# Project Report

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| **Project Type** | AI in Agriculture |
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## 1. Title:

Vision-Based Smart Farm Intrusion, Animal Detection, and Tractor Speed Monitoring System


## 2. Abstract

Modern agriculture faces significant challenges due to crop damage caused by unauthorized vehicles, grazing animals, and over speeding tractors. This project presents a vision-based monitoring system designed to protect crop fields using computer vision. The system detects animals (cow, goat, sheep, dog), unauthorized vehicles (car, bus, motorcycle, truck), and monitors tractor speed in real time. Alerts are generated whenever an intrusion or overspeed event occurs. The system leverages YOLOv8, a state-of-the-art object detection model, combined with a crop field boundary region of interest (ROI), object tracking, and speed estimation. All detections and alerts are logged for analysis, and visualizations provide concrete proof of system performance. This project demonstrates a low-cost, practical solution for small-scale farmers, combining AI detection and real-time alerting to prevent crop damage.


## 3. Introduction

Crop fields are vulnerable to multiple sources of damage:

1. **Animals**: Grazing animals such as cows, goats, and sheep may enter fields, destroying crops.
2. **Unauthorized vehicles**: Vehicles entering fields can physically damage crops.
3. **Tractors**: Over speeding tractors can harm crops or soil quality.

Traditional monitoring systems rely on manual supervision, which is labor-intensive and inefficient. This project proposes a computer vision-based solution that automates detection, tracking, and alerting, providing farmers with real-time protection and data-driven insights.

## 4. Objectives

1. Detect animals in crop fields.
2. Detect unauthorized vehicles entering crop fields.
3. Monitor tractor speed and detect overspeed events.
4. Generate real-time alerts to prevent crop damage.
5. Log detection data for visualization and analysis.

6. Provide a research-grade framework suitable for extension or further study.

## 5. Methodology

### 5.1 System Architecture

Camera / Farm Video → YOLOv8 Detection → Object Classification → Tracking → Decision Engine → Alerts

- **Camera / Farm Video**: Provides real-time video feed or recorded video.
- **YOLOv8 Detection**: Detects objects in each frame, including animals and vehicles.
- **Object Classification**: Differentiates animals, authorized tractors, and unauthorized vehicles.
- **Tracking**: Maintains unique identities of objects between frames.
- **Decision Engine**: Determines alerts based on crop field boundaries and speed thresholds.
- **Alerts**: Visual (video bounding boxes), textual (console or CSV), optional SMS/audio notifications.

### 5.2 Detection Classes

| Class Type | Examples | Purpose |
|---|---|---|
| Animals | Cow, Goat, Sheep, Dog | Crop damage prevention |
| Unauthorized Vehicles | Car, Bus, Truck, Motorcycle | Prevent crop destruction |
| Tractor | Tractor | Monitor speed and safety |

### 5.3 Crop Field Boundary (ROI)

- Defined as a rectangular area in the video frame.
- Alerts are triggered only if objects enter this area.
- Reduces false positives outside field boundaries.

### 5.4 Tractor Speed Monitoring

- **Speed Calculation**:
    1. Track tractor positions between frames.
    2. Measure pixel displacement → convert to meters using calibration.

3. Calculate speed (m/s → km/h).
4. Compare with predefined speed threshold (e.g., 8 km/h).

- Generates alerts if tractor exceeds threshold.

**5.5 Alert System**

- Alerts are logged in CSV with columns:
- Time | Object | Alert_Type | Speed_km/h | X | Y
- Alerts include:
  - ➢ Animal intrusion
  - ➢ Unauthorized vehicle intrusion
  - ➢ Tractor overspeed
- Optional: Real-time visual display on video with bounding boxes and speed labels.

**5.6 Data Logging and Visualization**

- Alerts are saved in CSV for further analysis.
- Visualizations include:
  1. Annotated video showing detections, labels, bounding boxes, and tractor speeds.
  2. **Time series plots**: Number of intrusions over time.
  3. **Histogram of tractor speeds**: Frequency of overspeed events.
  4. **Pie chart**: Proportion of alert types.
  5. **Heatmap**: Crop field hotspots where intrusions occur.
  6. Screenshots / key frames of alert events.

These provide quantitative and visual proof of system performance.

## 6. Implementation

1. **Environment**: Python, Google Colab, GPU runtime.
2. **Libraries**: ultralytics (YOLOv8), opencv-python, numpy, pandas, matplotlib, seaborn.
3. **Dataset**: Pretrained YOLOv8 model used, detecting animals, tractors, and vehicles.
4. **Code Flow**:

- ➢ Load video → Read frames → Run YOLOv8 → Classify objects → Check ROI → Append alerts → Draw bounding boxes → Calculate tractor speed → Display frame → Save alerts CSV.

5. **Output**:

   - ➢ Annotated video showing detections and alerts.
   - ➢ CSV file with all alert data.
   - ➢ Graphs and heatmaps for visualization.

## 7. Results

- **Detection**: The system successfully detected cows, goats, unauthorized vehicles, and tractors in crop fields.
- **Speed Monitoring**: Tractor overspeed events were accurately identified and logged.
- **Alerts**: Alerts were generated only when objects entered crop field, reducing false positives.
- **Visual Proofs**:
  1. Annotated video frames with bounding boxes and labels.
  2. Graphs showing tractor speed distribution and alert types.
  3. Heatmap highlighting areas of repeated intrusion.
  4. Time series plot showing animal/vehicle intrusions over time.

These results demonstrate reliable detection, real-time alerting, and actionable insights for farmers.

## 8. Discussion

- The system is low-cost and uses pretrained models, eliminating the need for custom datasets initially.
- **Limitations**:
  - ➢ Detection may fail in extreme low-light conditions.
  - ➢ Tractor speed estimation depends on pixel-to-meter calibration, may need real farm measurements.
  - ➢ Animals partially occluded by crops may be missed.
- **Future Improvements**:

1. Fine-tune YOLO on farm-specific animal/vehicle dataset.
2. Add real-time audio/SMS alerts.
3. Use multi-camera setup for full-field coverage.

4. Implement self-supervised learning to improve detection on field-specific conditions.

## 9. Conclusion

The project successfully demonstrates a vision-based monitoring system for crop field protection. It detects animals, unauthorized vehicles, and monitors tractor speed. Alerts and visualizations provide clear proof of system performance. This system can be deployed for small and large-scale farms, providing real-time monitoring, reducing crop damage, and enhancing agricultural safety.Key Contribution: A unified, low-cost, AI-powered system that protects crops from multiple damage sources with real-time detection, speed monitoring, and alerting.