ADRA

Autonomous Disaster Relief Assistants

Team Details

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Challenge Definition

Problem Description

Problem:

- Task of locating, rescuing and providing necessary relief supplies to disaster victims.
- Probability of delay in a rescue operation due to unforeseen and unavoidable circumstances, such as harsh weather and hazardous terrain.

Audience / Market:

- First-responders like EMS Personnels

Scenario:

- Stranded hikers and visitors in tourist spots in Arizona.

Motivation

- Avid nature lovers from Arizona.
- Often, hikers are stranded in the desert heat.
- Responders need to cover a large area quickly to find survivors and supply water.
- Current Search and Rescue procedures are slow or costly.

Requirements

Primary Objectives	Secondary Objectives
Human Localization	Easy Deployment
Environment Surveying	Minimal Training
Route Planning	Minimal Operator Controls
Package Delivery	Reasonable Cost

Solution

Desired Solution

Perform three important tasks:

1. Survey & Locate Victims:
   Survey a designated area and identify potential victims.

2. Relay Victim Coordinates:
   After identification, victim position coordinates are relayed back to base camp.

3. Deliver Supply Package:
   Deliver payload (can be communication aides, medical supplies, food packets, etc.) at the identified victim's target location.

Proposed Solution

S.No	Objective Type	Task	Solution
1	Primary	Surveillance	Mission initiation with target location parameters for first copter
2	Primary	Human Detection	Input imagery data processed for identifying humans at base camp
3	Primary	Package Delivery	Deploying second copter carrying payload for delivery
4	Secondary	Assembly & Deployment	Transportable components and on-site assembly
5	Secondary	Human Override	Operator can override the default copter behavior for surveying, detection & delivery

Performance Evaluation

Measures to Meet Challenge Needs

Criteria	Description	Target Goal
Assembly	Time taken to assemble the system at target site	The system should be assembled at the target location within **15** minutes.
Deployment & Data Gathering	Time taken for a component to be deployed from base camp & gather input data for processing	The system should be able to deploy a component to cover **2km** within **5 minutes** and gather image data for processing.
Detection Accuracy	Accuracy of identifying and detecting humans from the image data	The system should be able to detect humans with at least **90%** accuracy and within **250** milliseconds.
Delivery	Time taken to drop off the payload and the quality of payload at the target	The system should drop the payload without any damages to it

Performance Evaluation for Subsystems

Subsystem	Property Name	Target Goal	Status	Criteria Mapping
Navigation	Deployment	< 15 minutes	N/A	Assembly
	Estimated Time of Arrival	2km within 5 minutes	3km in 5 minutes	Deployment & Delivery
Communications	Data Transfer	95%	85%	Data Gathering
Power	Low Power	20% threshold	20%	Power Systems
Image Processing	Detection Accuracy	90%	N/A	Human Detection
	Computation Time	< 250 ms	~500ms	

Technical Ingenuity

Background

In a retrospective cohort study of search & rescue operations (conducted in the state of Oregon)

- 1997-2000:
  - 1040 searches, involving 1509 victims, 70 (4.6 %) died
  - Average SAR Time - 18.5 hours
- 2001-2013:
  - 1262 searches, involving 1778 victims, 115 (6.5 %) died
  - Average SAR Time - 19.75 hours

Solution Ingenuity

- A Modular system for first responders
- Combination of “surveillance” and “delivery”

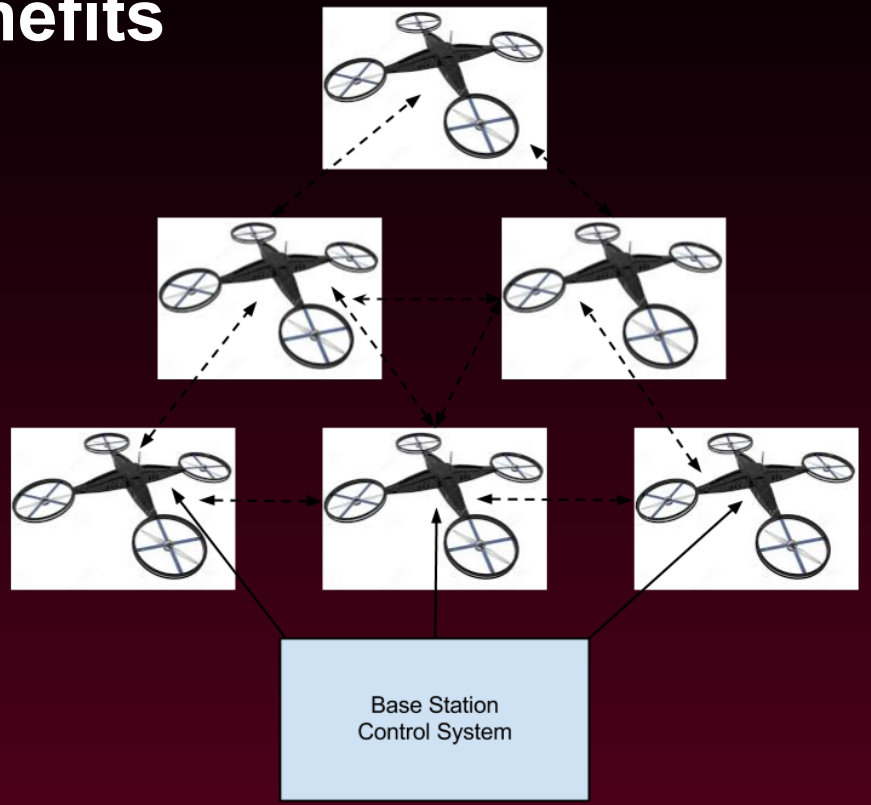
- Builds a foundation to allow first responders to work with UAVs:
  - Search Mission planning
  - Data aggregation & analysis
  - Display information for informed decision making
  - Delivers aid packages

Mesh Network

- WiFi Mesh Network created to link all quads in the field
- Implemented using IEEE 802.11s protocol
- Each quadcopter acts as an access point in a large Ad-hoc network
- Works similar to a WLAN, where quadcopters are differentiated via IP addresses
- Allows for easy management of large groups of quads

Mesh Benefits

- Ability to extend the range of the entire group
- Quadcopters can be added and removed and the network is able to easily manage the new additions or loses
- Allows for easy collaboration between systems on the network

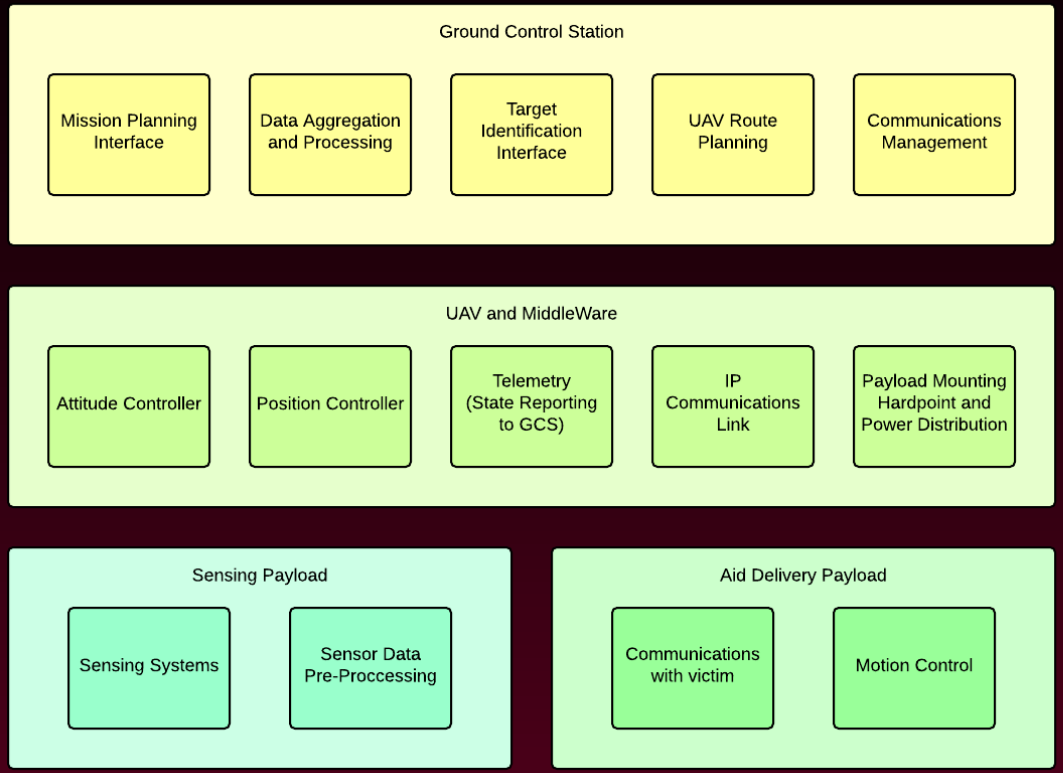


Collaborative System

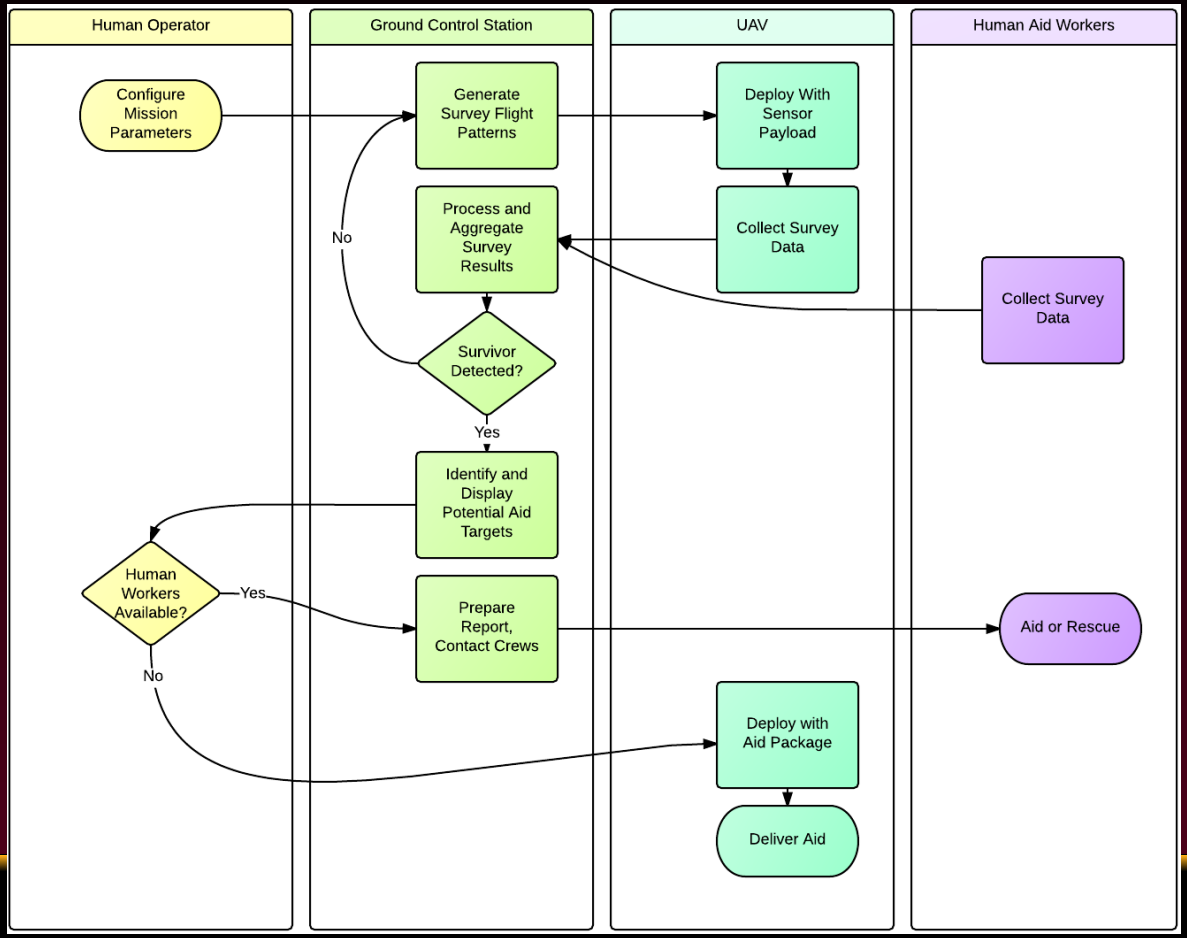
- Node based system allows for many configurations depending on terrain and scale of search
- Data from multiple UAVs is compiled into one report at master node
- Flight patterns are generated to allow for tiers of scans with verification

Project Execution

High Level Overview



Operation Workflow



Execution Challenges Summary

Some of the challenges faced during execution of the project are:

1. **Power Consumption Dilemma:**
   - **Problem:** Communication Overhead vs Image Processing Overhead
   - **Solution**: Optimization tests to reduce power consumption
2. **Low Power PoA:**
   - **Problem:** Loss of bots vs. Bot Recall
   - **Solution:** Default mode of bot recall, but can be overridden for additional surveying
3. **Bot Network Configuration:**
   - **Problem:** Single Coupling vs. Mesh Network vs. Zigbee
   - **Solution:** [Current: Peer-to-Peer, Future: Mesh Network]
4. **Object Detection:**
   - **Problem:** Default HOG Detection of OpenCV is designed for smaller image
   - **Solution:** Training the descriptor for our image data

Risk Handling

Area	Risk	Solution
Deployment	Damages while deployment	3m x 3m launchpad
Hardware	Damages to important copter components	Skeletal setup to support and protect the component
Flight Disturbance	Obstacles or other vehicles in airspace	Safety override for shutting down and landing [DISCLAIMER: Object avoidance is still not functional]
Environment Risk	Blades may cause damages to objects in close proximity	Propeller frames to cover accidental damages [DISCLAIMER: Still not fabricated]

Next Steps

- **Replaceable payload components for multi-domain project usage, like:**
  - Thermal Imaging for better identification
  - LIDAR, Laser Sensor for Indoor SLAM
- **Different configurations of UAVs**
  - Multicopter
  - Fixed Wing
- **Advanced communications systems**
  - Victim Communication System (for audio)
  - ZigBee (for better sensory communication)
  - Multicopter communication infrastructure (WiFi / Mesh / etc.)

Thank You