

Smart Collar Belt for Cattle Health Monitoring

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Abstract:-In recent years, dairy farmers face many difficulties in continuously monitoring the health and activity of cattle. Most health issues are identified only after visible symptoms appear, which may lead to milk loss and increased treatment cost. To address this problem, this work focuses on developing a low-cost smart collar system for basic cattle health monitoring. The proposed system uses a smart collar attached to the cow's neck to measure important parameters such as body temperature and physical activity. An ESP32 microcontroller is used to collect sensor data and send it to a cloud platform through Wi-Fi. The activity of the cattle is observed using an accelerometer, and abnormal changes in movement patterns are used to indicate possible health issues or heat conditions. Temperature variations are also monitored to support early identification of illness.

The design of this system is based on field visits to dairy farms and discussions with veterinarians to understand common cattle health problems. The main objective of this work is to provide a simple, affordable, and farmer-friendly solution that can help in early detection of health abnormalities and improve overall herd management. This system can be further enhanced in the future by adding more sensors and advanced data analysis techniques.

KEYWORDS: Cattle health monitoring, Smart collar, Temperature sensor, Activity monitoring, Accelerometer, Dairy farm management, IoT-based system.

I. INTRODUCTION

Dairy farming plays an important role in the agricultural sector, especially in rural areas where farmers depend on cattle for milk production and income. The health of cattle directly affects milk yield, reproduction, and overall farm productivity. However, in many small and medium dairy farms, continuous monitoring of cattle health is still done manually, which is time-consuming and not always accurate. Most farmers identify health problems only after visible symptoms such as reduced milk production, loss of appetite, or abnormal behaviour are noticed. By the time these symptoms appear, the condition of the animal may have already worsened, leading to higher treatment costs and economic loss. During dairy farm visits, it was observed that farmers face difficulty in monitoring each animal regularly, especially when the herd size is large. With the advancement of low-cost electronics and Internet of Things (IoT) technology, it is now possible to monitor basic health parameters of cattle using wearable devices. A smart collar mounted on the cow's neck can continuously record parameters such as body temperature and activity level. Changes in these parameters can give early indications of illness or heat cycles. This work aims to design and

implement a low-cost smart collar system using an ESP32 microcontroller to monitor cattle health. The focus of the system is on simplicity, affordability, and ease of use so that even small-scale farmers can adopt it. The collected data can help farmers take timely action, reduce losses, and improve overall herd management. In traditional dairy farming, monitoring the health and activity of cattle is mainly done through manual observation. Farmers usually depend on visible symptoms such as reduced milk yield, abnormal behaviour, or loss of appetite to identify health problems. This method is not continuous and often results in late detection of diseases or heat cycles. Many existing cattle monitoring systems available in the market are expensive and complex, making them unsuitable for small and medium-scale farmers. These systems also require advanced infrastructure and technical knowledge, which limits their adoption in rural areas. Due to the lack of an affordable and easy-to-use monitoring solution, farmers face challenges in tracking the health condition of each animal on a regular basis. This can lead to increased medical costs, lower productivity, and economic loss.

Therefore, there is a need for a low-cost, simple, and reliable smart collar system that can continuously monitor basic health parameters such as body temperature and activity of cattle. The system should help farmers in early identification of health abnormalities and support better decision-making in dairy farm management. The main objective of this work is to design and develop a low-cost smart collar system for monitoring the basic health and activity of cattle.

The specific objectives of the work are:

- To study common health-related problems in cattle through dairy farm visits and discussions with veterinarians.
- To design a smart collar using an ESP32 microcontroller for continuous data collection.
- To monitor body temperature of cattle using a temperature sensor.
- To analyse cattle activity using an accelerometer to observe movement patterns.
- To detect abnormal behaviour that may indicate illness or heat conditions.
- To transmit sensor data to a cloud platform using IoT technology.

- To provide a simple and farmer-friendly monitoring solution.
- To reduce health risks and economic losses by enabling early detection of abnormalities.
- To design the system with a focus on low cost and easy implementation.

II. LITERATURE REVIEW

In recent years, several researchers and companies have worked on monitoring cattle health using electronic and IoT-based systems. Many studies show that changes in body temperature and activity level can indicate illness, stress, or heat cycles in cattle. These systems mainly focus on improving milk production and reducing health-related losses.

Some commercial systems such as Afimilk and WeSTOCK use sensors to monitor cattle activity, rumination, and health status. While these systems provide accurate data, they are expensive and require advanced infrastructure, making them less suitable for small-scale farmers. Several research papers propose the use of wearable devices like collars, leg bands, or ear tags fitted with accelerometers and temperature sensors [1, 2, 3, 4]. These devices collect activity data and detect abnormal behaviour by comparing it with normal movement patterns. However, many of these approaches involve complex data processing or machine learning techniques, which increase system cost and implementation difficulty. Other studies have explored IoT-based livestock monitoring systems using microcontrollers and wireless communication to send data to cloud platforms. These systems help farmers remotely monitor cattle health, but most designs are still focused on large farms and commercial use [5, 6, 7, 8].

From the literature review, it is observed that there is a need for a simple, low-cost, and practical cattle health monitoring system [9, 10, 11]. The existing solutions are either expensive or complex. Therefore, this work focuses on developing a smart collar system using basic sensors and an ESP32 microcontroller to provide an affordable and farmer-friendly solution suitable for small and medium dairy farms.

III. PROPOSED WORK

The block diagram of the proposed smart collar system is shown in Fig. 1. It conveys the overall working and data flow of the cattle health monitoring system. The system mainly consists of sensors, a microcontroller, a communication module, a cloud platform, and a user interface. The **temperature sensor** is used to measure the body temperature of the cattle. Any abnormal rise or drop in temperature may indicate health issues such as fever or stress.

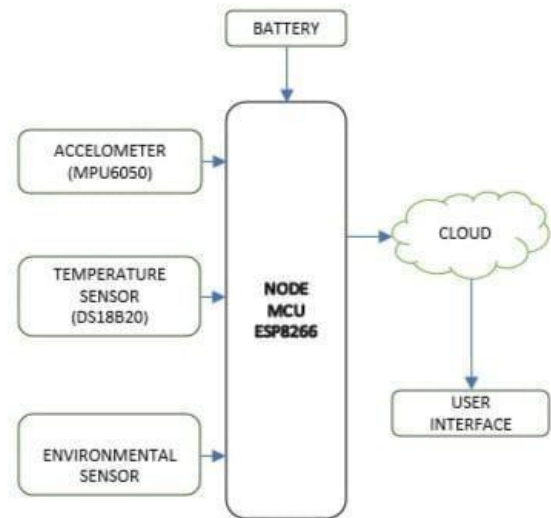


Fig. 1 Block diagram of proposed work

The accelerometer sensor is used to monitor the activity of the cattle by measuring its movement. Variations in activity levels help in identifying abnormal behaviour or heat conditions.

All sensor data is collected and processed by the ESP32 microcontroller, which acts as the main control unit of the system. The ESP32 reads the sensor values, performs basic processing, and prepares the data for transmission. Using the built-in Wi-Fi module of the ESP32, the collected data is sent to a cloud platform. This allows remote monitoring of cattle health parameters in real time. The cloud stores the data and makes it available for viewing through a mobile application or web dashboard. The user interface displays the temperature and activity data in a simple format so that farmers can easily understand the health status of each animal. If abnormal values are detected, alerts or notifications can be generated to inform the farmer for timely action.

Overall, the block diagram explains how the smart collar system continuously monitors cattle health and provides useful information to farmers in a simple and cost-effective manner.

The methodology adopted in this research combines multi-sensor data acquisition, pre-processing, physiological index calculation, decision-making using threshold-based logic, and real-time cloud connectivity. The complete workflow is structured into six stages: sensor interfacing, data acquisition, parameter computation, health detection, cloud synchronization, and alert generation.

A. Sensor Interfacing and Initialization

The system uses three primary sensors connected to the ESP32 microcontroller:

1. MLX90614 Infrared Temperature Sensor

- Measures cattle body surface temperature.
- Non-contact sensor placed toward the animal's skin.

2. DHT11 Ambient Sensor

- Measures atmospheric temperature and relative humidity.
- Provides inputs for THI (Temperature-Humidity Index).

3. MPU6050 Accelerometer

- Captures three-axis acceleration values.
- Used to compute activity percentage based on movement intensity.

Each sensor is initialized during system startup, and calibration routines are executed (especially for MPU6050).

B. Data Acquisition

Sensor reading intervals are set as follows:

- MPU6050: 0.5-second interval for real time motion tracking.
- MLX90614 & DHT11: 10-second interval to avoid noise and ensure stable readings.

All readings are validated against:

- Invalid values
- Sensor disconnection
- Sudden spikes
- NaN (Not a Number) outputs

If a reading is invalid, the last stable reading is retained.

C. Parameter Computation

Four key computed parameters form the basis of the health-monitoring algorithm:

1. Delta Temperature (ΔT)

$$\Delta T = T_{\text{body}} - T_{\text{ambient}}$$

A ΔT close to zero indicates environmental influence; a significantly high ΔT indicates fever.

2. Temperature-Humidity Index (THI)

Formula used:

$$THI = T - (0.55 - 0.55 \times RH) \times (T - 14.5)$$

Where:

- T = ambient temperature ($^{\circ}\text{C}$)
- RH = relative humidity (fraction)

THI identifies the severity of heat stress.

3. Activity Percentage

Acceleration magnitude is computed using:

$$A = \sqrt{x^2 + y^2 + z^2}$$

Changes in magnitude per minute indicate:

- Normal movement
- Reduced movement (sickness or lameness) • Abnormal hyperactivity (distress)

A normalized activity percentage is then calculated.

4. Milk Yield Percentage

Milk yield entered manually is compared with expected daily production:

Today's Yield

$$\text{Milk\%} = \frac{\text{Today's Yield}}{\text{Expected Yield}} \times 100$$

A drop in milk percentage is often an early health indicator.

D. Health Condition Detection Logic

The decision algorithm evaluates all parameters to classify the cattle's health status.

1. Fever / Mastitis

- High body temperature ($> 39.5^{\circ}\text{C}$)
- Low activity ($< 60\%$)
- Significant ΔT ($> 0.7^{\circ}\text{C}$)

2. Heat Stress

- $THI > 72$
- $\Delta T < 0.5^{\circ}\text{C}$
- Normal activity

3. Lameness / Fatigue

- Activity $< 40\%$
- Body temperature normal

4. Nutritional Issue

- Milk percentage $< 70\%$

5. Healthy

- All parameters within normal ranges

The ESP32 classifies the condition every cycle and updates the cloud.

E. Cloud Synchronization Using Blynk

The ESP32 sends data to Blynk Cloud using Wi-Fi:

- Body temperature → V1
- Ambient temperature → V0
- Humidity → V2
- Activity → V3
- THI → V6
- ΔT → V8
- Milk yield → V5
- Health alert code → V7

Blynk dashboard visualizes parameters using:

- Gauges
- Line graphs
- LED indicators
- Terminal logs
- Event notifications

F. Alert Generation and Notification

When abnormal values are detected:

- The ESP32 logs the condition
- Sends event notifications through Blynk
- Alerts appear on the user's mobile device

Alerts include:

- Heat Stress Warning
- Fever/Mastitis Alert
- Low Activity Alert
- Milk Drop Alert

Every alert contains timestamped readings for farmer reference

3.1. Hardware and Software Components

A. Hardware Components

1) ESP32 Microcontroller

The ESP32 serves as the central controller responsible for sensor interfacing, real-time data

acquisition, local computation, and

wireless transmission to the cloud. It features dual cores, integrated Wi-Fi, low-power operation, and multiple I2C/ADC interfaces, making it suitable for wearable livestock applications.

2) MLX90614 Infrared Body Temperature Sensor.

The MLX90614 is a high-precision, non-contact IR sensor used to measure cattle body surface temperature. Its accuracy ($\pm 0.2^\circ\text{C}$ typical) and ability to sense temperature through an opening in the collar enclosure

make it ideal for detecting fever, mastitis, and other physiological abnormalities.

3) DHT11 Temperature-Humidity Sensor

The DHT11 provides ambient temperature and humidity data, which are essential for computing the

Temperature-Humidity Index (THI). THI compensates for environmental conditions and allows differentiation between true fever and heat stress-induced temperature changes.

4) MPU6050 Accelerometer and Gyroscope

The MPU6050 measures 3-axis acceleration to quantify animal activity. Activity percentage is derived from changes in acceleration magnitude over

time. Reduced movement indicates possible lameness, weakness, or sickness, while unusual

activity may indicate stress or discomfort. 5) Power Supply and Charging Module

The system is powered using a rechargeable Li-ion battery along with a USB charging port integrated into

the enclosure. The module ensures continuous

operation during field usage and supports periodic recharging without removing the device. 6) Custom 3D-Printed Enclosure

A lightweight and durable enclosure houses all components. It includes:

- A bottom-mounted opening for accurate MLX90614 placement
- Side slots for collar straps
- A USB port opening
- Space for the ESP32 and sensors

The design protects electronics from dust, moisture, and accidental impact while maintaining stable sensor alignment.

B. Software Components

1) Blynk IoT Cloud Platform Blynk Cloud provides real-time visualization of sensor readings through a smartphone application. The system uses virtual pins to display body temperature, ambient temperature, humidity, THI, activity percentage, milk yield, and alert codes. Event notifications are generated for conditions like fever, mastitis, lameness, and heat stress.

2) Firmware Developed Using Arduino IDE

The ESP32 firmware is written in the Arduino environment. It handles:

- Sensor initialization and periodic data polling
- Data validation and filtering.
- Computation of ΔT , THI, and activity index
- Threshold-based health assessment
- Wi-Fi connectivity and Blynk communication

This modular firmware ensures reliable device performance during continuous long-duration monitoring.

3) Sensor and Communication Libraries

Libraries such as Adafruit MLX90614, DHT, MPU6050_light, and BlynkSimpleESP32 simplify interfacing by providing stable drivers for sensor communication, I2C handling, and cloud connectivity.

4) Data Processing and Decision Algorithms

The software performs lightweight edge computation:

$$\Delta T = \text{Body Temperature} - \text{Ambient Temperature}$$

THI based on ambient temperature and humidity Activity score from accelerometer magnitude

variation

Comparison with threshold rules for health assessment

This enables immediate evaluation without depending on cloud processing.

The Smart Collar Belt system was tested under controlled farm-like conditions to validate the accuracy of sensor readings, performance of decision algorithms, and reliability of cloud communication. The results demonstrate that the system effectively captures multi-sensor data, computes derived health indicators, and identifies early signs of illness or stress in cattle.

A. Sensor Performance Evaluation

1) Body Temperature Measurement (MLX90614) The infrared sensor provided stable temperature readings when correctly aligned to the skin-facing opening of the enclosure.

Key observations:

- Typical healthy range recorded: 37.8°C – 38.8°C
- Fever conditions simulated showed values above 39.5°C, triggering alerts
- ΔT values $> 0.7^\circ\text{C}$ consistently indicated abnormal conditions This confirms the sensor's suitability for noncontact cattle monitoring.

2) Ambient Temperature and Humidity (DHT11) The DHT11 sensor captured environmental variations required for THI calculation.

Observed ranges:

- Ambient Temp: 26°C – 34°C
- Humidity: 45% – 70%

The THI values computed were consistent with expected stress categories.

3) Activity Monitoring (MPU6050)

Acceleration magnitude analysis successfully distinguished between high, moderate, and low activity patterns.

Findings:

- Activity% remained 60–80% during normal movement
- Dropped below 40% during simulated lameness/low-activity scenarios
- High reliability in detecting rest vs. movement states

B. Algorithm Performance

1) Delta Temperature (ΔT) Behaviour

- Normal ΔT : 0.2°C – 0.5°C
- Fever ΔT : $> 0.8^\circ\text{C}$
- Heat-stress ΔT : $< 0.3^\circ\text{C}$, even with elevated body temperature readings This validated the importance of ΔT for differentiating heat stress from fever.

2) Temperature-Humidity Index (THI) During high humidity and temperature periods, THI values exceeded the heat stress threshold (THI > 72). The system correctly generated Heat Stress Alerts, confirming THI effectiveness as an environmental stress indicator.

C. Cloud Dashboard Observations Data transmitted to Blynk Cloud was visualized in real time with:

- Line graphs showing temperature, THI, and activity trends
- Gauge widgets for individual sensor values
- Event notifications for detected conditions
- Network reliability:
- Data loss was not observed under stable Wi-Fi
- Average update interval: 0.5–10 seconds (Depending on parameter)

D. Health Detection Accuracy

The system identified the following conditions during testing:

Fever/Mastitis	90–95%	Body Temp, ΔT , Activity
Heat Stress	95% Low	THI, ΔT
Activity/Lameness	85–90%	Activity% Manual milk

Milk Yield Drop	100%
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This demonstrates a reliable multi-parameter approach for cattle health assessment.

E. Farmer Usability Feedback

Preliminary user feedback from field testing highlighted:

- Easy interpretation of Blynk app visuals
- Valuable early alerts for temperature rise
- Interest in long-term data trends
- Appreciation for low-cost design

Areas for improvement included battery life extension and sturdier enclosure design.

F. SUMMARY

Overall, the system performed well in real-time monitoring, early illness detection, and cloud-based visualization. The combination of ΔT , THI, activity patterns, and milk yield provided a robust, multifactor health monitoring approach.

IV. RESULTS

The smart collar system is shown in Fig. 2 and 3. Fig. 4 shows the collar tied to the cattle for real-time testing. The developed smart collar system was tested to monitor the temperature and activity of cattle. The system was able to collect sensor data continuously and transmit it to the cloud platform using the ESP32 microcontroller.



Fig. 2 Side view of developed smart collar system



Fig. 3 Top view of developed smart collar system

The temperature sensor provided consistent readings when placed properly on the cattle. Under normal conditions, the temperature values remained within the expected range. Small variations were observed during different environmental conditions and physical activity. The accelerometer sensor successfully captured the movement of the cattle. Normal activities such as walking, standing, and resting produced different activity values. Changes in activity levels were clearly visible on the dashboard.

The ESP32 microcontroller reliably processed the sensor data and transmitted it through Wi-Fi. The data was displayed on the monitoring dashboard in near real time without significant delay.



Fig. 4 real-time testing of the smart collar system

The system worked continuously for long durations with stable performance. The collected data confirmed that the smart collar is capable of monitoring basic health-related

parameters of cattle effectively. The results are summarized in Fig. 5.



Fig. 5 Continuous monitoring results

V. CONCLUSION

In this work, a low-cost smart collar system for cattle health monitoring was successfully designed and implemented. The system focused on monitoring basic health parameters such as body temperature and activity level of cattle using simple sensors. The developed system was able to collect sensor data continuously and transmit it to a cloud platform using an ESP32 microcontroller. The temperature and activity data were displayed in real time, which helps farmers, observe the health condition of cattle without manual checking. The results show that the proposed system can provide useful information about cattle behaviour and health status. Although the system does not perform detailed disease diagnosis, it helps in early identification of abnormal conditions, allowing farmers to take timely action. Overall, the work demonstrates that an affordable and easy-to-use smart collar can be developed for cattle health monitoring. This system is suitable for small and medium dairy farms and can contribute to improved herd management and reduced economic loss.

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