Faza'a Swarm: Intelligent Swarm Drones for Search and Rescue

Senior Design Project
Term 232

Team 77

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Introduction

Problem Statement:
Reduce the search time for missing individuals in the desert environment by integrating the capabilities of swarm drones, AI models, and communication systems.

Elevator Pitch:
Search and rescue teams face a problem with long search times. So far Search and rescue teams need shorter search times, Faza'a swarm is a swarm of drones that use AI to reduce search time. Unlike traditional drones, the Faza'a swarm uses AI capabilities to detect missing persons in the desert.

Constraints:
➤ Absence of cellular communication (5G, 4G, 2G) in desert areas, and the other available systems such as LORA, Xbee have low data rates (less than 300kbps).
➤ The operating temperature of the swarm drones is 25 °C.
➤ Budget is 8000 SAR.

Target Specifications:
➤ Weight: 1.5 kg
➤ Flight Time: 10 minutes
➤ Range of the Communication System: 5 km
➤ Confidence of detection: 60% from 20 meters

Project Impact:
Economic Impact :
Reduced Costs & Time: By replacing expensive helicopter searches with AI-driven swarm drones, our project significantly cuts down on the cost and duration of search and rescue operations in desert environments. The use of low-cost, low-power ZigBee technology for drone communication further enhances affordability.

Societal Impact :
Enhanced Safety: Our drones quickly locate missing persons in the desert, improving survival rates without requiring internet access or telecom infrastructure.
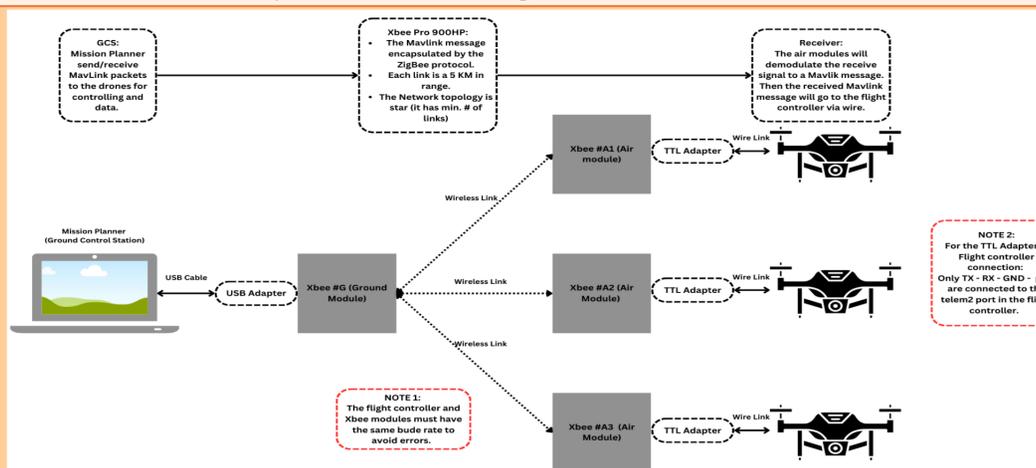
Environmental Impact:
Lower Emissions: Shifting from helicopter to electrical drone searches reduces CO_2 emissions. Our drones can also be solar-powered, promoting renewable energy use in harsh environments.

Prototype Design

Design Overview of a single drone:
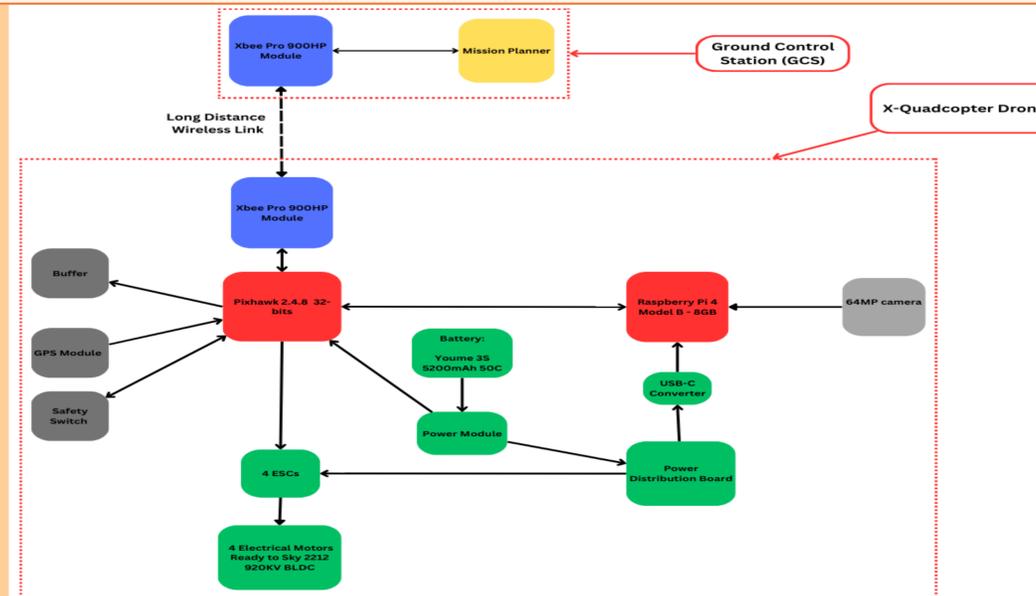
**Communication System Block Diagram:**

Final Design Summary:
Flight Time: The Drone motors consume 15.52A, the Xbee 0.3A, GPS 0.023A, and the Raspberry 1.2A. At Discharge safety of 15%, the Flying time equal to 12.8 min.
Communication System range: The link budget of the wireless link shows that the power received at 5 km is –71 dBm, which is bigger than the -101dBm receiver sensitivity
Confidence of detection: AI requires a ground sampling distance (GSD) of 0.6 cm/pixel to detect a human with a confidence of 60%. The 64MP camera can achieve a GSD of 0.6 cm/Pixel from 51 meters. Also, from 20 meters the GSD of the camera is 0.235 cm/pixel which indicates that the AI can detect a human from 20 meters with a confidence of 60%.
Wight: The drone designed with a total wight of 1.5kg with 0.15kg maximum payload. The payload of a single drone is 47g (Xbee) + 97g (Camera and Raspberry Pi 4) = 144g or 0.144 kg. Thus, the payload of the drone didn't exceed the maximum.

Main program Flowchart:
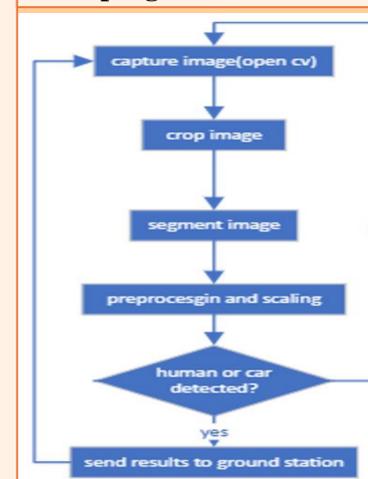
Testing and Validation

Ground tests:
We conducted multiple tests on the ground before the first flight for the machine vision system, and communication system and we also conducted comprehensive drone testing:
➤ The AI and camera system were able to detect a person from 70 meters at 0.85 confidence level with 50 seconds of processing time
➤ The communication system on the drones has been implemented in star topology. Also, the automatic repeat request (ARQ) system was enabled to increase the link quality from 65% to 97% which makes the link more stable.
➤ The maximum range of the communication system in urban areas is 600m, and 6.5 KM in clear line of sight (LOS) in non-urban according to the manufacturer. However, after many trials, we managed to get a range of 300m from 12m height inside the KFUPM campus.
➤ The drone's electrical circuits deliver power efficiently to the motors, flight controller, companion computer, and communication system.

Conclusions

In Conclusion, the project aims to increase the efficiency of search and rescue orations in the desert environments. The project implements swarm drones, AI detection Algorithms, and low-power communication systems. Despite the limited budget, we managed to build three drones that implements the above technologies to achieve the prototype specifications and the goals of the project. The prototype managed to achieve some of the specifications. Thus, in the future the prototype will be improved to enhance the computational speed, range of the communication system, and flying performance.