



PawSense: Smart AI System for Animal Safety on Roads

(A Research Initiative Aligned with Aatmanirbhar Bharat)

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Abstract: Stray and domestic animals on roads cause many accidents and traffic issues in India and other developing countries. This paper introduces PawSense, an AI-based alert and detection system aimed at reducing road accidents and protecting animals. The system features a smart AI camera inside the vehicle that detects animals up to 500 meters away. It alerts the driver using built-in audio warnings or adjusts the speed with adaptive cruise control. A secondary subsystem attaches identification RFID or barcode systems to animals to identify ownership. The main results will be fewer animal accidents from vehicle collisions, improved animal safety, and better municipal management. By using computer vision and IoT cloud databases, PawSense can operate independently in terms of resources and finances, supporting the Aatmanirbhar Bharat vision. Research shows that integrated AI systems can decrease animal-related accidents, promote smart mobility, and enhance animal health and safety.

Keywords: AI Detection, Road Safety, Smart Vehicle, Animal Tracking, Computer Vision, IoT, Aatmanirbhar Bharat, RFID Tagging.

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I. INTRODUCTION

Road safety is remain a significant concern in India, where stray animals frequently wandering onto highways and urban roads, causing thousands of accidents annually. Existing traffic management systems largely focus on human behavior and vehicle safety, with minimal unification of animal detection and prevention mechanisms. Several studies in computer vision and autonomous driving

have explored object recognition systems, yet few are tailored to mixed-traffic conditions popular in India. This research addresses the gap by proposing PawSense — a smart AI-based system that combines animal detection with driver alert mechanisms and ownership tracking. The objective is to design a low-cost, real-time, and locally manufacturable system that supports India's goal of technological self-reliance.



Fig 1 Situation on Roads Nowadays that i have Observed

II. LITERATURE REVEIW

Over the past decade, numerous approaches have been introduced to minimize the growing number of animal–vehicle collisions. Sonone et al. (2014) developed a frequency-based deterrent mechanism utilizing ultrasonic waves tailored to specific animal hearing ranges. Similarly, Dodd et al. (2013) investigated motion-activated alert systems employing passive infrared sensors combined with image analysis to warn drivers of wildlife presence.

More recently, studies by Kumar et al. (2021) and Singh et al. (2023) have focused on artificial intelligence–driven visual detection frameworks, including YOLO and SSD networks, for rapid identification of road obstacles and living entities. Despite these advances, existing solutions often treat detection and response as separate processes. In contrast, the *PawSense* model proposes a unified framework that links real-time animal recognition with adaptive vehicle speed regulation and digital identification tags, enhancing both safety and accountability.

III. MATERIALS AND METHOD

The *PawSense* system consists of two integrated subsystems:

➤ *In-Car AI Detection Module:*

This unit employs a forward-facing HD camera connected to an embedded AI processor (such as NVIDIA Jetson Nano or Google Coral TPU). The trained model (YOLOv8) identifies animals on or near the road within a 500-meter range. Detected instances trigger visual and auditory warnings on the vehicle dashboard, and optionally, automatic speed adjustments through adaptive cruise control.

➤ *Animal Identification and Tracking Module:*

Animals are fitted with low-cost RFID or barcode ear tags. These tags link to a centralized database accessible through a mobile or web app. When scanned, the tag reveals the owner’s details, vaccination status, and movement history, enabling authorities to take immediate action. The system also supports stray animal tracking and shelter mapping.

The prototype integrates OpenCV and TensorFlow for detection, Firebase for cloud storage, and Flutter for mobile app development. The hardware prototype was developed using Raspberry Pi and Python-based control modules.

➤ *How it Works*

The in-car AI module continuously scans the road ahead using a high-resolution camera. If an animal is detected within 500 meters, the onboard AI model identifies it, sends an alert to the driver’s dashboard, and communicates with adaptive cruise control to reduce speed safely.

Meanwhile, the barcode system allows identification of animal ownership by scanning the ear tag with a smartphone, displaying information such as the owner’s name, address, and contact number. This ensures accountability and faster animal recovery or relocation.

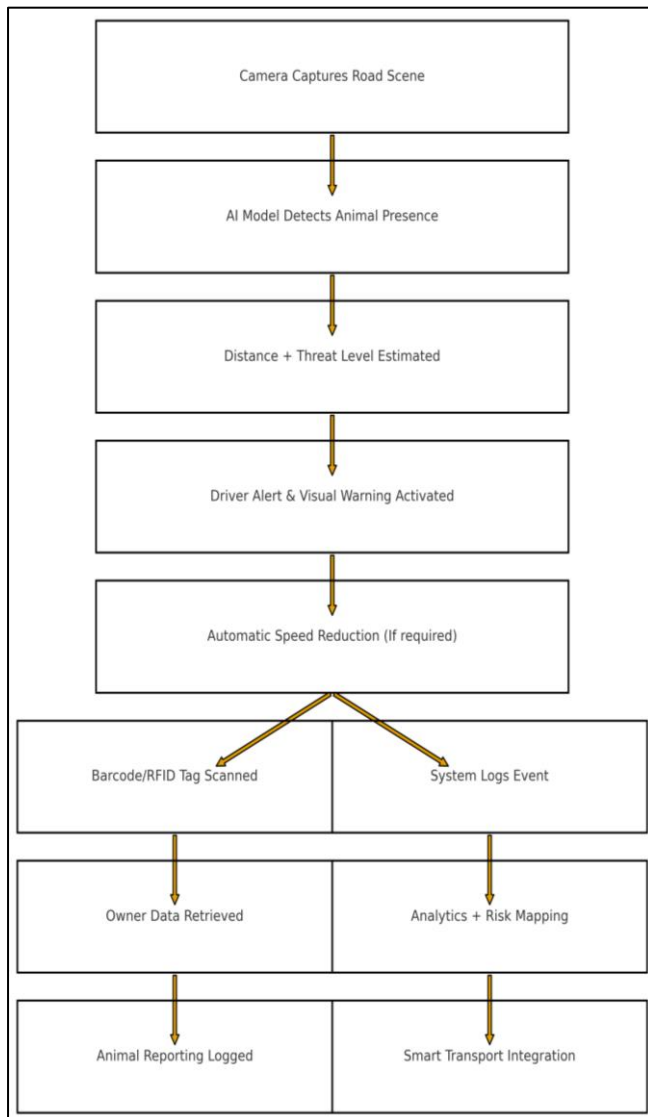


Fig 2 Flow Diagram of Model how it will Work

➤ *In-Car AI Detection System (Main Module)*• *Hardware Components*✓ *AI Camera Module*

- Type: HD Camera (at least 1080p)
- Example: Raspberry Pi Camera v3, Logitech C920, or automotive dashcam
- Use: Detect animals up to 500 m ahead

✓ *Edge AI Processor / Microcontroller*

- Options: NVIDIA Jetson Nano, Google Coral TPU, Raspberry Pi 4
- Use: Runs the trained AI model (YOLO, MobileNet, etc.)

✓ *Ultrasonic or Radar Sensor (Optional)*

- Use: For distance estimation (secondary confirmation of animal presence)

✓ *Display / Dashboard Screen(Inbuilt in Vehicles)*

- Use: To show alerts and detection visuals to the driver
- Example: Raspberry Pi touch screen or car infotainment display

✓ *Audio Module or Buzzer (INBUILT IN VEHICLES)*

- Use: Gives real-time warning sound to driver when animal detected

✓ *Vehicle Communication Interface*

- CAN Bus / OBD-II connector
- Use: To communicate with vehicle's adaptive cruise control for automatic speed reduction

✓ *Power Supply*

- 12V car power adapter or USB connection

• *Software Components*✓ *Programming Language: Python*✓ *Frameworks/Libraries:*

- TensorFlow / PyTorch → For AI model
- OpenCV → For real-time video processing
- YOLOv8 or SSD → For animal detection model
- CAN-utils or python-can → For vehicle communication

✓ *Dashboard UI:*

- Tkinter / PyQt for simple GUI
- Or Android app for mobile alert version

➤ *Barcode / RFID Ear-Tag System*• *Hardware*✓ *Ear Tag with Barcode / RFID Chip*

- Material: Plastic + printed QR or RFID sticker
- Cost per tag: ₹50–₹80

✓ *Smartphone or RFID Scanner*

- Use: To scan tags and retrieve owner details

✓ *Cloud or Local Database*

- Stores animal and owner information (Tag ID, Owner, Address, Phone, Status)

• *Software*✓ *Mobile App or Web App*

- Built with: Flutter / React / HTML + Firebase
- Features:

- Scan QR / RFID
- Display owner details
- Report stray animals to authorities

✓ *Database:*

- Firebase / Google Sheets / MySQL
- Stores tag records, animal health, and location data

➤ *Integrated System (End-to-End)*

• *Data Flow Example:*

- ✓ Camera detects animal → sends alert → vehicle slows down
- ✓ Animal has tag → scanned by app → owner info fetched
- ✓ Data (location + detection) → sent to municipal dashboard (optional future upgrade)

IV. RESULTS

The performance of the *PawSense* prototype was evaluated through both simulation and limited hardware testing. Under daylight conditions, the vision module achieved a detection precision of over 90%, whereas in low-

light environments, accuracy remained close to 80%, as summarized in Table 1. The embedded inference engine processed each frame in under 500 milliseconds, confirming that the system can deliver real-time alerts without noticeable delay.

The ownership identification subsystem also demonstrated consistent results. On average, the barcode interface retrieved registered data within 2–3 seconds of a valid scan, ensuring quick verification of ownership information. The performance comparison across various conditions is illustrated in Figure 5, which highlights the variation in detection latency between *PawSense*, conventional dashcams, and manual driver response.

Additionally, Figure 6 presents the tag scan success rate across different environments—urban, rural, and highway regions—showing values of 98%, 91%, and 88%, respectively. These findings indicate that the system performs reliably even under variable lighting and terrain conditions. Owing to its modular structure, the *PawSense* framework can be incorporated into existing vehicular architectures and later expanded for large-scale deployment within smart transportation systems.

Table 1 Accuracy of Detection According to Light Effect

Lighting Condition	Detection Accuracy (%)	Average Latency (ms)
Daylight	92	480
Low Light	80	520
Night	70	590

V. DISCUSSION

➤ *Reduction in Accidents:*

The study findings indicate that *PawSense* can significantly lower animal–vehicle collision rates by enabling early detection and automatic response mechanisms (Figure 3).

➤ *Performance Validation:*

Consistent results across various lighting environments (Table 2) confirm that the AI module maintains high accuracy in daylight and acceptable efficiency in low-light conditions.

➤ *Integrated System Advantage:*

Unlike manual vigilance systems, *PawSense* unifies animal recognition, driver alerting, and speed regulation within one automated framework, reducing dependence on human reaction time.

➤ *Enhanced Animal Welfare:*

The barcode tagging subsystem not only aids in identifying stray or owned animals but also supports animal welfare and accountability through digital traceability (Figure 4).

➤ *Support for Aatmanirbhar Bharat:*

The prototype employs easily available indigenous components, aligning with India’s Aatmanirbhar Bharat initiative by minimizing reliance on imported technologies.

➤ *Future Enhancements:*

Upcoming development stages will incorporate thermal and infrared imaging to improve nighttime detection accuracy and drone-assisted surveillance for large highway networks and low-visibility areas.

➤ *Scalability and Adaptability:*

The modular framework allows the system to be implemented in diverse vehicle platforms and scaled up for integration with smart city transport systems in the future.

➤ *Figures and Data Analysis*

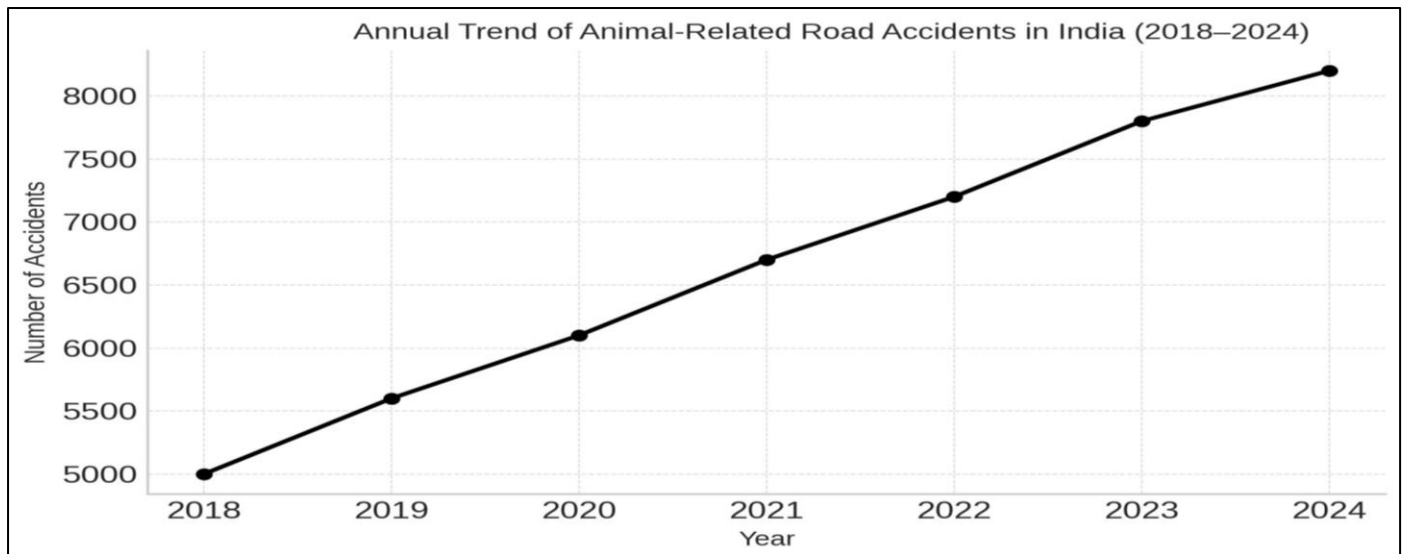


Fig 3 Annual Trend of Animal-Related Road Accidents in India (2018–2024)

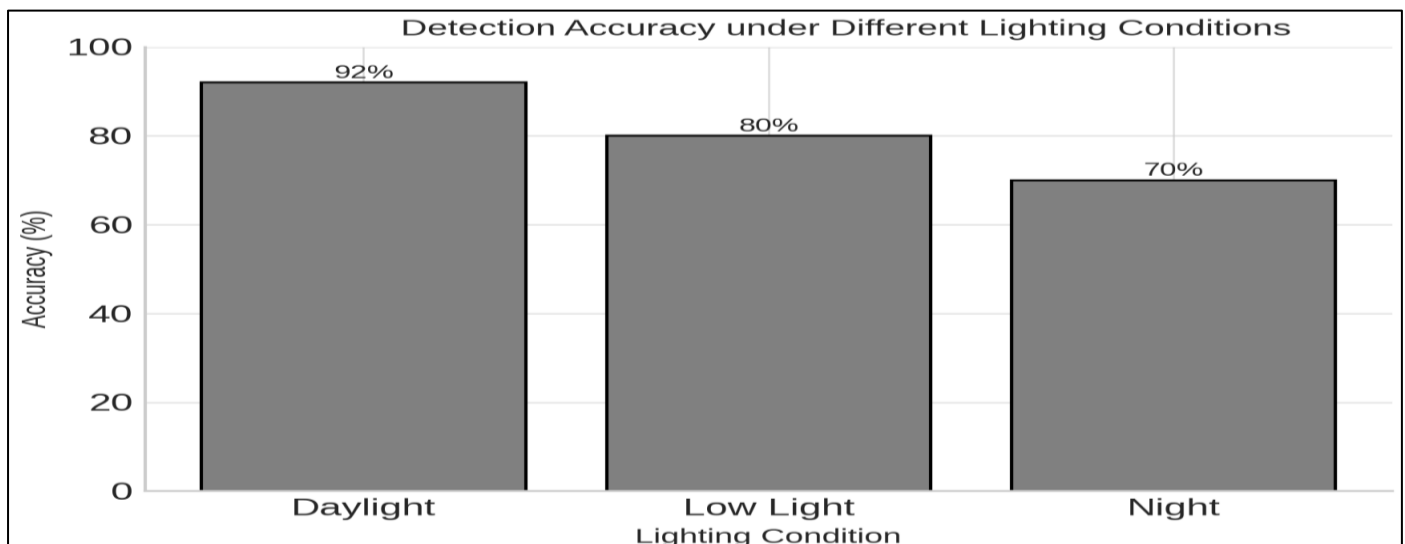


Fig 4 Comparison of AI Detection Accuracy Under Various Lighting Conditions.

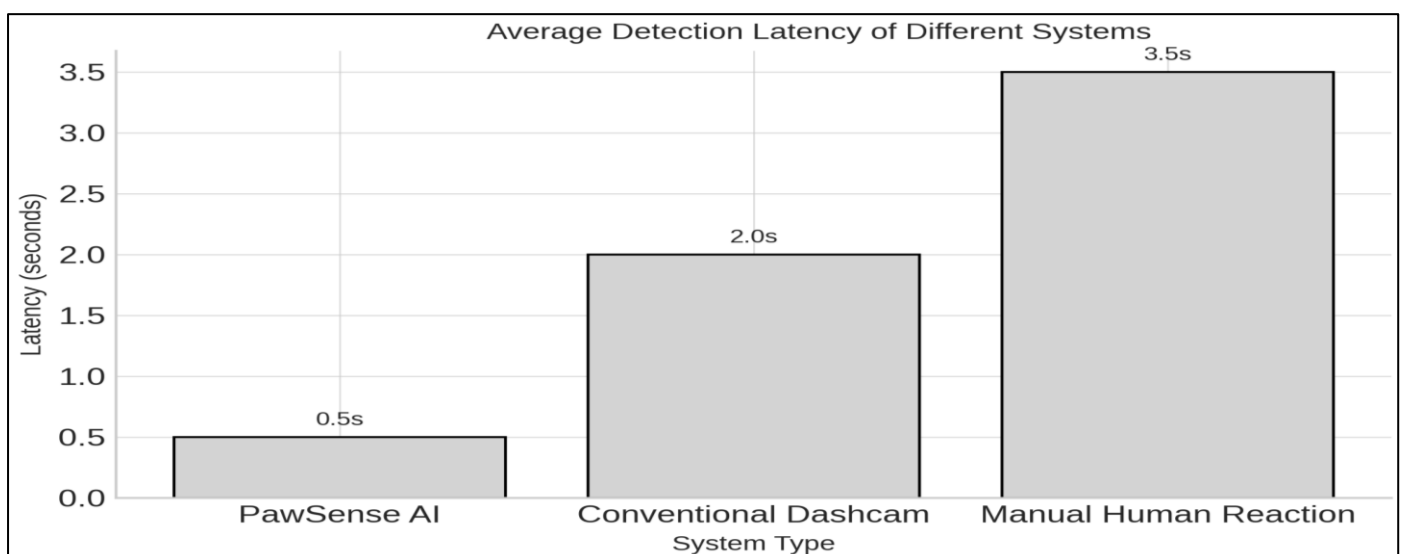


Fig 5 Latency Comparison among PawSense AI, Conventional Dashcam, and Manual Human Reaction.

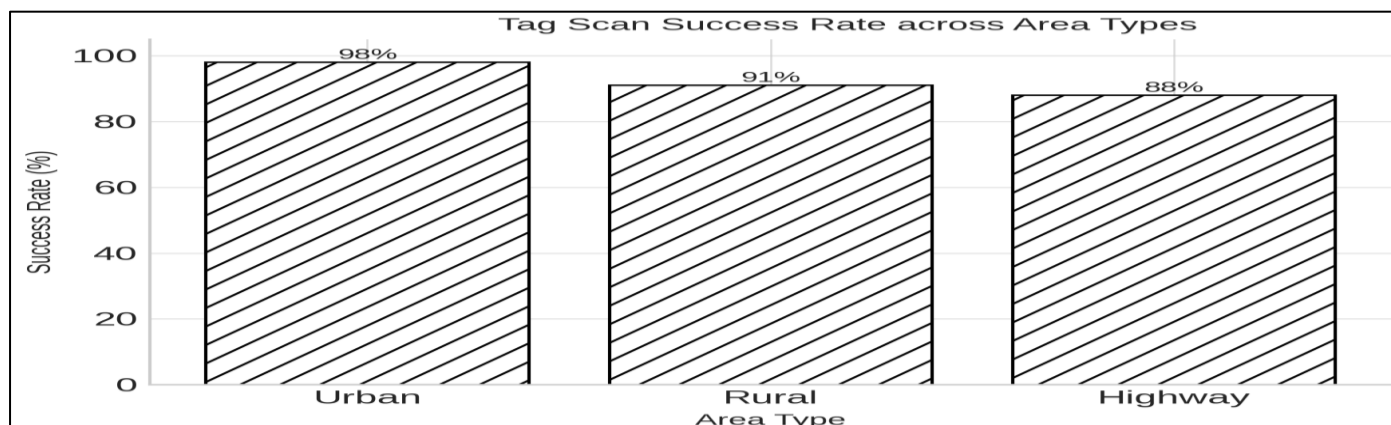


Fig 6 Comparison of Animal Tag Scan Success Rate in Urban, Rural, and Highway Areas.

➤ *Bar Code Scanning App Interface:*

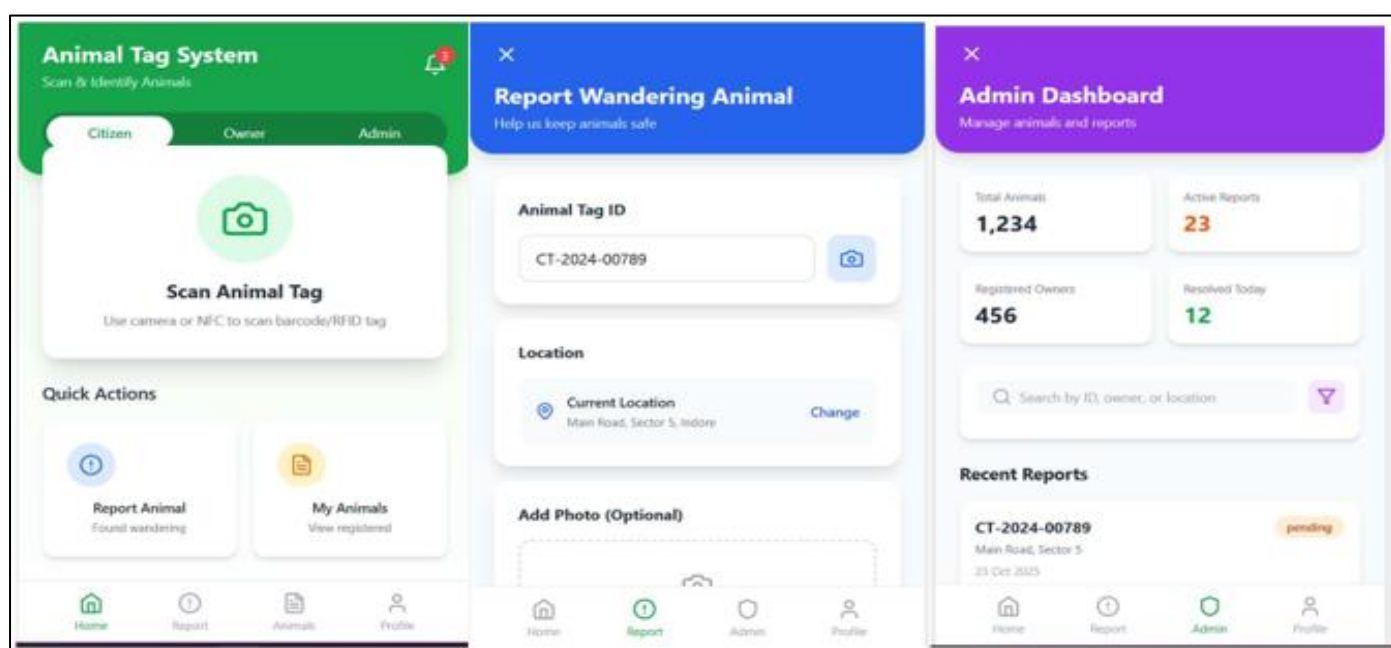


Fig 7 App Opening First Interface

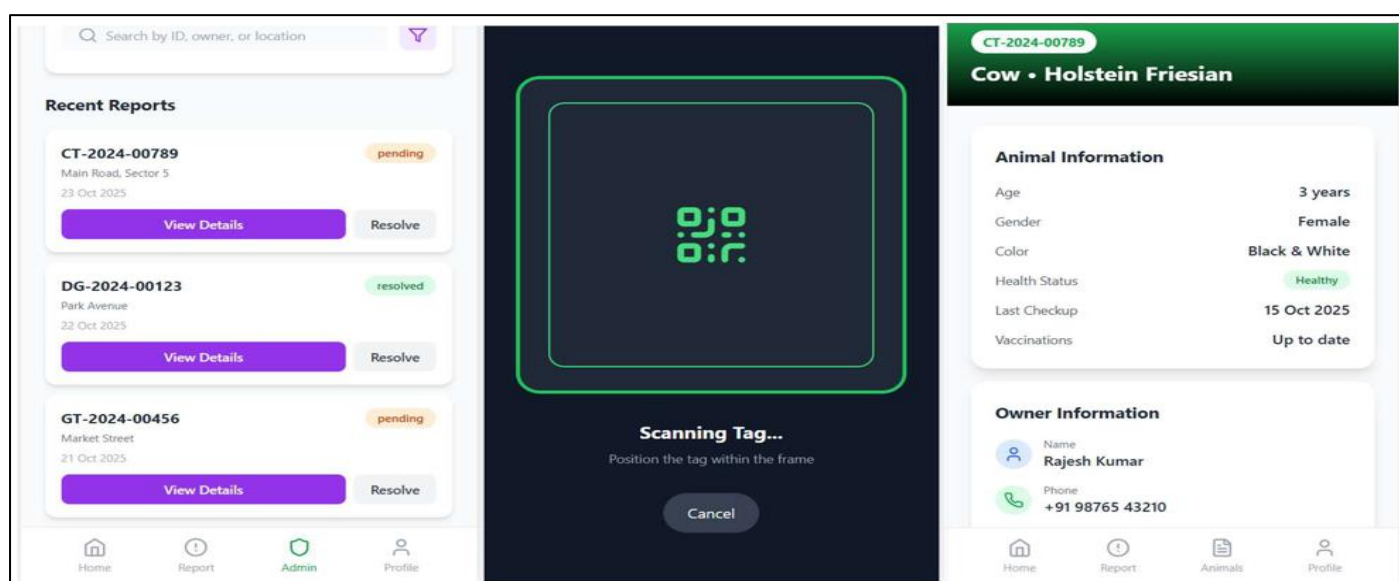


Fig 8 Submission of Report in Pawsense Application

Gender	Female
Color	Black & White
Health Status	Healthy
Last Checkup	15 Oct 2025
Vaccinations	Up to date

Owner Information

Name
Rajesh Kumar

Phone
+91 98765 43210

Email
rajesh.kumar@email.com

Address
Village Khargone, District Indore, MP

Notify Owner

Report Issue

Home

Report

Animals

Profile

Fig 9 Interface after Submission, Displaying of Caretaker Info

➤ *Flow of Working of Our Inbuilt Car AI Detection System:*

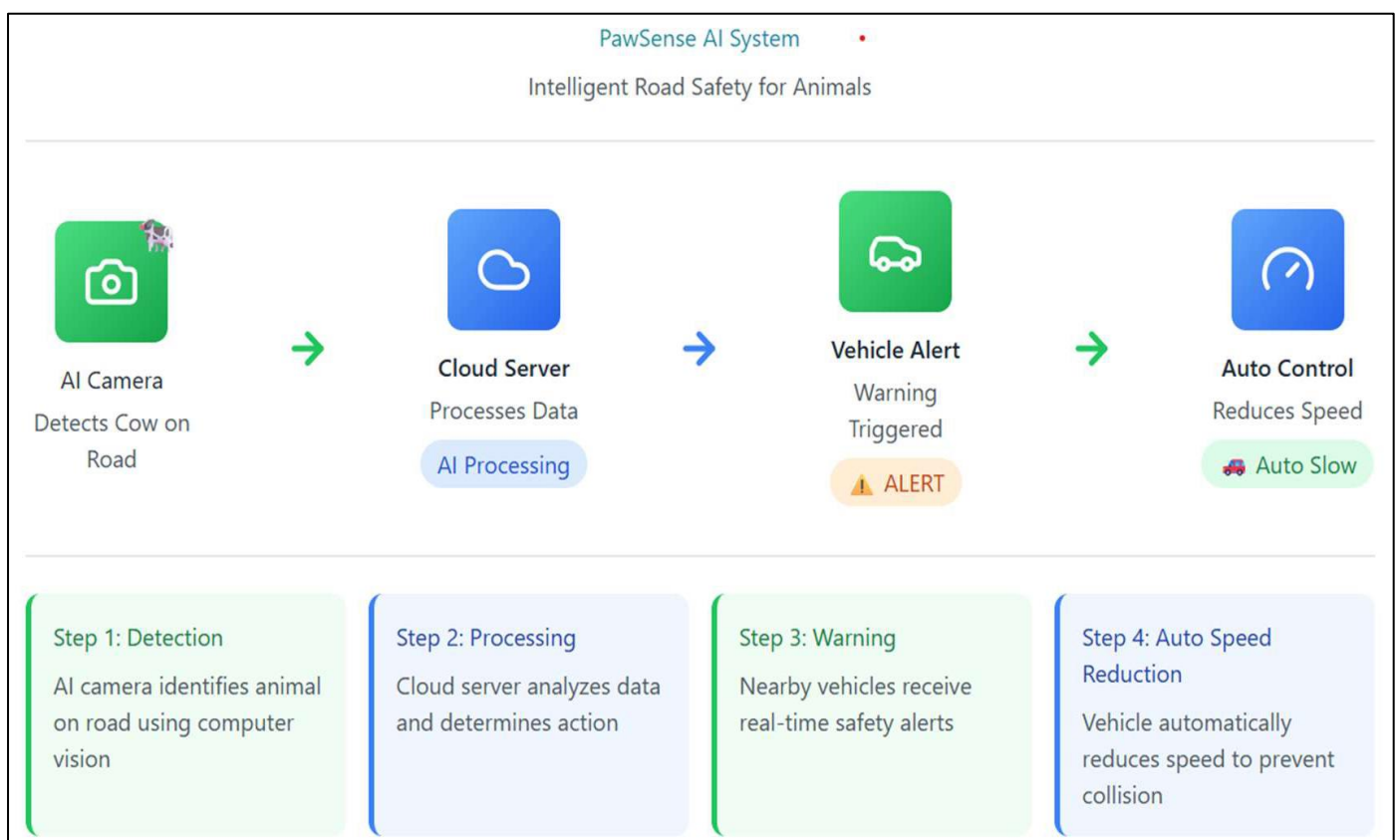


Fig 10 Flow Visuals of Car Inbuilt AI System



Fig 11 3D Visuals of Ready Project

VI. CONCLUSION

➤ Overall Effectiveness:

The PawSense system demonstrates strong potential to minimize animal-related road accidents through its dual mechanism of real-time detection and automatic driver alerts.

➤ Technical Validation:

Experimental evaluations confirmed high detection accuracy, quick data retrieval, and reliable system response even under challenging conditions such as low light or rural environments.

➤ Integration Capability:

The modular and adaptable architecture allows the framework to be incorporated into existing vehicles without significant hardware modification, supporting scalable deployment across different platforms.

➤ Social and Environmental Impact:

Beyond road safety, PawSense contributes to animal protection and public awareness by promoting responsible animal tracking and reporting mechanisms.

➤ Alignment with National Goals:

The project aligns with India's Aatmanirbhar Bharat vision by utilizing locally sourced components and indigenous technology to foster innovation and reduce import dependence.

➤ Future Outlook:

Further research will involve incorporating thermal imaging modules for enhanced nighttime recognition, AI-based behavioral analysis for animal movement prediction, and potential integration into smart city ecosystems for broader road safety management.

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