HEC-Sense: An AI-Powered Elephant Intrusion Prevention System

Leveraging AI for Wildlife Coexistence in Sri Lanka: **HEC-Sense** is an AI-powered elephant intrusion prevention system designed to mitigate human–elephant conflict in Sri Lanka. The system uses computer vision–based elephant detection and zone-wise risk classification to identify intrusions in real time and trigger appropriate deterrent actions such as alerts, lights, and sound signals. By combining low-cost hardware with intelligent software, HEC-Sense enables early warning, protects farmland, and promotes safer coexistence between humans and wildlife.

The Problem We're Solving: Human-Elephant Conflict in Sri Lanka

Crop Destruction

Elephants foraging in agricultural lands lead to significant crop loss, threatening farmers' livelihoods and food security.

Property Damage

Villages and farmlands experience extensive damage to homes, infrastructure, and property, causing substantial economic hardship.

Loss of Life

Fatal encounters affect both humans and elephants, disrupting ecological balance and causing profound societal impact.

Economic Strain

Beyond direct damage, conflicts impose indirect economic burdens, including healthcare costs, compensation, and reduced productivity.

This persistent conflict underscores the critical need for effective, sustainable prevention strategies.

Introducing HEC-Sense: Our AI-Driven Solution

HEC-Sense is a comprehensive multi-platform system designed to mitigate human-elephant conflicts in Sri Lanka. By leveraging advanced AI and real-time data, our system empowers communities and authorities to prevent intrusions and foster coexistence.

- **Early Detection:** Identifies elephants approaching human settlements and farmlands.
- **Behavioral Analysis:** Understands elephant intent to provide nuanced alerts.
- **Real-Time Alerts:** Delivers instant notifications to users, enabling timely intervention.

System Architecture: A Unified Approach

1. Mobile Application

Flutter/Dart

Real-time alerts, dashboard, and historical data for local users.

2. Web Application

Laravel/PHP

Comprehensive analytics, user management, and system configuration for administrators.

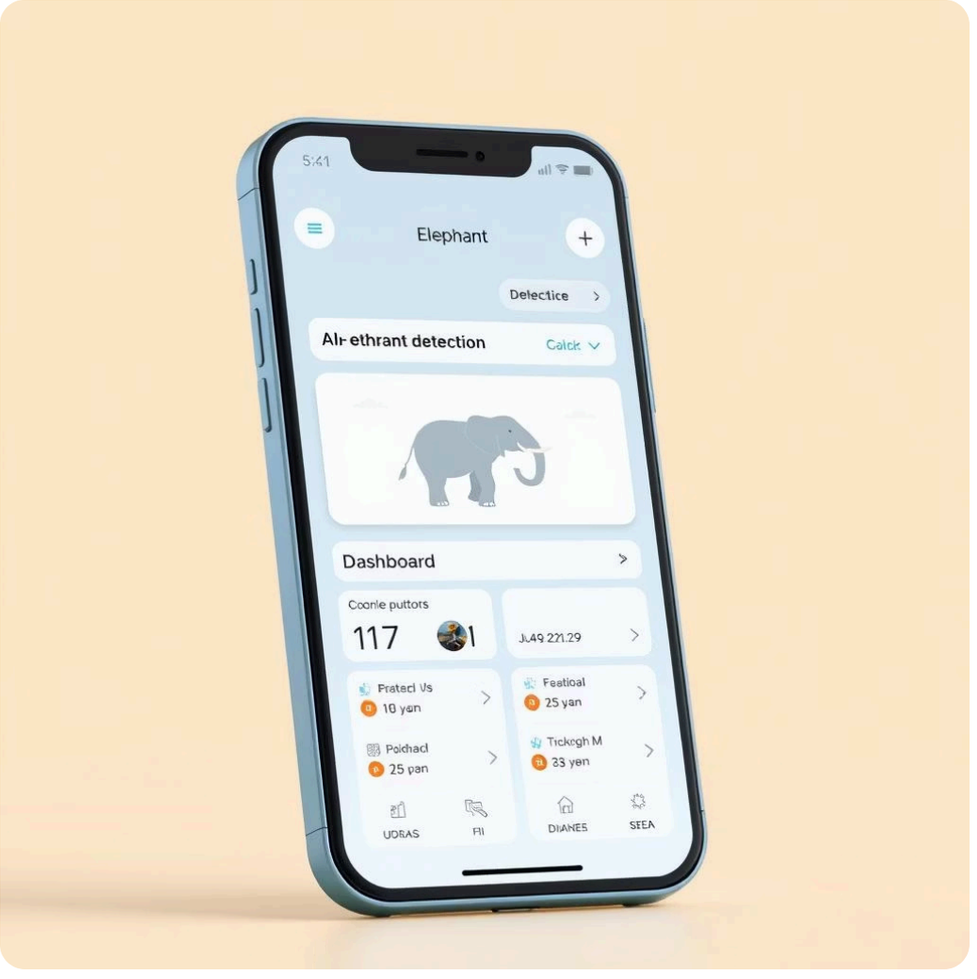
3. AI Application

Python

Core detection engine, behavior classification, and aggression prediction.

These three interconnected components work in harmony to provide a robust and intelligent intrusion prevention system.

Mobile Application: Empowering Local Communities



Target Users: Farmers, Villagers, Community Members

- **Instant Alerts:** Real-time notifications for elephant detections near designated zones.
- **Interactive Dashboard:** Visualizations of total sessions, detections, and alerts for local insights.
- **Behavior Analysis:** Charts illustrating elephant moods (calm, warning, aggressive) over time.
- **Multi-Language Support:** Available in English, Sinhala, and Tamil for widespread accessibility.
- **Detection History:** Access to past detection sessions and detailed data.

The mobile app acts as the primary interface for individuals on the ground, providing critical information to ensure safety and prevent conflict.

Web Application: Centralized Management & Analytics

Target Users: Super Administrators, System Managers

- **User Management:** Approve or reject new user registrations for controlled access.
- **Comprehensive Dashboard:** Visualizations of all detection sessions, alerts, and system-wide statistics.
- **Data Analytics:** Detailed charts on elephant behavior distribution and detection patterns.
- **System Configuration:** Manage settings, detection zones, and alert parameters.
- **Multi-Language Support:** Consistent with the mobile application, supporting English, Sinhala, and Tamil.

The web portal offers a powerful suite of tools for oversight, data analysis, and system maintenance, crucial for effective long-term management.

AI Application: The Intelligence Behind HEC-Sense

Real-Time Detection

Utilizes advanced computer vision algorithms to identify elephants in live video feeds with high accuracy.

Behavior Classification

Categorizes elephant behavior into 'Calm', 'Warning', or 'Aggressive' based on learned patterns.

Aggression Prediction

Analyzes posture, trunk movement, and ear position to anticipate aggressive intent, triggering automatic alerts.

Video & Data Processing

Processes video frames, extracts key data, and integrates seamlessly with the database for storage and analysis.

Built on Python, this core engine ensures robust, intelligent monitoring and immediate response capabilities.

Key Features & Transformative Benefits

Real-time AI Detection

Instant identification of elephants ensures proactive prevention.

Historical Data Tracking

Enables long-term analysis and refinement of prevention strategies.

Multi-Language Support

English, Sinhala, and Tamil interfaces ensure broad accessibility.

Behavioral Analysis

Mood detection (Calm, Warning, Aggressive) allows for nuanced responses.

Instant Alerts

Timely notifications to mobile users enable quick action.

Comprehensive Analytics

Dashboards provide insights into detection patterns and trends.

These features collectively contribute to a significant reduction in human-elephant conflict, protecting both lives and livelihoods.

Technical Implementation: Our Robust Stack

Mobile Development

Flutter: Cross-platform UI toolkit.

Dart: Programming language for Flutter.

Provider: State management for responsive UIs.

fl_chart: Libraries for dynamic visualizations.

Web Development

Laravel (PHP): Robust MVC framework for backend.

Blade Templating: Efficient frontend rendering.

Chart.js: Interactive charting library for dashboards.

MySQL: Relational database for data storage.

AI Development

Python: Primary language for AI logic.

Computer Vision Libraries: OpenCV, TensorFlow/PyTorch for object detection.

Video Processing: Libraries for frame extraction and analysis.

Machine Learning: Custom models for behavior classification.

Our chosen technologies provide a scalable, efficient, and maintainable foundation for HEC-Sense.

Current Implementation: System Requirements

Our current application setup demands significant computing resources to deliver optimal performance for real-time AI detection and video processing.

Core Specifications

- Minimum 8 GB of RAM required
- i5 or i7 processor recommended

Performance Considerations

- GPU is highly recommended for accelerated performance, significantly improving speed.
- CPU-only operation is possible but will result in slower processing.

This substantial computing power is crucial for the application's real-time AI detection and video processing capabilities. Future phases will explore transitioning to more efficient hardware, such as the Nvidia Jetson Nano, to optimize resource utilization.

Hardware Requirements: NVIDIA GIST 10 & Jetson Nano

The HEC-SENSE AI system relies on real-time detection and analysis, which demands significant computational power. To efficiently process live video feeds and execute sophisticated AI models in challenging environments, we leverage specialized NVIDIA hardware tailored for AI inference.

Overview

Compact edge AI processor

Key Specifications

- ARM-based processor
- 4GB RAM
- 128-core GPU

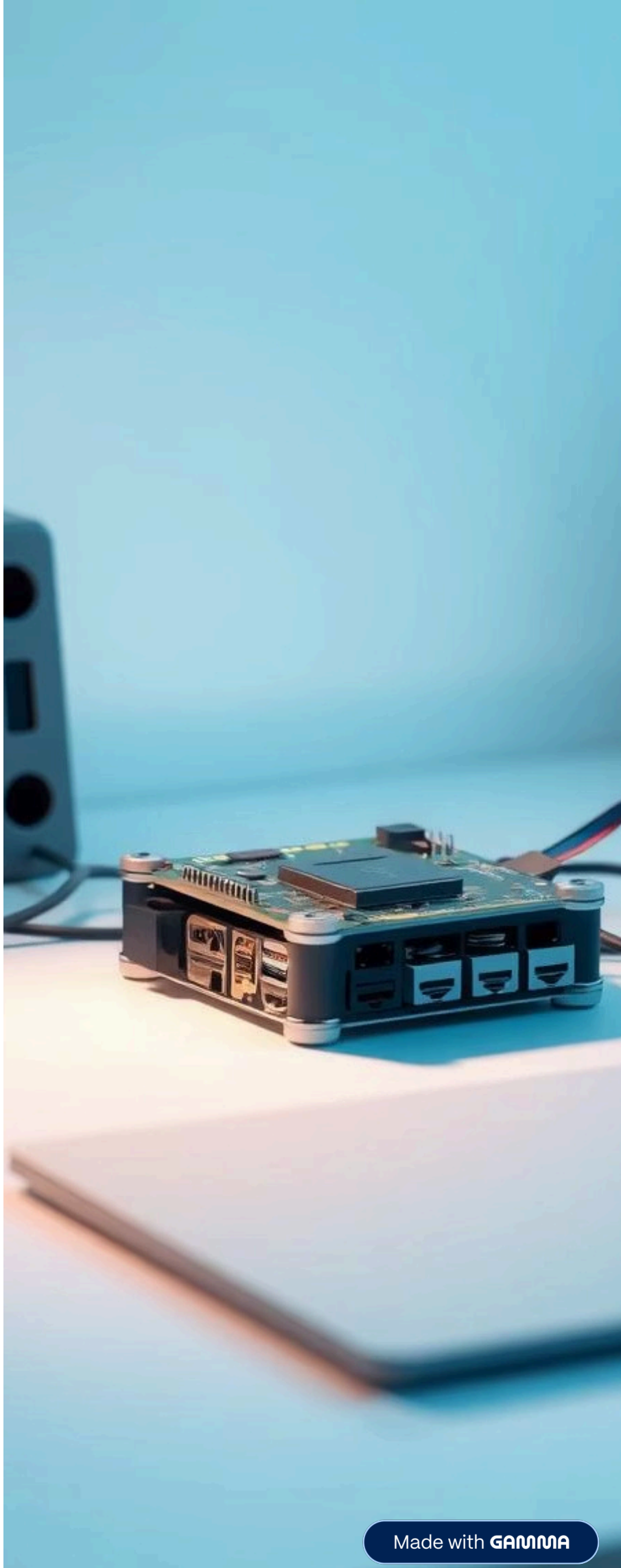
Benefits

- Portable, cost-effective
- Suited for remote farmland locations with limited power infrastructure

Use Case

Sufficient for single to dual camera feeds, providing reliable real-time detection at the edge

Price Tag: $869 USD (approximately LKR 280,500)



Future Work: PP2

- Integrate SMS/Call API to notify users and alert them via alarm
- Setup Arduino via PyFirmata
- Integrate red, green LED to react according to elephant mood
- Integrate Buzzer/Sound Audio Module to make noise

Thank You