Abnormality Detection In Dairy Cattle Using Real Time Temperature, Rumination Monitoring and 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 suppliedby 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 main symptoms associated with various bovine diseases are body temperature increase or decrease and lack of rumination. These major symptoms are monitored using noninvasive weightless sensors. 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.

Due to no food consumption the animal does not perform any rumination or chewing of cud. These symptoms are monitored using sensors in this paper to detect abnormality which can easily lead to identification of disease.

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 incorporatedfor the identification of moving cowsin 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 but only the abnormal behavior of the cow.

L.Kovács and et.al [2] have proposed in their paper, a short communication-based behavior monitoring system while the dairy cows are being milked. The main objective of this experiment is to identify the stress experienced by dairy cows while they are being milked using a Rotating Milk Stall (RMS). A high-capacity rotary milking system was used to study animals' stress responses to the milking process. Parameters such asstep behavior and variation in heart rate and rumination were monitored. The animals under study were adapted to the 72-stall RMS operated on the farm. A high-frequency (HF) component where the ratio of the low-frequency (LF) and HF components (LF/HF ratio) was used to monitor the heart rate variations while the cows were milked. Additionally, rumination behavior during milking was also investigated in dairy cows.These cardiac parameters were analyzed while the animal was milked in morning, afternoon, and evening milking processes in undisturbed standing (baseline) and in various the stages of like driving animals from the barn to the pre-milking holding pen, preparation of milk, milking, and waiting after milking in the milking stall. Polar Equine T56Hmobile recording system was used for recording Heart rate.Based on observations, the authors have noted that heart rate was greater during driving of animals than all other stages. After driving, a gradual decrease in HR was observed by them. A general linear model was used for calculating the difference in stepping frequency duringpreparation, milking, and waiting phases.The cow's behavior like rumination and stepping were observed manually by four spectators during the entire experimentation phase and the stalls were under surveillance. Though heart rate was recorded using a monitoring system, other constraints like rumination and stepping were recorded manually. The authors concluded that due to reduced rumination during milking in holding pen was not because of RMS but due to lack of relief in stalls. So, stalls must be less stressful for animals and must have several comforting aspects. This method is nearly manual, hence it requires man power. Furthermore, abnormality is observed only during certain intervals.

A. Poursaberiand et.al [3] have introduced a technique utilizing image analysis techniques for early lameness detection in dairy cattle. Data for the technique was gathered from two different dairy in Belguim. The database utilized consisted ofvideos from 28 lactating Holstein cows. These recordings were made when the cows passed a corridor while walking from the barn to the pasture ground.In the

paper, the authors have further explained about the need for preprocessing on raw due to non-predictable behavior of cows like stopping for a while in front of the camera or non-uniform walking behaviorwhile passing the corridors. Pinpointing location of cow in each frame of video is obtained usingbackground subtraction and statistical analysis of intensities in gray-scale image along with binarization. To track a cow across the video, a hierarchy background/foreground exaggeration was proposed. To find the accurate shape of the cow a combination of logarithm, exponential, background subtraction and statistical filtering were implemented. The status of lameness is based on curvature value which is calculated by detecting the arc of back posture and fitting a circle through selected points on the spine line. The authors have proposed a scoring method in which cows that did not exhibit any signs of lameness where were given score "1" whereas any presence of lameness was scored 2 or 3 based on the severity of lameness. Though this method classifies lameness and abnormal movements from normal behavior, it does not identify the individual cow. The system is also complex to implement.

A.Zambelis and et.al [4] have developed two scoring systems for measurement of extent of abnormal risingand lying-down behavior in dairy cows, and for assessment of the relation between the behaviors and the corresponding illness the animal is suffering from. For this study, forty-eight lactating Holstein cows were randomly selected. The tie stall were the cows were housed was installed with video cameras. The cows were monitored using the cameras for a duration of 24 hours for 10 consecutive weeks. In the first 3 weeks a observer constantly monitored the rising and lying down activities of the cows. The authors have set parameters forrisingbased on past observations like duration of rising in seconds, various attempts at rising, contact with environment either presence or absence, carpal joint's backward movement on, delayed rising, and horse rising. Similarly, for lying down parameters have been set such as duration of intention movements in seconds, duration of lying-down in seconds, attempts at lying-down, contact with environment either presence or absence,hindquarters shifting, slipping, and dog-sitting. Based on above parameters for rising and lying down, an event classifier calculates normality and abnormality. The classifier then categorizes each rising and lying-down event as normal which is scored 0 or abnormal which is scored 1, based on the presence of at least one abnormal behavior. The authors have stated that lying time is major parameter in abnormality i.e. greater the lying time or immobile the cow, the more abnormal it is. Additionally, multivariate mixed models were used to evaluate the relationship between each behavior with other parameters of rising and lying-down. The authors have identified a subset of the behaviors that was positively associated with injury severity and body size, and negatively associated with lying time. These scoring methods have also been used for identification of disease based on abnormality score. The probabilistic model despite being simple can also be misconstrued.

III. METHODOLOGY

The main symptoms of cows' illness can be identified by monitoring body temperature and chewing of cud movements. Any discrepancy in the temperatures or lack of movements in jaw can be regarded as an abnormality in the animal. The proposed work consists of two main modules. They are data collection module and abnormality detection module. These modules are responsible of collection of data through sensors from animals and then predicting abnormality based on collected data.

Data Collection Module: The main signs of abnormalityin cattle are temperature increase and lack of rumination. These signs are monitored using temperature sensor and accelerometer sensor. The data collected from the sensors are then sent to Database along with cow's Identification number (ID) for pinpointing the sick animal during diagnosis.

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

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 is 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 and rumination data are 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 and rumination in x, y, z dimensions as recorded by the accelerometer sensor. This helps in easy diagnosis of disease as well as quick identification of sick animal. The device is placed near jaw bone of the animal to monitor chewing of cud and 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.

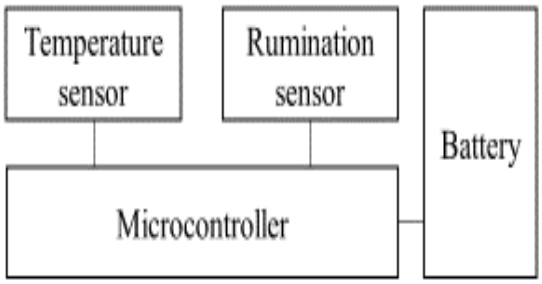

Figure 1. Device on animal

Figure 1 is the block diagram of the device module. The temperature sensor, rumination sensor, microcontroller and battery are connected. The sensors are connected to the microcontroller which in turn is powered by the battery. As soon as the sensors capture the monitoring data like jaw movement and temperature, the data is transferred to the microcontroller. The data uploaded in the server consists of four parameters. They are

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

These parameters will be then fed to abnormality detection module.

2. ABNORMALITY DETECTIONMODULE

The abnormality detection Module is nothing but a Recurrent Neural Network (RNN) which performs two different classifications to identify abnormal animals. The Neural Network utilises Long Short Term Memory (LSTM) to learn and differentiate abnormal animals 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.

Animal Abnormality Classification Algorithm

In this classification, the abnormal animals are segregated from normal animals based on their body temperature and rumination 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 behaviour. The cows will be classified as normally or abnormally behaving cows. Finally, after the classification, the normal animal's ID and abnormal animal's ID is obtained. The abnormal animal's ID is then sent as text message to the cattle caretaker. As the caretaker will attend to the animal immediately any underlying illness can be restricted from further worsening.

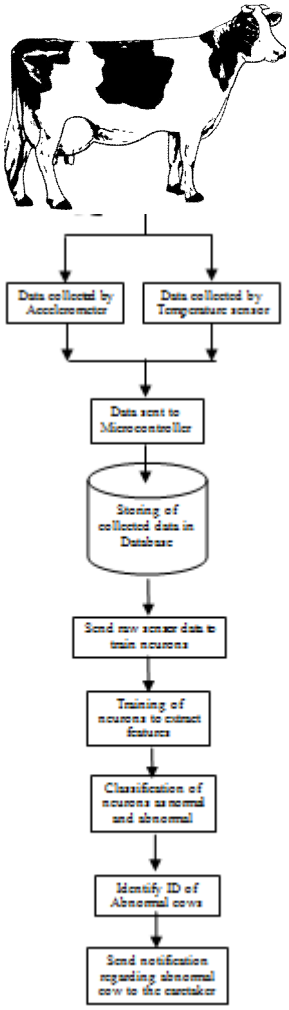

Figure 3. Flow Diagram of Abnormality detection in dairy cattle

IV. RESULTS

The device was affixed to jaw of the animal to monitor temperature and jaw movement. 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 rumination range for normal cow is 4 -16 g where g is measure of acceleration using accelerometer and anything from -16g to 3 g is the range of rumination for abnormal cow. Similarly, temperature range

for normal cow is 38^0C to 39.5^0C and the temperature range for abnormal cow is 39.5^0C to 42^0C. The body temperature and rumination were different for normal and abnormal cows.

Table 1. Observed Conditions for normal and abnormal cows

Condition	State
38°C and 4g	Normal
37°C and -3g	Abnormal
39°C and 11g	Normal
41°C and 1g	Abnormal
38.6°C and 11g	Normal
42°C and -6g	Abnormal

The accuracy of the abnormality detection algorithm is 98%.

V. DISCUSSION

In this experiment, the rapid increase in temperature and lack of chewing was distinguished easily. The discrepancy in body temperature and chewing of cud helps in ascertaining the disease in animalThis 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 3 cases of fever,4 cases of mastitis and 1 case of FMD. 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

Abnormal cows can be easily identified using abnormality detection using real time temperature and rumination monitoring. 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 animal diseases

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