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IOT and AI Based Smart Cattle Health Monitoring

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Abstract

Cattle health monitoring is essential in the modern world, because of the high demand for dairy products. Regular monitoring is essential to extend the lifecycle of cattle and maintain the quality of dairy products. Unfortunately, observing the health of cattle regularly is difficult in large farms where workers do not have enough time to do so. This paper described IOT devices such as skin temperature, heart rate, and motion sensor. Using this device, you can monitor cattle's heart rate, activity level, heat stress, the surrounding temperature, and sleep tracking. The IOT system is integrated with the cloud. A machine learning algorithm predicts the health status of cattle based on the sensor's real time data, observing the real time health status will alert the user if cattle suffer from a health issue, and a mobile app is developed to observe data visualization. Cattle health monitoring systems are designed to monitor the health of individual cattle and quickly diagnose and treat sick cattle.

Keyword: Cattle health monitoring • IOT device • Cloud system • Mobile app • Machine learning

Introduction

Animal husbandry refers to the management and care of domestic animals, such as cattle, pigs, chickens, and sheep, for the motive of producing food, fiber, and other products. Animal husbandry involves a wide range of activities, including breeding, feeding, housing, and healthcare, all aimed at improving the productivity, health, and welfare of the animals.

The goals of animal husbandry are to increase the quantity and quality of animal products, such as milk, eggs, and wool, while also ensuring the welfare and health of the animals. Animal husbandry practices may vary depending on the species of animal and the specific purpose for which it is being increased, such as for dairy production, etc.

Here we specifically researched on cattle husbandry "dairy cattle", dairy cattle are the most efficient of all farm livestock to provide protein and it is essential to keep dairy cows in good condition in order to ensure that the dairy products, such as milk, are of high quality.

The health of cattle is one of the most significant aspects that impact dairy cow productivity. Here are some key aspects of healthcare for dairy cattle:

Nutrition: Providing a balanced and sufficient diet is critical for the health of dairy cattle. The diet should include a mix of roughage and concentrate, along with clean and fresh water. A nutritionist can help to formulate a balanced diet based on the cow's nutritional needs.

Housing: Dairy cattle should be housed in a clean, dry, and well-ventilated environment. Overcrowding and poor ventilation can lead to respiratory diseases, while damp and dirty conditions can cause foot and udder problems.

Vaccinations: Vaccines are available for a number of diseases that affect dairy cattle, including bovine viral diarrhea, infectious bovine rhinotracheitis, and leptospirosis.

Parasite control: Parasites can cause a range of health problems in dairy cattle, including weight loss, anemia, and decreased milk production.

Reproductive management: Proper reproductive management is essential for maintaining the fertility of dairy cattle. This may include artificial insemination, pregnancy diagnosis, and management of calving.

Regular health checks: Regular health examinations can help to recognize health problems early before they become more serious.

By monitoring the health of cattle, farmers can take preventive measures such as administering vaccines, adjusting feed and nutrition, and providing appropriate treatments in a timely manner.

Cattle health monitoring is important for several reasons. First, it helps to ensure the welfare of the animals by identifying and treating any health issues as quickly as possible. Second, it assists in preventing diseases and parasites among animals, which can be costly and harmful to both the animals and the farmers who care for them.

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IOT devices are utilized to monitor the well-being of cattle, benefits of using IOT devices for cattle health monitoring include improved animal welfare, reduced healthcare costs, and increased productivity,

Literature Review

There is several existing cattle health monitoring systems that have been developed to monitor the health of cattle.

- Their research consists "live care", the IOT-based framework that automatically monitors the health of cows in a large cow farm. It tracks the health of cows by using IOT devices such as temperature sensor, accelerometers, heart rate sensor, saliva sensor, gas sensor, and microphone, to monitor on a daily basis, their research Cow Disease Prediction (CDP) algorithm, which is an unsupervised multi-class classifier that serves as the live care framework's central component. The CDP algorithm gets 100% and κ-means 98% accuracy, CDP algorithm is used to predict more cow diseases accurately such as certain health issues like fever, cyst, mastitis, pneumonia, black quarter, foot and mouth disease, etc. [1].
- Their research consists of a custom designed multi-sensor board to record several physiological parameters including skin temperature, heart rate, and rumination w.r.t surrounding temperature, humidity, and a camera for image analysis to identify different behavioral patterns, where data analytics will be performed using Machine Learning (ML) models to detect sick animals [2].
- Their research consists of data walking and scraping of the cow sent to collect on the server and report to the user known the cow's healthy by relating to the behavior. The purpose of the device helps to monitor cow behaviors and it can predict illness [3].
- Their research consists of collecting data from temperature sensors, heart rate sensors, and inertial measurement units mounted on the neck of a dairy cow. The collected data is stored and classified using machine learning to produce normal, less normal, and abnormal health classification outputs [4].
- Their research consists of "monitor" is an integration of a temperature sensor, GPS module, and a 3-axis accelerometer, transmission of data to an IOT server, After acquiring the necessary sensory information, the most significant features were strategically extracted for enhanced data interpretation. ML is used specifically on a 3-axis accelerometer. Thereafter, optimally tuned (XG Boost) and random forests classifiers were implemented to classify activities like 'standing', 'lying', 'standing and ruminating', 'lying and ruminating', 'walking', and 'walking and grazing'. XG boost accuracy ~97%, on the other hand, an optimally tuned random forest classifier demonstrated an accuracy of 94.21% [5].
- Their research consists to develop a dairy cow health management system, from health monitoring to the detection of cows that have been affected by the disease. We combine monitoring systems and detection systems into one application utilizing the IOT and intelligent system technology. The monitoring system processes the temperature and heart rate data of cows from the sensor, and then gives results of a cow's health condition, normal or abnormal. Their experiment on intelligent system used decision tree with 90% accuracy [6].

Further, to prolong the lifecycle of cattle and sustain the quality of dairy products, regular monitoring of cattle' health is essential. And the problem is, unfortunately, day-to-day monitoring of cattle's health is difficult, specifically in large farms where workers do not have sufficient time to observe the animals' health physically. This paper investigates the existing based technology and provides a comparison of the features offered by these systems and their limitations. This is the main motivation behind this paper to analyze the different research methods concerning cattle health monitoring and present a solution that will monitor the cattle in real time with the help of IOT along with ML and cloud based technology, and bring some new features. This paper presents the Following IOT sensors that can be considered to analyze cattle's health.

- Skin temperature sensor.
- Heart rate sensor.
- Motion sensor.

Purpose idea

In this study, we developed a new general health monitoring system for dairy cows, this paper investigates the existing research methods and those research methods where some are only IOT based, some are only ML base and some are IOT along with ML and the majority of research method uses 3 main IOT devices:

- Skin temperature.
- Heart rate.
- Accelerometer in our experiment also used this sensor.

Which was already mentioned? This IOT device can provide valuable insights into our system such as heart rate, activity monitoring, heat stress, the surrounding temperature, and sleep tracking, heat stress, and sleep tracking is the idea that we came up with as a new feature in general health monitoring of cows. And where AI is used to predict the status of cattle's health, continuously observing the real time health status will alert the user if cattle suffer from a health issue, and a mobile app is developed to observe data visualization

Monitoring system

Figure 1 show, the first section is about IOT devices; IOT devices such as skin temperature, heart rate, and accelerometer, these devices allow you to monitor the health of cows by these five parameters.

- Heart rate.
- Activity level.
- Heat stress.
- Surrounding temperature.
- Sleep tracking.

Monitor heartbeats: Heart rate is measured by pulse sensor, and the reading from a pulse sensor is provided as digital data in "BPM" format.

Monitor activity level: Activity level is measured by (MPU6050) sensor and the reading from an MPU6050 sensor is provided as digital data in the "X", "Y", and "Z" axis.

Monitor heat stress: Heat stress is measured by (MLX90614) sensor and the reading from an MLX90614 sensor is provided as digital data in the degree of Celsius. As well as this sensor provides humidity around cattle.

Monitor sleep tracking: Sleep tracking is tracked with the support of a pulse sensor along with activity level.

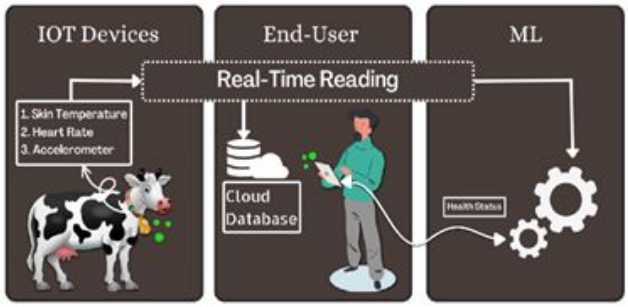

Figure 1. Shows, our experiment's proposed system included both monitoring and intelligent systems, a monitoring system used IOT sensors, and intelligent systems used machine learning.

Mobile app and firebase cloud

Figure 1 shows, the second section is about the end-user, end-user can access the mobile app for data visualization, mobile apps are often used for IOT (Internet of Things) devices because they offer a simple user interface for managing and interacting with IOT (Internet of Things) devices

Mobile app retrieved data from real time firebase cloud. Firebase real time database, easy to create and manage IOT applications that require real time data synchronization,

Machine learning

Figure 1 shows, the third section is machine learning, machine learning is used in "AI healthcare" i.e. cattle's overall health, and "air healthcare" is to predict cattle's overall health status. The status is displayed on the mobile app.

To predict "air healthcare" *i.e.* cattle's overall health, the random forest algorithm is used to train the model (Table 1).

S. no.	Status of activity monitoring	Definition
1	Standing	The cattle stand on its four feet with its head up or down.
2	Lying	The cattle sit on the surface with its head up or down.
3	Standing and Ruminating	The cattle stand on its four feet and ruminate with its head up or down.
4	Lying and Ruminating	The cattle sit on the surface with its head up or down and ruminate.

Table 1. Status of activity monitoring and definition.

Results

More than one of the cowsheds in "Mumbai" tested these smart collar on dairy cattle (Figures 2-4).

Figure 2. The collar with reflective belt ready for testing.

Figure 3. Experiments on cow.

Figure 4. Prediction of health on pashu collar (Front-End).

Discussion

Our findings suggest that general health monitoring holds promise as a practical solution to the body temperature issue. Because cattle have thick skin, the MLX90614 sensor provides inaccurate readings of body temperature. However, after conducting an experiment, we realized that we could obtain accurate readings of upper skin temperature, so we decided to convert body temperature to skin temperature in order to detect heat stress on cattle [7].

Heat stress is caused by a combination of environmental factors (relative humidity, solar radiation, air movement, and precipitation) (Figure 5).

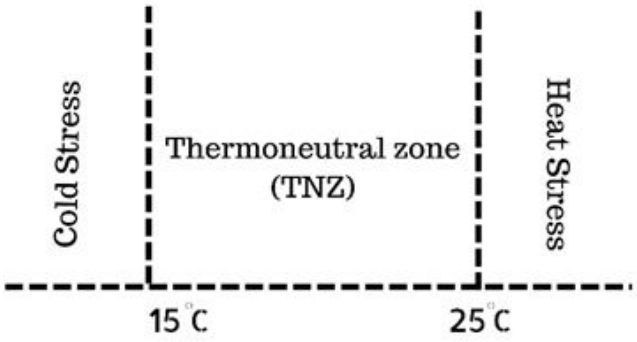

Figure 5. Thermo Neutral Zone (TNZ) of a lactating dairy cow (modified from C. A. Becker 2002).

Table 2 shows, this paper utilizes ambient temperature and relative humidity, which are readily available to the dairy producer on a daily basis and indicate slight to severe heat stress of dairy cattle as mild heat stress (THI 72 to 78), moderate heat stress (THI 79 to 89) and severe heat stress (THI>89) [8].

T°C	Humidity																				
	0	5	10	15	20	25	30	55	40	45	50	55	60	65	70	75	80	85	90	95	100
23														72	72	73	73	74	74	75	75
26							72	72	73	73	74	74	75	76	76	77	78	78	79	79	80
29			72	72	73	74	75	75	76	77	78	78	79	80	81	81	82	83	84	84	85
32	72	73	74	75	76	77	78	79	79	80	81	82	83	84	85	86	86	87	88	89	90
35	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
37	77	78	79	80	82	83	84	85	86	87	88	90	91	92	93	94	95	97	98	99	
40	79	80	82	83	84	86	87	88	89	91	92	93	84	96	97						
43	81	83	84	86	87	89	90	91	93	94	96	97									
46	84	85	87	88	90	91	93	95	96	97											
48	88	88	89	91	93	94	96	98													

Table 2. Temperature Humidity Index (THI) for dairy cows.

Also, our findings show that pulse rate in (BPM) and activity status can be used to measure sleeps status.

Conclusion

In vast farms where staff does not have enough time, it is challenging to regularly observe the health of the cattle physically so we came up with a general health monitoring system. We come to the conclusion that the discipline of animal husbandry uses an automated method for monitoring the health of cattle. Real time monitoring of a cow's general health is possible with the technique used in this paper. The system was tested on dairy cattle reliably and successfully. Since the electronic components are inexpensive, the system is cost effective. Thus, the system can monitor a cow's general health effectively.

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