JRAEE
Journal of Robotics, Automation, and Electronics Engineering
Vol. 1, No. 1, 2023, pp. 1-14
https://journal.uny.ac.id/v3/jraee

Enhancing Barn Hygiene through Smart Farming: A Goat Farm Case Study in Besijangkang using IoT

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ARTICLE INFO

Article History
Received 6 April 2023
Revised 13 April 2023
Accepted 27 April 2023

Keywords
Goat Farm,
Barn Hygiene,
IoT

ABSTRACT

Besijangkang farms currently rely on conventional management methods, including manual cleaning with broomsticks and inadequate lighting. The scattered droppings and urine on the floor pose challenge for efficient farm maintenance. To address these issues, a solution combining technology and conventional cage management has been proposed to allow remote access for breeders. Researchers have implemented Internet of Things (IoT) utilizing the ESP8266 NodeMCU microcontroller connected to Firebase Web. The integration of IoT in smart farming tools has proven successful and functional. The app enables remote control of the lights through designated buttons. A critical indicator for the goat farm is the urine volume, reaching full capacity at 778 liters, which triggers the illumination of the light near the component box. Furthermore, the DC motor and conveyor effectively manage the dirt load at 09.00, fulfilling their designated functions. By adopting IoT-based smart farming tools, Besijangkang farms can improve their hygiene system, enhance management efficiency, and empower breeders with remote accessibility, revolutionizing traditional farming practices for better productivity and sustainability.

Peternakan Besijangngkang saat ini mengandalkan cara pengelolaan konvensional, antara lain pembersihan manual dengan sapu lidi dan penerangan yang kurang memadai. Kotoran dan urin yang berserakan di lantai menimbulkan tantangan bagi pemeliharaan peternakan yang efisien. Untuk mengatasi masalah ini, solusi yang menggabungkan teknologi dan manajemen kandang konvensional telah diusulkan untuk memungkinkan akses jarak jauh bagi peternak. Peneliti telah mengimplementasikan Internet of Things (IoT) dengan memanfaatkan mikrokontroler NodeMCU ESP8266 yang terhubung Web Firebase. Integrasi IoT pada alat pertanian pintar telah terbukti berhasil dan fungsional. Aplikasi ini memungkinkan kendali jarak jauh lampu melalui tombol yang ditentukan. Indikator kritis untuk peternakan kambing adalah volume urin, mencapai kapasitas penuh pada 778-liter, yang memicu penerangan lampu di dekat kotak komponen. Selain itu, motor DC dan konveyor secara efektif mengelola beban kotoran pada pukul 09.00, memenuhi fungsinya yang telah ditentukan. Dengan mengadopsi alat pertanian pintar berbasis IoT, peternakan Besijangngkang dapat meningkatkan sistem kebersihan, meningkatkan efisiensi manajemen, dan memberdayakan peternak dengan akses jarak jauh, merevolusi praktik pertanian tradisional untuk produktivitas dan keberlanjutan yang lebih baik.

1. Introduction

Livestock in general is the activity of breeding and raising livestock to obtain benefits and resultsin improving the community's economy. In this case, several small to large companies are starting to get involved or cooperate with businesses in the livestock sector. In the Besijangkang area, Yogyakarta, livestock is one of the sectors that makes a major contribution to the local community's economy, it's just that there are problems that come with it. Besijangkang farms are conventional farms in terms of management, such as using a broom stick to clean the cages and inadequate lighting. Conventional farms tend to have a small workforce and consist of the farmer's own family. Thismakes breeders pay less attention to the condition of the cage so that the management is still not optimal.

The research was conducted from 2 August 2022 to 15 September 2022, the owner of the farm confirmed that the cleaning of goat droppings and urine that fell to the floor was still scattered, causing inconvenience to the livestock.

In this final project, one of the things researchers can do to overcome this condition is to apply smart farming technology. Smart farming is an idea to implement technology and innovation inan efficient and effective farm. Currently, the implementation of smart farming can use electronic automation systems and IoT technology. The IoT technology used by researchers is the ESP8266 NodeMCU microcontroller board which is connected to Firebase Web so that it can be accessed in real time.

According to a study conducted in 2019 in the Journal of Information Science, smart farming or smart farming is the concept of using technology and innovation in livestock to increase efficiency and productivity. Examples of technologies used include sensors and the Internet of Things (IoT). With this technology, a livestock monitoring system that can be carried out remotely and livestock monitoring can be done easily. Several studies also show that conventional goat farms are different from Internet of Things (IoT) based farms in terms of productivity and profits. However, there are still many farmers who choose conventional farms because the production costs are cheaper and easier todo. Although conventional farming is still widely practiced, there are a number of problems encountered, such as limited manpower and resources which have a negative impact on livestock health. Therefore, currently many farmers are switching to IoT-based farms which can be done remotely.

2. The Proposed Method/Algorithm

2.1. Design Concept

Identification of needs in the manufacture of tools is needed in the design tool. Needs that have been identified are then analyzed to obtain component specifically. Then enter the hardware design stage and software, then making tools and testing tools. The application of the Internet of Things (IoT) can make it easier for farmers to cage monitoring such as cage cleaners and lights automatically. Smart Farming here is in the form of an android application that can monitor cage cleaners and a lamp in which there is a feature for detecting the volume of goat urine, conveyor movement, time, monitoring the lights of the inner cage and outer cage. IoT implementation can turn farms into smart farms or smart farming, namely a livestock monitoring system that can minimize their work. According to Yuwono M. Dinata (2022), Smart Farming is a smart farm that uses Internet of Things(IoT) concepts and technology that utilizes internet networks and can be integrated into Android. These stages formulated in the flowchart below:

Figure 3.1. The flowchart above explains the condition or command of the Tool system ESP8266 based Automatic Enclosure Cleaner and Auto Lamp using the Smart Farm application.

Fig. 1. Tool design flowchart

2.2. Identification and Analysis of Tool Requirements

This smart farming tool requires software requirements and hardware requirements that can be operated. Steps for making a Smart Farming Tool for Cleaning Cages and Monitoring Lights using ESP8266 NodeMCU, Relay and Conveyor. The components needed are as follows:

- Hardware Requirements
  Hardware is a device that can be used physically and can be physically integrated directly with software. Identify the requirements needed to create the hardware for smart farming tools for cleaning and monitoring automatic lights is shown in the table below.

Table. 1. Hardware requirements

No.	Requirement	Component
1.	Microcontroller	ESP8266 NodeMCU
2.	Urine Volume Detection	Ultrasonic Sensor
3.	Hygiene System	Motor DC-MCG 26A and Adapter 9Volt
4.	Automatic lamp	Relay and Adapter 20 Volt
5.	Output	Relay
6.	Complementary	Tin
7.	Complementary	Socket
8.	Circuit Board	PCB
9.	Operator	Jumper

- Software Requirements
  In addition to hardware requirements to support manufacture tools, we also need a software that supports the working system of this final project.

Table. 2. Software requirements

No.	Software	Function
1.	Arduino IDE	Wi-Fi Module Programming
2.	Firebase	Realtime Database
3.	Kodular	Android Application Programming Blocks
4.	SketchUp2020	Design 3D

2.3. Block Diagram

The block diagram is a series of tools and systems that have functions each. The following is a block diagram of the circuit:

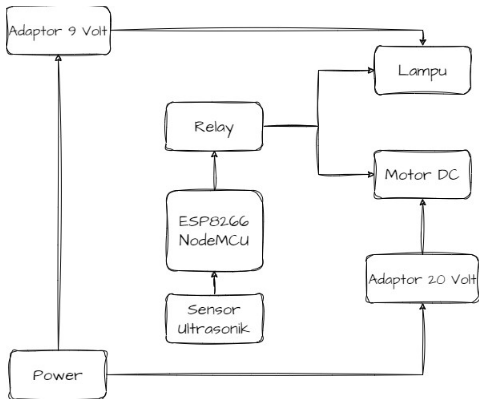


Fig. 2. Block Diagram

On the block on the left is an MCB (Miniature Circuit Breaker) or also a power supply which functions as a protection system in the event of an overload on the tool and minimizes short circuits. The MCB is connected to a 9 Volt adapter that is used to change the electric voltage on the lamp and a 20 Volt adapter that is used to change the electric voltage to the DC Motor to ESP8266 NodeMCU.

In the middle block there is a microcontroller that is used to process data, namely the ESP8266 NodeMCU then receives data from the ultrasonic sensor which will then transmit it into a larger current using a relay. The relay functions as an input that will change the voltage current on the lamp and the DC motor.

In the block on the right, the lights and the DC motor are output when the data sent by the ESP8266 NodeMCU is successful. The DC motor uses a 20 Volt Adapter which functions to change the voltage supplied from the DC Motor to the ESP8266 so that the DC Motor is able to lift the load on the gutter carpet. Meanwhile, the lamp uses a 9 Volt adapter which is used to change the amount of alternating current provided by the lamp into a direct current with a low value.

2.4. Research Design and Implementation

Schematic or schematic is a picture or diagram that shows how an electronic system or component works.

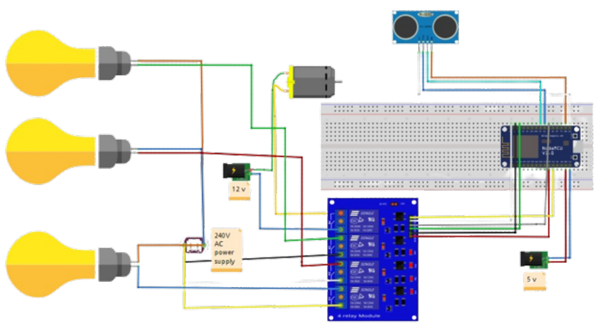


Fig. 3. Hardware schematic

In figure 3. Above is a hardware schematic designed using Fritzing software. Schematic design of the circuit begins by determining the input and output pins that will be used on the NodeMCU ESP8266 microcontroller to Relay and Ultrasonic Sensors. Then proceed with the wiring. Making a circuit schematic using fritzing. The following is the pin mapping table of the ESP8266.

Table. 3. Mapping pin schematic diagram

Pin VIN	Pin Out + Sensor Motor DC
Pin GND	Pin Out - GND Sensor Ultrasonic
Pin EN	Pin - DC Relay
Pin D7	Pin + VIN 1 Relay
Pin D8	Pin - Trig Ultrasonic
Pin D0	Pin + VIN 2 Relay
Pin 3V3	Pin VCC Ultrasonic + GND Motor DC
Pin TX	Pin + Jumper Pin Echo Sensor Ultrasonic
Pin D5	Pin + Jumper Pin DC Relay
Pin D6	Pin GND Motor DC

In table 3. above is the pin mapping on ESP8266 where there are 9 ESP8266 pins connected to relays, ultrasonic sensors, and DC motors. This 2-channel relay changes the amount of current supplied by the adapter so that it can be connected to the 3 lamps that have been designed and the ultrasonic sensor is already connected to the ESP8266, then connected to the 2-channel relay which can change the amount of current generated by the adapter. DC motors and conveyors are smart farming tools that work to clean goat feces using the smart farm application and implementation of outside lights as well as inside lights can be controlled using the smart farm application. Smart Farming here is in the form of an android application that can monitor cage cleaners and a lamp in which there is a feature for detecting the volume of goat urine, conveyor movement, time, monitoring the lights of the inner cage and outer cage. This tool will be processed using ESP8266 NodeMCU which later the device will receive data from Wi-Fi and smart farm applications. Ultrasonic Sensor serves to help process data from NodeMCU ESP8266 to the smart farm application using a goat urine volume detector and a lamp that automatically turns on when monitoring is successful, and all tools are running well.

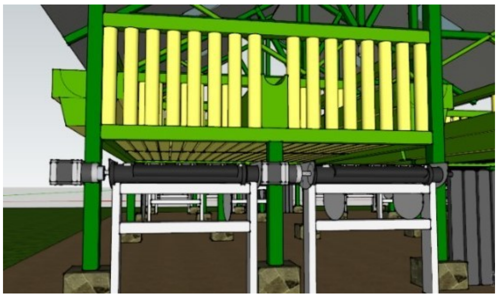


Fig. 4. Below view of the cage design

Fig. 5. Front view of the cage design

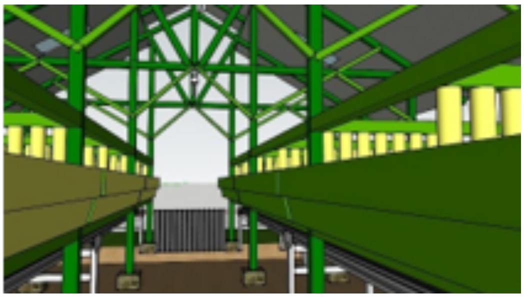


Fig. 6. Side view of the cage design

In figure above is a 3D cage design with 3 views, namely bottom view, front view, and side view which was designed using the SketchUp2020 software and adjusted to the conditions and size of the goat pen, which is 116 cm x 40 cm. This cage is designed according to the conditions, namely by requiring a conveyor cleaner that is at the bottom of the cage and lights that are inside and outside the cage. This 3D cage is a design of a conveyor cage cleaner and a lamp.

3. Method

The method used is utilizing IoT technology growing rapidly, widely used in all fields and become improvement or update for old methods make work easier. By using IoT in monitoring conveyor cage cleaners and automatic lighting can monitor the equipment without having to go to the cage, breeders can also save energy and work time in monitoring the tool. Notifications the smart farm application that has been integrated into firebase will be notified on android. The test plan for this tool is divided into 2, namely direct tool testing functional and performance tool testing. On tool testing this functional there are several test tables namely ESP8266 Testing, Ultrasonic sensor testing, and DC Motor Testing. Plan testing tool is created to plan functional testing of tool to be used. Things to be tested on the sensor input circuit and results overall analysis. From testing this tool can be seen the performance of the tool which has been made. This research is of the Real Design/Implementation type which is carried out using the ADDIE model (Analysis, Design, Development, Implementation, Evaluation).

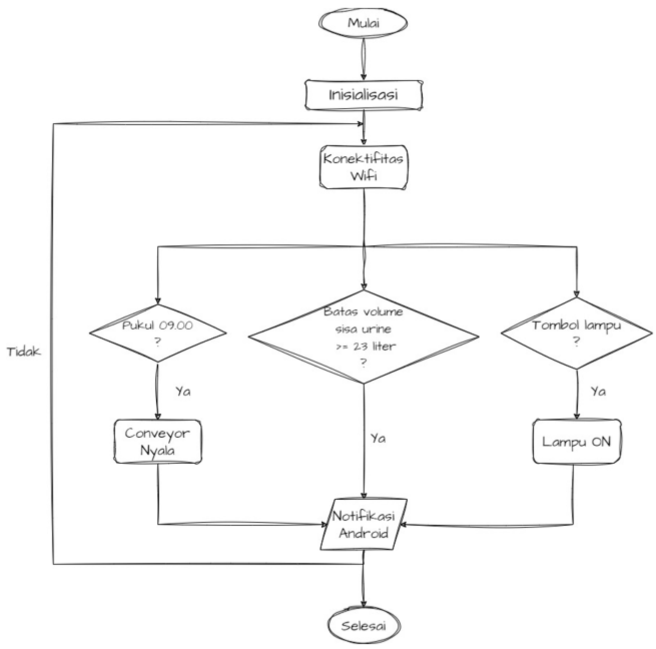


Fig. 7. Designing a smart farming tool system

3.1. Equation

Ultrasonic Sensor Testing with Ruler,

$$Error = \frac{|x - y|}{y} * 100\% \quad (1)$$

with known:
x = sensor measurement result (m)
y = ruler results (cm)
difference = abs(x – y)

The formula above is a way of calculating the error obtained from a comparison of measurements between a ruler (ruler) and an ultrasonic sensor.

Testing Ultrasonic Sensors in Detecting Urine Volume

$$V_{max} = Volume\ of\ Drum = \pi * r^2 * t \quad (2)$$

with known:
π = 3.14
r^2 = drum circle radius (cm)
t = drum height (cm)

The formula above is the volume formula for the maximum capacity of the drum (Vmax).

$$V_b = Drum\ Height\ Limit * \ Drum\ Circle\ Area \quad (3)$$

The formula above is the formula for the volume limit of the drum where the height limit of the drum is multiplied by the area of the drum.

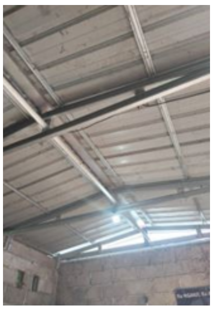
$$V_s = V_{max} * V_b \quad (4)$$

The formula above is the remaining volume formula that is displayed on the smart farm application and will be notified on Android.

4. Result and Discussion

4.1. Implementation

Smart Farming is a smart farm that utilizes the network internet that can be integrated into android applications, namely smart applications farm. The following is the implementation of the smart farming tool:


Outside light


Inside light


Cleaning conveyor


PCB Position

Fig. 8. Implementation

DC motors and conveyors are smart farming tools that work to clean goat feces using the smart farm application and implementation of outside lights as well as inside lights can be controlled using the smart farm application. This tool will be processed using ESP8266 NodeMCU which later the device will receive data from Wi-Fi and smart farm applications. Ultrasonic Sensor serves to help process data from NodeMCU ESP8266 to the smart farm application using a goat urine volume detector and a lamp that automatically turns on when monitoring is successful and all tools are running well.

4.2. Functional Test Results and Discussion

The results of this Functional Test are a test that the tool is running properly and function properly.

ESP8266 NodeMCU Testing

The purpose of testing the ESP8266 NodeMCU is to find out the voltage without load and after being loaded also to determine WiFi connectivity. ESP8266 NodeMCU is also used as a data processor for all components located in the component box. Test calculation This ESP8266 NodeMCU was obtained from measurements of the ESP8266 NodeMCU with a multimeter with a comparison of tools without load or with burden.

Table. 4. ESP8266 NodeMCU testing

No.	Testing	Hasil	
		No Load	With Load
1.	ESP8266 NodeMCU	3.34 Volt	3.34 Volt
2.	Wi-Fi Connectivity	Good	

Based on the test results in table 4.1. get voltage results NodeMCU ESP8266's no-load output is 3.34 Volts. Then the test results with the load is 3.34 Volts. Thus, no there is a difference in voltage when testing without load and when with burden.

Fig. 9. ESP8266 NodeMCU testing

The results of the NodeMCU ESP8266 voltage test can work properly. Then to test wifi connectivity by uploading the program on the NodeMCU ESP8266 board via the Arduino IDE with the NodeMCU ESP8266 position already attached to the USB cable connected to the laptop. After that, activate the hotspot on Android with the username and password according to the program, get the results of wifi connectivity on the NodeMCU ESP8266 running well. Then all the pins used are also capable of processing input into output.

Ultrasonic Sensor Testing

The purpose of testing the ultrasonic sensor is to find out the results of sensor measurements with a 30 cm ruler as many as 12 pieces and connected horizontally which will be displayed on the serial monitor. Then the measurement results are compared with the volume of urine in the drum. Then an ultrasonic function test is carried out with readings on the smart farm application to determine the success of data transfer.

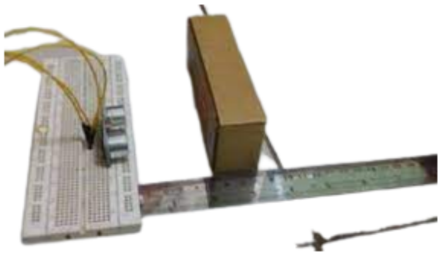


Fig. 10. Ultrasonic sensor testing of ruler

Table. 5. Ultrasonic sensor test table with ruler

No.	Ruler Results (cm)	Sensor Measurement Result (cm)	Difference (cm)	Error (%)
1.	0	0	0	0
2.	1.3	2	0.7	53.8
3.	10.3	10.6	0.3	2.91
4.	20.3	20.5	0.2	0.98
5.	30	30	0	0
6.	50.3	50.4	0.2	0.39
7.	100	100.4	0.4	0.4
8.	200	200	0	0
9.	300.3	300.5	0.2	0.06
10.	350	350	0	0

How to calculate the error obtained from a comparison of measurements between a ruler (ruler) and an ultrasonic sensor can be calculated using equation (4).

The equipment used in this study was a goat urine drum with a height of 3.5 m and a diameterof 0.54 m which had an ultrasonic sensor on top to detect goat urine when it was full.

Table. 6. Urine volume detection test on applications

No.	Test-	Residual Volume (Vs) (Liter)	Limit Urine Volume of Drum (Vb)(Liter)	Explanation
1	1	213.269	587.902	Lights off
2	2	50.941	750.23	Lights off
2	2	22.891	778.280	Lights on

So, the volume in the drum, which is 778,280 liters of urine, can be said to be full and the light on the component PCB will light up.

DC Motor Testing

Testing the DC motor was tested 2 times, namely testing using a tachometer and testing the condition of the DC motor so that the DC motor was functioning properly or not. The DC motor test can be carried out by measuring the voltage on the DC motor when the DC motor is supplied with an 18 Volt DC voltage source. Then the speed of the motor voltage can be measured using a tachometer.

Table. 7. DC motor condition testing

No.	Power	Condition
1.	OFF	Not Rotating
2.	ON	Rotating

In Table 7 is a table testing the condition of the DC Motor. Testing the condition of the DC motor is divided into two, namely when the power is ON and OFF. When the power is OFF the position of the DC motor will remain in the initial position, which is not moving. When the power is ON the position of the DC motor will move.

Fig. 11. Motor DC testing

In Figure 11 above is a DC Motor test whether it is running well or not. However, in testing the cleaning equipment, conveyor and gutter carpet, they were not able to lift the load for 1 week. And also, in the picture above it has not been able to minimize the occurrence of human error in DC motors.

4.3. Test Analysis

Tool testing is the most important stage in making a tool, because with a test we can find out the performance of the tool we make, whether it can operate according to its function and in accordance with what is in target, and from the results we can find out the advantages and disadvantages of the tools we make.

ESP8266 Test Analysis

Based on the test results in table 16 get the results NodeMCU ESP8266's no-load output voltage is 3.34 Volt. Then the results of testing with a load is 3.34 Volts. Thus, there is no difference in the voltage when testing without load and when with load. Voltage test results NodeMCU ESP8266 can work well. Then for test wifi connectivity by uploading the program on the NodeMCU ESP8266 board via the Arduino IDE with the NodeMCU ESP8266 position already attached to the USB cable connected to the laptop. After that, activate the hotspot on Android with the username and password according to the program, get the results of Wi-Fi connectivity on the NodeMCU ESP8266 running well. Then all the pins used are also capable of processing input into output.

Urine Volume Detection Test Analysis

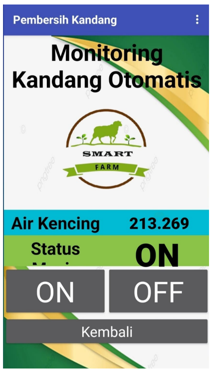


Fig. 12. Urine volume detection test analysis

From Figure 12 the test above, the volume displayed on the smart farm application is a calculation of distance with the formula distance = duration / 58.2. The formula is obtained from the HC-SR04 ultrasonic sensor datasheet. In the ultrasonic programming sketch for this smart farming project, it is written that distance = (duration/2) / 29.1. This formula can be interpreted that when the wave reflection occurs 2x the distance traveled. That is where the distance when the wave is emitted from the sensor to the goat urine and the distance when the wave bounces from the goat urine to the sensor.

Fig. 13. Urine volume block programming

After creating the programming block, make sure the ESP8266 has received power, is connected to the internet network, and the ultrasonic sensor is connected to the ESP8266. Then open the Smart Farm application on the smartphone, make sure the smartphone is also connected to the internet network. The following are the test results from the notification of the volume of urine that was carried out:

Fig. 14. Notification in apps

Conveyor Cage Analysis

DC motors use a 20-volt adapter to be able to lift the load. However, in testing the cleaning equipment, conveyor, and gutter carpet, they were not able to lift the load for 1 week. And also, in the picture above it has not been able to minimize the occurrence of human error on DC motors.

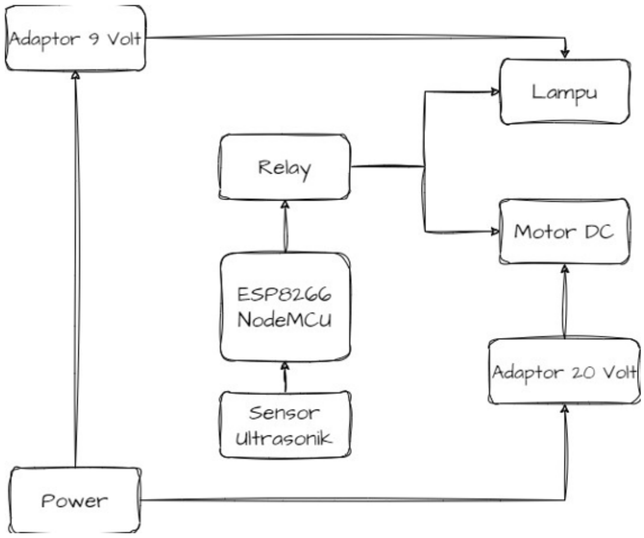


Fig. 15. Motor DC block programming

The programming block above is a notification on the smart farm application when the conveyor movement is running at the time that has been set. The following is a cage cleaner notification on conveyor movement in the smart farm application.

Fig. 16. Motor DC notifications

In the picture above is a notification from the DC Motor is working. Notifications can be monitored remotely from the house so that farmers do not need to go to the stables to control the movement of the DC motor.

Automatic Light Analysis

Automatic Light Analysis This automatic light can be monitored remotely without having to goto the cage so it can minimize the farmer's work. The following is a program block in modulars:

Fig. 17. Auto lamp programming block

The automatic light control system is running well and can be monitored using the smart farm application manually or automatically with a preset time of 17.00. This is very helpful for breeders in monitoring lights without having to go to the cage.

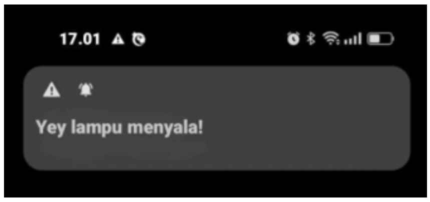


Fig. 18. Light notifications on Android

5. Conclusion

Based on the test results and discussion of the final project entitled Smart Farming is Internet of Thing (IoT) based cage cleaner it is concluded that the results of component testing and Smart performance Internet of Thing (IoT) based Cage Cleaning Farming works with good and fit for purpose. All systems are in the box PCB components, DC Motors and Ultrasonic sensors can be connected to The NodeMCU ESP8266 is then integrated into the Smart Farm application, on the application SmartFarm will display a dashboard containing cleaning monitoring cage, light control and detection of goat urine volume. Urinary volumes The goat is said to be full if the volume of urine has reached 778 liters and the remaining volume displayed on the smart farm application shows a volume of 22,891 liters or rounded up to 23 liters then the lamp near the component PCB will be light up. The DC motorcannot accommodate the load of goat manure for as long 1 week so that monitoring must be carried out periodically using smart farm application. The smart farm application is an application made for monitoring the Smart Farming tool for cleaning cages. Smart farm application using kodular plat-form, firebase and Arduino IDE so make it easier for workers to access on their respective cellphones.

Author Contribution: This journal has been compiled by Nurisma Zenita Dewi and has been approved by the Dean of the Vocational Faculty, Electronic Engineering Supervisor and Head of the Electronics Engineering Study Program.

Funding: "This research was funded by PT Sebangku Jaya Abadi"

Acknowledgment: Thank God for all the blessings of Allah SWT, the work of this final project is mine dedicated to the authors.

Conflicts of Interest: The authors declare no conflict of interest.

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