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IoT Based Monitoring System for Mobility Control of Dairy Cattle in Indonesia

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ABSTRACT

Providing appropriate space for movement is one of the best ways needed to increase cows' comfort in optimizing their productivity. Currently, several farms have made some changes to the housing system by implementing a free-stall housing system. The system makes the cows more comfortable to rest and do activities because they are not tied up. Due to the large number of cows that are kept, sometimes farmers find it difficult to detect the health condition of each cow individually. Hence, an early detection system is needed to control and monitor cattle activity. The study aimed to develop a monitoring system at the free stall barn farm based on the internet of things. The method used for the study adopted the steps in the System Development Life Cycle (SDLC). Microcontroller-based dairy cow mobility monitoring tool built with NodeMCU ESP8266, GPS sensor, 5v booster, 18650 battery and housing to protect all components. All components used cables with the provisions of the NodeMCU ESP8266 as the tool control centre, GPS sensor as a coordinate point reader, battery as a voltage source, and 5v voltage booster as a component that controls the tool and controls the power off or on. The tool works by getting a power source from the battery and then displaying all the components. The GPS antenna will search for satellites to determine the coordinates of the tool and the coordinate point information will be sent to the NodeMCU ESP8266. When the GPS antenna searches for coordinates, the NodeMCU ESP8266 will look for a WiFi connection in it to then be able to access the internet and send information from the GPS sensor to the hosting website.

Keywords: Cow monitoring system; IoT for dairy cattle; Mobility Control

INTRODUCTION

The development of the livestock industry is growing rapidly, both in small- and large-scale businesses. This situation is driven by the increasing demand for animal protein such as meat, eggs, and milk which have a better nutrition composition than vegetable protein in supporting the protein needs of humans. Milk is one of the food sources of animal protein besides meat and eggs (Al-amin et al. 2017; Pangestu et al. 2019). Most of the Indonesian population who live in rural areas take advantage of natural conditions to raise cattle. Livestock rearing is also an investment for farmers, especially on dairy farms. Dairy cattle are also considered quite profitable for their future life (Setyorini et al. 2017). In addition, dairy farming is also able to become a source of community income, because dairy cows can produce milk every day, so the revenue derived from the sale of milk flows every day.

Dairy cattle rearing can be done in several ways such as intensive and extensive systems. The intensive system is carried out with full rearing and generally, the cattle are tied (stall barn) (Herbut 2013; Angrecka and Herbut 2015; Pezzuolo et al. 2018). The extensive grazing system is carried out by grazing livestock in one pasture and releasing them (free stall barn). Currently, several farms have made some changes to the housing system by starting to implement a free-stall housing system. The system makes the cows more comfortable to rest and do activities because they are not tied up. The study aimed to develop a dairy cattle monitoring system at the free stall barn farm based on the internet of things by utilizing a microcontroller and various relevant sensors and integrating them with software technology to facilitate the monitoring and control process. This tool will monitor the movement or mobility of livestock in barns that are attached to livestock and are connected directly to the application using internet access so that the monitoring process becomes more effective and efficient.

METHODOLOGY

REQUIREMENTS ANALYSIS

The analysis was carried out by a literature study to collect all information related to the tool. Table 1 and 2 shows the equipment requirements and materials that are built-in in into the mobility monitoring tool. Information was obtained by discussing with the farmers, journals, and videos.

TABLE 1. Equipment requirements

No	Name	Quantity	Function
1	Solder	1	To connect lead to component
2	Scissors	1	To tidy up components
3	Screwdriver	1	To fasten the container
4	Multimeter	1	To check the suite

TABLE 2. Material requirements

No	Name	Quantity	Function
1	Battery	1	As a source of circuit voltage
2	NodeMCU	1	As a data processing component
3	GPS Module	1	As a location reader component
4	Step-Up 5V	1	As a voltage booster
5	Switch	1	As a control power in the circuit
6	Case	1	As a network protector
7	Breadboard	1	As a component liaison
8	Lead	1	As a component liaison
9	Cable	1	As a component liaison
10	Battery Holder	1	As a battery holder
11	Belt	1	As a tool binder to the cow
12	Adhesive	1	As a component reinforcement to the container

EQUIPMENT DESIGN

The circuit schematic was designed using Fritzing software. The design of the tool can be seen in Figure 1. The battery as a power source was connected to the switch so that it can disconnect and connect the power. The switch was connected to a voltage booster so that the voltage obtained from the battery becomes higher and more stable for the NodeMCU. The NodeMCU was connected to a GPS module to determine the location tool.

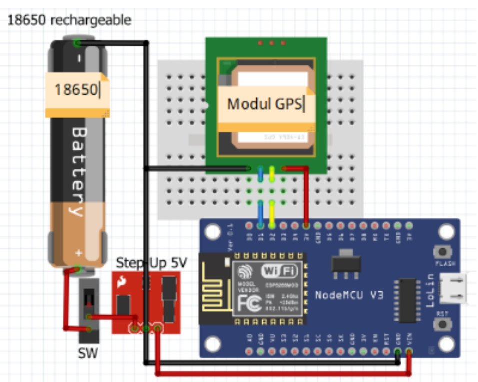


FIGURE 1. Sketch of The Electronic Circuitry

At this stage, the design for the container was also considered by using a web-based application, Tinkercad. The design of the container can be seen in Figure 2.

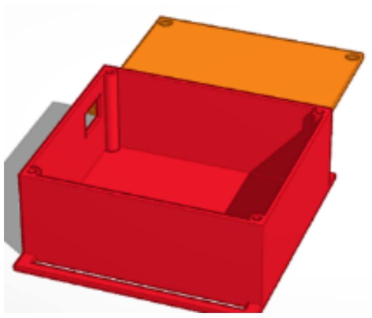


FIGURE 2. Sketch of the Container

IMPLEMENTATION

At the implementation stage, the circuit scheme was made as small as possible so that it is comfortable for cows to use during testing. The whole tool had dimensions of 9 cm long, 7 cm wide, and 5 cm high with a belt attached as shown in Figure 3.

FIGURE 3. The Container

TESTING

The test was conducted by attaching a device to the cows as shown in Figure 4. Testing was divided into 2 aspects: tracking tools and in terms of reports.

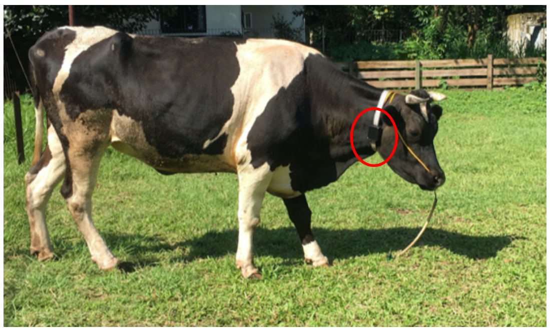


FIGURE 4. Device Installation

RESULTS AND DISCUSSION

DEVICE AND WEBSITE CONNECTION

The device and cattle must first be registered on the website. Figure 5 is a website display for the addition of cow data. Cows' information must be added to the cow table section so that monitoring of cows with equipment can be done by accessing the website page and can be monitored anywhere and anytime.

Figure 6 is a display for adding a data section. Users need to fill in the cows' information so it can directly connect to the website. The users also need to make sure that the device is already fitted to the cows. Both things must be done properly, because if one of them is not missing then the tools will not be able to monitor its movement.

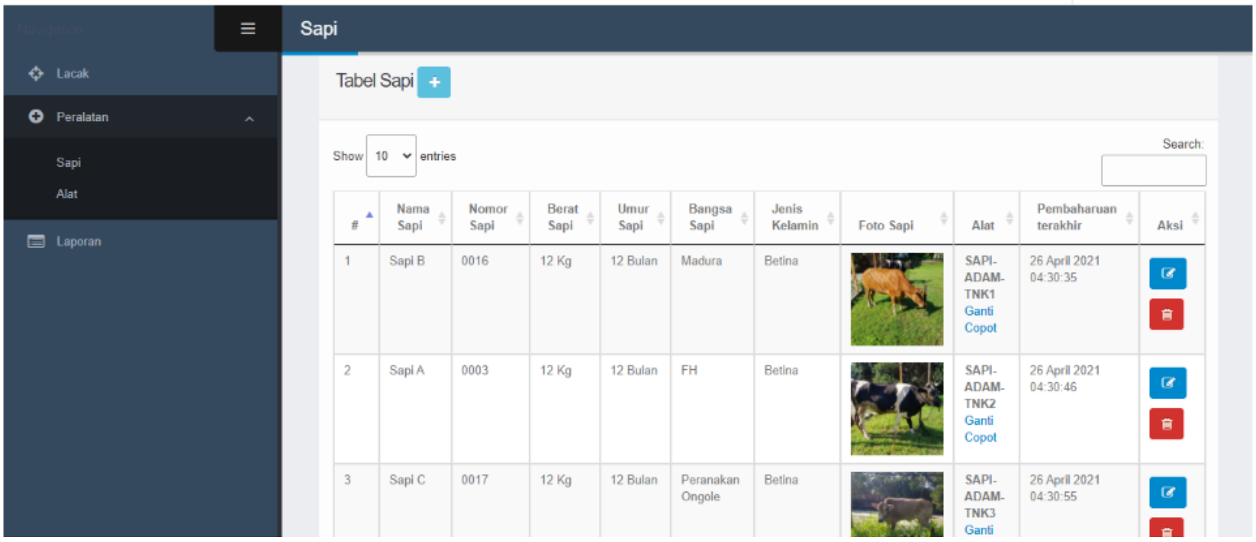


FIGURE 5. Adding Cow Data

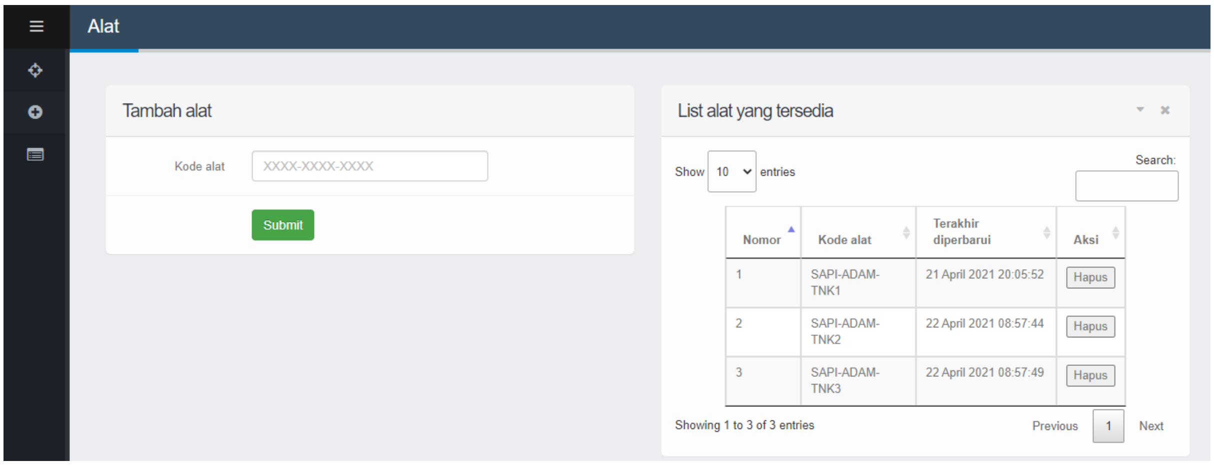


FIGURE 6. Adding Device Data

COW TRACKING

The part of the tracking website was used to see the position of the device that is attached to the cow. Users can also define their coordinates by entering values in the latitude and longitude fields which can be enlarged as desired if it is not clear. All devices listed on the website will read their location in this section, but this will only work when it is turned on the same day. For the accuracy of the device, the location point displayed is quite accurate, although sometimes there was a distance of about one meter, this is still within the tolerance limit. The missing point of location was due to inadequate internet conditions at the time of testing, so the tracking of cattle got a long lag time of up to two minutes (Figure 7).

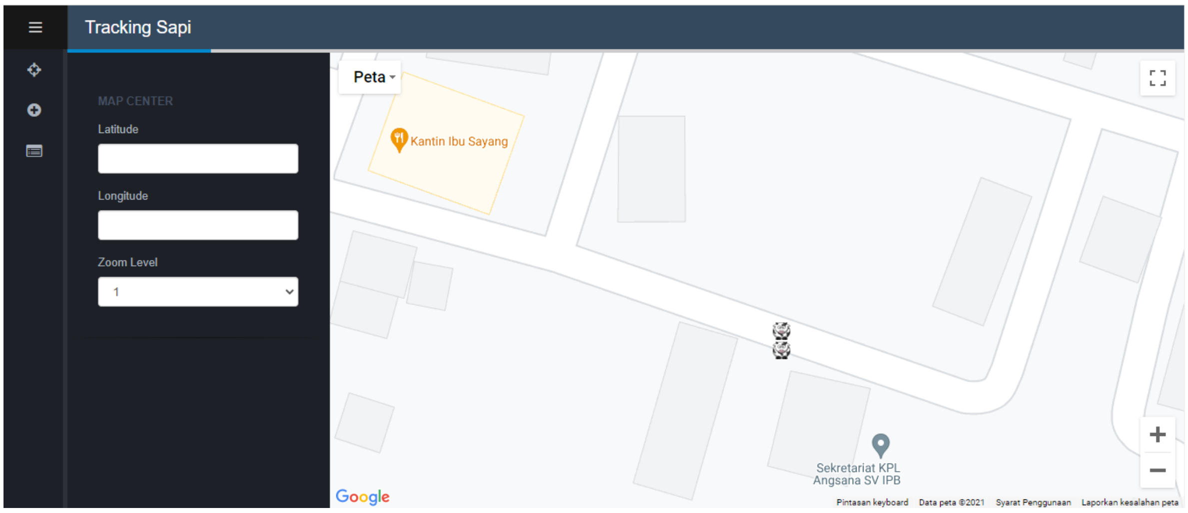


FIGURE 7. Cow Tracking

As shown in Figure 8, tracking cows can also be seen by satellite appearance with the latest objects on the map, this looks more real with actual field conditions.

FIGURE 8. Satellite View

COW REPORT

The report section contains all the coordinates and the history of the cattle movement. The report can be viewed with a text display or statistically as shown in Figure 9. The results of the report vary because the tests are also held with varying durations of time.

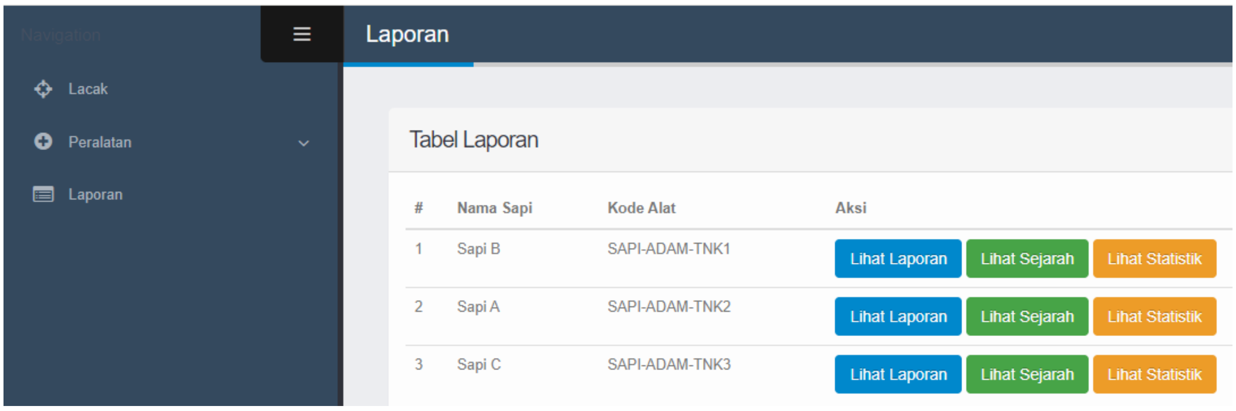


FIGURE 9. Report View

Figure 10 was a report for cattle which recorded the average speed of cattle and the total distance travelled by cattle during the test. The report table records every change in the movement, speed, and latitude-longitude coordinates of the cattle. The report table provides a feature to download report tables in various formats; a data search feature if users want to search based on a value; and a date search feature to make it easier to find data on a certain date.

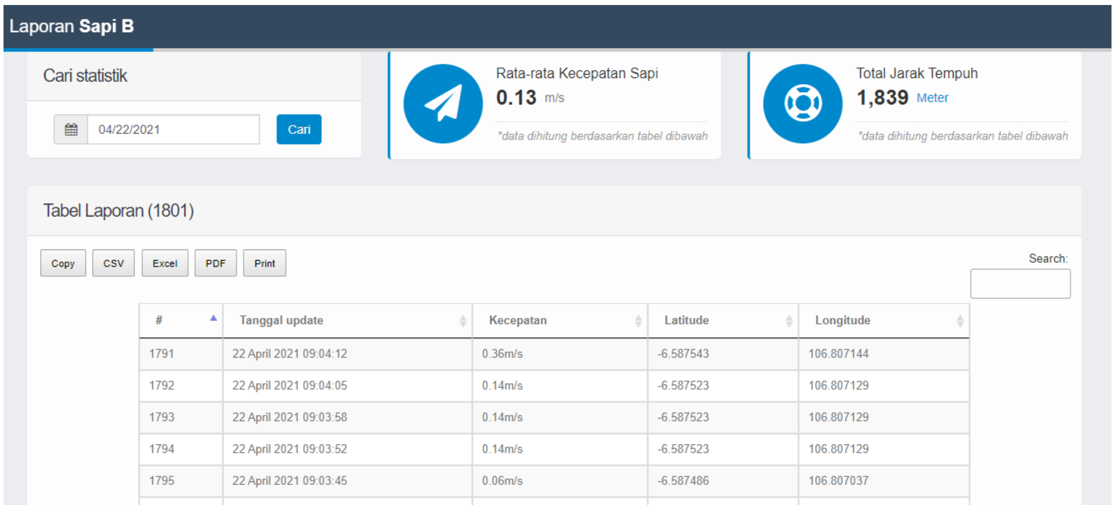


FIGURE 10. Cow Speed Report

Figure 11 describes a report for cattle. At the bottom of the report table there is the direction of the movement of cattle. The direction of movement of the cows is printed on the map in hours with the longest point where the cows have been.

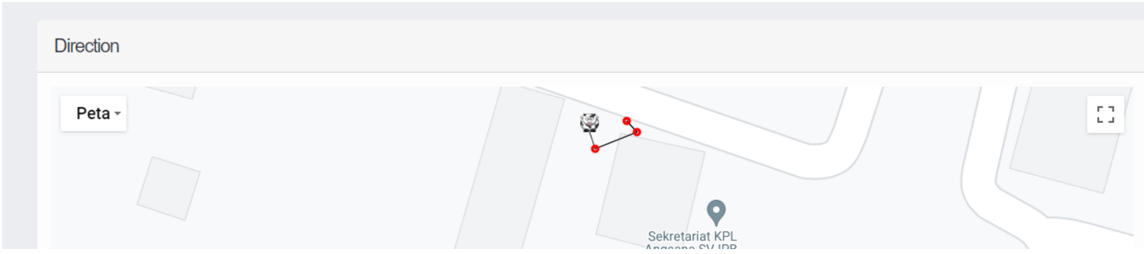
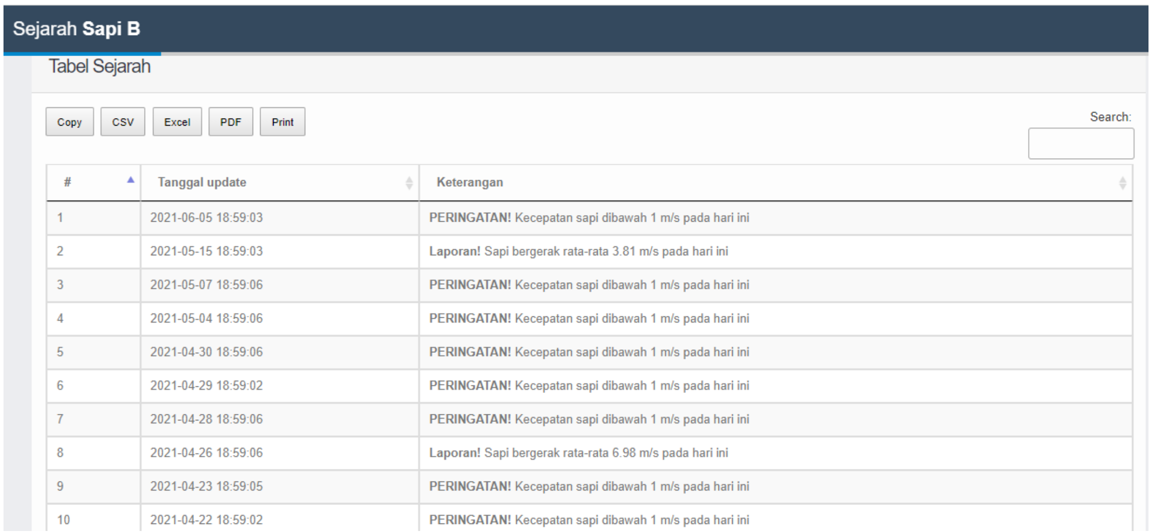


FIGURE 11. Direction Report

Figure 12 explains a history or record of all movements of cattle while the tool was turned on. This section also provides a feature for downloading tables in various formats and a search feature based on the desired keywords.


Sejarah Sapi B

Tabel Sejarah

Copy CSV Excel PDF Print Search:

#	Tanggal update	Keterangan
1	2021-06-05 18:59:03	**PERINGATAN!** Kecepatan sapi dibawah 1 m/s pada hari ini
2	2021-05-15 18:59:03	**Laporan!** Sapi bergerak rata-rata 3.81 m/s pada hari ini
3	2021-05-07 18:59:06	**PERINGATAN!** Kecepatan sapi dibawah 1 m/s pada hari ini
4	2021-05-04 18:59:06	**PERINGATAN!** Kecepatan sapi dibawah 1 m/s pada hari ini
5	2021-04-30 18:59:06	**PERINGATAN!** Kecepatan sapi dibawah 1 m/s pada hari ini
6	2021-04-29 18:59:02	**PERINGATAN!** Kecepatan sapi dibawah 1 m/s pada hari ini
7	2021-04-28 18:59:06	**PERINGATAN!** Kecepatan sapi dibawah 1 m/s pada hari ini
8	2021-04-26 18:59:06	**Laporan!** Sapi bergerak rata-rata 6.98 m/s pada hari ini
9	2021-04-23 18:59:05	**PERINGATAN!** Kecepatan sapi dibawah 1 m/s pada hari ini
10	2021-04-22 18:59:02	**PERINGATAN!** Kecepatan sapi dibawah 1 m/s pada hari ini

FIGURE 12. Movement Report

The graph below shows the average cow speed during the device test. The graph will generally be high when the cows move a lot, but this was also due to the long duration of the device being used. The longer the device is on, the longer the cow moves and the higher the count will be.

FIGURE 13. Statistical Report

Figure 14 is a brief statistic of cattle. Any graph information can be selected to view only when the device is turned on. This aims to facilitate the filtering of the desired information without displaying unnecessary information.

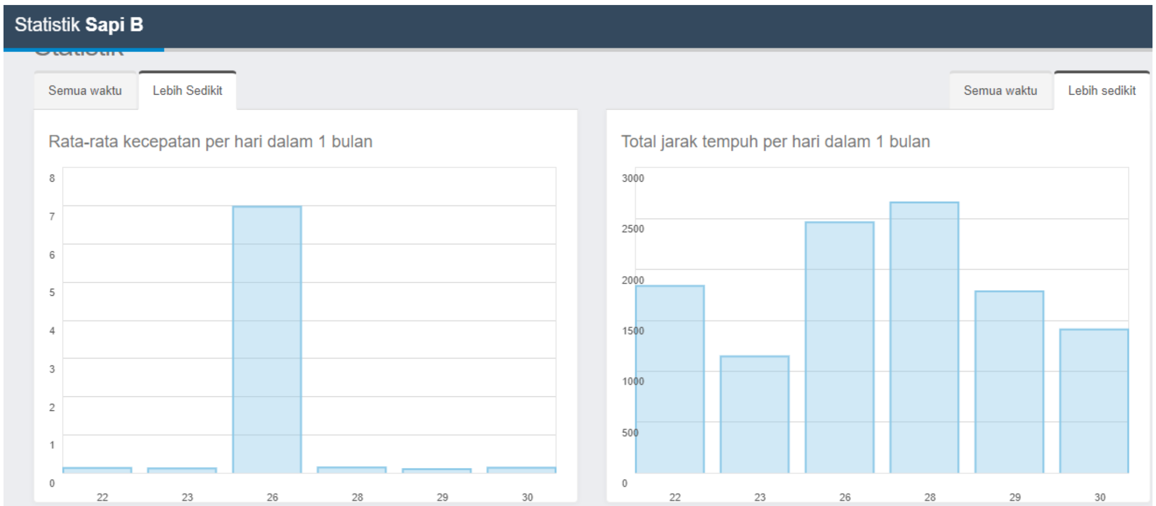


FIGURE 14. Short Statistical Report

Dairy cows are the main milk-producing livestock to meet the world's milk needs compared to other dairy-producing livestock (Herbut et al. 2015; Broucek et al. 2017; Shepley et al. 2017). Milk production is influenced by various things and the most important factor is the environment. Comfort is an important point that must be considered in improving the productivity of dairy cattle. Housing and equipment are an integral part of a dairy farming business which greatly affects the comfort of cows. Providing appropriate space for movement is one of the best ways needed to increase cows' comfort in optimizing their ability to produce good milk.

Modern dairy farms generally use a free stall barn system where the cows are free to move in the barn. Due to the large number of cows that are kept, sometimes farmers find it difficult to detect the health condition of each cow individually. Hence, an early detection system is needed to control and monitor cattle activity so that prevention can be carried out as soon as possible in cows that are detected to have problems in their legs or other activities (Novianta 2015; Satria et al. 2017; Mahendra et al. 2018; Putra et al. 2018; Isyanto et al. 2020). The process of monitoring dairy cattle grazing on new free stall farms has been developed in several previous studies (Table 3). The current system is generally separate for each issue such as tracking livestock location, livestock health issues, traffic-related issues and so on.

TABLE 3. Related Research - Literature Study Results

Research Topic	Research results and/or Gap
IoT - Livestock Monitoring and Management System (Ophir Isaac, 2021)	1. The process of onboarding cows with IoT devices- a cow necklace- still needs to be implemented. 2. Connectivity of the device to the cloud platform must be established and documented. 3. The user interface of the Mobile app needs to be defined. 4. Development of the mobile application stack has not been completed. 5. Some areas of deployment/field testing still need to be identified
Design of a Cattle Monitoring System Based on a Wireless Sensor Network for the Grazing System in West Timor, East Nusa Tenggara Province (Lasfeto, Setyorini and Lada, 2017)	1. Using temperature sensors and GPS sensors to monitor livestock. 2. Identify the behaviour of cattle on farms 3. Design a System Calibration Based on Wireless Sensor Networks (JSN) 4. Implementation and testing to determine the level of reliability of information generated by a monitoring system based on a wireless sensor network needs to be done 5. Testing the level of errors/errors that arise for improvement and wider development needs to be done

continue ...

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Research Topic	Research results and/or Gap
Smart IoT Cloud Based Livestock Monitoring System: A Survey (Vigneswari *et al.*, 2021)	1. Survey-based research found that many animals health and site monitoring techniques were used to prevent and manage livestock and various intelligent feeding techniques to address animal feeding problems. 2. The surveyed system still has some major drawbacks such as higher power consumption, complex structure and interface, and high installation and maintenance costs that make farmers unable to rely on it to adapt to the intelligent system. 3. The surveyed intelligent system also needs more support when installed on large farms. 4. It is recommended to build a smart system that can increase power consumption using solar power to operate when livestock is grazing in the field and can use batteries in the absence of sunlight. 5. Diseased cattle are detected by health monitoring and can be treated by feeding drugs along with grain through smart feeders.
Internet Of Things (IoT) Based Cattle Monitoring And Management (Nithin *et al.*, 2020)	1. The system built can eliminate traffic accidents that occur in livestock, find lost livestock, and manage health problems related to livestock. 2. The system works by uploading the current location to the database from the GPS via an internet connection. The location can then be viewed using the Android device. 3. The system has not presented the results of its implementation and testing
IoT Solutions for Farmers on Livestock Management in Smart City: A Bibliometric Survey (Gaikwad and Harikrishnan, 2021)	1. This study presents the results of a survey that describes various IoT-based technologies for farmers to manage livestock and daily livestock organization with intelligent systems. 2. Intelligent system can accurately and efficiently monitor livestock behaviour and detect animal status in terms of physiological and health. 3. IoT technology has reliable capabilities in terms of communication, cloud systems, hardware, and easy-to-use applications.
IoT-Based Cattle Health Monitoring System (Shinde, 2017; Kumari and Yadav, 2018; Suresh and Sarath, 2019)	1. Research that establishes specialized sensor technology as an important means of monitoring animal health and ensuring animal welfare in the rapidly changing conditions of automated farming. 2. Several bovine diseases have been studied and analysed of the symptoms associated with these conditions. These symptoms are then mapped to the types of sensors that can measure the behaviour.
Sensors for movement monitoring (Satria *et al.*, 2017; Mahendra, Susyanto and Siswanti, 2018; Isyanto, Ibrahim and Meilisha, 2020)	1. Describe the use of sensors for monitoring the movement of an object 2. The use of sensors that can be used to implement monitoring of dairy cows in free-stall barn farms.

CONCLUSION

Microcontroller-based dairy cow mobility monitoring tool was built with NodeMCU ESP8266, GPS sensor, 5v booster, 18650 battery and housing to protect all components. All components used cables with the provisions of the NodeMCU ESP8266 as the tool control centre, GPS sensor as a coordinate point reader, battery as a voltage source, and 5v voltage booster as a component that controls the tool and controls the power off or on. The device works by getting a power source from the battery and then displays all the components. The GPS antenna will search for satellites to determine the coordinates of the tool and the coordinate point information will be sent to the NodeMCU ESP8266. When the GPS antenna searches for coordinates, the NodeMCU ESP8266 will look for a WiFi connection in it to then be able to access the internet and send information from the GPS sensor to the hosting website.

Monitoring the movement of cows that are equipped with devices was carried out on the website. The parts that could be monitored were the location of the cow, the speed of movement of the cow, and the direction of movement of the cow. Based on the data stored on the website, the tool was functioning well with a limited note on the tool case that was not waterproof, and the GPS was still less accurate at one time. Suggestions for developing a microcontroller-based mobility monitoring tool for dairy cows were to add monitoring features such as monitoring when cows eat and rest. In addition, it is necessary to develop the tool container section so that it can be waterproof or resistant to impact by cows.

To overcome the problem of the container not being waterproof, the user can put rubber around the lid of the container to make it tighter, while for impact resistance. Users can also use stronger but lighter container materials such as acrylic. Suggestions for implementation, when using the tool, there must be a stable internet connection, to minimize the lag time in sending data from the tool to the website hosting.

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DECLARATION OF COMPETING INTEREST

None

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