AI-POWERED IOT SYSTEM FOR REAL-TIME LIVESTOCK HEALTH MONITORING AND LOCATION TRACKING

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ABSTRACT

The integration of Artificial Intelligence (AI), Machine Learning (ML), and the Internet of Things (IoT) in agriculture has revolutionized livestock management by enabling real-time health monitoring and location tracking. This paper presents an AI and ML-powered IoT system designed to enhance livestock welfare, optimize farm operations, and improve productivity. The system employs wireless sensors, GPS technology, and AIdriven analytics to continuously monitor vital health parameters such as body temperature, heart rate, movement patterns, and feeding behavior. Data is transmitted via an ESP32 microcontroller to a cloud-based platform, where ML algorithms analyze patterns, predict diseases, and detect anomalies. Farmers receive real-time notifications through a mobile or web application, enabling immediate intervention in case of health issues or unusual behavior. Additionally, GPS-based tracking prevents theft, optimizes grazing patterns, and manages herd movement efficiently. By combining AI's predictive analytics, ML-based health diagnostics, and IoT's real-time data acquisition, this system provides a costeffective, scalable, and intelligent solution for modern livestock farming, ensuring better animal health, reduced losses, and enhanced farm profitability.

Keywords: AI, ML, IoT, Livestock Health Monitoring, GPS Tracking, ESP32, Smart Farming, Predictive Analytics.

I INTRODUCTION

Livestock farming is a crucial part of global food production and rural economies, but traditional methods of livestock management often face significant challenges. Farmers struggle with delayed disease detection, inefficient resource utilization, theft, and difficulty in tracking animal movements across vast areas. Poor health monitoring leads to increased mortality rates, reduced productivity, and higher operational costs. In recent years, advancements in Artificial Intelligence (AI) and the Internet of Things (IoT) have opened new avenues for real-time livestock health monitoring and location tracking, providing a more intelligent and data-driven approach to farm management.

An AI-powered IoT system integrates wireless sensors, cloud computing, and machine learning (ML) algorithms to monitor key health parameters such as body temperature, heart rate, activity levels, and feeding behavior. These sensors collect and transmit realtime data to a cloud-based platform via microcontrollers like ESP32. AI-powered analytics process this data to detect anomalies, predict diseases, and alert farmers about potential health risks. Additionally, GPS-based location tracking helps prevent theft, monitor grazing patterns, and optimize herd management. By automating livestock health diagnostics and security measures, AI-driven IoT systems reduce human intervention, improve decision-making, and enhance farm productivity. This paper proposes an AIpowered IoT system for real-time livestock monitoring, aiming to ensure early disease detection, theft prevention, improved farm efficiency, and sustainable livestock management.

II LITERATURE REVIEW

The integration of Artificial Intelligence (AI) and the Internet of effects (IoT) in beast operation has led to significant advancements in real- time health monitoring and position shadowing. colorful studies have explored different approaches to enhance beast weal and productivity." COGNIHERD Livestock Health Monitoring Using Artificial Intelligence" (2025) by K. Darvesh et al. introduces the CogniHerd system, which employs AI and IoT technologies using ESP8266, Arduino Uno, and colorful detectors to collect real- time physiological and behavioral data. also," IOT and AI Grounded Smart Cattle Health Monitoring"(2023) by K. Darvesh, N. Khande, S. Avhad, and M. Khemchandani presents an IoT- grounded system that monitors cattle's heart rate, exertion situations, ambient temperature, and sleep patterns, integrating machine literacy algorithms for prophetic health analysis. In" AI Grounded Digital Twin Model for Cattle minding"(2022), Xue Han and Zihuai Lin developed a digital binary model using ranch IoT data to enable real- time monitoring and vaticination of cattle health countries. also," Deep literacy- Grounded Cattle exertion Bracket Using common Time- frequence Data Representation"(2020) by Seyedeh Faezeh Hosseini Noorbin et al. utilizes deep neural networks to classify cattle geste through time- frequence detector data analysis, abetting automated health monitoring. Another study," Animal Former Multimodal Vision Framework for Behavior- Grounded Precision Livestock Farming"(2024) by Ahmed Qazi, Taha Razzaq, and Asim Iqbal, introduces a multimodal AI- grounded vision frame that analyzes beast geste using videotape data, furnishing perceptivity into exertion patterns and relations. likewise," IoT- Driven Livestock Health Monitoring A Sensor- Based Software" (2024) by the International Journal of Research in Engineering and Technology presents a detector- grounded software system that monitors health parameters similar as body temperature, heart rate, and reflection patterns, enabling complaint vaticination and theft forestallment. " IoT- Grounded Beast Monitoring with Location Tracking and Smart Feeding" (2024) by Suhas A. Bhyratae et al. integrates IoT and cloud calculating for health monitoring, position shadowing, and smart feeding, using machine literacy for prophetic analysis. also," An IoT Livestock Health Monitoring System for growers" (2023) by Sheikh et al. introduces an IoT- grounded system for real- time physiological monitoring and data visualization through a web operation, easing timely interventions. Another study," IoT

Enabled Livestock Management" (2024) by the International Journal of Research Publication and Reviews, investigates the perpetration of IoT results for real- time health shadowing and behavioral analysis, addressing benefits and challenges. Incipiently," IoT Applications for Livestock Management and Health Monitoring in Smart Farming" (2024) by Dr. Akshaya Kumar Mohanty et al. evaluates colorful IoT bias for beast health monitoring, complaint forestallment, and reproductive health shadowing while agitating challenges related to connectivity, data security, and setup costs. These studies punctuate the transformative eventuality of AI and IoT in beast operation, perfecting productivity, complaint forestallment, and overall ranch effectiveness.

III EXISTING SYSTEM

The existing system for livestock health monitoring primarily relies on IoT-enabled wearable devices that track key physiological parameters such as skin temperature, heart rate, and movement using an accelerometer. These real-time readings are transmitted to a cloud-based database, where farmers and veterinarians can access health data remotely. However, while this system offers real-time monitoring, it still has certain limitations. The reliance on raw sensor data without advanced predictive analytics restricts the ability to detect diseases early.

Additionally, many existing solutions do not integrate machine learning (ML) models to analyse historical trends and predict potential health issues, leading to reactive rather than proactive healthcare management. Moreover, while the cloud database allows for centralized data storage, it may not always provide deep insights into livestock health patterns. As a result, current livestock monitoring systems require further advancements in AI and predictive analytics to enhance early disease detection, improve decisionmaking, and reduce operational costs.

IV DISADVANTAGES

The existing system lacks GPS tracking, making it difficult to monitor the real-time location of livestock and prevent theft. Additionally, while health parameters such as skin temperature, heart rate, and movement are monitored, there is no dedicated real-time alert system for immediate response, limiting timely intervention. Farmers still rely on manual monitoring, as they must check data from the cloud instead of receiving automated alerts, which can delay critical decision-making. Furthermore, the system does not account for environmental factors such as weather conditions or ambient temperature, which can significantly impact livestock health. These limitations highlight the need for a more comprehensive solution that integrates real-time alerts, automated notifications, and environmental monitoring to enhance livestock management.

V FLOW CHART

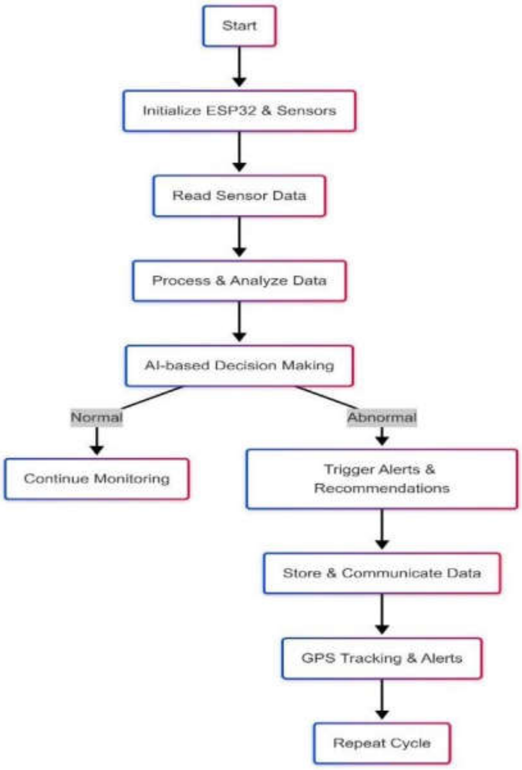

Fig.1: Proposed system flow chart

VI PROPOSED METHODOLOGY

The proposed system utilizes an ESP32 microcontroller to integrate both physiological and environmental sensors for comprehensive livestock monitoring. Physiological sensors collect vital health parameters such as temperature, heart rate, and movement, while environmental sensors track external factors like ambient temperature and humidity. The system is powered through a dedicated power supply and stores collected data on a MicroSD card for local backup. For real-time communication, the system employs a communication module that supports both Wi-Fi and GSM networks.

Data is transmitted via Wi-Fi to ThingSpeak or through a mobile network for cloud storage, ensuring accessibility from remote locations. The cloud storage system enables continuous data availability and real-time monitoring through a dashboard and analytics platform, allowing farmers to visualize trends and receive timely insights. This IoT-based solution enhances livestock management by enabling automated data collection, real-time alerts, and predictive analytics for early disease detection, improving overall animal health and farm productivity.

VII ADVANTAGES

An AI-powered IoT system offers significant advantages over traditional livestock monitoring methods by enhancing real-time health tracking, predictive analytics, and operational efficiency. Continuous monitoring of body temperature, heart rate, movement, and feeding behaviour allows for early disease detection, reducing mortality rates through timely veterinary intervention. Machine learning models analyse real-time data to detect patterns of illness and send automated alerts to farmers via mobile applications, enabling swift responses before visible symptoms appear. Additionally, GPS-enabled collars and geo-fencing technology provide automated location tracking, preventing theft and unauthorized movement, while AI-integrated drones and surveillance cameras further enhance farm security. Beyond health monitoring, AI optimizes productivity by managing feeding schedules based on livestock health, weight gain, and reproductive status, reducing manual labour through automated water and feeding systems. The system also proves cost-effective by minimizing veterinary expenses through early disease detection and is highly scalable for different farm sizes and livestock types, including cattle, sheep, poultry, and swine.

Furthermore, AI enhances environmental adaptation by analysing climate conditions and suggesting sheltering or watering adjustments to protect livestock from extreme temperatures, thereby reducing weather-related losses. In addition to improving livestock management, AI-powered IoT systems integrate with smart supply chains through blockchain technology, ensuring transparency in meat and dairy tracking before reaching the market. This prevents fraud and enhances food quality assurance. Overall, the implementation of AI and IoT in livestock farming transforms traditional methods into a more intelligent, automated, and scalable solution, improving animal health, farm security, and resource optimization.

VIII APPLICATION

The proposed AI-powered IoT system for livestock monitoring has diverse applications that enhance animal health management and farm productivity. By continuously tracking vital parameters such as body temperature, heart rate, and movement, the system enables early disease detection, reducing mortality rates and preventing outbreaks. AI-driven analytics provide automated health alerts and predictive diagnosis, allowing farmers and veterinarians to intervene promptly. Remote monitoring through cloud-based analytics ensures that farmers can access real-time health data via mobile applications, while historical data analysis helps improve decision-making. Additionally, AI optimizes

feeding schedules based on livestock health, weight gain, and reproductive status, while automated feeding and watering systems reduce manual labour and resource wastage. The system also minimizes veterinary costs by focusing on disease prevention and early detection, leading to lower emergency medical expenses. By automating data collection and monitoring, farm productivity is significantly improved, with better insights into breeding patterns and reproductive health. Designed for scalability, this system can be adapted for various livestock types, including cattle, sheep, poultry, and swine, making it suitable for both small-scale and large-scale farming operations.
Furthermore, its integration with smart agriculture systems ensures sustainable livestock farming by optimizing resource utilization. Overall, the AI-powered IoT system transforms traditional livestock management by combining real-time monitoring, predictive analytics, and automation, leading to improved efficiency, cost savings, and better animal health outcomes.

IX RESULT AND CONCLUSION

The implementation of the proposed IoT-based livestock monitoring system using the ESP32 microcontroller has demonstrated significant improvements in real-time animal health tracking and farm management. The integration of physiological and environmental sensors enables continuous data collection on vital parameters such as temperature, heart rate, and surrounding conditions. This data is efficiently processed and stored using a microSD card and transmitted via Wi-Fi or GSM networks to cloud-based platforms like ThingSpeak. The availability of real-time data on a cloud dashboard allows farmers to make informed decisions, optimizing animal care, reducing manual intervention, and improving overall productivity. In conclusion, the proposed system effectively enhances livestock management by automating health monitoring, enabling remote access to data, and providing timely alerts for disease prevention.The scalable and cost-effective nature of this system makes it suitable for both small and large-scale farms, ensuring better resource utilization and improved livestock well-being. Future enhancements can include AI-driven analytics for predictive health monitoring, automated feeding systems, and blockchain integration for improved supply chain transparency.

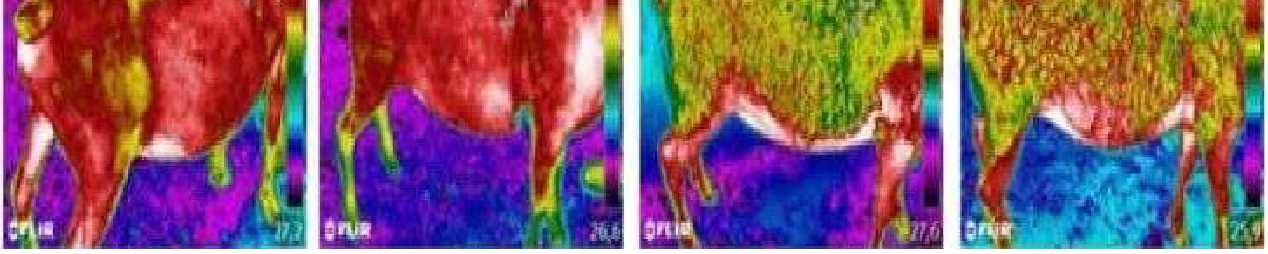

Fig 2 : Thermographic Analysis of Livestock for Health Monitoring

Thermographic analysis using infrared thermal imaging offers numerous advantages in livestock health monitoring. It aids in stress and pain detection by identifying abnormal temperature variations, which is particularly useful for post-surgical recovery and injury management. In reproductive health monitoring, it helps detect estrus cycles by recognizing hormonal temperature changes, improving breeding efficiency. Farmers can also use thermal imaging to identify early signs of mastitis in dairy cattle, as infected udders exhibit increased heat levels before clinical symptoms appear. Additionally, variations in abdominal temperature can signal digestive issues such as bloating or indigestion, enabling timely interventions. When integrated with AI and IoT systems, thermal imaging can generate automated health alerts, allowing immediate action if abnormal patterns are detected. It is also useful for assessing environmental stress, helping farmers implement measures to prevent heat stress or hypothermia. On a larger scale, the technology facilitates herd-level health management by identifying sick animals early and preventing disease outbreaks. Being a non-invasive and contact-free method, it reduces stress for animals and minimizes the risk of cross-contamination. Furthermore, by monitoring livestock thermal comfort, farmers can optimize ventilation, cooling, or heating systems, leading to energy efficiency and better environmental control. Ultimately, regular thermal monitoring ensures healthier livestock, contributing to improved growth rates, better milk production, and higher reproductive success, thereby boosting overall farm profitability.

Fig 3: IoT-Based Health Monitoring System for Livestock Using ThingSpeak Dashboard

The displayed ThingSpeak dashboard provides real-time monitoring of vital health parameters in livestock using IoT-based sensors. Each field chart represents time-series data collected from biometric sensors, which are essential for ensuring animal well-being. The temperature graph helps detect fever or hypothermia, enabling early disease identification. The pressure data can be correlated with respiratory health, while humidity levels play a role in preventing heat stress and dehydration. Light intensity monitoring helps regulate exposure to optimal lighting conditions, improving animal comfort and productivity. By leveraging IoT technology and cloud-based analytics, farmers can continuously track livestock health, receive real-time alerts for abnormal readings, and take preventive measures to reduce mortality rates. The integration of such smart monitoring systems enhances disease prevention, minimizes veterinary costs, and promotes sustainable livestock management.

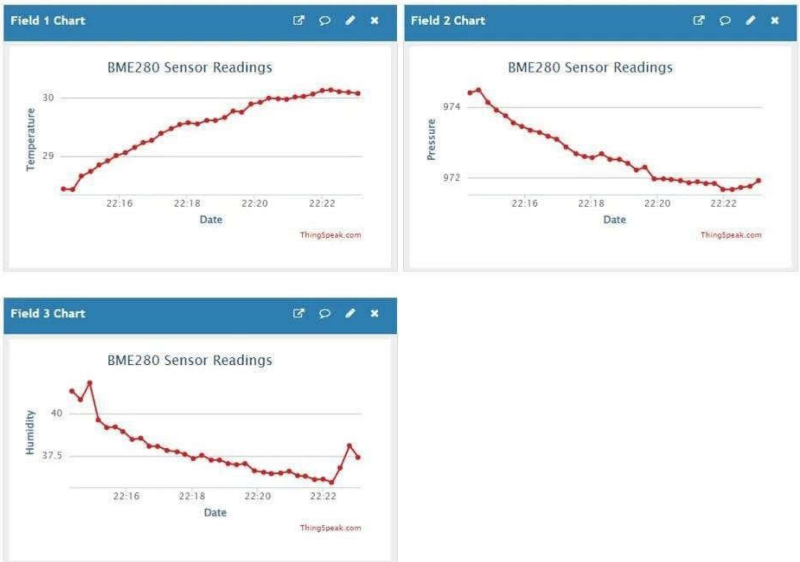

Fig 4 : IoT-Based Environmental Monitoring Dashboard in ThingSpeak

The data visualization on the ThingSpeak platform provides real-time monitoring of environmental parameters using the BME280 sensor, which measures temperature, pressure, and humidity. The temperature graph shows a gradual increase, indicating a warming trend, while the pressure graph exhibits a decline, suggesting possible atmospheric changes. The humidity graph demonstrates a decreasing trend, followed by a slight rise, highlighting fluctuations in environmental moisture levels. By leveraging cloud-based analytics, this system enables remote access to critical sensor data, allowing farmers to track environmental conditions affecting livestock. Such insights help in optimizing farm management by adjusting ventilation, hydration, and sheltering strategies to ensure animal well-being. The integration of IoT with real-time monitoring enhances decision-making, reduces manual labour, and improves overall efficiency in livestock farming.

X FUTURE SCOPE

The integration of IoT-based livestock monitoring systems is poised for significant advancements in the coming years. Future developments will focus on enhancing realtime health monitoring by incorporating advanced biosensors for detecting diseases, stress levels, and behavioural anomalies in livestock. AI-driven predictive analytics will enable early disease detection, reducing economic losses and improving animal welfare. GPSenabled smart collars, like the one shown in the image, will play a crucial role in livestock tracking, geofencing, and optimizing grazing patterns to improve farm efficiency.

Fig 5: Smart Livestock Monitoring

The use of 5G and edge computing will further enhance data transmission speed, allowing farmers to make instant decisions based on real-time analytics. Additionally, blockchain technology can be integrated to ensure transparency in livestock management, from farm to consumer. These advancements will contribute to sustainable farming practices, improved productivity, and better livestock health management, revolutionizing the agricultural industry.

XI REFERENCES

1) *Atzori, L., Iera, A., & Morabito, G. (2010). The Internet of Things: A survey. Computer Networks, 54(15), 2787-2805. doi:10.1016/j.comnet.2010.05.010*
Provides an overview of IoT technology, architecture, and challenges, foundational to understanding IoT applications in agriculture.
2) *Misra, S., Repswal, M., & Pal, S. (2021). IoT-based livestock monitoring: Current trends and future perspectives. IEEE Internet of Things Journal, 8(10), 8491-8508. doi:10.1109/JIOT.2021.3048982*

Discusses IoT-based livestock monitoring solutions, focusing on sensor technologies, data analytics, and implementation challenges.

3) *Jin, X., & Guo, H. (2019). A survey of livestock monitoring techniques using IoT-based technologies. Sensors, 19(7), 1787. doi:10.3390/s19071787*
   Surveys various IoT-based livestock monitoring techniques, focusing on the integration of different types of sensors and data fusion.
4) *Rojas, C., Masis, J., & Guevara, D. (2020). Real-time cattle monitoring system using IoT and computer vision.*
   International Journal of Advanced Computer Science and Applications, 11(7), 234-240. doi:10.14569/IJACSA.2020.0110730*
5) *Explores the use of IoT sensors and computer vision for cattle behavior recognition, including the challenges of real-time data processing.*
   Aggarwal, C. C. (2013). Data mining: The textbook. Springer.
   Provides a comprehensive overview of data mining techniques, including methods for handling multimodal data fusion and behavior recognition.
6. *Schieltz, J.M.; Okanga, S.; Allan, B.F.; Rubenstein, D.I. GPS tracking cattle as a monitoring tool for conservation and management. Afr. J. Range For. Sci.* ***2017****, 34, 173–177. [Google Scholar]*
7. *Fogarty, E.S.; Swain, D.L.; Cronin, G.; Trotter, M. Autonomous on-animal sensors in sheep research: A systematic review. Comput. Electron. Agric.* ***2018****, 150, 245–256. [Google Scholar] [CrossRef]*
8. *Rodgers, A.R. Tracking animals with GPS: The first 10 years. In Tracking Animals with GPS: An International Conference Held at the Macaulay Land Use Research Institute; Macaulay Land Use Research Institute: Aberdeen, Scotland, 2001; pp. 1–10. [Google Scholar]*
9. *Evans, J.C.; Dall, S.R.X.; Bolton, M.; Owen, E.; Votier, S.C. Social foraging European shags: GPS tracking reveals birds from neighbouring colonies have shared foraging grounds. J. Ornithol.* ***2016****, 157, 23–32. [Google Scholar] [CrossRef]*
10. *Tomkiewicz, S.M.; Fuller, M.R.; Kie, J.G.; Bates, K.K. Global positioning system and associated technologies in animal behaviour and ecological research. Philos. Trans. Roy. Soc. B* ***2010****, 365, 2163–2176. [Google Scholar] [CrossRef] [PubMed] [Green Version]*
11. *Pelusi, L.; Passarella, A.; Conti. Opportunistic networking: Data forwarding in disconnected mobile ad hoc networks. IEEE Commun. Mag.* ***2006****, 44, 134–141. [Google Scholar] [CrossRef]*
12. *Mekki, K.; Bajic, E.; Chaxel, F.; Meyer, F. A comparative study of LPWAN technologies for large-scale IoT deployment. ICT Express* ***2019****, 5, 1–7. [Google Scholar] [CrossRef]*
13. *Raza, U.; Kulkarni, P.; Sooriyabandara, M. Low Power Wide Area networks: An overview. IEEE Commun. Surv. Tut.* ***2017****, 19, 855–873. [Google Scholar] [CrossRef]*
14. *Berckmans, D. General introduction to precision livestock farming. Anim. Front.* ***2017****, 7, 6–11. [Google Scholar] [CrossRef] [Green Version]*