PSG iTech

2025 INNOVATORS CONCLAVE -HYDERABAD-

- **Problem Statement Title - Mobile Lifi Communication via Autonomous Drone Technology**
- **Theme - Defense Tech**
- **Team Name - NeuroMinds**
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LIFI Communication

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Mobile Lifi Communication via Autonomous Drone Technology

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PROBLEM STATEMENT DESCRIPTION

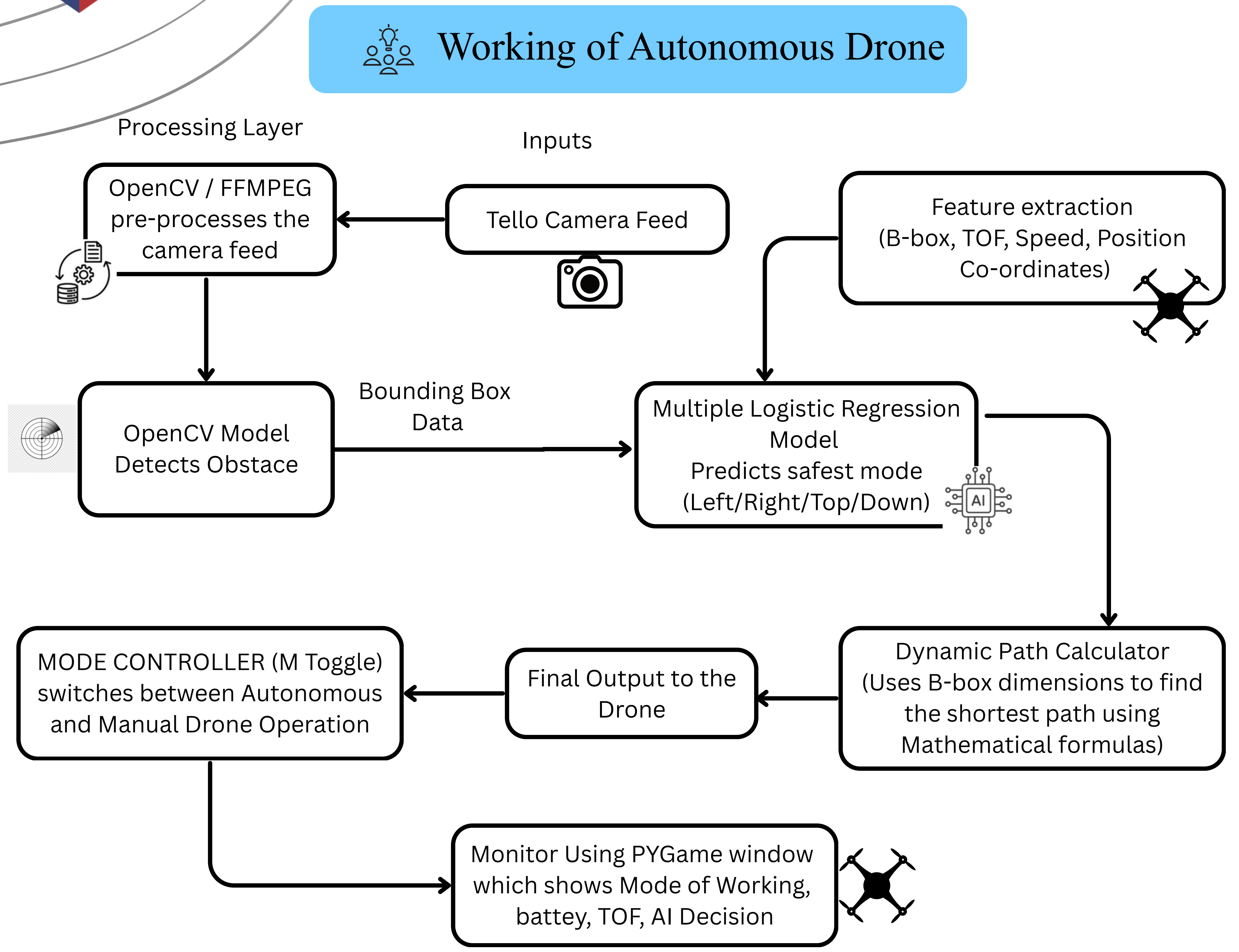
- Conventional static towers utilized in the defense sector lack adaptability once deployed, making them unsuitable for regions with dynamic or shifting terrains.
- Structural damage—caused by landslides, sabotage, or other disruptions—can result in complete communication blackouts across vast operational zones.
- Current Radio Frequency(RF)-based communication systems are highly susceptible to jamming, interception, and spoofing, thereby endangering mission-critical data and command security.
- In densely built environments or forested regions, the line-of-sight propagation of RF signals is frequently obstructed, leading to significant degradation in communication reliability.
- Hence the problem is:

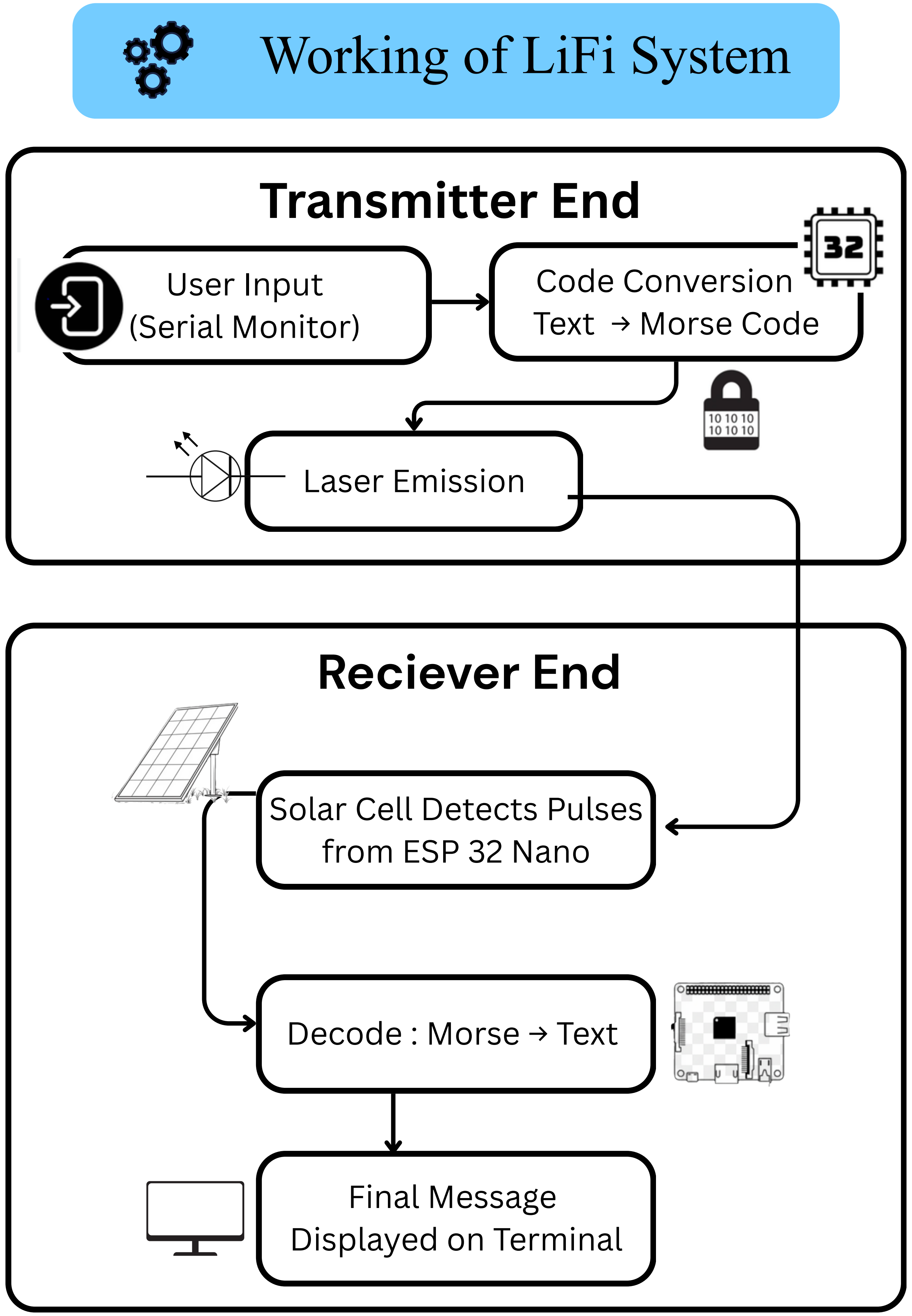
  How can we transform rigid and exposure-prone communication lines into adaptive, resilient networks for defense and disaster operations?

PROPOSED SOLUTION

- A Li-Fi–based optical communication system is proposed to replace vulnerable RF links.
- Enables secure, line-of-sight communication using light instead of radio signals, ensuring stealth and reliability.
- To overcome the disadvatages of the static tower , the transmitter of the LiFi system(initially) is mounted on the drone to make the communication system mobile.
- The mobility of the system mitigates the problem of line of sight which was the major diadvatage of LiFi communication and also the RF system.

FLOWCHART


Working of Autonomous Drone
Processing Layer
Inputs
OpenCV / FFMPEG pre-processes the camera feed
Tello Camera Feed
Feature extraction (B-box, TOF, Speed, Position Co-ordinates)
OpenCV Model Detects Obstace
Bounding Box Data
Multiple Logistic Regression Model Predicts safest mode (Left/Right/Top/Down)
AI
MODE CONTROLLER (M Toggle) switches between Autonomous and Manual Drone Operation
Final Output to the Drone
Dynamic Path Calculator (Uses B-box dimensions to find the shortest path using Mathematical formulas)
Monitor Using PYGame window which shows Mode of Working, battey, TOF, AI Decision


Working of LiFi System
Transmitter End
User Input (Serial Monitor)
Code Conversion Text → Morse Code
32
Laser Emission
Reciever End
Solar Cell Detects Pulses from ESP 32 Nano
Decode : Morse → Text
Final Message Displayed on Terminal

TECH AND FEATURES

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Tech Stack

OpenCV

Yolo V8

Mediapipe

scikit learn

React

ARDUINO

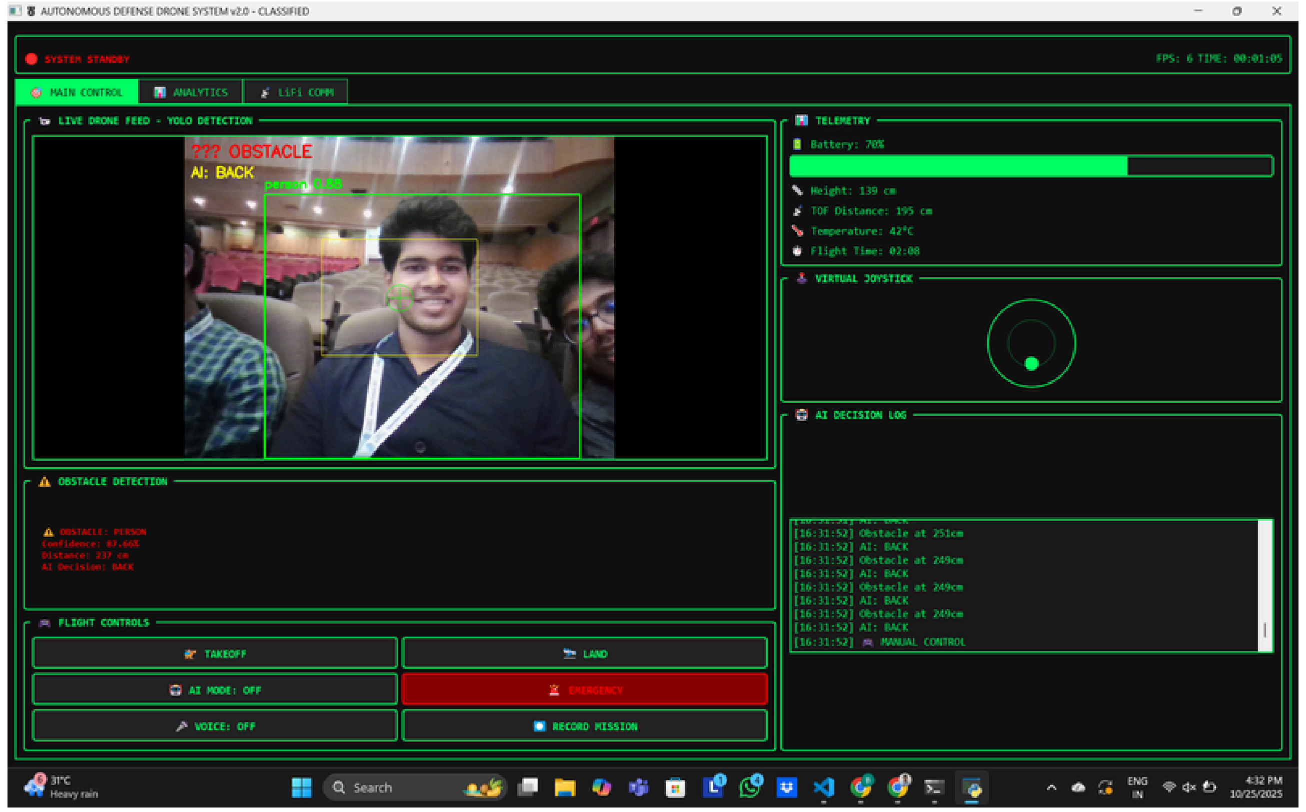
PI OS

TELLO

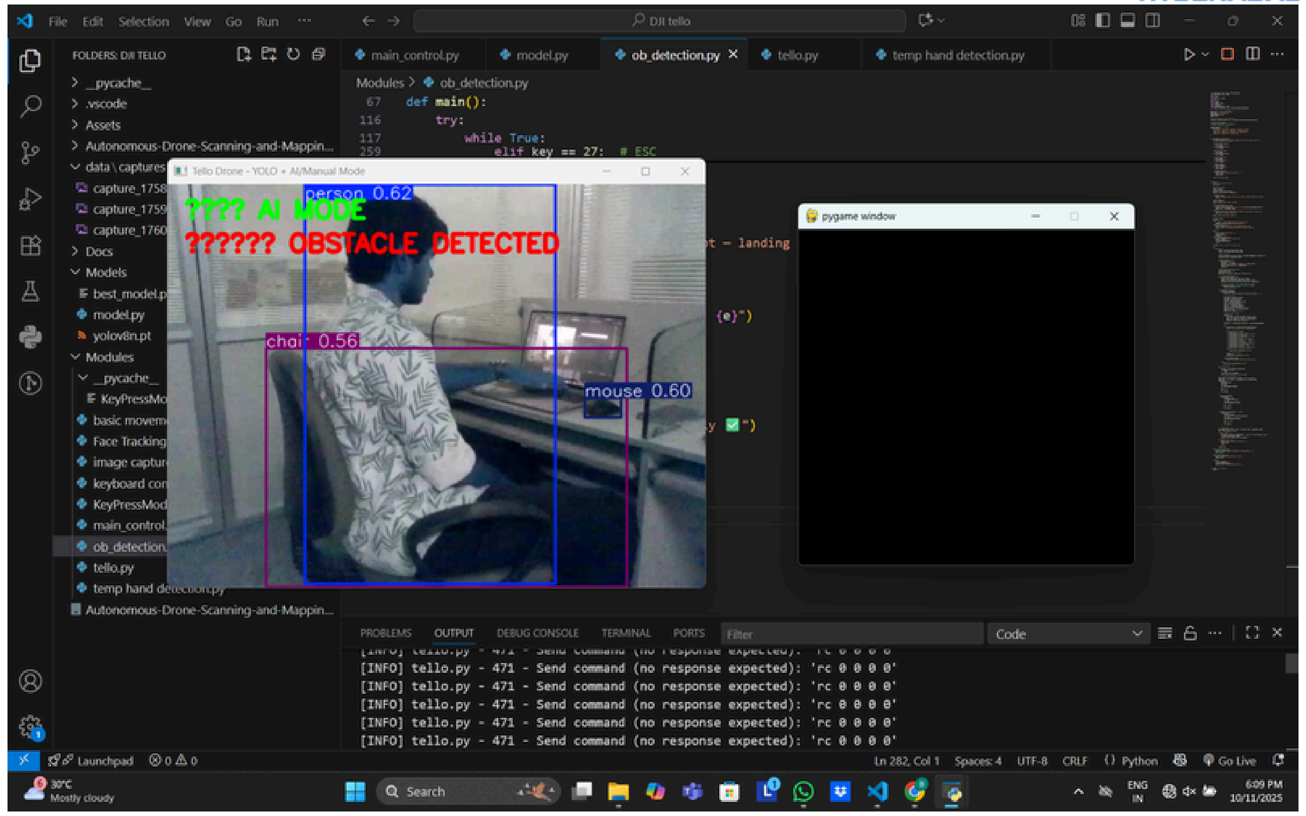
Features of the Prototype

- **Dual Communication:** Optical (Li-Fi) with RF fallback for stable connectivity.
- **AI / Manual Control:** Front-end interface to toggle flight modes and monitor drone in real time.
- **Secure Optical Link:** Morse-encoded, encrypted light transmission for stealth communication.
- **Integrated Flight System:** Simultaneous optical data and video streaming via Ryze Tello.
- **Adaptive Decoding:** Real-time ADC sampling and threshold adjustment for accurate signal detection.
- **Lightweight Hardware:** Compact ESP32 and Raspberry Pi 5 setup with low power usage.
- **Data Logging:** Front end records flight metrics, link performance, and AI control behavior.
- **Optical Amplification:** Coherent Laser passed through collimating or Fresnel Lens for more precise light signals.

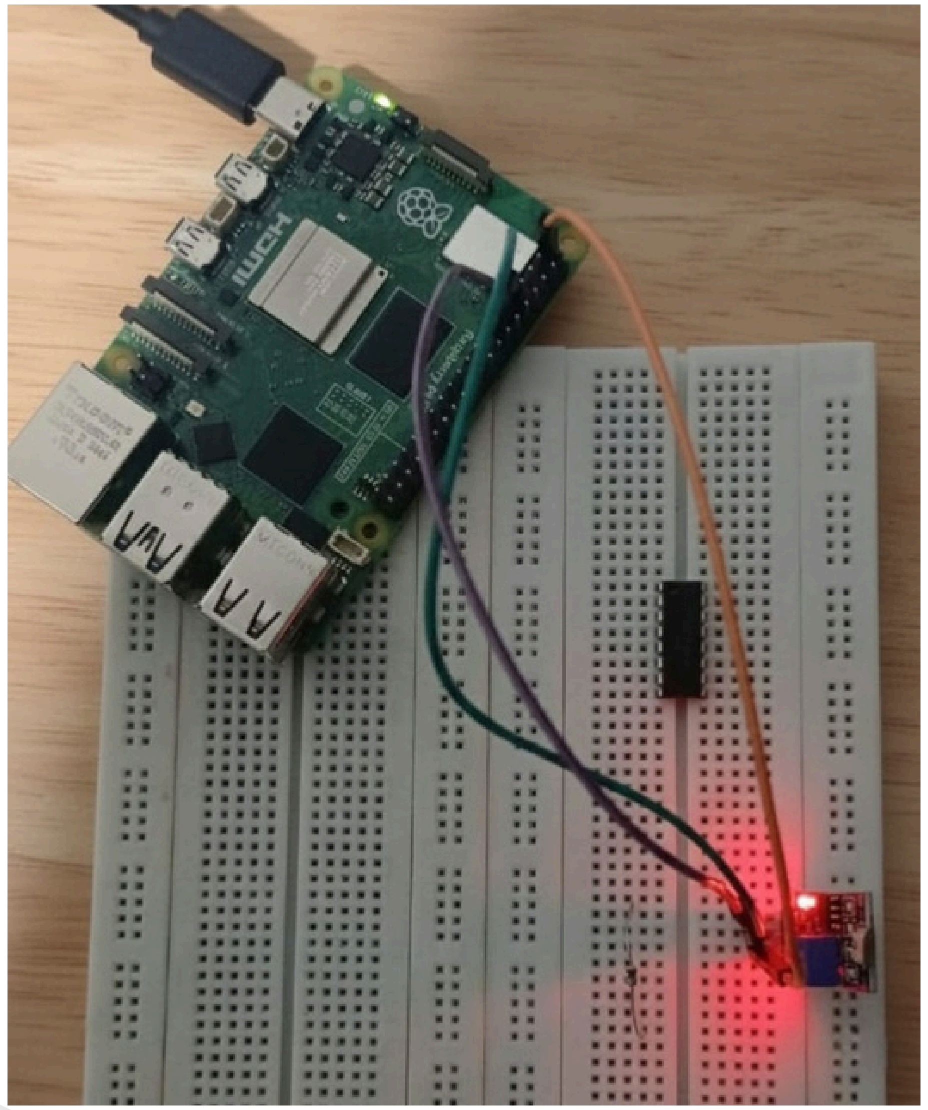
PROTOTYPE



GUI interface for Drone & Communication

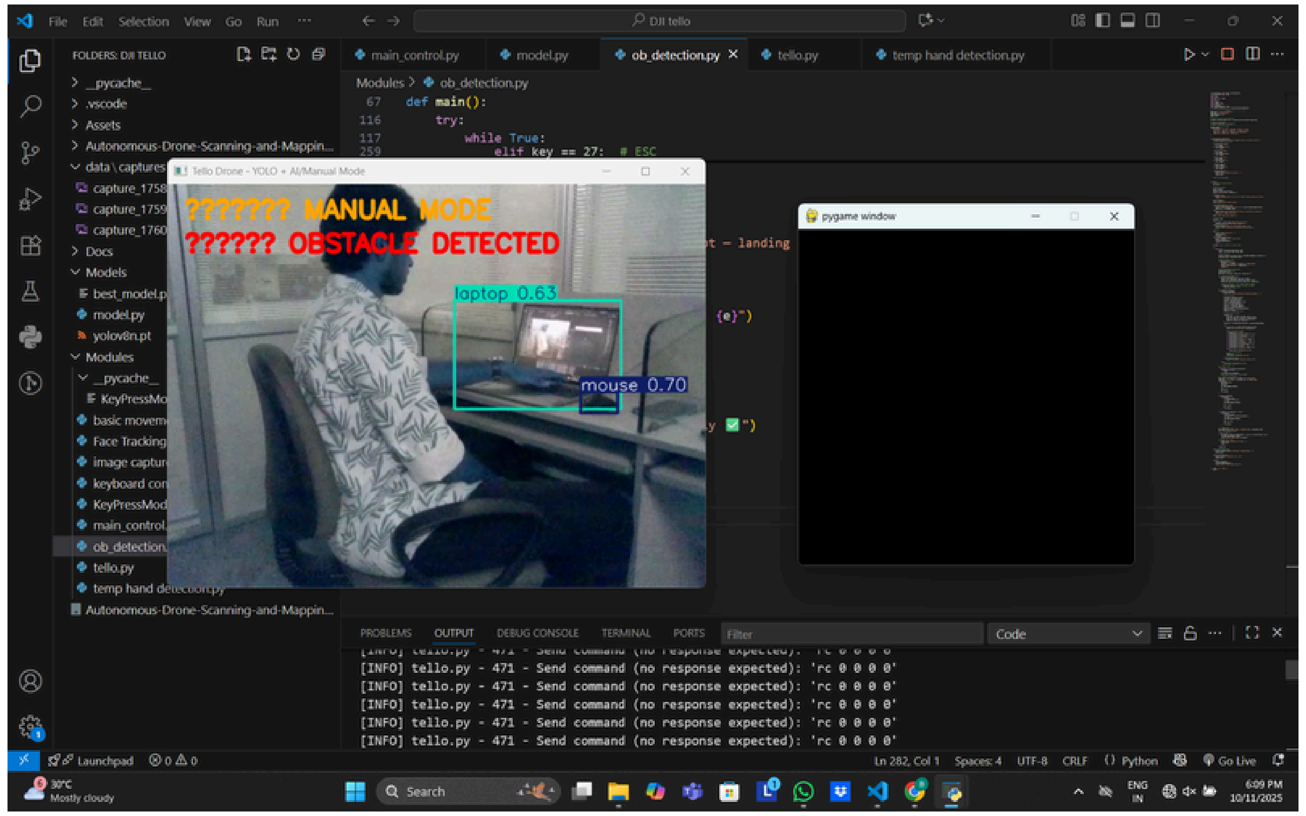


Drone Feed with AI and Manual Mode Toggle



Li-Fi Receiver - Raspberry Pi 5 + LDR

Li-Fi Transmitter ESP32-C3 Supermini



FEASIBILITY AND MITIGATION

FEASIBILITY

- Drone-based platform provides a proven, stable aerial base for optical communication, verified through existing UAV stabilization and control technologies.
- The design supports rapid deployment in field conditions, requiring minimal setup or ground infrastructure.
- The system drastically reduces infrastructure and maintenance costs compared to conventional RF towers
- Easy adaptability makes it feasible for use in civil applications such as rural communication, search-and-rescue, and emergency networks.

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MITIGATION

- **Line-of-Sight Dependency:** Optical communication requires clear visibility between drones.
- Ambient Light Interference: Sunlight or artificial lighting can disrupt optical signals.
- Limited Range: Effective only over short distances, reducing coverage area.
- Alignment Sensitivity: Precise positioning is needed for stable transmission.
- Power Constraints: Added modules increase power usage and reduce flight time.

IMPACT AND BENEFITS

BENEFITS

- **Secure Communication:** Covert Li-Fi and encryption prevent interception.
- **Reliable Data Transfer:** Maintains connectivity even in RF-restricted zones.
- **Scalable Architecture:** Can support single drones or large multi-drone fleets.
- **High adaptability:** Capable of dynamically repositioning to maintain connectivity across varying terrains and mission scenarios.

GAPS IDENTIFIED

- **Vulnerability of RF Links:** Current systems are easily jammed and intercepted.
- **Lack of Covert Channels:** No practical non-RF communication solutions for drones.
- **Limited Research Integration:** Few projects combine optical, acoustic, and AI-based control.
- **Real-Time Coordination Gap:** Inconsistent communication under dynamic flight conditions.

IMPACT

- Ensures **secure communication** by hovering in inaccessible high-altitude areas like **Ladakh, Siachen,** and **Arunachal**, where conventional towers cannot stand. Its capability for rapid, highly secure data transmission restores vital network links, supporting critical operations on India's most challenging northern and eastern fronts.
- In **disasters — landslides in Himachal, floods in Assam, earthquakes in Nepal** — this system brings back command, control, and coordination within minutes.

RESEARCH PAPERS

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2. Ryze Tech (DJI), “Tello Drone – User Manual,” 2018. [Online]. Available: https://dl.djicdn.com/downloads/Tello/Tello_User_Manual_EN.pdf.
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4. H. Haas, L. Yin, Y. Wang, and C. Chen, “What is LiFi?” J. Lightwave Technol., vol. 34, no. 24, pp. 5865–5875, Dec. 2015.
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