



# REAL-TIME LIVESTOCK HEALTH AND ACTIVITY MONITORING SYSTEM USING AI-BASED PATTERN RECOGNITION IN ANIMAL HUSBANDRY

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**Abstract:** Livestock farming plays a vital role in agricultural productivity, food security, and rural economic development, but continuous animal health monitoring remains difficult because traditional supervision depends on manual observation and delayed veterinary response. This study presents an intelligent livestock health and activity monitoring system using deep learning, embedded automation, and IoT communication for early disease detection and farm management. Images of healthy cattle and cattle affected by Lumpy Skin Disease are collected from a Kaggle dataset and used to train a CNN-VGG19 classification model. The trained model is deployed in a Flask based web application for real time disease prediction using uploaded animal images. Prediction results are transmitted to an Arduino UNO through serial communication for automated decision making. When disease is detected, the system activates a chemical sprayer and displays alerts on an LCD module. Healthy cattle continue under normal monitoring conditions. Additional features include RFID based boundary monitoring, manual food and water control through the Blynk application, and LCD based system status display. Experimental analysis demonstrates improved disease response efficiency, reduced labor dependency, and effective livestock safety monitoring for modern animal husbandry applications. The proposed framework supports reliable automated livestock supervision in small and medium scale farms efficiently.

**Index Terms** – Livestock Monitoring, Lumpy Skin Disease, CNN-VGG19, Deep Learning, Arduino UNO, Flask Application, RFID Monitoring, IoT Based Automation, Animal Health Detection.

## I. INTRODUCTION

Agriculture has undergone significant technological transformation with the adoption of artificial intelligence, embedded systems, and Internet of Things technologies to improve productivity, automation, and operational efficiency. Smart monitoring systems are increasingly being implemented in agricultural environments to reduce manual effort, improve decision making, and support sustainable farm management practices. Among different agricultural sectors, livestock farming requires continuous supervision because animal health, feeding conditions, hydration, and safety directly affect dairy production, meat quality, and economic stability. Traditional livestock management methods rely heavily on manual observation and periodic veterinary inspection, which are often inefficient, time consuming, and unable to provide early disease identification. Delayed recognition of infectious diseases can result in reduced productivity, higher treatment expenses, and rapid disease transmission among cattle populations [1]. Recent developments in deep learning and computer vision have enabled automated disease detection systems capable of analyzing

animal images with high classification accuracy. Convolutional Neural Networks are widely used for image based disease prediction because they effectively extract visual features such as lesions, swelling, abnormal skin texture, and visible infections from cattle images [2]. Integration of deep learning models with embedded controllers and IoT communication technologies has further improved automation capabilities in livestock monitoring systems. These intelligent systems can support real time disease prediction, automated response mechanisms, and remote farm supervision with reduced human dependency [3]. Lumpy Skin Disease is one of the major viral infections affecting cattle worldwide and has become a serious concern for livestock farmers because of its rapid spread and economic impact. The disease causes visible symptoms including skin nodules, fever, swelling, reduced milk production, and body weakness. Early identification of infected cattle is essential to prevent disease transmission and minimize productivity loss. However, existing livestock management approaches generally lack intelligent frameworks capable of performing automated disease analysis and rapid response operations. Most conventional systems also do not provide integrated monitoring for animal tracking, feeding management, and real time system status visualization [4]. This study presents an intelligent livestock health and activity monitoring system using a CNN-VGG19 model integrated with Arduino UNO, Flask application, RFID technology, LCD monitoring, and IoT based automation. Images of healthy cattle and cattle affected by Lumpy Skin Disease are collected from a publicly available Kaggle dataset and used for training and testing the CNN-VGG19 classification model. The trained model is deployed within a Flask based web application to perform image based disease prediction in real time. Uploaded cattle images are analyzed by the system to determine whether the animal is healthy or infected with Lumpy Skin Disease [5]. The prediction result generated by the Flask application is transmitted to the Arduino UNO through serial Rx and Tx communication using predefined control signals. When a disease condition is detected, the Arduino activates a chemical sprayer and displays warning messages on the LCD module. Under healthy conditions, normal monitoring operations continue without initiating disease alerts or spraying actions. The system also incorporates RFID based animal boundary monitoring to determine whether cattle remain inside or outside designated farm areas. Food dispensing and water supply operations are manually controlled through the Blynk application using ON and OFF commands for improved livestock management efficiency [6]. Continuous system monitoring is achieved through LCD based status display, enabling farmers to observe disease prediction results, spraying conditions, RFID alerts, and operational activities in real time. The integration of deep learning, embedded automation, RFID tracking, and IoT communication technologies demonstrates a practical solution for intelligent livestock supervision. The proposed system aims to reduce labor dependency, improve disease response efficiency, enhance animal safety, and support modern technology driven livestock farming practices suitable for small and medium scale agricultural environments.

## II. RELATED WORKS

Recent research in intelligent livestock monitoring has focused on combining artificial intelligence, image processing, embedded systems, and IoT communication technologies to improve disease detection and farm management efficiency. Deep learning based livestock health analysis systems have demonstrated strong capability in identifying visible disease symptoms from animal images. Researchers emphasized that traditional livestock monitoring approaches are inefficient because farmers cannot continuously supervise large numbers of animals in real time. Automated systems based on computer vision and machine learning have therefore become an important research direction in precision agriculture [7]. Several studies investigated the application of Convolutional Neural Networks for animal disease classification using image datasets collected from farms and online repositories. CNN architectures are preferred because of their ability to automatically extract visual features such as skin lesions, swelling, abnormal posture, and infection patterns without manual feature engineering. Research conducted on cattle disease detection reported that deep learning models outperform traditional machine learning techniques in classification accuracy. The study also highlighted the importance of preprocessing techniques including resizing, normalization, augmentation, and noise reduction to improve model performance under varying environmental conditions [8]. IoT integrated livestock monitoring frameworks have gained attention because they provide continuous communication between sensing devices, embedded controllers, and remote applications. Researchers developed smart livestock systems using microcontrollers, wireless communication modules, and cloud platforms to enable automated monitoring and rapid alert generation. These systems support data collection from multiple farm components including health devices and feeding systems. The integration of IoT communication with AI based prediction models has reduced labor dependency in livestock farms [9]. Researchers explored the use of pretrained deep learning models such

as VGG19, ResNet, MobileNet, and EfficientNet for disease prediction in agricultural applications. Among these architectures, VGG19 demonstrated stable feature extraction capability for disease related datasets. Studies showed that transfer learning techniques reduce training complexity and improve prediction efficiency when limited datasets are available. Comparative analysis between CNN architectures revealed that VGG19 produces reliable performance for visual disease identification tasks because of its deep layered structure [10]. Embedded automation has become another important research area in livestock management systems. Researchers proposed Arduino based control systems capable of performing automated responses after receiving prediction results from AI applications. These systems are commonly used to activate alarms, medicine sprayers, water pumps, and feeding mechanisms according to predefined control conditions. Serial communication methods using Rx and Tx channels have been widely adopted because of their low cost, simplicity, and compatibility [11]. Disease specific monitoring has also received attention because cattle diseases can spread rapidly. Studies related to Lumpy Skin Disease emphasized the importance of early symptom identification to prevent infection transmission among livestock populations. Researchers used image based analysis methods to identify visible symptoms such as skin nodules, swelling, and abnormal body texture. Deep learning based disease classification systems demonstrated improved efficiency in recognizing infected cattle compared to manual inspection approaches [12]. RFID technology has been integrated into several livestock monitoring systems for animal identification and movement tracking. RFID tags attached to animals help farmers monitor livestock movement inside designated farm boundaries. Research studies demonstrated that RFID based tracking systems improve cattle safety and reduce the possibility of livestock loss or unauthorized movement. When combined with LCD modules and embedded controllers, RFID systems provide status information regarding animal location and boundary conditions [13]. Several studies also focused on integrating mobile applications and wireless communication technologies into livestock management systems. IoT platforms such as Blynk have been used to control feeding systems, water pumps, and farm devices remotely through smartphones. Researchers highlighted that remote monitoring applications increase farmer convenience and improve operational flexibility. Notifications and manual control features allow faster response during emergency situations [14]. Recent advancements in smart agriculture encouraged the development of integrated systems that combine disease detection, automation, animal tracking, and monitoring into a single platform. Researchers proposed frameworks capable of performing image based health analysis while simultaneously managing feeding operations. Experimental evaluations showed that unified livestock monitoring systems improve reliability, simplify management processes, and support efficient agricultural automation [15]. Cloud computing and edge computing technologies have also been introduced in livestock monitoring research to improve data accessibility and processing capability. Cloud platforms enable storage of disease records, prediction history, and farm activity logs. Studies suggested that combining edge devices with AI models improves system responsiveness and reduces communication latency [16]. Researchers additionally investigated the role of LCD display modules in embedded livestock systems. LCD interfaces display prediction outcomes, RFID status, feeding operations, and system alerts. Studies concluded that LCD based monitoring improves usability [17]. Another important area of research involves automated chemical spraying systems for livestock treatment applications. Researchers designed controlled spraying mechanisms capable of delivering medicine only when disease conditions are detected. Automated spraying reduces unnecessary chemical usage and improves treatment precision compared to manual spraying practices. Embedded controllers are generally used to regulate spraying duration and ensure safe operation [18]. Performance evaluation remains a major focus in livestock disease detection research. Several studies analyzed system accuracy, prediction speed, communication reliability, and automation efficiency. Experimental results demonstrated that AI integrated livestock monitoring systems provide higher reliability and improved operational performance compared to conventional livestock supervision approaches [19]. Although significant progress has been achieved in intelligent livestock monitoring, many existing systems still operate with limited integration between disease prediction, embedded automation, RFID tracking, and remote monitoring applications. Several studies focused only on disease classification without implementing automated response mechanisms, while others concentrated mainly on IoT communication without deep learning integration. The proposed study addresses these limitations by combining CNN-VGG19 based disease prediction, Arduino controlled automation, RFID based monitoring, LCD visualization, and Blynk supported control operations. The integration of these technologies provides an efficient and practical solution for intelligent livestock management in modern agricultural environments [20]. The proposed framework supports early disease identification, automated response operations, livestock safety monitoring, and improved farm management efficiency through the combined application of deep learning, embedded systems, RFID technology, and IoT communication.

### III. PROBLEM STATEMENT

Traditional livestock farming faces significant challenges due to the absence of continuous and intelligent health monitoring systems. Farmers primarily rely on manual observation to identify diseases, which is time consuming, labor intensive, and often ineffective in detecting health issues during their early stages. Lumpy Skin Disease and other cattle illnesses may remain unnoticed until visible symptoms become severe, leading to reduced productivity and increased treatment costs. Existing livestock management approaches also lack automated mechanisms for disease identification, timely response, and animal boundary monitoring. Furthermore, inadequate monitoring of cattle movement and health conditions increases the risk of disease spread, livestock loss, and inefficient farm management operations.

### IV. OBJECTIVES

The primary objective of this study is to develop an intelligent livestock health and activity monitoring system for the early detection of Lumpy Skin Disease in cattle. Another objective is to train and implement a CNN-VGG19 deep learning algorithm using a publicly available Kaggle cattle image dataset containing Healthy and Lumpy Skin Disease samples. The study also aims to deploy the trained model through a Flask based web application for real time image prediction. Additional objectives include establishing serial communication between the Flask application and Arduino UNO, enabling automated chemical spraying, RFID based cattle boundary monitoring, LCD based status display, and efficient livestock management support.

### V. METHODOLOGY

**1) Data Collection and Preprocessing:** The methodology begins with the collection of Healthy and Lumpy Skin Disease cattle images from a publicly available Kaggle dataset. The collected images are carefully labeled and organized into different classes for supervised learning. Preprocessing operations such as image resizing, normalization, and data cleaning are performed to improve image quality and ensure compatibility with the CNN-VGG19 model. The prepared dataset is then divided into training, validation, and testing sets for effective model development and evaluation.

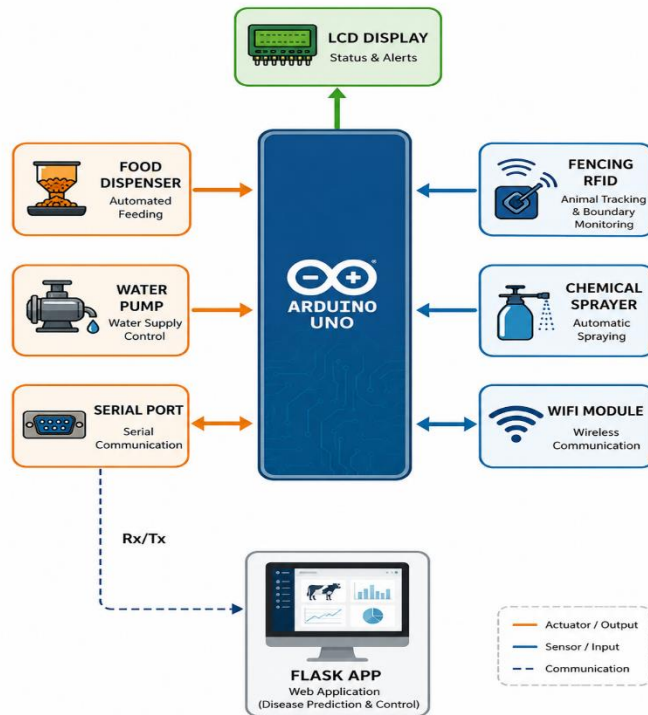
**2) Feature Extraction and Model Development:** Feature extraction is performed using the convolutional layers of the CNN-VGG19 architecture. The model automatically identifies important disease related characteristics such as skin lesions, nodules, swelling, and texture abnormalities from cattle images. VGG19 is selected because of its strong image classification capability and deep feature learning performance. The extracted features enable accurate differentiation between Healthy and Lumpy Skin Disease affected cattle.

**3) Model Training and Evaluation:** The CNN-VGG19 model is trained using the prepared dataset to learn disease classification patterns. During training, the model optimizes its parameters through multiple epochs while monitoring accuracy and loss values. After training, the model is evaluated using testing data to measure classification performance. Evaluation ensures that the trained model can accurately predict cattle health conditions on previously unseen images.

**4) Flask Based Prediction and Arduino Integration:** The trained CNN-VGG19 model is deployed within a Flask based web application for real time disease prediction. Users can upload cattle images through the application interface, and the system generates prediction results. The prediction outcome is transmitted to the Arduino UNO through serial Rx and Tx communication using predefined control signals. This integration establishes communication between the software intelligence layer and hardware control layer.

**5) Automated Monitoring and Response System:** Based on the prediction result, the Arduino UNO performs appropriate actions. If Lumpy Skin Disease is detected, the chemical sprayer is activated and an alert message is displayed on the LCD. Under healthy conditions, normal monitoring continues without triggering disease alerts.

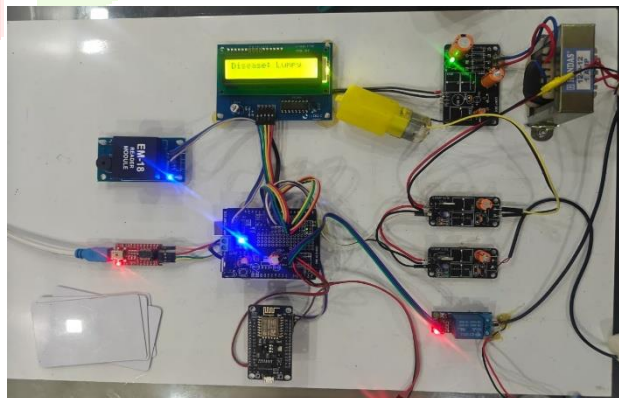
## VI. SYSTEM ARCHITECTURE



**Fig 1: System Architecture of Intelligent Livestock Monitoring System**

The system architecture is designed around the Arduino UNO, which functions as the central controller for coordinating all monitoring and automation activities. A CNN-VGG19 model deployed in a Flask application analyzes uploaded cattle images and predicts whether the animal is Healthy or affected by Lumpy Skin Disease. The prediction result is transmitted to the Arduino UNO through serial Rx/Tx communication. Based on the received signal, the Arduino controls various connected modules. A chemical sprayer is activated when disease is detected, while an RFID fencing module monitors whether cattle remain inside or outside the designated boundary. A food dispenser and water pump support livestock care operations, and a WiFi module enables Blynk based control. The LCD continuously displays prediction results, RFID status, and system alerts for effective livestock monitoring and management.

## VII. EXPERIMENTAL SETUP



**Fig. 2: Experimental Setup of Intelligent Livestock Monitoring System**

## VIII. CONCLUSION AND FUTURE WORKS

In this research, an intelligent livestock health and activity monitoring system was successfully developed using deep learning, embedded automation, RFID monitoring, and IoT communication technologies for modern cattle management applications. The proposed system effectively integrated a CNN-VGG19 based disease prediction model with Arduino UNO, Flask web application, LCD monitoring, RFID boundary detection, and Blynk supported control operations. Images of healthy cattle and cattle affected by Lumpy Skin Disease obtained from a Kaggle dataset were used to train and evaluate the deep learning model. Experimental results demonstrated that the CNN-VGG19 model achieved reliable classification performance with improved accuracy compared to other deep learning architectures. The Flask application enabled real time cattle image analysis and disease prediction through an interactive web interface. Prediction results were transmitted to the Arduino UNO using serial Rx and Tx communication for automated hardware response operations. When Lumpy Skin Disease was detected, the system activated the chemical sprayer and displayed warning alerts on the LCD module, while healthy cattle remained under normal monitoring conditions without unnecessary chemical activation. RFID based monitoring further improved livestock safety by identifying whether cattle remained inside or outside designated farm boundaries. Additional support for manual food dispensing and water supply control through the Blynk application enhanced operational flexibility and farm management efficiency. The overall system reduced labor dependency, improved disease response time, and provided continuous livestock supervision through intelligent automation. The integration of deep learning, embedded systems, RFID technology, and IoT communication demonstrated a practical and scalable approach suitable for small and medium scale livestock farming environments. Future work can focus on improving the scalability, intelligence, and practical deployment capability of the proposed livestock monitoring system. The dataset can be expanded by including additional cattle diseases, larger image collections, multiple cattle breeds, and different environmental conditions to improve model generalization and prediction reliability. Advanced deep learning architectures such as EfficientNet, ResNet, or hybrid attention based models can be implemented to further improve disease classification accuracy. Future systems can also integrate body temperature sensors, heart rate monitoring devices, and motion tracking sensors for multimodal livestock health assessment. Cloud based storage and analytics platforms may support long term disease history management, predictive analysis, and centralized monitoring for large scale farms. Edge computing integration can additionally improve response speed and reduce communication latency in real world agricultural environments.

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