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Detection of Milk Fever Based on Real Time Temperature Monitoring in Dairy Cattle Using Neural Network

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***Abstract* - Dairy farming industry is one of the key contributors to our country's economy making India one of the world's largest milk-producing nation. The Indian Dairy Industry engages in the procurement, production, processing, storage and distribution of dairy products like milk, cream, cheese, curd, yoghurt etc. The industry amounts to Rs. One Thousand billion which is approximately equals combined contribution of paddy and wheat. The country's milk is supplied by millions of milk farmers, who are predominantly the rural areas. It employs about nine million people on yearly basis out of which 71% are women. The bovine diseases that affect the livestock affect both the mortality of the animals and the economy of the country. The prognosis of diseases is obtained through physical examination which leads to late detection, treatment, slow recovery and prolonged suffering for the animals. The ill effects of the diseases can be mitigated easily when diagnosed early. It is also not possible for the cattle farmers to constantly monitor their animals. Many monitoring devices for cattle have been designed and implemented in foreign countries but they are expensive and costly when implemented here. All bovine diseases have similar symptoms with variations in their intensity. So, these symptoms can be easily generalized as abnormal behavior of the animal. The one of the main symptoms associated with various bovine diseases is body temperature increase or decrease. These major symptoms are monitored using noninvasive weightless sensor. Based on the values collected by sensors, the abnormality in animals can be detected and notification is sent to the caretaker regarding abnormal cows.**

I.INTRODUCTION

In India one of the world's largest milk-producing nation, dairy industry has been regarded as an instrument for social and economic development since early days. The country's milk is supplied by millions of milk farmers, who are predominantly the rural areas. The industry can be categorized as either producer-owned or professionally managed cooperative system. Despite the fact that the most of dairy farmers are illiterate and hold either small or marginal lands or in some case landless labourers, they together own 70% of the nation's dairy cattle population.

In many cases, dairy farming is the only source of income for many farmers. There are 96,000 local dairy cooperatives formed by 10 million dairy farmers who sell their products to state cooperative milk marketing federations through one of 170 milk producers' cooperative unions.

The main reason behind the establishment of this industry is to manage the national resources for enhancement milk production and upgradation of milk processing using latest technology. The crossbred technology in the industry has instrumented the viability of the dairy units by increasing an animal's milk production. This subsequent milk production at an increased exponential rate has led to a decrease in the price of milk for the consumers without compromising the profits of the dairy farmers. This in turn led to establishment of modern milk and milk product factories. These organized dairy factories have successfully engaged in the routine marketable production of pasteurized bottled milk and other dairy products.

The Indian Dairy Industry engages in the procurement, production, processing, storage and distribution of dairy products like milk, cream, cheese, curd, yoghurt etc. India as nation stands first in its share of dairy production internationally by producing around 100 million Tons of milk. The industry amounts to Rs. One Thousand Billion which is almost equal to combined contribution of paddy and wheat production. India with 1/5th of the world's bovine population mainly consisting of the Milch animals, that is composed of 45% indigenous cattle, 55 % buffaloes, and 10% cross bred cows. The industry employs about 8.47 million people and 71% of the employees are women.

The bovine diseases that affect the livestock affect both the mortality of the animals and the economy of the country. Diseases that commonly affect the dairy cattle are fever, mastitis, milk fever, Tick's disease, Food and Mouth Disease have similar symptoms such as decreased or increased body temperature and lack of food intake.

The main symptom for any cattle disease is body temperature which is monitored using temperature sensor in this paper to detect abnormality in temperature rise or fall thereby leading to identification of milk fever.

II. BACKGROUND

Predominantly in India, the only diagnosis method implemented in the cattle farms involve manual diagnosis of cattle diseases which is mainly tactile. The basic tool used by caretakers is their hands. Since contact between the animals and the caretakers is very brief i.e. only during milking or while herding, the diagnosis of disease is mostly well past the incubation period when the disease could have been easily cured. Mostly no monitoring device is used to check the animal constantly to identify the abnormality. The available diagnostic tools are much costly and are not indigenous. This has led to need for automatic monitoring gadget for animals in current technological environment. Though many such tools have been deployed in foreign nations, that is not the case in India. Many such sensors or tools used are intravenous in nature. The requirement of non-invasive sensor is needed to prevent any complications created by its invasive counterparts.

Gu Jingqiu and et.al [1] have proposed in their paper, image analysis and activities-based cow behavior recognition system. This paper introduces a rapid and accurate identification of cow reproduction and healthy behavior using mass surveillance video observing 400 herd of young cows. Additionally, lactating cows were taken as the research object for analysis of cow's behavior in the dairy activity area and milk hall ramp. The method of object recognition based on image entropy was incorporated for the identification of moving cows in the complex background. By calculating a minimum bounding box and contour mapping, the real-time capture of rutting span behavior and hoof or back characteristics were obtained. Additionally, continuous image characteristics and movement of cows were combined for fast differentiation of abnormal behavior of dairy cows from healthy behavior, thereby improving the identification of characteristics of dairy cows' accuracy. The main objective of this paper was to recognize cow's behavior based on image analysis, activities and also to capture abnormal behavior that has harmful effects on healthy reproduction and secondary objective is to improve cow behavior identification accuracy. Additionally, Hoof and Mouth was diagnosed through this method. Despite this being a continuous monitoring or surveillance system, it is very complex. The cost of implementation of the method is very expensive. It is also very tiresome to constantly monitor about 400 cows in a large grazing field as it requires several cameras and different angle focuses to obtain a precise behavior identification. This method does not single out the sick animal or perform any diagnosis of disease but only the abnormal behavior of the cow.

Y. Lee and et al [2] have proposed in their paper, a body temperature monitoring system using subcutaneously implanted thermo-loggers. The main objective of this experiment is to perform early detection of fever from infectious disease or physiological events. The body temperature was collected from different locations on cattle including rectum, reticulum, milk, subcutis and ear canal. In other to evaluate the temperature stability and reliability of subcutaneous temperature in highly fluctuating field conditions for continuous body temperature monitoring, long term subcutaneous temperature profiles were collected and analyzed from cattle in autumn/winter and summer season by surgically implanted thermo-logger devices. Purposes of this study was to assess subcutaneous temperature in the field condition as a reference body temperature and to determine any location effect of implantation on subcutaneous temperature profile investigated in dairy cows. The experiment was conducted on seven Holstein steers which were housed together in a free stall barn without any heating system which was enclosed with solid fences and roof. Rectal temperature was measured using a digital body thermometer MT-16C2 in summer and winter time. In summer, rectal temperature was measured during day time, 10 times a day at 1-hour intervals for 3 consecutive days, from eight Holstein calves and in winter-three times a day, at 10:30 AM, 1:30 PM, and 4:30 PM, for 4 consecutive days, from eight Holstein steers aged from 3 to 21-month-old. Subcutaneous body temperature was measured using button-shaped digital thermo-loggers which were preset to measure the body temperature at 1-hour intervals and surgically implanted into three different sites around neck area of steers during autumn to winter season and summer. Despite monitoring the body temperatures in different body parts of the cow subcutaneously, no further prognosis of disease was performed.

Bhisham Sharma and Deepika Koundal [3] have documented a study on various wireless sensor network (WSN)-based automatic health monitoring systems for monitoring various diseases of dairy cattle. The main objective of WSN-based intelligent monitoring systems in farm automation is to monitor the health of dairy cattle on regular basis. This monitoring system needs to be installed in local and remote locations of farms that will assist the concerned farmers in monitoring their cattle activities from diverse locations for the whole day. All collected factors from the automated system will be stored in a database. The number of sensors has been considered for measuring core body temperature within a bolus and through anus or ear in various papers that were compared by the authors for the study. In the paper, the authors have further explained about the various components and algorithms that were implemented by other experimenters in their papers. The study explains about various wireless sensors and the microcontrollers that were utilized for various cow health or disease diagnosis or feed monitoring system. This is just a study and only the pros and cons of different wireless data relay systems for cattle was discussed and nothing about the diseases or their prediction methods was proposed.

Abel Alarcón-Salvatierra and et.al (2018) have proposed E-DiagEnf, an ontology-based expert system that diagnoses cattle diseases based on a set of symptoms and provides recommendations for tackling the disease diagnosed. The main goal of this system is to decrease the dependency of farmers on veterinarians to cope with cattle diseases diagnosis and treatment. It is an expert system that relies on Semantic Web technologies for cattle diseases diagnosis. This methodology consists of six phases namely: problem assessment, data and knowledge acquisition, prototype development, complete system development, system evaluation, and integration and maintenance of the system. Though this method prognosis of disease based on symptoms fed by farmers, it might be too late before the farmer notices the symptoms in the animal. This system is also complex to implement.

C. Nusai and et al [5] developed a mobile expert system for disease diagnosis of dairy cow was developed for dairy cow farmers and animal husbandmen in Thailand. The application had both online and offline modes. The mobile expert system was designed to be easy and convenient for usage. In this research a method of disease diagnosis which consisted of disease screening step and disease diagnosis step was proposed. It establishes a novel model of knowledge representation for inference using gender, age range and significant weight of symptom for disease screening and established the model of uncertain knowledge representation for inference using the significant weight of symptom and the certainty factor of symptom occurred for disease diagnosis. From accuracy measurement results of the disease diagnosis by our expert system, which was compared with the veterinarian, it was found that our expert system provided the accuracy of 93.56 %. And the evaluation result of system user satisfaction with Likert-scale by dairy cow farmers and animal husbandmen were 4.80 and 4.65 respectively. The system method used to obtain all symptoms completely which resulted in accurate disease diagnosis. Such as providing the symptom description and images caused the users specified the certainty factor of symptom accurately and questioning additional symptoms of possible disease. Our mobile application has high efficiency and the application usage is easy and convenient. This method requires someone to monitor the cows and feed the symptoms to the system. It is not an automatic diagnosis tool and early detection is almost impossible here.

III. METHODOLOGY

The main symptom of cows' illness can be identified by monitoring body temperature. Any discrepancy in the temperatures i.e. any increase or decrease can be regarded as an abnormality in the animal. The proposed work consists of two main modules. They are data collection module and fever detection module. These modules are responsible of collection of data through sensors from animals and then predicting milk fever based on collected data.

Data Collection Module: The main signs of abnormality in cattle are temperature increase and decrease from normal range. This sign is monitored using temperature sensor. The data collected from the sensor is then sent to Database along with cow's Identification number (ID) for pinpointing the sick animal during diagnosis.

Fever diagnosis Module: It is nothing but a Recurrent Neural Network which constantly monitors the incoming data from sensors to identify any abnormalities in the temperature.

The experiment was conducted in a farm in in India from 3 months. Since all the cows in the farm were sent out for grazing, the feeding schedule was not scheduled. During the experimentation, the cows did not experience any discomfort as the components were affixed to the pre-existing rope tied around the animals, so that it can be steered or caught easily by the milkmen or caretakers. The animals also did not show any allergic reaction to the kit or device placed on it.

1.DATA COLLECTION MODULE

The Data collection or device module is affixed to the cow to monitor the major symptoms that are signs of abnormalities in the animal. The device has constant internet access which in turn aids in insertion of data directly into the remote database. The database has a unique access privileges which allows only the permitted devices to insert the data based on IP Address. Whenever the temperature data is obtained from the sensors, the microcontroller initiates data insertion in the database. The inserted data consists of cow's Unique Identification Number, temperature of body as recorded by the temperature sensor. This helps in easy diagnosis of disease as well as quick identification of sick animal. The sensor is placed near the ear canal of the animal while the microcontroller is placed near the neck to monitor body temperature. It continuously feeds the data into database for every 10 seconds. The grazing ground was within the Wi-Fi range hence data collection was possible.

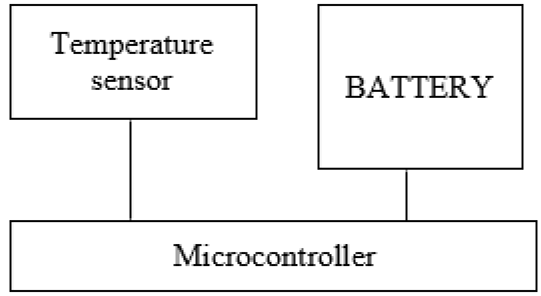

Figure 1. Device on animal

Figure 1 is the block diagram of the device module. The temperature sensor, microcontroller and battery are connected. The temperature sensor is connected to the microcontroller which in turn is powered by the battery. As soon as the sensor captures the temperature data, the data is transferred to the microcontroller. The data uploaded in the server consists of three parameters. They are

- Cow's Identification number.
- Body temperature of cow
- Data arrival time and date

These parameters will be then fed to fever detection module.

2.FEVER DIAGNOSIS MODULE

The Fever Diagnosis Module is nothing but a Recurrent Neural Network (RNN) which performs two different classifications to identify fever animals. The Neural Network utilises Long Short-Term Memory (LSTM) to learn and differentiate abnormal temperature from normal ones. Since it is a Neural Network initially the neurons are trained using known possible values and then the data from remote database is feed to neurons for classification based on gathered knowledge.

Abnormality detection Algorithm

In this classification, the abnormal temperature rises or rapid increase/decrease in body temperature is identified from stable body temperature recorded in the database. In this the training sample dataset will remain same for all the different testing sample. The raw data will be sent to train neurons to classify the data as normal or abnormal. The cows that have abnormal temperature is further scrutinized for diagnosis of milk fever based on decrease. Finally, after the classification and diagnosis, the healthy animal's ID and milk fever affected animal's ID is obtained. The sick animal's ID is then sent as text message to the cattle caretaker. As the caretaker will attend to the animal immediately for the illness that can be restricted from further deterioration.

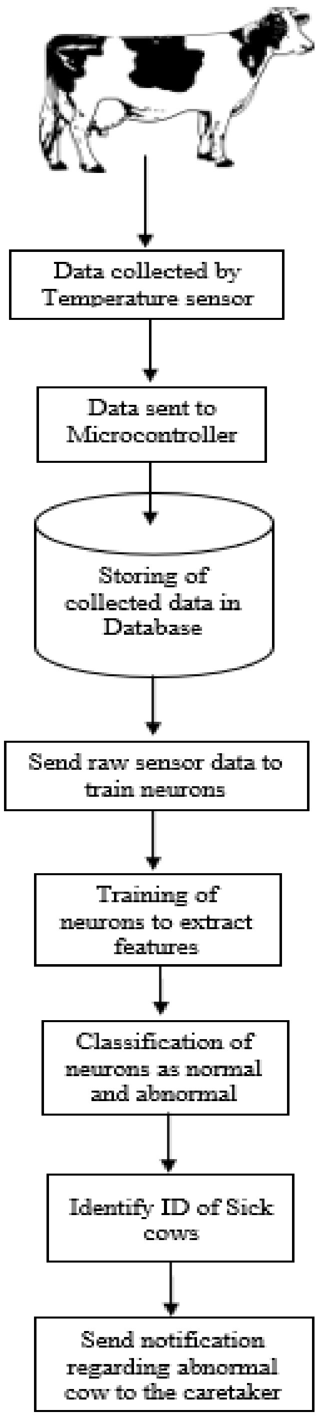

Figure 2. Flow Diagram of Abnormality detection in dairy cattle

IV. RESULTS

The sensor was affixed to ear canal of the animal to monitor temperature and the microcontroller was fastened to the neck of the animal. The average temperature observed was 38.460C. This device sends data to server through Wi-Fi. This data is then monitored using abnormality detection algorithm. The temperature range for normal cow is 380C to 39.5 0C and the temperature range for abnormal cow is 39.50C to 42 0C but for milk fever infected cow the temperature is less than 38 0C. The body temperature was different for normal, abnormal and milk fever infected cows.

Table 1. Observed Conditions for normal and abnormal cows

As we know that, worldwide trade of India become growing and also growing in term of population so that, the major challenging issues of India is waste management, according to analysis India generate the waste 62 million tonnes including recyclable and non-recyclable in every year that means waste generated per person per day average 0.75 kilogram.

Condition	State
38^0C	Normal
37^0C	Milk Fever
39^0C	Normal
41^0C	Abnormal
38.6^0C	Normal
42^0C	Abnormal

The accuracy of the abnormality detection algorithm is 98%.

V. DISCUSSION

In this experiment, the rapid increase in temperature was distinguished easily. The discrepancy in body temperature helps in ascertaining the disease in animal This observation was carried out over a period of 3 months. During this experiment carried out on 4 cows, 8 abnormalities were observed, which led to early diagnosis of 5 cases of fever,2 cases of mastitis and 1 case of milk fever. An alert was given to caretaker regarding cow's plight. After the caretaker attended the animal, it became evident that the cow was indeed suffering from an underlying disease.

VI. CONCLUSION AND FUTURE WORKS

Milk fever infected cows and abnormal cows can be easily identified using real time temperature monitoring based on neural network. Due to early detection of abnormality in this tool earlier treatment and recovery has been made possible leading to less to no loss of milk production. As the tool enhances early detection it also aids in avoiding spread of ailment to other animals in the same shed. It is not possible for cattle herders to constantly monitor their livestock, but this tool can persistently observe their herd. In large scale dairy farms, this device can be implemented to check the vitals of the animals and be monitored through the centralized server. This device is also cheap, non-invasive, and light in weight. The device can be extended for diagnosis of other animal diseases

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