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SMART LIVESTOCK MONITORING SYSTEM BASED ON THE INTERNET OF THINGS (IOT) FOR EFFICIENCY AND SUSTAINABILITY

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Abstract:

This research conducts monitoring of Livestock Based Internet of Things (IoT) for Efficiency and Sustainability. The monitoring tool will send the value to the web server. In the designed Android application, livestock owners will get information about the condition of their livestock. Based on the tools used, livestock owners can identify the heart rate of the condition of the livestock and the location of the livestock to ensure that the animals are in the database and geofencing area at predetermined location points. By using geofencing, you can provide notifications to users when livestock leave the geofencing area based on a predetermined location. To minimize the loss of livestock. The output of the research is an android-based application that can monitor animals and the condition of the animals. The tools in this study use the u-blox neo-6m GPS sensor to obtain latitude and longitude data which will later be converted into livestock locations and pulse heart rate sensors to obtain the heartbeat of a farm animal. The latitude and longitude data stored in the database will later be used to determine the location of livestock on the maps contained in the application. The method used is a research method in the field of hardware programming, the result of which is an application and tool to be able to detect the presence of livestock and the condition of livestock.

Keywords:

INTRODUCTION

The animal husbandry business is growing rapidly along with the increasing demand for animal products and their derivatives. Human population growth, urbanization, and lifestyle changes have driven higher demand for meat, milk, eggs, and other animal products. In addition, the livestock industry also employs many people, including farmers, feed mill workers, animal health officers, and various other related jobs. However, the livestock business is also faced with various challenges, including increasing global food demand, rising awareness about animal welfare, and climate change affecting environmental conditions for farm animals. Sustainability in the livestock business is therefore a key focus for many farmers and related industries.

Livestock is part of the agricultural subsector that continues to be developed to meet animal protein needs. Beef cattle farming is a very important part of human life to fulfill daily needs and is a promising business because it is one of the basic needs that are always needed by the community, especially cattle farming which has many benefits, ranging from meat, milk, to the skin can be processed. Therefore, this livestock business must be managed optimally to meet the needs of cattle in the country. The livestock business does not escape the process of combining production factors in the form of land, livestock, labor, and capital to produce livestock products. Many animals can be farmed depending on the region of origin, culture, and topography. To achieve sustainability, technology has become a key factor that contributes to efficiency and increased productivity in the livestock business. The use of advanced technologies, such as the Internet of Things (IoT), artificial intelligence (AI), smart sensors, and computer-based monitoring systems have opened up new opportunities for animal farms to improve management and animal welfare.

In the current condition, the utilization of the Internet of Things has been widely applied in various fields such as agriculture, animal husbandry, and various other fields. Many of the farmers have difficulties in developing their livestock business and many farms in Indonesia still need to make innovations and additional support, namely technological support. The IoT concept itself is very much needed in the livestock sector. Not a few farmers experience problems when taking care of their livestock such as distance, health and other information from livestock IoT works by utilizing programming instructions whose commands can generate interactions with fellow connected devices automatically even remotely. Based on the description of the problems above and the references read, what will be done in this paper is remote monitoring of livestock in the open based on the Internet of Things (IoT) by farmers.

RESEARCH METHOD

This research, methodology describes the modeling, implementation, and development procedures, the development in research of a smart Internet of Things (IoT)-based farm animal monitoring system for efficiency and sustainability.

This uses the hardware programming research method shown in the figure below:

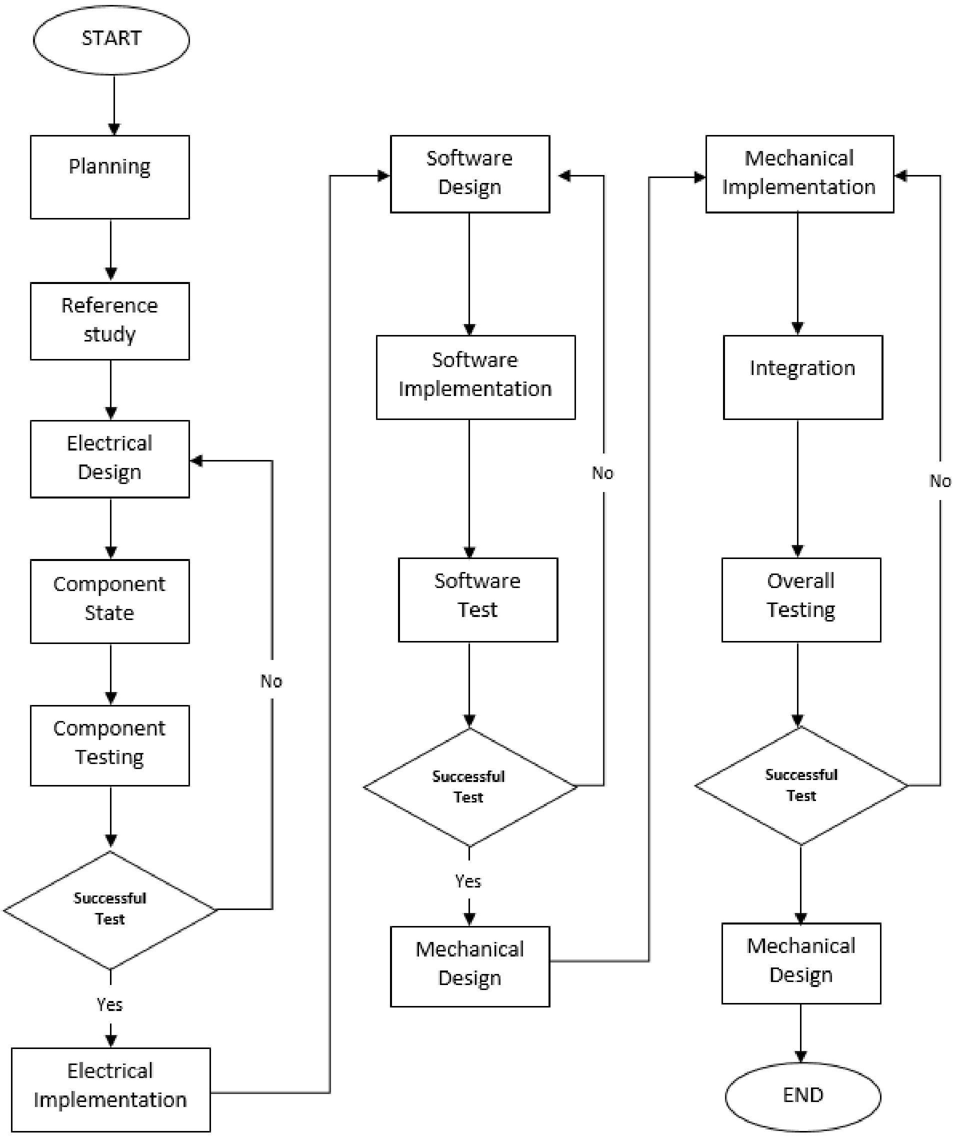

Figure 1: Hardware Programming Research Method

Based on the methodology above, the discussion of each stage in the methodology can be described as follows:

1. Planning the Research Design

In planning a research project, several important things need to be determined and considered, including:

A. Hardware Requirements Analysis

The research project planning stage is the activity stage of the system creation process. The components needed in system design are NodeMCU ESP8266, GPS Sensor, and Pulse Heart Rate Sensor.Pemilihan Modul Mikrokontroler

1. The microcontroller module used

The microcontroller module used to build this system only uses NodeMCU ESP8266. NodeMCU ESP8266 has the advantage of a microcontroller board connected to ESP8266. NodeMCU has packaged ESP8266 into a board that has been integrated with various features like a microcontroller and can be connected to wifi.

2. Sensor Selection

In making the IoT-based Outdoor Livestock Monitoring System, GPS sensors are used to determine the location of livestock and pulse heart rate sensors are used to determine the heart rate of this livestock. The sensor will be connected to the NodeMCU ESP8266 as a microcontroller and communication link between the device and the internet, the reading value from the sensor will be sent and stored in the database and then displayed through an Android application that will display the location of the farm animals and the heart rate of the farm animals.

B. Software Requirement Analysis

Analysis of software requirements for research on the Internet of Things-Based Smart Shoe Model using Arduino IDE which is used to facilitate the creation and development of the system to be built starting from writing the source program to uploading the compilation results, and serial terminal trials. The software for creating applications is the android studio.

1. Reference studies

After carrying out the system planning stage, then proceed with the initial research of the system, namely designing the mechanical circuit and components of the system model to ensure that all components can function properly and can be used optimally. This system uses a NodeMCU esp8266 microcontroller. System inputs use GPS sensors and pulse heart rate sensors. The system output is in the form of a display on the application and produces output from the sensors used.

2. Mechanic Design

The following are the component block parts that work as input, process, and output of the electrical design made. In the block diagram in the input section, there are GPS sensor components to find out the last location of livestock, temperature sensors, and pulse heart rate sensors to determine the heart rate of these livestock. In the process section, there is an ESP8266 NodeMCU which functions as an input from the sensor and a link to the wifi network to make it easier to send data using the internet. In the output section, there is an Android application that is useful for displaying the results of the sensor values.

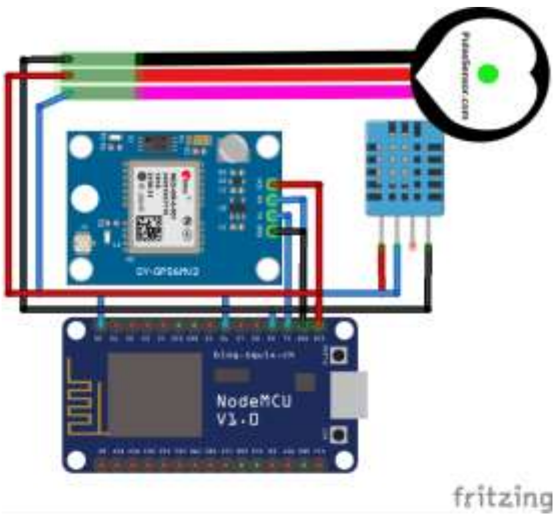

Figure 2. Electrical Design The following is an explanation of the Electrical Design circuit:

1) A power source (such as a battery or power supply) The battery or power supply that will be used in this circuit is 12V for the u- blox Neo6M GPS sensor, pulse heart rate sensor, temperature sensor, and NodeMCU ESP8266.
2) The microcontroller that will be used in the design of this electrical design uses NodeMCU esp8266 as the center of processing electronic signal input into the required electronic signal output and can connect to the available wifi network.
3) The control system design applied in this research uses the C Language programming control system to acquire serial data from the microcontroller circuit.

3. Component Procurement

At this stage the sensors used such as GPS sensors and heart rate sensors, NodeMCU ESP266 microcontrollers, and other needs are available. After all the components are available, the next step is to test each component.

4. Component Testing

At this stage, testing of all components that will be used using a multimeter is carried out, this testing includes input and output voltages from components and sensors, and testing using the PlatformIO serial monitor by looking at the output of each component.

C. Microcontroller Testing

To find out whether Arduino can function and connect well between Arduino and Arduino IDE software, this process is carried out by compiling the program and uploading the program to the Arduino IDE software. Performed by providing a voltage of 5-12v. The following NodeMCU esp8266 test results are in the table below

Table 1. NodeMCU ESP266 Testing

Microcontroller	Input Voltage	Output Voltage
NodeMCUESP8266	5 V	3,24 V
	12 V	3,29 V

D. Sensor Testing

Testing of the u-blox Neo-6M GPS sensor and pulse heart rate sensor was carried out. Testing is done by providing a voltage of 5V. This sensor test is carried out by measuring the voltage of the multitest cable connected to the ground sensor cable while the multitester cable is positive with the analog pin or digital output of the sensor.

Table 2. Sensor Testing

No.	Sensor and Component Name	Input Voltage	Output Voltage
1.	u-blox Neo-8M GPS Sensor	5 V	4,78 V
2.	Sensor Pulse Heart Rate	5 V	4,78 V
3.	DHT11 Temperature Sensor	5 V	4,78 V

From the test results, it is known that the output of several sensors given an input voltage of 5V produces a variety of output voltages, this is by the needs of each sensor and component.

1. Electrical Implementation

This stage is the electrical design stage that has been made before for an overview of the electrical implementation.

2. Software Design

For the software design of this "smart livestock monitoring system based on the Internet of Things (IoT) for efficiency and sustainability" can be seen in the figure below.

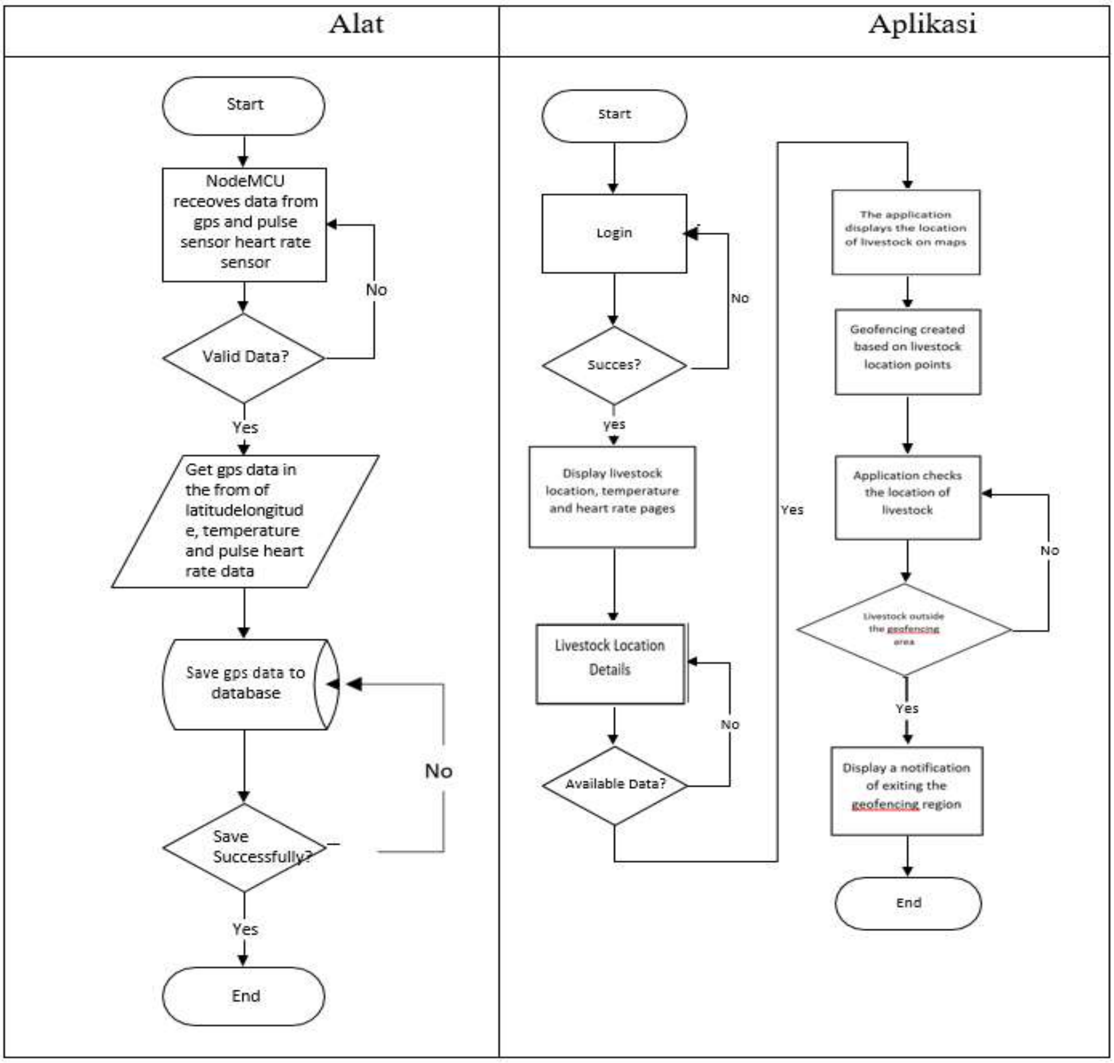

Figure 3. Software Design

The system flowchart explanation above starts when the device is turned on and then checks the internet connection if it is connected, it will initialize all components to be connected. Then the sensor will send a value to be read by the Arduino Uno and the sensor reading value is sent to the NodeMCU ESP8266 which will be stored in the database and then displayed on the Android application.

1) NodeMCU will receive input from the u-blox Neo-6M GPS sensor, temperature sensor, and pulse heart rate sensor.
2) Sensor data received by the NodeMCU espp8266 will be sent to the database.
3) GPS sensor data will be used to create livestock location points on application maps.
4) Geofencing is created based on the location point of the farm animals.
5) The application will check if the farm animal is out of the geofencing area.
6) For the application display, the results of the initialization of parameter values on the u- blox Neo-6M GPS sensor and pulse heart sensor stored in the database will then be displayed on the Android application. The design of the Android application can be seen in the following figure.

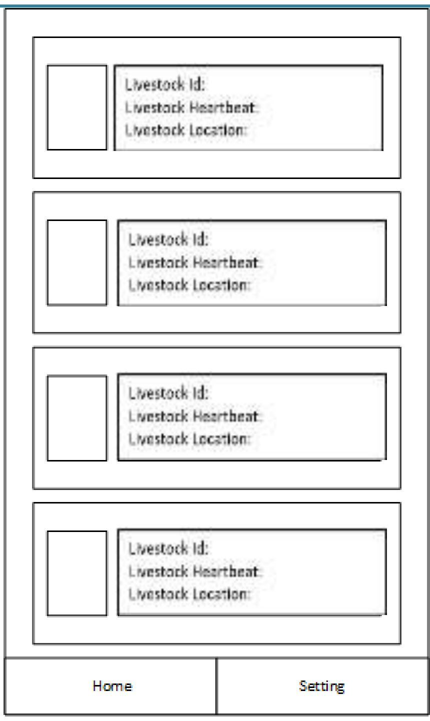

Figure 4. Application Design

1. Software Implementation
   At this stage of software implementation is a description of the software design that has been made before. Displays in the form of a smart shoe user location page in the form of the last location of smart shoe users. For images of software implementation can be seen in the following figure.

Figure 5. Software Implementation

2. Software Test
   Software testing is done by observing the value of the detection results on the sensor. Whether the software can function properly or not. This test is done by running the functions in the running application.
3. Mechanical Design
   Mechanical design is the initial design of a tool that will be made in the form of a picture. With a height of 6 cm, width of 8 cm, and length of 12 cm. In the mechanical design that already has a GPS sensor that is used to get the user's location. In addition, there is also a NodeMCU esp8266 microcontroller to receive input from the sensor.

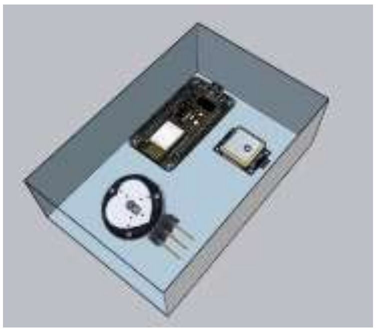

Figure 6. Mechanical Design

4. Mechanical Implementation
   This stage of mechanical implementation is the stage of making tools from mechanical design drawings that have been made previously then after the implementation is complete, integration or assembly is carried out.
5. Mechanical Implementation
   This stage of mechanical implementation is the stage of making tools from mechanical design drawings that have been made previously then after the implementation is complete, integration or assembly is carried out.
6. Integration
   This integration process is carried out based on the mechanical design process, electrical design, and software design so that it will become a whole tool. In the assembly of the system model that has been made has a size of 6 cm high, 8 cm wide, and 12 cm long.

Figure 7. Assembly Model

RESEARCH RESULTS

The results of this research are the results of the previous stages that have been described starting from the planning process, and design, to the overall implementation of a smart livestock monitoring system based on the Internet net of Things (IoT) for efficiency and sustainability. The results of this study complete several things that become references and references to get maximum results. In this study, a u-blox neo-6m GPS sensor is used to obtain latitude and longitude data which will later be converted into the location of farm animals, and a pulse heart rate sensor to get the heart rate of farm animals. The latitude and longitude data stored in the database will later be used to determine the location point of farm animals in the maps contained in the application. NodeMCU microcontroller is also used to send u-blox neo-6m GPS sensor data and pulse heart rate sensor to the database. Tools for smart livestock monitoring systems based on the Internet of Things (IoT) for efficiency and sustainability, can be seen in the following figure.

Figure 8: Implementation of the Tool on Livestock

a. Overall Test of the tool for livestock

This stage tests all system functions, starting from testing hardware, programs, application user interfaces, and notifications in the application. If there is a system that cannot function properly, a mechanical implementation process will be carried out on the system. The overall test includes functional tests and validation tests.

b. Functional Testing

Functional testing aims to determine whether the voltage flow entering the circuit is by the needs or not, so this test is carried out so that it can function properly as it should. In this testing process, it is carried out by testing the voltage output of the sensor used using a multimeter and a program. Used by using a multimeter and tool program.

c. Overall System Testing

After several series of tests that have been carried out on each existing component, the next stage is testing the entire system made. The first step is to assemble all the components, then upload the program to the NodeMCU esp8266 microcontroller. As for some of the tests carried out on the overall system, among others:

1. Testing the checking of the device on the serial monitor on the Arduino IDE, checking the connectivity of the ESP8266, whether it is connected to the surrounding network so that it gets a dynamic IP which can then be called to make a connection with the monitoring interface, as shown below.

Figure 9. ESP8266 Connectivity Testing

2. Testing the IoT-based Livestock Monitoring System Model. Performed when the device is first activated and all components used have functioned as needed as shown in the following figure.

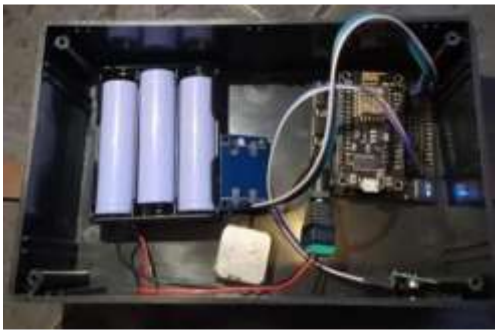

Figure 10. Testing the Tool Model

3. In testing the user interface that displays the login page that can be accessed through the Android application. The following display of the login page can be seen in the following figure.

Figure 11. Login Page

On the main page will display data on farm animal id, farm animal heart rate, and location of farm animals this data is displayed based on data stored in the database. The following is for the appearance of the main page.

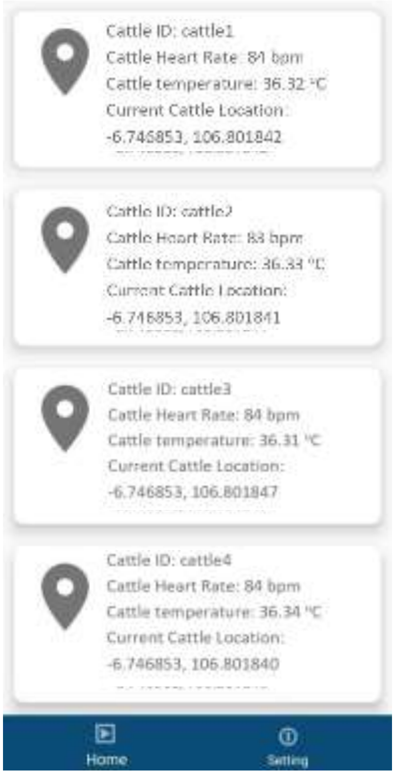

Figure 12. Main Page

The farm animal location page will display the last location data of farm animals according to the data from the u-blox neo6m gps sensor stored in the database, the heart rate of farm animals based on pulse heart rate sensor data stored in the database, and the geofencing area at a predetermined location point. The farm animal location page can be seen in the image below.

Figure 13: User Location Page

VALIDATION TEST

This stage is carried out to know how to work and whether the function can run properly by the previously made system design. This study uses the u-blox neo 6m GPS sensor which is used to obtain latitude and longitude data which will be used to obtain the last location of livestock. In addition, a pulse heart rate sensor is also used to obtain data on the heart rate of livestock, and a temperature sensor to determine the temperature of livestock. Before the farm animals are released outside the cage, their temperature and heart rate will be checked if they are in good condition, then they will be released outside the cage. To measure the performance of the u-blox neo8m GPS sensor, temperature sensor, and pulse heart rate sensor can be seen in the sensor testing table below:

Table 3. Sensor Validation Test

No.	Livestock Id	Location of Livestock	Livestock Heartbeat	Livestock Temperature
1	Livestock1	-6.647220, 106.841370	84 bpm	36,32 °C
2	Livestock2	-6.6251472,106.7705223	83 bpm	36,33 °C

3	Livestock3	-6.645867, 106.843537	84 bpm	36,31 °C
4	Livestock4	-6.644247, 106.847238	84 bpm	36,34 °C
5	Livestock5	-6.648073, 106.849716	83 bpm	36,34 °C

Based on the validation test of the u-blox neo6m gps sensor, pulse heart rate sensor and temperature that has been carried out when the NodeMCU esp8266 microcontroller receives input data in the form of latitude and longitude as well as temperature and heart rate data of these farm animals will be sent by NodeMCU to the database. The following is a graph of temperature and heart rate data for farm animals.

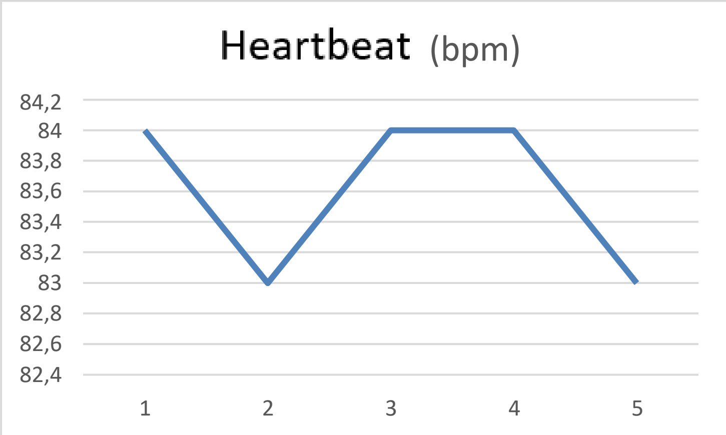

Figure 14: Graph of Livestock Heart Rate Data

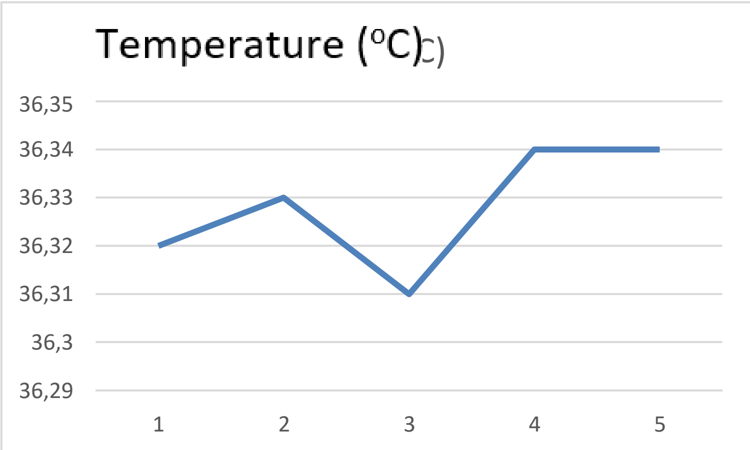

Figure 15. Livestock Temperature Data Graph

Latitude and longitude data stored in the database will later be used in the application as the last location point of livestock. When the location point of the farm animal has been obtained, geofencing is made at the specified location point. Geofencing here is used as a limitation of the livestock area. The geofencing user interface can be seen in the figure below.

Figure 16. Geofencing User Interface

Based on the geofencing user interface above, the geofencing area is depicted with a red circle with a radius of 200 meters. Geofencing here can provide notifications to users when farm animals leave the specified geofencing area. The following is a notification display when farm animals leave the geofencing area

Figure 17. Notification of livestock leaving the geofencing area

So that users can find out when they are outdoors or in nature when farm animals walk out of the geofencing area that has been determined, it can minimize the loss of farm animals. In research on the IoT-Based Livestock Monitoring System Model in Open Nature using LI-ION LITHIUM 1500 mAh battery resources as many as three batteries to run components used such as GPS sensors, pulse heart rate sensors, and NodeMCU esp8266. The following is a table of testing the use of LI-ION LITHIUM 1500 mAh batteries.

Table 4. Battery Usage Testing

Testing	Battery Capacity	Usage Duration
1	4500 mAh	7 Hours
2	4500 mAh	7 Hours
3	4500 mAh	7 Hours
4	4500 mAh	7 Hours
5	4500 mAh	7 Hours

Based on the battery test above, the use of a 4500 mAh LI-ION LITHIUM battery is sufficient to run the components used in the IoT-based Livestock Monitoring System Model which can last for about 7 hours. With the formula obtained from www.convert-formula.com/ah-wh, the calculation is 3 3.7 V 1500 mAh batteries stacked in series, 49.94 Wh is obtained with 80% efficiency, the power obtained is 39.952 Wh and the load used is NodeMcu 0.6A, Gps Sensor 0.35A, and Heartpulse Sensor 0.12 A using a voltage of 5 V, then 5, 35W and can be calculated by 39.925 Wh / 5.35 W = 7.46 H which means about 7 hours and if you want to use it for 12 hours then the battery capacity needs to be added around 7200 mAh each formula obtained from the calculation of 5.35W x 12H / 0.8 / 11,1V = 7.2297Ah.

CONCLUSION

Based on the research that has been done, the IoT-based Livestock Monitoring System in the Open to know the last location of livestock and the heart rate of livestock. So it can be concluded by using the u-blox neo6m gps sensor to find out the last location of farm animals, the temperature sensor is used to determine the temperature of farm animals, and the pulse heart rate sensor is used to determine the heart rate of farm animals which can be seen through the android application. This study uses LI-ION LITHIUM 1500 mAh batteries as many as 3 batteries as a power source for the tool and is sufficient to run the components used in the IoT-Based Farm Animal Monitoring System Model which can last for 7 hours. In this study, the data obtained from the u-blox neo6m gps sensor in the form of latitude and longitude data, temperature sensors in the form of livestock temperature, and pulse heart rate sensors in the form of livestock heart rate data which will be sent by the NodeMCU esp8266 microcontroller to the database.

Location data stored in the database is used to determine the location point of farm animals on application maps while pulse heart rate data is used to determine the heart rate of farm animals and temperature to determine the temperature of farm animals. So that users can monitor the condition of these farm animals. In the application, geofencing is also created which is used as an area boundary at a specified location. By using geofencing, it can provide notifications to users when livestock leave the geofencing area based on a predetermined location. So that it can minimize the loss of livestock.

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