A NOVEL WIRELESS ESTRUS-DETECTION PROBE TECHNOLOGY FOR HEALTH-CARE APPLICATIONS OF COWS AND ITS MEMS SOLUTION

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This paper successfully presents a novel wireless probe, which consists of a micro accelerometer, temperature sensor and ring electrodes, for detecting estrus cycle of cow by in-situ measuring her posture, virginal temperature and resistance. Using the novel wireless probe in a two-week experiment, the estrus time of the cow had been successfully identified. Before the estrus, there are variations of both virginal temperature (~0.4°C) and resistance (~15%). In addition, the origins of noise signals in resistances, which are common and severe issue for similar bio-impedance measurement and low accuracy, had been successfully confirmed by using the novel probe.

1) INTRODUCTION

With the rapidly increasing needs of milk, beef meat and related products, the breeding efficiency of cattle should be improved. Therefore, the artificial insemination technology is playing more and more significant roles in achieving the purpose of high breeding efficiency. As a matter of facts, the detection of the estrus peak and thus the ovulation of each cow, is critical for the success of the artificial insemination, and thus for realizing an effective breeding program. At present, visual observation, heat-mount detectors, chin-ball markers, detector animals and electronic heat detection devices are used for detecting the estrus of cows [1-3]. Among these methods, visual observation has the highest detection efficiency but it strongly depends on personal experiences and skills of farmers. Without enough training for a long time, high detection efficiency could not be realized by the visual observation. Unfortunately, more than half of the heat and ovulation occur within the time of from 18:00 of evening to early morning of next day, the visual observation method is heavy burden for farmers. In addition, the cattle industry is facing the severe problems of rapidly aging population. Since 2010, more than 30% of the farmers are elder than 65 years in Japan. Heat-mount detectors, chin-ball markers and other similar methods are low cost but only be used as support for the visual observation.

Therefore, there have been continuous efforts in developing electronic detection technology [1-6]. For example, it was noticed that the cattle will be restless during the heat. Odometers are used for recording the walking behaviors and the heat could be identified. However, such methods are not suitable for Japan and other countries in which the cattle have limited spaces. They are also subject to environmental factors. Manual probing technologies are developed for measuring the temperature and conductivity. Most of the manual probing technologies are involved of either temperature or conductivity of virginal tissues of the cows. High detection efficiency is successfully achieved and some of them have been already commercialized [6]. Some of them are also integrated with wireless technology. However, as we know, the estrus is an complicated bio-phenomenon so that its determination should be involved of more than only one parameter. Therefore, in this work, we would present a newly-developed wireless probe for the heat detection.

2) SENSOR DESIGN AND EXPERIMENTAL

Figure 1 is photo of the prepared prototype of the wireless probing sensor. Stopper consisted of three ring-type rim. The electrodes are made of titanium and there are two pairs. There is a temperature sensor and accelerometer integrated directly onto the circuit board. Therefore, the sensor prototype could sense temperature and conductivity of the virginal tissue, but also its own position and direction information could be achieved by using the accelerometer, which is important in analyzing the measured data.

Figure 1 Photograph of the wireless probing prototype. The left is the as-prepared circuit boards.

Figure 2 is photography of the cow with the wireless probe prototype inserted. The experiment was lasted for 16 days. The temperature and conductivity data were wireless transferred to a receiver nearby.

Figure 2. Photography of the cow with the wireless probe sensor.

3) RESULTS AND DISCUSSION

Figure 3 are the measured resistance and temperature of the virginal tissue. The virginal temperature shows periodical curves. At the day time, the virginal temperature is higher than that in the night by about 0.4 or 0.5 degree. It was also found that the virginal temperature had varied slightly with the daily behaviors of the cow. For example, during the feeding, the virginal temperature increased slightly, too. The measured resistance varied much, which was not only with the estrus cycle, but also with the environmental factors. Both the resistance and virginal temperature data show that the occurring of ovulation is accompanied with the decreasing resistance and virginal temperature. However, the lowest virginal temperature was before the occurring of the ovulation. It indicated that if the virginal temperature and resistance could be precisely monitored, the estrus and ovulation could be precisely identified and predicted. On the contrary, through the monitoring of only one parameter, the identification of the estrus would...
be difficult and its detection efficiency would be low.

Figure 3 Measured resistance of temperature in virginal.

Figure 4 lists the measured data of the accelerometer and the resistance. The behavior of the cow was successfully identified and the measured resistance strongly depends on it. For example, when the cow stood up, the measured resistance would be higher. It suggested that such variations of the measured resistance are strongly related with the contact between the electrode and the virginal tissue. If the contact is properly kept, such noises could be reduced [7-8].

Figure 4 Measured data of the accelerometer and the corresponding resistance.

4) CONCLUSIONS

In this work, a wireless virginal probe is successfully developed and be proved to be effective for detecting the heat cycle of the cow, which is very important for realizing a high efficiency breeding program. It was also confirmed that the high heat detection efficiency could be expected by using the wireless virginal probing sensor, in which temperature sensor, accelerometer and resistance electrodes are integrated. Noise origins were also successfully identified in this work, and a good and stable contact is required between the virginal probe and tissue. MEMS-based film electrode would be a solution to this problem.

References