Classification system for estrus behavior of cow using an Accelerometer

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Abstract— **Generally, estrus of cow can be observed from its body such as swollen vagina, slime and mydriasis or its behaviors such as bellow out, ride piggyback with the other or let the other rides piggyback. These symptoms will only occur within 18 hours. To access the best result, therefore, the insemination should be processed during on 9-18 hours of that period time. Therefore, this project proposes the application of accelerometer for checking estrus of cow. The accelerometer is installed on the cow's front leg. When the cow rides piggyback the other, resulting the output signal of accelerometer is changed. This signal will be sent to the microcontroller for processing and send the signal through wireless to computer for displaying. The proposed system will be useful to improve efficiency of the insemination.**

I. INTRODUCTION

Recently, the automated system for classification and monitoring of animal behavior has been widely growing because such system could provide useful information to identify health problems or a risk of animals for disease. With regard to an automated system for detection of estrus in cow, it has also been studies due to it could improve high rates of detection and reproduction [1] . High rates of estrus detection have an important impact on realization of gestation. The high accuracy of detection can improve insemination results, controlled calving interval and total pregnancy rate [1-3].

In many studies, an automated system for monitoring the behavior of animal has been reported. Most studies employed various sensor systems such as global positioning system (GPS), radio frequency identification (RFID), and accelerometer for the key parameters to recognize the cow's behavior. For example, recent studies have been conducts (GPS) and accelerometer for positioning of a herd of dairy cows in the field [4-12]. However, in regard to the automatic estrus detection, an efficient activity type classification using tri-axial accelerometer becomes a major method for detecting estrus events in dairy cattle [3, 13-15].

In literatures, there are different classification methods that provide for estrus detection such as Support Vector Machines (SVMs), Kalman filter, and , fuzzy logic classifiers, etc [1]. However, most of these techniques needed to construct with an excessive amount of mathematical operations and used highly-resources requirements. Thus, these methods may be unsuitable applying with the resource-constrained embedded devices, particularly when employing with a low-cost microprocessor.

According to this work, we have interested to detect the estrus of cows by using the accelerometer for the sensor device. The aim of this paper is attended to modify a simple behavioral classification technique for classifying estrus of cattle using acceleration data with a high classification rate and available to implement with resource-constrained approach.

This paper is organized as follows: Section II gives related work of accelerometer classification methods. Section III presents the accelerometer sensor and data collection. Section IV modifies the technique for classification. Section V. evaluates of the success rate classification. Finally, Section VI concludes the use of classification method.

II. RELATED WORK

According to the research of Roelofs et al. [16], they stated that the estrus in mammals is a behavioral symptom and strategy to ensure that female is mated close to the time of ovulation, an internal and invisible event. As for dairy cows, the estrus can be observed from its body such as swollen vagina, slime and mydriasis. The other observation is that the behavior of such animal has been changed, for example, the estrus cow will ride or let the other cows ride piggyback.

To detect such symptom, the research carried out by Yin et al. [2] described the method of detecting estrus into two major categories, that are by the manual measuring and the automatic monitoring. The traditional of estrus detection is performed by visual reservation such as changing in body and milk temperature, changing in vaginal mucus resistance, walking and mounting activity [1]. However, most of these approaches are made by a skilled farmer and based on their experience. It may costly and inaccurate operation when dealing with a large scale of animals [2].

As for the automated detection, this opens up the possibility of monitoring large numbers of animals over long periods of time with minimum human intervention [15]. In recently, automated monitors are now based on accelerometer has becomes a major technology of estrus detection. Such device has a growing term in the behavior literature. There were applied different classification approaches which relied on local statistics from acceleration data to build objective models. Roelofs et al. [13] applied statistical tests for estrus detection and as predictor for time of ovulation in dairy cattle by using a mean of recent activity compared to reference mean values. Further, Jonsson et al. [14] assessed and detected the estrus by using on-line individual model of activity and lying data in dairy cows. Such study combines information from step count and leg tilt sensors in order to improve detection scheme reliability with the use of low cost sensors.

As for estrus detection in cows, there were applied different classification approaches such as SVMs, Kalman filter, and fuzzy logic classifiers in different studies. Analysis of time series which estimated by Kalman filter from acceleration patterns were presented in Cornou and Christensen [17]. Firk et al. [18] detected estrus by combining of activity measurements with information about previous estrus cases, this analysis used a fuzzy logic model to detect the results. Later, Zarchi et al. [19] improved the estrus detection by fuzzy logic classification of the alert utilizing the period between estrus.

III. ACCELEROMETER SENSOR AND DATA COLLECTION

To consider the automated system to classify the animal behavior, such systems comprises of server based and embedded devices as shows in Fig. 1. The server based or the main processing element is a center computer that receives data from embedded devices. The embedded device or sensor node will take acceleration data from accelerometer, data from each sensor node corresponds to the 3-axes acceleration values (x, y, and z) captured in a fixed time step and sent these data via wireless transceiver or wireless sensor network to the server for classifying and showing the result of its behavior following by time series plotting. In practical terms, the use of automated system is applied in outdoor environments, ZigBee (IEEE 802.15.4) is a wireless transceiver that is used to communicate between the server center and sensor nodes [10, 11, 20-22].

In practical terms, when measuring the cow behavior, sensor device with containing the accelerometer was fitted around a leg of animal. Fig.2 shows the relationship between the acceleration and the angle of each axis. Please note that, when the animal is standing, the Y and Z-axis is perpendicular to a leg while the X-axis is perpendicular to the ground.

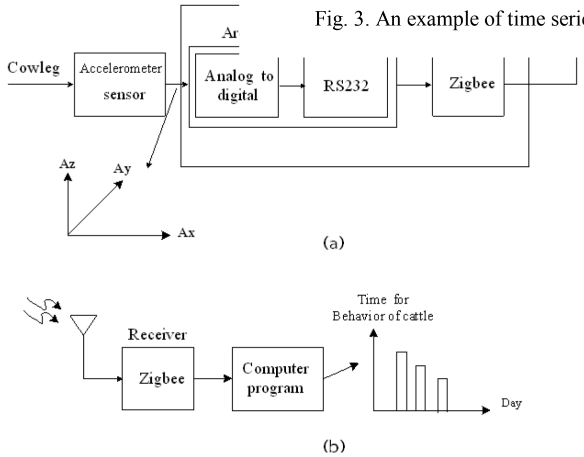

Fig. 1. Block diagram of automated system for classifying the animal behavior: (a) embedded devices (b) server based system

Fig. 2. Accelerometer sensor attached around a leg of cow during testing.

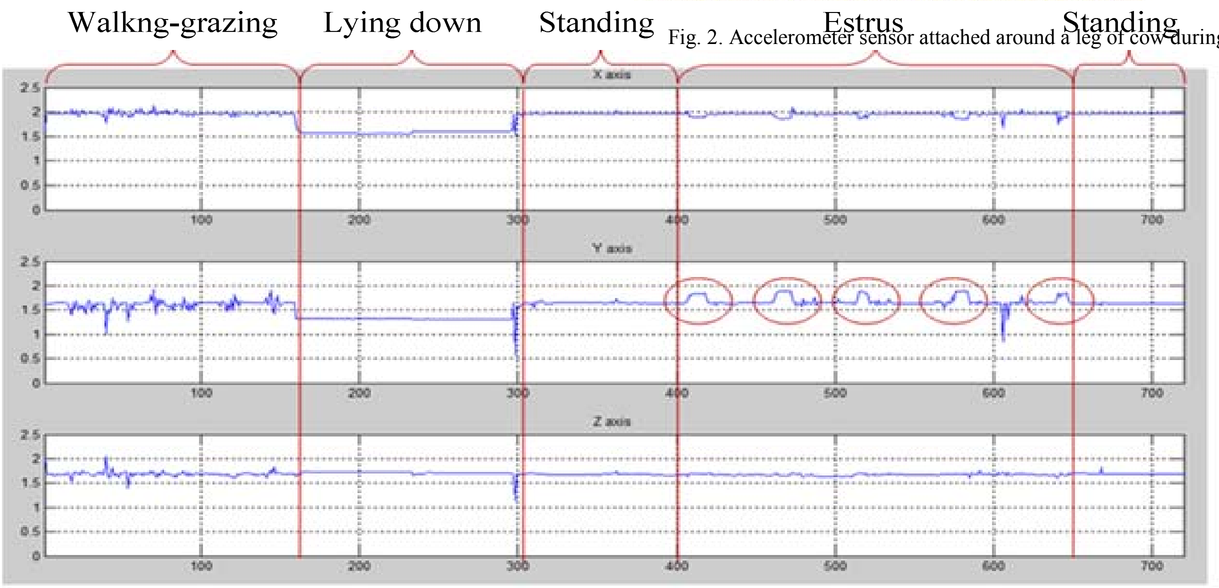

Fig. 3. An example of time series plotting of acce

To collect the raw data of such animal, acceleration data were measured every 1 s (sample rate 1 Hz) in three dimensions using a digital accelerometer. An example of time series of acceleration data can be shown in Fig.3, the graphic represents the 3-axes values (X, Y, and Z) that showed different voltage level of each activity. It can be seen that each activity displays a distinct acceleration pattern.

IV. Modified Technique for Detecting Estrus

According to the classification method to classify the estrus of cow in an outdoor environment, the consecutive acceleration data (60 s) interval were calculated the mean value in each axis and sorting the behavior by comparing with threshold level (mean reference value). To simplify for classification approaches, the mean and variance reference values will be calculated and compare with a set of the current data. The mean reference value (μ_{ref}) of each axis was measured every second approximately in 4 hours, calculated as:

$$\mu_{ref} = \frac{1}{n}\sum_{t=1}^{n} X_t \qquad (1)$$

Where n corresponds to the number of measurements (e.g. n = 14,400), X(*t*) is data measurement at time *t*. The examination of variance reference is calculated as:

$$\sigma_{ref}^{2} = \frac{\sum_{t=1}^{n}\left(X_t - \mu_{ref}\right)^2}{n} \qquad (2)$$

An example of the cow behaviors is given in Fig.3, the figure shows the time series plotting of accelerometer signal (X, Y, and Z). This work classified the dairy cow activity in terms of the variable lying down, standing, walking and looking for the grass, and estrus activity. From the figure, the estrus has occurred when the cow rode piggyback the others. This behavior results the output signal of accelerometer changing. Please note that when the estrus is happening, the output level of standing and walking-grazing behaviors of X and Z axis stay in the same level. However, the Y axis data display as a distinct acceleration pattern. The variation of Y level is higher than the other activities.

To classify the estrus detection, we employ the output level of Y axis data which display a higher level variation as compare which other activities. Therefore, the classification of such activity is considered by comparing with the threshold level of variance reference value of Y axis.

V. Results

To test the success rate of classification of cow behavior, cow was installed wireless sensor node attachment around a leg of cow over 5 days. The acceleration data were measured with a sampling rate at 1 Hz. The results of estrus detection were determined by comparing the percent agreement between manual observation and the proposed classification method. The result was found that the proposed method provides an efficient result as compare to the manual technique.

VI. Conclusions

This paper is attended to detect the estrus behavior of cow in an outdoor environment using acceleration data. The estrus is detected when the cow rides piggyback the other, this behavior results the output signal of accelerometer changing. To classify such activity, the detection employed the threshold level of acceleration data to separate the estrus behavior. Overall, the results of estrus detection show clearly improved performance, this is also a practical way of implementing this technique in outdoor environment with low-cost system.

VII. Future Work

This paper has established simple behavior detection for detecting estrus in dairy cows. The detection was detected when the cow rides piggyback the other. From the results, we may improve the detection by using other methods such as from lying data or other activities. This can be confident that the acceleration data from sensor do not affect overall behaviors and so they are an efficient tool for classifying the behavior of animals. The next work attends to address and improve the new detection algorithms model for detecting dairy cows in estrus.

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