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FMD and Mastitis Disease Detection in Cows Using Internet of Things (IOT)

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Abstract

The Dairy Industry is one of the fastest-growing industries in the world. With an increase in milk production in the world, there is an increase in the number of cattle's too. One of the major challenges which are faced by the Agriculture and Dairy industry is the healthcare of cattle. Dairy alone cannot be responsible for the health monitoring of various cattle; therefore, farmers need to step up and contribute by taking care of their cattle. South Asian countries like India, Sri Lanka, Bangladesh, Nepal, Bhutan etc. where cattle is majorly being infected by various diseases like FMD (Foot and mouth Disease) and Mastitis which may lead to profuse problems like decrease in the quantity and quality of milk in cows, infertility in cows which causes a lot of economic loss. FMD (Foot and Mouth Disease) is a Virus spread disease, whereas Mastitis is a bacterial disease. The main aspect of the paper will reflect on the detection of FMD and Mastitis Disease in cows using the Internet of Things (IoT). To execute this task, different sensors are used to delineate various parameters in animals like Temperature, Motion, Sound, etc. Micro-Controller and Machine Learning Algorithm (Neural Networks) will also be used for the detection of these diseases.

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1. Introduction

According to Food and Agriculture Organization (FAO), the per capita consumption of milk per country is

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increasing day by day [1]. Consequently, dairy industries are required to keep up with the demands of the ever-increasing population consistently [2]. South Asian countries like India, Bangladesh, Bhutan etc. where the community is on the rise, dairies are promoting farmers to implement artificial insemination for increasing the number of cattle[3]. This has led to farmers being less careful towards their cattle's health. This flawed approach has overgrown to promote diseases FMD and Mastitis in cows and buffaloes.

FMD (Foot and Mouth Disease) spreads danger to cattle in many developing countries [4]. It is a viral outbreak, which can lead to symptoms like Fever, Blisters in mouth and feet, Lameness, and so forth. If FMD is not treated in time, it reduces the efficiency of the cattle by leaving them weakened and reduces the milk-producing capability. Meaning, the infected animals cannot be brought back to its original ability of giving milk. FMD spreads when cattle drink contaminated water when kept in contaminated facilities [5]. Once the infection kicks in, FMD generally starts appearing between 3-6 days.

Mastitis is puffiness of the mammary gland and swelling of the udder [6]. "As per estimates referred in ICAR's National Agricultural Innovation Project, the annual loss due to mastitis was around Rs16,702 million"[7]. This disease reduces the milk giving a capacity of cows. Mastitis is caused by a bacterial infection in the udder tissue of the cow. One of the reasons how it is propagated is when an improper method is employed to milk the cows. In developing countries, it is difficult for a farmer to implement farm automation. Therefore, they generally milk the cow with their hands. This method comes with the risk of an unhygienic environment for the activity as the farmer's hands might be carrying pathogens (virus/bacteria) which could get the cow's udders infected[8]. This infection in the mammary gland of the cow causes Mastitis. It is also generated if the hygiene conditions of the particular farms are not within appropriate standards. In overpopulated countries, farmers might not have the privilege to provide cattle with significant grazing lands, so most of the bulls are tied and fed at stationary locations. Since cows are related, they excrete at the same place, and if these excreta are not cleaned in proper time, it will lead to the development of pathogens, causing diseases like Mastitis. Because of Mastitis, the quality of milk is deteriorated, which in turn leads to an increase in the processing cost of milk for the dairy. This is one of the major problems which is being faced by all the developing and developed countries.

There are three stages in which Mastitis can be detected: -

- **Clinical Mastitis:** Farmer can have some hint that cattle might be infected as in this case there occur clots in milk/Flakes, the udder may swell a bit, the temperature increases, more decrease in milk production[9],
- **Sub Clinical Mastitis:** -Farmer cannot predict this case as the cow shows very fewer symptoms like gradual rise in temperature, increase in Somatic cell count (SSC) in the milk, Decrease in Milk production. Cows start averting food [10].
- **Contagious Mastitis:** It is the extreme condition of Mastitis where the swelling of the udder is in its peak, Rapid reduction in the quantity of milk. Somatic cell counts are more than 300,000 Cells/ml [11].

2. Components

After studying the cattle behaviour, there are various parameters which can be selected and used to monitor the health conditions of cows/buffaloes. The sensors are Rumination Sensors, Temperature Sensor and motion sensors: -

Rumination Sensor: This type of sensor has a microphone, and the data generated from the sensor will be sent to the cloud through the Controller over the same network. This sensor is tied on the neck of the cows/buffalo because whenever the rumination process will start the sensor can generate data quickly [12].

Motion Sensor: This type of sensor measures the three-dimensional motion of the cattle. This will help in analysing the movement of the cow and will help to discriminate whether the cow is infected or not based upon its average daily motion. This sensor can be clubbed with the rumination sensor and can be fitted on the neck or the leg of the cow to measure the desired motion of the cow [13].

Temperature Sensor: Increase in Temperature will help us to judge whether any disease is infecting the animal or not. Therefore, this type of sensor is used to sense the body temperature of the cattle, since cattle have furs one cannot achieve a proper body temperature, for that one needs to measure the vaginal temperature which gives us the most accurate temperature. The data from this sensor will be sent to the cloud and can be analysed [14] [15].

Raspberry Pi 3 controller: It is a small computer with, memory card where one can store data if required, Ethernet port, Wi-Fi module so that connection of sensors to the Micro-Processor and then to the cloud becomes easy. Availability of HDMI port and USB helps it to connect with Monitor and Keyboard. It is simple to use and is productively efficient. Using Pi sending of information to the cloud will become easier [16].

3. Approach

As we know the types of diseases and their symptoms, we can select some parameters on which we can go about with our approach. The parameters that are chosen are Temperature, Rumination sound and Motion because the parameter selected have specified sensors available and can be used appropriately.

The process will start from placing the sensors to their respective positions; once the sensors are connected to Raspberry Pi on the same network, we can start transferring data to the cloud. The standard body temperature of the cow is 38.5°C, and that of Buffalo is 38.2°C. The body temperatures of the given cattle will be dependent on ambient temperatures, type of breed and other external conditions too. The maximum temperature of the cow can go up to 105°F after which there may be fatal. Similarly, by plotting the values of the motion sensor and Rumination Sensors, we can find out the abnormal behaviour of the cows.



Fig.1. (a) and (b) shows the infected mammary gland of female cattle suffering from Mastitis disease.

3.1. Flow Chart

The Flowchart shown in figure explains the process of automatic detection of Mastitis and FMD disease in cattle through IOT based technique.

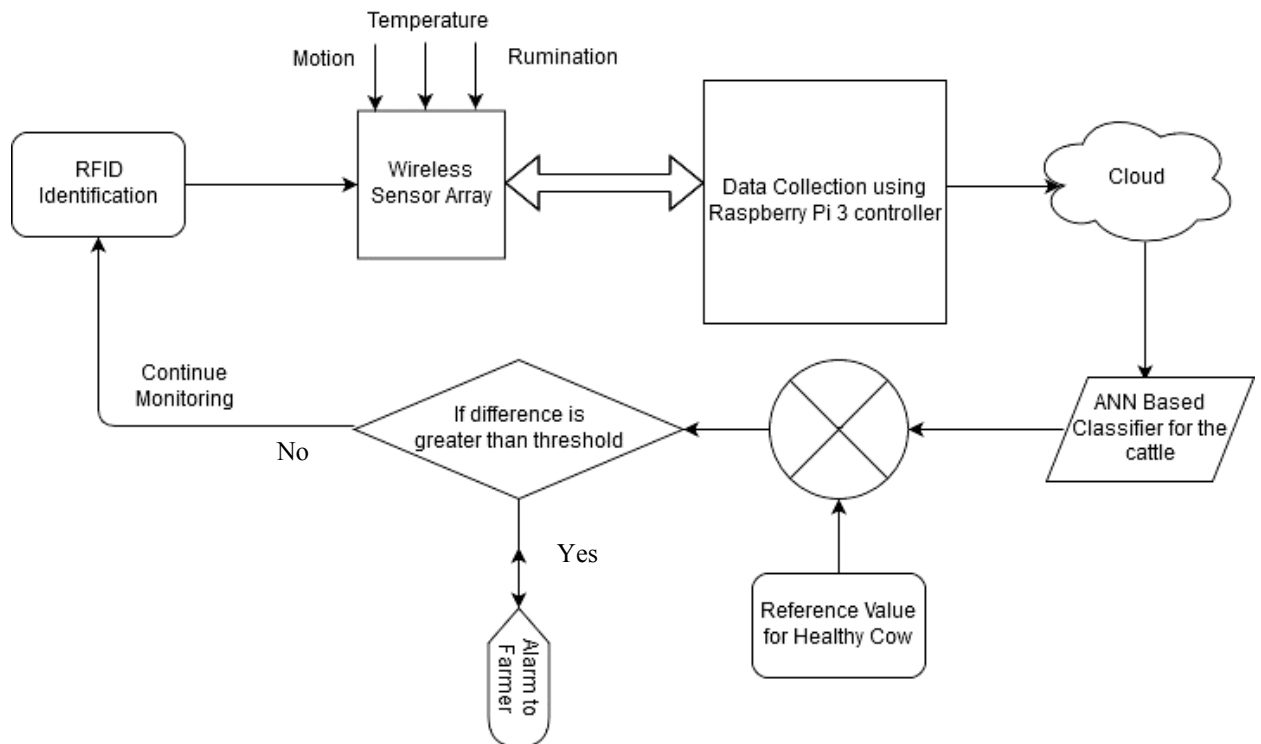


Fig.2. shows the flowchart of the proposed model.

Radio Frequency Identification (RFID) tagging helps in the identification of cow. Wireless sensor array is an array of sensors (Motion, Rumination and Temperature) which is mounted on the cow and communicate with the raspberry pi to send data to it. Raspberry pi is used to send data which is received from the sensors to the cloud. Cloud is used to store large amount of data. Artificial Neural Networks (ANN) based classifiers and reference data of a healthy cow is used for the comparison.

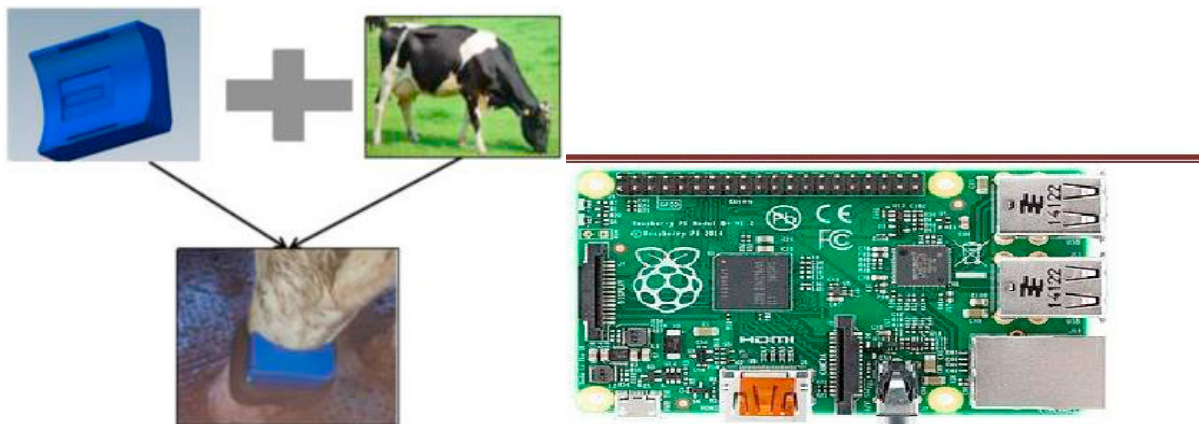


Fig. 3. (a) Temperature Sensor, Kou, H., Zhao, Y., Ren, K., Chen, X., Lu, Y., & Wang, D., *PLOS ONE*, 12(4), e0175377. doi: 10.1371/journal.pone.0175377; (b) Raspberry Pi 3

Fig.3. (a). Shows the use of temperature sensor on the cow. In the flow chart, when the process starts, there is an RFID tagging done to every cattle. This tagging helps in the unique identification of the animal. The data collected from an array of Wireless sensors having three sensors (Temperature, Rumination and Motion) are mounted on a single board and is sent to Raspberry Pi which then sends the data onto the cloud. After that, data passes through the Artificial Neural Network (ANN) Classifier, which is compared with the Reference data of a healthy cow. This generates an error and if the error created is higher than the threshold limit a message will be given to the farmer that something might be wrong with the cow and the veterinary should be called as soon as possible it. One can also plot the respective parameters and then predict using the same NN algorithm in such a way that if the cow which took seven days to show the exact symptoms can be reduced to 3-4 days just by observing the trends of the parameters used. This will help in the reduction of sickness in cows.

4. Conclusion

The future expansion of the proposed model can be done by actual implementation of the above model by using hardware which are sensors and controller and then monitoring the real time data to find the disease. The proposal of using the Internet of Things (IoT) in the detection of Mastitis and FMD will have a significant impact on the reduction of these diseases because of the use of Neural Networks and smart sensors. This will reduce the lousy quality of milk produced in the cows, which in turn will reduce the processing cost of dairies, thus benefiting the Agriculture and Dairy Industries in various economical ways. If the proposed implementation is done in a sophisticated manner, the efficiency of milking cows will not be decreased, and the chances of infertility among the cows will be reduced thus will reduce the burden of the cost of healthcare of cattle which is developed on the shoulders of farmers. The proposed paper will bring social and economic change in the Agriculture and Dairy Sector.

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