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Analysis Y Axis Estrus Detection System Based On Percentile Method

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Abstract : *A failure in detecting 'estrus' is one of the factors that can cause reproductive problems and low pregnancy rates in cattle groups. Generally, detecting estrus can be done by looking at cattle behavior in vulva condition. Beside that, there are some cows that their sub estrus or silent heat do not really show their estrus symptoms physically, such as the vulva swells, flushes and the clear liquid comes out by hanging from the vulva or seen at the base of the tail. Based on these conditions, it can be clearly seen that not all breeders are able to detect animal estrus properly. From the aforementioned problem, it was proposed a system that can detect 'estrus' of cattle based on the cattle's movements. The system was built by using Arduino based accelerometer that hopely can detect estrus by sending the warning system to the breeder. The results of system performance testing using percentile approach compared to expert results obtained an accuracy of 77.77%.*

Keywords : *Arduino, Accelerometer, Estrus, Bali Cattle*

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I. Introduction

Bali cattle is one of the Indonesian local type cows that come from Bali. Nowadays, it has been spread to almost allover Indonesia even to other countries such as Malaysia, the Philipines, dan Australia [1]. The efficiency level of cattle's reproduction is not optimal yet and face many challenges. there are still many cases of reproductive problems to the maturity of female livestock which cause low cattle productivity [2]. In addition, reproductive management errors are due to the low understanding of estrus, improper detection of estrus, the accuracy of marriage, low nutrition, and the environment, so that it can lead to late reporting of estrus symptoms efficiency.

A failure in detecting estrus is one of the factors that can cause reproductive problems and low pregnancy rates in cattle groups. The farmer's knowledge of the estrus cycle is one of the important factors for marital success [3]. Farmers often have difficulty knowing the correct estrus time because it is not detected [4]. The estrus cycle is carried out through visual observations based on signs such as restless cows, rising temperatures which are generally characterized by the color of reddish cow vulva, vaginal thickening, decreased appetite and even disappearing altogether. As well as the behavior of other cows arises and the discharge of mucus from the genitals (vulva) [5]. The problem that has occurred so far in animal estrus detection is that farmers check one by one twice a day by looking at the physical condition of the cow. In addition there are cows that subestrus or silent heat, do not show symptoms of estrus physically. Based on these conditions, it can be seen that not all breeders are able to detect animal estrus properly. Therefore we need a device that can detect estrus by observing the motion of the cow.

From the description above, a system that is able to detect estrus in cattle based on cow's motion has been proposed. The system was built using an Arduino microcontroller based accelerometer which is expected to be able to detect the occurrence of estrus by sending a warning to the farmer. After knowing the time of estrus, farmers can take the right steps so that the success of pregnancy can occur more optimally.

II. Literature Review

2.1 Bali Cattle

Bali cattle are descended from wild cows called Banteng (Bos sondaicus) who have undergone a process of domestication for years. The advantage of Bali cattle is that it is easy to adapt to the new environment, so it is often called pioneer cattle. Payne and Hodges (1997) state that Bali cattle have the genetic potential of local cattle plasma which has a comparative advantage compared to imported cattle. These

advantages include excellence in utilizing high fibrous forage, tropical climate adaptability and high fertility (83%) and carcass percentage (56%) and good carcass quality [6].

2.2 Estrus Cycle

Estrus is the time when female animals are willing to accept males for copulation. The estrus cycle in cattle lasts for 21 days. The average estrus lasts for 18 hours and ovulation begins 11 hours later. To be able to explain the estrus cycle based on symptoms seen from outside the body, one estrus cycle is divided into 4 phases Table 1, namely Proestrus, Estrus, Metestrus and Diestrus [7].

Table 1: The length of the estrus cycle period in cattle

Proestrus (days)	Estrus	Metestrus (days)	Diestrus (days)
3	12-24 hours	3-5	13

In the estrus phase, the balance of the pituitary hormone shifts from follicle stimulating hormone (FSH) to luteinizing hormone (LH) which results in an increase in LH, this hormone will help ovulation and the formation of the corpus luteum seen after estrus. The ovulation process will be repeated regularly every fixed period of time which is one cycle of lust (Toelihere,1985).

2.3 Percentile

Percentile is a value that divides the frequency of data distribution into one hundred groups of equal size. In other words the percentile is the value that divides each 1% frequency in the distribution. The first percentile is a point in the distribution which is the limit of one percent of the lowest frequency. The second percentile is a point that limits the lowest two percent frequency in the distribution. The third percentile is the point that limits the lowest three percent distribution frequency. And so on, the ninety-nine percentile is a point that limits 99 percent of the frequency below the distribution of one percent above the distribution. Percentile is abbreviated as P1, P2, P3, ... P97, P98, P99 [8].

Percentile uses:

1. To change the raw score (raw data) to a standard score (standard value)
2. Percentile can be used to determine the position of a student that is on the percentile of how the student gets a position in the middle of his group.
3. Percentile can also be used as a measuring instrument to determine / set the limit value to pass on a test or selection.

Percentile formula :

$$P_n = data\ ke - \frac{i\ (n+1)}{100} \qquad (1)$$

P_n : percentile to-n
n : amount of data
i : 1,2,3,…,99

2.4 Accelerometer

An accelerometer is a device used to measure acceleration and the impact of gravity on acceleration. This 3 axis accelerometer sensor has several properties that exist because of its ability to represent three axes. Figure 2 is an analogy of the axis on the 3 axis accelerometer. The X axis represents a rotational motion. The Y axis represents the motion of the slope on the Y axis. The Z axis represents a movement of turning or bending over a plane [9].

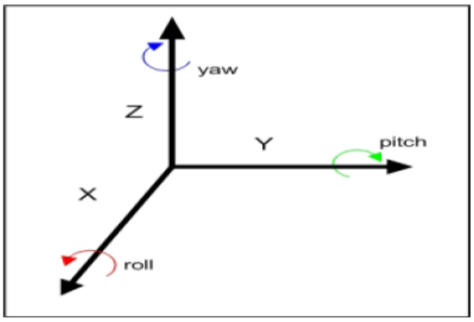

Figure 1 : The analogy of the axis on the 3-axis accelerometer

III. System Design

The detection system design and built is a system that can detect estrus in cattle and send warnings to cattleman. This system is able to work automatically without human supervision to detect estrus in cattle. This system combines a microcontroller and an accelerometer to detect estrus in cattle.

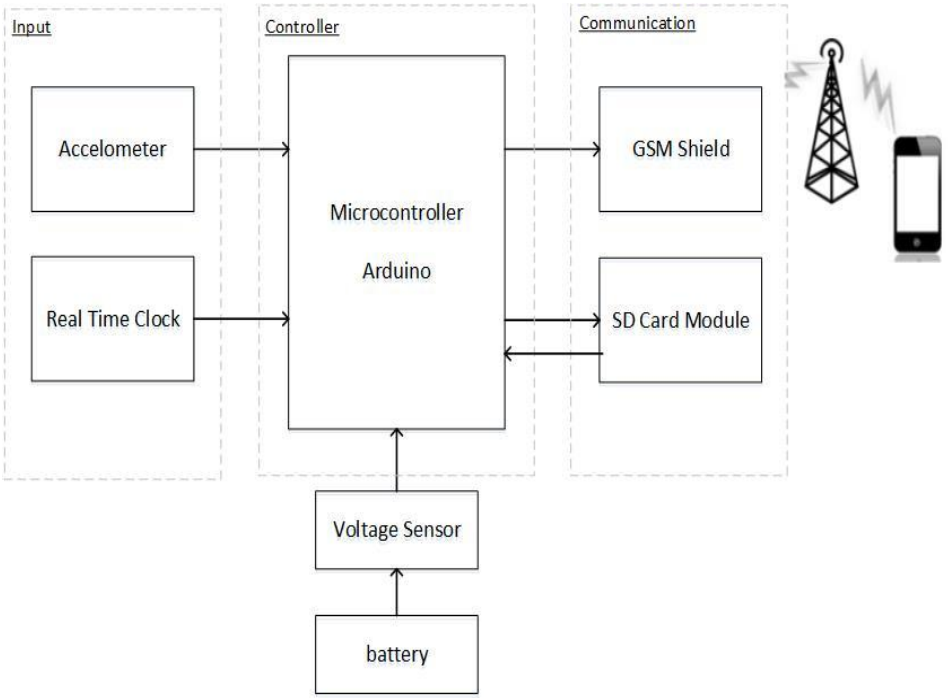

Figure 2 : Block Diagram

In Figure 2 the design system is divided into 3 modules. The input module is a set of settings, algorithms and sensors to capture a condition which will then be forwarded to the controller. The component used in the input module is the ADXL335 accelerometer sensor and this accelometer sensor can find out the movements carried out by cattle based on the y axis. The Controller module which has the function to read data movements y axis based on the cattle activity from periodic measurements made by the accelerometer sensor and will be stored in memory. The controller module uses Arduino nano that is a circuit board equipped with the Atmega328 microcontroller. Real Time Clock (RTC) is a module that can count time (from seconds to years) and has a function as a store for time and date to log data that will be stored later. There is also a voltage sensor to determine the voltage of the battery installed. After the sensor finished reading the data, it is received by the microcontroller and stored in memory and it detected estrus, the microcontroller will instruct to send a message to the breeders through the communication module. The process of sending data used wireless media. The hardware used here is the GSM Shield. Data transmission with wireless is more efficient than cable communication, considering that the cattle used as research objects are moving objects and quite many in quantity. The microcontroller will also instruct to send a message when the battery voltage that are read by the voltage sensor is at a minimum.

The design system in this study is shown in Figure 3. The system starts by measuring the y axis by the accelerometer. Furthermore, the recorded data by the accelerometer is sent to Arduino. Measurement data will be stored in the log to be used as history. The stored data will be processed using percentile method.

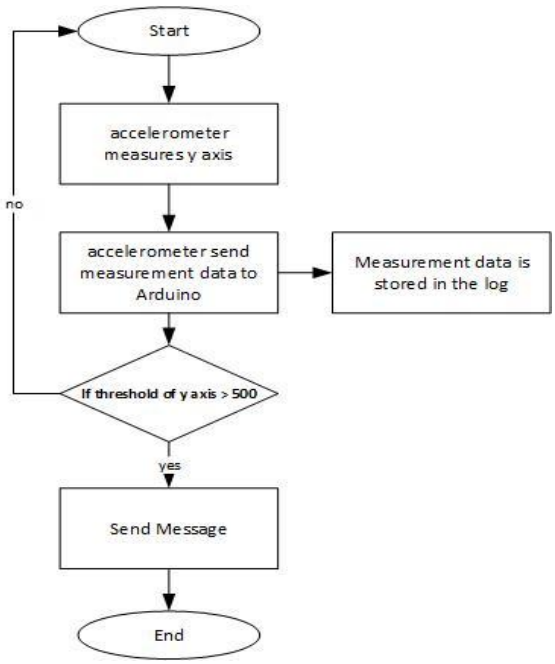

Figure 3 : *Flowchart* system planning

IV. Result And Discussion

4.1 Hardware Implementation

The physical form of the design of an Arduino-based estrus detector in Figure 4 is assembled on a PCB board using an accelerometer as a sensor that detects the occurrence of estrus based on the motion of a cow. The dimensions of the pelican case used are 14.9cm long, 10.3cm wide and 5.4cm high. Has an overall weight of 400 grams. And the entire component used requires 48 mAh of power. Figure 5 is the back of the estrus detector, there is a battery holder, battery and switch. The estrus detector consists of several components, namely:

a. Micro SD Card module that functions to store cow movement data that comes from the accelerometer and stores centroid data of estrus and centroid not estrus.
b. GSM shield SIM800l functions to send messages when the memory is not installed, the battery runs out and estrus detection.
c. Stepdown to reduce the voltage needed for SIM800l because the voltage needed by SIM800l is 3.7v.
d. RTC to show the time starting from seconds, minutes, hours, dates, months to years.
e. Voltage sensor serves to measure the voltage of the battery.

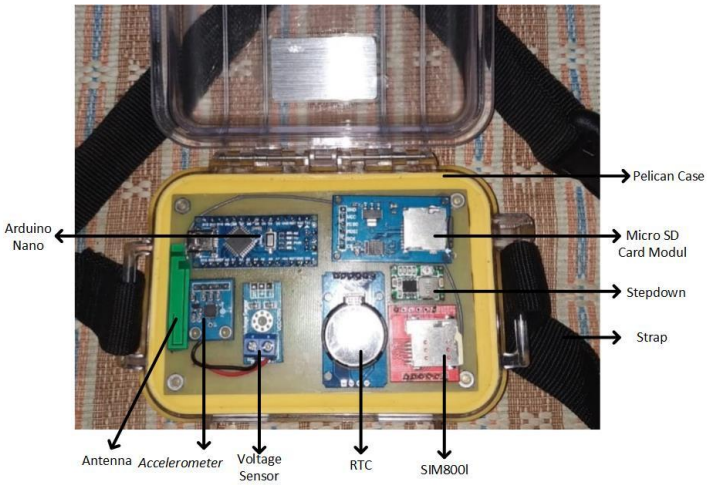

Figure 4 : The display of estrus detector

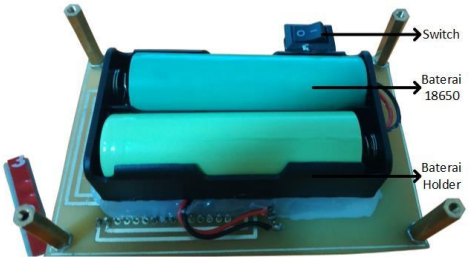

Figure 5 : Display of the backside of the estrus detector

The installation procedure for estrus detection devices can be seen in Figure 6. The tool is applied to the cow to be studied. Installation of the equipment must be in accordance with the installation procedure as shown in the figure to show the configuration of the x, y and z axes. The x axis is an upright, the y axis detects looked down and looked up movements and the z axis detects turning movement to the right and left.

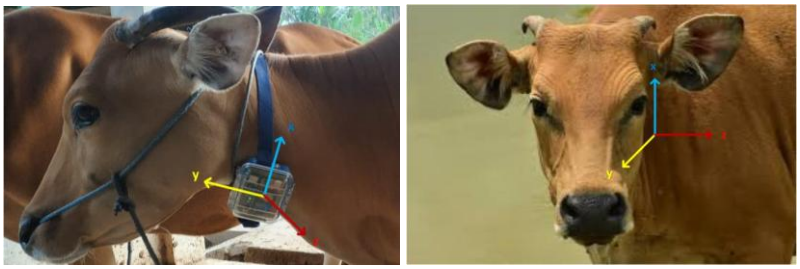

Figure 6 : Installation of tools on bali cattle

4.2 Data Calculation and Analysis

Percentile is a value that divides the frequency of data distribution into one hundred equal groups. The system starts by measuring the y axis by the accelerometer. Stages of calculations are carried out namely:

1. Data on cattle movements on the y axis
2. Determine the estrus threshold value on each axis. To determine the threshold value of cattle experiencing estrus or Non estrus, the percentile method is used. The percentile value used is 0.75. The value of 0.75 is obtained from the simulation results from the data obtained.
3. With a 0.75 percentile the value is 380 on the y axis
4. After getting the threshold value, count on the y axis.
5. If the threshold value on the y axis> 500 then the cow experiences estrus. If the data obtained shows a value that is below the threshold then the cow is non estrus

Figure 7 shows a graph with the y axis. It shows the movement of cattle in estrus condition. From the data obtained, the estrus cows show a graph that shows that their appetite decreased on the y axis and the movements of climbing on the other cattles.

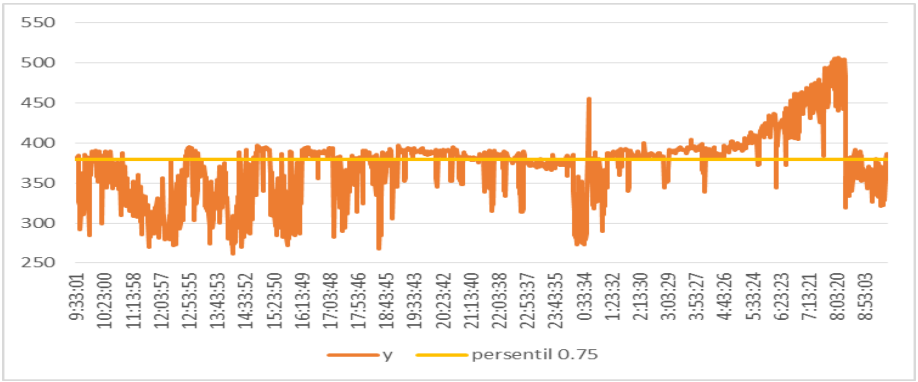

Figure 7 : Graph of movement activities of estrus cattle

According to some expert, there are 2 models in estrus cows, namely cattles that show estrus symptoms physically and there are estrus cattle without showing symptoms called silent heat. The decrease in appetite is probably due to estrus activity, where the animal estrus has excessive activity which affects the reduced appetite, as well as the influence of high estrogen levels so that this results in blood glucose levels rises. If the

glucose level is sufficient then the animal does not need to eat. It effects on reduced appetite. One of the stands out symptoms of estrus in cattle is the decrease in appetite accompanied by a heightened lust (manifestation of high levels of the hormone estrogen). High estrogen causes anxious cattle to look for males and mating. The estrus cattle in the pasture will carry out active movements, jumping up and down, running to attract males. But cattles that are anchored by binding certainly cannot make free movements such as running or jumping, limited back and forth movements, but more head position above due to decreased appetite. One of the dominant symptoms of estrus is the sound of moans. Estrus cattle repeatedly sound or estrus sounds can be used for one marker that can be observed for estrus measurements

Figure 8 shows a graph with the y axis which shows the movement of cattle in non-estrus conditions. From the graph, it can be seen that non-estrus cattle show different activities with estrus cattle as the appetite does not decrease seen on the y axis and it is seen they are not climbing other animals.

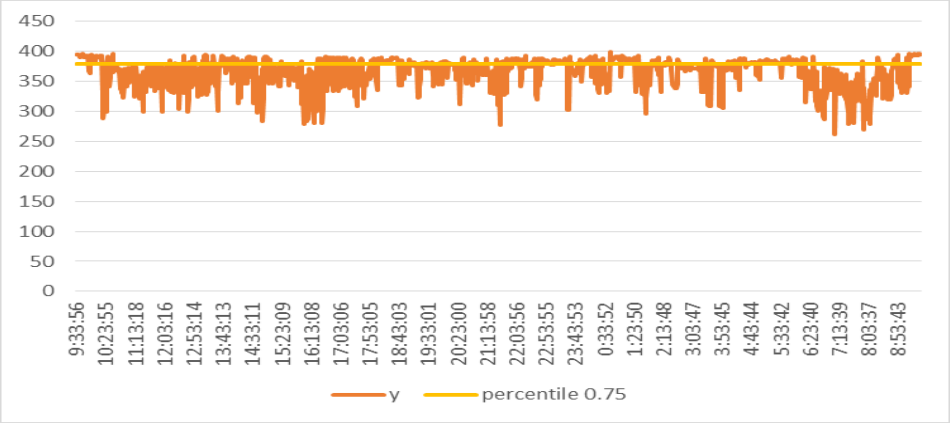

Figure 8 : Graph of movement activities of non-estrus cattle

4.3 Experiment

4.3.1 Software Testing

Software testing on the estrus detection system uses blackbox testing. This test requires the input to see the output. The blackbox test results state that all functions of the system runs well and the system gives the results as the expected output. The results are shown in Table 2.

Table 2 : SMS function testing table

No.	Testing	Expected results	Observation	Test result
1.	The function of sending battery status.	The device able to send SMS when the battery runs out.	When the battery runs out, the device sends an SMS.	[√]Successful [ ] Not successful.
2	Send status of memory function.	The device able to send SMS when the memory is not installed or unreadable.	When memory is not installed the device sends SMS.	[√]Successful [ ] Not successful.
3	Function of sending estrus status.	The device able to send an SMS when estrus detected.	When estrus detected the device sends SMS	[√]Successful [ ] Not successful.

4.3.2 System Performance Testing

Testing has done by comparing the results of calculations using percentile 0.75 and Expert Testing. The test results can be seen in table 3.

Table 3: Testing result

Data	Date	Percentile 0.75	Expert
1.	07/01/2019	Non Estrus (unsend SMS)	Estrus
2.	09/01/2019	Non Estrus (unsend SMS)	Estrus
3.	10/01/2019	Estrus (send SMS)	Estrus
4.	14/01/2019	Estrus (send SMS)	Estrus
5.	21/01/2019	Estrus (send SMS)	Estrus
6.	23/01/2019	Estrus (send SMS)	Estrus
7.	28/01/2019	Estrus (send SMS)	Estrus
8.	30/01/2019	Estrus (send SMS)	Estrus
9.	06/02/2019	Estrus (send SMS)	Estrus
10.	11/02/2019	Estrus (send SMS)	Estrus
11.	16/01/2019	Estrus (send SMS)	Non Estrus
12.	17/01/2019	Non Estrus (unsend SMS)	Non Estrus
13.	18/01/2019	Non Estrus (unsend SMS)	Non Estrus
14.	04/02/2019	Non Estrus (unsend SMS)	Non Estrus

15.	13/02/2019	Non Estrus (unsend SMS)	Non Estrus
16.	18/02/2019	Estrus (send SMS)	Non Estrus
17.	04/03/2019	Non Estrus (unsend SMS)	Non Estrus
18.	11/03/2019	Non Estrus (unsend SMS)	Non Estrus

Table 3 shows that the test results using percentile 0.75 comparing to the expert results, obtained an accuracy of 77.77%. According to the experts, such as Reproductive Veterinarians, these findings have been able to use to recognize the emergence of symptoms of lust in Bali cattle. It states that the overall results of detection of the system can help the breeders. However, this system must be developed more to get better results. The low of accuracy values are caused by several things. One of them causes that makes the results less optimal obtained in this study according to Prof. Dr. drh. Tjokorda Oka Pemayun, M.Sc, that the decrease in appetite does not only occur during estrus, but also occurs in sick cattle. Moreover, the detection of the behavior of estrus cattle can only be used to know the signs of estrus but not a peak estrus. So, it is necessary to do research to find out the peak of estrus such as knowing when the mucus is out or the peak of estrogen hormone levels. Therefore, it will provide optimal results later.

V. Conclusion

Based on the findings of the research and the results of testing the estrus detection system using an Arduino-based accelerometer, it can be concluded that each function of the system gives results that are suitable to the expected output based on blackbox testing. This tool produces a communication system as a sign or warning by sending messages to the breeders namely: the estrus cattle, low battery, and memory status. And accuracy obtained to determine the condition of cattle (estrus / non estrus) using percentile 0.75 is 77.77%.

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