parameters.

V. ACKNOWLEDGMENT

The author is particularly grateful to the Director of PPI Madiun, Amirulloh, who has provided data access so that the author can carry out this research properly.

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Early Detection of Overheating in Motorcycle Disc Brakes Based on Arduino

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Abstract— The braking system is very important on a motorcycle. The primary function of the braking system is to slow down and even stop the motorcycle. The braking system using disc brakes on motorcycles is commonly used today, especially on automatic transmission motorcycles. One of the disadvantages of disc brakes is the heat caused by the disc's friction with the brake pads if you apply continuous braking. This continuous braking is often done by a motor rider when crossing downhill roads in mountainous areas. Excessive heat in the disc brakes causes the brake fluid to boil, resulting in air bubbles resulting in braking failure. The failure of the braking system on a motorcycle is hazardous for the rider and others. The experimental method detects braking system failure by catching the disc brake's temperature with a touchless temperature sensor, MLX90614. Temperature detection is processed with Arduino as a control, and the temperature is displayed on the LCD. If the disc brake temperature is above 200ºC, a buzzer is activated as a warning to the driver. The test results show that the system can display a temperature reading on the LCD lower than the thermometer gun, with the most inferior reading difference of 0.2ºC and the highest 0.4ºC. The system can also display notifications to users on disc brake temperatures above 200ºC, namely at temperatures of 211.1ºC, 224.3ºC, and 237.5ºC, which were achieved at 200, 225, and 250 seconds.

Keywords: Early Detection, Disc Brake, MLX90614, Temperature Sensor, Arduino.

I. INTRODUCTION

The rapid development of the automotive industry and intense competition among automotive manufacturers have made automotive manufacturers competing to produce faster than before. Therefore, we need a better braking system too. The braking system is a virtual device in a vehicle, especially a motorcycle. The primary function of the braking system is to slow down the vehicle and even stop it. The speed of the vehicle can be appropriately controlled. The principle of the braking system is to convert kinetic energy into heat energy [1]. Heat energy in disc brakes is generated by the friction between the metal disc and the brake pads when it comes into contact during braking.

The brake system with disc brakes is widely used on motorcycles that use automatic transmissions. This type of motorcycle relies entirely on disc brakes to control the speed of the motorcycle. Automatic motorbikes are motorbikes that are in great demand by most people in Indonesia because of their practicality. Automatic motorbikes have been chosen because many riders find them easier and more comfortable to operate.

One of the causes of the many accidents on this automatic transmission motorcycle is the braking system's malfunction. Braking failure often occurs in mountainous locations where there are many downhill roads. When braking is done, friction between the iron disc and the brake pads, causing heat. Also, the lack of knowledge of motorcyclists in continuously braking disc brakes may result in brake failure. Because in automatic transmission motorbikes, there is no engine brake plus the burden on the vehicle and the rider that must be borne by the disc brakes, over a long period, there will be overheating of the disc brakes. Overheating the disc brakes will result in 1) The caliper's seal expands, and the caliper piston jams. 2) The disc brake disc that is too hot will expand and make the surface slippery so that the brake pads cannot grip the disc surface [2]. The disc brake condition that is too hot and constantly rubbing against the brake lining will transfer heat to the brake fluid through the piston, causing the brake fluid to boil and air bubbles form, causing false air and causing the disc brake to malfunction [3]. This braking system's failure is hazardous and can have fatal consequences for the rider and others. Peneliti melakukan kajian berdasarkan

Arduino is known as a micro controlling device that is well known by many hardware developers. Arduino's open-source nature that can be modified easily, supported by a large library of programs, integrated modules, and a relatively low price, has now become a favorite in making various electronics and robotics projects. At this time Arduino is widely used as a control device in various fields including robotics [4]-[9], agriculture [10]-[13], and the automotive sector [14]-[17]. The researcher also conducted a study to support the results of the discussion of this paper [18]19].

Based on the foregoing is necessary to make modifications to the motorcycle disc brake braking system by adding an overheat detection device using Arduino. The function to provide early warning in the form of a buzzer sound to motorcyclists before the braking system failure occurs, which can be fatal to the rider and other people.

II. RESEARCH METHODOLOGY

This study was designed using an experimental research model through the following stages:

- Problem Identification is carried out by conducting a literature study to determine the core of this research.

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- Model design is critical in realizing the real system. The purpose of designing the model is to plan the design of hardware and software.
- Model testing of the model that has been designed will be carried out. The purpose of this test is to ascertain whether the model that has been designed is following what is desired and to anticipate any errors that may occur in its implementation.
- Conclusions are drawn based on the analysis or interpretation of the data from the model testing that has been done.

Software design is the definition of functional requirements and preparation for the design of a system. System design can be defined as depicting, planning, and sketching or arranging several separate elements into a complete and functional unit, including system block diagrams, system flowcharts, user interface design, and database design.

A microcontroller-based system cannot operate based only on the design of hardware components but also requires a sequence of instructions known as a program. Designing software based on a microcontroller system must be following the working principles of the system being built. Flowcharts are generally used to describe the sequence of detailed instructions and the relationship between one instruction and another. The overheating detection workflow diagram for motorcycle disc brakes shown in Figure 1.

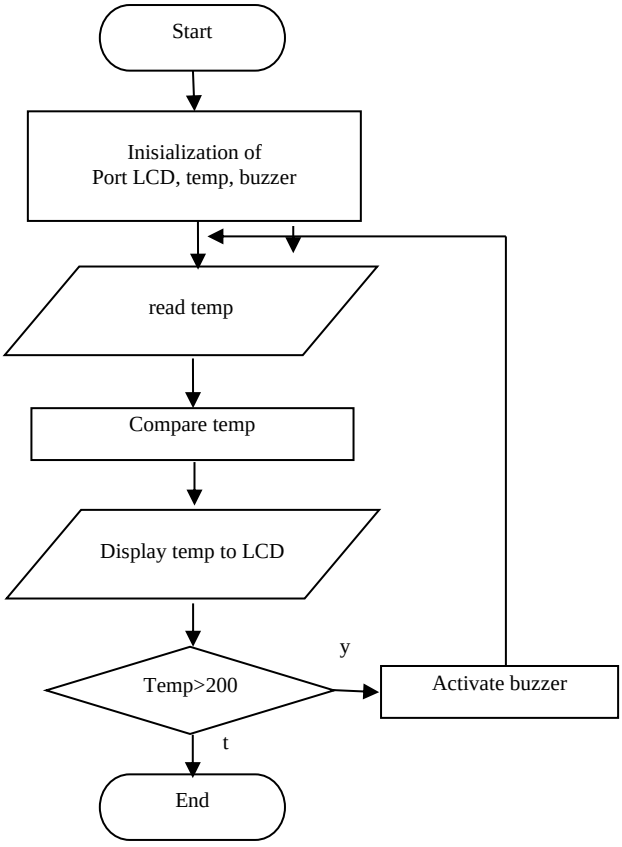

Figure 1. Workflow diagram

After the hardware and software design stages are complete, it is continued with the implementation stage. This implementation stage is the stage of translating the results of designing hardware and software. Next, the testing phase is carried out, which aims to determine the performance of the system being built.

A. Disk Brake Components

Disc brake systems are more widely used than drum brakes. This is because disc brakes have many advantages compared to drum brakes. Disc brakes are used on the front wheels only or both wheels. The disc brake components are slightly different from the drum brake components, but they still have the same function: to slow down or stop the motorbike. The disc brake braking system consists of several components: reservoir tank, brake lever, brake pump, brake hose, brake caliper, piston, piston seal, brake pads, and discs, as shown in Figure. 2.

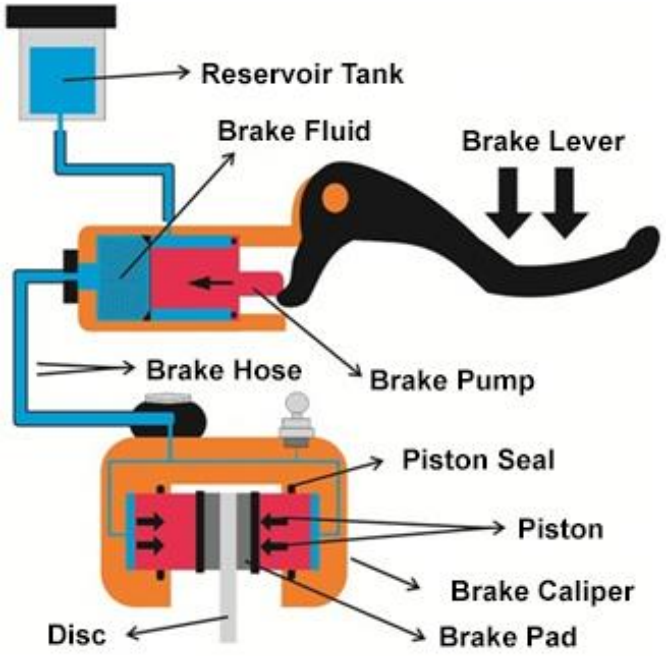

Figure 2. The components of a disc brake on a motorcycle.

The working principle of disc brakes is that when the brake lever is pressed, the pump will press the brake fluid in the reservoir tank so that pressure is passed through the brake hose to the brake caliper. Inside the brake caliper, there is a piston where there is caliper pressure. This piston will move outwards, pushing the brake pads and friction between the brake pads and the disc, thereby reducing the vehicle speed.

This research measures the heat temperature at the source of the heat, namely the disc. Kinetic energy is converted into heat energy when the disc rubs against the brake lining. If you apply continuous braking, the disc will become very hot even until the disc burns, as shown in Figure 3. This overheating condition can cause several problems,

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which are considered the cause of the disc brake malfunction described above.

Some automatic transmission motorcycles adopt disc brakes only on the front wheels, while the rear wheels adopt drum brakes. The disc brake at the front wheel position can be seen as in Figure 4. In comparison, other brands adopt disc brakes on both wheels. The position of the rear disc brake can be seen in Figure 5.

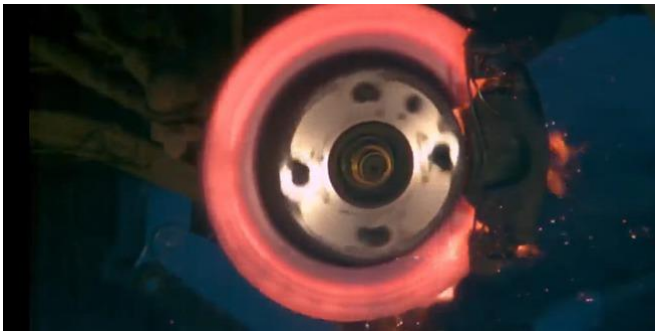

Figure 3. The disc's burning condition.

Figure 4. Disc brake in front-wheel position.

Figure 5. Disc brake in rear wheel position.

In operation, disc brakes require brake fluid to provide hydraulic pressure to the brake calipers so that they can push the piston. When the piston is pushed out, the brake pads are automatically pushed towards the disc, causing friction. The brake fluid used in this study is the DOT-3 type, as shown in Figure 6.

This type of brake fluid was chosen because it is the type of brake fluid most commonly used by motorcyclists. This brake fluid has a dry boiling point of 205^{o} Celsius, the lowest among other brake fluid types such as DOT-4 and DOT-5 [20].

Figure 6. DOT-3 brake fluid.

B. Sensor Module MLX90614

Overheating detection of disc brakes requires a heat-sensing sensor. Due to the disc condition that is always rotating or in a situation that is still in motion, a heat sensor is needed, requiring direct contact with the heat source. The sensor used must be a sensor that can read the heat range below or above the DOT-3 brake fluid's boiling point. Based on this, a sensor that suits the conditions mentioned above is selected, namely the MLX90614 sensor.

The MLX90614 sensor is a non-contact infrared temperature sensor with high accuracy. This sensor operates in a voltage range of 3.6 - 5 Volts DC. The measured object's temperature ranges from -70^{o} C to 382.2^{o} C with an accuracy level of 0.02^{o}C. Measuring distance from the object 2 - 5 cm according to the page [21]. This sensor is often used in the industrial world to measure moving objects such as rotating shafts in electric motors. Due to its high accuracy and precision, this sensor can also be used in various commercial applications.

Figure 7. MLX90614 temperature sensor.

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Several studies that measure the accuracy of the MLX90614 sensor based on a distance from 1 - 5 cm have reported that the measured value on the sensor is smaller than the mercury thermometer with a range of 4.4^{o} C at 1 cm and 8.64^{o} C at a distance of 5 cm when the object temperature indicates 50^{o}C according to the mercury thermometer [22]. As an illustration of the MLX90614 non-contact temperature sensor, as in Figure 7.

C. Arduino Uno

The Arduino Uno, which is used as a controller in this study, operates at a voltage of 5 volts DC, the recommended input voltage is 7-12 volts DC, but the input voltage limit that can be tolerated is between 6-20 volts DC, the Atmega328P microcontroller, 14 digital I/O pins available, six pins PWM, 6 pins Analog input, with each pin having a current of 20mA. The Arduino Uno has a clock speed of 16MHz and has 32 KB of flash memory, 2 KB of SRAM, and 1 KB of EEPROM. This Arduino Uno was chosen because the motorbike has a working voltage of 12 - 13.6 volts DC, so it is still compatible when used as an Arduino Uno input voltage. As an illustration of the Arduino Uno controller board, it can be seen in Figure 8.

Figure 8. Arduino Uno controller board.

D. LCD 16x2 Module

A data display module is needed to display research data from the Arduino controller board independently, namely a 16x2 LCD (Liquid Crystal Display). This module uses liquid crystal material to display data in the form of numbers, letters, and images. This module is easy to find in everyday life, for example, on game bots, calculators, and even television. This 16x2 LCD consists of 16 columns and two rows, is equipped with backlight lamps, has 192 characters, can be addressed with 4 bits or 8 bits, and a programmed character generator. An illustration of this 16x2 LCD can be seen in Figure 9.

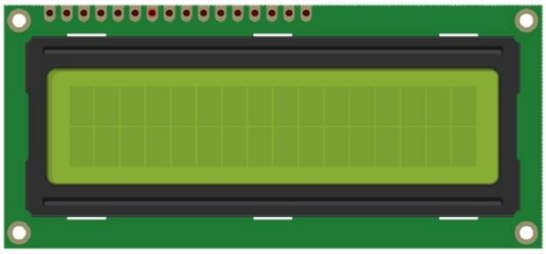

Figure 9. LCD 16x2 module.

The 16x2 LCD module is the most comfortable medium for observing the display of control results from the Arduino board because it produces many good character displays. The 16x2 LCD can output 32 characters at a time consisting of 16 characters in the first and second lines.

E. I2C (Inter-Integrated Circuit) Module

In general, this 16x2 LCD has 16 control pins for operation. This is, of course, very wasteful using Arduino pins. Therefore it is necessary to add a special module to control this 16x2 LCD so that it can be controlled via the I2C (Inter-Integrated Circuit) line using this I2C module. The 16x2 LCD can be controlled via just two pins, namely SDA (Serial Data) and SCL (Serial Clock), to save Arduino pins' use. This I2C module is a two-way serial communication standard specifically designed to use two separate channels to send and receive data. The I2C system carries information from the I2C to the controller via SDA and SCL channels. The device connected to this I2C module can be operated as a master or slave. It is called the master because it initiates a data transfer on the I2C bus by forming a start signal and ending data transfer by forming a stop signal and generating a clock signal. Meanwhile, it is called a slave because the device is the device the master is pointing at. An illustration of the I2C module can be seen in Figure 10.

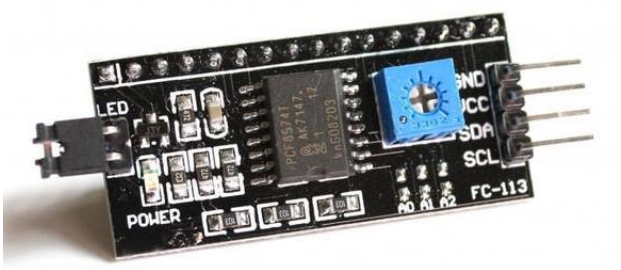

Figure 10. I2C LCD *interface.*

F. Buzzer

The buzzer is a component that can emit sound vibrations in the form of sound waves that can be heard by humans. The basic principle of the buzzer is to convert electrical signals into sound vibrations. In the direction, it resembles a loudspeaker but has a more straightforward function. Buzzer used in everyday life is generally used as an alarm. There are two types of the buzzer, namely an active buzzer -- a buzzer with its sound, and a passive buzzer that does not have its sound, so an oscillator circuit is needed to generate the buzzer sound waves.

Figure 11. Active buzzer.

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In this research, the buzzer used is an active-buzzer. This active buzzer is sufficient to be fed with a voltage of 5 volts DC to emit sound waves. An illustration of this active buzzer can be seen in Figure 11.

III. Result and Discussion

This research starts with hardware design followed by software design. The hardware design of overheating detection of motorbike disc brakes can be seen in Figure 12.

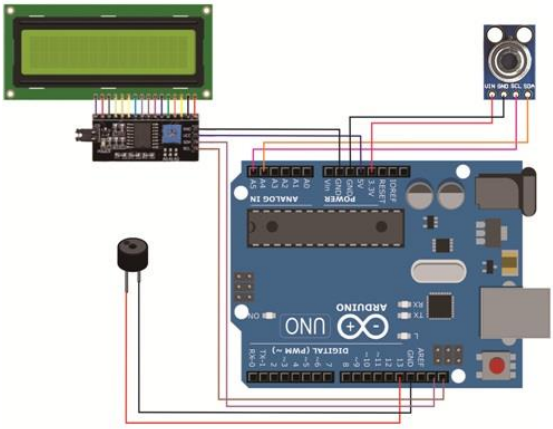

Figure 12. Hardware design.

The system detects heat from the disc via the MLX90614 non-contact temperature sensor. Data from the temperature sensor is sent to Arduino via an analog pin. The sensor's data is then processed by Arduino and displayed on the LCD via the SDA and SCL serial pins to the I2C module. When the temperature exceeds the maximum allowable limit, Arduino will activate digital pin 13 to sound the buzzer.

Figure 13. System hardware implementation.

Hardware implementation is the stage of implementing hardware by the plans that have been made so that the system works according to its needs and functions. The hardware consists of several modules and basic electronic components. Hardware is arranged according to the function of the software so that it can be connected to others.

The hardware implementation stage consists of an Arduino UNO, an MLX90614 temperature sensor, an active buzzer, an LCD module, and an I2C module. This hardware's parts are interconnected and integrated according to the disc brake heat detection requirements and functions.

The software implementation consists of instructions on the Arduino IDE that aim to read data from the temperature sensor, process sensor data, display sensor data on the LCD, and sound the buzzer as shown in the program listing below.

```
#include <LiquidCrystal_I2C.h>
#include <Wire.h>
#include <Adafruit_MLX90614.h>
Adafruit_MLX90614 mlx = Adafruit_MLX90614();
LiquidCrystal_I2C lcd = LiquidCrystal_I2C(0x27,16,2);
int buzzer=13; //pin untuk buzzer
void setup() {
Serial.begin(9600);
lcd.init();
lcd.backlight();
pinMode(buzzer, OUTPUT);
lcd.setCursor(0,0);
lcd.print("Deteksi");
lcd.setCursor(0,1);
lcd.print("Suhu Piringan");
delay(5000);
lcd.clear();
mlx.begin();
}
void loop() {
float objek = mlx.readObjectTempC();
  if (objek >=200){
    buzzer_on();
lcd.setCursor(0,1);
    lcd.print("Suhu Tinggi");
    buzzer_off();
  }
  else if (objek <200){
    buzzer_off();
lcd.clear();
lcd.setCursor(0,1);
    lcd.print("Suhu Rendah");
  }
lcd.setCursor(0,0);
  lcd.print("Suhu =" );
lcd.setCursor(7,0);
  lcd.print(objek);
  lcd.print(char(0xdf));
  lcd.print("C");
}
void buzzer_on (){
digitalWrite(buzzer, HIGH);
delay(1000);
}
void buzzer_off (){
digitalWrite(buzzer, LOW);
delay(1000);
}
```


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Testing of the system aims to test the capabilities of the system based on predetermined specifications. Testing of this system is carried out on the capabilities of the system, namely:

- System accuracy in detecting disc brake heat.
- System ability to display temperature to LCD.
- The system's ability to display notifications by sounding the buzzer according to the specified temperature.

Figure 14. Testing with an electric motor.

System testing is done using an electric motor 1 HP 2800 rpm as a substitute for the wheels' rotation. Testing of this system is carried out by being given a fixed braking load, and then the electric motor is rotated regularly at a speed of 2800 rpm. The distance between the sensor and the disc is 5 cm. As a comparison of measurement accuracy, another tool is used in the form of a thermometer gun to determine the difference in the system's measurement results on the LCD screen with a thermometer gun. Then the disc brake heat is detected periodically every 25 seconds. The results of testing with an electric motor can be seen in Table 1.

TABLE 1.
SYSTEM TESTING RESULTS

Time second	Thermo-meter Gun (ºC)	Temperature System (LCD) (ºC)	Difference (ºC)	Buzzer
25	94,7	94,5	0,2	*off*
50	121,3	120,9	0,4	*off*
75	143,4	143,1	0,3	*off*
100	164,8	164,4	0,4	*off*
125	177,2	176,8	0,4	*off*
150	186,7	186,5	0,2	*off*
175	197,3	196,9	0,4	*off*
200	211,5	211,1	0,4	*on*
225	224,6	224,3	0,3	*on*
250	237,9	237,5	0,4	*on*

IV. CONCLUSION

The trials conducted show that the results of designing hardware and software for overheating detection of Arduino-based motorcycle disc brakes can be summarized as follows. The system can display temperature detection into the LCD. The detection of disc heat generated by design differs from the Thermo gun of at least 0.2ºC and a maximum of 0.4ºC, a more excellent value on the thermometer gun. The system can issue notifications in the form of a buzzer sound at system temperatures of 211.1ºC, 221.3ºC, and 237.5ºC, which were achieved at 200, 225, and 250 seconds.

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Improvement of DC Motor Speed Control for Mobile Robot to Minimize Slip Phenomenon

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Abstract— Slip on the mobile robot has a significant impact on the maneuver and the accuracy of the mobile robot movement. The slip phenomenon occurs because of the loss of traction between the surface and the wheels due to the spontaneous acceleration or declaration application. This paper presents a method to improve DC motor performance by using slip control as an observer such that the slip phenomenon effect can be minimized. The performance that will be analyzed is the accuracy of motor speed and robot position accuracy when the robot is moving. The result shows that the Root Mean Squared Error (RMSE) for the motor speed performance that does not use slip control is 2.680, the system using slip control produces RMSE 1.3393. Regarding the robot position accuracy, the RMSE of the system that does not use slip control is 0.0379, the system using slip control is 0.0065.

Keywords— Slip, Omnidirectional, Mobile Robot, DC Motor Speed.

I. INTRODUCTION

Mobile robots are one type of robot that can be implemented in many fields, starting from industry, defense and security, transportation, and others. As explained by Pandey et al., the research on mobile robots is still developing today in [1]. There are various problems found in the issue of mobile robots. One of them is maneuverability. Issues in the mobile robot maneuvering experiment. The resulting precision reaches an error of approximately 15 degrees using a speed of 8 m/s [2].

The mobile robot with Omni-directional drive has the advantage of maneuvering because of the wheels' unique structure. There are rollers around it with a certain angle to the direction of the wheels. Mobile robots can maneuver in various directions in the planar plane, as stated Long [3]. This capability is since the mobile robot is equipped with wheels with a roller around it with a certain angle to the direction of rotation of the wheels. For a standard Omni wheel, the angle is perpendicular to the wheel rotation, and for a mecanum wheel, the angle is 45º from the direction of the wheel rotation. This allows the wheels to rotate according to the actuator's rotation and also to rotate laterally. Generally, a mobile robot is used more than 3 Omni wheels to become an omnidirectional robot.

The Omni wheel on a mobile robot with an Omni-directional drive, which is implemented in fast movement [4]. The Omni wheel has simple control and steering but has limited traction. This affects the slip phenomenon [5] detected slip using redundant encoders on an omnidirectional wheeled mobile robot. The largest slip occurred at the Omni wheel (three wheels), which reached 0.3 m/s. Also, slip occurs when the robot accelerates or decelerates spontaneously or at a high rate. If this slip occurs continuously, it will cause the control to be inaccurate so that the mobile robot's motion precision level will decrease.

To minimize the occurrence of slippage on the mobile robot, it is necessary to apply settings during acceleration and deceleration so that it does not occur spontaneously at high rates. This acceleration setting should not be too low or too long because it will cause the maneuvering of the mobile robot to be less than optimal. A achieve maximum results. These accelerations and decelerations must be carried out as quickly as possible but do not cause traction between the wheels and the floor surface to be lost to avoid slippage. DC motors are also implemented in many different case studies, including for data processing in automatic sliding doors [6] and for adjusting the speed and direction of rotation of the umbrella drive [7].

In this study, a mobile robot actuator control system will be built, in this case, a DC motor to reduce slippage occurrence. Acceleration settings will be applied to each actuator based on parameters that affect the actuator's strength and torque. This research aims to build a control system to reduce the slip problem on the mobile robot driving wheel to increase the precision and efficiency in its movement.

II. RESEARCH METHODOLOGY

This section discussed four sub-sections regarding omnidirectional kinematics, control of dc motor, slip control, and mobile robot movement control.

A. Omnidirectional Kinematic

Mobile robot kinematics is the study of motion in mobile robots regardless of the supporting factors. Kinematics only discusses how the robot moves or changing positions in a field of work. The kinematics of mobile robots depend on the type of locomotion. This is because the type of drive affects the ability of the robot to change positions. For the mobile robot with the omnidirectional wheels, the configuration is depicted in Figure 1.

Taheri H., *et al*, explained in [12] regarding the kinematics of Omni wheel configuration which is depicted in Figure 1. i is the index of wheels. v_x and v_y are robot linear velocities with the [*m/s*] unit. ω_z is robot angular velocity with the [*rad/s*] unit. v_{ir} is the velocity of the passive roller in the wheel i. $v_{i\omega}$ [*m/s*] is the velocity vector concerning the wheel revolutions, (i =

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0,1,2,3) ϵ *R*. S_i and E_i are the coordinate system of *i* th wheel. P_i is the wheel's center point. α_i is the angle between OP_i and X_R.

Meanwhile, X_R, O, Y_R are the mobile robot's base frame, the Cartesian coordinate. θ is the orientation angle. l_{ix} is half of the distance between front wheels, and l_{iy} is half of the distance between the front wheel and rear wheel.

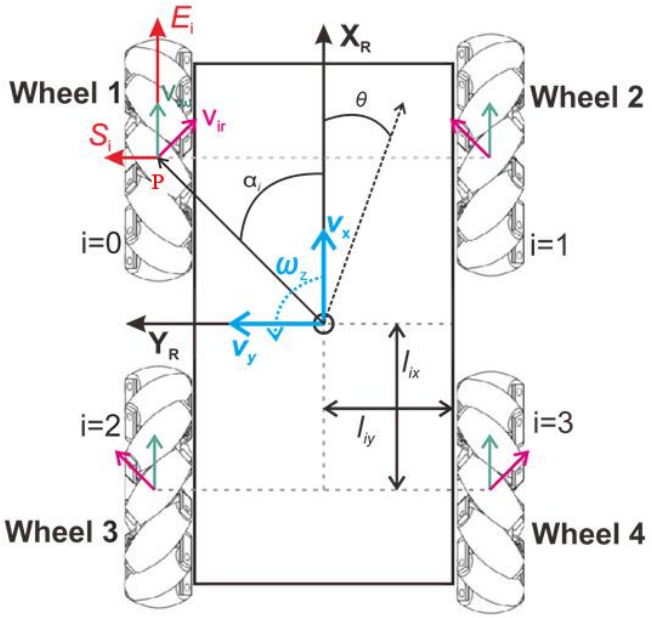

Figure 1. Mechanical design of omnidirectional wheels

The configuration of the wheel is illustrated in Figure 2. Based on Figure 2 and Figure 1, the wheel velocity (center point) concerning the frame X_ROY_R is described in Equation (1)(2).

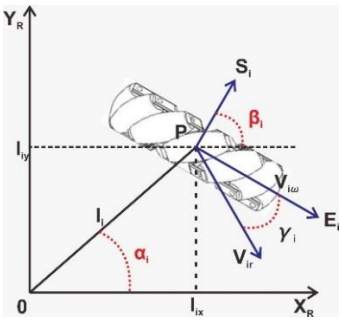

Figure 2. Wheel configuration in the robot frame

$$\begin{bmatrix} V_{iX_R} \\ V_{iY_R} \end{bmatrix} = \begin{bmatrix} \cos\beta_i & -\sin\beta_i \\ \sin\beta_i & \cos\beta_i \end{bmatrix} \begin{bmatrix} v_{S_i} \\ v_{E_i} \end{bmatrix} \quad (1)$$

$$\begin{bmatrix} V_{iX_R} \\ V_{iY_R} \end{bmatrix} = {}^{w_i}T_{P_i}\, {}^{p_i}T_R \begin{bmatrix} \omega_i \\ v_{i_r} \end{bmatrix} \quad (2)$$

With ${}^{p_i}T_R$ is the transformation matrix calculated from the *i*-th center of the wheels concerning the robot coordinate system. Because the motion of the robot is planar, then it is explained in Equation (3)(4)(5),

$$\begin{bmatrix} V_{iX_R} \\ V_{iY_R} \end{bmatrix} = \begin{bmatrix} 1 & 0 & -l_{i_y} \\ 0 & 1 & l_{i_x} \end{bmatrix} \begin{bmatrix} v_x \\ v_y \\ \omega \end{bmatrix} \quad (3)$$

$$\begin{bmatrix} V_{iX_R} \\ V_{iY_R} \end{bmatrix} = T' \begin{bmatrix} v_x \\ v_y \\ \omega \end{bmatrix} \quad (4)$$

$$\begin{bmatrix} V_{iX_R} \\ V_{iY_R} \end{bmatrix} = T' \begin{bmatrix} v_{X_R} \\ v_{Y_R} \\ \omega_R \end{bmatrix} \quad (5)$$

Meanwhile for ${}^{w_i}T_{P_i}$ is regarding the wheel motion principle of *i*-th wheel. The configuration of wheel motion is described below,

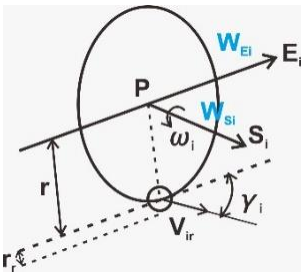

Figure 3. The *i*-th wheel configuration

The v_{ir} is the velocity of *i*-th wheel for the S_i P_i E_i frame. Meanwhile, w_{Ei} is the free roller tangential velocity that is touching to the floor. The equations are described in Equation (6)(7), with *i* = 0, 1,2, 3,

$$v_{i_r} = \frac{1}{\cos 45} r_r \omega_i \quad (6)$$

$$w_{Ei} = r_r \omega_i \quad (7)$$

Based on Figure 3, the v_{Si} and v_{Ei} (velocity of *i*-th wheel) in S_i P_i E_i frame can be depicted as transformation matrix in Equation (8)(9)(10),

$$\begin{bmatrix} V_{S_i} \\ V_{E_i} \end{bmatrix} = \begin{bmatrix} 0 & \sin\gamma_i \\ r_i & \cos\gamma_i \end{bmatrix} \begin{bmatrix} \omega_i \\ v_{i_r} \end{bmatrix} \quad (8)$$

$$\begin{bmatrix} V_{S_i} \\ V_{E_i} \end{bmatrix} = {}^{w_i}T_{P_i} \begin{bmatrix} \omega_i \\ v_{i_r} \end{bmatrix}$$

With,

$$v_{Ei} = \omega_i r_i + v_{ir} \cos\gamma_i \quad (9)$$

$$v_{S_i} = v_{ir} \sin\gamma_i \quad (10)$$

Then for the inverse kinematic formulation of the robot, based on Equation (2)(3), it can be obtained in Equation (11),

$$\begin{bmatrix} \omega_i \\ v_{i_r} \end{bmatrix} = {}^{w_i}T_{P_i}{}^{-1} . {}^{p_i}T_R{}^{-1} . T' \begin{bmatrix} v_{X_R} \\ v_{Y_R} \\ \omega_R \end{bmatrix} \quad (11)$$

With the determinant ${}^{wi}T_{Pi}$ and ${}^{Pi}T_R$ are not equal to zero. After that, to obtain the linear velocity (v_{ir}) and the rotational

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velocity (ω_i) of i-th wheel, it can be derived in Equation (12)(13)(14),

$$\begin{bmatrix} v_{X_R} \\ v_{Y_R} \\ \omega_R \end{bmatrix} = T^{+} \begin{bmatrix} \omega_i \\ v_{i_r} \end{bmatrix} \quad (12)$$

$$\begin{bmatrix} \omega_i \\ v_{i_r} \end{bmatrix} = T \begin{bmatrix} v_{X_R} \\ v_{Y_R} \\ \omega_R \end{bmatrix} \quad (13)$$

$$\begin{bmatrix} \omega_i \\ v_{i_r} \end{bmatrix} = \begin{bmatrix} \cos\beta_i & -\sin\beta_i \\ \sin\beta_i & \cos\beta_i \end{bmatrix}^{-1} \begin{bmatrix} 0 & \sin\gamma_i \\ r_i & \cos\gamma_i \end{bmatrix}^{-1} \begin{bmatrix} 1 & 0 & -l_{i_y} \\ 0 & 1 & l_{i_x} \end{bmatrix} \begin{bmatrix} v_{X_R} \\ v_{Y_R} \\ \omega_R \end{bmatrix} \quad (14)$$

With $l_{iy} = l_i \sin \alpha_i$, and $l_{ix} = l_i \cos \alpha_i$ and considering that all the wheels size are the same. Then obtained the transformation matrix as stated in Equation (15),

$$T = \frac{1}{-r} \begin{bmatrix} \frac{\cos(\beta_i-\gamma_i)}{\sin(\gamma_i)} & \frac{\sin(\beta_i-\gamma_i)}{\sin(\gamma_i)} & \frac{l_i \sin(-\alpha_i+\beta_i-\gamma_i)}{\sin(\gamma_i)} \\ -\frac{r\cos(\beta_i)}{\sin(\gamma_i)} & -\frac{r\sin(\beta_i)}{\sin(\gamma_i)} & -\frac{l_i \sin(-\alpha_i+\beta_i)r}{\sin(\gamma_i)} \end{bmatrix} \quad (15)$$

Recall that there is a relation between the angular and linear velocity for each joint (ω_i and v_{ir}). Then the inverse kinematic is formulated as in Equation (16)(17),

$$\begin{bmatrix} \omega_1 \\ \omega_2 \\ \omega_3 \\ \omega_4 \end{bmatrix} = \frac{1}{-r} \begin{bmatrix} \frac{\cos(\beta_i-\gamma_i)}{\sin(\gamma_i)} & \frac{\sin(\beta_1-\gamma_1)}{\sin(\gamma_1)} & \frac{l_i \sin(-\alpha_i+\beta_i-\gamma_i)}{\sin(\gamma_i)} \\ \frac{\cos(\beta_2-\gamma_2)}{\sin(\gamma_2)} & \frac{\sin(\beta_2-\gamma_2)}{\sin(\gamma_2)} & \frac{l_2 \sin(-\alpha_2+\beta_2-\gamma_2)}{\sin(\gamma_2)} \\ \frac{\cos(\beta_3-\gamma_3)}{\sin(\gamma_3)} & \frac{\sin(\beta_3-\gamma_3)}{\sin(\gamma_3)} & \frac{l_3 \sin(-\alpha_3+\beta_3-\gamma_3)}{\sin(\gamma_3)} \\ \frac{\cos(\beta_4-\gamma_4)}{\sin(\gamma_4)} & \frac{\sin(\beta_4-\gamma_4)}{\sin(\gamma_4)} & \frac{l_4 \sin(-\alpha_4+\beta_4-\gamma_4)}{\sin(\gamma_4)} \end{bmatrix} \begin{bmatrix} v_X \\ v_Y \\ \omega_Z \end{bmatrix} \quad (16)$$

$$\begin{bmatrix} v_X \\ v_Y \\ \omega_Z \end{bmatrix} = T^{+} \begin{bmatrix} \omega_1 \\ \omega_2 \\ \omega_3 \\ \omega_4 \end{bmatrix} \quad (17)$$

B. DC Motor Control

DC motors are commonly used as wheel drives in mobile robots. Some of the advantages of using a DC motor besides the low cost are the relatively simpler rotational speed settings compared to the other types of motors. Many methods can be used to adjust the rotational speed of a DC motor, including using PI control or PID control, fuzzy control, and the other types of control as conducted by Ang, *et al*, in [11] and Tzou, *et al*, in [8].

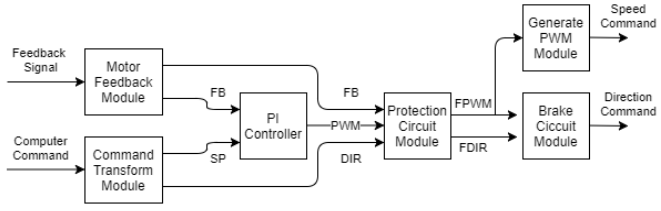

Figure 4. The architecture of the DC Motor velocity controller

Shih-an Li, *et al*, in [11] designed a DC motor control system for mobile robots using their FPGA chip processor. The control used is the PI controller equipped with a protection circuit module to avoid damage to the motor driver IC due to the large back-EMF that appears, mainly when the motor rotates in the opposite direction repeatedly. The architecture of the motor control is illustrated in Figure 4.

C. Slip Control

In this research, a mobile robot with a mecanum wheel configuration will be used as the test object. The actuator control system will be built to reduce the slip on the drive wheels when the robot maneuvers. The actuator used is a Geared DC motor connected to the mecanum wheel. Each actuator has a rotary encoder sensor and a current sensor. The configuration of the mobile robot is shown in Figure 5.

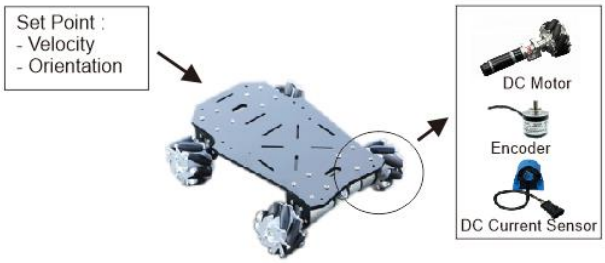

Figure 5. The mobile robot configuration

Motion control of the mobile robot used kinematics motion. The input parameters of the motion are velocity and orientation. The kinematic Equation's output is the number of motion vectors on each actuator (in this case is a DC motor).

The DC motor rotation is regulated using the Pulse Width Modulation (PWM) technique to allow the DC motor to produce rotations with varying speeds. Slip-on the drive wheel will occur when the wheel loses traction or its maximum friction. This can be caused by too high or spontaneous acceleration or deceleration. In the case of the omnidirectional wheel, especially the mecanum wheel, the possibility of slippage is very high because the touchpoint of the wheel to the floor surface is very small, and the touchpoint is on a roller with a 45 ^{o} inclination of the wheel plane.

So to reduce the slippage, the slip estimation is applied to the system. Figure 6 describes the control of motor DC using slip estimation based on the observer. Using the set point of angular velocity (RPM) will be processed using PID control to produce signal control. PID control is used to adjust the DC motor's speed in real-time to match a given set point. The output of PID control (signal control) will be processed into the driver motor based on current.

Then the output (current) equipped with the slip estimation is calculated. Besides the current from the drive motor output, the current estimate from the observer is calculated. The current estimation is becoming feedback in this system. The input is the result of slip estimation based on the observer. The output of the system is RPM that has been added to the slip

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control estimation. The process will be looped until it is following the specified RPM set of points.

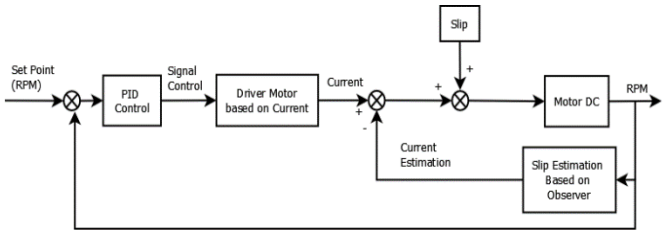

Figure 6. The control of motor equipped with slip estimation

III. Result and Discussion

The results consist of three parts. The experiment regarding DC motor speed using PID controller, current sensor, the system without using slip control, and the system using slip control.

A. DC Motor Speed using PID Controller

This experiment is carried out by running a DC motor following the RPM setpoint value given. Observe the motor's response, whether the motor speed can equal or near the given RPM setpoint, and maintain motor rotation if there is a disturbance (briefly held).

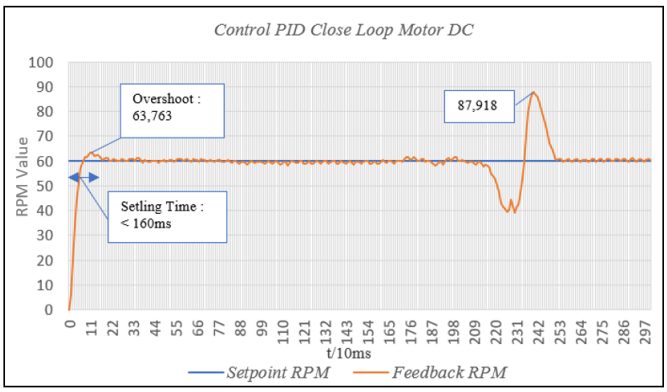

Figure 7. The PID response graphic for RPM 60

By using combination values between RPM speed and PID value (Kp, Ki, and Kd). When RPM speed of 60 and configuration parameters PID Kp = 4.05, Ki = 210, and Kd = 0.0004, the response is depicted in Figure 7. A graph produced by the motor's movement when the setpoint speed is 60 RPM. Settling time on DC motor RPM feedback takes less than 160 milliseconds. Then the overshoot that occurred was up to 63.763 RPM. When the motor is disturbed by being held for a moment, the PID control system will respond to maintain the speed setpoint that has been given to the control system, even though it takes around 250 milliseconds. There is a value of RPM achieved 87.918 RPM.

The RPM value is set to be 180. the result is shown in Figure 8. Based on Figure 8, the settling time on DC motor RPM feedback takes less than 120 milliseconds. Then the overshoot that occurred was up to 187.347 RPM. When the motor is disturbed by being held for a moment, the PID control system will respond to maintain the speed setpoint that has been given to the control system, even though it takes around 250 milliseconds. There is a value of RPM achieved 322.351 RPM.

The next RPM given is 360. The response is illustrated in Figure 9. Figure 9 takes less than 320 milliseconds for the system to achieve the settling time. Then for the overshoot, the system reaches 379.347 RPM. Meanwhile, when the motor is being held for a while (as the disturbance), the PID control system needs around 76 milliseconds to stick to the setpoint value. Although in the process, it also happens the RPM value about 379.347.

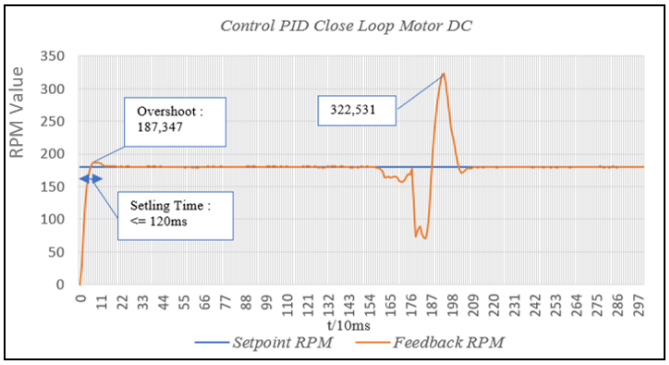

Figure 8. The PID response graphic for RPM 180

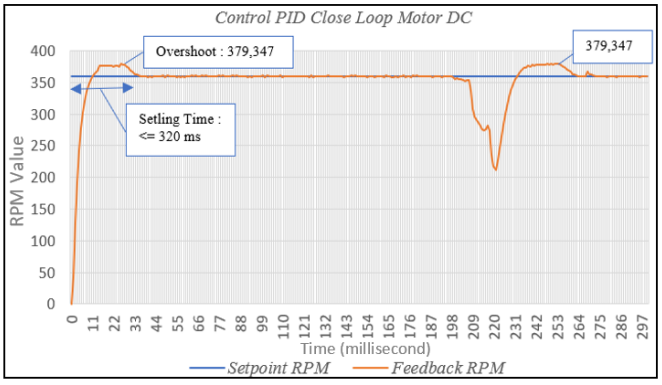

Figure 9. The PID response graphic for RPM 360

B. System without Slip Control

The system testing is carried out without using a slip control, which causes the slip phenomenon effect. Some of the things that are analysed by the occurrence of slip are the motor speed response as seen from the RPM value, the effect of the slip on the wheel distance, the odometry of the robot's movement, and the orientation of the robot.

Firstly, the motor speed response is analysed using the RPM value that is illustrated in Figure 10. In the Omni mechanism, there are four motors. Figure 10 is a graph that shows the motor speed response when the robot is moving. As shown in Figure 11, there is one motor that slips. It affects the RPM, which suddenly rises and then falls back to the initial RPM. The deviation of the RPM value occurs during 0.25 seconds. Figure 10 is tested with 1303 data from 0 up to 3 seconds. Then it is presented with 20 sample data in Table I.

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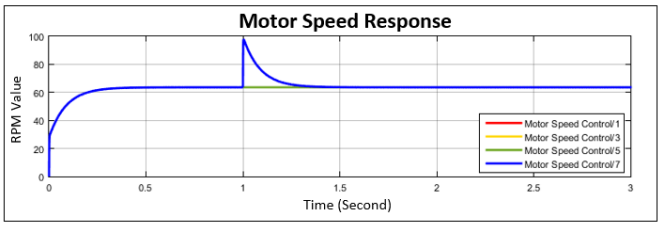

Figure 10. Motor speed response graphic

TABLE I
SAMPLE OF MOTOR SPEED RESPONSE DATA

Time (Second)	Motor 1 (RPM)	Motor 2 (RPM)	Motor 3 (RPM)	Motor 4 (RPM)
3.155E-30	1.2748E-25	1.2748E-25	1.2748E-25	1.2748E-25
0.125035	55.121477	55.121477	55.121477	55.121477
0.277876	62.154554	62.154554	62.154554	62.154554
0.4303563	63.393123	63.393123	63.393123	63.393123
0.5829469	63.610256	63.610256	63.610256	63.610256
0.735910	63.643545	63.643545	63.643545	63.643545
0.8889701	63.642603	63.642603	63.642603	63.642603
1.0131593	63.661718	63.661718	63.661718	94.727632
1.1654113	63.661960	63.661960	63.661960	69.048447
1.3161291	63.662038	63.662038	63.662038	64.544272
1.4689969	63.662064	63.662064	63.662064	63.731436
1.6214590	63.662028	63.662028	63.662028	63.649816
1.7741517	63.662025	63.662025	63.662025	63.630047
1.9266971	63.662011	63.662011	63.662011	63.645975
2.0797650	63.662019	63.662019	63.662019	63.634277
2.2323524	63.662009	63.662009	63.662009	63.648773
2.3853151	63.662012	63.662012	63.662012	63.644992
2.5264256	63.662012	63.662012	63.662012	63.644989
2.6775622	63.662058	63.662058	63.662058	63.579117
2.8320720	63.662009	63.662009	63.662009	63.648748
2.985034	63.662012	63.662012	63.662012	63.644988
3	63.662002	63.662002	63.662002	63.658890

As depicted in Figure 10, it is shown that Motor 4 has some error data concerning the set point. The setpoint value is 63,662 RPM. Then for the root mean square error is formulated in equation 18. Based on equation 18, it is found that the RMSE of Motor 4 is 2.680.

$$RMSE = \sqrt{\frac{\sum_{i=1}^{N}(x_i - \widehat{x_i})^2}{N}} \qquad (18)$$

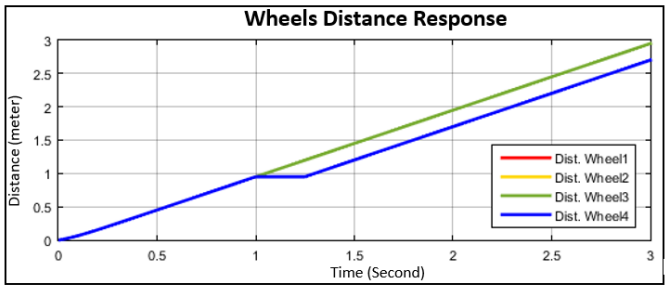

Figure 11. Wheels distance response

The next parameter that is analyzed is the wheel's distance. Figure 11 shows how the response of the wheel distance. The experience of each wheel *concerning the* slip effect. As shown in Figure 11, *a wheel* has *a* different response *concerning* the other. The blue line represents the fourth wheel. The different response means that the wheel is experiencing a slip. Meanwhile, *they have the same response for the other wheels and* don't experience the slip phenomenon.

Then for the next experiment is analyzing the slip phenomenon concerning the odometry of the robot. Figure 12 describes the result. As illustrated in Figure 12, the robot's odometry is represented by the robot's position in x – y coordinate. As shown in Figure 12, the value of the y coordinate is not always 0. Meanwhile, the robot's true condition moves straight along the x variable axis (the y variable value of the y coordinate should constantly be 0). The y variable value has a deviation of up to 5 cm away when the slip phenomenon occurs.

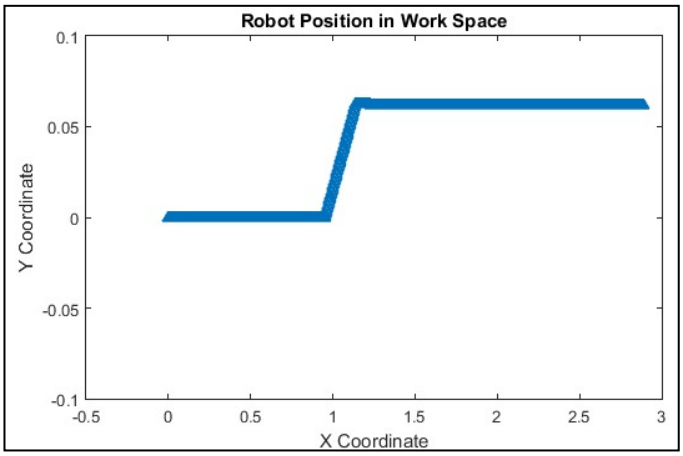

Figure 12. Robot position concerning slippage phenomenon

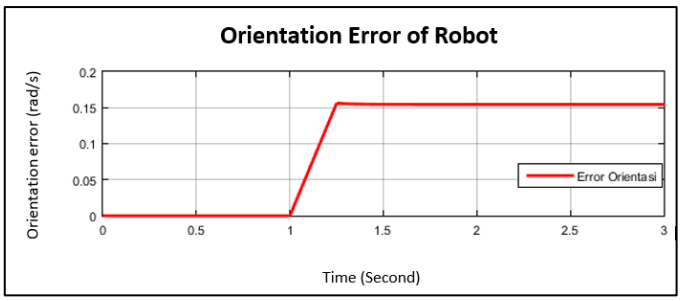

Figure 13. Robot orientation error

TABLE II
SAMPLE OF ROBOT POSITION DATA

Time (Second)	Position X (Meter)	Position Y (Meter)	Orientation Reference	Error Orientation
3.155E-30	3.159E-57	0	0	0
0.1272278	0.0893554	0	0	0
0.2797668	0.2325576	0	0	0
0.4323865	0.3835703	0	0	0
0.5854305	0.5363379	0	0	0
0.749891	0.7007497	0	0	0
0.9029303	0.853782	0	0	0

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Time (Second)	Position X (Meter)	Position Y (Meter)	Orientation Reference	Error Orientation
1.0272355	0.9712874	0.0067986	-0.0169965	0.0169965
1.1794486	1.085447	0.0448518	-0.1121295	0.1121295
1.4120825	1.3010042	0.0619284	-0.154821	0.154821
1.7181022	1.6071278	0.0618245	-0.1545613	0.1545613
1.8700789	1.7591069	0.0618221	-0.1545554	0.1545554
2.0231691	1.9121976	0.0618217	-0.1545542	0.1545542
2.1758943	2.0649228	0.0618216	-0.154554	0.154554
2.3287401	2.2177686	0.0618216	-0.154554	0.154554
2.4817792	2.3708078	0.0618216	-0.1545539	0.1545539
2.6345035	2.523532	0.0618216	-0.154554	0.154554
2.7873492	2.6763777	0.0618216	-0.154554	0.154554
2.9403883	2.8294169	0.0618216	-0.1545539	0.1545539
3	2.8890285	0.0618216	-0.1545541	0.1545541

The next factor that is analyzed when the slippage phenomenon occurs is the robot orientation error. Figure 13 describes the orientation error of the robot. As illustrated in Figure 13, the robot orientation error starts occurring after 1 second of running. The error achieves up to 0,15 rad/s. The orientation error happened when the slip occurs, and there is not slip control applied in the system. Figure 12 and Figure 13 are taken from 1303 data. The table which represents the data in 20 samples is in Table II. Based on equation 18, the RMSE for this experiment is 0.03799.

D. The System Applied Slip Control

In this experiment, the system testing applied slip control. With the same parameters analyzed with the System Without Slip Control experiment, we will see different results.

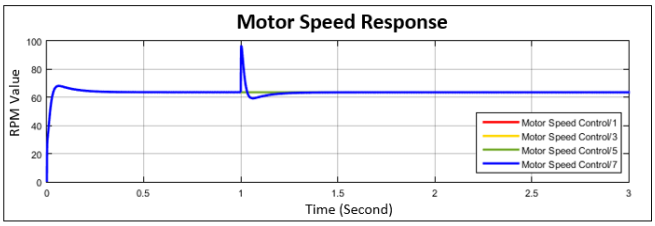

Figure 14. Motor speed response graphic using slip control

Firstly, regarding the motor speed response. By applying the slip control, the result is illustrated in Figure 14. Figure 14 tells that all of the wheels respond concerning the RPM value parameter's slip phenomenon. As seen in Figure 14, the fourth wheel (Motor 4) is experiencing RPM's deviation value for 0,1 second (after 1-second timing). Meanwhile, for the other spins, their response is as expected, although the slip phenomenon occurred. Only the fourth wheel contributed the deviation value. Figure 14 is consists of 1308, from 0 to 3 seconds for the time. Then if it is sampled into 20 of 1308 data, the result is presented in Table III. With the same setpoint value of the one that does not use the slip control, and by applying the RMSE, it is found that the RMSE is 1.339.

TABLE III
SAMPLE OF MOTOR SPEED RESPONSE USING SLIP CONTROL DATA

Time (Second)	Motor 1 (RPM)	Motor 2 (RPM)	Motor 3 (RPM)	Motor 4 (RPM)
3.1E-30	1.2E-25	1.2E-25	1.2E-25	1.2E-25
0.12014	66.3022	66.3022	66.3022	66.3022
0.26833	64.2160	64.2160	64.2160	64.2160
0.42118	63.8107	63.8107	63.8107	63.8107
0.57389	63.7202	63.7202	63.7202	63.7202
0.72695	63.7356	63.7356	63.7356	63.7356
0.87979	63.7286	63.7286	63.7286	63.7286
1.00435	63.6620	63.6620	63.6620	95.8573
1.15363	63.6620	63.6620	63.6620	61.9277
1.30658	63.6620	63.6620	63.6620	63.3443
1.45981	63.6619	63.6619	63.6619	63.5361
1.61272	63.6619	63.6619	63.6619	63.5488
1.76474	63.6619	63.6619	63.6619	63.6436
1.91783	63.6619	63.6619	63.6619	63.6213
2.07094	63.6619	63.6619	63.6619	63.5629
2.22353	63.6619	63.6619	63.6619	63.5977
2.37593	63.6619	63.6619	63.6619	63.6372
2.52902	63.6619	63.6619	63.6619	63.6004
2.68124	63.6619	63.6619	63.6619	63.65
3	63.662	63.662	63.662	63.6596

Secondly, about the wheel's distance response using the slip control. The graphic response is illustrated in Figure 15. The four wheels have the same response. All four wheels perform uniformly although the slip occurred during the experiment. No one of the wheels contributes to the deviation value of the robot distance.

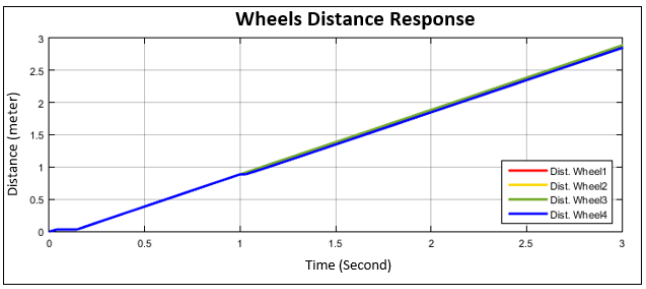

Figure 15. Wheels distance response using slip control

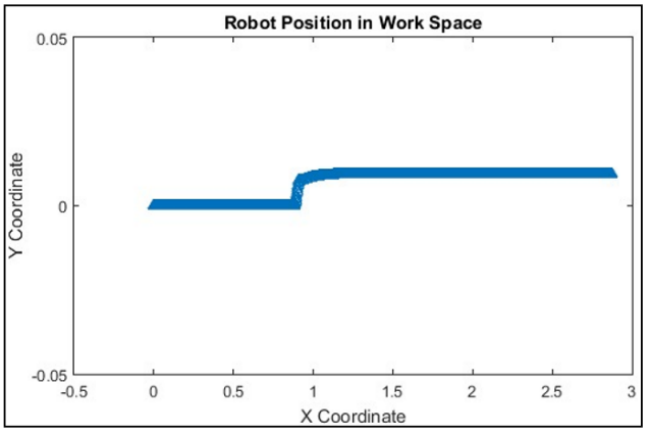

Figure 16. Robot position concerning slippage phenomenon using slip control

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Third, regarding the odometry of the robot. When the system applies slip control, the result is shown in Figure 16. The robot's position in the x-y coordinate when the system was using the slip control. Based on Figure 16, the y variable value has a deviation value of not more than 0.05 meter. The last is regarding the orientation of the robot. The graphic response is depicted in Figure 17. Figure 17 shows that the orientation error of the robot raises when the time is after 1 second. The error achieves less than 0.03 rad/s. For the data of Figure 16 and Figure 17, they consist of 1308 data during 0 up to 3 seconds, represented in Table IV. But Table IV only represents the 20 data. By using equation 18, the RMSE of this experience is 0.0060.

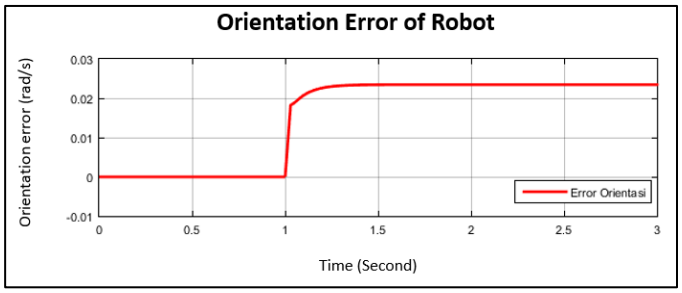

Figure 17. Robot orientation error using slip control

TABLE IV
SAMPLE OF ROBOT POSITION DATA

Time (Second)	Position X (Meter)	Position Y (Meter)	Orientation Reference	Error Orientation
3.155E-30	3.159E-57	0	0	0
0.1201472	0.0297522	0	0	0
0.2723005	0.1585689	0	0	0
0.4299344	0.3167258	0	0	0
0.5879128	0.474789	0	0	0
0.7449291	0.6318192	0	0	0
0.9033389	0.7902306	0	0	0
1.0296622	0.9091499	0.007405088	-0.0185127	0.0185127
1.1872549	1.0651504	0.008997348	-0.0224934	0.0224934
1.3440035	1.2215667	0.009329676	-0.0233242	0.0233242
1.5015434	1.379052	0.009384206	-0.0234605	0.0234605
1.6595837	1.5370837	0.009392901	-0.0234823	0.0234823
1.8163793	1.6938777	0.009394507	-0.0234863	0.0234863
1.9744263	1.8519246	0.009394603	-0.0234865	0.0234865
2.1319285	2.0094267	0.009394626	-0.0234866	0.0234866
2.2887661	2.1662642	0.009394784	-0.023487	0.023487
2.4467655	2.3242637	0.009394655	-0.0234866	0.0234866
2.6038471	2.4813452	0.009394766	-0.0234869	0.0234869
2.7612539	2.638752	0.009394791	-0.023487	0.023487
3	2.8774981	0.009394822	-0.0234871	0.0234871

IV. CONCLUSION

Based on the experiment between applying and not applying the slip control, it can be concluded. Motor speed response without using slip control has a more significant Root Mean Squared Error (RMSE). The RMSE for the experiment without applying slip control is 2.680. Meanwhile, for the investigation, by using slip control is 1.3393.

Regarding the robot position (odometry of the robot), the system applying slip control produces a smaller RMSE—the one which is not using slip control yields RMSE 0.0379. Meanwhile, for the system which applying slip control, producing RMSE 0.0065.

Then for the robot's wheels distance response, the system that is applying the slip control produces less deviation value. The one that does not use slip control is experiencing the fourth wheel's deviation value, about 0.25 meters. Meanwhile, the deviation value is 0 meters for all wheels for the system that is applying the slip control.

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Intercept Algorithm for Predicting the Position of Passing the Ball on Robot Soccer ERSOW

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Abstract— ERSOW is the name of a wheeled soccer robot that competes in the *Kontes Robot Sepak Bola Indonesia* (KRSBI). The soccer robot plays a soccer game based on the rules adapted from the human soccer game. The ERSOW team was formed in 2016. Starting in 2017, ERSOW participated in the KRSBI with the Middle Size League (MSL) type. Research in the field of wheeled soccer robots is mostly carried out on robot intelligence, such as how robots detect and look for balls, dribble, pass the ball, avoid opponents, and communicate in teams. This research focuses on the ability that the robot can pass the ball in KRSBI 2020. There are adjustments to the rules for its implementation online where the robot has to pass the ball and score as many goals as possible. The robot's ability to know the direction of ball movement and cut the ball movement or intercept is needed. By utilizing data processing from vision to obtain ball speed data and speed algorithm calculations, the passing ball method has a small chance of missing. Based on the results of experiments that have been carried out, the success of ERSOW in passing using this method is 94.7%.

Keywords— Robot Soccer, ERSOW, Passing the Ball, Middle Size League

I. INTRODUCTION

The soccer robot is one of the robots that continue to be developed to represent technological advances. Robot soccer has a fast development. This is due to robot competition in Indonesia. ERSOW (EEPIS Robot Soccer On Wheeled) developed robots' ability to pass the ball to other robots in a team. One of the prestigious national level competitions is the *Kontes Robot Sepak Bola Indonesia- Beroda* (KRSBI-B).

KRSBI-B is regulated according to the international soccer robot competition rules at the RoboCup Middle Size League (MSL) [1] by adjusting conditions in Indonesia, for example, in field size and others. ERSOW (EEPIS Robot Soccer On Wheeled), developed by Politeknik Elektronika Negeri Surabaya, consisting of 3 robots. One attack robot named Okto, a defense robot named Hendro, and a goalkeeping robot named Jamil.

ERSOW in 2020 is a continuation of previous research in 2018. The robot has four motors, and each of which is an Omni wheel. The purpose of using the four Omni wheels is to make the robot more stable and balanced when moving to find the ball, dribbling the ball, or avoiding obstacles. The main controller on the ERSOW robot is a PC or Laptop, and the sub-controller is STM32F4 Discovery. The main controller serves as the robot's strategic center, processing the vision results from the camera, receiving data from the referee box, and sending commands to the sub-controller. As for the sub-controller, retrieving data from the sensors is then sent to a PC using serial communication. Besides that, the sub-controller acts as a liaison between the main controller and the actuator [2].

KRSBI-B 2020 has an adjustment in its implementation online by requiring the robot to pass the ball to another robot in one team, avoid obstacles, and score as many goals as possible. The most important aspect in the KRSBI-B match in 2020 is the robot's ability to pass the ball because the robot has to pass the ball at least two times before kicking the ball into the goal. The challenge faced is how the robot can receive the ball pass so it doesn't miss and can receive the ball perfectly. If the pass is missed, the team will deduce the total points earned in one session.

The use of the previous method when passing the ball just relies on odometry data to determine another robot's position [3][4] that is targeted between the feeder robot and the receiving robot. This has a problem because odometric data always has a slip error with a range of 2-10 cm. And if this error accumulates, the robots' position data will be wrong so that the ball often misses. The Flex Sensor Glove is used to move the wheelchair robot [5], and the Automated Guided Vehicle method is used to adjust the placement of goods in the position of the rack arrangement [6].

However, knowing the direction of the ball coming and cutting the ball's movement is very necessary for developing the ability to pass the ball so that it does not miss so that several supporting variables are needed, namely ball speed data and time prediction.

II. RESEARCH METHODOLOGY

Figure 1 describes the ERSOW workflow diagram. The camera takes images to be processed into predetermined objects such as balls, obstacles, and fields. The data obtained on the camera is collected and then processed by the control system. Data is sent to the main microcontroller. The main computer processes data from the referee box via wifi communication then give commands to the sub-controller to move the DC motor to determine where the robot should move. Data from the IMU MPU-9150 sensor is used to determine the direction of the heading and mapping the robot's location. PID is used to adjust the motor speed. The robot kicks on the goal after getting the ball, and the robot's position is in the direction of the goal [4].

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The robot's ability to cut ball movement or ball interception can be made based on ball speed. To determine the point of intersection, it is necessary to calculate the time (t) to cut the movement of the ball and the heading (θ), which represents the direction of the intersection concerning the position of the robot [10]. The calculation of time (t) can be called time prediction and it is used to get the multiplier constant value in the velocity algorithm to get the right and appropriate intersection point. The intersection point obtained from the time prediction is a prediction point, namely the addition of the ball's initial position value when the ball moves every time in Cartesian space on the X-axis and Y-axis. If the time prediction value is small, the intersection point will be close to the moving ball's starting point. In addition to time prediction, heading (θ) is also significant to determine the robot's direction facing the incoming ball and provide a constant direction of increasing speed until it reaches maximum speed. Heading (θ) of the robot against the ball can also be obtained from ball detection while processing vision [4][10][9].

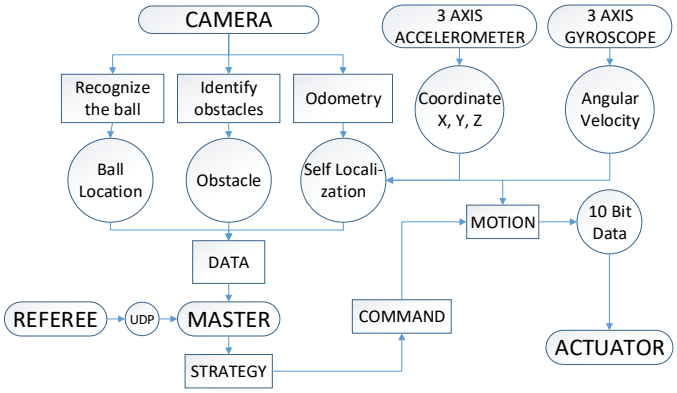

Figure 1. Robot ERSOW workflow diagram

A. *Speed Data of The Direction of Motion of The Ball*

The robot can determine the direction of the ball's movement and the point where the ball's movement will be cut, so it needs ball speed data obtained from the vision process in detecting the ball [4][9][10]. Figure 2 is an example of the image captured by an OmniVision camera. Where the image results from OmniVision can reach the area around the robot by 360°.

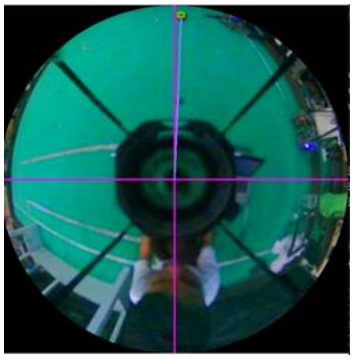

Figure 2. ERSOW Vision View

The ball's direction can be obtained from the velocity data. The velocity data is a vector quantity with a value and direction in the X-axis and the Y-axis. Meanwhile, the ball movement's intersection point is obtained from the velocity value multiplied by the predetermined Time Prediction.

B. *Get Timing Prediction*

Determining the right Time Prediction to determine the ball movement's intersection point when receiving the pass is very necessary. The smaller the value of Time Prediction, the intersection point of the ball's movement will be closer to the moving ball's starting point. Meanwhile, if the greater the value of the Time Prediction, then the ball movement's intersection point will be further away from the moving ball's starting point.

C. *Kicker ERSOW*

For the kicker, ERSOW uses a solenoid component supplied with voltage from a capacitor to produce a magnetic field that can attract the shaft. This motion is used as ball propulsion. The kicker and dribble sections are attached to the center base. The kick is done by applying a voltage of 500 volts to the solenoid [9]. The PWM arranges pressure on the kicker, and the ball is ejected in the intended direction [9]. Figure 3 is an example of a kicker model on the ERSOW soccer robot which is built from selenoid

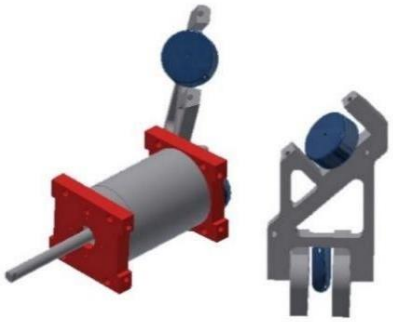

Figure 3. Robot ERSOW kicker

D. *Robot Moving Control*

Of all the variables needed for the passing ball method, it is necessary to combine it with the robot's control system itself [4] to move to the target (the point of intersection and direction towards the ball) precisely.

The ability of the soccer robot to pass is needed. In previous matches, ERSOW relied on the ability to find balls and communication between robots only. So that the results of the match are not optimal, and collisions often occur between robots. To make a ball pass between robots requires coordination of the two robots. The transfer robot needs to pay attention to the position of the receiving robot. Meanwhile, the receiving robot must adjust to the ball trajectory line from the feeder robot's kick. Figure 4 describes the coordination form of the two robots.

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The feeder robot has a certain coordinate position to the field. However, the feeder robot's heading must point to the angle formed between its coordinates and the ball receiving robot. The passing robot kicks the ball towards the ball receiving robot. While the ball receiving robot has arbitrary coordinate positions to the field with the heading facing the ball's corner, which refers to the field or theta (θ).

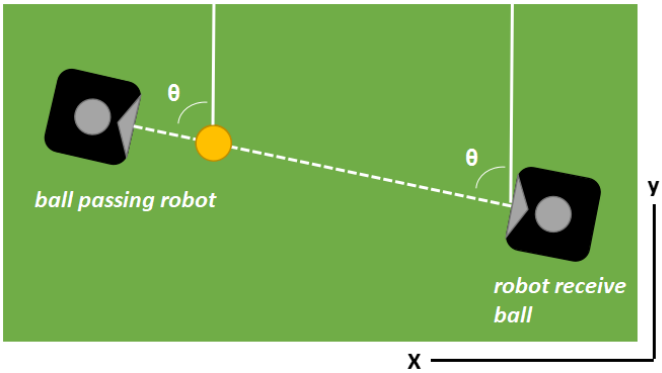

Figure 4. ERSOW coordination flow

The ball receiving robot must be able to predict the point where the ball meets itself. In this algorithm, the ball prediction is known through the data on the ball's position, velocity, and direction in Equation 1.

$$Pi = Pb + Vb \,.\, TP \tag{1}$$

Where:
Pi = Prediction of Ball Position
Pb = Current Ball Position
Vb = Ball Speed
TP = Time Prediction

The variable *Pi* is determined to calculate the ball's position in real-time and add the ball speed. TP is a time prediction to adjust the inertness of the ball when caught. Thus Pi is known based on the ball's position in real-time added to the predicted distance. The predicted distance is obtained from the ball velocity (Vb) times the Prediction Time (TP).

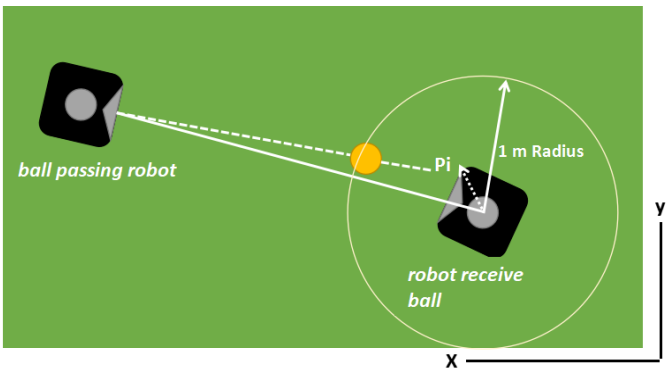

Figure 5. The movement of the ball receiving robot

After getting the prediction point, the ball receiving robot moves to the prediction point when the distance between the ball and the receiving robot is less than 1 meter.

TP determination is done by setting arbitrary values according to prediction needs. System testing calculates the robot's success when passing the ball to the ball receiving robot.

Figure 5 shows that the heading of the receiving robot is always facing the ball. When the ball reaches a radius of 1 meter from the middle of the robot, the robot moves towards Pi. Receiving the ball by the robot is done by dribbling the robot. The ERSOW robot is equipped with a dribble mechanism, two wheels with an angled installation to grip the ball.

ERSOW robot movement using PID (Proportional, Integral, Derivative) control. The robot moves to Pi at speed according to the PID Control calculation. The feedback data used is the robot's location data based on the floor rotary sensor calculation. The speed calculation results are then transformed using the following inverse kinematic Equation (2) to control each Omni wheel.

$$\begin{bmatrix}\omega_1\\ \omega_2\\ \omega_3\\ \omega_4\end{bmatrix} = \frac{1}{R}\begin{bmatrix}\sin\left(\frac{\pi}{4}\right) & \cos\left(\frac{\pi}{4}\right) & R\\ \sin\left(\frac{3\pi}{4}\right) & \cos\left(\frac{3\pi}{4}\right) & R\\ \sin\left(\frac{5\pi}{4}\right) & \cos\left(\frac{5\pi}{4}\right) & R\\ \sin\left(\frac{7\pi}{4}\right) & \cos\left(\frac{7\pi}{4}\right) & R\end{bmatrix}\begin{bmatrix}V_x\\ V_y\\ V_\theta\end{bmatrix} \tag{2}$$

III. Result and Discussion

Table I the results of the farthest passing distance suitable for the experiment.

TABEL I
PASS DISTANCE

No	The distance the robot passes the ball (cm)	Time (t)
1	200	3 - 4
2	180	2 - 4
3	120	2 - 3
4	100	1.5 - 2.5

Figure 6 illustrates when the ball receiving robot can receive the ball passed from the robot team.

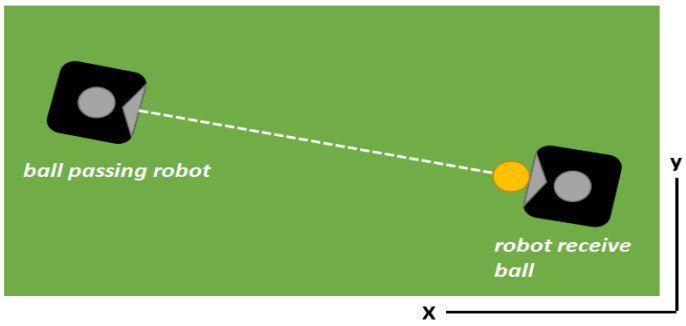

Figure 6. Robot Successfully passes the ball

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Figures 7 and 8 are real experiments of the ERSOW robot to implement the ball passing algorithm using the interception method.

Meanwhile, passing the ball is considered unsuccessful when the ball cannot be received by the receiving robot and has also touched the ball's body. Table II shows the results of the ball pass algorithm experiment.

Figure 7. ERSOW passes the ball

Figure 8. Robot receiving the ball from the pass

Based on the results of the experiment passing and receiving the ball as shown in Figure 7 and Figure 8, the two robots successfully passed the ball 18 times out of a total of 19 attempts, or 94.7%. The ball that is passed from the robot is successfully received by the receiving robot directly. However, on the 11th try, the ball receiving robot did not succeed in receiving the ball. The ball bounced after hitting the bumper of the robot. The results of the experimental data record when the robot passes the ball as in Table II.

TABLE II
EXPERIMENT RESULTS

Experiment	Robot Passes the Ball	Status
1	Successful	Ball successfully received
2	Successful	Ball successfully received
3	Successful	Ball successfully received
4	Successful	Ball successfully received
5	Successful	Ball successfully received
6	Successful	Ball successfully received
7	Successful	Ball successfully received
8	Successful	Ball successfully received
9	Successful	Ball successfully received
10	Successful	Ball successfully received
11	Not successful	Bouncing ball
12	Successful	Ball successfully received
13	Successful	Ball successfully received
14	Successful	Ball successfully received
15	Successful	Ball successfully received
16	Successful	Ball successfully received
17	Successful	Ball successfully received
18	Successful	Ball successfully received
19	Successful	Ball successfully received

Based on the results of 18 successful passing experiments, the average time for the two robots to make one pass at a distance of 180 cm is 2.44 seconds. Thus, the minimum distance to pass the ball to the robot according to the KRSBI regulations is 100 cm, and the maximum distance for optimal passing the ball is 180 cm. The experiments in this study were carried out in ideal conditions, where the field without the opposing robot team. So the robots can feed each other at a distance of up to 180 cm. Table III is the average time for the robot to successfully receive the ball from the other robots.

TABLE III
TIME PASSING BALL

Experiment	Time (t)
1	3
2	2
3	4
4	2
5	2
6	2
7	3
8	2
9	2
10	3
11	-
12	3
13	2
14	2
15	2
16	2
17	3
18	3
19	2
average value	2.44

IV. CONCLUSION

Based on the testing results, this algorithm has success in feeding 94.7% with a mean time of 2.44 seconds during the experiment 19 times. The proposed algorithm is feasible to apply to the ERSOW Robot. Failure to pass the ball is due to the ball hitting the robot's body to bounces off. Research development is needed to optimize the time of passing the ball

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on the ERSOW robot. As the subsequent development, the time to pass the ball will be optimized.

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Identification of Freshness of Marine Fish Based on Image of Hue Saturation Value and Morphology

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Abstract— Euthynus is one of the fish that is widely consumed for the enjoyment of the people of Indonesia or abroad, because of its very soft quality, easy to obtain, and contains a lot of essential protein amino acids that are good for the body. This research aims to identify the freshness of the fish purchased based on the eyes and fish gills. The initial process of identifying the freshness of fish uses several methods. Image input process through image object taking using a cell phone camera. The image object is used to determine the value of the RGB image object. RGB color extraction clarifies the value obtained from the image object before proceeding to the next process. Image resize is the process of cutting the image on the desired object part. Image conversion using the HSV method was used to determine the freshness of fish in the gills. The Local Binary Pattern method is used to determine the freshness of the fisheye. The next step is to refine the RGB image into Morphology. The KNN (K-Nearest Neighbor Method) method is used to group objects based on learning data closest to the object. The journal analysis results on the comparison of methods, after 45 trials for each method, found that the Hue Saturation Value method obtained the highest success by 90% and for the texture value obtained 85% success.

Keywords— Hue Saturation Value (HSV), Morfologi Local Binary Pattern (LBP), K-Nearest Neighbor (K-NN).

I. INTRODUCTION

The fishery sector in Indonesia especially in North *Sulawesi* is a field that uses a lot of technological sophistication. However, some parts still utilize human assessment to determine the quality of fresh fish. In general, fish traded in a dead state are also often alive. The decrease in fish quality can be seen from the discoloration of fish skin, eyes, gills, and fish meat texture. These changes are caused by enzymes, chemicals, and bacteria's activity so that the fish is not worth trading, let alone consumed by humans [1].

Fish contains many nutrients that are very beneficial for the body, but the fish is sold in a ruined state is also alive. Observing the freshness of selaroides leptolepis fish is done by introducing discoloration in digital imagery using the least-squares method. This research aims to build a management application system of images that can detect the level of *selar* fish freshness.

The data used are ten samples of the fish's image. They were taken every 1 hour for 15 hours, and then obtained 150 image data to processed and analyzed by a method form and displayed in the specified place, and the histogram RGB grayscale. The last process is a calculation with the least square method. In the last operation, we do an image matching test with imagery stored as training data. The conclusions result whether the image (very fresh, fresh, quite fresh, not fresh, or very not fresh), the percentage of desegregation of *selar* fish, and the length of time the fish die. This study used 150 samples of the comb fish's fish image is still very fresh until the fish is not very fresh (rotten). The results showed 125 appropriate imagery, and 25 did not match the percentage of system accuracy of 83.333% [1].

Research related to cob fish has been conducted to determine the quality of frozen cob fish by using the Naïve Bayes method and its color using the HSV method, resulting in the classification of fish quality. The system's products can acquire image data well in lighting conditions under a 5-Watt lamp with a white cloth cover and for hue color information value successfully obtained for all imagery from the implementation test of image processing obtained. Then from the worshiper, Naïve Bayes received the results in the form of an accuracy of 72.727%. The computational time test received an average computing time of 468,864 ms [2].

The next study design system determines the level of freshness of skipjack fish using the Curve Fitting method. Based on digital imagery of fish eyes, based on research has been done detecting skipjack fish's freshness seen from the length of time the fish is at room temperature. The research used ten samples of skipjack fish imagery that taken every 1 hour for 10 hours, obtained 100 image data, and then processed and analyzed by curve fitting method. In the beginning, it was processed with the image processing by cropping the edges of the eyes of the original image and then continued with the equalization of the size (resize) to 1000 x 1000 pixels. Then, change the image format to *.png. After the picture has been processed, the data test results of the

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skipjack fish's images have been for how many hours at intervals of 1-10 hours at room temperature. The result showed that from 100 samples of fish, 83 corresponding images and 17, 83% of them did not match.

Many nutrients are very beneficial for a fish's body, but often fish are traded in a ruined state. By observing the freshness of skipjack fish is done by introducing discoloration in digital imagery using the curve fitting method. This research aims to build an image management application system to detect the level of freshness of skipjack fish seen from the length of time the fish is at room temperature. The data used are 10 samples of skipjack fish imagery taken every 1 hour for 10 hours and obtained 100 image data, and then processed and analyzed by curve fitting method. The first process begins with the image processing by cropping on the edge of the original image's eyes and then followed by equalizing the size (resize) to 1000 x 1000 pixels and changing the image format to *.png. After the image has been processed, then calculate the average value of RGB using the application system.

Furthermore, the curve fitting method so that polynomial regression equations are used to calculate and obtained as the basis of the application system. The last process conducted an image matching test with imagery stored as training data and obtained conclusions whether the skipjack fish's image has been for how many hours at room temperature at intervals of 1-10 hours. This study showed from 100 fish samples, 83 corresponding images, and 17 did not match the system's accuracy by 83% [3].

Research related to fish eyes has also been conducted to determine the quality of fish. This research aims to classify the freshness of fish that focuses on fish eyes and gills with RGB method used to find RGB value of the fisheye and gill image and Fuzzy Logic method used for a determination process image classification. In this study, there were still 44% errors in output at the time of system testing. Fish Freshness Determinant Image Processing is an image processing technology used to determine the quality of freshness of fish seen from fish gills by using an image or image of fish gills. This technology can be used for the public who want to know the quality of fresh fish that will be bought or that will be processed before consumption to get good nutrition for body tissues. The system consists of six main stages. The first thing that is done to determine the freshness of fish is to change the image or image of the gills to the HSV color model (Hue, Saturation, Value). The second step is done Morphological process consisting of Opening and Closing. The third step is Segmentation Color and Remove Small-Object to get the binner value and remove the smallest object around the gill object you want to crop. This section is intended to make it easier to distinguish Foreground and Background from gill imagery. The fourth step is the Object Detection process, where this section aims to determine where the values of the upper, lower, and right-left borders for later cropping: step five cropping and Fuzzy Logic. Cropping is the process of cropping an image only on the desired image object. The Fuzzy Logic process is intended to export color characteristics for the operation of image recognition with existing samples for later determining the quality of freshness of fish. And the last or sixth step is a process with the NN (Nearest Neighbor) Method to classify objects based on learning data that is closest to the object [4].

Furthermore, research determines the freshness of fish seen from the gills. Freshness fish is an image processing technology used to determine the quality of freshness of fish seen from fish gills by using an image or image of fish gills. By changing the image or gill image to HSV color model (Hue, Saturation, Value). The second step is done Morphological process consisting of Opening and Closing. The third step is Segmentation Color and Remove Small-Object to get the binner value and remove the smallest object around the gill object you want to crop. This section is intended to make it easier to distinguish Foreground and Background from gill imagery. The fourth step is the Object Detection process, where this section aims to determine where the values of the upper, lower, and right-left borders for later cropping process: step five cropping and Fuzzy Logic. Cropping is the process of cropping an image only on the desired image object. The Fuzzy Logic process is intended to export color characteristics for the operation of image recognition with existing samples for later determining the quality of freshness of fish. And the last or sixth step is to proceed with the NN (Nearest Neighbor) Method is used to classify objects based on learning data closest to the object [5]. Identify Formalized Raw Fish Using HSV Value and Artificial Neural Network Learning Vector Quantization (LVQ) From Raw Fish Imagery. The research was conducted using HSV Imagery (Hue- Saturation-Value) and in the results obtained, the success rate for fish imagery of 42 fish imagery can recognize very well up to 50% [5].

Determine the quality of fish meat through the eyes of fish. The study uses image processing with image acquisition stages, preprocessing using contrast stretching, cropping, and scaling. At the extraction feature stage using HSV and Grayscale. Classification process using Fuzzy Logic algorithm. This study using 50 fish samples consisting of three types of fish. The classification process's result with the accuracy of the overall system in bloated fish is 93%, milkfish is 89%, and

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cob fish is 88%. The result of a classification of the freshness of fish meat using fish eye image based on fuzzy logic method has good results [6].

One of the superior and popular fruits is Apples. They have many varieties that can be distinguished by the color and shape. The Hue Saturation Value (HSV) and Local Binary Pattern (LBP) features were used in this study as the extraction of color and shape features in the fruit, which would later be used as a feature of the color shape of the apples to be studied. The K-Nearest Neighbor (K-NN) is one of the methods of artificial intelligence used in this study to classify the values obtained from the extraction of HSV and LBP features. The study uses 800 images, consisting of 600 trained images and 200 test images. The results of evaluation obtained from the K-Nearest Neighbor method overall show that the average precision value can be 94%, 100% for recall, and 94% for accuracy [7].

KNN method makes it easier to detect the texture of fish that is still fresh or not for consumption, and the detection results are faster. To produce efficacy using the KNN method. Researchers will develop a research method to identify sea fish's freshness based on hue-saturation value and morphology image using an application system based on previous research. This application is used to minimize the choice of sea fish that is still good for consumption and facilitate the community in the use of the application. The implementation of KNN for image processing is used to classify the size of chicken eggs with an accuracy value of 88.8% [8] and for fruit type recognition based on the Lab Colour Feature and the Co-Occurrence Texture with an accuracy value of 92% [9].

Research on Signature Image Identification using Local Binary Pattern on android-based smartphones. The system uses the Local Binary Pattern (LBP) method as its feature extraction and Manhattan Distance as its introduction. The LBP operator is a texture descriptor that uses a grayish value comparison of the neighboring pixels. The collection of training data is carried out by doing 10 times the data collection of 50 participants with the number of training data as many as 500 samples. The test was conducted 5 times per participant with an average test result of 80.8% and the highest test of 94% [10].

Food research on Food Image Classification system Using HSV Color Moment and Local Binary Pattern with Naïve Bayes Classifier. From the results of the study, the extraction of features from each image was then carried out classification using Naïve Bayes Classifier. Based on test results if only using the HSV method produces an accuracy value of 65%. Also, the results of tests conducted using the HSV method resulted in 65% accuracy and the LBP method resulted in 60% accuracy [11].

Image color segmentation with Hue saturation Value color detection to detect objects. Based on the test results from the analysis, it was concluded that user control in terms of color sample determination and color tolerance played an important role in the segmentation process. The object detection process will process the color segments generated by the segmentation process so that it can be known how many objects are detected, the area, and the center point of each object [12].

Furthermore, research on Detection of Freshness of Milkfish Based on Digital Image Processing. milkfish freshness detection system based on digital imagery, used fish head image, especially the eye area. The image of the milkfish's eye is extracted in the RGB color space by taking the red color. The color red according to the human eye is the value of channel R is higher than channel G or B. White color visible to the human eye also has a high value of channel R but appears as white because it has a high channel value of G and B as well. So that the red color value used is the difference between the color R and the color G and B in the input image. The result of the addition of milkfish imagery forms a vector of features that will later be included in the SVM. This research trial uses the imagery of android device camera acquisition results. The image resolution used is 4000 x 3000. SVM kernel used is RBF kernel with a parameter value of gamma 0.1, error 0.1, and degree of 1. The test results showed an accuracy of 98.2% [13].

Implementation of digital image processing for the detection of fish freshness using android devices, In the research of milkfish freshness detection system based on digital imagery, used fish head image, especially the eye area. The image of the milkfish's eye is extracted in the RGB color space by taking the red color. The color red according to the human eye is a higher value of channel R than channel G or B. White color visible to the human eye also has a high value of channel R but appears as white because it has a high value of channel G and B as well. So that the red color value used is the difference between the color R and the color G and B in the input image. Before entering the feature extraction, the background image of milkfish is given green color using the masking technique. The purpose of masking is to facilitate the process of extracting features. The extraction of milkfish imagery forms a feature vector that will be included in the Support Vector Machine (SVM). This research trial uses the imagery of android device camera acquisition results. The image resolution used is 4000 x 3000. SVM kernel used is RBF kernel with a parameter value of gamma 0.1, error 0.1,

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and degree of 1. The test results showed an accuracy of 98.2% [14].

Then the milkfish freshness detection system uses imagery, the research aims to find the best solution in checking the freshness of milkfish in small and medium enterprises. The technique of checking the freshness of milkfish so far is still determined using microbiological and chemical analysis. This technique is considered less appropriate because, in addition to requiring a lot of human energy that is vulnerable to making mistakes and physical fatigue, it also requires a large cost and a long time, thereby affecting the production of milkfish. This research proposed an image processing method with the technique of finding the difference of values R, G, B in the reference image (trained) with input image (test) for the next value of the difference is calculated by the equation Euclidian (Length) and compared with the threshold value (T). The reference data used is 5 fresh milkfish, so that the reference image is generated at the position of R = 160, G = 35, B = 35, and threshold = 55. From testing of 10 fresh milkfish resulted in a detection value of 100%, and testing of 10 fresh milkfish resulted in a detection value of 80%. And has been tested the results of fishermen's observations and freshness detection tool banding fish against 30 samples of fresh fish, then produced a fresh fish detection value of 100% to the observation of fishermen [15].

II. RESEARCH METHODOLOGY

The discussion of this paper uses research methods in Figure 1. After taking the image, the first process of research flow of image input and gills on cob fish has done imagery with RGB process on the image object to be processed.

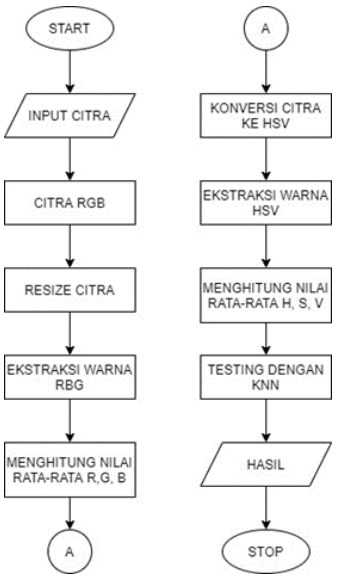

Figure 1. Research Flow of Fish Freshness Identification Based on HSV Image and Morphology

The Resizing an image on the part of the object that will be done research object after it is done the extraction process of image color with RGB color, after doing the RGB color extraction process than from the image object is calculated the average value of R-value, G, B. after knowing the RGB value of the image object. The process continued using hue saturation method Value (HSV), after doing the HSV process then proceeds to the Morphological method to refine the results of the image process, after everything is done experiments then the results of the experiment using the KNN method will know the results of the image object that is examined.

A. *Parameter Freshness of Fish*

Based on its freshness, fish can be classified into four quality classes. Namely, fish whose freshness level is excellent (prime), fish whose freshness is good (advanced), fish whose freshness is backward (medium), and fish that are no longer fresh (rotten). As soon as the fish dies, changes will lead to decay caused by bacterial activity—chemical changes caused by enzymes and airborne fish's oxidation process [1].

B. *Image Processing*

1) Input Image: This study using sample data of 50 fish, each photographed on the eyes and gills. Digital image of fish obtained by RGB color model (Red, Green, Blue), PNG (Portable Network Graphics) extension input and displayed in the form of matrix m x n, according to the size of the image fisheye.

2) Cropping Image: After the fisheye's digital image with the color model of RGB with the extension JPG (Joint Photographic Expert Group), we managed to input. We did cropping imagery on the edge of the fisheye and stored it with png-extension image format (Portable Network Graphics), then obtained cropping image results.

3) Resize Citra: The matrix reading process will produce a digital image matrix with pixel values between 0 - 255 and different image sizes in the RGB color dimensions, making it easier for the next process. It is necessary to resize the process to equalize all digital imagery sizes with the command 'imresize'.

4) Convert RGB to HSV: The resized RGB matrix image is converted to a grayscale image matrix using the "RGB2gray" command so that the image is obtained with the grayscale image color model [1].

C. *Digital Image*

Mathematically the light intensity function in a two-dimensional field is symbolized by $f(x, y)$, which in this case (x, y), is the coordinates on a two-dimensional field, and $f(x,$

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y), is the intensity of light (brightness) at the point (x, y). Light is a form of energy, and it is not so that the intensity of light is worth 0 to infinity. To be processed with a digital computer, an image must be represented numerically with discrete values. Digital images whose size is N x M are commonly expressed with a matrix that is N rows and M columns based on equations (1).

$$f(x,y) = \begin{bmatrix} f(0,0) & f(0,1) & \dots & f(0,M-1) \\ f(1,0) & f(1,1) & \dots & f(1,M-1) \\ \vdots & \vdots & \ddots & \vdots \\ f(N-1,0) & f(N-1,1) & \dots & f(N-1,M-1) \end{bmatrix} \quad (1)$$

The row index (1) and column index (2) represents a coordinate of the point on the image, while f(1, 2) is the intensity (degree of grayness) at the point (1, 2). The matrix form of Equation (1) above can be based on Equation (2).

$$A = \begin{bmatrix} a_{0.0} & a_{0.1} & \dots & a_{0.M-1} \\ a_{1.0} & a_{1.1} & \dots & a_{0.M-1} \\ \vdots & \vdots & \ddots & \vdots \\ a_{N-1.0} & a_{N-1.1} & \dots & a_{N-1.M-1} \end{bmatrix} \quad (2)$$

Where, $a_{i,j} = f(1, 2)$, so that the matrix in Equation (1) is the same as the matrix in Equation (2) [1].

D. Cropping

Cropping is the processing of imagery to cut one part of an image based on an equation (3).

$$\begin{aligned} &X2 = X - XL \text{ UNTUK } X = XL \text{ SAMPAI } XR \\ &Y2 = Y - YT \text{ UNTUK } Y = YT \text{ SAMPAI } YB \end{aligned} \quad (3)$$

where, (xL,yT) and (xR,yB) are the coordinates of the upper-left corner and lower-right corner of the crop image The image size becomes w2 = xR – xL dan H2 = yB –YT [3].

E. Digital Image Elements

The image contains some basic elements. The basic elements are manipulated in image processing; they are [16]:

- Color is felt by the human visual system against the wavelengths of light reflected by objects. The wavelength is a property of color. The color received by the eyes is the result of a combination of light with different wavelengths. Color combinations that give the widest range of colors are red (R), green (G), and blue (B).
- Brightness is also called light intensity. The brightness of a pixel (dot) in an image is not a rill intensity but is the average intensity of an area surrounding it.
- Contrast reveals the spread of light and dark in an image. Images with low contrast are characterized by most of the image's composition is light or mostly dark. On images with good contrast, dark and light compositions are evenly distributed.
- Contour. Contour is a state caused by a change in intensity in neighboring pixels. Due to changes in intensity, the human eye can detect the edges of objects in the image.
- The shape is the intrinsic property of a three-dimensional object, with the understanding that shape is the main intrinsic property for the human visual system. In general, the image formed by the eye is two-dimensional, while the object seen is generally tri mantra (three-dimensional). Object shape information can be extracted from the image at the beginning of pre-management and image segmentation.
- The texture is defined as the spatial distribution of grayish degrees within a set of neighboring pixels. So texture cannot be defined for a pixel. The human visual system receives image information as a whole. The observed image resolution is determined by the scale at which the texture is perceived.
- Time and Movement. The response of a visual system applies not only to the space factor but also to the time factor. For example, if still images are displayed quickly, they will see a moving image.
- Detection and Introduction in detecting and recognizing an image, it turns out that human visual systems work and involve human memory and thinking.

F. Hue Saturation Value Image (HSV)

HSV images define a color space (or sometimes called a color system or color model) as a cardinal system specification and a subspace in that system. Each color is expressed with a single dot in it. The purpose of the formation of color space is to facilitate the specification of color in the form of a standard. The most recognized color space on computer devices is RGB, which corresponds to the human character in capturing colors in Figure 2.

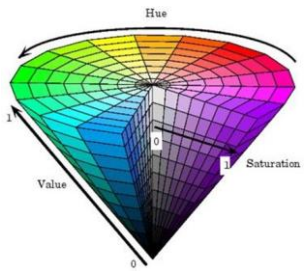

Figure 2. Color Space Hue Saturation Value

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There are several ways to get grades H, S, V based on R, G, and B. Simple way, according to Acharya and Ray, based on equations (4)(5)[16].

$$S = 1 - \frac{\min(R,G,B)}{V} \quad (4)$$

$$V = \frac{R+G+B}{3} \quad (5)$$

G. Morfologi Image

Morphological operation is an image processing technique based on the form of segment regions in imagery. Because it is focused on the object's shape, this operation is usually applied to binary images. Usually, that segment is based on an object of concern. Segmentation can be done by distinguishing between objects and backgrounds. Then, by utilizing a development operation that converts color imagery and grayscale into binary imagery. The binary value of the resulting image represents 2 circumstances: object and not object (background). Although it is more widely used in binary imagery, morphological operations are often used on grayscale images and colors. The morphological operations result can be utilized for decision-making with further analysis. These operations consist of Dalasi, Erosion, closing, and opening [16].

Dilation operations Are performed to increase the segment size of the object by adding layers around the object. There are 2 ways to perform this operation: converting all the background points adjacent to the border point into object points or more easily set each point whose neighbor is the object point to be the object point. The second way is to turn all the points around the border point into object points, or more easily set all the neighboring points of an object point into object points based on equations (6) [16].

$$g(x,y) = f(x,y) \oplus \mathrm{SE} \quad (6)$$

Erosion operations are the opposite of dilation operations. The size of the object is reduced by eroding the object surroundings in this operation. The way that can be done there is also 2. The first way is to turn all border points into set points, and the second way by setting all the points around the background point to the background point based on Equation (7) [16].

$$g(x,y) = f(x,y)\theta SE \quad (7)$$

The opening operation is a combination of erosion and dilation operations performed sequentially, but the original image in the erosion first only then the results are dilation. This operation is used to disconnect parts of an object that are connected with only 1 or 2 dots, or eliminate small objects and generally remove the boundary of a large object without significantly changing the object area. The opening is an idempotent based on an equation (8) [16].

$$f(x,y) \cdot SE = (f(x,y)\theta SE) \oplus \mathrm{SE} \quad (8)$$

Closing operations are a combination of dilation and erosion operations performed sequentially. The original image is dilated first. Then the result is erosion. This operation is used to close or eliminate small holes present in an object's segments, merge adjacent objects, and generally smoot large objects' boundaries. It is done without changing the object significantly, based on Equation (9) [16].

$$f(x,y) \blacksquare SE = (f(x,y) \oplus SE)\theta SE \quad (9)$$

The result of the opening process is smoothing the boundaries of the object, separating the objects' boundaries, separating the objects that previously went hand in hand, and disappearing the objects that are smaller than the size of the structuring. The closing process tends to smooth the object to the image but by connecting the fragments and eliminating the object's holes. Because the Morphological process used only the opening process to smooth the results of objects that have been processed by using several previous methods. Closing Operation is carried out by performing dilation surgery first and then followed by an erosion operation.

H. Local Binary Pattern (LBP)

Local Binary Patterns (LBP) is one of the algorithms used to extract image texture features that use statistics and structure. Timo Ojala first introduced the LBP method. The LBP operator uses a grayish value comparison of the neighboring pixels. Local Binary Patterns is a method of extracting texture features that are rotation invariant. Lbp value itself is based on the thresholding process then the value is multiplied by the binary weight. For example, sampling points P=8 and radius R=1, LBP value calculation is shown in Equation (10).

Threshold				*Bobot*				
5	9	1	1	1	0	1	2	4
4	4	6	→ 1		1	128		8
7	2	3	1	0	0	64	32	16

(10)

Where looking for the value of LBP can be seen in Equation (11) [10]. With variables *xc*, *yc*: central pixel point, *p*:circular sampling points, *P*:j number of sampling points, *gp*:the

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grayscale value of p, gc:pixel center, and variable s : threshold function.

$$LBP_{p,R}(x_c, y_c) = \sum_{p=0}^{p=1} s(9p - 9c)2^p$$
$$s(x) = \begin{cases} 1, x < 0 \\ 0, x \geq 0 \end{cases} \quad (11)$$

I. Convert RGB to HSV

Algorithm HSV (*Hue, Saturation, Value*)

- Take a value on each pixel of a colored image (R, G, B).
- Normalize RGB with equations (12).

  r= R/(R+G+B) (12)
  g= G/(R+G+B)
  b= B/(R+G+B)
- Converging normalized RGB values into HSV color spaces based on equations (13).

$$V = \max(r.g.b)$$

$$H = \begin{cases} 0 & jika\ S = 0 \\ \frac{60(g-b)}{SV} & jika\ V = r \\ 60\left[2 + \frac{(b-r)}{SV}\right] & jika\ V = g \\ 60\left[4 + \frac{(r-g)}{SV}\right] & jika\ V = b \end{cases}$$

$$H = H + 360 \qquad Jika\ H < 0 \quad (13)$$

$$h\,(hue) = \begin{cases} 0, & jika\ \max = min \\ 60^0\ x\left(\frac{G-B}{\max - min}\ mod\ 6\right), & jika \max = R \\ 60^0\ x\left(\frac{B-R}{\max - min} + 2\right), & jika \max = G \\ 60^0\ x\left(\frac{R-G}{\max - min} + 4\right), & jika \max = B \end{cases}$$

- Repeats in step 1 against all pixels on the image. The following is the process of converting RGB to HSV if written in the form of equation (14) Normalization of RGB:

$$r = \frac{R}{255};\ g = \frac{G}{255}\ ;\ b = \frac{B}{255} \quad (14)$$

Transformation of RGB to HSV, V = max (r, g, b) based on equation (15).

$$S = \begin{cases} 0 & jika\ V = 0 \\ 1 - \frac{\min(r,g,b)}{v} & jika\ V > 0 \end{cases} \quad (15)$$

$$V = max$$

Values for s and v in HSV are defined in Equation (16).

$$s = \begin{cases} 0 & ,jika \max = min \\ \frac{\max - \min 0}{V} & ,otherwise \end{cases} \quad (16)$$

J. Segmentation Process

Segmentation algorithm that is:

- Check the value of each pixel that has been converted to HSV.
- Deploy thresholding value span *H*>254.
- Suppose the value is between the ranges between thresholds. In that case, the image is the foreground. Suppose the value generates the range with the object value. Why infer the resulting foreground because the threshold result is greater than the foreground result, so if the value is less than 254, then read with the value foreground.
- Repeat step 1 against all pixels on the image.

K. Character Extraction

For the color in the search by dominant color such as red or green can be done every pixel that the imaging system must be maintained into red or green. This can be done if the color space used is HSV. In the HSV system, the hue component expresses color as commonly understood by humans.

feature Extraction Based on Color, Shape, and Texture for Animal Image Retrieval. Under the supervision of *SONY HARTONO WIJAYA*. The differences in color, shape, and texture characteristics between each animal cause difficulties in animal image retrieval. Therefore, a specified technique is needed to obtain patterns from each animal s feature so that image retrieval might works properly. One of the techniques to obtain the pattern done by feature extraction. This research tries to develop an image extraction method in a Content-Based Image Retrieval approach by using three image visual features (color, shape, texture).

In this research, a Fuzzy Color Histogram (FCH) for color feature extraction is used through computing the membership function using the Cauchy function. In FCH, one color may belong to two bins histogram or more with different membership functions. Then, the shape feature is extracted using edge direction histogram, where each image is processed using Sobel edge detection, and then the direction is

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mapped into a defined bin histogram. For texture feature extraction, the process uses a co-occurrence matrix by computing the values of energy, moment, entropy, maximum probability, contrast, correlation, and homogeneity. Similarity value between image query and images in the database is computed based on its features, those are color, shape, texture, and its combination. Recall and precision value resulted in this research shows the largest average precision value is obtained from a searching process using index combination (color, shape, texture) of feature extraction. Keywords: feature extraction, Fuzzy Color Histogram, edge direction histogram, co-occurrence matrix iii [17].

L. Object Detection

The detection process of this object is shown to get the location of the value of the upper, bottom, right-left border on the object for later cropping.

M. K -Nearest Neighbor (K-NN)

KNN is one of the Instance-Based Learning group. NN is done by looking for groups of objects in the training data closest (similar) to objects in new data or data testing. This technique is very simple and easy to implement. Learning data can be projected into multiple-dimensional spaces. Each dimension represents a feature of the data [4]. The beginning of the program design process that will be made has been determined by using the KNN method to know the research object's classification results. The process does not eat a short time and produces an accurate object. Define between two distances of points in data training (x) and points in data testing (y). Euclidean formulas are used based on equations (17).

$$d(x,y) = \sqrt{\sum_{i=1}^{n} f(\text{xi:yi}) - (wi)^{\ 2}} \qquad (17)$$

III. RESULT AND DISCUSSION

The research data used as data on the freshness level of cob fish is in the eyes and gills of fish, amounting to 80 data on cob fish's eyes and gills—examples of digital imagery of fish eyes and gills on Figure 3.

Figure 3. image of the eyes and gills

The freshness detection process results such as Figure 4 of the eye and gill processes of cob fish were successfully processed and obtained an image comparison that is most similar to that to be tested. Describe in the form of a type of freshness of fish displayed on the bottom right, while for the image of gills located on the bottom left is a picture of gills that have been trained.

Figure 4. Examples of System Test Results

The experiment identified the freshness of sea fish by using 2 objects, namely eyes and gills, in the training data did 7 or up to 8 times to be able to get accurate test data with results that can be ascertained matched with expert results, if the results of the system declared fresh. Experts declared fresh. Then the system is declared correct and vice versa if the system states not fresh, experts declare not fresh, then the system is declared valid if the results are both inaccurate, then the results are declared invalid. The training data was conducted using 45 image objects and testing using 30 times but included in the report only 7 experiments between the eyes and gills of fish.

In the experiment, many obstacles can lead to inaccurate results. In the taking of image objects, the user may be less focused when taking objects. It will get inaccurate results. Test results of training data on the system of identification of freshness of sea fish, especially in cob fish test results as below.

Cob Fish Eye Test data in Table I, where the data only testing results in the table below states the image of the test data of each object is different not only by using 1 object with each experiment different each object, the results of the study if the system with experts declared fresh then the accuracy is declared valid but from the results of the system experiments and experts are not the same then the results of accuracy is declared invalid.

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TABLE I
FISH EYE DATA TEST

Image Data Test	Fish Gill Characters	Training	Experts	Accuracy
Insang_ikan1	Fresh	4	Fresh	Valid
Insang_ikan2	Fresh	5	Not Fresh	Not Valid
Insang_ikan3	Fresh	4	Fresh	Valid
Insang_ikan4	Not Fresh	4	Not Fresh	Not Valid
Insang_ikan5	Not Fresh	5	Fresh	Not Valid
Insang_ikan6	Not Fresh	3	Not Fresh	Valid

Cob Fish Gill Test data in Table II is the same as the previous test data in the eye but this object is used for the gills of cob fish.

TABLE II
FISH GILLS DATA TEST

Test data image	Fish Eye Character	Trial	Expert	Accuracy
Mata_ikan1	Fresh	7	Fresh	Valid
Mata_ikan2	Fresh	8	Fresh	Valid
Mata_ikan3	Fresh	7	Fresh	Valid
Mata_ikan4	Fresh	7	Fresh	Valid
Mata_ikan5	Segar	8	Segar	Valid
Mata_ikan6	Not Fresh	3	Not Fresh	Valid
Mata_ikan7	Not Fresh	3	Fresh	Not Valid

IV. CONCLUSION

Based on the experiment results, the authors found 20 invalid data from the 45 RGB experiment, 10 invalid data from 45 HSV color experiments, and 15 invalid data from 45 texture experiments using the Local Binary Pattern (LBP) method. Therefore, the result of the research obtained the least in the error rate is HSV Imagery. In the process of comparing methods after 45 experiments on each image object and using the same method, it was obtained that the Hue Saturation Value method achieved the highest success of 90%. For the texture, a value obtained 85% success. Identification of Freshness of Sea Fish based on HSV Imagery and Morphology has the highest accuracy using HSV color extract because the color extraction can detect from gradation of black to white color. Capture image objects more accurately and makes the desktop design even better to be used properly. Taking more methods needed to be processed because of the number of methods listed in the system, so the process is relatively slow.

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Usability Analysis of Website-based Applications by Adopting User Satisfaction Models

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Abstract— Technological developments in supporting and assisting all human work activities are felt to be equally beneficial. *Shirouoshien* is a business that is engaged in commerce and offering products that it sells to its customers. *Shirouoshien* uses a website-based application to promote products more efficiently. Evaluation of the *shirouoshien* application aims to find out how the usability of the website is for users. In general, the criteria that determine that a website is usable (has a high level of usability) is if users can find and get what they need and understand from the *Shirouoshien* website. The main problems to be examined in this study then the problem will be broken down into several. The main issues need to be considered in the usability analysis of website-based applications, variables that influence user acceptance of the application in the usability framework, and factors that describe the acceptance and use of website-based applications. In general, through analysis of the usability aspect in the next development plan framework, this application still needs further improvement and development to meet customer needs regarding products and product promotion. The results and general discussion through usability aspect analysis in the next development plan framework still need further improvement and development to meet customer needs related to products and product promotion.

Keywords— Usability Analysis, Website-Based, User Satisfaction Model.

I. INTRODUCTION

Technological developments in supporting and assisting all human work activities are felt to be equally beneficial. Technology is one of the information media needed in human life to get faster and more precise information. As an information medium, it cannot be separated from the need for an internet network. The internet is a network that unites the network to communicate, exchange information in the form of files, videos, sound, and so on [1]. One of the benefits that can be felt from technology support is in websites [2].

Use of the website as a forum for sharing information, sharing events that occur, job information, etc. Companies use Web-based applications to support company activities or get the information needed [3]. A website is a medium widely used to disseminate information and promotion widely in a company [4]. *Shirouoshien* has a website address www.*shirouoshien*.com, a website that utilizes technology to disseminate information and promotions that can provide great benefits for owners and users because it can be accessed anytime and anywhere online that users can quickly obtain information and can access from anywhere and anytime. The website will provide online services to users rapidly as expected by information users.

The *shirouoshien* website includes information about products sold and ongoing promotions in the *shirouoshien* business. What is shared are product prices, product photos, product descriptions, product types and colors, ordering methods, transaction methods, etc.[5]. This is so that users get accurate information in accessing the latest things from *Shirouoshien* so that users do not have to wait or confirm to the admin about the availability of goods.

The making of the website application has been completed, and to determine the quality of the information system, it is necessary to measure its usability [6]. Usability is the quality level of a system that is easy to learn, easy to use, and encourages users to use it as a positive tool in completing tasks [7]. Evaluation of the *shirouoshien* application aims to find out how the website's usability is for users [8].

In general, the criteria that determine that a website is usable (has a high level of usability) is if users can find and get what they need and understand from the *Shirouoshien* website. To make it easier to understand the main problems, examine what aspects need to be considered in website-based applications' usability analysis. What are variables that influence user acceptance of the application in the usability framework? How do these factors describe the acceptance and use of web-based applications?

The formulation of the problem is intended to determine what aspects need to be considered in developing website-based applications, Knowing user acceptance of the *Shirouoshien* application in the usability framework, knowing how the variables are connected with the user's approval of the application based on the *shirouoshien* website. Usability is defined as optimizing the interaction between the user and the system that can be done interactively to get the right information or complete an activity in the application better. A website-based application is to be more effective, efficient, and can allow users to complete their activities in the application.

II. RESEARCH METHODOLOGY

Usability in testing an application based on the *Shirouoshien* website is survey research. Survey research is

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research that takes samples directly from the population [9]. Judging from the problem, it aims to analyze the relationship and influence (cause-effect) of two or more phenomena through hypothesis testing. The research model used is a research model Green and Pearson [10] shown in Figure 1 described in the research model Green and Pearson.

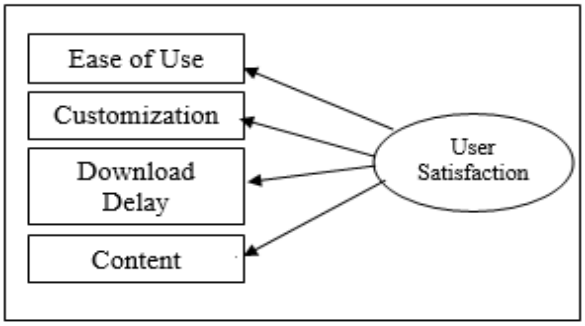

Figure 1. Research Model Green and Pearson

Research subjects are application users who have purchased and used application services [3]. The sample is an element of the population chosen to represent the study population [11]. Sampling used the random sampling method, namely sampling that provides an equal opportunity to be taken to each population element [8]. This method also uses criteria for the sample. The criteria set are people who have access rights to the application in login data and the *shirouoshien* website's password.

The data collection method is done by using a questionnaire survey method for application users [9]. Surveys are conducted to obtain feedback on user perceptions of the application. The data used in this is primary data [12]. Primary data is data obtained directly from online questionnaires on the website [13]. The application is used as a promotional medium and distributes questionnaires to the samples in this data collection.

The sample size is adjusted to the analysis model used, namely *Structural Equation Model* (SEM) [14]. In this regard, the SEM sample size is 100-120 samples or as much as 5-10 times the estimated number of variables. Therefore, the required number of respondents should be 120 respondents. A variable is something that differentiates or varies the value [15]. The value can be different at different times, even if it is aimed at the same object or person. Following the analysis model used is the Structural Equation Model (SEM). The variables used include exogenous variables, indicator variables, and endogenous variables as described in Table I. Definition of Variable Constructs Research is a table that describes the indicators of each variable construct in Table I.

TABLE I
RESEARCH VARIABLE CONSTRUCT DEFINITION

Construct	Indicators	Code
Ease of use	Serving structure	XI
	Ease of access	X2
	clarity of presentation of information	X3
Customization	Interesting material	X4
	Personalization	X5
Download delay	Speed of finding information	X6
	Control over material	X7
Content	Information specifications	X8
	Fulfillment	X9
	Sufficiency of material	10
Satisfaction	Convenience	Y1
	Continue to access the website	Y2

The main instrument is a questionnaire [10]. Measurement of variables is carried out using a Likert scale, namely the scale used to measure attitudes, opinions, and perceptions, according to the equivalent of giving a score to each alternative answer [6]. The measurement procedure is that respondents are asked to state their agreement based on each respondent's perceptions. The answer consists of seven choices, namely: Vey Strongly Disagree (VSD), Strongly Disagree (SD), Disagree (D), Neutral/No Argue (N), Strongly Agree (SA), Very very Much Agree (VVMA). Filling in the questionnaire form will be associated with the website application database username, so the questionnaire data will not record the results of the questionnaire as valid data. Apart from that, if not all of the customers filled out the questions, the data was considered invalid.

Giving value (scoring) is done for answers strongly agree, a value of 7, and so on decreases until the answer is very strongly disagreed, given a value 1. The weight of the respondents' answers can be seen in Table II.

TABLE II
THE WEIGHT OF THE RESPONDENT ANSWER

Answers	*Abbreviation*	*score*
Very strongly disagree	VSD	1
Strongly Disagree	SD	2
Disagree	D	3
Neutral/no argue	N	4
Agree	A	5
Strongly agree	SA	6
Very very much agree	VVMA	7

III. RESULT AND DISCUSSION

The data collection method using a questionnaire. In this case, the respondent's subject is a *shirouoshien* business customer who buys and needs *shirouoshien* product information. The data collection results are in the form of a questionnaire that has been successfully stored and is suitable for analysis user invalid is 1.5%, incomplete filling questionnaire 4.7% and the questionnaire is eligible 93.8%. For more detailed data, see Table III. The results of data collection.

TABLE III
THE RESULTS OF DATA COLLECTION

information	Total	%
A questionnaire with *user* invalid	5	1.5
Incomplete filling questionnaire	16	4.7
The questionnaire is eligible	319	93,8
Total	**339**	**100**

The number of questionnaires distributed to *shirouoshien* business customers obtained questionnaire data with many invalid users 5 (1,5%) invalid after as many username and

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passwords 16 (4,7%) incomplete and the rest 318 (93,8%) filling is complete. This data can be made into a flowchart (path diagram) of the quality relationship between the construct and its indicators. The path analysis was developed to study the effect of the independent variable's direct and indirect effects on the dependent variable. The path analysis used is illustrated in Figure 2 Path analysis.

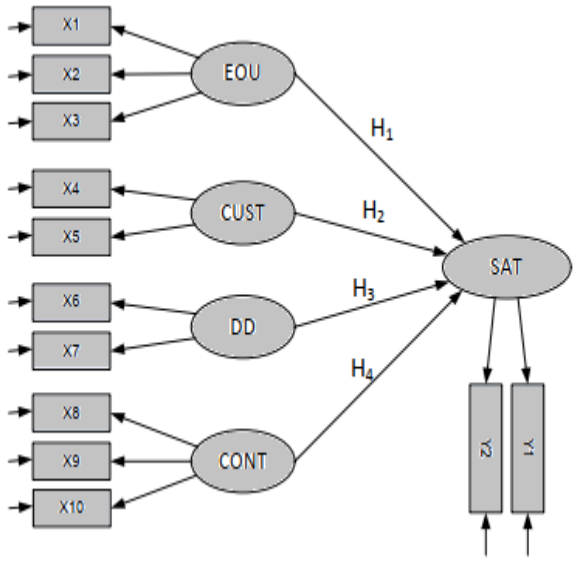

Figure 2. Path analysis

A good model is influenced by the indicator validity and construct reliability. Therefore, it is necessary to test the validity and reliability of the model from the data obtained. Based on the formation of the structural equation, the following is a measurement model. The application used is a LISREL application that is intended for modeling calculations, including structural equation modeling, multilevel structural equation modeling, multilevel linear and nonlinear models, and so on. The data that has been obtained from the survey results are then entered into the measurement model as a theoretical basis for measuring user satisfaction using the application LISREL 8.80. The validity testing is used to identify that unobserved variable through confirmatory factor analysis (CFA). If the value *factor loading* of each construct more than 0,5 (λ > 0,5), then declared valid. The estimation results in Table IV. Regarding the loading factor of all valid indicators and the model evaluation process can be continued.

TABLE IV
VALUE LOADING FACTOR INDIKATOR

Construct	Kode	Loading factor
Ease of use	XI	0.77
	X2	0.86
	X3	0.73
Customization	X4	0.80
	X5	0.67
Download delay	X6	0,86
	X7	0.71
Content	X8	0.91
	X9	0.91
	10	0.96
Satisfaction	Y1	0.89
	Y2	0.72

Based on the estimates as shown in Table IV. Obtained loading factor data from all indicators is not less than 0.50. thus, all indicators can be declared valid, and the model evaluation process can be continued. The measurement model's reliability is used *composite reliability measure* (composite reliability measure) and *variance extracted measure* (variant extract size).

TABLE V
MODEL RELIABILITY TEST RESULTS

Construct	CR	VE	Explanation
Ease of use	0.8265	0.6146	Good reliability
Customization	0.7061	0.5476	Good reliability
Download delay	0.7621	0.6177	Good reliability
Content	0.9485	0.8599	Good reliability
Satisfaction	0.7807	0.6429	Good reliability

The composite reliability of a construct is calculated as Equation (1)

$$Construct\_Reliability = \frac{(\sum std.loading)^2}{(\sum std.loading)^2 + \sum e_j} \quad (1)$$

Seen the results of the model reliability test in Table V. The results of reliability calculations are obtained *construct reliability* (CR) > 0.7. As for the variant extract, it can be calculated with the following Equation (2).

$$Variance\_Extracted = \frac{\sum std.loading^2}{N} \quad (2)$$

For all value Variance Extracted (*VE*) > 0.50. thus concludes that the reliability of the measurement model (Kontruk) is well based on table V. The goodness index *of fit* can be seen in Table VI. The calculation goodness of fit results index.

TABLE VI
THE RESULT OF GOODNESS OF FIT CONSTRUCT INDEX CALCULATION

Criteria	Result Model	Critical Value	Conclusion
X2 Chi-square	62.26	Small	*Be accepted*
Signifivance probability	0.03620	≥ 0,05	*Pretty goog*
RMSEA			
GFI	0.036	≤ 0,08	Good
AGFI	0.97	≥ 0,90	Good
CMIN/DF	1.1416	≤ 0,90	Good
TLI	0.99	≥ 0,90	Good
CFI	0.99	≥ 0.95	Good

Testing the hypothesis of the structural model that is formed, the coefficient of the relationship between variables is obtained. The coefficient consists of the relationship between the latent variables and the latent variable formation's manifest variables' contribution value. The relationship that occurs in this structural model is the basis for evaluating the

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hypothesis. The significant level of each connection between latent variables is seen from t-value must be greater than 1.96 for positive relationships and less than -1.96 for negative relationships (level of trust α = 0.05). Based on the calculations results, the researcher needs to perform model respecification to improve the data. *Ease of use* application and user satisfaction have the first hypothesis (H1), which reads: ease of use on the application *shirouoshien* website directly influences customer satisfaction.

The results show that operating the *shirouoshien* application (ease of use) does not directly affect the satisfaction (satisfaction) of *shirouoshien* website visitors. The results show that operating the *shirouoshien* application (ease of use) does not directly affect shirouoshien website visitors' satisfaction. In this model, it is also known that the ease of use aspect tends to have a more negative influence on the satisfaction of *shirouoshien* website visitors. So it needs to be understood that visitors to this application website tend to want to find more specific information and do not pay attention in general to the use or operation of the *Shirouoshien* application. The second hypothesis (H2) reads: Customization on the application website directly affects visitor satisfaction. The research results provide information that the website's appearance can be presented in a personal way and different in presentation (customization) between visitors or customers to one another on the *shirouoshien* website.

From the coefficient value on the results of the research model respecifications, it can be seen that the customization aspect explains 16% of the variation in the aspects of application visitor satisfaction. In this model, it is known that the customization aspect tends to hurt visitor satisfaction *shirouoshien* websites. So it can be concluded that further development regarding website-based promotional applications is considering this hypothesis's results. In common language, website visitors are not too concerned with access speed than applications.

Download delay and user satisfaction in the third hypothesis (H3) states that the application process's speed (download delay) on the application website directly affects visitor satisfaction. Based on the value of the coefficient on the results of the research model respecification, it can be seen from the variation in the aspects of application visitor satisfaction that the download delay aspect tends to have a more positive influence on visitors' satisfaction the *shirouoshien* website.

Content and user satisfaction are the fourth hypothesis stating that the content of the material on the shirouoshien website directly affects visitor satisfaction. This aspect explains that the content of the *shirouoshien* website material can contribute to website visitors' satisfaction. From the coefficient value obtained from the model respecification results, it can be seen that the content aspect explains 42% of the variations in the customer satisfaction aspects of this application. It can be seen that the content aspect tends to have a positive influence on customers or website visitors.

IV. CONCLUSION

Based on the results of the analysis above, it can be concluded that firstly, the ease of using the application does not have a direct positive effect on user satisfaction of the *Shirouoshien* website application. Second, display information specifically for each *shirouoshien* website visitor. Third, the speed of data access and processing in applications does not directly affect customer satisfaction. Fourth, the presentation of information related to company product and service rates has an immediate positive effect on customer satisfaction. Fifth, in general, through analysis of the usability aspect in the framework of further development plans, this application still needs further improvement and development to meet customer needs related to products and promotional products.

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Implementation of Multiprocessing and Multithreading for End Node Middleware Control on Internet of Things Devices

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Abstract— Previously, an educational robot system was built by incorporating Internet of Things (IoT) elements. Over time, this educational robot has been implanted with a middleware. Middleware has a role in receiving command data from the real-time database, access sensors, actuators, and sending feedback. Middleware contains protocols that translate commands between high-level programming and Raspberry Pi hardware. The focus of this research is to improve the performance of the middleware to pursue processing time efficiency. For this reason, it is necessary to implement multiprocessing and multithreading in handling several tasks. The CPU division has been adjusted automatically to not work on just one core or block of memory. Several program functions can run in parallel and reduce program execution time efficiently. The tasks handled are sensor reading and actuator control in the form of a motor. Testing has been carried out to perform multiprocessing and multithreading tasks to process six sensors and five actuators. Multiprocessing requires an average of 1.00% to 15.00% CPU usage and 2.70% memory usage. Meanwhile, multithreading involves an average of 1.00% to 71.00% CPU usage and 3.30% memory usage.

Keywords— Raspberry Pi, Internet of Things, Multiprocessing, Multithreading, Middleware**,** Educational Robot.

I. INTRODUCTION

Various aspects of human life have been affected by technological advances that continue to develop so far. The Internet of Things (IoT)[1] is one of the big technological advances[1]. The advancement of the IoT field itself enters the technical or industrial sector, but with the emergence of a development board with such requirements to become a learning module, development in the world of education has also increased. Despite the many historical developments, IoT developers have only one goal, namely to support human life.

Unfortunately, the rapid development of IoT has not been matched by adequate learning methods. At present, the interest in studying the IoT field is very strong, but there is not much software that provides IoT building learning media. It is also hard for beginners who want to learn about IoT to learn the fundamentals of programming comprehension since one of them is a programming grammar that is very hard to understand. In developing your own IoT device, you also need hardware or modules that are not cheap, especially when doing trial experiments and error is possible.

Generally, the IoT infrastructure is designed with the Raspberry Pi [2]. Raspberry Pi is an SBC (Single Board Computer), which in terms of size is practically the size of an ATM card, has a 40-pin GPIO like a microcontroller, has computer capabilities, and is relatively affordable. Middleware can also be built using Raspberry Pi to solve one of the challenges of the industrial revolution 4.0 for controlling electronic devices [3]. This study uses Raspberry as SBC. This is because there is a lot of support from forums for continuous research, the availability of sensor and actuator modules in the open market, and many people have used it for the development of IoT infrastructure.

Applications must pay attention to the needs of the crowd, especially for a beginner who wants to learn about IoT. They need help and explanation regarding the learning process of understanding programming logic in the IoT area. From here on, the author wants to build a Raspberry Pi that can be assembled modularly and operated by ordinary people via the Raspbian OS Interface framework.

This research focuses on designing middleware on educational robots so that it is hoped later to create a protocol for accessing sensors and controlling actuators with commands that have been developed. The software is often used to coordinate embedded system implementations and so that the system works well and can also be timely and effective. In related research [4], middleware is a programming layer that links high-level programming on the Raspberry Pi with block programming.

This programming layer is used based on the user method of interpreting commands with high-level programming, which are then passed on to the middleware sensors or actuators. Based on [5], It is also possible to view middleware as a protocol that translates commands between the Raspberry Pi and high-level programming. The goal of this development is to encourage optimum hardware performance. This research aims to embed the middleware built on the Raspberry Pi in the form of wiring on the GPIO, which is modular.

II. RESEARCH METHOD

A. Middleware for IoT Devices

Research of [6] provides an Information Flow of Things (IFoT) middleware architecture, a system for the collection, interpretation, and mixture of real-time and scalable data based on the sharing of data processing between IoT devices. There are several parameters in the basic definition of IFoT. Each layer of the IFoT middleware has a function:

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1. *Task Allocation Mechanism*: consists of split class and task assignments class. Recipe split class reads recipes between applications and divides them into tasks that can be executed in parallel. Assignments class distributes assignments divided among IFoT modules.
2. *Flow Analysis Function*: consists of learning class, judging classes, managing classes. The learning class analyzes the time series of sensor data, sequentially ordering, and building / updating the model. The judging class analyzes the flow of data using the built model. The managing class manages cooperative operations for distributed processing.
3. *Flow Distribution Function*: consists of a publishing class, broker class, subscribe class. In the IFoT middleware, a publish/subscribe system is adopted to distribute flows between IFoT nodes, which aims to realize loosely coupled flows and scalable messages. The publish class is placed on the sending side, the subscribe class is placed on the receiving side in the communication between the IFoT nodes. The broker class manages the distribution of data according to the topics defined by the subscription class.
4. *Sensor/actuator Integration Function*: consists of sensor class and actuator class. Each class of hardware and sensor/actuator communication interfaces and provides an interface for streaming distribution functions.

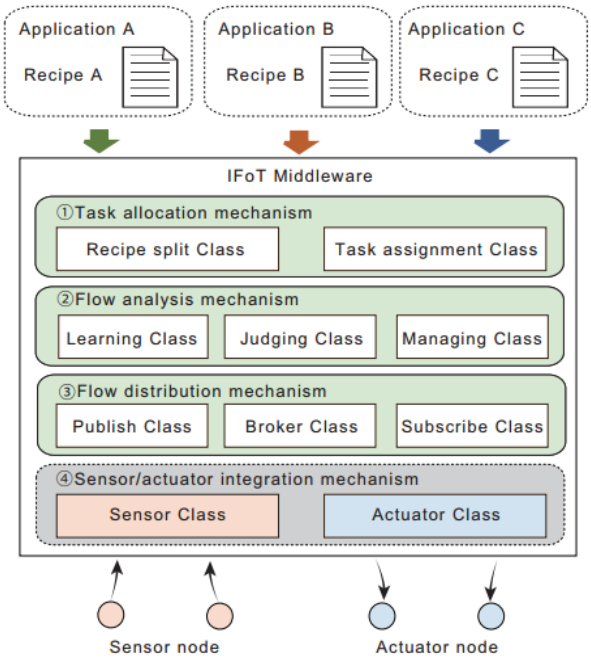

Figure 1. The logic architecture of the IFoT middleware

Figure 1 presents IFoT's logical architecture. Restricted functions, namely the flow distribution function and the flow analysis function, are necessary to implement the IFoT prototype. The first feature is a Mosquitto-built flow propagation function, an application that uses the communication protocol of MQTT. In terms of online machine learning, the flow analysis feature was developed using Jubatus, which has more capabilities. A framework handles any process between many modules. Using OpenRTM-aist, the program was constructed.

B. *Multithreading and Multiprocessing on Python*

Based on [7], a thread is the sequential execution of a program from a machine instruction. A thread can run in parallel with other threads in a process. A process can contain multiple threads. Each thread can execute a set of instructions (a function) independently and run parallel to other processes or threads. To be an active thread that is different in a process, the thread will divide the empty memory address, then share its data structure.

Thread-based parallelism is a standard for making parallel programming. Note that the python interpreter is not completely thread-safe [8]. In python, fully able to use multithreading, it requires a global lock called GIL (Global Interpreter Lock). The essence of GIL is that it can only execute a thread from a python program. A GIL is never enough to avoid the trouble of a program [9]. If multiple threads try to access the same data in an object, the program will terminate in an inconsistent state.

Process-based parallelism is parallel programming that implements the shared memory paradigm. A python program that implements multiprocessing will use one or more processors to access the main memory. In python, multithreading does not require GIL because each process will run on a different CPU to access the main memory. In contrast to multithreading, which uses multiple threads.

C. *Firebase Real-time Database*

Firebase real-time database is a product in the form of a cloud-hosted database from Google [10]. Firebase uses JSON to sync data in real-time whenever a client connects. This study uses the REST API to access the Firebase real-time database URL as a REST endpoint. Firebase allows users to access the real-time database directly from the program on the client and access it securely. The database of the Firebase real-time database is NoSQL[11]. In Firebase, the real-time database API is designed only for operations for fast execution.

D. *System Design*

The architecture starts from giving the system driver instructions that include the class of sensor and actuator. The only way to control sensors and actuators is to give a command line with any declared parameters so that the command can read/write the sensor or actuator. Figure 2 shows the types of sensors and actuators that have been specifically defined in our research middleware system.

There are some key points in applying middleware on the Raspberry Pi, including the reading of the command notation sent and the control over the devices to be used. In the middleware, the processing of incoming data, the translation, the operation of functions to access sensors and actuators as a process or thread is performed. Starting from reading the header and then matching it to the given function code map, each data obtained will be parsed

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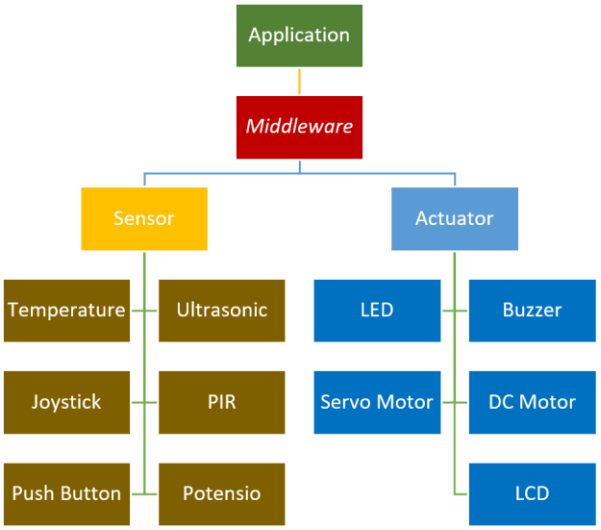

Figure 2. Sensors And Actuators That Can Be Accessed On The Raspberry Pi With Our Middleware Framework

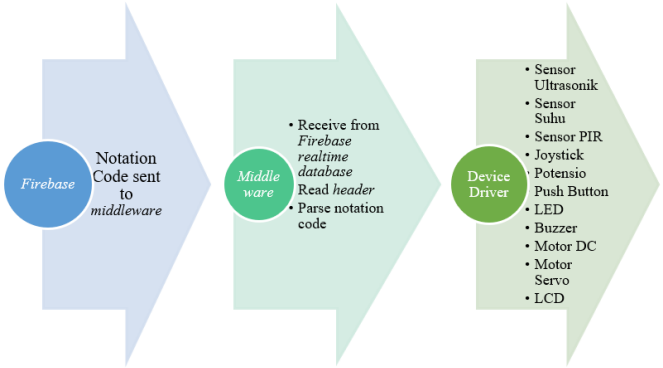

Figure 3. Workflow system

The initial stage in Figure 3 is that the Firebase real-time database's incoming data will be accommodated in a variable first. Next, the Firebase real-time database's data will be parsed with the specified parameters or function code. Each data that is sent is a set of instructions for access sensors or actuators with feature and parameter codes. Each data information structure has the same information structure, but each sensor and actuator incorporate a distinctive number of parameters. Figure 4 is the program code notation for each block.

<header>,<parameter - n>,<parameter - n>,…….<parameter - n>

Figure 4. Program code notation for each block

There are two headers, namely a header for sensors and a header for an actuator. Then followed by several parameters which contain the type of sensor, arguments, and feedback. The ON or OFF state is the next parameter. Where ON is used to activate a sensor or actuator as a process. Meanwhile, OFF is used to deactivate sensors or actuators by stopping the process/thread. There is an additional parameter which, according to its characteristics, functions to access sensors and actuators. Headers and parameters are separated using a comma (","). The temperature sensor access notation parameters are shown in Figure 5.

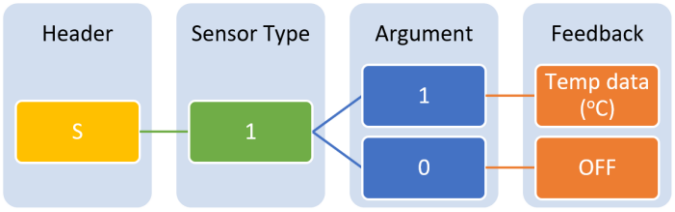

Figure 5. Temperature sensor access notation

The distance sensor's notation is to retrieve and display data in the form of the distance in front of it in centimeters. The following is a notation for retrieving data from a distance sensor which is presented in diagrammatic form shown in Figure 6. The feedback from this notation is the output of the activated distance sensor reading process/thread.

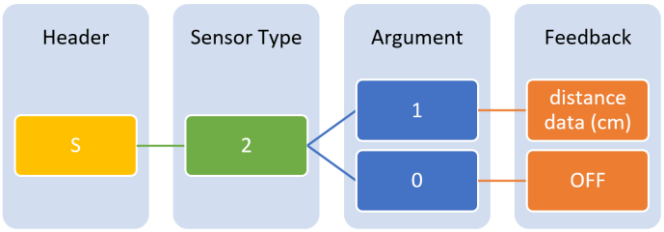

Figure 6. Distance sensor access notation

The notation on the PIR sensor is to retrieve and display data in the form of 1/0 logic when there is movement or not around the sensor. The notation of data collection from the PIR sensor can be seen in Figure 7.

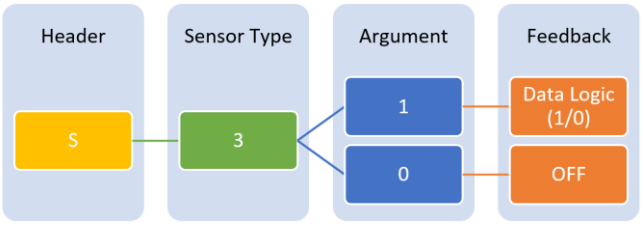

Figure 7. PIR sensor access notation

The joystick's notation is for retrieving and displaying data in the form of X and Y coordinate values when the lever is moved. Figure 8 is a diagram for retrieving data from the joystick. The feedback from this notation is the X and Y coordinate of the joystick.

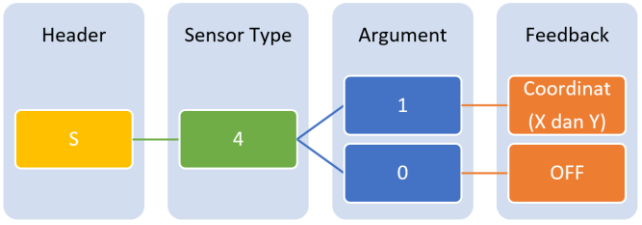

Figure 8. Joystick access notation

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Figure 9 is a notation for retrieving data from a potentiometer, which is presented in diagrammatic form. The potentiometer's notation is to retrieve and display data in the form of ADC values 0 to 1024 when the lever is rotated right or left.

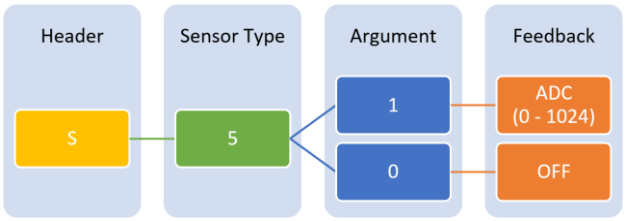

Figure 9. Potentiometer access notation

The notation for turning the LED on or off with time parameters is presented in Figure 10. The parameters provided are the LED label number and time. Meanwhile, the feedback that can be read is the output of the activated LED thread or process.

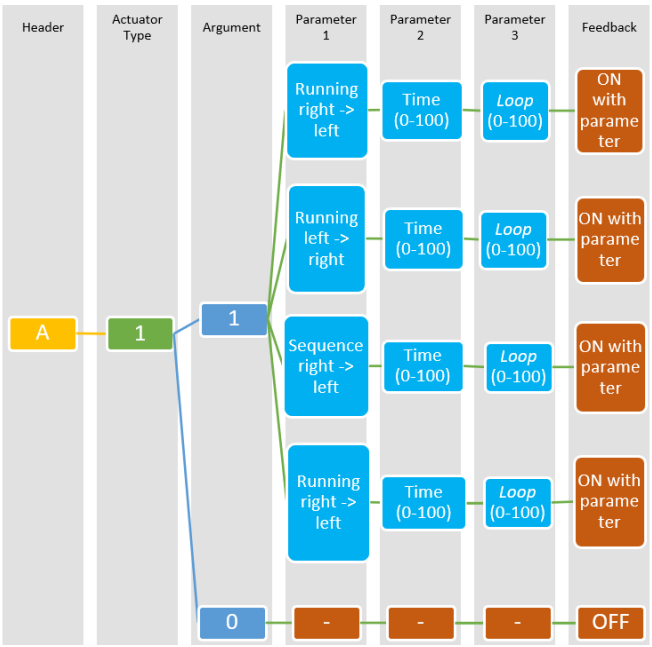

Figure 10. LED access notation

E. Multiprocessing and multithreading

In an operating system, the multiprocessing approach is a parallel computation model, where each task performed is considered a process. [12]. In general, small tasks are always in a process (big task). Please note that the threads are always in the same block of memory addresses. Therefore, data processing uses shared memory in one logical processor. This is different from middleware that uses multiprocessing. Instead of being threads, the middleware process that uses multiprocessing is divided into several sub-processes. This makes it possible to use another logical processor contained in the CPU in some of the jobs that are subprocesses. There is a 4-core or logical processor on the Raspberry Pi.

It is expected that from the use of this multiprocessing, the task contained in the middleware can be immediately divided into 4 cores. But back to the nature of an operating system, which has the right to fully control each process or thread which will run on which core in a CPU. In this study, a comparison was made between the use of multiprocessing and multithreading in the middleware that was built.

A declaration is required in the main program to make every function that runs each sensor and actuator a process. The declaration on the main program is shown in Figure 11. If each function that runs each sensor and actuator wants to be a thread, it must declare the main program to show a function to be a thread when executed. The declaration on the main program is shown in Figure 12.

```
if __name__ == '__main__':

        battery=multiprocessing.Process(target=statb
attery)
        temperature=multiprocessing.Process(target=s
uhu)
        us=multiprocessing.Process(target=jarak)
        pir=multiprocessing.Process(target=ir)
        joystick=multiprocessing.Process(target=joy)
        potensio=multiprocessing.Process(target=trim
pot)
        button=multiprocessing.Process(target=push)
        barled=multiprocessing.Process(target=led,
args=(lednum,waktu,))
        buzzer=multiprocessing.Process(target=buzz,
args=(pitch,duration,))
        rotomfw=multiprocessing.Process(target=motor
fw, args=(waktu,kn,kr,))
        rotombw=multiprocessing.Process(target=motor
bw, args=(waktu,kn,kr,))
        servo=multiprocessing.Process(target=srv,
args=(sudut,))
        lcd=multiprocessing.Process(target=tampil,
args=text,))
```

Figure 11. Declaration of the main program to be a process

```
if __name__ == '__main__':

        battery=threading.Thread(target=statbattery)
        temperature=threading.Thread(target=suhu)
        us=threading.Thread(target=jarak)
        pir=threading.Thread(target=ir)
        joystick=threading.Thread(target=joy)
        potensio=threading.Thread (target=trimpot)
        button=threading.Thread(target=push)
        barled=threading.Thread(target=led,
args=(lednum,waktu,))
        buzzer=threading.Thread(target=buzz,
args=(pitch,duration,))
        rotomfw=threading.Thread(target=motorfw,
args=(waktu,kn,kr,))
        rotombw=threading.Thread(target=motorbw,
args=(waktu,kn,kr,))
        servo=threading.Thread(target=srv,
args=(sudut,))
        lcd=threading.Thread(target=tampil,
args=text,))
```

Figure 12. Declaration of the main program to be a thread

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III. Results and Discussion

Testing is done via a remote connection from the laptop to the raspberry device. The laptop has core specifications Intel i3-7100U @ 2.4 GHz x 4, 4GB RAM with OS Win 10 64 bit. While the raspberry has specifications a Broadcom BCM2837 @ 1.2 GHz x 4 processor, 1 GB RAM, and Raspbian Stretch 2017 OS. The tests that have been carried out include every command notation sent, the response time between the start of the command being sent to the middleware being able to execute a function. The middleware's speed in making a process, the speed of middleware in creating a thread, and the comparison of multiprocessing usage with multithreading on CPU usage and memory usage.

Table I shows the response time between the command notation sent from Apps until the middleware can respond to command data. Middleware is capable of executing a process in seconds. Testing is carried out for each process, and data is taken from 5x sending orders individually.

Table I
Temperature Sensor Access Testing With Multiprocessing

Notation	Response time (s)	Multiprocessing execution time (s)	Trial
S,1,1	01s:389ms	1,1056	1
	01s:102ms	1,1065	2
	01s:789ms	1,1049	3
	02s:129ms	1,1079	4
	01s:827ms	1,1089	5

Table I shows that the response time between commands sent from Apps to the middleware to respond is between 1 second to 2 seconds. The test in Table I is carried out at night to get a good and stable internet speed. While the execution time of a process starts from initialization to become a process, and sending 1x data takes > 1 second. The next test is to take the response time between the command notation sent from Apps until the middleware can respond to command data and the middleware's speed in executing a thread in seconds. Tests are carried out on each thread, and 5x data for sending orders are taken individually, shown in Table II.

Table II
Temperature Sensor Access Testing With Multithreading

Notation	Response time (s)	Multiprocessing execution time (s)	Trial
S,1,1	01s:829ms	1,1329	1
	01s:126ms	1,1442	2
	01s:912ms	1,1484	3
	01s:127ms	1,1582	4
	02s:892ms	1,1393	5

Table II shows that the response time between the commands sent and the middleware able to respond is between 1 second to 2 seconds. Meanwhile, the thread execution time starts from initialization to become a thread, and sending 1x data takes> 1 second. The test was conducted at night with good and stable internet conditions. The next test is carried out sequentially, and data is taken from 5x individual orders which are shown in Table III.

Table III
Temperature Sensor Access Testing Sequentially

Notation	Response time (s)	Multiprocessing execution time (s)	Trial
S,1,1	01s:102ms	1,1279	1
	01s:923ms	1,1397	2
	01s:124ms	1,1383	3
	01s:721ms	1,1472	4
	01s:436ms	1,1394	5

Table IV is the test results of CPU usage and memory usage data between multiprocessing, multithreading, and sequential access to temperature sensor functions. The function is carried out individually, and 5 times the sampling is taken.

Table IV
CPU and Memory Usage Testing for Multiprocessing, Multithreading, and Sequential Temperature Sensor Access

Multiprocessing (%)		Multithreading (%)		Sequential (%)	
CPU	**Memory**	**CPU**	**Memory**	**CPU**	**Memory**
8,7	2,4	8,7	2,8	10,5	2,7
7,7	2,4	7,9	2,8	10,3	2,7
8,3	2,4	8,9	2,8	9,9	2,7
9,1	2,4	9,7	2,8	10,7	2,7
8,9	2,4	9,3	2,8	9,7	2,7

From the 4 test points whose results are shown in Table I-IV, it can be concluded that the command notation test was successful. In testing the second point, namely retrieving response time data between commands sent from Apps until the middleware can respond to commands and retrieving data when creating a process or thread from initializing to becoming a process/thread. Multiprocessing and multithread tests are carried out with 5 individual running processes/threads. The sequential method is carried out 5 times the program runs because sequential programming can only run 1 loop at a time.

CPU usage and memory usage are also compared when a function is accessed using multiprocessing or multithread or sequential programs. Figure 13 is a graph showing the comparison of CPU and memory usage for temperature sensor access.

Analysis on temperature sensor testing using multiprocessing, multithreading, and sequential programs is that there are differences in the completion of the 1x program loop and CPU and memory use. After a 1x program loop, multiprocessing records a slightly faster time than multithreading or sequential. This happens because multiprocessing uses different addressing space and CPU-core in carrying out each process. While multithreading uses the same CPU-core addressing space, the process execution is slightly faster than the execution of a thread. A thread's execution uses more CPU usage and memory usage because it is in the same addressing space. A sequential program has the

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same character as the execution of a thread. This is because, in general, a program that is executed will become a thread. So there is not much difference between CPU usage and memory usage between multithreading and sequential.

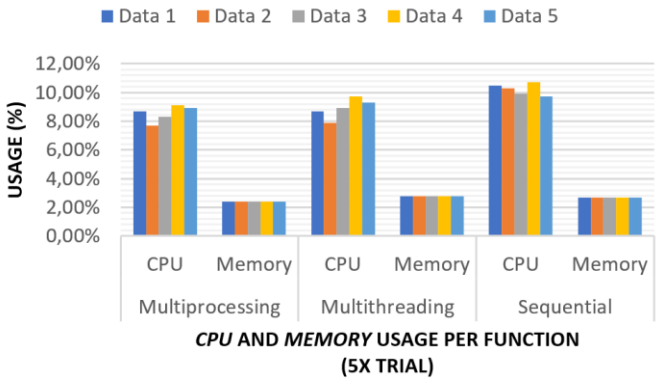

Figure 13. Comparison graph between CPU and memory usage on temperature sensor access

The next test is to test the system when it is used to access a servo motor. Table V shows the response and execution times using multiprocessing on servo motor access.

TABLE V
SERVO MOTOR ACCESS TESTING WITH MULTIPROCESSING

Notation	Response time (s)	Multiprocessing execution time (s)	Trial
A,4,1,10	02s:696ms	2,9388	1
	02s:205ms	2,1954	2
	02s:205ms	2,0789	3
	01s:806ms	2,1595	4
	02s:154ms	2,1391	5

The test in Table V shows that the response time between commands sent from Apps to the middleware to respond is between 1 second to almost 3 seconds. Meanwhile, the process execution time starts from initialization to a process, and sending 1x data takes> 2 seconds.

TABLE VI
SERVO MOTOR ACCESS TESTING WITH MULTITHREADING

Notation	Response time (s)	Multiprocessing execution time (s)	Trial
A,4,1,10	01s:478ms	2,1688	1
	01s:579ms	2,2465	2
	01s:442ms	2,3921	3
	02s:581ms	2,6232	4
	02s:251ms	2,2477	5

The results of the multithreading servo motor access test can be seen in Table VI. The response time between Apps' commands until the middleware can respond is between 1 second to almost 2. While the thread execution time starts from initialization to becoming a thread, and sending 1x data takes> 1 second.

TABLE VII
CPU AND MEMORY USAGE TESTING FOR MULTIPROCESSING, MULTITHREADING, AND SEQUENTIAL SERVO MOTOR ACCESS

Multiprocessing(%)		Multithreading(%)		Sequential (%)	
CPU	Memory	CPU	Memory	CPU	Memory
1,70	2,70	0,70	2,70	0,70	2,70
1,10	2,40	0,70	2,70	0,70	2,70
1,20	2,70	0,70	2,70	0,70	2,70
1,70	2,70	1,30	2,70	1,30	2,70
1,80	2,40	0,87	2,70	0,70	2,70

Table VII is the test results of CPU usage and memory usage data between multiprocessing, multithreading, and sequential when accessing servo motors. This time, the function is also carried out individually, and 5 times the sampling is taken.

Comparison of CPU usage and memory usage when a servo motor function is accessed using multiprocessing or multithread or sequential programs is shown in Figure 14.

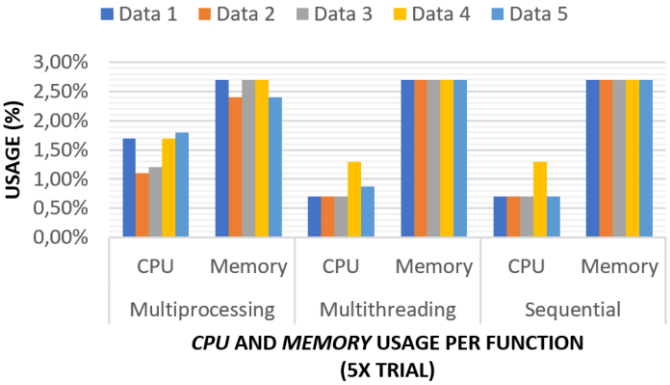

Figure 14. Comparison graph between CPU and memory usage on servo motor access

Analysis on servo motor testing using multiprocessing, multithreading, and sequential programs is that there are differences in the completion of the 1x program loop and CPU and memory use. After a 1x program loop, multiprocessing records a slightly faster time than multithreading or sequential. However, in experiments 1 and 2, the completion was slower. This happens because multiprocessing uses different addressing space and CPU-core in carrying out each process. While multithreading uses the same CPU-core addressing space, the process execution is slightly faster than the execution of a thread. A thread's execution also uses CPU usage and memory usage more because it is in the same addressing space. Besides, the difference in experiments 1 and 2 occurs because it coincides with extensive processes carried out by the OS so that the process carried out by the user is slightly slowed down. There isn't much difference between CPU usage and memory usage between multithreading and sequential. Several conditions indicate that a small task such as servo motor access is sometimes better done as a threat than a process because the job is only one time, not continuous like the sensor reading function.

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IV. CONCLUSION

In multiprocessing, it will be more optimal to do complex or continuous work such as reading sensors. When used to access a sensor, a process is not always faster than a thread. Such as temperature sensor access, whose execution time is in the range <1,0001s, when it becomes a process and execution time, is in the range> 1,1001s when it becomes a thread. Meanwhile, multithreading will be more optimal for doing small or non-continuous work such as actuator access. When used to run sensors, not always a thread will execute faster than a process. For example, the servo motor access has an execution time of up to 2.9388s on the first try when it becomes a process and up to 2.6232s execution time on the fourth try when it becomes a thread.

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Social Media Analysis Using Probabilistic Neural Network Algorithm to Know Personality Traits

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Abstract— The Internet creates a new space where people can interact and communicate efficiently. Social media is one type of media used to interact on the internet. Facebook and Twitter are one of the social media. Many people are not aware of bringing their personal life into the public. So that unconsciously provides information about his personality. Big Five personality is one type of personality assessment method and is used as a reference in this study. The data used is the social media status from both Facebook and Twitter. Status has been taken from 50 social media users. Each user is taken as a text status. The results of tests performed using the Probabilistic Neural Network algorithm obtained an average accuracy score of 86.99% during the training process and 83.66% at the time of testing with a total of 30 training data and 20 test data.

Keywords— Social Media, Probabilistic Neural Network, Personality Traits, Personality.

I. INTRODUCTION

Today, the internet is becoming a new digital space and producing a new generation. Generations raised in modern cultural environments or digital media are interactive and computer literate, and traditional media will change to digital media. One of them is social media, which is quite influential [1]. Some of the existing social media like Twitter, Facebook, path, etc. According to the Ministry of Communication and Informatics (*Kemenkominfo*), Indonesia has the fourth rank of Facebook users after the USA, Brazil, and India. There are 65 million active Facebook users, with 33 million active users per day [2].

Social media is a site where everyone can create a personal page, share information, and communicate with several friends connected with the user. Everyone involved in it feels that they know each other more than anything, even though they have never physically met face to face [3]. According to [2], social media's emergence makes a person dissolve their privacy space into public space. Making him do not hesitate to show his person's activities or moods by showing all his friends through social media [2]. With this openness, a person's personality can be seen from social media's status or mood expression.

Several methods or tests in psychology are used to determine personality, including the MBTI (Myers-Briggs Type Indicator), DISC (Dominance, Influence, Steadiness, Compliance), and the Big Five. The Big Five personality consists of openness (O), conscientiousness (C), extraversion (E), agreeableness (A), and neuroticism (N). The O personality is active in imagination, sensitive to aesthetics, cares about personal feelings, is interested in differences, intellectual curiosity, and freedom of opinion. C personality is closely related to impulse control, controlling oneself for careful planning, arrangement, and doing tasks. Personality E is an active person, has self-confidence, likes to talk or fussy, is optimistic, likes to have fun, and feels cheerful. Personality A always makes others first, has sympathy for others, and wants to help. The N personality tends to experience negative feelings such as fear, sadness, awkwardness, anger, guilt, and hatred [4].

Text mining is used to determine the source of knowledge in a document in text form. In the application using text mining, data patterns, trends, and extraction of knowledge from potential text data are obtained in previous research conducted by [5] and [6] used text mining to analyze sentiment. Also, [7] also use text mining for cases of character detection. The PNN (Probabilistic Neural Network Algorithm) algorithm is an Artificial Neural Network (ANN) that can be used to solve classification problems. By using PNN, the process can be carried out faster. This is because PNN only requires one training iteration [8]. [9], [10] and [11] also use the PNN algorithm to solve the case. Also, issues related to texts using the PNN method have been carried out by [6].

Based on the background above described by the researcher, this study uses a probabilistic neural network algorithm to find the model (features) and solve cases of detection of a personality based on the statistics contained in social media.

II. RESEARCH METHODOLOGY

Stages in this research, the author is inspired by and references previous research related to this journal's background problems. The research related to this journal includes: Twitter Analysis To Know A Person's Character Using The Naive Bayes Classifier Algorithm.

Research conducted by [7] analyzed a person's character through Twitter social media, character classification using the MBTI test, to determine a person's character through social media, using the Naive Bayes algorithm. Produce accurate results, where the classification carried out by experts and the classification using the Naive Bayes algorithm is the same.

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In the study [12], it was observed that Facebook status information could be used to determine a person's personality, especially for employee tests, making it easier and shortening the time for hiring employees. In this research, the algorithm used is Back Propagation. In his research, the accuracy rate obtained was 84.00%.

Selection of Smoothing Parameters on Probabilistic Neural Network Using Particle Swarm Optimization for Text Detect in Images Research conducted [13]. Detect text with little training data used the PNN algorithm. PNN algorithm to detect text has a high level of Accuracy 75.42% using only 300 data.

In the study [14][15], Facebook status information can be used to find out a person's personality, especially for student tests, making it easier and shortening the time for personality student. In [14] research, the algorithm used is PNN. The accuracy rate obtained was 60.00% from 25 respondents in his research, with 10 data training and 15 data testing. In [15], Naïve Bayes Classifier's algorithm with an accuracy of 88% from the same respondent.

Campus Sentiment Analysis E-Complaint Using Probabilistic Neural Network Algorithm In research [6], the PNN algorithm was applied to classify complaints in e-complaints. In his research, complaints are classified into two, namely positive complaints and negative complaints. By using the PNN algorithm, the accuracy rate reaches 90%.

In this study, several stages will be carried out. Namely, the first is data collection by taking a predetermined social media status. After that, perform the data preprocessing process. This process is carried out in several stages: case folding, tokenization, remove punctuation, stop words, standardization, and stemming. The next stage is weighting words using TF-IDF and performing the classification process using the Probabilistic Neural Network Method and the Evaluation process.

A. Data Collection

The data used in this study are social media status. The social media used in this study are only limited to Facebook and Twitter. The data collection process uses a scrapping technique and is stored in the form of CSV data. Social media users whose data were taken were students of *Universitas Merdeka Pasuruan* who had taken a psychological test. The status used in this study is only text status, not status in the form of images, videos, links, and icons. Also, the status taken is the latest status owned by the user. Table I show some example of data.

TABLE I
EXAMPLE DATA

User_a	*biar gak terlalu sumfek .. dangdutan aja dulu*
User_b	*Astaghfirullah, jauhkan saya dari orang ini ??biar gak ketawa terus*
User_c	*Cinta tak sekadar tentang materi dan malam mingguan.. Cinta yang mengalir ditemani kesederhanaan adalah yang terbaik.. Cukup mabar mobile legend, biar aku yang akan membantumu dapat banyak kill kalau perlu sampai savage dan kita sama2 maju ke divisi yang lebih tinggi :D*
User_d	*Bisa nggak sih kamu g seperti itu ke aq*

B. Pre-processing

Pre-processing is a step used to clean up data that is not sufficient to influence the classification process. This process is important because the data used at this stage is rough, so that the documents produced in this process can facilitate the classification process.

The preprocessing process was applied to all data used in this study. Furthermore, the data will be divided into 2 types of data: training data and testing data. The training data from the preprocessing results are used to form features, where this feature is used as a reference for carrying out the calculation process during training and testing. The preprocessing process has several stages that must be carried out, including:

1) Case Folding: Process used to change the capital letter on all social media statuses contained in the training data document and test data to lowercase

2) Tokenization: Process used to change each social media status's claims separated by each word as shown in Table II. This process applies to training data and testing data.

TABLE II
EXAMPLE OF TOKENIZATION

Sentence	*Bisa nggak sih kamu g seperti itu ke aq*
Tokenization	*"bisa","nggak","sih","kamu","g","seperti","itu","ke","aq"*

3) Remove Punctuation: Remove punctuation performs a process to remove all punctuation in the training data and test data.

4) Stopwords: After doing the tokenization process, the next step is to do the stopwords process. This process deletes individual words based on the word dictionary. The word dictionary is a list of conjunctions and words that are considered to have no influence or meaning in the classification process. Table III provides an example of the stopwords process.

TABLE III
EXAMPLE STOPWORD

Sentence	*Bisa nggak sih kamu g seperti itu ke aq*
Tokenization	*"bisa","nggak","sih","kamu","g","seperti","itu","ke","aq"*
Stopwords	*"bisa","nggak","kamu","g","seperti","aq"*

5) Standardization: Process standardization is a process used to convert abbreviated words into standard words. For example, the word "not" is changed to "no", the word "g" is changed to "no" and the word "*aq*" is changed to the word "I" as shown in Table IV.

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TABLE IV
EXAMPLES OF STANDARDIZATION

Stopwords	*"bisa","nggak","kamu","g","seperti","aq"*
Standardization	*"bisa","tidak","kamu","tidak","seperti","aku"*

6) Stemming: Process used to convert words into root words. This process is done by removing the affixes contained in each word. For example, the word "appreciate" will be changed to the root word "appreciate" by removing the affix "*meng*", the word "hit" is changed to the root word "hit" by removing the affix "*mem*".

C. TF-IDF Weighting

At the word weighting stage, the Term Frequency - Inverse Document Frequency (TF-IDF) method is used to get each word's weight value in each document. The word weighting process is carried out using the TF-IDF algorithm. TF-IDF works by counting the number of occurrences of a word multiplied by the log value of the number of documents used compared to the number of documents containing the word. The Tf-IDF method can provide maximum Value for unique words or words that do not frequently appear in other documents.

The formula used to calculate the TFIDF method is shown by equation (1).

$$X_i = TF_j \; x \; tdf_j \quad (1)$$

Where:
X_j = Value for the ith word
TF_i = The number of occurrences of the ith word
tdf_i =, where n is the number of documents$\log \frac{n}{df_i}$
df_i = number of documents containing the ith word

D. Probabilistic Neural Network (PNN)

A probabilistic Neural Network (PNN) is an algorithm that belongs to the neural network family. PNN has several layers and weights. The PNN algorithm performs the classification process with only one step so that it can provide faster output.

In this study, the PNN architecture used is 4 layers, including the input layer, pattern layer, summation layer, and output layer, as shown in Figure 1.

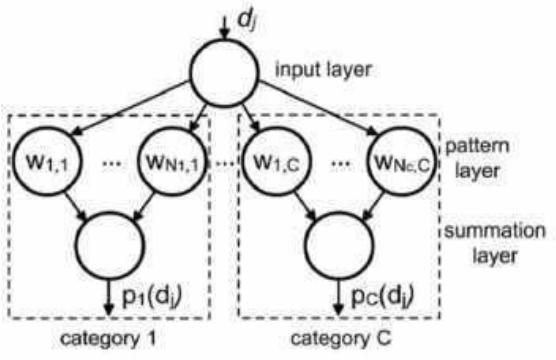

Figure 1. Architectures probabilistic neural network.

The PNN method performs the classification process by taking the largest probability value generated in the output layer. The stages used for the calculation process of the PNN method include:

- The first stage determines the PNN method's parameters in the form of the number of categories or classes and the number of neurons in the pattern layer and the Gaussian Value.
- Stage 2 performs a random weight generation process.
- Stage 3 performs the calculation process for each neuron in the pattern layer using equation (2) [9].

$$\phi(X, W_i) = e^{\frac{-(X-W_i)^T(X-W_i)}{2\delta^2}} \quad (2)$$

Where *X* variable is the input vector, Wi is the weight vector that connects the input layer and the pattern layer. And the parameter is a smoothing parameter.δ

- Stage 4 performs the calculation process on the summation layer by taking the neurons' sum in each class in the pattern layer. Equation (3) shows the formula for calculating the summation layer stage.

$$\sum_{k=1}^{n} \phi(X, W_i) \quad (3)$$

Where:
ϕ = Pattern layer at X, and Wi

- Stage 5 or the final stage carries out comparing each Value generated at the summation layer stage. Input layer The most considerable Value at the summation layer stage will be selected as the Value in the output layer and used to determine the selected class based on max values.

E. Testing

In this study, testing was carried out using various training data and tests to find the best classification model. Each combination of training data testing and test was run in 10 folds.

The accuracy value is obtained by comparing the number of correct data with the total number of data multiplied by 100%, as in equation (4). It is said that the data is correct if the results of the expert analysis are the same as the results issued by the system.

$$Accuracy = \frac{correct\ data}{total\ data} x100\% \quad (4)$$

III. RESULT AND DISCUSSION

Social media analysis uses a probabilistic neural network algorithm to find out someone, aiming to find out whether the status written by users on social media describes the character they have.

The data used for testing is the social media status data for Facebook and Twitter. Social media users whose status were taken were students of the Universitas Merdeka

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Pasuruan who had taken a psychologist test. Ten each was taken from the social media Facebook and Twitter. All user statuses are collected into 1 status document to get the user character results from the user status document.

Testing the combination of training data and testing data is done by dividing the amount of data. The data sharing technique was carried out by randomly selecting data in each class with a predetermined composition. The probabilistic neural network method is a stochastic algorithm. Testing is done by taking the average score of Accuracy obtained from the running process 10 times for each combination.

TABLE V
TESTING RESULTS OF THE COMBINATION OF TRAINING DATA AND TEST DATA

total			Average Accuracy (%)	
Training Data	**Features**	**Test Data**	**Testing**	**Testing**
15	4137	35	81,334	56,665
20	4593	30	85	71
25	5241	25	82	75.6
30	5312	20	86.99	83,666
35	5957	15	79.14	73,713

Table V shows that the combination of training data and test data with the best average score of Accuracy when the number of training data is 30 and test data is 20 with an accuracy score of 86.99% and 83.666%. From these results, we can see that when the training data is less than 30, the average accuracy score is more than 75%. But during the testing process, the Accuracy average score obtained was not satisfactory. So it can be said that the resulting model has not provided the best accuracy score. Meanwhile, when the training data is more than 30, it gives an average Accuracy score that is unsatisfactory during the training and testing process. This shows that the increasing number of features does not guarantee a model that can provide the best results because features can be increased and become noise.

IV. CONCLUSION

From the analysis and testing results to analyze social media using a probabilistic neural network algorithm to determine a person's character in the training and testing process, an average accuracy of 86.99% and 83.66% was obtained. Accuracy is obtained by a combination of training data and test data of 30 and 20, respectively. The test results show that the number of features cannot determine the best classification model. So that researchers suggest continuing this research by adding methods for feature selection.

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Optimizing K-Means Algorithm by Using Particle Swarm Optimization in Clustering for Students Learning Process

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Abstract— In the implementation of learning, several factors affect the student learning process, including internal factors, external factors, and learning approach factors. For example, the physical and spiritual condition of students. Physiological aspects (body, eyes and ears and talents of students, student interests). External factors, for example, environmental conditions around students, family, teachers, community, friends) Thus, learning achievement is significant because educational institutions' success can be seen from how many students learning achievement. This research's first focus is to do student clustering based on their learning process using 11 parameters. Second, using the PSO algorithm to get maximum clustering results. The research data were obtained from vocational secondary education institutions in the city of Pasuruan. The data is obtained from the results of school reports and questionnaires as much as 100 student data. Data attributes include environmental features, social features, and related school features to group student data for learning data processing. From the classification results using the PSO method, the silhouette value is 0.97140754, very close. These results indicate that the PSO method can improve the K-Means clustering method's performance in the classification process of student learning interest.

Keywords— Learning process, Optimization Algorithm, PSO, K-Means, Clustering

I. INTRODUCTION

Today, education is one of the essential aspects in changing one's mindset. The quality of education can be observed from the obtained internal support (family) and external support (environment). Education is an effort, influence, protection, and assistance for children to let them be independent, or instead of helping children to be able to carry out their life tasks [1]. Educational institutions are considered to be successful as the learning process quality is given to the students. Therefore, several factors affect the learning process, including internal factors, external factors, and learning approach factors [2]. Internal factors (factors within students), for example, students' physical and spiritual condition. Namely: physiological aspects (body, eyes, and ears) and psychological characteristics (student intelligence, student attitudes, student talents, student interests, and student motivation). External factors (factors from students' outside), for example, students' environment. Namely: social environment (family, teachers, community, friends) and non-social environment (home, school, equipment, and nature).

Meanwhile, students' learning approach factors include students' strategies and methods to learn subjects, including a high approach, medium approach, and low approach. Meanwhile, data mining is a term to describe the information contained in a set of data. Data mining is the process of using static techniques, mathematics, artificial intelligence, and machine learning to separate and identify useful information and related knowledge from large databases [3].

K-Means is one of the clustering methods in data mining. The determination of K's value must be determined at the beginning of the study by considering each group's differences. Also, the parameter being chosen is the cluster center, which was randomly assigned. The better the centroid determination, the more precise and faster the grouping process will be. Since the centroid is determined randomly, the accuracy level is sometimes not valid and often appears local optima (local solution) [4].

Particle Swarm Optimization Algorithm (PSO method) can optimize the centroid value on K-Means with promising results[5], [6]. PSO can also optimize the centroid value by referring to the local optima in real numbers[6]. Some related studies have been carried out by [7][8] regarding the implementation of K-Means to classify students based on students' learning process [8][9].

The results of research with 100 students and 11 attributes as the participants, it was known that as many as 120 students were in a right learning achievement cluster, 104 students were in medium learning achievement cluster, and 125 students were in low learning achievement cluster with a silhouette score of 0.669253108828133. Thus, the current study's first focus was to classify students based on their learning process using 11 parameters. The second focus was using the PSO algorithm to get maximum clustering results.

II. RESEARCH METHODOLOGY

This study used (1) literature study, (2) Survey and Questionnaire, (3) Application Design, (4) Algorithm PSO and K-Means (5) Test result (6) Analysis of Test Results. With the existence of a research concept framework, it is hoped that it can clarify the research contribution that will be carried out, as shown in Figure 1.

The initial stage for conducting research was to conduct literature studies based on the research topics taken. The studied literature is related to data clusters using the K-Means method. The research data were gathered from secondary vocational schools in Pasuruan.

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The data was obtained from the results of school reports and questionnaires as much as 100 student data. The data attributes included environmental features, social features, and related school features.

An analysis is a method after literature study and data collection on cases in the study. This study's analysis started from input data used and needed to produce a grouping of each data [10.8]. The data inputted were nominal and numeric. Each value that exists was the data category. The following description is an overview of the data presented in the current study.

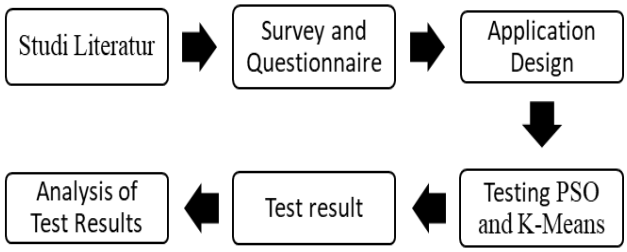

Figure 1 Flowchart of research work

A. *Particle Swarm Optimization (PSO)*

PSO is an optimization method that represents solutions to problems in the form of particles with stochastic properties. The workflow of the PSO can be explained as follows [14]:

- We are using particle best and global best available.
- Updating particles' position by adding the new velocity and the previous position with the following Equation (1).

$$v_i(t) = vw_i(t-1) + c_i r_i \left(x_{pi} - x_i\right) + c_2 r_2 \left(x_{gi} - x_i\right)$$
$$x_i(t) = x_i(t-1) + v_i(t) \quad (1)$$

where:
i = particle index
t = iteration
w = inertia
v_i = velocity of the *i-th* particle
x_i = position of the *i-th* particle
x_{gi} = best position of all particles (global best)
x_{pi} = best position of *i-th* particle (particle best)
$c_{1,2}$ = learning rate *r1,2* = random number [0.1]

- Evaluating the fitness of each particle.
- I was comparing and updating particle best and global best for each particle based on fitness.
- If the stop criteria were met, it would stop. Otherwise, go back to step 1.

B. *K-Means Algorithm*

The K-Means method was used to search for clustering data. It was starting by determining the number of clusters (*K*) and the initial centroid that was randomly selected. The centroid was the average of observations that were in a cluster. In cluster formation [10] suppose that a data matrix $\{X_{ij}\}$ was $n \times p$ where $i = 1, 2, \ldots, N,$ and $j = 1,2, \ldots, p$.

To know the data, the researcher did some steps, those are:

- Assume the initial cluster number *K*.
- Find the Ck centroid
- Calculate each object's distance to each centroid using the Euclidean distance, or it could be written as follows Equation (2).

$$d(x_i, c_i) = \sqrt{(x_i - c_i)^2} \quad (2)$$

- Arrange each object is arranged to the nearest centroid, and the collection of objects formed a cluster.
- Determine the new centroid of the newly formed cluster, where the new centroid was obtained from the average of each object located in the same cluster.
- Repeat step 3, if the initial and new centroids were not the same, to produce the best silhouette in its class.

III. Result and Discussion

In analyzing the students' interests and talents, it is necessary to consider several aspects: internal factors, external factors, social environment, and learning approach factors. From these factors, some information was obtained. Then a conclusion was drawn in determining students' interest in learning [8][11]. In this case, the researchers conducted student clustering based on the learning process using 11 parameters, namely: Family Condition (k1), Family Support (k2), Internet Access (k3), Mother's Education (k4), Father's Education (k5), Study Time (k6), Family Relations (k7), Silent Time (k8), Frequent Leave (k9), Health (k10), Absence (k11).

Table I
Clustering in Determining Student Interest in Learning

K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11
2	2	2	4	4	2	4	3	4	3	6
1	1	1	1	1	2	5	3	3	3	4
1	2	1	1	1	2	4	3	2	3	10
1	1	1	4	2	3	3	2	2	5	2
1	1	2	3	3	2	4	3	2	5	4
1	1	1	4	3	2	5	4	2	5	10
1	2	1	2	2	2	4	4	4	3	0
2	1	2	4	4	2	4	1	4	1	6
2	1	1	3	2	2	4	2	2	1	0
1	1	1	3	4	2	5	5	1	5	0
1	1	1	4	4	2	3	3	3	2	0
1	1	1	2	1	3	5	2	2	4	4
1	1	1	4	4	1	4	3	3	5	2
1	1	1	4	3	2	5	4	3	3	2
2	1	1	2	2	3	4	5	2	3	0

Description of the dataset in Table I:

- The condition of the family (1: Living together, 2: Divorced).
- Support from family (1: yes, 2: no).
- Internet access while studying (1: yes, 2: no).

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- Mother's last education (0: no school, 1: elementary school, 2: junior high school, 3: senior high school, 4: college).
- Father's last education (0: none, 1: elementary school, 2: junior high school, 3: senior high school, 4: college).
- Student duration (1: < 2 hours, 2: 2 hours - 5 hours, 3: 5 hours-10 hours, 4: > 10 hours).
- Students' relationships with their families (1: very bad, 2: bad, 3: fair, 4: good, 5: very good).
- The duration of silence after studying (1: very much, 2: a lot, 3: enough, 4: a little, 5: little).
- Chance to play with friends (1: very much, 2: a lot, 3: enough, 4: a little, 5: little).
- Students' health (1: very bad, 2: bad, 3: fair, 4: good, 5: very good).
- Student attendance at school (attendance 0-93).

The test was carried out after the input data analysis, and system design was carried out. The grouping process was carried out into 3 clusters (*K = 3*). The 3 clusters can produce the best Silhouette coefficient value. Based on the results of the cluster. The K variable random center points or centroids were determined. Measurement of each data distance to the center points was carried out using the Euclidean distance calculation. The smallest distance value for one centroid was obtained from the distance calculation results so that the data would be affiliated with the cluster data from the nearest cluster. After making sure that data 1 to the number of data was included in group one, then the new centroid's determination was based on each cluster's existing data. This process was repeated until the data was entered in 3 groupings, as in the K-means and PSO processes.

```
Cdistance jarak = new Cdistance(input,centroid);
    Ccluster kluster = new Ccluster(jarak);
    kluster.kluster();
    System.out.println("Hasil Kluster");
    // for(int i=0;i<kluster.getKluster().length;i++){
    //  for(int j=0;j<kluster.getKluster()[i].length;j++){
    //     if(kluster.getKluster()[i][j]>0)
    //             System.out.print(kluster.getKluster()[i][j]+" ");
    //  }
    //  System.out.println();
    // }
    ArrayList<ArrayList<Integer>> dataKluster;
    dataKluster = kluster.getKlusterDinamis();
    for(int i=0;i<dataKluster.size();i++){
       for(int j=0;j<dataKluster.get(i).size();j++){
          System.out.print((dataKluster.get(i).get(j)+1)+" ");
       }
       System.out.println();
    }
    for(int n=0;n<10;n++){
       System.out.println("iterasi "+(n+2));
       centroid.nextCentroid(kluster);
       System.out.println("Centroid");
       for(int i=0;i<centroid.getData().length;i++){
          for(int j=0;j<centroid.getData()[i].length;j++){
             System.out.print(centroid.getData()[i][j]+" ");
          }
          System.out.println();
       }
       kluster.kluster();
       dataKluster = kluster.getKlusterDinamis();
       System.out.println("Hasil Kluster");
       for(int i=0;i<dataKluster.size();i++){
          for(int j=0;j<dataKluster.get(i).size();j++){
             System.out.print((dataKluster.get(i).get(j)+1)+" ");
          }
          System.out.println();
       }
    }
```

Each process determined the centroid value based on this grouping; each result of the silhouette value determined the closest distance. In determining interest in learning, the K value would vary in determining each cluster's closest distance. Here are the results of the trial process in the application in Table II.

TABLE II
RESULTS OF PSO AND K-MEASN ALGORITHM IN STUDENTS 'LEARNING INTEREST PROCESS

The Number of K	Clustering	Silhouette Value
1	2	0.97140754
	6	0.267029056
	7	0.738606824
2	2	0.97140754
	6	0.639433666
	7	0.617561222
3	2	0.97140754
	6	0.594086774
	7	0.121294603
4	2	0.97140754
	6	0.582772673
	7	0.595558189
5	2	0.97140754
	6	0.594086774
	7	0.550932925
6	2	0.97140754
	6	0.267029056
	7	0.60066234
7	2	0.97140754
	6	0.267029056
	7	0.600113095
8	2	0.97140754
	6	0.594086774
	7	0.230460594
9	2	0.97140754
	6	0.609257434
	7	0.595558189
10	2	0.97140754
	6	0.594086774
	7	0.738606824
	2	0.97140754

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It was based on testing the system to find each variable's proximity value processed using K-Means and the Particle Swarm Optimization Algorithm. It optimized the centroid value on K-Means with good results, with some interactions, the Silhouette value was obtained in each of the interactions.

IV. CONCLUSION

From the results of the application trial, it can be concluded that for the classification of student interest in learning obtained from the results of school reports and questionnaires, as much as 100 student data. The external cluster is 0.97140754, and the Internal factor is 0.594086774, and the learning approach factor is 0.738606824. The silhouette value of that size is obtained because the distance between the data is very close. These results indicate that the PSO method can improve the k-means clustering method's performance in the classification process of student learning interest.

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