

Low-Cost Wearable Neck Belt for Real-Time Dairy Cattle Health Monitoring System

N Umapathi¹, B Vivekanandam², Brojo Kishore Mishra³

¹ Jyothishmathi Institute of Technology and Science ; ² Lincoln University; ³ NIST University
nrmapathi@gmail.com

Abstract: Through the introduction of an affordable, wearable neck belt that enables real-time health monitoring of dairy calves, this initiative seeks to revolutionize the dairy industry. The gadget tracks vital health indicators including temperature, heart rate, and feeding habits by integrating cutting-edge sensors and communication components. Farmers will receive real-time insights through a specialized smartphone application, facilitating effective herd management and early disease diagnosis. To guarantee accuracy and dependability, the prototype will go through extensive testing in a variety of dairy conditions. Following a successful validation process, the technology will be marketed as a cost-effective way to increase dairy productivity and reduce financial losses brought on by cattle health problems. In addition to improving animal comfort, this invention gives farmers access to cutting-edge equipment for accurate livestock management.

Keywords: Internet of Things; Animal tracking; GPS; Livestock.

Introduction

Milk and other dairy products provide vital nutrients, making dairy production an important part of world agriculture. In addition to being a major source of foods high in protein, cattle also help with agricultural tasks like transportation and plowing. The demand for animal-derived products is predicted to increase by 71% in the upcoming years because to a growing worldwide population and shifting dietary preferences, especially in nations like Brazil, China, India, and parts of Africa (Neethirajan and Kemp, 2021). Despite having 16.5% of the world's dairy cattle population, India produces 8.4% of the world's milk, with an industry worth over 48 billion US dollars.

In order to guarantee early disease identification, prompt treatment, and general animal welfare, the move to intensive dairy production has raised the demand for efficient health monitoring. Dairy calves are at serious risk from diseases including Foot-and-Mouth Disease (FMD) and Lumpy Skin Disease (LSD), which can result in decreased milk output, problems with reproduction, and monetary losses. Ruminants are the main victims of LSD, a viral disease that causes fever, skin lesions, and decreased productivity. LSD has killed around 70,000 livestock in India and Pakistan alone. Similarly, fever, mouth blisters, and excessive salivation are the symptoms of FMD, a highly contagious viral infection that affects animals with cloven hooves and costs India some 60 million US dollars a year in lost revenue (Tiwari et al., 2013). All together, cattle illnesses are thought to cause an estimated loss per year. Conventional health monitoring techniques need a lot of work and effort. A solution is provided by Precision Dairy Farming (PDF), which uses technology breakthroughs to monitor critical behavioral and physiological trends in real time. Important health indicators that give important information about the health of cattle are body temperature, heart rate, respiration rate, and feeding activity. A healthier and more productive herd can be ensured by preventing disease outbreaks and drastically lowering mortality rates by early anomaly identification.

Related work

IoT-based systems for tracking the health of cattle have been the subject of numerous studies. Anuj Kumar and G.P. Hancke created a system that uses the PIC18F4550 microcontroller and ZigBee technology to track variables including temperature, humidity, and heart rate. Despite its ability to facilitate long-distance communication over a mesh network, ZigBee has limitations, such as higher power consumption and less security than Wi-Fi. Furthermore, it is less appropriate for high-frequency monitoring applications because to its low data transmission rate. Other studies have concentrated on Arduino Uno-based monitoring systems that measure animal health metrics by integrating many sensors. Sensor data is gathered by these systems, processed by the microcontroller, and wirelessly sent to cloud-based platforms for real-time analysis. It is possible to program alarms and notifications to notify caregivers of anomalous readings so that prompt action can be taken.

In veterinary medicine, electrocardiography (ECG) is essential for identifying cardiovascular diseases in animals. Research examining ECG data highlights how crucial it is to identify heart rate anomalies, which may be early warning signs of

underlying medical conditions. Modern cow monitoring systems that use ECG analysis can increase diagnostic precision and support better livestock management.

Proposed System Design

The NodeMCU ESP32 is a versatile microcontroller with built-in Wi-Fi and Bluetooth capabilities, making it ideal for IoT applications. In this project, it acts as the central processing unit, interfacing with multiple sensors to collect data, process it, and transmit it to a cloud platform over Wi-Fi for real-time monitoring and analysis via a user interface. The ESP32's multiple GPIO pins, ADCs, I2C, UART, and SPI support allow seamless integration of diverse sensors. The max30100 Heart rate sensor communicates with the ESP32 using I2C (SDA and SCL pins). These I2C pins are connected to the digital pins of the ESP32, which allows the sensor to send real-time health data to the microcontroller for further processing and transmission. The ADXL335 accelerometer is responsible for capturing acceleration data in three axes (X, Y, Z). It is connected to the analog pins of the ESP32 for reading the raw analog signals. The ESP32 processes these analog signals to detect motion, orientation, and vibration. The DS18B20 is a digital temperature sensor that communicates with the ESP32 via one-wire protocol. It connects to a digital pin on the ESP32 (with a pull-up resistor).

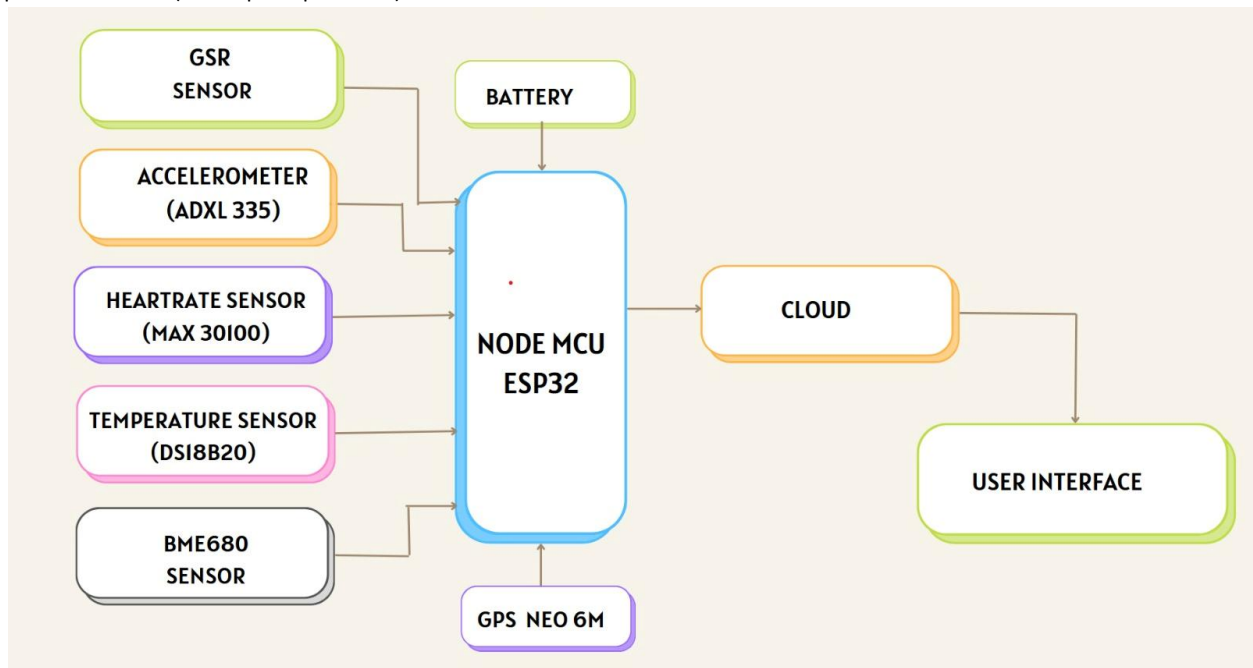


Fig 1 Block diagram of proposed system.

The GSR (Galvanic Skin Response) sensor connected to the analog input pin of the ESP32 to capture the analog voltage corresponding to skin conductance. The BME680 sensor communicates with the ESP32 using I2C (SDA and SCL pins). These I2C pins are connected to the digital pins of the ESP32 for efficient data exchange. The NEO-6M GPS module communicates with the ESP32 via UART. Specifically, the GPS module's TX pin is connected to the RX pin of the ESP32, and the GPS module's RX pin is connected to the TX pin of the ESP32. This allows bidirectional communication between the two devices for transmitting real-time geolocation data. The Battery provides the necessary power supply to the NodeMCU ESP32 and all connected sensors. It ensures uninterrupted operation of the system, making it suitable for portable and remote monitoring applications.

Hardware Components:

MAX30100 Heart Rate Sensor: Measures heart rate and blood oxygen levels, providing vital insights into cardiovascular health.

ADXL335 Accelerometer: Captures movement and orientation data to monitor activity levels and detect anomalies such as injuries or inactivity.

DS18B20 Temperature Sensor: Tracks body temperature, detecting fever or hypothermia as indicators of illness.

GSR Sensor: Measures skin conductivity to assess stress levels and detect physiological changes.

BME680 Environmental Sensor: Monitors ambient temperature, humidity, air pressure, and air quality to ensure optimal living conditions.

NEO-6M GPS Module: Enables real-time location tracking to prevent cattle loss and ensure security.

Battery Module: Provides a stable power source for the wearable device, ensuring uninterrupted operation.

The IoT-based system transmits collected data to a cloud platform, where farmers can access real-time health metrics via a mobile app. This allows proactive decision-making and timely medical intervention.

Results and Observations

The system was tested on multiple cows, continuously tracking their health parameters and environmental conditions. A sample dataset collected from one cow is shown below:



Fig 2 : Cow with Monitoring Belt

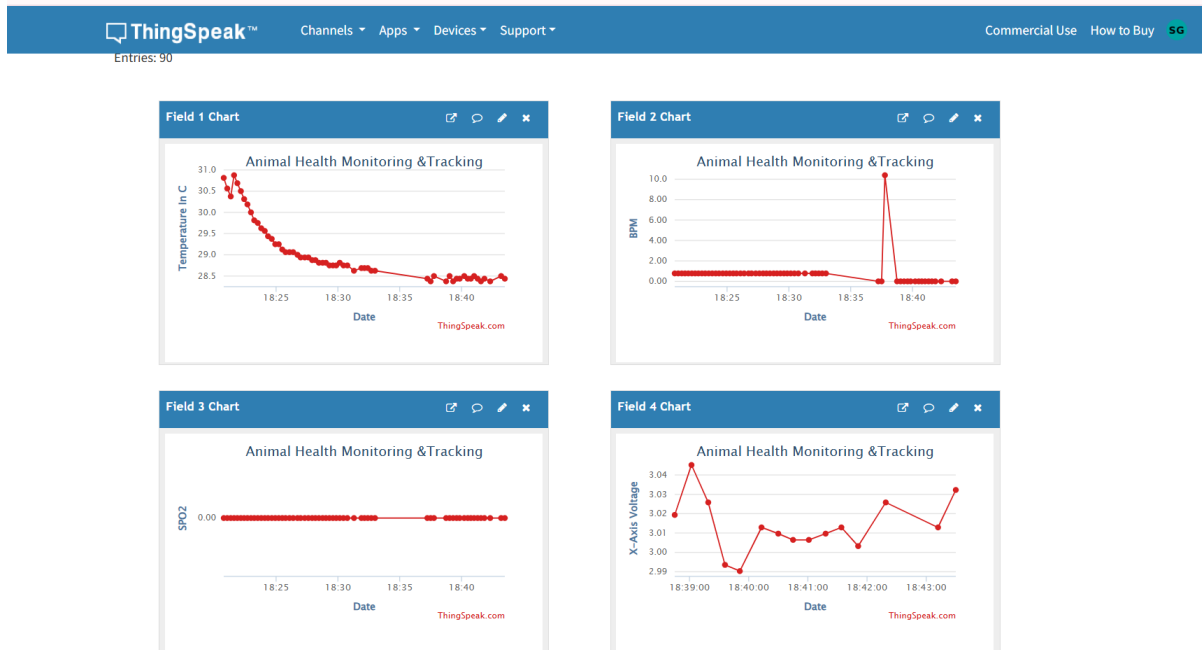


Fig 3: Real-time monitoring of health parameters using ThingSpeak

Table 1. Health Monitoring Data for Cow

Time	Temperature (°C)	Heart Rate (BPM)	Activity (Voltage)	GSR Value	Location
6:00 AM	37.5	60	2.5	50	18.5092N, 79.9769E
12:30 PM	39.0	65	2.3	45	18.5091N, 78.9767E
6:00 PM	38.5	62	2.4	48	18.5092N, 78.9763E

Table2 .Environmental Monitoring Data

Time	Temperature (°C)	Humidity (%)	Pressure (hPa)	Gas Resistance (Ohm)
6:00 AM	25.77	73.45	985.57	53.82
12:30 PM	38.95	50.38	959.69	50.13
6:00 PM	23.14	77.64	990.44	59.58

The data confirmed the system's capability to monitor cattle health effectively. Heart rate and body temperature variations were observed throughout the day, while GPS tracking ensured the cattle remained within designated grazing areas.

Conclusion

Vital health indices and environmental factors can be tracked in real time with the proposed IoT-based cattle health monitoring system. Farmers may proactively control the health of their cattle and lower death rates and financial losses by combining a number of sensors with a cloud-based platform. The method is appropriate for large-scale dairy farming operations because to its cost-effectiveness and scalability. Future advancements will concentrate on boosting AI-powered analytics for prognostic health evaluations and increasing device power efficiency for extended use.

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