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OPTIMIZATION OF LIVESTOCK MONITORING SYSTEM IN OUTDOOR BASED ON INTERNET OF THINGS (IOT)

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Abstract— *Livestock businesses are often underestimated by the public because they are associated with less hygienic working environments. However, the demand for livestock products such as meat and milk is increasing, providing significant business opportunities. Several obstacles, such as livestock loss and the capital required for cage construction, are barriers to starting a livestock business. Livestock losses, especially in outdoor farms, often occur because of the lack of proper monitoring and data collection. Therefore, technology is required to overcome this problem. The application of IoT technology is an effective solution for overcoming this problem. By utilizing sensors, such as GPS, temperature, and heart rate, farmers can monitor farm animals remotely using Android applications. In this study, a U-blox Neo6m GPS sensor was used to track the location of farm animals, a temperature sensor was used to monitor the temperature conditions of farm animals, and a heart rate sensor was used to determine the health of farm animals that had been tested. The use of a 1500 mAh LI-ION LITHIUM battery as a power source proved to be sufficient for 7 h. The results showed that this IoT-based Outdoor Livestock Monitoring System can provide information on the last location of livestock as well as real-time heart rate and temperature data in the database. This innovation opens opportunities for farmers to improve livestock management and monitoring efficiently, minimize losses, and increase the productivity of their livestock business.*

Keywords*: Animal health, animal health monitoring, heart rate sensors, IOT, livestock farming, location tracking, real-time.*

Intisari— *Bisnis peternakan sering kali dianggap remeh oleh masyarakat karena terkait dengan kondisi lingkungan kerja yang kurang higienis. Namun, permintaan akan produk peternakan seperti daging dan susu sapi semakin meningkat, memberikan peluang bisnis yang besar. Meski demikian, beberapa kendala seperti kehilangan hewan ternak dan modal yang dibutuhkan untuk pembangunan kandang menjadi hambatan dalam memulai usaha ternak sapi. Kehilangan hewan ternak, terutama pada peternakan di alam terbuka, sering terjadi karena kurangnya pengawasan dan pendataan yang tepat. Untuk mengatasi masalah ini, penerapan teknologi IoT menjadi solusi yang efektif. Memanfaatkan sensor-sensor seperti GPS, suhu, dan detak jantung, peternak dapat memantau hewan ternak secara jarak jauh melalui aplikasi Android. Dalam penelitian ini, penggunaan sensor GPS U-blox Neo6m untuk melacak lokasi hewan ternak, sensor suhu untuk memantau kondisi suhu hewan, serta sensor detak jantung untuk mengetahui kesehatan hewan telah teruji. Penggunaan baterai LI-ION LITHIUM 1500 mAh sebagai sumber daya alat telah terbukti mencukupi kebutuhan selama 7 jam. Hasil penelitian menunjukkan bahwa sistem pemantau hewan ternak pada Alam terbuka berbasis iot ini dapat memberikan informasi lokasi terakhir hewan ternak serta data detak jantung dan suhu hewan secara real-time ke dalam database. Inovasi ini membuka peluang bagi peternak untuk meningkatkan pengelolaan dan pengawasan hewan ternak secara efisien, meminimalisir kehilangan, serta meningkatkan produktivitas dalam usaha peternakan mereka.*

Kata Kunci*: Kesehatan hewan, monitoring kesehatan hewan, sensor detak jantung, IOT, manajemen ternak, pelacakan lokasi ternak, real-time.*

INTRODUCTION

Animal husbandry, the practice of raising and breeding animals for commercial purposes, has received inadequate recognition in Indonesia. This is because it is synonymous with working in a dirty and unhygienic environment. However, in reality, animal farming can be a lucrative business with great potential in Indonesia [1][2]. Livestock farming in Indonesia is a significant business sector and has been the focus of several studies. Regulation of the Minister of Agriculture of the Republic of Indonesia No. 13/2017 emphasizes the importance of livestock business partnerships based on mutual needs, strengthening, benefits, respect, responsibility, and dependence [3]–[5].

In this case, animal farming is underestimated by Indonesians. This business is synonymous with working in a dirty and unhygienic environment. Animal husbandry is not limited to raising animals; raising and breeding the difference lies in the objectives set [2]. Farming is carried out by business people seeking profit with the application of management principles to the factors of production that have been optimally combined [4]–[6]. The public demand for beef and milk has increased cattle business opportunities, and many people are starting to look at them, but problems such as losing livestock and capital to build cattle pens make some people reluctant to start a cattle business [1], [7]–[9].

Farmers often experience livestock losses. Lack of supervision and an undetectable number of livestock cause unnoticed losses. One farm that is difficult to monitor is open farming. The small population of livestock and the loose livestock system in the open will result in the neglect of officers collecting data [10]. Monitoring livestock using technology could be a solution to this problem. Currently, the Internet of Things has been widely applied in various fields such as agriculture and animal husbandry and various other fields.

Many farmers who experience difficulties in developing their livestock businesses and many farms in Indonesia still need to make innovations and additional support, namely technological support [5], [11], [12]. In agriculture, it is crucial to have monitoring systems in place to prevent crop damage caused by unwanted animals, as this can negatively affect productivity. Farms also face challenges in remote management and monitoring, and intelligent farm management systems based on IoT techniques can provide efficient and secure solutions [1], [5], [8], [13].[6]

The livestock industry, which is experiencing many problems due to declining farm numbers, an aging workforce, and the spread of diseases and epidemics, is seeking solutions through Internet of Things (IoT) sensors and artificial intelligence (AI) technology [14]. The use of IoT technology by farmers and stable managers allows for the monitoring of livestock biometric data, which are then analyzed using AI algorithms. This technology enables the early detection of disease signs, even those that are difficult for experienced individuals to identify, leading to increased productivity and smart farming practices that facilitate remote work with fewer people [11].

The concept of IoT itself is needed in the field of animal husbandry. Many 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 from a distance [15][5][12]. Previous research on monitoring livestock has been conducted [11]–[16],[17]–[21] but monitoring animal conditions, including heart rate, has not been conducted. Based on the description of the problems above and the references read, what will be done in this research is remote monitoring of livestock in the open based on the Internet of Things (IoT) by farmers.

MATERIALS AND METHODS

A. System Architecture

The main components of the adopted system are mobile applications, cellular phones, databases, GPS sensors to determine the last location of the livestock, and heart rate sensors to determine the heart rate of the livestock. The mobile application was developed using NodeMCU ESP8266, which functions as an input from the sensor and is connected to a Wi-Fi network to facilitate data transmission via the internet. The output section contains an Android application that is useful for displaying the value of the sensor results.
Mobile applications and integrated sensors were the main components of this system. A GPS sensor was used to track the last location of the farm animal, while a heart rate sensor was used to monitor the heart rate of the animal. The application development process involves the use of an ESP8266 NodeMCU to connect the sensors with a Wi-Fi network so that data can be easily transmitted over the Internet. An Android app was used as an interface to display the values obtained from the sensors, allowing users to monitor the health and location of farm animals in real time.

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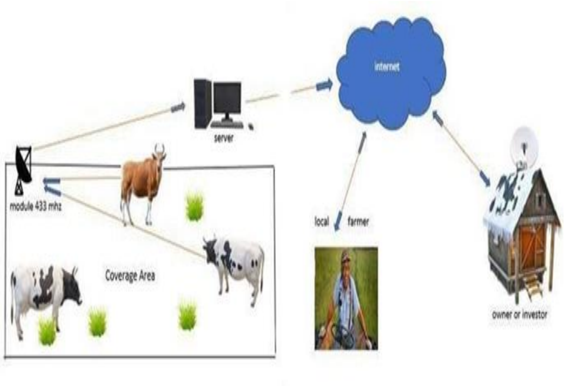

Figure 1. System architecture Livestock Monitoring

B. System Requirement and Implementation

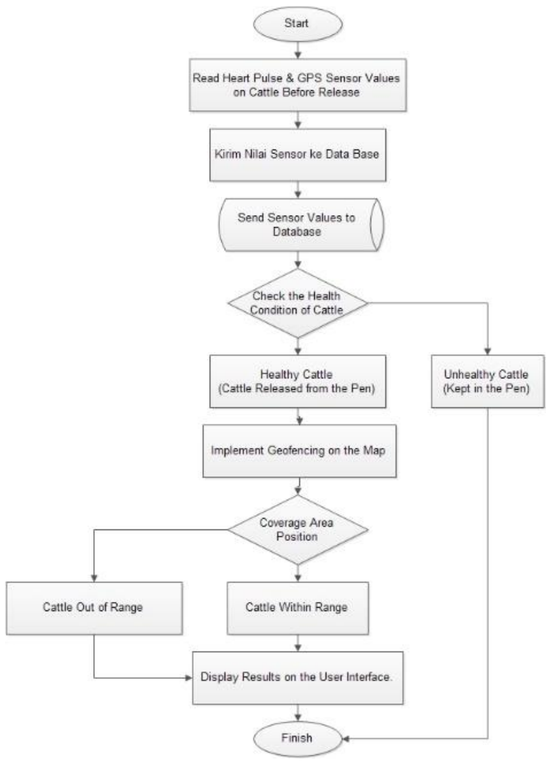

Figure 2. System architecture Livestock Monitoring

The system flowchart explanation above starts when the device is turned on and then checks the internet connection if it is connected, initializing all components to be connected to each other. The Arduino Uno receives a value from the sensor, which is subsequently transmitted to the NodeMCU ESP8266 for storage in the database, and subsequently displayed on the Android application.

1 NodeMCU receives input from the u-blox Neo-6M GPS sensor, temperature sensor, and pulse heart rate sensor.
2 The sensor data received by NodeMCU espp8266 were sent to the database.
3 GPS sensor data were used to create livestock location points on the application maps.
4 Geofencing was performed based on the location of the farm animals.
5 The application checks whether farm animals are outside the geofencing area.
6 For the application display, the results of initializing the parameter values on the u-blox Neo-6M GPS sensor and pulse heart sensor stored in the database were displayed on the Android application.

RESULTS AND DISCUSSION

In this section, we present The In results obtained when we tested the mobile platform using the u-blox neo-6m GPS sensor to obtain latitude and longitude data, which will later be converted into the location of livestock and the pulse heart rate sensor to obtain the heart rate of livestock. NodeMCU microcontroller was used to send u-blox neo-6m GPS sensor data and pulse heart rate sensors to the database.

A. Implementation of the Tool on Livestock

Implementation of the Iot-based livestock monitoring system model is an advanced stage in realizing, in this study, using a u-blox neo-6m GPS sensor to obtain latitude and longitude data that will later be converted into the location of livestock and a pulse heart rate sensor to obtain the heart rate of livestock. The latitude and longitude data stored in the database will later be used to determine the location 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. The tool used for the IoT-based Livestock Monitoring System Model is shown in the following figure.

Figure 3. Implementation of the device on livestock

B. System Testing

Testing the device on the serial monitor on the Arduino IDE, checking the connectivity of the

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ESP8266 and whether it is connected to the surrounding network to obtain a dynamic IP that can then be called to make a connection with the monitoring interface.

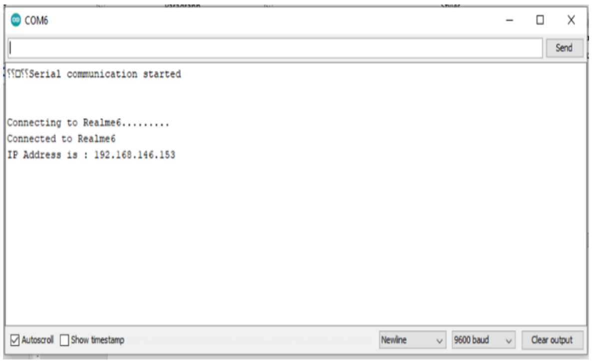

Figure 4. ESP8266 connectivity testing

The image clearly shows a computer screen containing several lines of black and white text, completed with several lines of code arranged systematically. Each code line provides important information for the serial communication process. Initially, the first line of code indicates the start of serial communication, followed by the second and third lines of code, which illustrates that the computer is successfully connected to the Realme device. Details of the Realme device's IP address, 192.168.144.153, are also provided in the fourth line of code, which provides a complete picture of the connection between the computer and the device.

In addition, the fifth through eighth lines of code provide additional information. The fifth line indicates that the computer is in autonomous mode, while the sixth line shows the time signature display on the screen. The serial communication baud rate, 1000, is stated in the seventh line of the code, and the eighth line of the code reveals that the computer is outputting data from the Realme device. As such, the image provides a comprehensive overview of the communication process between the computer and the Realme device, covering various aspects such as connection, mode status, and data exchange.

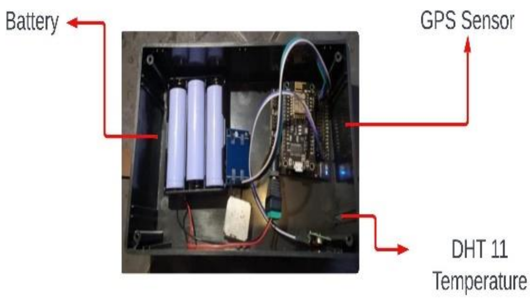

Figure 5. Assembly Model

The process of assembling an electronic device starts with a comprehensive design stage, which includes mechanical, electrical, and software design. The mechanical design ensures the shape and structure of the tool, the electrical design details the electronic components to be used, and the software design specifies the controlling software. The figure shows that electronic tool components were produced in accordance with the design. After the production stage, the process continues to the assembly stage, in which the components are combined into a single unit. Various assembly techniques such as welding, soldering, and nailing have been used to create a complete and functional electronic device.

During the assembly stage, each component underwent a series of tests to ensure that it functioned properly and met the set standards. Once the assembly was complete, the electronic device underwent a test run to verify its performance according to the desired specifications. This assembly process illustrates a planned and systematic approach for building an electronic device, from design to commissioning, to ensure optimal quality and performance.

The login form is simple, yet efficient, and is divided into two columns that make it easy for users to enter information. The first column is reserved for entering the email address, whereas the second column enters the password. Below the password field, there is a login button that allows users to access the platform or the system in question. This compact design ensures order and ease of use and provides users with an intuitive and quick login experience.

Figure 6. Livestock location notification complete with heartbeat

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The image shows a smartphone with a screen that is dominated by a map application. The top of the screen is a status bar that shows time, date, and battery status. The bottom of the screen is a navigation bar consisting of home, back, and recent app buttons. At the top of the map is a button to zoom in or out of the map and a button to display the directions. At the bottom of the map is information about the user's location, including the address, phone number, and website.

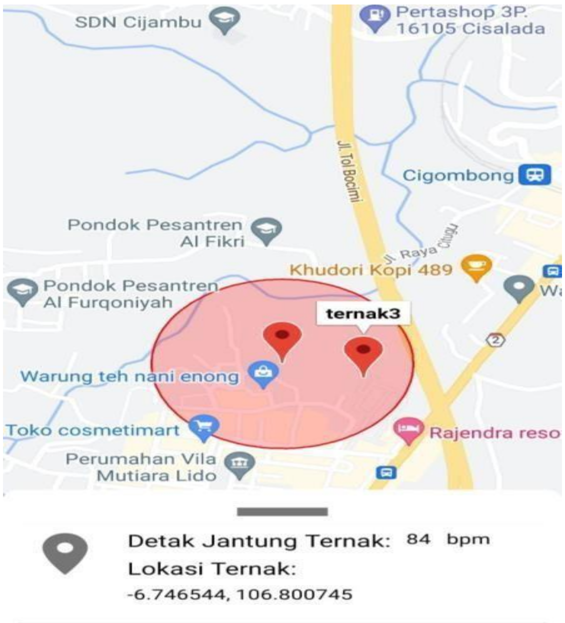

Figure 7. Livestock Monitoring

Picture 7 of a cattle position with heartbeat. The image shows a map of the Cijantung region of West Java, Indonesia. A red circle is located in the center of the map, indicating the location of the cattle 3. Below the red circle is information about the location of Cattle 3, including coordinates, heart rate, and time. Based on the information provided, Cattle 3 was located at coordinates -6.746544 and 106.800745. Livestock 3 has a heart rate of 84 bpm, indicating that livestock 3 is in good health. This image can be used to monitor the health and location of livestock.

C. Validation Test

The validity test is shown in Table 1, which shows information about farm animals kept in a place. The table contains five rows and three columns. The first column shows the farm animal number, second column shows the location of the farm animal, and third column shows the heart rate of the farm animal.

Table 1. livestock monitoring test results

No	Id of livestock animal	Location	Heartbeat
1	Ternak 1	-6.647220, 106.841370	84 bpm
2	Ternak 2	-6.6251472, 106.7705223	83 bpn
3	Ternak 3	-6.645867, 106.843537	84 bpm
4	Ternak 4	-6.644247, 106.847238	84 bpm
5	Ternak 5	-6.648073, 106.849716	83 bpm

Table 1 presents the results of livestock monitoring tests conducted on several livestock animals in different locations. Each entry in the table includes the ID of the livestock, the location of the animal (expressed in geographic coordinates), and the heartbeat of the animal in bpm (beats per minute). The observation results indicated that the heartbeat of the livestock animals ranged from 83 to 84 bpm. From the listed data, it can be seen that livestock 1, 3, and 4 have a heartbeat of 84 bpm, whereas livestock 2 and 5 have a heartbeat of 83 bpm. With this information, monitors can observe the health and behavior of livestock at specific locations by noting recorded variations in heartbeat.

The documented livestock monitoring in Table 1 provides important information about the heartbeat of livestock animals at different locations. From the presented data, it can be observed that the heartbeat of livestock ranged from 83 to 84 bpm, indicating a stable level of heartbeat within that range. The location of each livestock is represented by geographic coordinates, allowing monitors to accurately track the position of the animals. Considering these results, monitoring the heartbeat of livestock animals can serve as a useful health indicator and provide insights into the animals' responses to their environment in various locations. The validation test of the u-blox neo6m gps sensor and pulse heart rate sensor was carried out when the NodeMCU esp8266 microcontroller received input data in the form of latitude and longitude, and the heart rate data of these farm animals were sent by the NodeMCU to the database.

The smartphone screen interface image shows several important notifications related to the monitoring of livestock health and location. The first notification notifies that Livestock 1 has moved out of the preset geofencing area, a useful function to restrict livestock movement. Owners can respond quickly to this notification to address situations in which livestock may be outside the desired boundary.

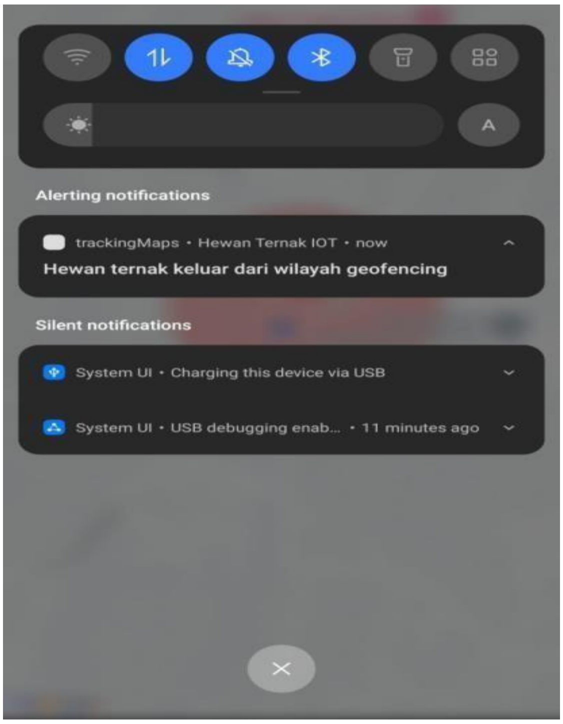

Figure 8. Notification Livestock Monitoring

The second notification provides information on the high heart rate in livestock 2, which may indicate stress or health issues. With this notification, livestock owners can immediately provide necessary medical attention, improving their ability to proactively care for and monitor livestock health. Meanwhile, the third notification notifies the monitoring device being charged via the USB, ensuring the continued functionality and availability of monitoring data. Overall, these notifications provide livestock owners with an effective tool to quickly respond to livestock health conditions and locations in real time. The results of this study provide valuable insights for farmers in understanding the causes of high heart rate detection in their livestock, which include factors such as stress, unsuitable environmental conditions, and certain diseases. With a better understanding of these causes, farmers can take appropriate corrective actions to reduce high heart rates in their livestock and improve their overall health conditions. This also helps improve the quality of livestock care and overall farm productivity.

CONCLUSION

Several significant conclusions can be drawn from research on the Internet of Things (IoT)-based Outdoor Livestock Monitoring System. The research findings demonstrate the effective use of the u-blox neo6m GPS sensor and pulse heart rate sensor in real-time monitoring of the location and health of livestock animals. The combination of these two sensors enables efficient and accurate monitoring, with an Android application serving as a user interface for easy access to collected data. Furthermore, the results of the trials indicate that five 1500 mAh LI-ION LITHIUM batteries provide sufficient power support for reliable system operation over 12 h. The data generated by these sensors were integrated into a database through the NodeMCU esp8266 microcontroller, affirming the system's successful utilization of sensor technology and data transmission. These conclusions offer an innovative contribution to the development of real-time monitoring solutions for livestock health in outdoor locations. The research findings also revealed a variation in livestock heart rates ranging from 83 to 84 bpm, with livestock 1, 3, and 4 registering a heart rate of 84 bpm, whereas livestock 2 and 5 registered a heart rate of 83 bpm. This additional information provides further insight into the health and heart rate responses of the monitored livestock. Further research should expand the scope of monitoring by integrating additional sensors that can provide more detailed information about the health and behavior of livestock animals. Further research is required on the energy efficiency and reliability of the system over a longer period. The integration of new technologies or the development of algorithms for data analysis could also be the next step in improving the effectiveness and reliability of this monitoring system. Thus, future research can make a greater contribution to the development of innovative solutions for monitoring livestock in outdoor environments.

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