AUTONOMOUS DEFENCE DRONE SIMULATION FRAMEWORK WITH REAL-TIME AI VISION AND INTELLIGENT MISSION CONTROL

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Introduction:

1. Unmanned Aerial Vehicles (UAVs) are increasingly being used in defence, surveillance, and disaster management applications. However, most existing systems require significant human intervention and lack real-time intelligent decision-making capabilities. This creates limitations in scalability, response time, and operational efficiency in critical environments such as border surveillance and emergency response.

2. To address these challenges, this project proposes an AI-powered drone simulation framework that integrates real-time computer vision with intelligent decision-making modules. The system processes live video input to detect objects such as humans, vehicles, and potential threats using deep learning models. Based on these detections, the system performs basic reasoning and simulates drone actions such as tracking, patrolling, and scanning.

3. The project is designed as a modular software-based framework that enables safe testing and development without requiring physical drone hardware. This allows experimentation with AI-driven autonomy in a controlled virtual environment and provides a foundation for future deployment in real-world UAV systems.

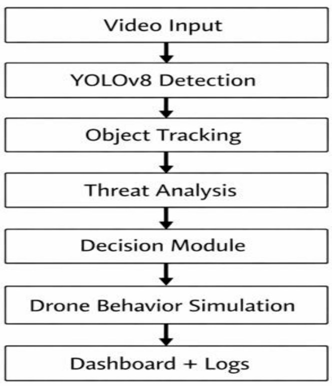

Figure 1: Sample detection output showing identified objects and threat classification

Objectives:

1. To develop a real-time object detection system using YOLOv8 for identifying humans, vehicles, and potential threats.
2. To implement an object tracking mechanism for continuous monitoring of detected entities.
3. To design a basic decision-making module that interprets detection results and generates appropriate actions.
4. To simulate drone behaviors such as tracking, patrolling, and scanning based on detected scenarios.
5. To build a simple dashboard for real-time monitoring, visualization, and logging of system activity.
6. To create a modular framework that can be extended to full autonomous drone systems in the future.

Methodology:

1. The proposed system follows a modular pipeline architecture for processing and decision-making.
2. Initially, video input is captured either from a camera or pre-recorded footage. This input is passed to the perception module, where the YOLOv8 deep learning model is used for real-time object detection. The system identifies relevant objects such as humans, vehicles, and suspicious items.
3. To enhance temporal consistency, an object tracking module is incorporated to maintain identities of detected objects across frames. This enables continuous monitoring of targets.
4. The detected objects are then analyzed by a decision-making module, which applies rule-based logic to classify situations such as normal activity or potential threats. For example, the simultaneous detection of a person and a weapon is classified as a threat scenario.
5. Based on the decision output, the system simulates drone behaviors such as tracking a target, patrolling an area, or scanning the environment. These actions are represented logically within the system rather than being executed on physical hardware.
6. A dashboard interface is used to display real-time video feed, detection results, system decisions, and activity logs. The logging module records system events with timestamps for further analysis.
7. This modular architecture ensures flexibility and allows future integration with advanced modules such as LLM-based reasoning, ROS2 navigation, and multi-drone coordination.

Result and Conclusion:

1. The system successfully performs real-time object detection using YOLOv8 and demonstrates the ability to identify humans and potential threat scenarios. The integration of tracking and decision logic enhances the system's capability to simulate intelligent behaviour.
2. The prototype validates the feasibility of combining computer vision and decision-making modules in a UAV simulation framework. Although full autonomy is not yet achieved, the current implementation provides a strong foundation for further development.
3. The system operates in near real-time and demonstrates stable performance across different test inputs.

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Future Scope:

The future scope of this project includes:

1. Integration of LLM-based mission planning for natural language command understanding.
2. Implementation of ROS2-based autonomous navigation and control systems.
3. Integration with simulation platforms such as AirSim or Gazebo.
4. Development of multi-drone coordination and swarm intelligence.
5. Deployment on real drone hardware for real-world testing.