

**DURBAN UNIVERSITY OF TECHNOLOGY**

**Smart Monitoring Dashboard for Livestock in Rural Areas Using Nanotechnology-Enabled Devices**

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DECLARATION

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**Research Scope**

This research focuses on developing an advanced livestock monitoring and tracking system using nanotechnology to address the limitations of current solutions. Existing livestock tracking methods fail to detect whether an animal is still alive, has been standing in one position for too long, or has been stolen. To overcome these challenges, this study explores the integration of Nano sensors that can continuously monitor vital signs such as heart rate, temperature, and movement patterns in real-time.

The research will involve designing and implementing Nano sensors that can be embedded into livestock for precise health and location tracking. These sensors will transmit data wirelessly to a cloud-based system, where farmers can receive alerts through a mobile application when abnormal activity is detected. The system will incorporate machine learning algorithms to analyse livestock behaviour, helping farmers identify potential health issues, inactivity, or theft risks more accurately.

The scope of the study includes testing the accuracy, efficiency, and durability of the Nano sensors under different environmental conditions. It also examines the effectiveness of real-time tracking in reducing livestock losses due to theft or undetected health problems. Additionally, the research explores energy-efficient solutions for Nano sensor operation, ensuring long-term usability in remote farming areas.

This study is limited to the initial design, prototype testing, and evaluation of the nanotechnology-based tracking system. Future work may involve large-scale implementation and further refinements to enhance system reliability and adoption in the agricultural sector.

**Keywords: Cattle Tracking Technology, GPS Live stock tracking,**

**Link(**[IEEE Xplore Search Results](https://ieeexplore.ieee.org/search/searchresult.jsp?queryText=Livestock%20health%20monitoring&highlight=true&returnType=SEARCH&matchPubs=true&ranges=2020_2024_Year&returnFacets=ALL&refinements=ContentType:Journals), [IEEE Xplore Search Results](https://ieeexplore.ieee.org/search/searchresult.jsp?newsearch=true&queryText=Cattle%20Tracking%20Technology)

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**RFID technology**

RFID technology has been widely explored for its role in livestock management, particularly in tracking and monitoring animals to enhance traceability, productivity, and decision-making in farming operations. It improves traceability by providing unique identifiers for animals, which helps with disease control and food safety. The integration of RFID with mobile applications further enhances real-time data access, improving herd management and health monitoring.

Despite these benefits, several challenges hinder widespread adoption. One significant issue is the high cost of implementation, as RFID tags and readers remain expensive, making it difficult for small-scale farmers to adopt the technology. Additionally, seamless integration of RFID data with cloud-based databases and mobile applications is essential for effective livestock management, yet many existing systems lack proper integration with farm management software, reducing their efficiency. Hardware limitations, including global chip shortages, have also slowed the production of advanced RFID devices. Furthermore, signal interference, particularly in metal-rich environments, affects data accuracy, while security risks such as unauthorized access to livestock information present additional concerns.

RFID technology enables real-time data collection and secondary data analysis in livestock management, capturing key animal metrics such as weight, movement, and medication history to help farmers make informed decisions. Analyzing usage statistics from RFID readers and mobile apps can further optimize system functionality by tracking user interactions and improving design. Future advancements in RFID technology are expected to focus on integrating Artificial Intelligence to enhance decision-making in livestock tracking. As costs decrease, adoption is likely to expand beyond cattle to include smaller livestock species like sheep and poultry. Additionally, improvements in Bluetooth and Wi-Fi-enabled RFID readers will enhance connectivity, allowing real-time data transfer to cloud systems for more efficient remote monitoring.

While RFID has shown significant potential in livestock management, a gap remains in addressing its limitations through innovative technologies. One emerging solution is the integration of nanotechnology with RFID systems. Nanotechnology can enhance RFID sensors by improving their sensitivity, durability, and efficiency, potentially reducing costs and making the technology more accessible to small-scale farmers. Nano-enabled RFID tags could offer better data accuracy, lower energy consumption, and improved resistance to environmental factors such as extreme weather conditions or signal interference. Additionally, the use of nanosensors in animal tracking could provide real-time health monitoring at a molecular level, detecting early signs of disease before visible symptoms appear. However, research on the combination of RFID and nanotechnology in livestock management remains limited, creating an opportunity for further exploration and development to address existing challenges and improve the effectiveness of animal tracking systems.

**TRACKING USING IOT AND GPS**

The research addresses the inefficiencies of traditional livestock monitoring methods, which rely heavily on manual observation. This approach often results in the inability to detect health issues early, significant labour intensity, inconsistent data collection, and challenges in tracking livestock movement. To overcome these limitations, the study proposes an IoT-based livestock health monitoring and GPS location tracking system, utilizing real-time data transmission and cloud storage via Google Firebase. The system integrates sensors such as the DHT11 and MLX90614 for temperature and humidity monitoring, as well as an ESP32 microcontroller for data collection and transmission using the nRF24L01+PA+LNA module. The data is processed and stored in Firebase, enabling farmers to access real-time updates via a mobile application developed in Flutter, which also integrates Google Maps for GPS tracking. Calibration and testing of the sensors ensure accuracy, with plans for further testing on live livestock to validate the system’s practical application.

The findings highlight the system’s effectiveness in monitoring livestock health parameters such as temperature, heart rate, and environmental conditions, with notifications sent to farmers when abnormalities are detected. The system successfully transmits data over a distance of 413 meters, surpassing traditional Wi-Fi capabilities, and offers millisecond updates through Firebase for real-time decision-making. The mobile application provides an intuitive interface for monitoring livestock data, though further improvements, such as enhancing sensor contact and adopting energy-efficient solutions like mesh networking, are needed. The current prototype, tested in a laboratory setting, faces challenges such as high power consumption, environmental limitations affecting data transmission, sensor calibration inaccuracies, and mobile connectivity issues in rural areas. Additional refinements, including solar-powered energy solutions and improved sensor placement, are recommended to enhance the system’s practicality.

Furthermore, the research explores GPS tracking and accelerometer-based methods for livestock monitoring on rangelands, addressing challenges related to grazing behaviour, health monitoring, and labour intensity. GPS collars provide continuous tracking of livestock movements, while accelerometers capture behavioural patterns such as grazing, resting, and traveling. The collected data is analysed using GIS software to assess grazing distribution and movement efficiency. This approach allows for improved livestock management strategies, enabling optimized grazing patterns, enhanced health monitoring, and real-time response capabilities. Additionally, genetic markers associated with livestock movement have been identified, suggesting the potential for selective breeding to enhance grazing distribution efficiency. Overall, the study demonstrates the advantages of integrating IoT and GPS technologies in livestock monitoring, providing a scalable solution that enhances productivity, reduces labour requirements, and improves animal welfare. However, further field testing and refinements are necessary to address power consumption, environmental constraints, and sensor accuracy, ensuring a fully functional and reliable system for real-world agricultural applications.

**Advancements in Precision Livestock Health Monitoring: Early Disease Detection and Noninvasive Temperature Tracking in Cattle**

The two articles address critical challenges in livestock health management, focusing on early disease detection and non-invasive monitoring. The first article tackles the early diagnosis of Bovine Respiratory Disease (BRD) in dairy calves, a significant health issue causing high mortality and economic losses. The second article focuses on developing a noncontact system for monitoring body temperature in cattle, which is essential for early fever detection and overall health management. Both studies leverage precision technologies and machine learning to provide innovative solutions, but they differ in their specific objectives, datasets, methodologies, and findings.

The BRD study emphasizes the labour-intensive nature of traditional diagnosis methods and the shortage of skilled labour, particularly exacerbated by the COVID-19 pandemic. To address this, the authors propose a framework that integrates IoT-based precision technologies to monitor calves' behaviour, such as feeding patterns and activity levels, to detect BRD before clinical signs appear. The dataset used in this study includes data from 159 calves, combining automatic sensor data (e.g., pedometers and RFID-tagged feeders) with manual health examinations. The methodology involves data collection, processing, and feature selection using a cost-sensitive approach called Cost Optimization Worth (COW). Machine learning models are then applied to predict BRD status, achieving diagnostic accuracies of up to 88% for BRD detection, 70% for perfick status, and 80% for chronic cases. The study highlights the importance of optimizing feature selection to balance prediction accuracy and budget constraints. However, limitations include the dataset's limited generalizability, dependence on sensor accuracy, and high initial costs for precision technologies.

In contrast, the second article addresses the inefficiency and stress caused by traditional health monitoring methods, such as blood tests and manual temperature measurements. The authors propose a noncontact system that uses infrared (IR) imaging, environmental data, and machine learning to estimate deep body temperature in cattle. The dataset includes 315 data sets, with environmental parameters (temperature, humidity, illuminance), IR images, and deep body temperature measurements (vaginal temperature) as the target variable. The methodology involves developing regression models (linear regression, polynomial regression, SVR, KNN, RF) and incorporating moving distance data to improve accuracy. The system achieves high accuracy in estimating rumen temperature, with an R² value of 0.826, and demonstrates the ability to detect health abnormalities like rumen acidosis. However, the study acknowledges limitations such as the initial testing on a single subject, challenges in measuring moving distance, and the need for long-term validation across different conditions and breeds.

Both studies demonstrate the potential of integrating precision technologies and machine learning to improve livestock health management. The BRD study focuses on early disease detection through behavioural monitoring, while the noncontact temperature monitoring study emphasizes non-invasive health tracking. Despite their advancements, both studies identify gaps that need addressing. The BRD study's reliance on specific sensor technologies and its limited generalizability highlight the need for broader validation across different breeds and environments. Similarly, the noncontact temperature monitoring study's dependence on a single subject and challenges in continuous measurement underscore the necessity for further research to enhance system robustness and applicability.

A notable gap in both studies is the lack of integration between behavioural monitoring (as in the BRD study) and physiological monitoring (as in the temperature study). Combining these approaches could provide a more comprehensive health management system, enabling early detection of both behavioural and physiological changes indicative of disease. Additionally, both studies highlight the need for cost-effective solutions to make these technologies accessible to a wider range of farmers, particularly those with limited budgets. Future research could explore hybrid models that integrate multiple data sources, improve sensor reliability, and reduce costs, ultimately bridging the gap between advanced technology and practical farm applications.

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