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FOREWORD

ULTIMA Greetings!

Ultima Computing : Jurnal Sistem Komputer is a Journal of Computer Engineering and Electrical Engineering at Multimedia Nusantara University which presents scientific research articles in the field of Computer Systems as well as the latest theoretical and practical issues, including Edge Computing, Internet-of-Things, Embedded Systems, Robotics, Control Systems, Network and Communication, System Integration, and other topics in the field of Computer Engineering and Electrical Engineering.

In this December 2021 edition, ULTIMA Computing enters the 2nd Edition of Volume 13. In this edition there are six scientific papers from researchers, academics and practitioners in the fields of Computer Engineering and Electrical Engineering. Some of the topics raised in this journal are: Allergen Recognition in Food Ingredients with Computer Vision, Modeling and Controlling the Actuator Joint Angle Position on the Robot Arm Base Using Discrete PID Algorithm, Hand Gesture Detection for American Sign Language using K-Nearest Neighbor with Mediapipe, Implementation of Lossy Compression Method for Storage Saving on Fog Computing, Automatic Warning System for Weather Station Power Supply and Unmanned Vehicle Steering Control System Using Proportional Control Algorithm.

On this occasion we would also like to invite the participation of our dear readers, researchers, academics, and practitioners, in the field of Engineering and Informatics, to submit quality scientific papers to: International Journal of New Media Technology (IJNMT), Ultimatics : Jurnal Teknik Informatics, Ultima Infosys: Journal of Information Systems and Ultima Computing: Journal of Computer Systems. Information regarding writing guidelines and templates, as well as other related information can be obtained through the email address ultimacomputing@umn.ac.id and the web page of our Journal here.

Finally, we would like to thank all contributors to this December 2021 Edition of Ultima Computing. We hope that scientific articles from research in this journal can be useful and contribute to the development of research and science in Indonesia.

December 2021,

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Allergen Recognition in Food Ingredients with Computer Vision

Elisa Belinda Johan[+], Aminuddin Rizal*
Teknik Komputer, Universitas Multimedia Nusantara
Tangerang, Indonesia
[+]elisa.belinda@student.umn.ac.id, *aminuddin rizal@umn.ac.id

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***Abstract*— The process of recognition and classification of food is very important. It can be useful for consumers who are sensitive in choosing foods that they want to consume. Considering that some food ingredients are allergens that can cause allergies for some people. This paper aims to design and build an Android-based system to detect food ingredients that can facilitate consumers in getting information about all allergens contained in the. The application is created by implementing Optical Character Recognition (OCR) algorithm and using Boyer Moore algorithm to do the word matching (string matching). The experiments were performed with trial of OCR, Boyer Moore, light sources, and technical words (uncommon words). Our experiment shows more than 90% accuracy obtained with different scenario applied.**

***Index Terms*— allergen, Android, Boyer Moore, food label, Optical Character Recognition**

I. INTRODUCTION

Food packaging has an important role in marketing a product. Product packaging becomes an advertising medium from producers to consumers. However, in reality the packaging that was made and designed to protect the product from contamination and damage now also serves to make it easier for customers to recognize the product[1].

Packaging is also a means to convey food information to the following consumers about the composition and nutritional value of food. This information becomes important for consumers who have rules in consuming food. The information provided is the result of calculations and research conducted by nutritionists.

The term food allergy is used to describe an adverse immune response to food. Allergy is a person's immune response to a substance or substance that is considered harmful to the body. Allergy is an important issue that must be considered because it is present at all levels of society. At the age of the first year of life, a child's immune system is relatively immature and very vulnerable. If he has atopic talent, he will be easily sensitized and develop into allergic diseases to certain allergens such as food and inhalants[2].

Table 1 shows the estimated level of food allergies of children and adults. Based on the table, it can be concluded that the food ingredients that are commonly found in packaged foods and which most often cause allergies are milk, eggs, nuts, wheat, and soy.[3].

Public awareness of allergic diseases is currently relatively low. Many people think that allergies are just an ordinary disease, even though allergies can cause greater costs and threats if left unchecked and not handled properly[4].

For allergy sufferers, the ingredients information listed on the food label is very important. However, these food ingredients cannot be easily found on food labels because they are generally included in the form of other nutrients such as casein as a protein in milk. Therefore we need to understand the labels on packaged foods that we will consume[5].

TABLE 1. ESTIMATED FOOD ALLERGY RATES

Prevalence	Infant/Child	Adult
Milk	2.5%	0.3%
Egg	1.5%	0.2%
Peanut	1%	0.6%
Fish	0.5%	0.4%
ShellFish	0.1%	0.2%
Wheat, soy	0.4%	0.3%
Sesame	0.1%	0.1%
Overall	5%	3% to 4%

Therefore, computer vision-based applications means to be an ideal solution for allergen recognition since it is mimic how we as human to see the ingredients list. Computer vision will facilitate consumers in finding the possibility of containing food ingredients that can cause allergies, including foods that most often cause allergies such as milk, eggs, nuts, wheat, and soybeans and their processed [6].

An computer vision-based solution had proposed by Ozlem et. al. [7] which conducted by using an application to scan barcodes to detect these food products. The mobile application created by this researcher has fairly complicated steps to get the final result. The results of this study stated that the application made makes it easy to monitor the contents of packaged food products. Different with previous work, in this research we use direct approach to scan the food labels and extract the information then comparing the extracted text with our allergen database. We do some scenario to test our system performance including testing on different type of the food package and illumination.

Allergen data that will be used for application is from the Asthma and Allergy Foundation of America (AAFA), an organization dedicated to finding drugs and controlling asthma, food allergies, nasal allergies, and other allergic diseases[8]. Data from AAFA will then be entered into our database.

II. IMPLEMENTATION

Our application was developed and run under Android OS. We use rear smartphone camera to capture the food package. Several stages need to be perform in order to get the classification result. Fig. 1. Shows our overall process we embed to the program.

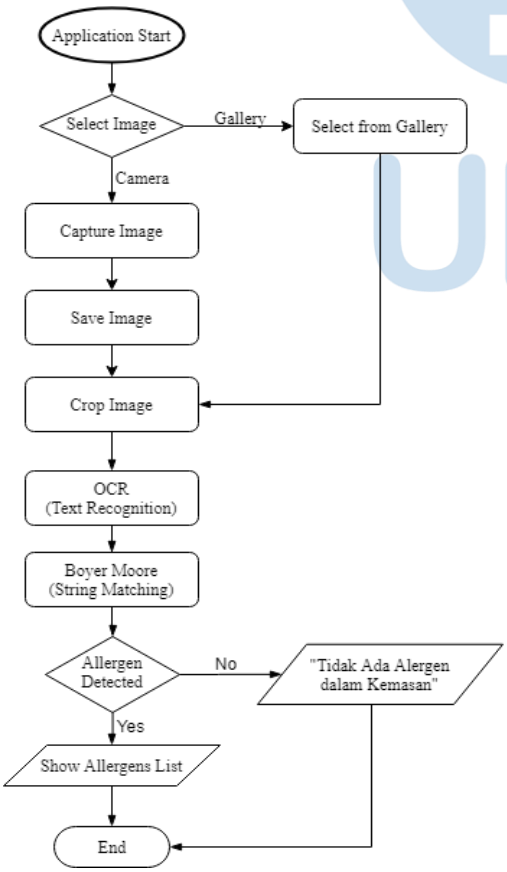

Fig. 1. Allergen Recognition Application Flowchart

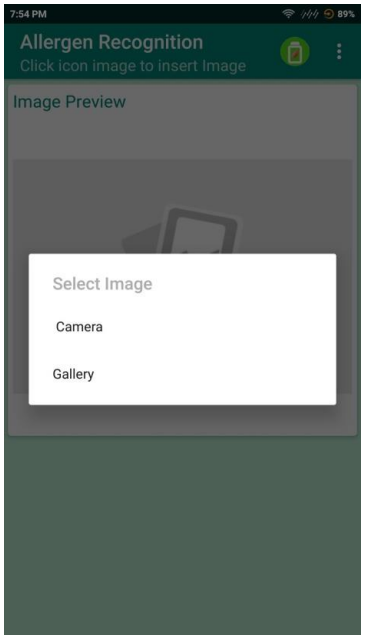

Fig. 2. Select Image Options

A. Application Start

When the application is first opened, the user will be presented with the main page. On this page there is a button to take pictures to check the allergen content.

Fig. 3. Crop Image

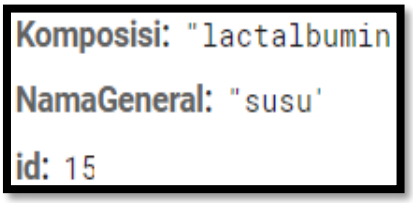

Fig. 4. Example of Data Format in Database

B. *Select Image*

When the button is selected, a dialog box will appear titled Select Image with 2 choices, namely the Camera and Gallery options. Display options can be seen in Fig. 3. On the main page also displays a display titled "Image Preview" which is a temporary display when there is no image selected by the user.

C. *Crop Image*

After selecting one of the Select Image options as in Fig. 4 then the selected image will enter the cropping or cropping process. On this page there are features such as image rotation or image flip. The cropping process is done manually by the user in the food composition section with the aim to facilitate the next process, namely the OCR process so that it does not detect parts that do not need to be detected. The appearance of the crop page can be seen in Fig. 4.

Image cropping is a library [9] for cropping images provided for Android. This feature has several capabilities, namely powerful (zoom, rotation, multi-source), customizable (shape, limits, style), and optimized (async, sampling, matrix)[9/17].

In this research, the image cropping feature that will be used is the zoom feature, namely image magnification, rotation / flip, and window aspect ratio to 1: 1, 4: 3, 16: 9 or custom. Cropped images will be set as bitmaps or Android URIs.

Fig. 5. Allergen Detected

Fig. 6. Allergen Not Detected

D. *Text Recognition*

OCR implementation is to do text recognition of images that are inputted by the user after cropping. Text recognition is performed on images that have been set by bitmaps. There is a repetition that OCR will detect text until it reaches the item size limit where the item is an object to detect text. The detected text will be entered into an array which will then enter the string matching process.

The library that we use for implementing this algorithm is Google Play Service. The author chose this library because it contains an interface for each of Google's services and also provides an API that allows us to resolve any issues at runtime, such as Google Play APK services that are missing, defective, or expired. In addition, if we want to access newly added features or products, we can upgrade the library to the latest version when the library is released. The library used is a release for computer vision namely play-services-vision version 16.2.0 which is devoted to android-based development.

E. *String Macthing*

Boyer Moore's algorithm is used to do word matching or can be called string matching between text that has been recognized by OCR and allergen data in the database. First of all you have to check string validity. In Boyer Moore's algorithm there are two terms namely content which means the whole text, and pattern which is a word. If the content is null or empty, and if the length of the content is less than the length of the pattern, the application will return a false value, which means the application failed to do word matching.

Boyer Moore's algorithm is to check the matching (string matching) between text in this context is written

as content that has been recognized with allergen data from the database where the data or pattern to be found is allergen data from the database. This method checks from the rightmost pattern. If a pattern is found that matches the content, it will return the value of the pattern found.

F. Database

In developing applications, the authors use the Firebase platform. Firebase is a service from Google that is used to facilitate application developers in developing applications. One of the functionalities of Firebase is a realtime database service that we use to store allergen data. Realtime database has the ability to store and synchronize application data in milliseconds.

The database will be hosted in the cloud. Data will be saved as JSON and then synchronized in realtime to each client that has been connected so that all clients can receive the latest data updates automatically.

In this study, the database stores allergen data in the form of id, composition, and general name of the allergen. Fig. 5 is an example of a storage format in the database. "Komposisi" is the name of the allergen (processed / technical) which may appear on food packaging, "NamaGeneral" is the name of the main allergen of the ingredient, for example in Fig. 5 ingredients is "lactalbumin" which is processed from milk (susu) so that it has a generalized name "susu".

G. Allergen Prediction

If there are allergens in the image selected by the user, then the display will show a list of allergens as can be seen in Fig. 6. If no allergens are detected in the image, the results will state that there are no allergens on the packaging as can be seen in Fig. 7. If the packaging contains food ingredients that are processed from the main allergen ingredients (milk, beans, chocolate, wheat, and eggs), then what will be displayed on the application is the name of the main allergen only.

III. Experiment and Result

A trial was conducted to test the performance and accuracy of the allergen recognition application that was created. Experiments carried out with several scenarios such as testing using the camera and using the gallery. The mobile application was developed under Android Studio with a Intel Core I7 CPU, while smartphone used in the experiment is Redmi Note-4.

Table II. Overall Result on Illumination Variation

No	Kemasan	Jumlah alergen yang seharusnya	Jumlah Alergen Berdasarkan Cahaya Kamera Mobile										Total False	Total Error	Total Error (%)	Akurasi (%)
			Percobaan ke-1	Percobaan ke-2	Percobaan ke-3	Percobaan ke-4	Percobaan ke-5	Percobaan ke-6	Percobaan ke-7	Percobaan ke-8	Percobaan ke-9	Percobaan ke-10				
1	Beng-beng	15	13	13	12	14	15	14	15	15	14	14	11	0.073	7.333	92.7
2	Youvit	0	0	0	0	0	0	0	0	0	0	0	0	0.000	0.000	100.0
3	Togo	16	16	15	16	15	16	16	15	16	16	16	3	0.019	1.875	98.1
4	Lifepack	0	0	0	0	0	0	0	0	0	0	0	0	0.000	0.000	100.0
5	MaxVita	5	3	4	4	5	5	4	3	4	5	5	8	0.160	16.000	84.0
6	Oat	7	7	7	7	7	6	7	7	7	7	6	2	0.029	2.857	97.1
7	Bagelen	7	7	7	7	7	7	7	7	6	7	6	2	0.029	2.857	97.1
8	Nabati	6	5	6	5	6	5	6	6	6	6	5	4	0.067	6.667	93.3
9	Cokusi	2	2	2	2	2	2	2	2	2	2	2	0	0.000	0.000	100.0
10	Cappucino	4	4	4	3	4	4	4	4	4	3	4	2	0.050	5.000	95.0
													Rata-rata akurasi			95.7

Table III. Results of Uncommon Word Detection

No	Alergen	Kandungan Alergen Utama	Alergen Kata Teknis Terdeteksi										Total False	Total Error	Total Error (%)	Akurasi (%)
			Percobaan ke-1	Percobaan ke-2	Percobaan ke-3	Percobaan ke-4	Percobaan ke-5	Percobaan Ke-6	Percobaan ke-7	Percobaan ke-8	Percobaan ke-9	Percobaan ke-10				
1	Tagatose	susu	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	0	0	0.000	100
2	Lecithin	kedelai	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	0	0	0.000	100
3	E476	kedelai	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	0	0	0.000	100
4	E322	kedelai	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	0	0	0.000	100
5	E412	kacang	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	0	0	0.000	100
6	E1105	telur	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	0	0	0.000	100
7	E966	susu	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	0	0	0.000	100
8	E412	kacang	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	0	0	0.000	100
9	E411	gandum	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	0	0	0.000	100
10	E479	kedelai	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	0	0	0.000	100
													Rata-rata akurasi			100

Fig. 7. Uncommon Word

A. *Experiment Scenario*

The study was conducted by conducting an experiment that is doing text recognition on 10 different packages which were carried out 10 times experiments for each package.

The trial was carried out by running the application with the input image captured by the mobile camera used for this study using lighting derived from the mobile camera flash.

The trial was also conducted with light coming from LED lamps with a large power of 5W, 220-240V, 50 / 60Hz, 38mA in a room measuring 3x3 meters.

The success of the test results is seen from the results of allergens that are issued. This experiment was carried out to find out what light was more effectively used to support the application to run and produce the most accurate results.

Another Trials are carried out by running applications with image input that include unfamiliar allergen words, names of some ingredients, especially incomprehensible additives, or different names used for certain types of food unknown to consumers, for example emulsifiers namely food additives with the code "E". Fig 8. Is showing the example of uncommon word used in ingredient.

The expected result is the accuracy of the application in detecting the allergen. This test is done by taking 10 words of processed / chemical allergens as samples to be used for the experiment. The experiment will be carried out 10 times.

B. *Evaluation Metrics*

In the trials conducted for this study have the test metrics to be obtained from these trials. The test metric sought is the level of application accuracy that is expected to be of high value to find out how big is the suitability of the implementation of the algorithms used for the allergen recognition application made. Following are the formulas used to get the test results.

$$\text{Total False} = \sum_{i=1}^{n} Total - detected \quad (1)$$

$$\text{Total Error} = \frac{\text{Total False}}{\text{Jumlah yang seharusnya} * n} \quad (2)$$

$$\text{Accuracy}(\%) = 100 - \text{Total Error}(\%) \quad (3)$$

$$\text{Average Accuracy} = \frac{\text{Total Accuracy}(\%)}{10} \quad (4)$$

Total Error is a way to get the error value generated from 10x experiments. Total Error is obtained by dividing the Total False by the number of words or allergens that should be multiplied by n where n is the number of experiments carried out in this study as many as 10 times the experiment, and Total False is the total error that occurs from 10 times the experiment.

Accuracy (%) is a way to get the accuracy value of each experiment on one package. This value is obtained from the difference in the value of success that is 100 (%) with the value of Total Error (%) where Total Error (%) is the value of Total Error in percent.

Average Accuracy is obtained by finding the average value of Total Accuracy (%) of 10x experiments that have been conducted. The value obtained is what will be the final value to find out the accuracy of a wanted to find.

C. *Result*

From the results of experiments on detecting and logging the technical allergen words (hidden) that have been carried out, the calculations are then performed to get the accuracy level. Table III shows a sample of test data for allergen difficult words.

In Table III, an experiment of 10 times the word technical allergen was conducted. The results listed in the column "Alergen Kata Sulit Terdeteksi" have 2 output values. The TRUE value states that the application successfully detected the allergen, while the FALSE value states the application failed to detect the allergen.

IV. DISCUSSION

From the results of word detection and logging experiments that have been carried out with a mobile camera light and a 5W LED light, the next step is to calculate the accuracy level. Table II shows trial data using mobile camera light .

The calculation of illumination variation is done using the formulas (1) – (4). From the calculation results, the average accuracy for trials using mobile camera light is 95.7% while the average accuracy for trials using 5W LED light is 97%. This states that the use of applications supported with 5W LED light is better at providing accurate data to the user when compared to using a mobile camera light.

The calculation is done using the formulas (1) – (4). From the calculation results, the average accuracy obtained for the test of difficult allergen words is 100%.

When the packaging is composed of a technical word or processed allergen material, the application will automatically translate the technical word or processed into the name of the main allergen it contains. The main allergen names are milk, eggs, nuts, wheat,

and soy. Fig. 10 is an example of packaging with the technical word "E412" and Fig. 11 shows the results of an application that provides output or information in the form of translation "E412" which contains the main allergen ingredient "kacang".

V. CONCLUSION

A. Conclusion

Based on the results of testing and research that has been done, it can be concluded the results of the study are as follows.

1). Allergen recognition application called Allergen Recognition has been successfully designed and built using OCR (Optical Character Recognition) algorithm and Boyer Moore algorithm. Applications that are built based on mobile can be used on devices that have an Android operating system. The programming language used to build applications is the Java language using the Android Studio Integrated Development Environment (IDE). The implementation of text recognition is done using the OCR algorithm while the string matching process is implemented using the Boyer Moore method.

2). This application has been evaluated by conducting several experiments to get the level of accuracy such as the OCR algorithm experiment, Boyer Moore algorithm, different light sources, and difficult word testing. When compared with applications made by Ozlem Durmaz Incel and Mustafa Incel, the advantage of the author's application is the use (flow) of a simpler application with an average overall application accuracy of 97.9%.

B. Suggestion

Based on research that has been done, suggestions that can be given for the development of allergen recognition applications in the future are as follows.

1). Adding real time recognition feature.

2). Adding text to speech feature so that the application can also be used for people who do not have the ability to read writing. Real-time inference will be possible with evidence [10]. And text to speech algorithm will be added based on [11].

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Modeling and Controlling the Actuator Joint Angle Position on the Robot Arm Base Using Discrete PID Algorithm

Machdiar Rohman[1], Dede Irawan Saputra[2]
Universitas Jenderal Achmad Yani, Program Studi Teknik Elektro
Cimahi, Indonesia
[1]machdiarrohman@gmail.com, [2]dedeirawan.saputra@lecture.unjani.ac.id

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***Abstract*— DC motor is a motor that is easy to apply. Its application in robotic DC motor control often occurs errors due to the existing load, so that the DC motor becomes inaccurate. The control used is PID (proportional integral differential). This PID control system works by processing calculations based on the control variables Kp, Ki, and Kd to achieve the conditions according to the expected setpoint. To make a DC motor position control device can be controlled with a PID controller. In practice, the variable to be controlled in this research is position control in the form of degrees. With the Arduino Mega controller, the motor driver as a DC motor rotation controller, the DC motor is given feedback in the form of an encoder sensor, the software used is the Arduino IDE. The results showed that PID control can correct errors and transient responses with a time constant value of 1.50 seconds, a rise time of 1.60 seconds, a settling time of 2.30 seconds and a delay time of 1.20 seconds and a peak time of 1.6 seconds and an error value of 0.33% through tuning parameter Kp = 16 Ki = 0.001 Kd = 16.**

***Index Terms*— Motor DC, Discrete PID, System response**

I. INTRODUCTION

DC motor is a type of drive that is often used in all fields, one of which is the field of robotics and control [1]. DC motors in the field of robotics can be controlled to regulate speed [2], position or a combination of them [3]. DC motor has a fast response, but still has a steady state error [4]. To reduce steady state error value of DC motor as position control, a controller is needed. The PID controller is the most widely used because it is simple and easy to learn and tuning its parameters. More than 95% of processes in the industry use these controllers. This controller is a combination of proportional (P), integral (I), and derivative (D) controllers [5], [6].

In most speed control systems, what is desired is to keep the rotational speed constant for all load conditions, not set the rotational speed to vary over time as the reference input changes. Not so with the positioning system. In these systems, system accuracy is usually measured not only by steady-state error for step inputs, but also by steady-state error for time-varying inputs. This is usually termed as following error. The addition of a PID controller can actually improve performance of positioning system in terms of magnitude of this following error [7].

As for some control positions for application of DC motors in the field of robotics, namely controlling position of motor on the goods moving robot with input in form of images that are read by camera [8]. Then, control the PID Training Kit ELABO TS 3400 Using a Position Sensor which is implemented on a DC motor whose control uses a potentiometer [9] Next, the use of a DC motor on an arm flip folding machine that uses PID control [10]. In this study, the application of a DC motor to the basic motion of the robot arm will be carried out to determine the position of the robotic base arm using the discrete PID method by providing input via a serial monitor.

The design of base arm robot is carried out by using actuator base arm robot in form of a brushed DC motor to achieve the angular position of encoder sensor [11] with motor control in form of the PID method [12]. There are several approaches that can be implemented, one of which is discrete PID [13]. The design of the PID controller in discrete domain is expected to approach the application of using a microcontroller and is expected to be able to increase transition response and reduce the value of base movement error with a predetermined constant on the PID controller. The determination of initial design carried out by transfer function modeling process using identification system of open loop and close loop approaches [14] with System Identification Matlab tools [15].

II. DESIGN SYSTEM

A. Movement Mechanism Design

At this point components that used in the robotic arm are computer controller which functions is to determine the input angle which inputted through the

serial monitor, then there is the Arduino Mega microcontroller which will give command, then DC motor functions as an actuator that will move the robot arm and the last is in the form of a controller. PID controller to determine the final position of the robot arm as shown in the open loop block diagram in Fig. 1. Then in Fig. 2. is a block diagram of a close loop system where the system has a hall sensor that functions as a feedback sensor that can make motor determine rotation direction and angle of the motor.

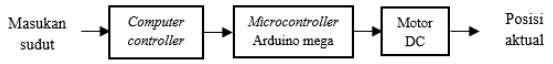

Fig. 1. Open loop arm robot system

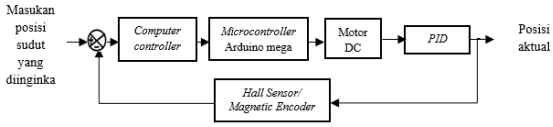

Fig. 2. Close loop arm robot system using PID controller

The schematic diagram of robotic arm shown in Fig. 3. consists of a robotic arm base, Arduino mega, encoded DC motor, L298N H-Bridge module driver, buck converter, and 12V power supply. The power supply is used as a voltage source for motor driver and buck converter. Buck converter convert 12V voltage source into 5V voltage. The 5V voltage source is used for the encoder voltage source from the encoder contained in the DC motor. The motor driver will provide a voltage source to DC motor and input pin of the motor driver will be connected to PWM pin on Arduino Mega, and output pin of the motor driver will be connected to DC motor. Furthermore, motor encoder contained in the DC motor will be connected to pins 2 and 3 of the Arduino as an interrupt pin.

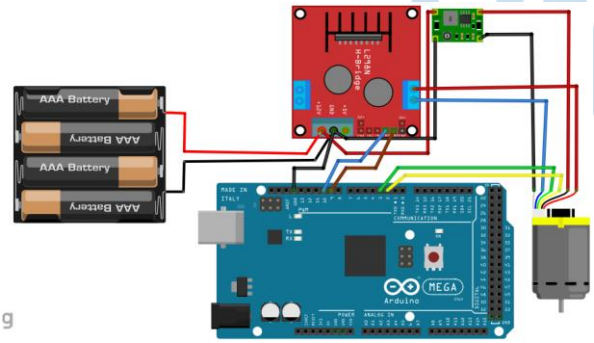

Fig. 3. Schematic diagram base arm robot

First base arm robot will initialize the DC motor, then angle value is entered on serial monitor. After angle value is entered, the robot is ready to use. Furthermore, the robot that has received angle input value, will be applied to the PID controller constant and the input will be calculated and adjusted to the input on serial monitor that has been inputted previously. Then the robot will move with a calculated angle and the movement process ends the flow process of the robotic arm system as shown in Fig. 4.

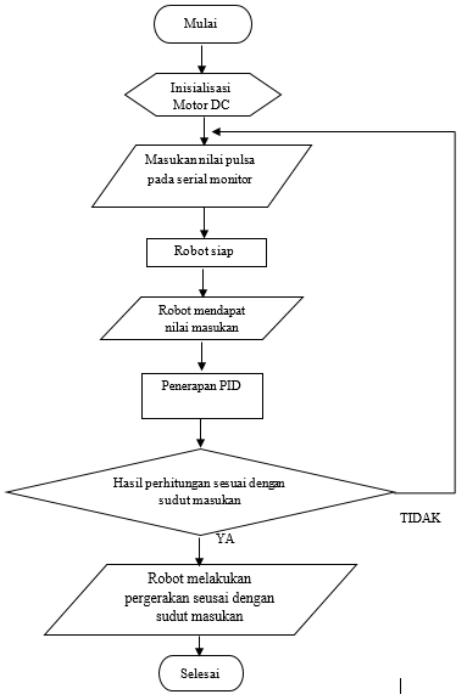

Fig. 4. Flowchart of arm robot control system using PID controller

B. *Software Design*

The software design is carried out using a system identification toolbox to create a mathematical model in the form of a transfer function from designed base arm robot and simulink is used to simulate the control system with PID algorithm.

1. *System identification toolbox* (SIT)

SIT is used to determine a mathematical model in form of a transfer function of DC motor actuator contained in the robot's base arm. The transfer function equation will be used to simulate encoder position control system with PID algorithm on simulink. Fig. 5. shows the transfer function generated by SIT.

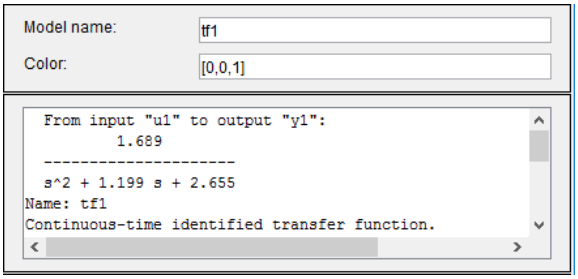

Fig. 5. Transfer function parameter result from modeling

The transfer function generated by SIT in continuous domain is a transfer function in the form of a close loop. The system is converted into an open loop system as shown in equation 1 so that it can be modeled in discrete form using the c2d function in Matlab with a sample time of 0.1 seconds as shown in equation 2.

$$G(s) = \frac{1{,}689}{s^2+1{,}199s} \quad (1)$$

$$G(z) = \frac{0{,}007912z + 0.007404}{z^2 + 1{,}82z + 0{,}8195} \qquad (2)$$

2. Simulink

Simulation on the MATLAB simulink software is carried out to generate data that will be used as a comparison with implementation of the designed base arm robot. There are 4 simulations used, namely close loop control simulations in discrete and continuous domains and PID close loop control simulations in discrete and continuous domains as shown in Fig. 6 to Fig. 9.

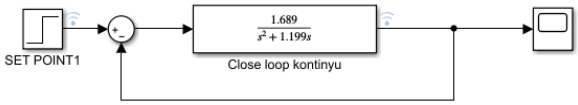

Fig. 6. Continuous domain close loop control simulation

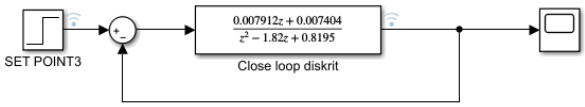

Fig. 7. Discrete domain close loop control simulation

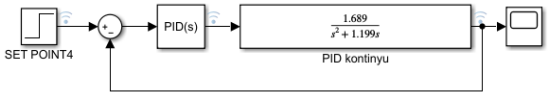

Fig. 8. Continuous PID close loop control simulation

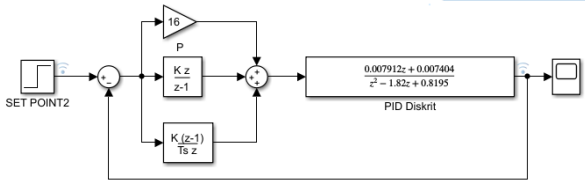

Fig. 9. Discrete PID close loop control simulation

III. Result and Discussion

The robotic base arm is made as shown in Fig. 10. The manufacture of this robotic base arm is intended to run three main systems, namely the open loop control system for base arm robot, the close loop control system for base arm robot, and the close loop control system for PID base arm robot.

Fig. 10. Design result of the robotic base arm

In this process an effort is made to improve the system performance of the base arm robot. The following are results of trials and comparisons that have been carried out on each system.

A. Open Loop Control System Base Arm Robot

Testing response of open loop position control on the base arm robot is carried out to determine enhancement pulses response generated by encoder to be converted into angles when given a PWM signal as input. Data from sampling result of open loop control response test on base arm robot, is processed using system identification toolbox (SIT) and produces a mathematical model with transfer function in equation 1.

After obtaining transfer function equation from modeling process in system identification toolbox (SIT), an open loop position control simulation was performed on MATLAB simulink. The results of position control simulation can be seen in Fig. 11 and actual condition of open loop control is shown in Fig. 12.

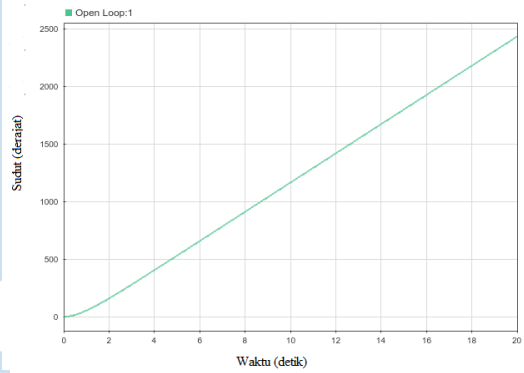

Fig. 11. Angle response graph of open loop position control simulation

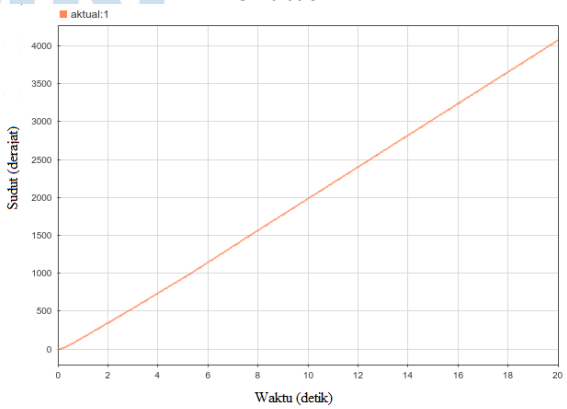

Fig. 12. Actual angle response graph of open loop position control

Based on Fig. 11 and Fig. 12 test results, it was found that response of open loop position control base arm robot from increasing angle of encoder could not reach steady state. With these results, the plant model used is assumed to be changed to a close loop condition to achieve steady state conditions.

B. *Close Loop Control System Base Arm Robot*

Closed loop position control system is made after system response from open loop position control system cannot reach a steady state. Testing of close loop position control system is carried out with the aim of knowing the characteristics of close loop response, the test is carried out by comparing real system response with simulation response in continuous and discrete domains performed on Simulink. In close loop experiment, motor angle position was tested by setting a setpoint value of 90º. Sampling time used in simulation setpoint is 0.1 seconds as shown in Fig. 13, Fig. 14, and Fig. 15.

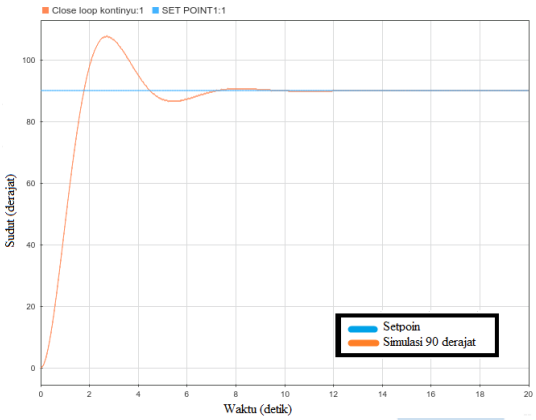

Fig. 13. Response of 90º continuous close loop control simulation

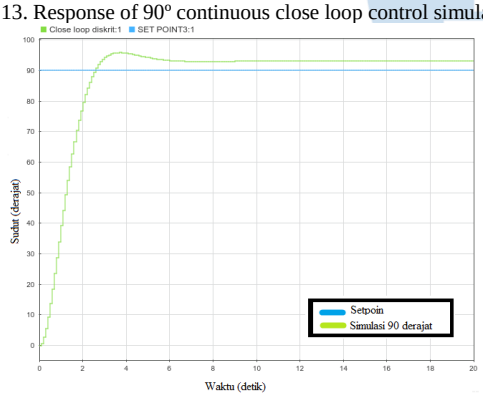

Fig. 14. Response of 90º discrete close loop control simulation

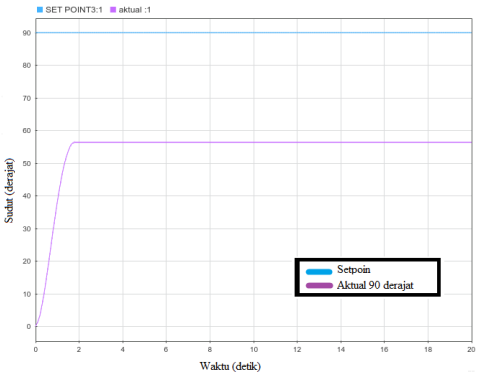

Fig. 15. Actual response of 90º close loop control

Responses that shown from continuous and discrete close loop simulation reaches desired setpoint. However, actual response of motor shows that rotation angle of the motor is in a steady state and cannot reach 90º setpoint

C. *Close Loop PID Control System Base Arm Robot*

Testing response of PID close loop position control is done by comparing data from simulation test results with data from implementation test results. As in close loop experiment, PID close loop experiment was carried out by setting motor angle position setpoint value of 90º. Sampling time used in simulation is 0.1 seconds.

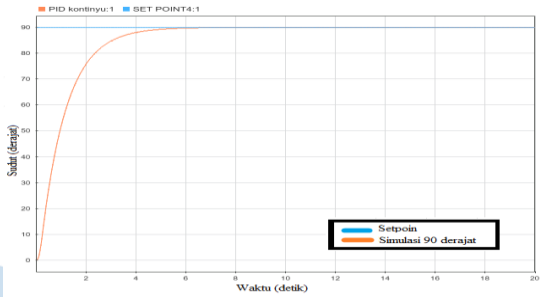

Fig. 16. Response of 90º continuous close loop PID control simulation

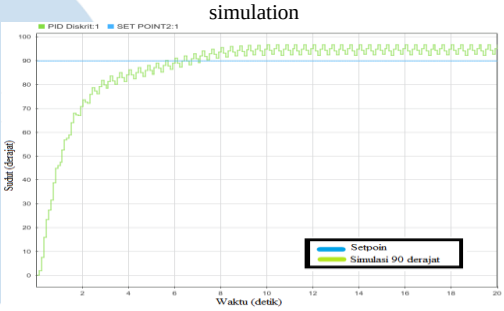

Fig. 17. Response of 90º discrete close loop control simulation

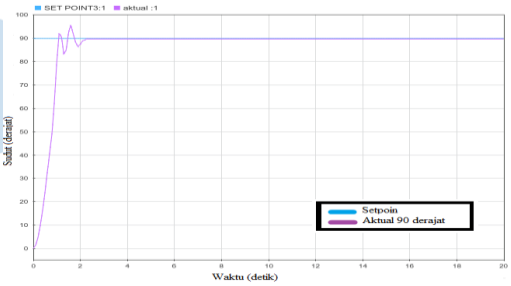

Fig. 18. Actual response of 90º close loop PID control

Responses that shown from Fig. 16 to Fig. 18 reaches a steady state at specified setpoint, which is an angle of 90°.

D. *Comparison of system*

Comparison of actual transient response, close loop and close loop PID at 90º angle from the system was carried out.

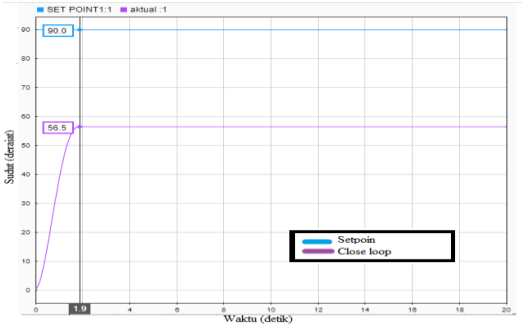

Fig. 19. Close loop position control transient response graph

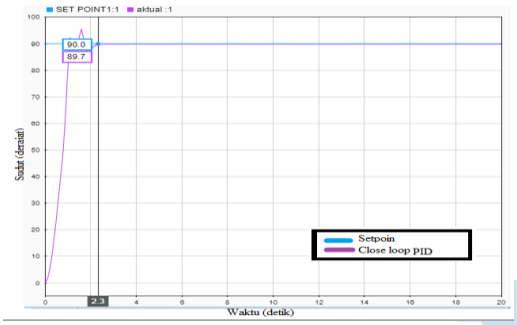

Fig. 20. Close loop PID position control transient response graph

Transient response of close loop control system shown in Fig. 19 has an error value between actual condition and setpoint of 33.5º and reaches a steady state condition at 1.90 seconds with a value of 56.5º. While transient response of close loop PID control system shown in Fig. 20. has an error value between actual condition and setpoint of 0.3º and reaches a steady state condition at 2.30 seconds with a value of 89.7º. Comparison error value response characteristics of close loop position control algorithm and PID close loop position control can be seen in Table 1 below.

TABLE 1. RESPONSE COMPARISON OF *CLOSE LOOP* AND *CLOSE LOOP* PID

	Error Value	***Steady state***	***Steady state Value***
Close loop	33,5º	1,90 second	56,5º
Close loop PID	0,3º	2,30 second	89,7º

Transient response characteristics that can be measured include:

a. Time constant, time required for motor to reach 63.2% of maximum angle.
b. Rise time, time required for motor has increased by 10% - 90% at steady state.
c. Settling time, time required for motor to enter stable area as big as 5% of steady state.
d. Delay time, time required to reach 50% of steady state.
e. Peak time, time required to reach resulting peak value.

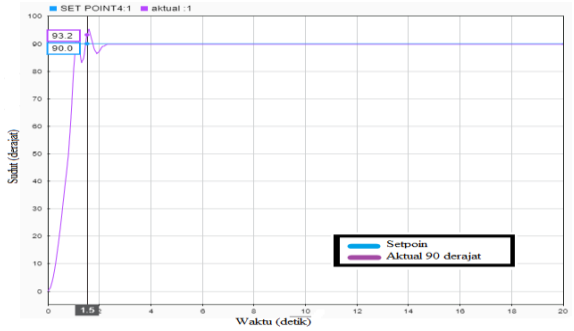

Fig. 21. Time constant implementation of PID close loop position control

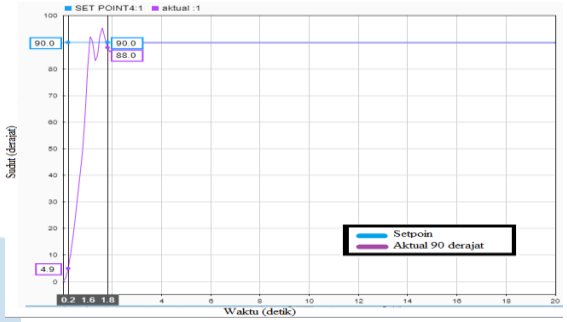

Fig. 22. Rise time implementation of PID close loop position control

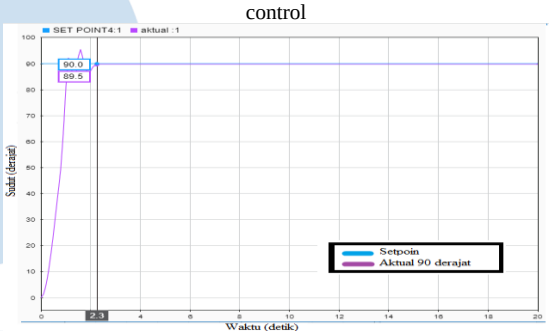

Fig. 23. Settling time implementation of PID close loop position control

Based on Fig. 21, Fig. 22 and Fig. 23, characteristics of transient response in the implementation of PID close loop position control have a time constant of 1.5 seconds, a rise time of 1.6 seconds, and a settling time of 2.3 seconds.

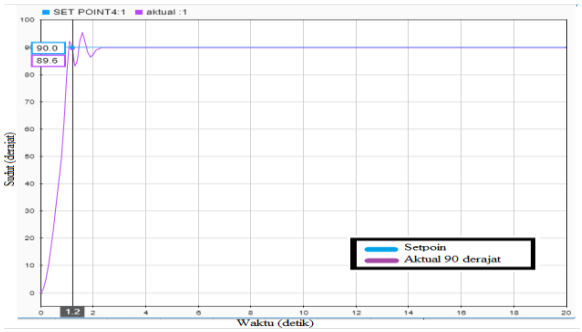

Fig. 24. Delay time implementation of PID close loop position control

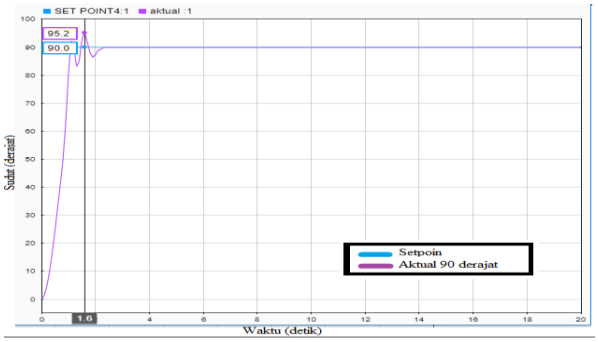

Fig. 25. Peak time implementation of PID close loop position control

Characteristics of transient response in the implementation of PID close loop position control shown in Fig. 24 and Fig. 25 have a delay time value of 1.2 seconds and a peak time of 1.6 seconds. Overall transient response resulting from the system is shown in Table 2.

TABLE 2. CHARACTERISTICS OF TRANSIENT RESPONSE *CLOSE LOOP* PID POSITION CONTROL

	Time constan	***Rise time***	***Settling time***	***Delay time***	***Peak time***
Actual	1,5 second	1,6 second	2,3 second	1,2 second	1,6 second

Then the last test was carried out in form of testing the response to difference setpoint value on PID close loop control with results that can be seen in Fig. 26.

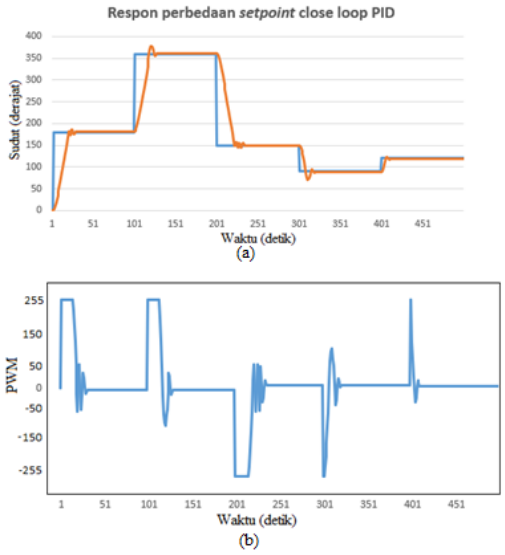

Fig. 26. Angle output response test graph (a) and PWM output graph (b) PID close loop control setpoint value

Angle control response in each setpoint increase experiment shown in Fig. 26, it can be seen that when the setpoint is at a value of 180°, 360° and 120° the response to an increase in angle tends to occur small and stable oscillations which are marked by an increase in the PWM value towards 255 but when the setpoint is at the value of 150° and 90°, the response to an increase in angle begins to slow down and oscillations tend to be large and are clearly visible when the setpoint is at 90°. The PWM output is able to adjust the value with a nominal value of 255 to -255 in order to maintain stability of output angle with the setpoint specified in PID close loop control.

IV. CONCLUSION

Based on design, measurement, and analysis. It can be concluded that the PID parameter implemented in the system transfer function has a Kp value of 16, a Ki of 0.001, and a Kd of 16 obtained through PID tuner in Matlab. The results of comparative analysis from close loop control and PID close loop control show that the PID close loop control is better than the close loop control, because it is able to optimally control the angle position which has an error value of 0.33% with a value of 0.3º. Close loop PID control has a transient response with a time constant of 1.50 seconds, a rise time of 1.60 seconds, a settling time of 2.3 seconds and a delay time of 1.2 seconds and a peak time of 1.6 seconds and for development of this research, it is recommended that the controller be developed by adding other controllers such as an anti-windup controller to reduce interference with the system. The use of Zigler-Nichole method in determining the PID parameters mathematically in future research. Addition of an upper arm robot that is integrated with the base arm robot.

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Hand Gesture Detection for American Sign Language using K-Nearest Neighbor with Mediapipe

Arsheldy Alvin[1], Nabila Husna Shabrina[2], Aurelius Ryo[3], Edgar Christian[4]
Fakultas Teknik dan Informatika, Universitas Multimedia Nusantara, Teknik Komputer
Tangerang, Indonesia
[1] arsheldy.alvin@student.umn.ac.id, [2] nabila.husna@umn.ac.id, [3] aurelius.ryo@student.umn.ac.id,
[4] edgar.christian@student.umn.ac.id

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***Abstract*— The most popular way of interfacing with most computer systems is a mouse and keyboard. Hand gestures are an intuitive and effective touchless way to interact with computer systems. However, hand gesture-based systems have seen low adoption among end-users primarily due to numerous technical hurdles in detecting in-air gestures accurately. This paper presents Hand Gesture Detection for American Sign Language using K-Nearest Neighbor with Mediapipe, a framework developed to bridge this gap. The framework learns to detect gestures from demonstrations, it is customizable by end-users, and enables users to interact in real-time with computers having only RGB cameras, using gestures.**

***Index Terms*— hand gesture, neural network, mediapipe, image processing, touchless.**

I. INTRODUCTION

In this modern era, technology is growing rapidly. One of the goals of existing technologies is to facilitate human life. Every existing device always has an interface that allows the user to control the device. This interface is always evolving from physical buttons, touch screens, to no-touch at all like voice commands and hand gestures.

Currently, there are many devices that use voice commands, especially on smartphones that we often use, voice commands themselves are based on speech recognition algorithms, ranging from being used to type text to performing commands to AI, such as Google Assistant, Siri, Google Home, and Alexa uses voice commands to control it. However, the voice command itself has several shortcomings in its implementation, namely the sound around the environment should not be too noisy so that the commands ordered can be delivered properly and the system is not slow when processing incoming voice [1] . Therefore, another alternative to interact with the computer is to use hand gestures. Hand gestures can facilitate user mobility and flexibility in using a device or program. Coupled with the presence of the Covid-19 pandemic which requires maintaining a distance so that control with touch is enough to give its own sense of worry.

In addition to being an option for the interface of a device, hand gesture detection itself can also be applied to the communication system for friends who have hearing problems or are deaf. [16] Based on the official website of the United Nations (UN), the World Federation of the Deaf (WFD) states that there are around 72 million people who have hearing problems worldwide as of 2020. One of the communication media for deaf friends is to use sign language.

Therefore, we created a project about hand gesture detection that can detect the movement or pose of the hand to be implemented in sign language recognition. The method used to perform hand gesture detection, of course, is to use computer vision which goes through several adjustments and filters on the hand. Then, the data obtained will be processed to be able to provide the appropriate output.

We use the framework from MediaPipe to detect the hand on the camera, and the K-Nearest Neighbor (KNN) algorithm to predict the gesture on the hand. MediaPipe is a cross-platform framework for building multimodal applied machine learning pipelines that can be used to detect hands. KNN is an algorithm used to predict the hand gesture displayed on the camera. The reason we chose MediaPipe to detect hands is that it is easy to use and can provide output in the form of hand landmark coordinates [14]. Furthermore, the KNN method was chosen because it only needed to classify an alphabet using hand coordinates from the MediaPipe output plus the use of KNN which was quite easy to implement and had a fairly high accuracy value. This can be proven by various kinds of research conducted [17]. We also use a sign language dataset with the American Sign Language standard, please note that not all sign languages are the same, for example people who already know American Sign Language will not understand when communicating with people who use

British Sign Language [2]. The reason for choosing American Sign Language as the dataset is that American Sign Language is the main sign language used in the United States and has been known and adopted by several countries around the world, one of which is Indonesia, namely SIBI (Indonesian Sign Language System) which developed from ASL absorption. SIBI itself has been inaugurated in Law No. 2 of 1989 and is an introduction to communication in the Special School (SLB) curriculum [15]. However, almost every country has its own sign language. According to the European Union of the Deaf, on its website it is explained that there is no universal use of sign language in the world [18]. The method starts by creating a dataset containing the hand coordinates of the alphabet. The creation of this dataset uses the help of MediaPipe which will provide hand coordinates from hand drawings. After that the dataset will become data to train the KNN model in order to classify the alphabet.

II. Literature Review

A. Hand Tracking

There are various kinds of literature that discuss how to do hand tracking via video or static images. To achieve this, a camera that can produce RGB images is needed [10]. The camera will provide output in the form of images or videos to the MediaPipe framework [3]. MediaPipe will first run the palm detector on the image. Palm detector on MediaPipe works using a model that works like BlazeFace [4]. To detect the hand, it is very difficult to detect the fingers at once, therefore, MediaPipe uses a model that will detect the palm first. This is because the palm is a fairly small object and can be modeled easily using the Bounding Box method which will not be affected by the aspect ratio [5]. The model will then be run by mapping 21 coordinates on the detected palms. This model will provide output in the form of 21 coordinates of the fingers, a marker of the presence of a hand or not, and a marker of the left or right hand.

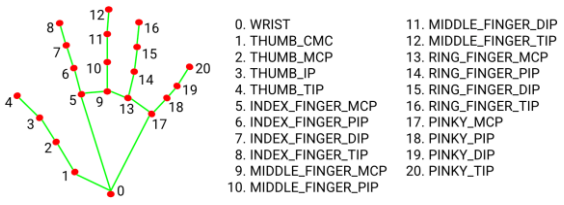

Fig. 1. Hand Landmark

B. K Nearest Neighbor Classifier

K Nearest Neighbor or abbreviated KNN, is a supervised learning method that classifies classes based on the k closest neighbors. Where the purpose of this method is to classify new objects based on previous data. KNN classification is a well-known method used for image classification [12]. KNN itself first works by determining the value of k which determines the number of neighbors to be used. Then the distance from the k neighbors will be calculated using the Euclidean distance.

$$d(\mathbf{p},\mathbf{q}) = d(\mathbf{q},\mathbf{p}) = \sqrt{(q_1-p_1)^2+(q_2-p_2)^2+\cdots+(q_n-p_n)^2} = \sqrt{\sum_{i=1}^{n}(q_i-p_i)^2}. \quad (1)$$

After calculating the distance, k neighbors will be taken according to the results of the distance calculation. Then from the k neighbors, the number of data points for each class that is included in the calculation distance will be calculated. After that, to determine the new data class, the largest number of neighbors from the class will be seen. In KNN itself, there are various ways to determine distance and similarity [6]. Although this KNN method is easy to implement, there are various weaknesses, namely poor performance in overcoming data that has very large dimensions and performance that is influenced by the magnitude of the value of k neighbors [8].

C. Data Scaling

Data scaling is a process that is carried out before classifying data. This process will transform the existing value into the existing scale. To achieve this process can be done normalization or standardization of data [9]. This normalization process is carried out with the aim of distributing data evenly and increasing the value of system accuracy. There are several normalization techniques including min-max normalization, z-score normalization, decimal scaling and sigmoidal normalization.

$$Z-SCORE = \frac{X_i - \overline{X}}{SD} \quad (2)$$

III. Methodology and Implementation

A. Design Stage

Hand Gesture Detection for Sign Language is intended to detect hands and provide output in the form of letters from the sign language demonstrated by the user's hand. To achieve this, the researcher uses the MediaPipe framework to detect hands and cv2 to do hand capture via a webcam as well as several libraries that support data processing, namely matplotlib, pandas, numpy, and sklearn. Matplotlib, pandas, and numpy are used for reading dataset files to plotting data, while sklearn is used for training data. The following is an architectural design for alphabet gesture recognition.

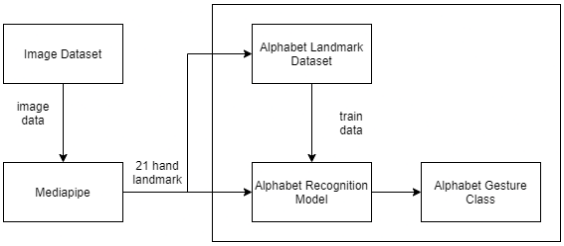

Fig. 2. Project Architecture

B. *Implementation Stage*

The programming language used in this project is Python. To facilitate the design, the researcher used the Jupyter Notebook coding environment which was run on the 2019 ASUS Vivobook A412FL laptop with the following specifications :

CPU : Intel Core i5-8265U CPU @ 1.60GHz
GPU : NVIDIA GeForce MX250 2GB
RAM : 8GB

To implement hand gesture detection for sign language, several stages are needed, namely:

1. *Creating a sign language dataset in the form of coordinates*

This is due to the unavailability of a sign language dataset that has the coordinates of 21 landmarks belonging to Mediapipe. The dataset used is an image dataset which contains a total of 87.000 images, with each image having a size of 200 x 200 pixels. There are 29 classes in the dataset consisting of 26 alphabets and 3 classes of space, delete, and nothing. After finding the dataset, each image in the dataset needs to be modified using the MediaPipe Hands API [7] which can output hand landmark coordinates from static images. Each landmark output from MediaPipe will be assigned a class according to the file name and inserted into the csv table. [13] Every 21 landmarks produced by MediaPipe will be entered in the form of values x[i] and y[i] where i denotes the landmark number in Fig. 1. So that each alphabet will have 42 features consisting of x1 and y1 to x21 and y21. Referring to the weakness of KNN, namely KNN is prone to high dimensionality where this can make the space that can be occupied by each instance bigger so that there is a possibility that the nearest neighbor of an instance can no longer be said to be "near" because the dimensions of the instance space increase [11], the researchers choose to use only the landmark x[i] and y[i] even though there are up to z[i] where x[i] and y[i] represent the width and height, respectively. While z[i] represents the depth, whose value will decrease when the landmark is getting closer to the camera. When using the z value, each alphabet will produce 63 features. This can cause a decrease in performance in the KNN model, because KNN cannot handle very large dimensional data. So the researchers decided that only using x[i] and y[i] would provide more optimal performance.

TABLE 1. DISPLAY OF OUTPUT IN CSV

	class	x1	y1	x2	y2	x3
0	A	0.295849	0.679613	0.209038	0.612926	0.147883
1	A	0.277914	0.728127	0.168684	0.634556	0.107125
2	A	0.273304	0.750424	0.153818	0.649119	0.087932
3	A	0.260779	0.758578	0.142449	0.658145	0.081542
4	A	0.264733	0.761643	0.144033	0.670212	0.077731

In this implementation, the researcher created 1000 training datasets with 24 alphabets. The making of 1000 training datasets is because not all data in the image dataset is readable, then the researcher only uses 24 alphabets, because the J and Z alphabets use movement so further implementation is needed to read movement.

2. *Machine learning model validation*

The dataset used in this project is a dataset that has just been previously created so that researchers do not have a test dataset to validate or evaluate machine learning models. Therefore, the researcher uses the train/ test split method which is used to validate the model with each data being processed and divided into training and testing data. This split is done in a 67:33 ratio with the help of sklearn's train_test_split library.

```
from sklearn.model_selection import train_test_split

# We will take 33% from 1000 for our test data.
# Recommended value 80:20, 67:33, 50:50
X_train, X_test, y_train, y_test = train_test_split(X, Y, test_size=0.33)
```

Fig. 3. Display of the train/test split process for model validation

3. *Scaling the dataset*

The divided dataset is scaled with the StandardScaler method from the sklearn library. This method works like z-score normalization. In accordance with the previous chapter, this process serves to improve the performance of the KNN algorithm.

```
from sklearn.preprocessing import StandardScaler
scaler = StandardScaler().fit(X_train)

X_train = scaler.transform(X_train)
X_test = scaler.transform(X_test)
```

Fig. 4. Display of scaling data process

4. *Generating classification model*

In making the classification model, the researcher uses the KNeighborsClassifier library belonging to sklearn. This library makes it easy to create KNN methods. In this model, the researcher uses 3 neighbors with an automatic algorithm from the library, the default weight function is uniform, the default metric is minkowski.

```
from sklearn.neighbors import KNeighborsClassifier
classifier = KNeighborsClassifier(n_neighbors=3)
classifier.fit(X_train, y_train)
```

Fig. 5. Display of fitting model classifier process

IV. RESULT

A. *Testing Scenario*

Researchers conducted 2 types of testing, namely testing with the help of a library and direct testing. For testing with the help of the library, the researcher aims to determine the accuracy value of the existing model. Meanwhile, in direct testing, the researcher aims to try this project in real-time.

Direct testing was carried out by 2 examiners with 2 significantly different conditions. The following is an explanation of the test conditions :

1. Examiner A
   Device : Laptop Lenovo G470 i5-2410M (2011 released)
   Brightness : dim
   Amount of testing : 2 times for every alphabets
2. Examiner B
   Device : Laptop ASUS VivoBook A412 FL i5-8265U (2019 released)
   Brightness : bright
   Amount of testing : 2 times for every alphabets

B. *Result with Library Assistance*

After the fitting process with the KNN method was successful, the researcher calculated the accuracy of the existing model with the help of sklearn's classification_report and accuracy_score. From this model, the researcher obtained an accuracy of 0.944 from a scale of 0-1, which means that it shows good accuracy.

```
from sklearn.metrics import classification_report, accuracy_score
print(classification_report(y_test, y_pred))
print(accuracy_score(y_test, y_pred))
```

```
              precision    recall  f1-score   support

           A       0.93      0.99      0.96       297
           B       0.96      0.99      0.97       325
           C       0.97      0.99      0.98       335
           D       0.98      0.97      0.97       339
           E       0.93      0.97      0.95       320
           F       0.98      0.98      0.98       316
           G       0.98      0.99      0.98       361
           H       0.98      0.99      0.99       328
           I       0.97      0.97      0.97       343
           K       0.94      0.98      0.96       332
           L       0.98      0.98      0.98       330
           M       0.85      0.84      0.84       311
           N       0.85      0.84      0.85       332
           O       0.97      0.93      0.95       339
           P       0.96      0.94      0.95       327
           Q       0.94      0.96      0.95       322
           R       0.90      0.91      0.91       321
           S       0.93      0.92      0.93       292
           T       0.97      0.94      0.96       342
           U       0.84      0.86      0.85       331
           V       0.92      0.84      0.88       339
           W       0.99      0.97      0.98       349
           X       0.94      0.92      0.93       343
           Y       0.98      0.94      0.96       346

    accuracy                           0.94      7920
   macro avg       0.94      0.94      0.94      7920
weighted avg       0.94      0.94      0.94      7920

0.9440656565656566
```

Fig. 6. Classification Report & Accuracy Score

In addition to the accuracy score, the researcher also plots the Error Rate K Value with a K value range from 1-40 which can be used to adjust what is the best K value to use.

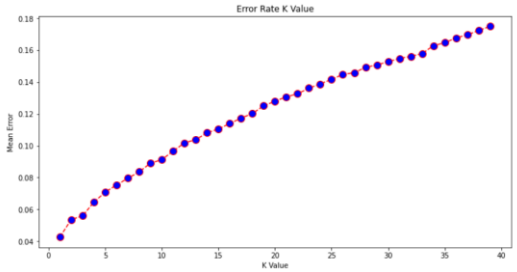

Fig. 7. Error Rate K Value Graph

C. *Result of Direct Testing*

In the final stage, the researcher conducted a trial on the existing model directly by detecting the hand and obtaining an alphabet that was in accordance with the American Sign Language that had been included in the dataset. Researchers use the help of the cv2 library to do hand capture via webcam and the Mediapipe framework to detect hands and obtain the coordinates of hand landmarks captured by the webcam and then predict what alphabet is being demonstrated based on existing models.

The test results are as follows :

1. Examiner A :

   The alphabet can be predicted when the webcam with the help of the Mediapipe framework detects the presence of a hand so that in low light conditions, the distance between the hand and the webcam must be closer to be readable by the webcam. As long as the webcam reads the presence of a hand, the expected output of the alphabetical prediction will appear. From 2 trials for all alphabets, all alphabets can be predicted with some adjustment of hand distance with the webcam. So, it can be concluded that even in dim conditions as long as the hand can still be read by the webcam, the sign language will still be predictable.

2. Examiner B :

   With good lighting, the entire alphabet can be predicted well because the webcam is able to capture a clear hand image so that the Mediapipe framework is able to recognize every part of the hand that practices sign language well.

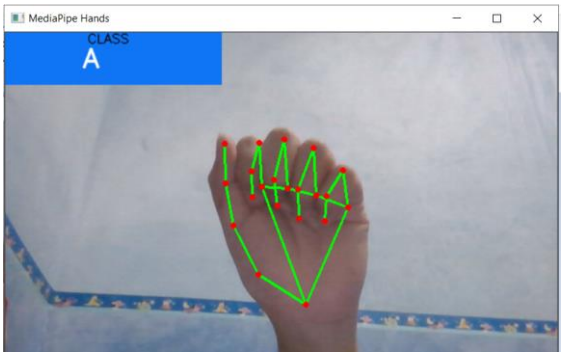

Fig. 8. *Hand Gesture* Alphabet A

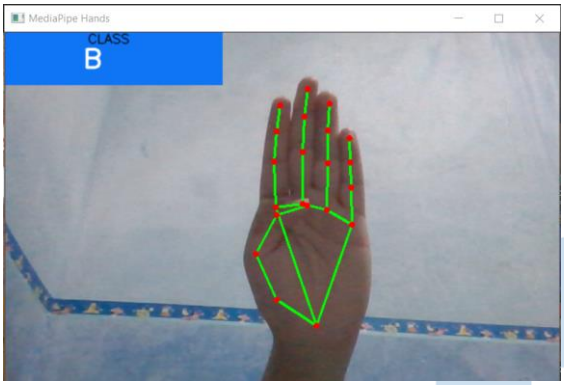

Fig. 9. *Hand Gesture* Alphabet B

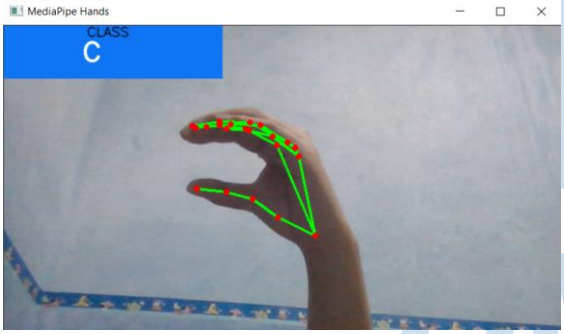

Fig. 11. *Hand Gesture* Alphabet C

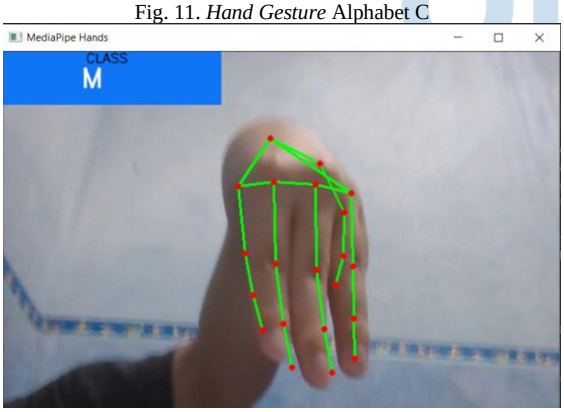

Fig. 10. *Hand Gesture* Alphabet M

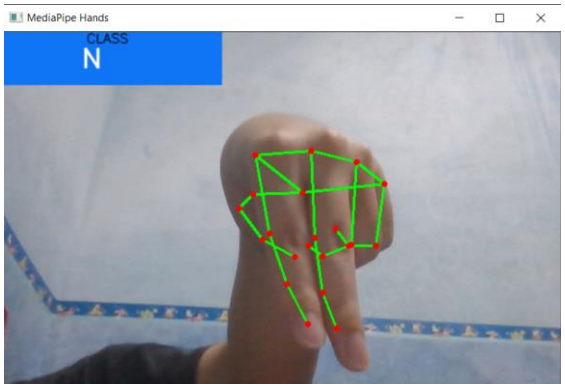

Fig. 11. *Hand Gesture* Alphabet N

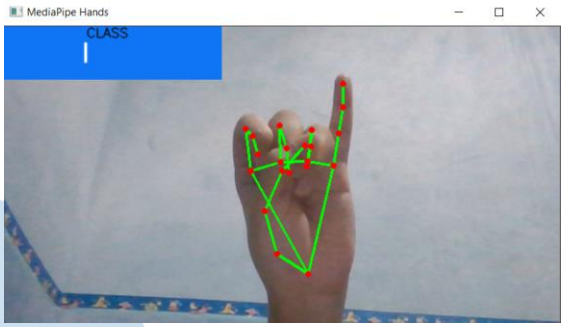

Fig. 12. *Hand Gesture* Alphabet I

Above are some of the results of the American Sign Language demonstration trials which were then detected and translated into the alphabet. Almost all alphabets can be read and translated well, except for some alphabets that may be a bit difficult to detect such as J and Z. However, apart from that, some alphabets that have similarities to their coordinate points, such as the M and N alphabets can still be distinguished and legible even though almost similar.

V. CONCLUSION

In this research, we propose a system that can detect sign language with the American Sign Language standard that can achieve real-time detection performance on desktop platforms, the workings of the researcher's detection system is based on the coordinates of 21 hand landmarks generated by MediaPipe. From these coordinates there are x, y, and z values for mapping hand gestures. The researcher suggests using only x and y values to improve the performance of the KNN model. This is due to the weakness of KNN in dealing with large-dimensional data. Then there are weaknesses in the system that the researcher proposes, namely the lack of datasets. To achieve an optimal system, a large number of datasets are needed so that it can detect the alphabet from various angles. Later, this system can be improved by using the Modified KNN model to obtain better results.

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Implementation of Lossy Compression Method for Storage Saving on Fog Computing

Rachmat Indra Permadi[1], Dany Primanita Kartikasari[2], Fariz Andri Bakhtiar[3]
Fakultas Ilmu Komputer, Universitas Brawijaya
Malang, Indonesia
[1]ripermadi@student.ub.ac.id, [2]dany.jalin@ub.ac.id, [3]fariz@ub.ac.id

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***Abstract*— Video surveillance is a technology that uses a camera as an image receiver and a monitor or Television (TV) as an image producer to covers certain areas. In the application, video surveillance was installed for monitoring the area using a camera. The camera will record the situation that occurs periodically, then send it to the virtual storage room via internet network and then display it on a monitor/TV. However, video surveillance has weaknesses in significant data/video output. Based on that problem, the concept of fog computing is applied, using a Cloud Circuit Television (CCTV) camera to monitoring for 24 hours. However, these experiments have a large data output until it reaches 4 GB storage. To reduce the data storage, this study uses a lossy compression method. The concept of fog computing is applied to compress video using the lossy compression method. The lossy compression codec used in this study is; H.263, H.264, and MJPEG (Motion Joint Expert Group) format. The result of a video with the H.263 codec has an excellent efficiency value than other codecs, which is 66%.**

***Index Terms*— Video Surveillance, Fog Computing, Lossy Compression**

I. INTRODUCTION

Cloud Computing is a service that combines computer technology with virtual internet-based development [1]. Cloud computing provides services to users for access data or applications remotely and store data without using traditional hardware. However, in its application with IoT, there are weaknesses, namely bandwidth limitations to process data transfers [2]. Fog Computing is a further development of Cloud Computing is a concept in the realm of Distributed Computing, which allows services from the cloud to be pulled to the network edge that functions for distance and latency from end-users to the cloud [3]. By combining these two technologies, all computing can be performed at the network edge (fog) for the distance and latency that must be performed on the cloud. However, there are several weaknesses in fog computing, one of which lies in the storage space. The storage space contained in fog computing devices is very limited, but the limited storage capacity is used to store large videos.

Based on the experiments that have been carried out previously, the concept of fog computing is applied, which is connected to a CCTV camera installed in a room for 24 hours. The video recorded on the CCTV camera will go to the fog point to check using a motion detection algorithm, checking is carried out to determine whether the object is in the room or not. From these experiments, the results obtained are quite large recordings of 4 GB. The large size of the video used for computing the checking process can fill the storage space of the fog node.

To overcome this problem, a lossy compression method is applied. The lossy compression method can save storage space because the burden of large video sizes is reduced by reducing the size of the video. By applying the lossy compression method to the fog node, this study makes storage efficiency in the fog node the primary goal. This research uses a lossy compression codec H.263, H.264, and MJPEG. The result of a video with the lossy compression method gets efficient results after the system performs the compression process on the video before the data is saved to the cloud.

II. LITERATURE REVIEW

A. Cloud Computing

Cloud computing is a parallel and distributed computing system of interconnected computers with a single server to provide users based on Service Level Agreement (SLA) [1]. Cloud computing provides to users to be able for access the applications, data and do storage remotely without use a traditional hardware using third-party servers or known as cloud storage. Cloud computing has two main architecture is Front-End and Back-End. The architecture is connected to each other via the internet. The Front-End can be a sensor, client, or any application that uses a cloud service. Back-End is the cloud system which consists of computer, servers and data storage [4].

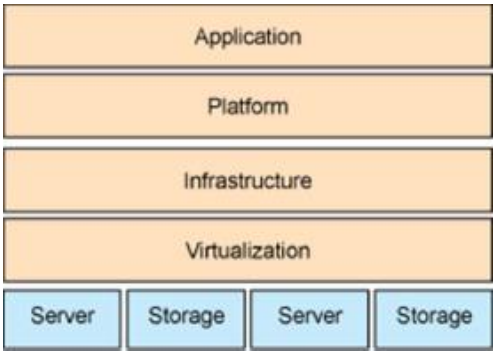

Fig. 1. Layers of cloud computing architecture

There are three types of services provided by cloud computing system is a Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS). SaaS is a cloud computing service with applications provided by providers via internet. PaaS provides services in the form of cloud users can develop their own applications. IaaS provides all cloud computing service from resources, storage, networking and other to users.

B. *Fog Computing*

Fog computing is a computing services system that has set of connected devices located at the edge of network with support from cloud service providers to provide convenience in user storage and communications [5]. Fog computing and cloud computing have difference in computing process, where fog computing do at the edge of network and cloud computing do at the server center.

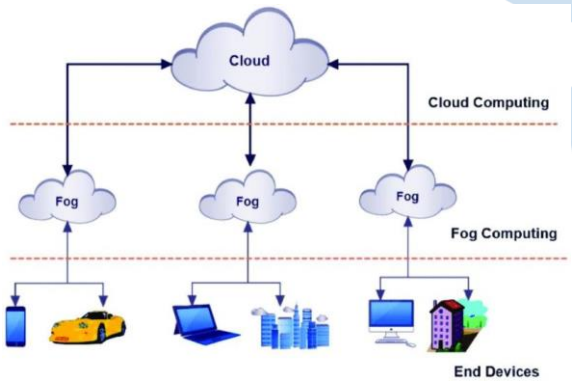

Fig. 2. Fog computing architecture.

The concept of fog computing is to provide network services near nodes. Fog has the responsibility to provide compute, storage and networking services between end nodes in IoT and cloud environments. Figure 2 shows some architectures in fog computing that provide services in an IoT environment using networks system such as Wireless Sensor Network (WSN), Virtual Sensor Network (VSN), VANET, and Private Area Network (PAN) [6].

C. *Multimedia Network*

Multimedia network has 2 different meanings, namely network and multimedia. A network (computer network) is a collection of computers and other supporting computer devices connected to each other in a single unit. Computer network media is divided into 2, namely, via cable (wired) or wirelessly (wireless) so that it allows users to exchange information with each other, such as sending documents and data.

While multimedia comes from 2 words, namely 'multi' which means many, and 'media' which means something that is used to convey or carry something. It can be interpreted that multimedia is the use of computer devices to display various kinds of information such as sentences or text, images, audio, video, and others. Based on the two definitions above, it can be concluded that Multimedia Network is the use of computers connected to each other to combine text, images, audio, video, and others to interact with each other [7].

D. *Real-Time Streaming Protocol*

RTSP (Real Time Streaming Protocol) is a application level protocol for controlling real time restricted data transmission over a network. RTSP can transmit audio and video data in real time controlled and on demand, provide services such as fast forward, rewind, stop, play and other control functions. RTSP do not transmit streaming data itself unless using RTP (Real-time Transport Protocol). The advantage of RTSP is that it provides a state-of-the-art connection between the server and client, allowing the user to pause or replay a position in the stream. In its implementation, RTSP can be connected with compression services such as MPEG-4 and H.264, where users can view video with sound [8].

E. *Lossy Compression*

Lossy Compression is when the data compressed. Lossy Compression is based on the assumption the data hold lot of information than humans being perceived. Thus, irrelevant data can be deleted [9]. In other words, this method is uses for reduce size of data for content, handling, storage and delivery. One of the advantages is the application of multimedia files such as video (MPEG-4, MKV and WMV) which can make the file size much smaller than the original size using the Discrete Cosine Transform algorithm.

F. *Discrete Cosine Transform*

Discrete Cosine Transform (DCT) is common lossy compression technique for processing compression of image and audio. DCT is used to convert data to summation a series of cosine waves that oscillate at different frequencies [9]. DCT involves using the Cosine function and real coefficients, whereas the Fourier Transform using the sine and cosine functions is much more efficient because fewer functions are required to approximate the signal. Both Fourier are spatial domains into frequency domains, and their respective functions convert something back. The stages in this DCT method are video data is processed starting from the prediction stage, then

transform & quantization and entropy encoding then comes out as a codec sequence. Furthermore, the results of the codec sequence will be reprocessed through the stages of entropy encoding, rescale & inverse transform, and reconstruction, so that it becomes a video. The stages of the process are displayed in Figure 3. Encode stage is the first step input into a context vector it's a codec and then a decode is a context vector to generate the output of the video.

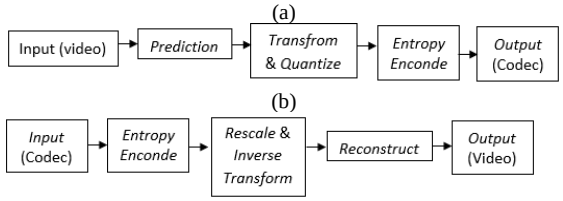

Fig. 3. (a) Stages of Encode and (b) Decode DCT Method.

G. *H.263 (MPEG-4 ASP)*

The H.263 video codec is the standard for compression of video at low bit rates. The H.263 is primary objective for encode video at very low bit rates in applications such as public telephone, narrowband integrated service digital and cellular networks. H.263 has seven basic types of frames of which only the first two are mandatory, which are independently encoded Intra also called I-frames. The I frames are encoded without reference to the other frames being encoded relative to the previous or I P frames, whereas the B frames are predicted bidirectional, i.e. they are predicted concerning the past and future frames. The compression given is the highest in the B-frame and the least in the I-frame. In addition to this PB, Increase in PB, EI and EP [10].

H. *H.264 (MPEG-4 AVC)*

H.264 is an standard video encoding also known as a MPEG AVC, represents an advanced video compression technology. This standard was developed in collaboration with the International Organization for Standardization's MPEG (ISO/IEC/SG29/WG11) group and the International Telecommunication Union's video coding expert group (VCEG, ITU-T/SG16/Q.6). H.264 codec for application in low bitrate video to high definition video.

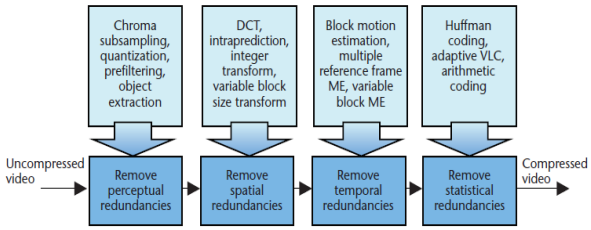

Fig. 4. Compression video stages.

Fig. 4 shows the various techniques that video encoding algorithms use to reduce redundancy. Video compression algorithms have various techniques that can be used to reduce redundancy in some ways, these techniques are applied. The H.264 video codec is standardization for decoding process not a encoding process.

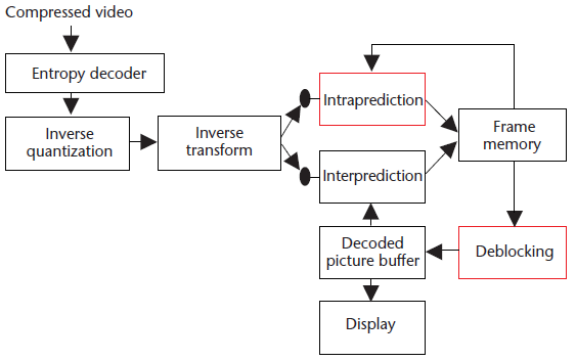

Fig. 5. H.264 codec decompression stages.

Fig. 5 shows the key components of the H.264 decoder. This decoding structure, without the new Intra-prediction and Deblocking components in H.264, like most video codecs in use today [11].

I. *MJPEG (Motion JPEG)*

MJPEG is a video compression format in which each video frame or interlaced plane of a digital video sequence is compressed separately as a JPEG image. MJPEG is recently used by video recording devices such as digital cameras, IP cameras, and webcams; and with a non-linear video editing system. The MJPEG format has the disadvantage that it requires higher bandwidth than H.264, MPEG-2 and MPEG-4. However, in the case of vehicles, MJPEG is preferred because video is usually used to store event-oriented still images or to transmit them to other devices [12].

MJPEG (Motion JPEG) is widely used in the field of non-linear editing. MJPEG can be used for frame editing and multi-layer image processing. This method treats a motion video sequence as a continuous still image. This compression method compresses each frame individually and completely. In the editing process, each frame can be saved randomly and can be edited according to the accuracy of the frame. Since MJPEG only compresses spatial redundancy within frames and does not compress redundancy differences between frames, the compression efficiency is not high.

J. *Motion Detection*

Motion detection is the process of detecting the change or moving of an object. It can be processed mechanical or electrical method. Motion detection is crucial for image processing in the system [13]. It has been widely used in computer vision applications such as MPEG4 image compression, target tracking, video retrieval, human recognition and visual surveillance. The motion detection has an objective for locating foreground objects in the scene to further analysis [14]. The video can be captured using a stationary or moving camera such as IP Camera [15].

K. *OpenCV*

OpenCV (Open-Source Computer Vision) is a library that is used to process images and videos so that we can get the information in them. OpenCV has more than 2500 optimized algorithms, including a range of machine and machine learning algorithms. This algorithm can detect and recognize faces, identify objects, classify human actions in videos, track camera movements, track moving objects, etc.

The advantage of using OpenCV is that it can make more use of time and resources in image processing and is easy to translate. In addition, OpenCV is open source, so it is easy to obtain. In its application, there are 3 ways to perform motion detection with OpenCV, including the following:

- Frame differencing: The frame differencing method uses two or three adjacent frames based on time series images to reduce and obtain the different images.
- Background subtraction: Commonly used methods for segmenting motion in static images. It will detect moving areas by subtracting the current pixel-by-pixel image from the reference background image created by averaging the image over time in the initialization period.
- Optical flow: The optical flow method uses a motion target's characteristic vector that changes over time to detect areas of motion in a sequence of images [13].

III. RESEARCH METHODS

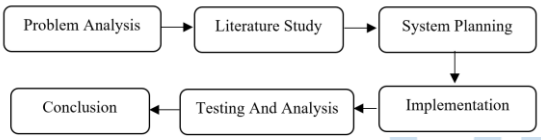

Fig. 6. Research Methods.

The first step for this research is to conduct a literature study. This step is done to collect all references related to the research. The reference collection stage in this literature study also includes an analysis of problems and system requirements. The collected references include a description of the theory to the chosen method to solve the problem.

When all references and requirements for the system have been obtained, the next step is system design. This stage is done by designing the form of the system that will be used according to the needs analysis. After completing the system design, the system will be implemented at the implementation stage. The implementation stage is carried out the functions of the requirements that have been designed. The results of the implementation stage will be tested at the system testing stage. System testing is carried out to measure the success of the system based on predetermined parameters. After the test results are obtained, conclusions can be drawn from the research conducted and suggestions for possible future research.

IV. SYSTEM PLANNING

A. *System Topology*

In the design of the topology will be made 3 nodes. The first thing that needs to be done is to design the topology of sending video from the camera to the fog node which is then forwarded to the cloud server.

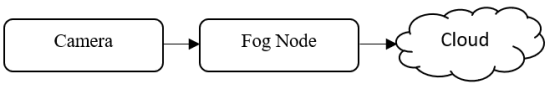

Fig. 7. System Topology

In Figure 7 it is explained that the camera will stream to the fog node. Then the fog node is in charge of performing video compression, computing, and uploading videos. While the cloud is in charge of storing the videos that have been computed.

B. *System Flowchart*

The system flowchart explains the design of the running process of the system that will be used in the implementation of the lossy compression method in fog computing. The system flowchart will be shown in Figure 8 below.

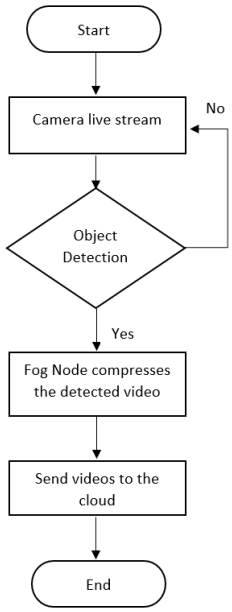

Fig. 8. System Flowchart

C. *System Architecture*

System architecture is a description of the system that will be implemented in the system. The system architecture on the system will be shown in Figure 9. below.

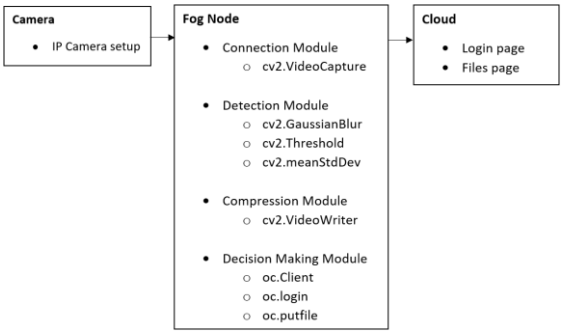

Fig. 9. System Architecture

The modules used in this system are libraries belonging to OpenCV (cv2) and OwnCloud (oc).

D. *Evaluation Method*

The evaluation method is a stage that is carried out after implementation is complete. In the evaluation method, there is a testing stage which will later prove that by using the compression method, the resulting video will be minimized, so that it does not burden the storage on the fog node. In this study, there are several scenarios that exist to test the effect of the compression method on the fog node and analyze the results obtained including CPU usage and memory usage. All tests were recorded at 20 fps and run for 1 hour (3600 seconds) to obtain similar results. There are parameters used in this test, including; Compression results and fog node performance are based on CPU Usage and Memory Usage. In this study, three test scenarios will be used. The test scenario can be seen in Table 1.

TABLE 1. TESTING SCENARIOS

No.	Scenario	Explanation
1.	Scenario 1	The OpenCV implementation uses the H.263 lossy compression codec for 1 hour duration of recorded.
2.	Scenario 2	The OpenCV implementation uses the H.264 lossy compression codec for 1 hour duration of recorded.
3.	Scenario 3	The OpenCV implementation uses MJPEG lossy compression codec for 1 hour duration of recorded.

V. EXPERIMENT AND RESULT

A. *Camera Implementation*

In this research, an IP Camera has a specification with is 3 megapixel and FHD 1080P maximum video output resolution. The IP Camera can operate using the wireless network with 3 antennas behind. It will be used to record video then be streamed to the fog node. On the camera used there is an RTSP protocol that is used to stream. The data streamed here are all frames recorded by the camera. Later these frames will be processed by the fog node before being sent to the cloud.

Fig. 10. IP Camera

B. *Fog Node Implementation*

In this research, fog node uses Raspberry PI 4 as a microcontroller that will perform computation, compression and video upload. When the streaming process takes place, computations will be carried out in the form of motion detection to determine whether there are moving objects in the video. The duration of this experiment is 1 hour in 2x3 room with 1 detected person. After the computing process is complete, the compression process will be carried out to compress the video. After the compression process, the video will be forwarded to the cloud. The compression method used is the lossy compression method. The lossy compression method aims to produce videos that are smaller but still usable. The codecs used are H263, H.264, and MJPEG with .mp4 container. In the lossy compression method, the resulting video is in .mp4 format with a resolution of 640x480p. Pseudocode lossy compression can be seen in Table 2.

TABLE 2. PSEUDOCODE LOSSY COMPRESSION

```
START
   SET threshold value
   GET start time
   SET fourcc lossy codec
   SET output video
   DEF distMap (frame1, frame2)
      GET frame1 distance value
      GET frame2 distance value
      CALCULATES   different   between
frame
      CALCULATES  absolute  difference
norm
      CALCULATES   normalize   distance
value
      RETURN distance
   SET stream source
   GET check1
   GET check2

   WHILE True
      GET check3
      IF check3 = True
         GET rows and columns
         CALCULATES distance frame1 and
frame3
         SET GaussianBlur smoothing
         GET threshold value
         CALCULATE standardDeviation
      IF stDev > sdThresh
         CREATE FILE
```

```
        GET endTime
           SET durasi
           IF durasi > durasi_rekam
              SET selesai = True
    RELEASE camera
    RELEASE output
    PROGRAM upload1
    GET destroyAllWindows
    PROGRAM lossy
END
```

C. *Cloud Server Implementation*

The cloud server used in this study is Amazon Web Service which uses a web-based storage application to store video data recorded from the camera node. The storage application used is OwnCloud. AWS is used because it can provide highly reliable, scalable and low cost of infrastructure in the clouds. Its very easy to access servers, storage, and a broad set application services in over internet [17]. OwnCloud has a freely available software which seen a rapid development and one of the open source STaaS products. The OwnCloud appears to be geared towards running on other web servers and operating system does exist. Other benefit of using OwnCloud, client can make standard file upload, download, delete, rename, capabilities, default web interface allows user to play a media file, viewing images in the gallery and maintain a calendar and contact list [18].

Fig. 11. OwnCloud login page.

D. *Compression Ratio*

This parameter is used to calculate the relative reduction in data size represented by different compression algorithms. By using the Space Saving method by determining the cut in size that is proportional to the uncompressed size using equation (1).

$$Space\ Saving = 100x(1 - \frac{compressed\ video\ size}{original\ video\ size})(1)$$

Based on the test scenarios that have been carried out, the following results were obtained:

TABLE 3. COMPARISON OF COMPRESSION RESULTS

Trial	Lossy Compression		
	H.263	H.264	MJPEG
1	56.347 KB	166.248 KB	304.725 KB
2	57.986 KB	165.788 KB	303.030 KB
3	56.763 KB	167.452 KB	302.571 KB
4	58.759 KB	165.691 KB	303.269 KB
5	57.391 KB	166.455 KB	303.988 KB
6	57.087 KB	167.411 KB	303.442 KB
7	58.802 KB	165.652 KB	304.547 KB
8	56.447 KB	167.137 KB	304.202 KB
9	56.058 KB	165.783 KB	303.596 KB
10	57.184 KB	165.887 KB	302.178 KB

The results of the compression ratio will be displayed in graphical form in the following figure.

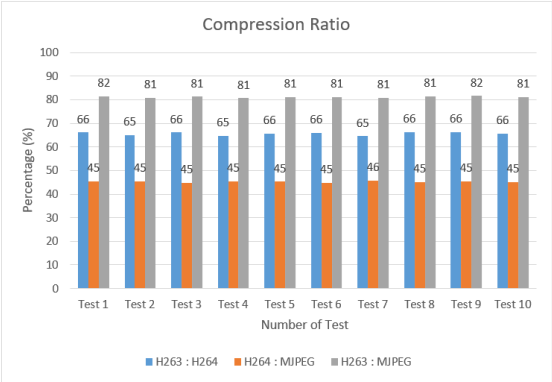

Fig. 12. Compression ratio.

The result of the compression space saving is H.263 codec has the highest compression is 58.802 KB at Trial 7 and lower compression is 56.058 KB at Trial 9. The H.264 codec has the highest compression is 167.452 KB at Trial 3 and the lowest compression is 165.691 at Trial 4. The MJPEG codec has the highest compression 304.752 at Trial 1 and the lowest compression is 302.178 at Trial 10. Based on the result in Table 3, is H.263 codec has a smaller compression file size than H.264 and MJPEG codec.

E. *CPU Usage Utility*

CPU Usage is the amount of time for which CPU for processing an instruction of computer program, the example is waiting input/output data. This parameter is used to see CPU Usage performance on the fog node when motion detection is running. CPU Usage is monitored using the formula in Table 2 for ten trials. The following are the results of the CPU Usage test results can be seen in Table 4.

TABLE 4. COMPARISON OF CPU USAGE ON FOG NODE

Trial	CPU Usage (%)		
	H.263	H.264	MJPEG
1	22.1	19.8	22.2
2	24.1	25.2	24.0
3	24.7	23.9	26.3
4	23.3	25.1	23.0
5	23.5	26.8	25.8
6	24.2	26.5	25.7
7	23.3	26.3	25.6
8	24.8	27.8	26.3

9	24.5	26.9	24.7
10	24.1	27.8	24.6

F. Memory Usage Utility

Memory Usage Utility is the amount of memory available when the applications running on your system. This parameter is used to see the performance of Memory Usage on the fog node when motion detection is running. Memory Usage is monitored using the formula in Table 2 for ten trials. The results of the Memory Usage test on the fog node can be seen in Table 5.

TABLE 5. COMPARISON OF MEMORY USAGE ON FOG NODE

Trial	Memory Usage (%)		
	H.263	H.264	MJPEG
1	22.3	22.6	23.1
2	24.5	25.4	25.6
3	22.2	23.0	25.2
4	23.5	24.2	23.9
5	26.9	31.5	25.1
6	23.6	26.1	26.3
7	23.0	25.2	26.8
8	22.8	25.2	23.0
9	23.1	25.9	25.3
10	22.4	30.5	27.0

VI. CONCLUSION

Based on the results of the tests conducted by comparing three different types of lossy compression codecs with 1 hour duration of recorded. It can be seen that the H.263 codec produces a greater efficiency value than other codecs, which is 66%. Codec H.263 produces an average video size of 57,282 KB. Then, the H.264 codec produces an average video size of 166,350 KB. While the MJPEG codec produces an average video size of 303,555 KB. The H.263 codec has a greater efficiency because of the standard video compression is at very low bit rates. This codec commonly can be used in application such as cellular network, public telephone networks and narrow band integrated service digital network.

The utility value of the fog node does not have a significant difference using three different types of lossy compression codecs. Codec H.263 produces an average utility value of 23.8% and 23.4%, respectively. Then, the H.264 codec produces an average utility value of 25.6% and 25.9%. While the MJPEG codec produces an average utility value of 24.8% and 25.1%.

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Automatic Warning System for Weather Station Power Supply

Mumtazanisa Fairuzen[1], Angga Rusdinar[2]*, Fiky Yosef Suratman[3], Denny Darlis[4]
[1,2,3]School of Electrical Engineering, Telkom University, Bandung, 40287, Indonesia
[4]School of Applied Science, Telkom University, Bandung, 40287, Indonesia
[1]mumtazfairz@student.telkomuniversity.ac.id, [2]*anggarusdinar@telkomuniversity.ac.id,
[3]fysuratman@telkomuniversity.ac.id, [4]dennydarlis@telkomuniversity.ac.id

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Abstract— **Weather observation is one of the important factors in agriculture. Data from weather observations can be used for various things, including to predict future risks due to these weather conditions. An Automatic Weather Station (AWS) is needed to read weather conditions continuously. Some of the devices that will be built for the AWS system are data communication, sensors, and power supply. AWS is usually installed in certain areas where there is no power source. Hence, it takes a power supply system that can stand alone and has a security system that can monitor the components connected to the system in real time.This research successfully designed a power supply system for a weather station that is equipped with current and voltage measurement features for its load as well as a warning system feature in case of interference on GSM SIM900-based Weather Station. Based on the results of the study the system using solar cell modules has an efficiency of 14,1% and is supported with the help of batteries that can be recharged through solar energy. Using the INA219 sensor to measure the voltage and load current connected to devices that have an error percentage value of less than 1%, the data is then uploaded to Thingspeak. Testing of warning systems at the Weather Station is conducted using Magnetic reed sensors capable of detecting changes when the separation distance between the sensor and other magnets is more than 3cm**.

***Index Terms*— GSM; INA219; Magnetic Reed; Power Supply; SMS; Weather Station**

I. INTRODUCTION

Observation of weather elements is necessary for human well-being and needs. The observed weather elements will be used as material to predict the weather in the future. This weather element data is very useful to know the climatologist of an area, so that humans can take advantage of these weather conditions according to the needs of each party. Weather data can also be used to reduce or even avoid the risk of bad weather [1].. The data to be recorded are temperature, light intensity, humidity, air pressure, wind direction, wind speed and rainfall. Everything that has been recorded by the Weather Station will be stored in the form of data. Weather station observation system (WS) has been developed for quite a long time in developed countries, but the price is quite expensive, therefore it is still very limited to use in Indonesia [2].

The Weather Station operating system is designed as a detection of changes to the sensors that have been determined to obtain weather forecast materials and recorded data will be sent to the station center using a data communication network system. Then the Weather Station device needs to get enough power to power up its sensors. It gets the power source from solar cell, since the sun produced more energy than we will ever need then solar energy is the most reliable source of power for sensors in weather station. Thus, the energy absorbed will be stored in the battery. In its design, this system utilizes one of the renewable energies that is solar energy by using solar cells. These renewable energy resources depend on weather conditions. Therefore, if bad weather occurs then this system cannot function, and renewable electricity is not stored. There needs to be a battery as a storage area for electrical energy generated from solar cells [3]. In previous research weather stations using solar cells as power supplies have the advantage of not only being able to cut spending but also make it easier to monitor systems in areas with resources that are not easily accessible for a long time. The use of solar cells also includes an environmentally friendly design [4].

Previous research has not featured voltage and current monitoring on loads, and there is no safety warning system at the Weather Station. Thus, research on our research is the power source for weather stations that have automatic security systems. The research added features to monitor the load of the Weather Station on the first node (rainfall sensor, wind direction and wind speed) and the second node (temperature, humidity, air pressure and light intensity sensors), the measurement results can be accessed on ioT (Internet of Things) platforms. Weather Station automatic security system is intended in the form of information in the event of theft or interference in both the solar cell module and the panel box door by utilizing magnetic reed sensors and sent via SMS in real-time.

In previous research, it has been done to create a GSM-based home automation system by sending data

via SMS that can only be intended for active and registered numbers only. The use of GSM in the study because the GSM security infrastructure is reliable, can provide maximum reliability so that outsiders cannot monitor the information sent or received [5]. Therefore, this study uses gsm architecture in sending warning notifications about weather station security in the form of SMS (Short Message Service) to phone numbers registered on the system.

II. METHOD

A. Weather Station

A weather station is a device that collects data related to weather and environment using various and different sensors. This tool applies different types of sensors that use all the parameters that can be measured. Weather Station observation system (WS) has been developed long enough in developed countries, but the price is quite expensive, so it is still very limited to use in Indonesia [6].

This weather station system measures environmental parameters such as temperature, wind direction, wind speed and others using a variety of sensors and there is a security system on the Weather Station that will send notifications in case of obstacles such as stolen solar panels or panel boxes that are forcibly opened on the weather station system [6].

B. Power Supply

A power supply system is the most important component in an electrical circuit. If the electrical energy produced is not stored, it should be used immediately after it is generated. To increase the utilization of energy produced by the existence of an energy storage system [3]. Energy storage systems can use rechargeable batteries, this component can convert chemical energy into electrical energy [7].

C. Photovoltaic Solar Cell

Energy is one of the resources that are important for human life, but non-renewable resources will run out. Now, solar energy is widely utilized around the world. The development of products utilizing photovoltaic solar cells demonstrates the importance of conserving energy as well as awareness of the importance of the role of renewable energy as well as photovoltaic solar cells producing clean energy that is very beneficial and does not damage the environment [8].

Photovoltaic (PV) is a system or direct way to convert solar radiation or foton into electrical energy. This system utilizes the principle of photovoltaic effect, which is where a photovoltaic cell can absorb light energy and convert it into electrical energy. This energy is interpreted as a phenomenon of the emergence of electrical voltage due to the contact of two electrodes connected with the solid or liquid system when obtaining light energy [9]

The main advantage for weather station using solar cell that it can provide enough energy consumption for long periods of time. In this research we use 20WP solar cell module.

D. GSM

GSM (Global System for Mobile Communication) was an idea that emerged from the cell-based portable radio framework at bell laboratories in the mid-1970s and GSM was the name of an institution established in 1982 to create a typical European mobile phone standard [10].

GSM is now the most well-known standard for mobile phones in the world developed to gain extensive capabilities for voice services as well as short message (SMS) services. This GSM application can only accept SIM cards (Subscriber Identity Module) and operates through a subscription to a mobile operator [11].

- *GSM SIM900*

GSM SIM900 GPRS is a GSM modem that can be used with Arduino Uno. This module can perform its functions as in other mobile phones, send messages, make, or receive calls and connect with GPRS, TCP/IP and others thus allowing this module to be integrated for many IoT projects. This module uses AT Command as its command information [12].

TABLE 1. GSM SIM900 SPECIFICATION

Specification	GSM SIM 900
Network	quad-band 850/ 900/ 1800/ 1900 MHz
GPRS Class	Class 10/ 8
GPRS mobile station class	Class B
Dimension	24 x 24 x 3 mm
Weight	3.4 g
Control Via	AT-Command (GSM 07.07,07.05 and SIMCOM enhanced AT Command)
Output Voltage	3.4 V – 4.5 V
Temperature	-40º- 85ºC

- *GPRS*

General Packet Radio Service (GPRS) it is a new set of GSM-bearer services that provide packet mode transmission in GSM networks, as well as cooperate with external data packet networks. One of the standout and important features of this GPRS is that the device's handheld device is always connected to the internet, so there is no dial-up connection that must be completed for its data access. GPRS users will be able to send and receive end-to-end data transfer mode packages. GPRS is divided into two categories [13].

1. *POINT TO POINT* (PTP)
2. *POINT TO MULTIPOINT* (PTM)

- *SMS*

Short Message Service (SMS) is a technology that can exchange (transmit) messages through mobile devices such as mobile phones. Messages that have been sent from the sender's phone are stored in a short message (SMS center) which will then be forwarded to the recipient's phone. SMS messaging services have no more than 160 characters [14].

E. Internet of Things

The IoT platform used is Thingspeak, Thingspeak is a web based open IoT API platform. Thingspeak serves to store data from various 'IoT applications' and display their output in the form of graphs. It requires help from an internet connection to communicate through Thingspeak which serves as a 'data packet'. Thingspeak can work on data from sensors connected to the host microcontroller.

III. SYSTEM REALIZATION

A. Function Diagram System

To achieve our goal, we designed a function diaphgram shown below

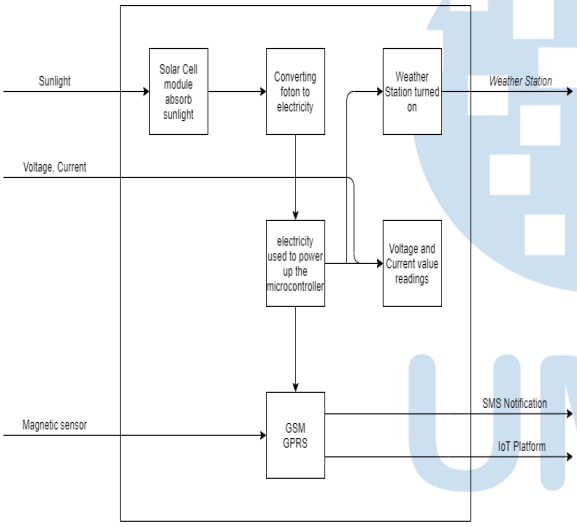

Fig. 1. Function Diagram System

Power supply system with sun radiation source using solar cell and there are sensors that can monitor current and load voltage and the measurement results will be displayed on the IoT platform. Used magnetic sensors placed in two places, namely on the solar panel and on the door of the Weather Station box as a warning system that will notify alerts when solar panel is stolen, or weather station control box doors are forcibly opened using GSM module as data communication.

With this system is expected to be an effective solution as a load monitoring system on the Weather Station and Weather Station security warning system.

The working principles of this system are:

1. The initial stage of the work of this system is the input of energy produced by solar cells.
2. Then, the incoming energy will be stored in the solar battery.
3. The battery will function as a power source of the overall work of the Weather Station system.
4. The sensor can detect voltage and current on the sensor load contained in the sensor.
5. Sensor load detection results will appear on Thingspeak.
6. If the solar panel does not exist or the panel box is forcibly opened it will send text message alert to the registered user number.

B. Hardware Design System

The design of our power supply system with warning system for Weather Station is shown in Fig. 1. The architecture consists of solar cell module, solar charge controller, 12V 7Ah battery, INA219 sensor, Magnetic reed, Arduino Uno and GSM SIM900 module.

Fig. 2. Hardware Design System

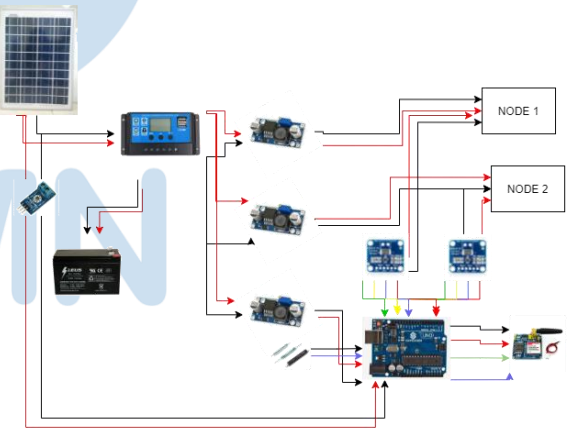

Fig. 3. Wiring Design System

C. Software Design System

The picture below shows as steps of a process in sequential order, known as flowchart.

Fig. 4. Software Design System (Flowchart)

Starting with charging the battery using a solar panel with an SCC controller. Batteries connected to SCC will activate the Weather Station and GSM systems as load monitoring systems and security systems that then wait for the connection network to connect to the internet. When connected to the internet, GSM will process the data of load measurement parameters on the Weather station which will then be sent to the IoT (Thingspeak) platform. In Thingspeak will appear data on load measurement parameters on the Weather station system. If the solar cell module is detached from the weather station pole or the door is opened by other than the management then GSM will send warning notifications in the form of sms (text message).

IV. Result and Discussion

In this chapter will be discussed about the results of testing and analysis of the realization of tools in accordance with the design of the system.

A. *Voltage Testing on 20 WP Solar Cell Module without Load*

The voltage test of the 20 WP solar cell module aims to determine the output voltage of the panel that matches the specifications on the panel used.

The test was conducted five times from June 12 to June 16, 2021, from 08.00 - 18.00. The tool used to see the output voltage of the solar cell module is to use a digital multimeter (Sanwa CD800a).

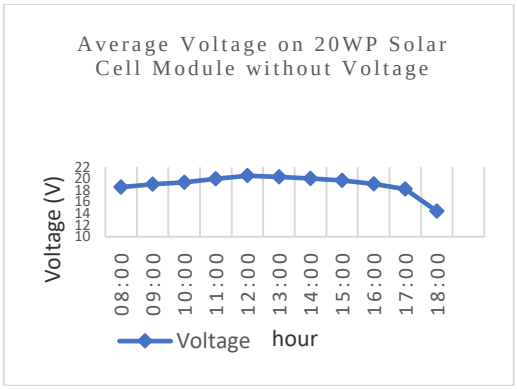

Fig. 5. Average Voltage on 20 WP Solar Cell Module without Voltage

Based on the test results, the average maximum voltage is 20.52 V at 12:00.

B. *Voltage and Current Testing on a 20 WP Solar Cell Module and 12 V 7Ah Battery*

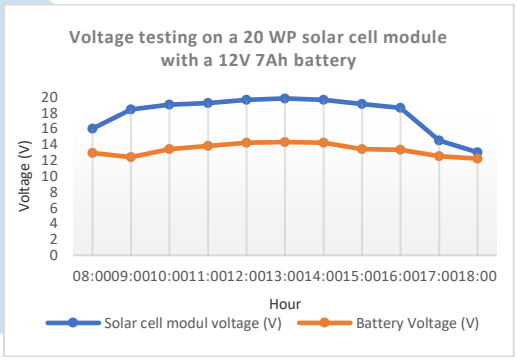

Fig. 6. Voltage Testing on 20 WP Solar Cell Module and 12 V 7 Ah Battery

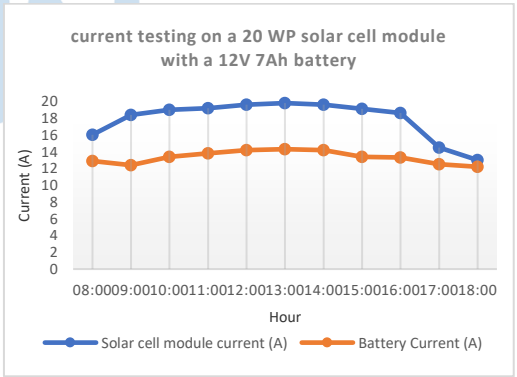

Fig.7. Current Testing on 20 WP Solar Cell Module and 12 V 7 Ah Battery

The most efficient battery charging time is when 12:00 - 14:00 with a voltage that can reach 14.30 V. Because at that hour the solar cell module gets the most light intensity.

C. *Efficiency Testing on Solar Cell Module*

This test aims to determine the efficiency of the 20 WP solar cell module with the influence of light intensity.

$$\eta_{(\text{Efficiency})} = \frac{Pmax}{I \times A} \times 100\% \quad (1)$$

nb :
P_{max} = Power in the cell (Watt)
I = Sunlight Intensity (watt/m^2)
A = Area of solar cell module (m^2) → 0,155m^2

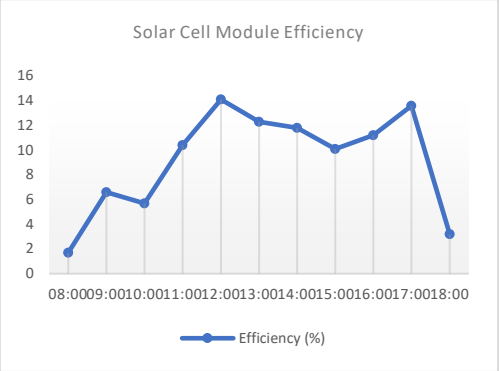

Fig.8. 20 WP Solar Cell Module Efficiency

The graph above shows the efficiency of the 20WP solar cell module measured from 08:00 to 18:00. The maximum efficiency obtained by solar modules reaches 14% while the minimum efficiency is less than 2%.

D. Testing on INA219 Sensor

The INA219 sensor test aims to find out if the sensor is functioning properly on load measurements on a weather station system that will be compared to the current and voltage of a multimeter.

$$\textbf{Error Value} = \frac{|\,Multimeter\ Measurement - INA219\,|}{Multimeter\ Measurement} \textbf{x100\%} \quad (2)$$

TABLE 2. INA219 VOLTAGE AND CURRENT TESTING ON NODE 1

NODE I						
TEST NO.	VOLTAGE (V)		ERROR (%)	CURRENT (MA)		ROR (%)
	NA219	LTIMETER		NA219	MULTIMETER	
1	6.16	6.16	0	256.3	255.3	0.39
2	6.10	6.16	0.97	256.3	253.7	1.02
3	6.16	6.16	0	246,6	243.0	1.48
4	6.16	6.16	0	251.7	249.6	0.84
5	6.16	6.16	0	256.3	254.9	0.54
AVERAGE			0.19	AVERAGE		0.85

As shown in the table above, it indicates that the INA219 sensor can read the voltage quite accurately with a percentage error value of 0.19%. As well as the percentage for the current reading of 0.85%.

TABLE 3. INA219 VOLTAGE AND CURRENT TESTING ON NODE 2

NODE 2						
TEST NO.	VOLTAGE (V)		ERROR (%)	CURRENT (MA)		ROR (%)
	NA219	LTIMETER		NA219	MULTIMETER	
1	8.16	8.16	0	78.2	78	0.25
2	8.16	8.16	0	78.4	77.9	0.64
3	8.17	8.16	0.12	77.9	78.2	0.38
4	8.15	8.16	0.12	78	77.8	0.25
5	8.16	8.16	0	77.9	77.6	0.38
AVERAGE			0.048	AVERAGE		0.38

The table above, shows the result of current and voltage measurements from INA219 for node 2. The INA219 sensor that reads voltage and current is accurate, which has an error percentage value of 0.048% for voltage and 0.38% for current.

E. Measurement Testing on Magnetic Reed Senor

The test aims to make sure that sensor could give the right output, to know the condition of the sensor within a certain range as well as the sending time interval for the security system on the solar cell module and the control box. To run the test, we used digital multimeter (Sanwa CD800a).

This test is done at intervals of distance of 0 cm to 10 cm.

TABLE 4. MEASUREMENT TESTING ON MAGNETIC REED SENSOR

Testing no.	Distance (cm)	Voltage (V)	*Output*
1.	0	0	*ON*
2.	1	0	*ON*
3.	2	0	*ON*
4.	3	0	*ON*
5.	4	0.01	*OFF*
6.	5	0.12	*OFF*
7.	6	0.17	*OFF*
8.	7	0.2	*OFF*
9.	8	0.23	*OFF*
10.	9	0.25	*OFF*
11.	10	0.3	*OFF*

F. Warning System via SMS

Sending the notification alert sms on Weather Station on verified number by system. To make the test work out, we used Telkomsel as system provider. Data were observed for a week from June 28th to July 30th with five data each for warning system on solar cell module and warning system on control box.

TABLE 5. WARNING SYSTEM ON SOLAR CELL MODULE

No	date	Time		Telephone no.	nb
		Sent	receive		
1	June 28th 2021	23.37	23.39	081283755***	Solar panel is lost!!!

2	July 7th 2021	12.09	12.11	081283755***	Solar panel is lost!!!
3	July 21st 2021	09.24	19,25	082284953***	Solar panel is lost!!!
4	July 24th 2021	20.56	20.57	082284953***	Solar panel is lost!!!
5	July 26th 2021	13.12	13.12	082284953***	Solar panel is lost!!!

TABLE 6. WARNING SYSEM ON CONTROL BOX

No	Date	Time		Telephone No.	nb
		Sent	Receive		
1	July 24th 2021	15.00	15.01	081283755***	Door opened !
2	July 26th 2021	13.00	13.02	081283755***	Door opened !
3	July 29th 2021	14.20	14.23	082284953***	Door opened !
4	July 30th 2021	20.56	20.57	082284953***	Door opened !
5	July 30th 2021	19.31	19.31	082284953***	Door opened !

G. *Sending Data on ThingSpeak*

Data will show on ThingSpeak using graph. The test aims to show up the measurement of INA219 sensor on node 1 (windspeed sensor, wind direction sensor, rain gauge sensor) and for node 2 (humidity sensor, light intensity sensor, air pressure sensor and temperature). With microcontroller program using Arduino and integrated with GPRS communication has 5000ms delay.

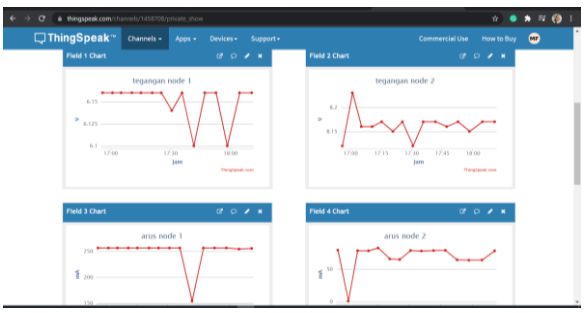

Fig. 9. ThingSpeak Output

H. *System Result*

The picture below is a Weather Station that has been made with a box dimension of 50x20x50 cm, with a pole height of 250 cm and the dimensions for the solar cell module used are 433x354x17 mm. This weather station is placed behind Building P of Telkom University's Faculty of Electrical Engineering.

Fig. 10. Power Supply System with Warning System on Weather Station

V. CONCLUSION

We conclude that:

1. The system using solar cell module 20WP with the 12V 7Ah battery as the energy storage. With the highest average Voltage is when 12.00 with 20,52V without load. There is also the highest efficiency percentage at 12.00 with 14,1%.
2. Voltage and current measurement by INA219 Sensor are appropriately accurate with the voltage error percentage at 0,19% and current error percentage at 0,85% for node 1. Therefore node 2 have the voltage error percentage at 0,048% and current error percentage at 0,38%. The result will be sent and show on ThingSpeak using communication module GSM SIM900.
3. The security system is installed under the solar cell module and the Weather Station panel box door can already send a warning notification that there is a theft of components at the Weather Station using GSM SIM900. GSM will send a warning notification when the distance of the cell module with the mast is detached with a minimum distance of 1 cm. Similarly, the weather station panel box door will send a warning notification if the door is open with a distance of at least 1 cm.
4. Warning system will notify by sending sms that have different sending and receiving time, the delay is between 10 seconds to 5 minutes depending on its provider network.

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Unmanned Vehicle Steering Control System Using Proportional Control Algorithm

A. T. Furqon[1], A. Rusdinar[2*], A. Zamhuri Fuadi[3] , M. Hardiyanto[4], and U. Sakiman[5]
[1,2,3]School of Electrical Engineering, Telkom University, Bandung, 40287, Indonesia
[4,5] PT. Pindad Indonesia, Bandung, Indonesia
[1]adritamma@student.telkomuniversity.ac.id, [2]anggarusdinar@telkomuniversity.ac.id*,
[3]azamzamhurifuadi@telkomuniversity.ac.id

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Abstract— **Teleoperation vehicles such as Unmanned Ground Vehicles can be used for surveillance or exploration, including the detection of mines. PT. Pindad plans to develop a vehicle for minesweeping. In this research, a prototype of an unmanned vehicle system was built. The vehicle had a steering system that can be remotely controlled, which allows for more maneuverability. A Proportional Integrated and Derivative control was attached to the system as a method that we used in this research. The PID control has the ability to speed up and generate system responses according to user requirements. The experiment result showed that the system got a rise time response of 1.6 seconds and a steady state error of 0%, and the percentage comparison between the angle given by the remote control and the angle read by the rotary encoder is 97.89 %**.

***Index Terms*— PID; Remote control; Steering system; Ziegler-Nichols**

I. INTRODUCTION

A steering system on a vehicle is responsible for changing the vehicle's direction through the vehicle's front wheels [1]. Ackermann Steering System is a steering system used by cars in general [2]. The steering system is divided into two types, manual steering and power steering [3]. In a manual steering system, humans power is fully needed to turn the steer. While in the power steering system, the driving force is obtained from hydraulic or electric power that uses a driving motor [4]. Technological developments in the steering system are increasingly varied. Currently, an autonomous car has also been developed that can move on its own without having to be controlled by the driver. However, this research does not use an autonomous system because the autonomous system is not ready yet for all types of environments [5]. This research is used a remote control for the controller to make it more flexible in its use.

Teleoperated driving, also called teleoperator driving, is a technology that transitions to driverless systems. Teleoperator driving, as the name suggests, is controlled by a human operator via a communication network. A key advantage of teleoperated driving is that it allows humans to drive in complex situations where an autonomous vehicle cannot. Human operators can therefore drive in situations where human drivers can still perform appropriately despite the complex environment. Another benefit of teleoperated driving is its independence from high-precision road maps, which is one of the main limitations of autonomous driving [6].

This research aims to create a steering control system on an Information and Autonomous Control System (Inacos) laboratory electric car. The research is focused on making the steer turn according to the desired angle. We were using a remote control because this research becomes a prototype that will be implemented into the Badak Panzer belonging to PT. Pindad as a UGV (Unmanned Ground Vehicle). UGV which is one type of teleoperation vehicle, is a mechanical device with manual or automatic controls that can lift things above the ground without direct human involvement [7]. They are, usually used for surveillance or exploration task likes detects mine on the ground or landmine [8] [9]. This Badak Panzer will be used as a minesweeper war vehicle. Therefore, the Badak Panzer is controlled using a remote control, so it can be controlled from afar.

II. METHOD

A. General Method

This research is using the experimental method. We did some experiments with the steering system of an electric car belonging to Inacos laboratory as a prototype of Badak Panzer. In Inacos laboratory, researchers collected data from PID parameter values obtained from calculations using Ziegler-Nichols Method, then did some testing to steering system after implementing the PID parameter values to the system.

B. PID Controllers

PID controllers that consist of Proportional, Integral, and Derivative Controller is the most common feedback control [10]. PID controllers are often used in industrial plants because they are simple and robust

[11]. The PID is also widely used in a variety of applications such as automotive, robot motion control, process control, and aeronautics. PID offers a simple control strategy for fixing past (I), present (P) as well as future (D) errors. This makes PID the preferred control strategy for engineers because it is easy to implement and performs well without a precise analytical model of the system to be controlled. [12]. The stabilization of the system is needed in this research to make a perfect output response to control the steer of an electric car. PID control also has an advantage, simple to use, and easy to implement [13].

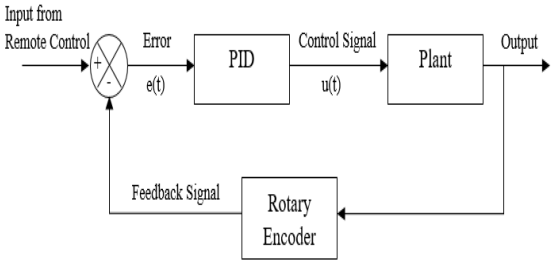

Fig. 1. PID diagram block system

The PID control block diagram is divided into several parts, there are:

- The input is the set point value of the remote control that controlled by the user and the error value that processed by the microcontroller
- PID control is a value that used to correct the error value and process it in order to eliminate/minimize errors
- The plant is a medium that controlled using an actuator in the form of a DC motor and produces an output in the form of PWM which will determine the direction of motion of the motor which will later determine the direction of the steering.

In this research, PID control is used to adjust the motor so that the output produced is not far from the rotation angle given by the remote control. To determine the PID parameter, the Ziegler-Nichols method is used. The reason for choosing PID is because it is easy to combine with other control methods such as Fuzzy and Robust. In addition, PID is a control to determine the precision of a system with the characteristics of the feedback on the system [14]. Feedback on this research is obtained from the rotary encoder.

Figure 1 shows that a rotary encoder is used as a sensor to read the direction and rotation of the DC motor. This is called as a closed loop system because the sensor is used as feedback of the system. The PID control calculates and gives a control signal value u(t) as a command for the plant to move, just as the remote control does. U(t) can be obtained from equation 1

$$U(t) = K_p e(t) + K_i \int e(t)\,dt + K_d \frac{de(t)}{dt} \quad (1)$$

Where Kp is 20, Ki is 0, and Kd is 0. Those values were obtained based on tests that we did on the system. The value of the error system (e(t)) is obtained from the difference of input value and a feedback signal.

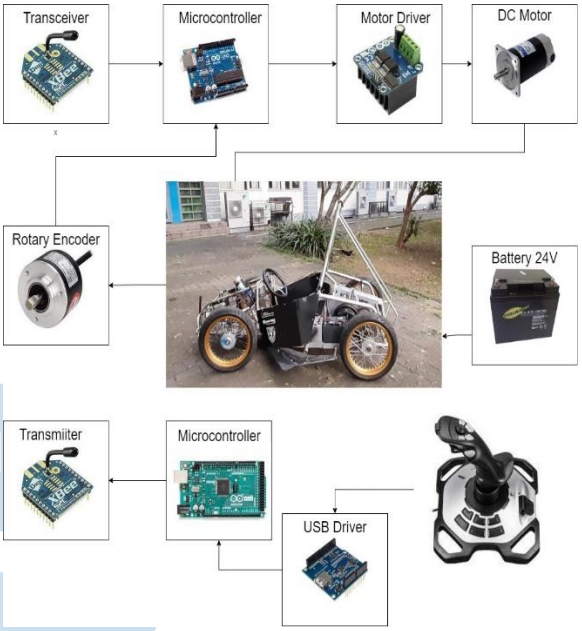

Fig. 2. Steering system using remote control

Based on figure 2, the steering system in this research is designed as a system on the steering of an electric car by adding a DC motor to the steering column to move the steering wheel according to the commands given by the remote control. To drive the steer, a DC motor is used as an actuator. The DC motor is connected to the steering column using a gear. The microcontrollers that will be used are Arduino Mega and Arduino Uno. Arduino Mega is used to forwarding commands from the remote control to the transmitter. At the same time, Arduino Uno functions as a signal processor obtained from the transceiver which is forwarded to provide pulses to drive the motor.

The communication system used for data communication from the remote control to the microcontroller is radio frequency. To ensure that the rotation on the steering wheel is in accordance with that given by the remote control, a sensor is used to check the angle generated by the motor. The controller method used is the PID method. If it is not appropriate, then the sensor will give a feedback signal or feedback to the microcontroller that the steering angle is not appropriate. Then the microcontroller will give a command to the motor to move the steering wheel to match the signal given by the microcontroller.

C. Ziegler-Nichols Method

Ziegler-Nichols method is a method that uses to looking for PID parameter values. There are many

methods used for PID controllers, but none has replaced the Ziegler Nichols method [15]. PID parameter value can be obtained by calculating some value to Ziegler-Nichols tuning rule on the table I

TABLE I. ZIEGLER-NICHOLS TUNING RULE

Control Type	Kp	Ti	Td	Ki=Kp/Ti	Kd=TdKp
PID (classic)	0.6Ku	Tu/2	Tu/8	1.2Ku/Tu	0.075KuTu
P	0.5Ku	-	-	-	-
PI	0.45Ku	Tu/1.2	-	0.54Ku/Tu	-
PD	0.8Ku	-	Tu/8	-	0.1KuTu
Pessen Integration	0.7Ku	2Tu/5	3Tu/20	1.75Ku/Tu	0.105KuTu
Some overshoot	Ku/3	Tu/2	Tu/3	(2/3)Ku/TU	(1/9)Ku/TU
No overshoot	0.2Ku	Tu/2	Tu/3	(2/5)Ku/TU	(1/15)Ku/TU

In the design of PID control, Kp, Ki, and Kd parameters are needed. To get the value of each of these parameters, the author uses the Ziegler-Nichols method. At the time of tuning obtained the value of Ku= 50 and Tu = 0.12. To use this tuning rule, we must find the Ku and Tu values first. Ku ultimate gain is a condition of sustained oscillations. The period of sustained oscillations is designated as Tu. The first step to use the method is to insert the Kp value only. Then changes Kp value until we get the constant oscillation. After we get the constant oscillation, we obtained critical gain or Ku. Next, we can obtain Tu from the period value when the output response has constant oscillation [15]. We will take the PD parameter value as an example for the calculation. Here is an example of the calculation.

PD value is consists of Kp and Kd. Based on the table, to get the Kp and Kd we use the equation from PD row.

- Kp = 0.8Ku

  Kp = 0.8(50)

  Kp = 40
- Kd = 0.1KuTu

  Kd = 0.1(50)0.12

  Kd = 0.6

  So we get Kp = 40 and Kd = 0.6

From the calculation in this research, the PID parameter value are

TABLE II. PID PARAMETER VALUE

	Kp	Ki	Kd
PID	30	500	0.45
P	25	0	0
PI	22.5	225	0
PD	40	0	0.6

D. Remote Control 3D Pro Joystick

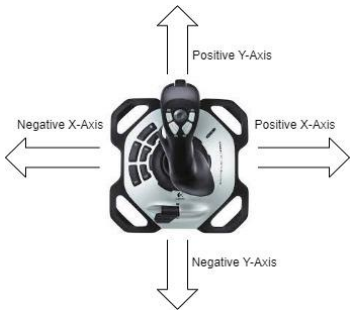

Fig. 3. 3D pro joystick axis illustration

A joystick is an electronic device that can translate the movements of a user's hand into digital signals that can be translated into computer language. Based on its basic design, a joystick consists of a flexible stick that is attached to a circuit board. This circuit board is connected to the computer. This circuit carries electricity from one point of contact to another. In the neutral position (without pushing or pulling the lever control), the conductive material on the circuit board does not generate electricity. Therefore, the circuit will not send a signal to the computer. This research using USB Host Shield to connecting remote control or joystick to the microcontroller.

The 3D Pro Joystick is the remote control used in this research. The reason for using this joystick is because it has many buttons and is very flexible in its use. In use, the joystick is defined as having two axes, namely the X-axis and the Y-axis. The illustration is shown at figure 3. The X-axis consists of a negative X-axis and a positive X-axis. The negative X-axis is a command to turn left, while the positive X-axis is a command to turn right. The Y-axis consists of a negative Y-axis and a positive Y-axis. The negative Y-axis is a command for braking and the positive Y-axis is a command for accelerating.

E. Configuration Communication Device

Fig. 4. XBee S2C module

The XBee S2C module is used as a radio communication medium to connect a remote control to the electric car. There needs to be an exchange of information, or communication, between the remote control and the steering system's microcontroller. As part of this communication, the remote control will send commands to the XBee (transmitter) for forwarding to XBee (transceiver), which will then send the commands back to the steering system's microcontroller for processing.

Digi International offers a 2.4GHz XBee model that's standardized with IEEE 802.15.4, with low power consumption for short distances [16]. There are two modules used, the first one as a transmitter and the second as a transceiver. Configuration of both S2C XBee devices can be done using the XCTU software. Here is the configuration of the two XBee S2C devices using the XCTU software.

TABLE III. CONFIGURATION TRANSMITTER AND TRANSCEIVER XBEE

Parameter	Transmitter	Transceiver
Channel	C	C
PAN ID	107	107
DH	0	0
DL	FFFF	0
MY	0	0
CE	Coordinator [1]	End Device [0]
BD	115200 [7]	115200 [7]

F. Steering System's Flowchart

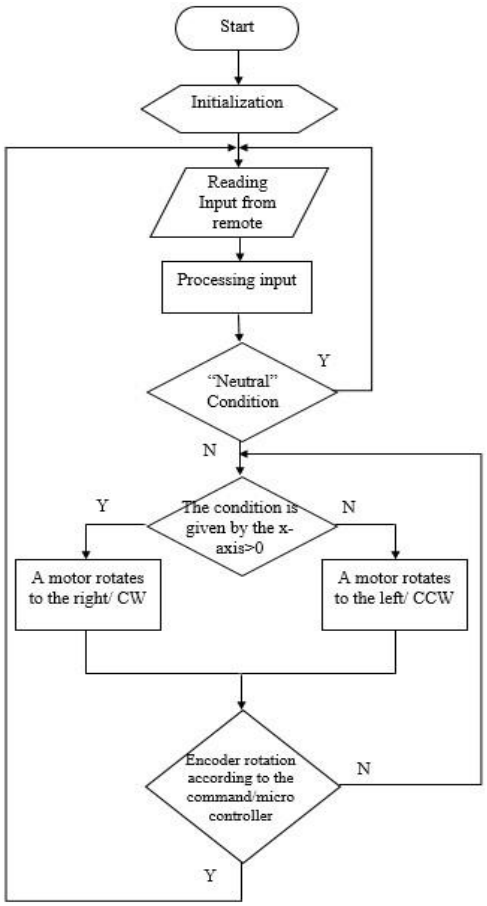

Fig. 5. Steering System's Flowchart

The figure above is a flowchart for the steering control system that has been designed. Starting from the start which is continued by initializing the input and output pins. Then read the input signal from the remote control that controlled by the user. After that, the input signal is sent by the transmitter and then the transceiver will receive and processed by the microcontroller. If there is a command to change the steering direction from the remote control, the microcontroller will send a signal to the DC motor to move the steer according to the command given. After the steer is moved, the sensor will read whether the angle that is driven is in accordance with the commands given by the remote control. If it is not suitable then the DC motor will move the steer until it gets the desired angle. If appropriate, it will return to the input reading state to wait for the next command.

III. TESTING AND RESULT

A. PID Control Parameters Testing

The PID parameter was tested using values obtained from the previous method. The values were placed on the system and compared with the predetermined set point outcome to test which response was better. The set point specified in this test is 70.

1) Kp=30, Ki=500, Kd=0.45

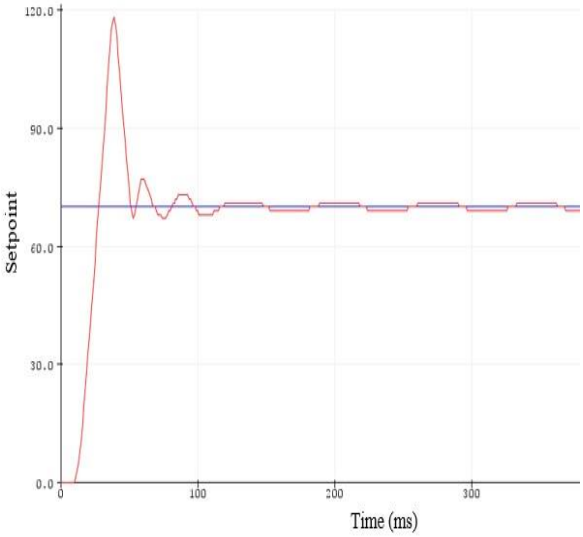

Fig. 6. Kp=30, Ki=500, Kd=0.45 response

Figure 6, shows that the DC motor's response can respond to the set point quickly, which is indicated by a rise time of 0.2 seconds. There is also a large overshoot, which is 68%. However, the steady state error is small, which is close to 5%.

2) Kp=25, Ki=0, Kd=0

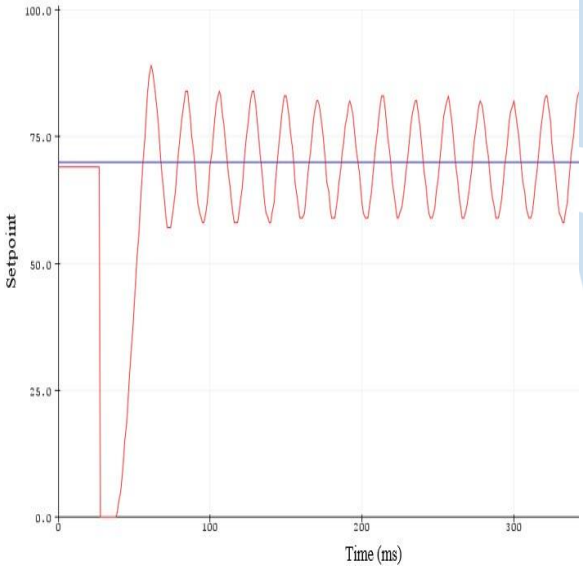

Fig. 7. Kp=25, Ki=0, Kd=0 response

Figure 7 shows that the response of the DC motor to the set point is slower than the previous PID value, indicated by a rise time of 0.4 seconds. The resulting overshoot is reduced to 22.8%. However, the steady state error increases to 14.2%.

3) Kp=22.5, Ki=225, Kd=0

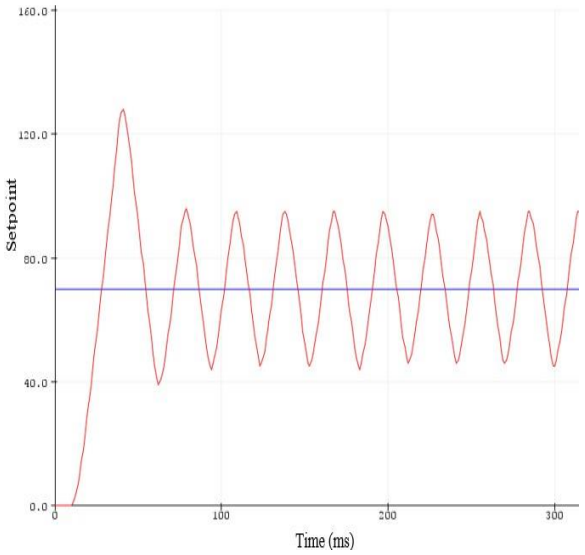

Fig. 8. Kp=22.5, Ki=225, Kd=0 response

Figure 8 shows that the DC motor's response can respond to the set point quickly as indicated by the rise time approaching 0.2 seconds. The overshoot is greater than the two previously tested PID values, which is 85%. The steady state error is also greater, namely 42.8%.

4) Kp=40, Ki=0, Kd=0.6

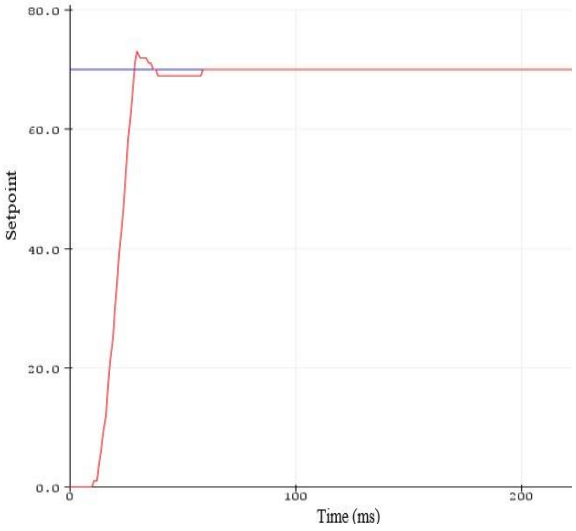

Fig. 9. Kp=40, Ki=0, Kd=0.6 response

Figure 9 shows that the system response is getting better. It was shown by 0.2 seconds of rise time and overshoot, which decreased drastically from the previous tuning value, 4.2%. The steady state error is also close to 0% and the system has received a response according to the predetermined set point. After testing several PID parameter values, the last parameter value was chosen, Kp= 40, Ki=0, Kd=0.6. However, when applied to the system using a remote control, the DC motor movement becomes very slow and does not respond according to the target given by the remote control.

As a solution, the PID parameters Kp=20, Ki=0, and Kd=0 are chosen. This value is selected based on the results of the experiment testing parameter 2. The reason is because of all the values tested, the results given are better responses because they have a fast rise time and smaller overshoot than other parameter values. The following is a graph of the output response of these parameter values.

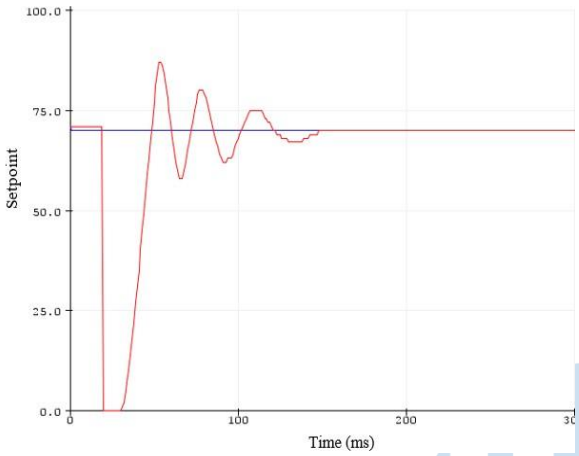

Fig. 10. Kp=20, Ki=0, Kd=0 response

Figure 10 shows that the results of the specified parameter values have a rise time of 0.3 seconds and an overshoot of 22.85%. The steady state error of the system is also close to 0%. The value of this parameter is used in the steering control system in this research.

B. *Steering System Testing*

After determining the value of the PID parameter, a trial was carried out on the steering of an electric car. The steering test on an electric car is by testing the car when turning right and turning left. There is a rotary encoder as a rotation sensor on the DC motor and feedback for the system that has been made. The rotary encoder is mounted on a DC motor using a shaft connected to the gear that is used to drive the steering column.

At testing, an additional component was used MPU6050 module, as a sensor that functions to determine the orientation of the direction based on angular momentum. As a calculation to get the angle from the rotary encoder, the formula is used to divide the PPR rotary encoder, which is 600 by 1.667, to produce an angle of 360 or can be seen in equation 2 below

$$360° = \frac{PPR}{x} \quad (2)$$

$$x = \frac{600}{360^0}$$

$$x = 1.667$$

Where:

PPR: pulse per revolution rotary encoder (600)

x: the value of angle

After the value of x is found, the value of x is entered into the program to convert the rotary encoder value into an angle, and then testing is carried out. Here are the test results.

TABLE IV. TURNING RIGHT TEST

No	Steering angle (remote control)	Steering angle (rotary encoder)	Wheel angle	Time (second)
1	45.59º	43.19º	5.40º	01.71
2	66.59º	64.19º	11.21º	02.27
3	87.58º	90.58º	15.04º	01.58
4	95.98º	92.38º	20.28º	01.25
5	107.98º	107.38º	23.91º	01.63

TABLE V. TURNING LEFT TEST

No	Steering angle (remote control)	Steering angle (rotary encoder)	Wheel angle	Time (second)
1	41.39º	37.79º	5.65º	1.53
2	61.79º	58.79º	10.78º	1.73
3	70.98º	70.79º	15.26º	1.54
4	102.58º	97.78º	20.36º	1.68
5	107.98º	109.18º	24.36º	1.82

The test data in Tables IV and V show a big difference between the target and steering angles from the remote control and rotary encoder. While the comparison between the angle given by the remote control and the rotary encoder is not too much different. In the table, it can also be calculated that turning the wheel one degree takes 4.5-7º on the motor to achieve the desired angle according to the target. When measuring the wheel angle with the steering angle, there is a large enough difference. In table VI, there is a difference of about 30º between the angle on the wheel and the steer. This is reasonable because there are some factors from steering electric car's mechanical.

Steering electric car's mechanical this research is not using a steering mechanism as most common cars do. A common car uses a rack and pinion system for steering and Inacos' electric car does not. The mechanical of Inacos' electric car consists of the steering column and tie rod of the car's wheel connected as one. So there is a little bit difficult to calculate the error of the steering car's mechanical. This research also focused on the electrical part only which is the ratio of angle from the remote control and the angle produced by the DC motor.

TABLE VI. MANUAL TURNING STEERING TEST

No	Wheel angle	Steering angle
1	15.64º	46.72º
2	20.48º	53.65º
3	34.62º	66.83º

IV. CONCLUSION

After testing the application of PID on the electric car steering system, the ratio between the angle given by the remote control and the angle read by the rotary encoder is not too far, which is at 2-5º. The time required for the DC motor to reach the desired angle ranges from 1.5 to 2 seconds. It's just that there is a significant difference in the angle given by the remote control with the angle on the wheel. This can be caused by several factors, one of which is the steering car's mechanical. In the designed steering control system, gear connects the DC motor to the steering column.

We initially used a gear ratio of 1:1, but the DC motor cannot turn the wheels easily. As a result, the DC motor and the motor driver quickly overheat. Then the gear ratio is changed to 1:2. The existence of a gear ratio of 1:2, the difference between the steering angle, and the tire angle of 30º can make the DC motor rotate at a bigger angle to produce the wheel angle that is on target. Based on the table IV and V, the comparison or comparison between the angle produced by the remote control and the angle produced by the DC motor, which is then read by the rotary encoder, has a slight difference with an accuracy of 97.89% and a steering control system can be designed according to the direction given by the remote control using PID control with only P controller with Kp=20.

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- The word "data" is plural, not singular.
- The subscript for the permeability of vacuum μ_0, and other common scientific constants, is zero with subscript formatting, not a lowercase letter "o."
- In American English, commas, semi-/colons, periods, question and exclamation marks are located within quotation marks only when a complete thought or name is cited, such as a title or full quotation. When quotation marks are used, instead of a bold or italic typeface, to highlight a word or phrase, punctuation should appear outside of the quotation marks. A parenthetical phrase or statement at the end of a sentence is punctuated outside of the closing parenthesis (like this). (A parenthetical sentence is punctuated within the parentheses.)
- A graph within a graph is an "inset," not an "insert." The word alternatively is preferred to the word "alternately" (unless you really mean something that alternates).
- Do not use the word "essentially" to mean "approximately" or "effectively."
- In your paper title, if the words "that uses" can accurately replace the word using, capitalize the "u"; if not, keep using lower-cased.
- Be aware of the different meanings of the homophones "affect" and "effect," "complement" and "compliment," "discreet" and "discrete," "principal" and "principle."
- Do not confuse "imply" and "infer."
- The prefix "non" is not a word; it should be joined to the word it modifies, usually without a hyphen.
- There is no period after the "et" in the Latin abbreviation "et al."
- The abbreviation "i.e." means "that is," and the abbreviation "e.g." means "for example."

IV. Using the Template

After the text edit has been completed, the paper is ready for the template. Duplicate the template file by using the Save As command, and use the naming convention as below

ULTIMATICS_firstAuthorName_paperTitle.

In this newly created file, highlight all of the contents and import your prepared text file. You are now ready to style your paper. Please take note on the following items.

A. Authors and Affiliations

The template is designed so that author affiliations are not repeated each time for multiple authors of the same affiliation. Please keep your affiliations as succinct as possible (for example, do not differentiate among departments of the same organization).

B. Identify the Headings

Headings, or heads, are organizational devices that guide the reader through your paper. There are two types: component heads and text heads.

Component heads identify the different components of your paper and are not topically subordinate to each other. Examples include ACKNOWLEDGMENTS and REFERENCES, and for these, the correct style to use is "Heading 5."

Text heads organize the topics on a relational, hierarchical basis. For example, the paper title is the primary text head because all subsequent material relates and elaborates on this one topic. If there are two or more sub-topics, the next level head (uppercase Roman numerals) should be used and, conversely, if there are not at least two sub-topics, then no subheads should be introduced. Styles, named "Heading 1," "Heading 2," "Heading 3," and "Heading 4", are prescribed.

C. Figures and Tables

Place figures and tables at the top and bottom of columns. Avoid placing them in the middle of columns. Large figures and tables may span across both columns. Figure captions should be below the figures; table heads should appear above the tables. Insert figures and tables after they are cited in the text. Use the abbreviation "Fig. 1," even at the beginning of a sentence.

TABLE I. TABLE STYLES

Table Head	**Table Column Head**		
	Table column subhead	***Subhead***	***Subhead***
copy	More table copy		

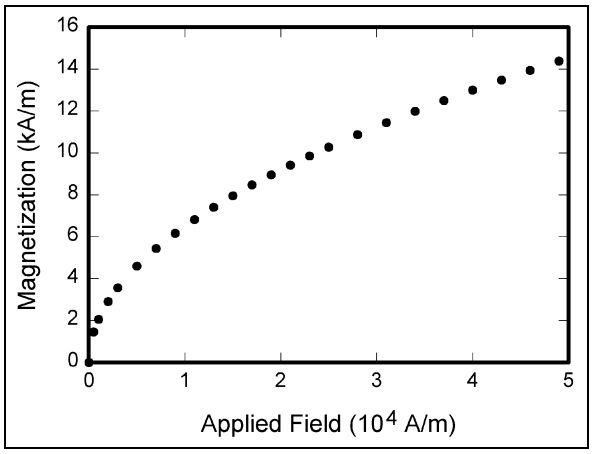

Fig. 1. Example of a figure caption

V. Conclusion

A conclusion section is not required. Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions.

Appendix

Appendixes, if needed, appear before the acknowledgment.

ACKNOWLEDGMENT

The preferred spelling of the word "acknowledgment" in American English is without an "e" after the "g." Use the singular heading even if you have many acknowledgments. Avoid expressions such as "One of us (S.B.A.) would like to thank ... ." Instead, write "F. A. Author thanks ... ." You could also state the sponsor and financial support acknowledgments here.

References

The template will number citations consecutively within brackets [1]. The sentence punctuation follows the bracket [2]. Refer simply to the reference number, as in [3]—do not use "Ref. [3]" or "reference [3]" except at the beginning of a sentence: "Reference [3] was the first ..."

Number footnotes separately in superscripts. Place the actual footnote at the bottom of the column in which it was cited. Do not put footnotes in the reference list. Use letters for table footnotes.

Unless there are six authors or more give all authors' names; do not use "et al.". Papers that have not been published, even if they have been submitted for publication, should be cited as "unpublished" [4]. Papers that have been accepted for publication should be cited as "in press" [5]. Capitalize only the first word in a paper title, except for proper nouns and element symbols.

For papers published in translation journals, please give the English citation first, followed by the original foreign-language citation [6].

[1] G. Eason, B. Noble, and I.N. Sneddon, "On certain integrals of Lipschitz-Hankel type involving products of Bessel functions," Phil. Trans. Roy. Soc. London, vol. A247, pp. 529-551, April 1955. (*references*)

[2] J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68-73.

[3] I.S. Jacobs and C.P. Bean, "Fine particles, thin films and exchange anisotropy," in Magnetism, vol. III, G.T. Rado and H. Suhl, Eds. New York: Academic, 1963, pp. 271-350.

[4] K. Elissa, "Title of paper if known," unpublished.

[5] R. Nicole, "Title of paper with only first word capitalized," J. Name Stand. Abbrev., in press.

[6] Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, "Electron spectroscopy studies on magneto-optical media and plastic substrate interface," IEEE Transl. J. Magn. Japan, vol. 2, pp. 740-741, August 1987 [Digests 9th Annual Conf. Magnetics Japan, p. 301, 1982].

[7] M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.

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Scientia Garden Jl. Boulevard Gading Serpong, Tangerang
Telp. (021) 5422 0808 | Fax. (021) 5422 0800