PROJECT ABSTRACT

ESP32-CAM Wildlife Camera Trap with Night Vision

A PIR-triggered wildlife camera trap — ESP32-CAM with 850 nm IR night illumination capturing timestamped images to microSD on a battery-friendly deep-sleep design — delivered as a built-to-order student project with firmware, power-budget worksheet, report, PPT and viva kit.

01. Title

ESP32-CAM Wildlife Camera Trap with Night Vision

02. Introduction / Background

Camera traps are a cornerstone of modern wildlife ecology: unattended cameras that photograph animals on trails, at water holes and near nests, revealing species presence and activity patterns no human observer could collect around the clock. The enabling trick is passive-infrared (PIR) sensing — a pyroelectric element that detects the moving heat signature of a warm body — used as a wake trigger so the power-hungry camera sleeps until needed. The ESP32-CAM puts a capable camera, SD storage and WiFi-capable microcontroller on one student-budget board, and 850 nm infrared LEDs provide night illumination invisible to animals and humans alike.

03. Problem Statement

Commercial camera traps cost far more than a student budget, and manual wildlife observation does not scale across nights and seasons. What is needed is a buildable, explainable trap: motion-triggered capture with day and night capability, timestamped image storage, and a power design that lets the unit sit unattended — all from commodity modules a student can wire, program and defend in a viva. The project must also be honest about field realities: enclosures, clock drift and trigger tuning.

04. Objectives

- Wake the ESP32 from deep sleep on HC-SR501 PIR motion interrupts.
- Capture still frames with the OV2640 at configurable resolution and JPEG quality.
- Illuminate night scenes with an 850 nm IR LED ring invisible to animals.
- Store timestamped JPEGs to microSD with chronological filenames.
- Select day/night capture mode automatically via ambient-light sensing.

- Minimize idle draw through deep sleep, with a power-budget worksheet for field-life estimation.
- Provide adjustable PIR sensitivity and hold time for trail tuning.

05. Proposed Methodology

The HC-SR501 is characterized first: its sensitivity and hold-time potentiometers are tuned against human walk-throughs at measured distances. The ESP32-CAM firmware implements the wake chain — PIR interrupt, camera boot, ambient-light check, optional IR enable, capture, SD write, return to deep sleep — with JPEG quality and resolution as configuration constants. An LDR gates the IR ring for night operation. Current is measured in sleep and active states to complete the power-budget worksheet, from which field-life estimates are derived arithmetically rather than claimed. Lab testing covers trigger latency, night illumination throw and multi-day simulated deployment with timestamp review.

06. System Architecture / Working

Armed, the unit rests in deep sleep with only the PIR sensor powered. A warm moving body crossing the detection cone drives the sensor output high, firing a wake interrupt. The ESP32 boots the camera, checks ambient light, enables the IR ring if dark, captures the frame, encodes JPEG, and writes it to microSD under a timestamped filename — optionally capturing a second frame after a short delay. The controller then returns to deep sleep. Timestamping uses the firmware clock; an RTC add-on is documented for multi-week deployments.

07. Hardware / Software Requirements

- ESP32-CAM module (OV2640 camera, microSD slot).
- HC-SR501 PIR motion sensor (adjustable range up to ~7 m).
- 850 nm IR LED illuminator ring.
- MicroSD card for image storage; battery pack.
- LDR module for day/night detection.
- Weatherproof housing guidance (enclosure fitted by buyer).
- Software: Arduino IDE (C/C++ firmware).

08. Expected Outcomes

A working trap that captures timestamped images on motion triggers, day and night, with wake-to-capture latency targeted well under a second and night illumination effective over a few metres. The power-budget worksheet yields a defensible field-life estimate from measured currents. The demo — triggering captures in the lab, viewing the IR illumination in darkness and reviewing the timestamped image log — exercises every subsystem.

09. Applications

- Wildlife presence and activity surveys.
- Farm intruder and crop-raid monitoring.
- Nest and burrow observation.
- Security and trespass detection demos.
- Teaching platform for low-power embedded design.

10. Future Scope

Cellular or LoRa upload would remove the SD-card retrieval step; on-device species classification with a tiny ML model is an active research direction. Solar charging, a DS3231 RTC for drift-free timestamps, and a proper IP-rated enclosure complete the path from prototype to field instrument.