Swarming Robots

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Executive Summary

Every day in locations around over the globe, human beings place themselves in situations dangerous to their health for the benefit of others. Examples of this would be soldiers going to war, police officers performing their duties, and rescue workers trying to save the lives of those affected by disasters, natural or otherwise. Technology exists to make the lives of a population safer, but these people risk life and limb perform their duties because a replacement for the human body and mind has yet to be created.

Even though creating something with the physical and mental abilities is still beyond our capabilities, creating tools to reduce the risks inherent in such dangerous situations is not only possible, but achievable. The aim of this project is to create a number of vehicles that can not only cooperate to accomplish simple missions, but adapt to changing situations in real time.

Problem Statement

With military zones disaster zones becoming increasingly dangerous, having autonomous robots helping to search areas without needing to put human life in danger will be a very important asset. The goal for this project is to build a swarm of mobile robots that interface with the world via a "command center" laptop. This swarm will be able to receive missions from the command center and automatically determine how they are going to search the area and deploy themselves internally. The robots will have GPS sensors and a webcam to be able to navigate and search the given area. Our team will also need to develop the communication lines from the swarm to the command center, the control code for the swarm, the mission logic software and the command center interface.

Acknowledgments

Lockheed Martin will supply the necessary funding to complete this project. Lockheed Martin will provide technical expertise when necessary.

Operating Environment

The testing environment for the project will not be extreme conditions. A wide open field free of any substantial obstacles will serve as the testing grounds for the hardware and network. This area was chosen because the goal of this project is not to extensively test the hardware and mobility of the vehicles; it is to test the process of the vehicles communicating over an ad-hoc network while performing a mission. Since the open field will not provide any real issues for the project virtual obstacles will be provided such as, losing network connection or vehicle malfunction, and physical objects will be provided for the vehicles to detect.

Assumptions

Network

1. Maximum number of nodes – 254
2. Testing area of one square mile
3. Minimal radio interference in testing area
4. All instructions and data must be sent over ad-hoc network

Vehicle

1. Will not be tested in harsh environment
    a. Temperature will not exceed 110 degrees Fahrenheit
    b. Water will not be an issue
    c. Terrain will be easily traversable
2. *The system will only be run on the hardware selected by the team.*
3. Must be able to run for 30 minutes continuously
4. Must send and receive all commands and data over ad-hoc network

Limitations

Time - Two semesters to research, plan , design, implement and test the system
Money - Approximately $3000 dollars in our design budget
Experience - The team has collective knowledge building software, working with hardware, some experience with networks and exposure to embedded systems programming.

Functional Requirements

High priority:

1. The network must be able to remain continuously connected via Wi-Fi
2. If a node drops out of the network; each node must calculate where to move in order to repair the network, inferred based on the previously recorded GPS coordinates of the other nodes.
3. If a node drops out of the network, all remaining nodes must be informed about the loss within 20 seconds
4. The network must be ad-hoc
5. A node must be able to join another node in an ad-hoc network within 10 seconds of coming within range of it
6. Nodes in the network must be able to work together to complete mission objective, which may include directing the network to a location or issuing commands to a node's sensor.
7. Routes must be planned and re-planned dynamically as needed
8. Use sonar sensors to detect obstacles larger than the radius of the wheels within 2 meters from the RC car
9. Ability to autonomously drive within 5 meters of a given coordinate that is reachable with the current battery life
10. Control point of view of onboard camera with a lateral range of +/- 180 degrees from front of car and vertical range of +/- 45 degrees from a plane parallel to the car
11. The command center issues a mission assignment to the vehicles, from a predefined list
12. Command center can display multiple views (GPS map, video feed, mission status, sensor values)
13. Minimum number of vehicles – 4
14. Each vehicle must have general payloads(video feed, image capture/recognition, etc)
15. Each vehicle must have a unique payload, physical or virtual (robotic arm, bucket, water bottle, etc)

Medium Priority

1. Data must be continuously shared about each node with all other nodes in the network
2. Each node must continuously track information about all other nodes
3. The system must be able to share output from any arbitrary sensor type
4. At any point in time, the current information that a node has about each other node in the network must not be older than 20 seconds
5. Transmit all data between RC cars and Command center up to a range of 70 unobstructed meters
6. Ability to determine location within 5 meters accuracy while stopped or 8 meters while moving
7. Ability to process 240p streaming video at 15 fps minimum with 16 bit color (minimum color requirements for an android phone)
8. Camera controller should be able to rotate 180 degrees in 1 second for both vertical and horizontal rotation
9. The RC car must be able to maintain a minimum speed of 3.4 mph (standard march speed)
10. Monitoring of vehicle information at a defined interval (GPS location, battery life, etc)
11. Command center needs to log each vehicles information for mission summary report

Non-Functional Requirements

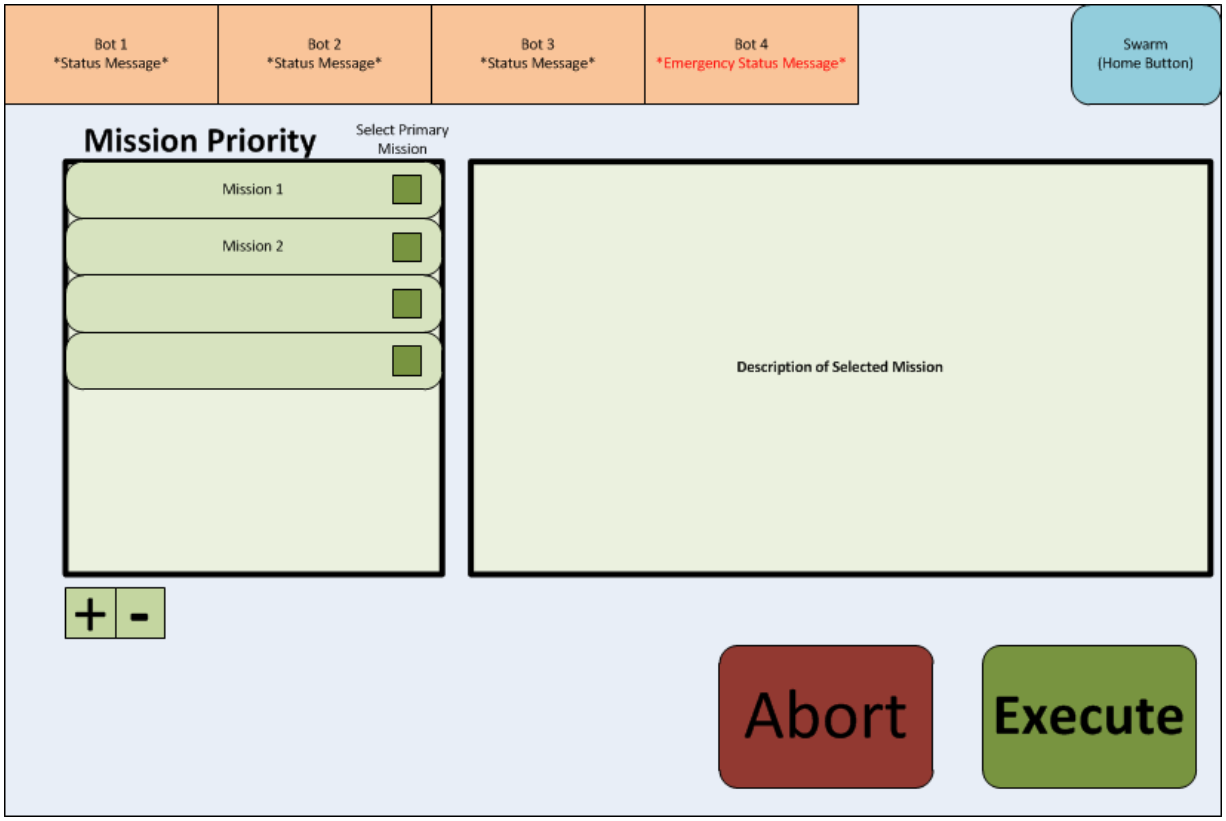
1. RC car can weigh no more than 10 lbs
2. The RC car shall run on electric motors
3. Locations will be determined by GPS coordinates
4. System must support the 802.11n and g WiFi protocols
5. The system must support up to 254 nodes
6. The system must be able to detect when data from the network has been corrupted and notify the sender
7. The system must support distances of 75 yards between nodes in ideal conditions
8. Bots must have enough battery capacity for 30 minutes of constant operation

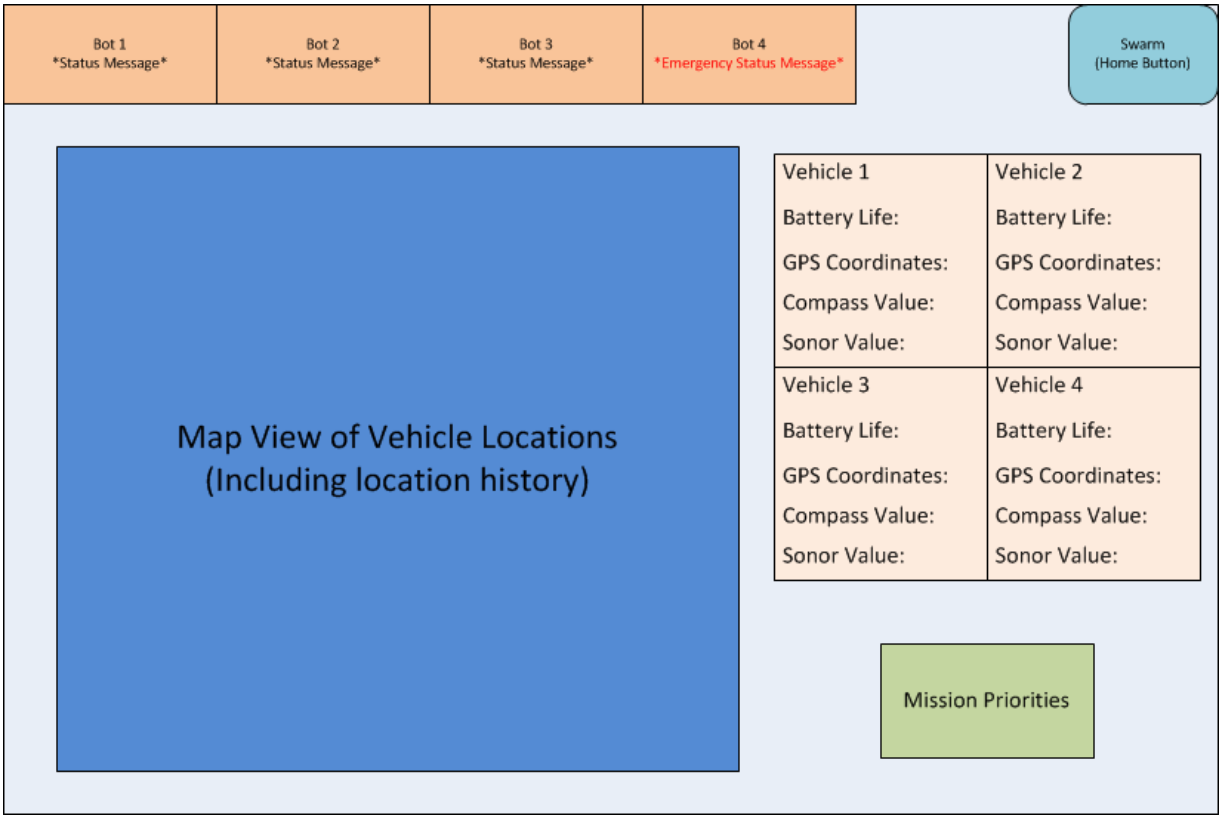
Security Design Considerations

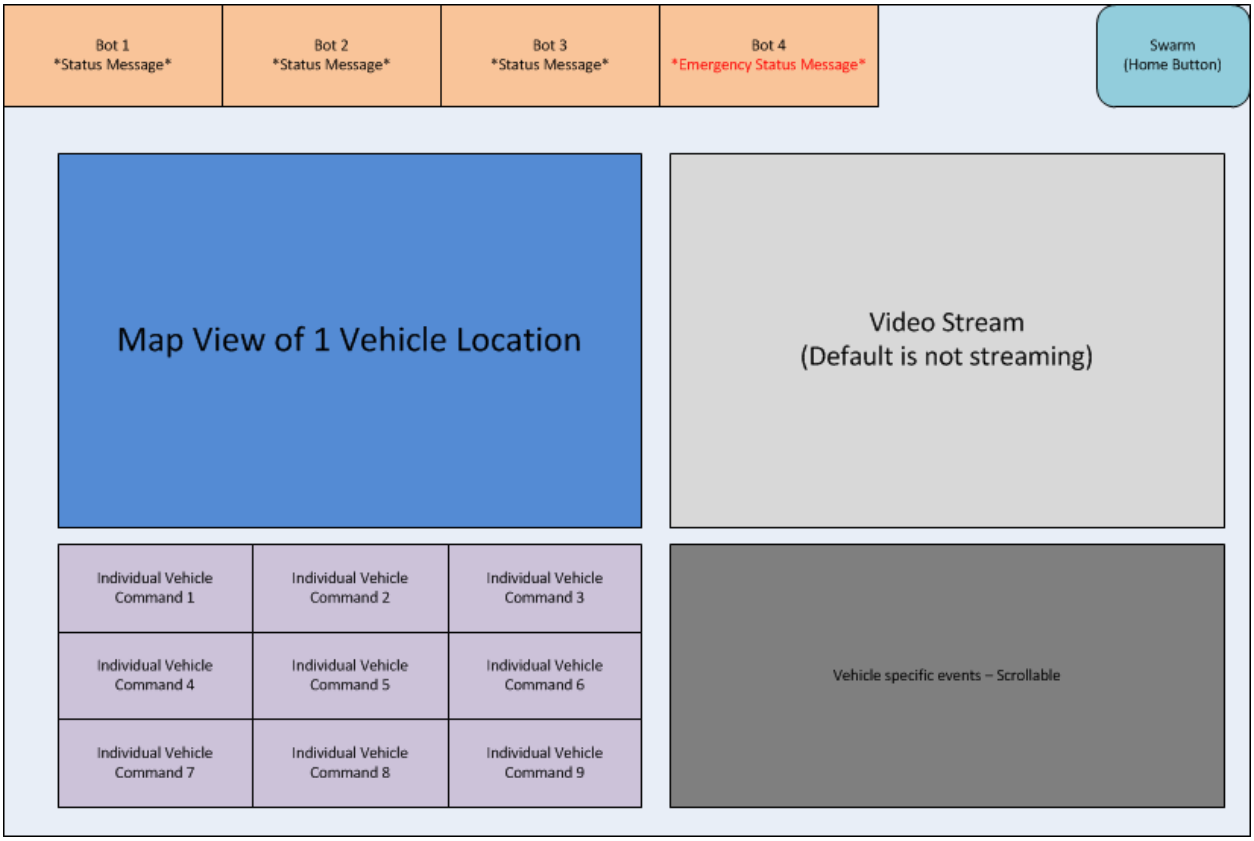
For this particular project, security will be given little consideration. Security implementation can be included as a final extra step but is not required at this time. However, simple security measures are encouraged if practical and straightforward to include. We will hold security considerations on a low priority. However, this project will be designed with the understanding that future development of this project will include and require strict security measures.

Solution Approach

We have designed three screen templates for the Command Center Application: Mission Priority (Top of Page 7), Swarm (Bottom of Page 7), and Individual Bot (Top of Page 8). The user will be shown the Mission Priority page upon initialization of the application, and then directed to the Swarm page, where the user will spend the majority of their time.


Bot 1
Status Message
Bot 2
Status Message
Bot 3
Status Message
Bot 4
Emergency Status Message
Swarm
(Home Button)
Mission Priority
Select Primary Mission
Mission 1
Mission 2
Description of Selected Mission
+
-
Abort
Execute


Bot 1
Status Message
Bot 2
Status Message
Bot 3
Status Message
Bot 4
Emergency Status Message
Swarm
(Home Button)
Map View of Vehicle Locations
(Including location history)
Vehicle 1
Battery Life:
GPS Coordinates:
Compass Value:
Sonor Value:
Vehicle 2
Battery Life:
GPS Coordinates:
Compass Value:
Sonor Value:
Vehicle 3
Battery Life:
GPS Coordinates:
Compass Value:
Sonor Value:
Vehicle 4
Battery Life:
GPS Coordinates:
Compass Value:
Sonor Value:
Mission Priorities



Phase 1

Reverse engineer previous projects to better understand what needs to be redesigned

Phase 2

1. Redesign vehicle chassis and electronics
2. Study vehicle ESC with ISU RC club's help
3. Reprogram Arduino code
4. Implement transport protocol and add features
5. Video streaming and visual processing
6. Database to store vehicle information
7. Mission Programming

Phase 3

Design the command center graphical user interface to aid in information retrieval, mission assignment and overall functionality.

Phase 4

1. Testing and refinement
2. Get as many eyes and hands on the project as possible
3. Create list of changes that can be quickly implemented from user feedback
4. Final document and poster creation

Phase 5

Demo at Jack Trice in April or May 2013

Work Distribution

	Douglas	Matt H	Matt K	Zach
Arduino & Construction	30%	20%	5%	40%
PandaBoard Coding	10%	30%	20%	30%
Networking	25%	25%	45%	5%
GUI	25%	25%	25%	25%

Closing Summary

With military zones disaster zones becoming increasingly dangerous, having autonomous robots helping to search areas without needing to put human life in danger will be a very important asset. The goal for this project is to build a swarm of mobile robots that interface with the world via a “command center” laptop. This swarm will be able to receive missions from the command center and automatically determine how they are going to search the area and deploy themselves internally. The robots will have GPS sensors and a webcam to be able to navigate and search the given area. Our team will also need to develop the the communication lines from the swarm to the command center, the control code for the swarm, the mission logic software and the command center interface.

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