**1. Track(s) Chosen:**

AI in Defense and Disaster Response

**2. Problem Statement:**

Mass disasters like ***earthquakes, floods, and collapsed buildings*** inhibit conventional ***survivor detection by smoke, debris, no GPS/network infrastructure, and humongous, unstructured terrain***. There is an urgent requirement for an ***AI-driven autonomous drone swarm system*** **to detect survivors in real time through fused sensor data even in very degraded environments.**

**3. Introduction:**

We are an interdisciplinary team interested in combining **Artificial Intelligence and robotics to assist in disaster relief efforts**. We propose ***Zephyr*** , an **end-to-end simulated autonomous drone platform to identify survivors** from combined ***visual (thermal + RGB) and RF (Bluetooth/Wi-Fi/SOS beacon) signals***. We've designed our simulation on a ***ROS2 + Gazebo setup*** that is meant to depict **scalable, modular, and adaptive survivor search missions for GPS-denied and infrastructure-poor environments.**

**4. Proposed Solution:**

***Zephyr*** addresses the pressing need for **disaster rescue missions to quickly and precisely locate survivors where traditional infrastructure, cellular, and GPS signals are weakened or non-existent**. Our ROS2- and Gazebo-based autonomous drone swarm leverages **Artificial Intelligence (AI), bio-inspired swarm coordination, and multi-modal sensor fusion to navigate intelligently** and in collaboration. Each drone is an independent agent that perceives signs of **human presence with combined thermal and RGB vision (with YOLOv8) and RF signal triangulation from Wi-Fi, Bluetooth, or SOS beacons.** The multi-sensor approach offers improved robustness in adversarial **environments such as smoke, dust, or darkness, where individual sensing modalities may be compromised**. Inspired by ant pheromone-based communication, our drones create virtual pheromone trails to avoid overlap and enable dynamic coordination. ***Utilizing Reinforcement Learning (RL), drones adapt to adjust their path planning, spatial memory decay, and role-switching behavior based on real-time success measures and environmental feedback***. This modular, scalable, and testable system can mimic real-world disaster scenarios and possible integration with live disaster recovery operations, ***resulting in life-saving outcomes in defense and humanitarian missions through robotics-aided leading-edge AI.***

**5. Solution Description:**

**1. Locating Survivors**  
***Thermal + RGB Vision with YOLOv8:*** Our flying robots use smart models to identify human beings. RGB vision operates in daylight and heat vision operates at night or where visibility is low.  
***RF Signal Triangulation:*** Each drone behaves as if it can receive RF signals (like Bluetooth or phone beacon), which is important in locating human beings. The system operates on a signal loss model that expresses real signal attenuation.  
***Sensor Fusion algorithm:*** This fuses RF and vision detections into a single confidence score to identify human beings.

**2. Smart Coordination**  
***Drone Behavior By Role:***  
***Scout:*** Scout drones search new regions not previously mapped.  
***Verification:*** Verification drones travel back to the previous signal location in the regions identified as having a survivor.  
***Relay:*** Relay drones will relay communications to the base or link with the other drones.  
***Dynamic Role Switching:*** Drones switch roles in real-time to maximize performance based on RF signal strength and difficult terrain.

**3. Biological Procedures**  
***Virtual Pheromones:*** The drones provide virtual pheromones to indicate locations of interest/landmarks to the group map that they share.  
***Stigmergy-Based Communication:*** The use of virtual pheromones allow simple decentralized communication for the drones to convey search priorities.  
***Anti Congestion Protocols:*** Protocols will set constraints on spacing to spread out traffic, avoid congestion within a single area, maximize search area coverage while minimizing search redundancies.

**4. Memory Over Time**  
***Grid-Based Confidence Mapping:*** There exists a grid of many 1 x 1 cell cells covering the area in which there was a probability of finding survivors in each cell.  
***Decay Mechanism:*** Instances of detection have a time decay that occurs until something new is documented; wherever people move away from old leads.  
***Reinforcement Updates:*** Whenever a drone receives new visual or RF detections, the confidence score in each drone is raised to suggest locations for the swarm to promote the most meaningful collaboration.

**6. Tech Stack:**



