Analysis of Cattle Activity using IOT

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***Abstract*— Maintaining good animal health is crucial for the success and sustainability of cattle farming, particularly in dairy and agriculture. Despite routine surveillance methods, large-scale farms often struggle with effective manual monitoring. To overcome these challenges, this study explores the use of Internet of Things (IoT) technology for tracking cattle activity and improving livestock management. However, despite the institutionalized daily surveillance, challenges inevitably crop up, especially on extensive farms. In this study, IoT technology. system focuses on real-time health monitoring by analyzing key indicators such as heart rate, rumination, body temperature, and GPS-based movement to ensure early detection of health concerns.The collected sensor data is transmitted to a cloud-based system, where Artificial Intelligence (AI) and Machine Learning (ML) algorithms process and analyze it. These intelligent systems help detect abnormalities, allowing farmers to take preventive measures before serious health issues arise. The use of predictive analytics enhances farm operations by providing valuable insights for better decision-making.This IoT-driven solution offers a cost-effective and scalable alternative to traditional monitoring methods, reducing labor efforts while ensuring round-the-clock surveillance. By leveraging real-time data, farmers can proactively manage cattle health, enhance productivity, and improve resource utilization. Ultimately, this technology-driven approach supports sustainable agriculture by fostering healthier livestock, optimizing milk production, and ensuring overall farm efficiency.**

Keywords— Cattle health, animal well-being, milk production, agricultural sustainability, surveillance challenges, labour constraints, disease detection, Internet of Things (IoT)

I. Introduction

Ensuring cattle health and promoting sustainable farming are essential aspects of modern agriculture, particularly due to the challenges associated with labor-intensive monitoring on large farms. This study explores the implementation of Internet of Things (IoT) technology in cattle management by continuously monitoring vital health parameters, including heart rate, rumination, body temperature, and GPS location**.** The data collected by IoT sensors is transmitted to a centralized system**,** where Artificial Intelligence (AI) and Machine Learning (ML) algorithms process and analyze the information to identify anomalies and potential health risks.

The primary objective of this research is to facilitate early detection of health issues, allowing farmers to take preventive measures to enhance herd management and ensure agricultural sustainability. This IoT-powered system provides a cost-effective approach for real-time cattle health monitoring, leading to improved surveillance, enhanced data management, and better decision-making. Moreover, the study emphasizes the significant role of IoT technology in driving sustainable and efficient livestock farming. The paper includes a literature review, a detailed methodology, a discussion of research findings, and an analysis of results. Lastly, the conclusion highlights key insights and suggests potential directions for future research. This paper employs the Internet of Things technology in cattle management, where real-time heart rate, rumination, body temperature, and GPS location are analyzed. Real-time data from IoT sensors are imported into a centralized platform where these data undergo AI and ML algorithms for analysis and anomaly detection. The purpose of this paper is to fast diagnose health issues, enabling proactive intervention and optimized herd management, hence enhancing agricultural sustainability. This research provides a low-cost solution to the health monitoring of cattle, which in turn will translate into benefits for farming in terms of better surveillance, improved data management, and a more informed basis for decisions. It further underlines the transformative potential of IoT in being able to promote sustainable livestock management. The paper starts with a literature review, explains the methodology, presents the findings, and concludes by interpreting these results. A conclusion summarises key findings of significance and informs future research directions. This research provides a low-cost solution to the health monitoring of cattle, which in turn will translate into benefits for farming in terms of better surveillance, improved data management, and a more informed basis for decisions. It further underlines the transformative potential of IoT in being able to promote sustainable livestock management. The paper starts with a literature review, explains the methodology, presents the findings, and concludes by interpreting these results. A conclusion summarises key findings of significance and informs future research directions.

II. Literature Review

Cattle managing and monitoring their health continuously is a major concern worldwide, with an increasing incidence rate in recent years. Several studies have been done in this field for

exploring the use of machine learning algorithms for the diagnosis and prediction of cattle health. In this review, we summarize the findings of twelve recent studies that have used various machine learning algorithms for the analyzing the cattle health monitoring.

It focuses on mapping of sicknesses in dairy cow to the relevant sensors which will help in future to create smart system in future. This paper identifies three sensors which are temperature, accelerometer and microphone that are required to decide the fitness of the cattle [1].

The WSN is employed for monitoring cattle health for early and correct detection of diseases and their prevention from spreading [2]

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The proposed system consists of non-invasive, wearable sensors that will be placed on the cow's neck. Basic information about health, sensors, the layout and improvement of a prototype is deliberated. The said prototype will have three foremost elements, they're -sensing, statistics processing and facts analysis [3].

It uses Arduino UNO, GSM, ESP8266 Wi-Fi module to create a smart health monitoring system. Uses GPS to know the location of the cattle and a DHT 11 sensor which records the environment condition [4].

The primary goal of this method is to create a smarter cattle farming infrastructure and to enforce a non-invasive wearable to hint livestock physiological and biological activity by using IOT. The system saves farmers time and maintenance costs ensuring better cattle health and high yield[5].

The paper gives a review of the structured overview of the dairy health management sensor systems. It says about levels in which the senor system can be integrated and also the outcome can be predicted [6].

This paper uses low cost GPS and prediction algorithm to give high classification rates. We managed to achieve an average classification success rate of 86.2 percent of the four activities for our dataset: eating / seeking (90.0 percent), walking (100 percent), lying (76.5 percent), and standing (75.8 percent) [7].

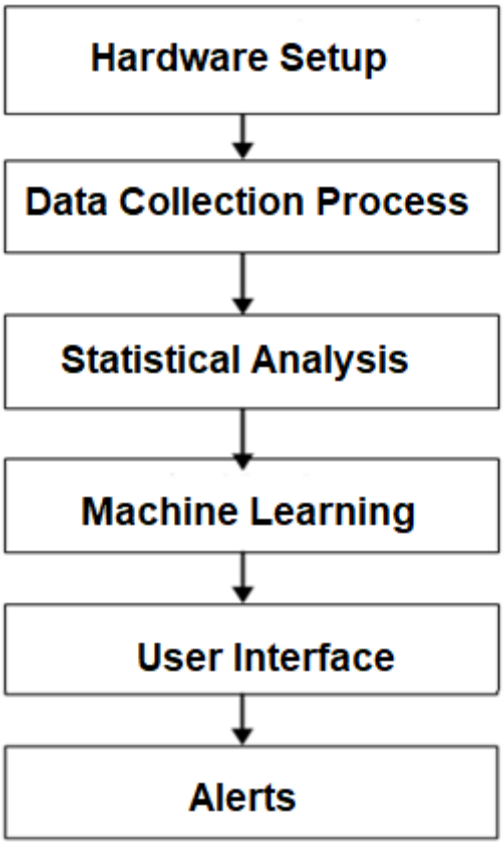
The solution proposed facilitates a preferred requirement to continually assess the circumstances of individual animals, to aggregate and report these data to the farmer manager.The proposed IRP can notably decrease the impact of mobility beneath varying "off" probability, different amount of sensor node and therefore the prevalence of network reconfiguration [8].
The papers focus on GPS collars on the cattle to monitor the movement of the cattle. The results of these tests show that the collars generally provide data with horizontal accuracies between 4 and 5 m [9].

Wireless Sensor is installed on farms to help in increasing the productivity of the cattle and the farm. Web application which displays the various condition of the environment of the farm and also has options to change the environment condition [10].

This paper reviews other cattle monitoring systems and hence the importance of using wireless sensor networks to monitor bovine core body heat and site. Cattle temperature and location are defined [10].
Through the development of IoT in Industry 4.0, large data in almost every field of life have become inevitable to be monitored and processed. It's found that surveillance experiments in the animal farming sector have also been quickly expanded. Besides science research, programs for tracking and monitoring of animal health and effectiveness are being developed [11].

III. Methodology

This paper will adopt a mixed-method approach to verifying the effectiveness of IoT technology in monitoring cattle activity for better livestock management. Quantitative data collected through multiple sensors from the cattle's body are included. The process for data collection and statistical analysis is outlined below in detail:



1 Architecture

A. Hardware Setup

The We've connected a microcontroller called Arduino Uno to various sensors, including the DHT11 for temperature and humidity detection, the LM35 for body temperature detection, a heart rate sensor, and a GPS module. The hardware system is connected to a cloud platform, such as the ThinkSpeak platform, through their API.

This gives a platform to present the entire data that is taken through the to clean and format data before doing any operation with it.

B. Data Collection Process

IoT-based quantitative data collection plays a crucial role in monitoring cattle health and activity. This process involves equipping selected cattle with advanced sensors that continuously track key physiological and behavioral parameters. These sensors operate 24/7, capturing vital data such as heart rate, rumination patterns, body temperature, and precise geographic location. The collected real-time data is then transmitted seamlessly to a cloud-based platform, where it undergoes further processing and analysis. By leveraging this technology, farmers gain valuable insights into the well-being of their livestock, enabling early detection of health anomalies and improved decision-making. This approach enhances cattle management efficiency, reduces manual monitoring efforts, and supports sustainable livestock farming practices.

C. Statistical Analysis

To effectively analyze cattle health metrics, descriptive statistical methods are applied. Key indicators such as mean, median, and standard deviation help summarize data variations, while visual tools like histograms, scatter plots, and heat maps provide clear insights into trends and distributions. Establishing baseline physiological parameters allows for continuous monitoring and early detection of abnormalities. Additionally, significance tests are conducted to identify patterns and correlations, offering valuable insights into how IoT-based monitoring influences different farming environments. This data-driven approach enhances decision-making, improves livestock management, and supports proactive health interventions for cattle.

D. Machine Learning

Once the statistical analysis of the data is complete, machine learning models such as Decision Trees, K-Means clustering, and Support Vector Machines (SVM) will be implemented to categorize different cattle activities. These models will facilitate both binary and multi-class classification, allowing for accurate identification of behavioral patterns and potential health anomalies. Decision Trees will help in making rule-based classifications, K-Means will be useful for grouping similar activity patterns, and SVM will enhance classification accuracy by identifying complex relationships within the data. By leveraging these algorithms, the system can efficiently detect deviations from normal behavior, enabling timely interventions and improving overall cattle management.

E. User Interface

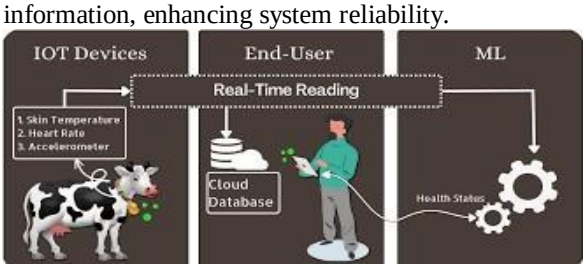
After applying all the machine learning models, we will present the data using parameters tailored to cattle based on the sensors, even if there are multiple cattle. These parameters will generate separate graphs displaying heart rate, humidity, GPS data, rumination, and temperature. On these features, the User Interface will show if that specific cattle is healthy or unhealthy to the farmers.

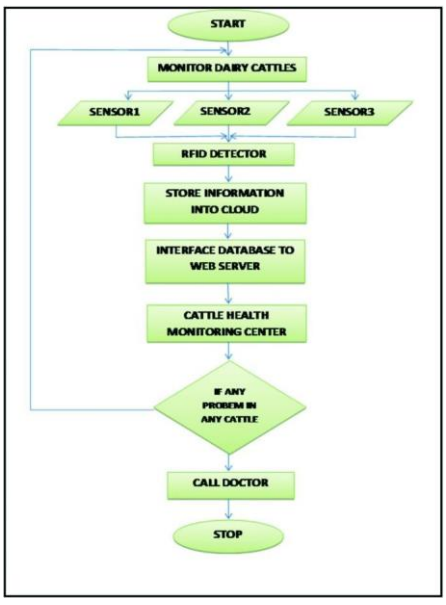
F. Alerts

In the event of any abnormal activities, notifications are immediately forwarded to the User Interface of the farmers.

IV. PROPOSED SYSTEM

1. **Sensor Nodes:** These are placed on cattle to monitor their movements, physiological parameters, and activity patterns. They collect real-time data, including heart rate, rumination, temperature, and location, ensuring comprehensive health tracking.
2. **Data Acquisition Layer:** This facilitates seamless data transmission from sensor nodes to the processing system using reliable wireless communication protocols such as Bluetooth, Wi-Fi, or LoRa. It ensures efficient data flow for real-time monitoring.
3. **Edge Computing/Gateway Devices:** Before transmitting data to cloud, devices may perform preliminary data preprocessing, such as filtering noise, aggregating sensor readings, compressing data. This step enhances efficiency and reduces bandwidth usage.
4. **Central Processing Unit (Cloud Platform):** The cloud platform serves as the core analytical hub, receiving sensor data, performing in-depth analysis, and generating insights. It identifies abnormalities in cattle behavior and triggers alerts for early intervention.
5. **Analytics and Decision Support:** By leveraging machine learning and AI algorithms, predictive analytics detect health risks and provide actionable recommendations for farmers. These insights enable proactive livestock management and disease prevention.
6. **User Interface:** A well-designed, user-friendly dashboard allows farmers to access real-time health reports, activity trends, and alerts. It provides visual analytics, making it easier to interpret data and take necessary actions.
7. **System Integration & Security:** The system is designed for seamless integration with existing farm management solutions while ensuring robust data privacy and security. Encryption techniques and authentication protocols safeguard sensitive information, enhancing system reliability.





Sr.No	Authors	Year	Disease	Machine learning algorithm	Dataset input	Remarks	Conclusion
1	Khalid El Moutaonakil, Hamza Jdi Brabim Jabir, and Noureddine Falih	2023	IoT-based Cattle Monitoring Systems and Dashboards	IoT. Technology	Cattle data collected via IoT sensors	IoT based monitoring enhances real-time tracking and analysis of livestock conditions	IoT solutions improve cattle health monitoring, productivity and decision making
2	Jai Ganesh Rajendran, Manjunathan Alagatsamy,Vaishnavi Sexa, Paramathi Mani Dinesh Balamurugan Rajangam, and Kannadhasan Suriyan	2023	A system that uses wireless sensors to keep track of cattle health	Wireless Sensor Network (WSN)	Health parameters collected via sensors	Wireless networks enabled health monitoring automateng and reduce manual dependency	WSN plays a crucial role in continuous health tracking and efficiency in animal husbandry
3	K. Darvesh, N. Khande, S. Axhad, and M Khemchandani	2023	A smart system that uses JoT to monitor the health of cows	IoT, Data Analytics	Cattle health and behavioral data	Provides early notifications to farmers regarding health status, behavioral shifts, and daily activity of cows	IoT-based systems enhance cow monitoring, allowing better health tracking and farm management
4	Jebangit Arshad, Talha Ahmad Siddiqui, M. Ismail Sheikh, M. Sadeed Waseem, M Abu Bakar Nawaz, Elsayed Tag Eldin, and Ateeq Ur Rehma	2023	Installing an intelligent and secure system to keep track of cattle health.	IoT Data Collection	Daily cattle activity and health monitoring data	Enables real-time cattle health monitoring and provides daily updates to farmers	Improves cattle care by allowing timely precautionary measures

5	Melchizedek Alipio and Maria Lorena Villena	2023	Smart wearable devices and sensors used to monitor the cattle health	Wearable Devices, Biosensors	Health parameters collected via biosensors	Assesses and categorizes wearable devices for farm cattle health monitoring	The use of biosensors enhances precision in cattle health tracking
6	Ashmitha G., K. M. Daniel, J. Saravanan, K. Ayyar, and K. S. Jaibhavani	2023	A sustainable system that uses smart technology to IoT to track and manage livestock health.	IoT, AI-based Data Analytics	Real-time cattle tracking and health data	Detects cattle, analyzes health conditions and provides essential notifications to farmers	Sustainable monitoring systems improve cattle heath management and decision-making
7	Research and Markets.com	2023	Global Animal Heath Monitoring Software Market by Animal Type	Cloud-Based, On-Premises Deployment	Animal types (Cattle Horses, Poultey)	Research focuses on the impact of inflation forecasts on animal.	Market trends and deployment methods influence the adoption of animal health monitoring

Table 2: Literature Survey

V. ALGORITHM

1) **Support Vector Machines (SVM):** Support Vector Machines (SVM) aim to determine the most effective hyperplane for distinguishing between different activity classes within a feature space. When applied to cattle activity analysis, SVM can classify behaviors such as resting, walking, and feeding using data from sensors like accelerometers, GPS, temperature monitors, and heart rate trackers. The key goal of SVM is to establish a hyperplane that maximizes the margin between different activity categories, ensuring clear separation. This optimal hyperplane is mathematically defined to enhance classification accuracy.

following manner: $w \cdot x+b=0$

where

□

w is the weight vector, and □, b is the bias

CODE:

```
from sklearn.svm import SVC
svm = SVC(kernel='linear',
C=1.0) svm.fit(X_train, y_train)

y_pred = svm.predict(X_test)
```

K-Means Clustering: K-Means Clustering is an unsupervised machine learning technique used to categorize data into kkk groups based on shared characteristics. Unlike supervised learning methods like SVM, which require labeled datasets, K-Means operates independently of predefined labels, making it effective for uncovering hidden patterns. In cattle activity analysis, this approach helps group similar behaviors, such as grazing, resting, or walking, using sensor data. The value of kkk determines the number of clusters, representing different activity patterns within the herd.

Cluster Analysis:

The identified clusters provide insights into various activity patterns. Each cluster is examined to determine the dominant features associated with it, enabling a deeper understanding of the data. By leveraging domain expertise, appropriate labels can be assigned to categorize different behavioral trends effectively.

CODE:

```
from sklearn.cluster import KMeans kmeans =
KMeans(n_clusters=k, random_state=42)
kmeans.fit(X_scaled)
clusters = means.labels_ data['cluster'] = clusters
```

Decision Trees: Decision Trees are a supervised learning technique used for both classification and regression tasks. They function by systematically splitting data into smaller subsets based on specific attributes, forming a tree-like structure of decisions. In cattle activity analysis, Decision Trees can help categorize different behaviors by utilizing data collected from various sensors, such as accelerometers, GPS, temperature monitors, and heart rate sensors.

CODE :

```
from sklearn.tree import DecisionTreeClassifier
clf=DecisionTreeClassifier(random_state=42)
self.fit(X_train, y_train)
y_pred = calf.predict(X_test)
```

VI. RESULTS AND DISCUSSION

The system efficiently gathers data from cattle, including temperature, activity levels, heartbeat, rumination, and humidity. This information is transmitted to the cloud, where machine learning algorithms analyze it to detect potential health issues. If any abnormal patterns are identified, alerts are immediately sent to the farmers' dashboard. The system is capable of monitoring both individual and multiple cattle, providing continuous real-time readings. By detecting early signs of illness, it enables timely intervention, reducing health risks and treatment costs. This approach enhances animal welfare, lowers operational expenses, and supports data-driven decision-making for effective herd management. Though still in its early stages, the system has the potential to revolutionize cattle farming.

Below are some of the results shown about cattle's health with respect to it's temperature count, humidity count and heartbeat count with regarding to one day time frame of hourly basis.

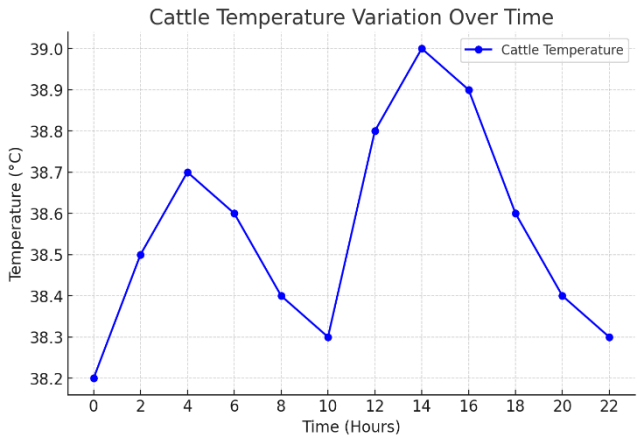


Fig1. Temperature Graph

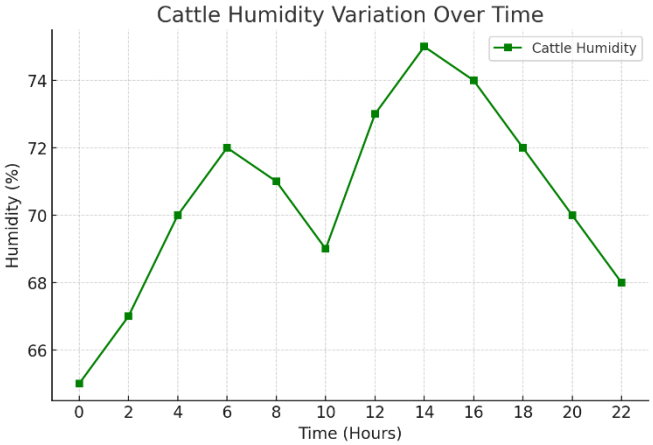


Fig2. Humidity Graph

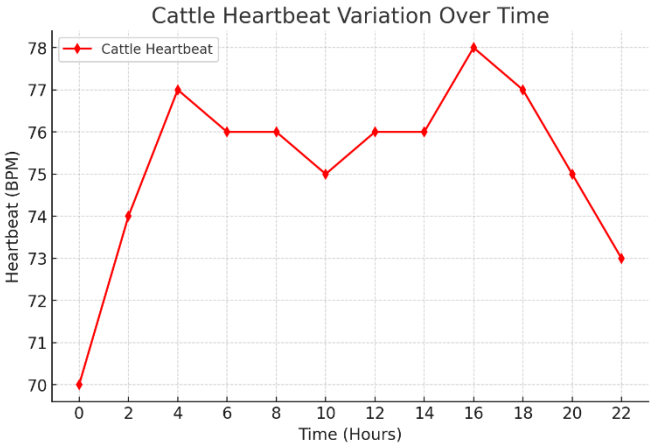


Fig3. Heartbeat Graph

VII. CONCLUSION AND FUTURE SCOPE

By integrating the Internet of Things (IoT) with machine learning, farmers can optimise their livestock management. This data-driven approach leads to improved cattle health, increased productivity, and sustainable farming practices.

By combining the Internet of Things (IoT) with machine learning, farmers can enhance livestock management through real-time monitoring and data-driven insights. This innovative approach promotes better cattle health, boosts productivity, and supports sustainable agricultural practices.

1.Precision Livestock Farming (PLF): Integrating cattle health monitoring with PLF technologies, such as automated feeding systems, allows for a more comprehensive approach to livestock management.

2.Early Disease Detection: Advanced sensors and analytical tools enable early identification of diseases in cattle, facilitating prompt intervention and preventing the spread of infections within the herd.

3.Blockchain Integration: Incorporating blockchain technology ensures secure, transparent storage and sharing of sensor-collected data, enhancing data reliability and traceability.

4.Personalized Health Plans: Future advancements may enable the system to generate customized health plans tailored to individual cattle based on their medical history and current condition.

5.Precision Medicine Integration: The cattle health monitoring system can incorporate precision medicine techniques to develop personalized treatment strategies, further improving animal welfare and management efficiency.

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