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IoT-Enabled Smart Agriculture with Precision Irrigation and Farm Security

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Abstract The proposed system presents an intelligent agricultural solution that integrates smart irrigation using PWM control with AI-based animal intrusion detection to improve crop yield and farm security. The irrigation system efficiently controls water flow using Pulse Width Modulation, ensuring optimal usage of water resources. Alongside this, a real-time animal detection system is implemented using the YOLOv8 deep learning algorithm. A USB camera connected to a laptop continuously monitors the field, and the trained YOLOv8 model detects animals using a dataset prepared via Robo flow. When an animal is detected, the system activates a buzzer alert and sends instant notifications to the farmer through the Telegram application. This integrated system provides a smart, automated, and real-time solution for efficient irrigation and crop protection, reducing manual effort and minimizing losses due to animal intrusion.

Keywords: Artificial Intelligence, Machine Learning, Air Defense, Threat Prediction, Simulation System

I. INTRODUCTION

Agriculture is essential for food production, yet farmers face issues like inefficient water usage and crop damage from animal intrusion. Traditional irrigation methods often waste water, while conventional security systems fail to provide real-time alerts. To overcome these challenges, this project presents an integrated solution combining smart irrigation using PWM for controlled water distribution and AI-based animal detection with deep learning. This combined approach improves water efficiency, enhances crop protection, and supports reliable, modern smart farming practices with better productivity and sustainability for future agricultural development.

II. LITERATURE SURVEY

Existing agricultural systems generally operate as separate units without proper integration. Irrigation systems rely on basic timers or manual control, which often results in inefficient water usage and wastage. Animal detection methods mainly use simple sensors such as infrared and ultrasonic, which lack accuracy and are unable to identify specific animal types. Additionally, these systems do not include real-time alert mechanisms for farmers. As a result, overall system efficiency is reduced, response time is delayed, and the risk of crop damage increases, highlighting the need for a more advanced and integrated smart farming solution.

III. PROPOSED SYSTEM

The proposed system integrates smart irrigation and AI-based animal detection into a unified platform for efficient farming. PWM technology regulates water flow, ensuring optimal irrigation, while a USB camera captures real-time field images. These images are processed using the YOLOv8 algorithm trained on a Robo flow dataset to detect animals accurately. When an animal is identified, a buzzer is activated and an alert message is sent via Telegram. The system runs on a laptop-based unit, enabling real-time monitoring, improved crop protection, reduced water wastage, and enhanced overall agricultural productivity and field security.

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A. Technologies Used

Technology	Purpose
Python	Core logic and simulation
YOLOv8 Algorithm	Real-time animal detection using deep learning
Robo flow	Dataset preparation, annotation, and model training
USB Camera	Captures live video from the agricultural field
PWM Controller	Controls water flow efficiently in irrigation system
Telegram	Sends instant alert messages to farmers
Buzzer	Provides local alert and helps scare animals away

IV. FUNCTIONAL MODULES DESCRIPTION

1. Irrigation Control Unit
The System Uses PWM Technology to Regulate Water flow efficiently based on predefined conditions, reducing water wastage and ensuring optimal irrigation.

2.Image Acquisition Unit
A USB camera continuously captures real-time video from the agriculture field, enabling constant monitoring of the surroundings.

3.Data Preprocessing Unit
Captured video frames are processed and prepared for analysis, ensuring prper input for the AI model and improving detection performance.

4.Animal Detection Unit
The YOLOv8 algorithm analysis each frame to detect animals, draw bounding boxes, and classify them into categories such as cow, dog, or buffalo.

5.Alert& Response Unit
When an animal is detected, the system activates a buzzer and sends instant alert messages to the farmer via Telegram for immediate action.

6.Integration Unit
This module ensures smooth coordination between the irrigation system and animal detection system, allowing both to work simultaneously without interruption.

7.Monitoring & Logging Unit
All system activities, detections, and alerts are recorded for performance analysis, system improvement, and future reference.

V. PROPOSED SYSTEM BLOCK DIAGRAM

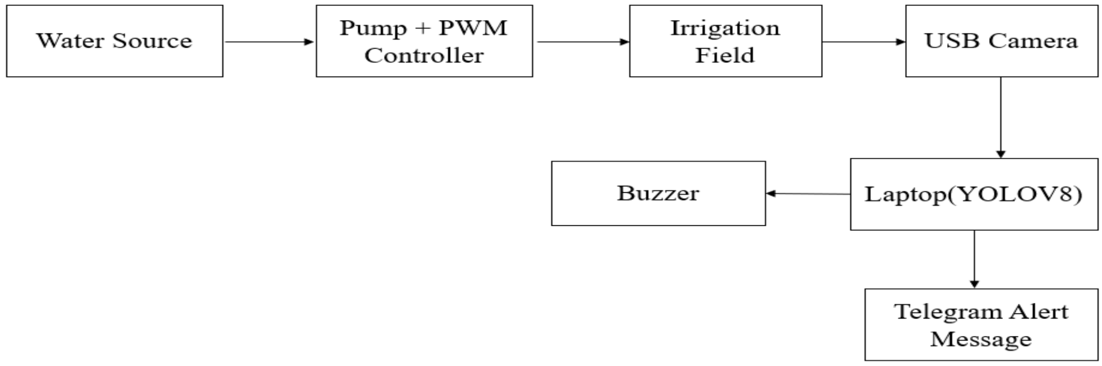

Figure 1. Proposed System Block Diagram

VI. IMPLEMENTATION DETAILS

This section explains how the system is actually built and works technically

[1]. System Design Approach

The Proposed system is developed using a modular design approach that combines smart irrigation system design approach.

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[2]. **Field Monitoring Environment**
A real-time monitoring setup is created using a USB camera placed in the agriculture field. The camera continuously captures live video

[3]. **Data Handling and Preprocessing**
Captured video frames are processed by resizing, normalization, and noise reduction techniques to ensure compatibility with the AI model and improve detection accuracy.

[4]. **Machine Learning Model Implementation**
The YOLOv8 deep learning algorithm is implemented for object detection. The model is trained using a Robo flow dataset to identify animals such as cows, and monkey with high accuracy.

[5]. **Decision-Making Mechanism**
Based on the model output, the system determines whether an animal is present. If detected, it classifies the object and initiates appropriate actions.

[6]. **Alert Mechanism Integration**
When an animal is detected, the system activates a buzzer and sends real-time alert messages to the farmer via Telegram, ensuring immediate response.

[7]. **Data Logging and Storage**
All detections, alerts, and system actions are recoded for monitoring performance, analysis, and future improvements.

[8]. **User Interface /Output Display**
The system provides output through bounding boxes on detected animals and alert notifications, enabling easy understanding of real-time field conditions.

[9]. **Irrigation control Integration**
PWM-based irrigation is integrated into the system to regulate water flow efficiently, ensuring proper water usage while monitoring filed security simultaneously.

VII. EXPERMINTAL RESULTS

The proposed system integrates IoT-based precision irrigation with AI-based animal detection for smart agriculture. The hardware module automatically controls irrigation based on soil moisture, temperature, and rainfall, ensuring efficient water usage. The software module detects multiple animal classes with high accuracy (≈90% precision, m AP ≈0.82) and triggers a buzzer alert along with Telegram notifications. Experimental results confirm reliable performance, reduced water wastage, and effective real-time crop protection, making the system a scalable solution for efficient and secure farming.

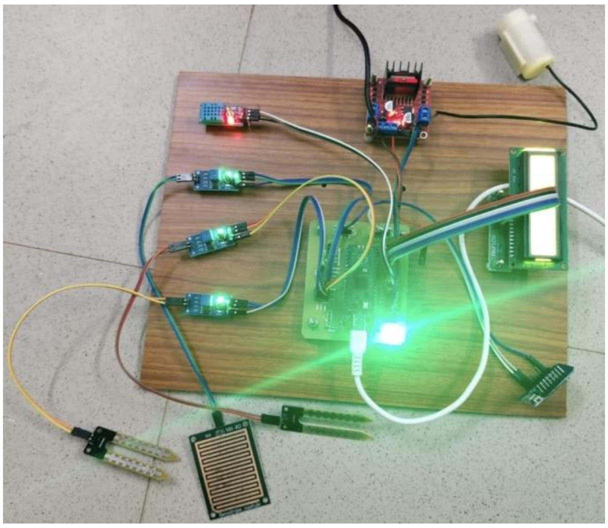

Fig: Smart Agriculture Hardware Kit Setup

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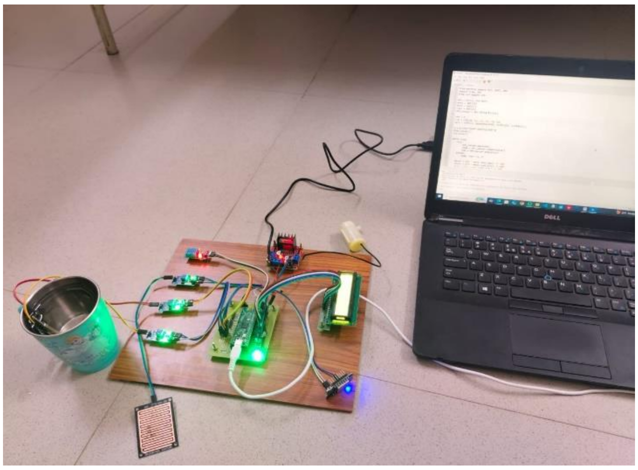

Fig: Smart Agriculture Hardware Kit Connected to Laptop for Testing

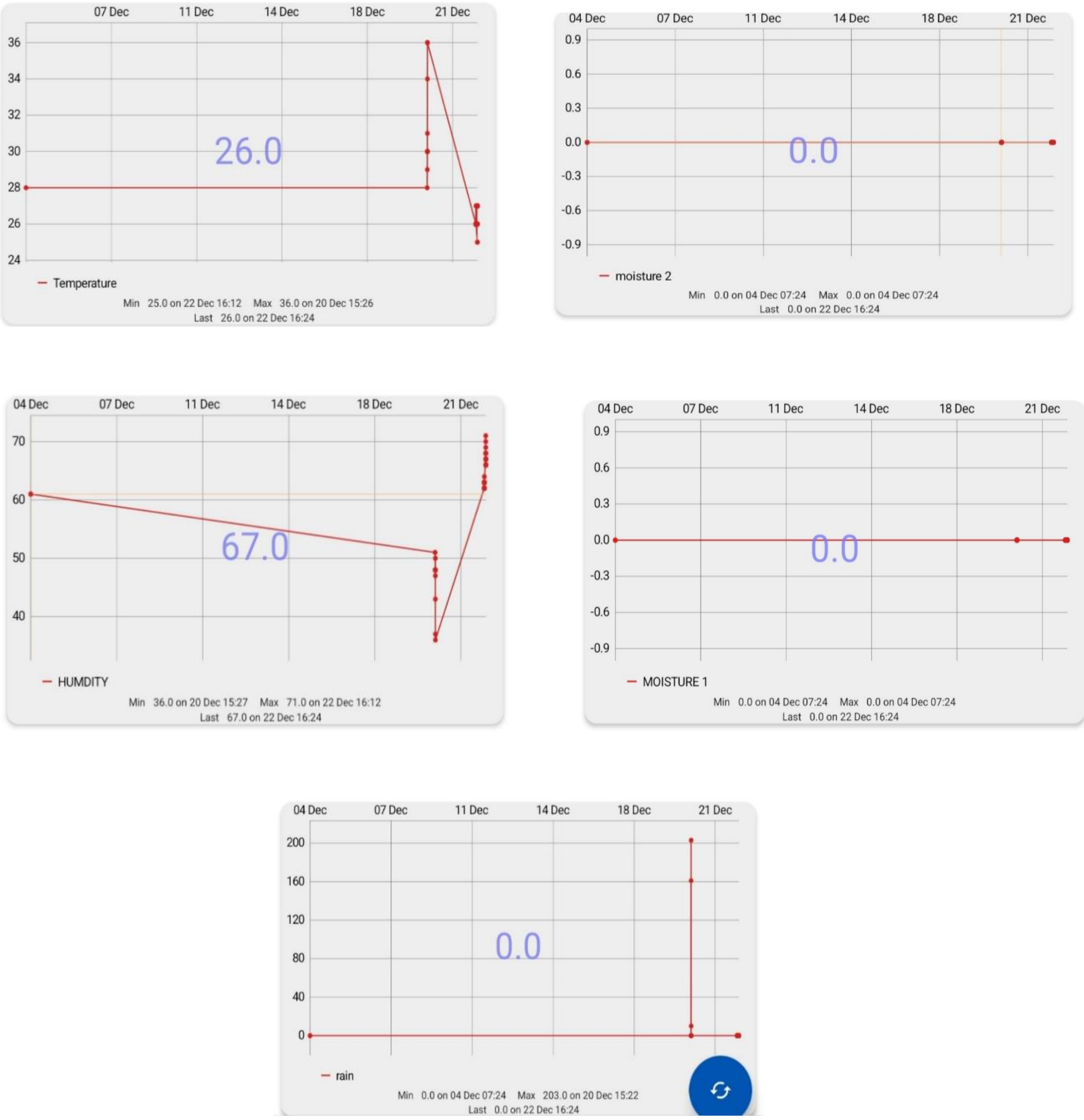

Fig: Graphs Observed

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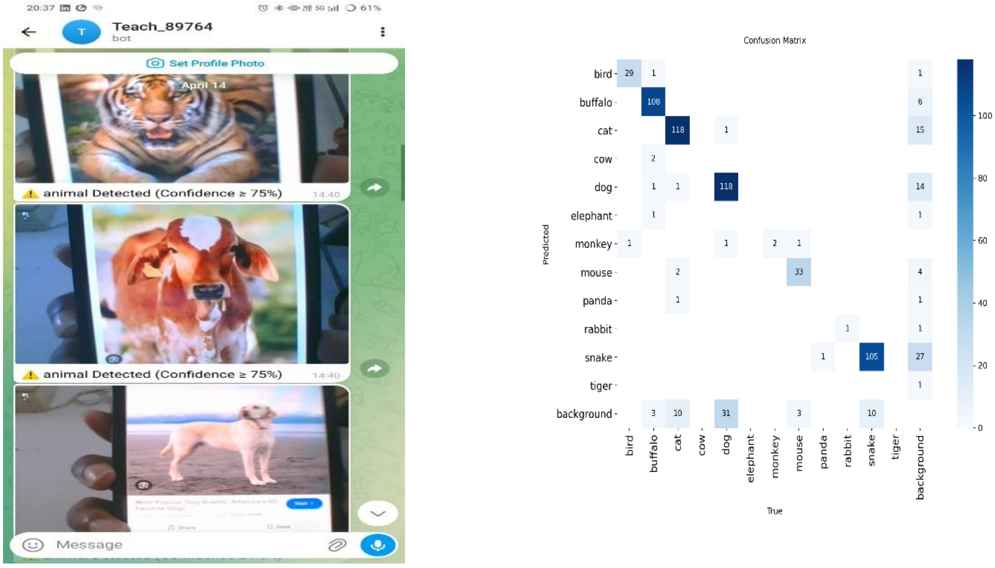

Fig: Confusion Matrix and telegram alerts message to phone for animal detection

Fig: Animal Data set using YOLOv8

VIII. CONCLUSION

The proposed Smart Agriculture System integrates IoT-based precision irrigation with AI-based animal detection to improve farming efficiency. The system automatically controls irrigation based on environmental conditions, ensuring optimal water usage. It also accurately detects animals and provides real-time alerts through a buzzer and Telegram notifications. Experimental results confirm reliable performance, high accuracy, and effective real-time operation.

IX. FUTURE SCOPE

[1] Real-Time Data Integration
The system can be enhanced by incorporating live data from radar, satellite, or IoT-based sensors instead of relying only on simulated inputs, improving real-world applicability.
[2] Advanced AI Model Enhancement
More sophisticated deep learning architectures can be implemented to increase prediction accuracy and efficiently handle complex and high-dimensional threat patterns.
[3] Multi-Target Tracking Capability
The system can be extended to simultaneously detect, track, and analyze multiple aerial objects, enabling large-scale defense scenario handling.
[4] Autonomous Decision Support
Future versions may include intelligent decision-making mechanisms that can recommend or initiate defensive

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actions based on threat severity levels.

[5] Cloud-Based Deployment

Deploying the system on cloud infrastructure can improve scalability, data accessibility, and real-time processing capabilities.

[6] Enhanced Visualization Techniques

Integration of advanced visualization methods such as 3D mapping and geospatial intelligence can provide better situational awareness.

[7] Security and Access Control

Implementing secure authentication mechanisms and role-based access control can improve system reliability and protect sensitive operational data.

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