Search & Rescue Drone

PROJECT PLAN

MAY 1736
Client: N/A
Adviser: Rafael Radkowski
Team Members/Roles:
Jarid Ingebrand - Team Leader
Collin Farrell - Communications Leader
Blake Skaja - Web Master
Mark Rusciano - Team Concept Holder
Team Email: cfarrell@iastate.edu,
Team Website

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Contents

1 Introduction

1.1 Project statement

Natural disasters such as earthquakes, tornadoes, hurricanes, volcanic eruptions and tsunamis are occurring with increasing frequency around the world, yet manpower, cameras, and binoculars are still our primary way of finding survivors. While survivors cannot use their phones to call for help, they are still radiating signals which can be detected to pinpoint survivors.

We propose building a cost effective and mobile survivor-detection platform that can be attached to any drone to autonomously search an affected area. Since 81% of Americans carry a mobile device, we can locate survivors by measuring the signals that their cell phones constantly radiate. To improve the location accuracy to search and rescue responders, we will supplement our radio detector system with a thermal camera which uses a different method as a failsafe to pinpoint survivors that are on a roof or out in the open. Although, we intend to equip our detection platform prototype with a low-cost camera, more advanced thermal cameras could even look for people buried in rubble.

1.2 purpose

The motivation behind the project is that of humanitarian aid. Our work benefits survivors of natural disasters and afflicted areas. It aids first responders to natural disasters by displaying locations and concentrations of people with cell phones. The located people are all potential survivors therefore they are good places to focus the effort of the rescuers.

1.3 Goals

We have divided our project into two parts: 1) The survivor-detection platform, and 2) The quadcopter. The first stage will be a working proof of concept to secure funding to build phase two.

1) Phase one is a survivor-detection platform built around a Raspberry Pi consisting of the components listed in Table 1. The Pi will collect radio-frequency data and thermal data to identify survivors, and broadcast this data to the base station. The base station will plot survivor locations on a map, link images of survivors to these points, and give a count of found survivors. This platform can be used handheld or attached to any commercial drone, plane, or quadcopter for manual or autonomous flight.

2) The objective of phase two is a purpose-built autonomous quadcopter that we will use for testing and refining our analysis algorithms. We will use the map data and located radio signals to plan a flight path. We will further perform test flights that gather real data and transmit it back to our base station for real time analysis and

rendering. This phase will produce an all-in-one autonomous solution so first responders can focus their efforts on the rescue.

2 Deliverables

Our mount, with these included sensors attached: thermal camera, accelerometer, magnetometer, compass, and a GSM patch antenna. A testing drone (quadcopter), which will require our mount be lightweight and well balanced. Deliverables for stretch goals: proof of use after a natural disaster with documented usefulness from first responders.

We request $500 to realize phase one of this project. Every part listed in Table 1 has been researched and selected because it fulfills our specifications in a cost effective manner.

Table 1: Proposed budget

Stage One Budget		
Component	**Purpose**	**Price**
YKS 3DR Radio Telemetry Kit	Pi to Ground Telemetry	$28.58
FLIR Lepton Dev Kit	Thermal Camera	$259.99
Pi GPS	GPS	$49.95
Magnetometer/Accelerometer/Compass	Retrieve angle and direction for Images	$24.95
GSM Patch Antenna	Measure Wi-Fi and GSM Signals	$64.95
RTL-SDR	Software Defined Radio for GSM signals	$31.95
3D Printer Fillament	Printing a bracket to hold our sensors	$35.58
Various Bolts/Connectors/Wires/Glue	Assembly	$4.05
	Total	**$500.00**

3 Design

We have divided our project into four section and each group member is directly responsible for one part. Each person will research their section and report back to the group. We will discuss the findings and decide the best course of action for that part. We consider this a research cycle. As we increase the number of cycles the quality of our project will increase overall. If we cannot agree on the best course of action we have agreed to run the problem by our advisor for additional suggestions.

Jarid Ingebrand is integrating the thermal camera with the Raspberry PI data platform. The PI will be carried by the quadcopter and collects all of the data from the sensors. This data is then submitted back to the ground station. To accomplish this I am going to configure our software to take images using the thermal camera. Next, I am going to collect many images using our camera and use the data to create an algorithm that can identify survivors.

Collin Farrell is creating the pi code for the cell phone wi-fi, radio, and bluetooth detection. These methods will all work together to pinpoint cell phone locations. Once all of these methods have detected a cell phone, they will be packaged on the pi and sent back to the base station. To accomplish this task, Collin will use the GSM patch antenna to detect radio frequencies emitted by phones when cellular service is enabled, offer a spoofed wi-fi connection for phones to connect to, and offer bluetooth connectivity from the pi to connect to any nearby phones with bluetooth enabled. These combined efforts will allow for a pinpoint location of nearby cell phones thus aiding survivors.

Blake Skaja is creating the front end application which will allow users to see and interact the the flow of data that our drone is gathering. We will be using Google Maps to generate heatmaps in real time, which will allow search teams to quickly identify hot spots for possible survivors. This will be a web based application that will have multiple components, including a map, thermal camera feed and a console for seeing the raw data feed. There will also be a desktop application that will run on a laptop that is connected to a telemetry link. This homebase application will be responsible for taking the serial data from the drone, converting it to a useable format and sending it to our webserver and database for more interaction.

Mark Rusciano is working on configuring the software defined radio to report signal strength of key frequencies of the active bands on popular consumer devices. He will also be investigating antenna technologies to maximize our ability to hone in on consumer devices and not on radio towers/cell towers/WiFi access points. He will be implementing the MAVLink protocol on the Raspberry Pi to send this data over telemetry radios to base. He will also be assisting in decoding these messages on the base station. He will determine bandwidth constraints on the telemetry radios so we can determine how much the images being transmitted must be compressed. If we receive funding for phase two, he will be using his prior knowledge of quadcopters to assist in putting together a purchase and integrating our systems with a flight controller at the core/

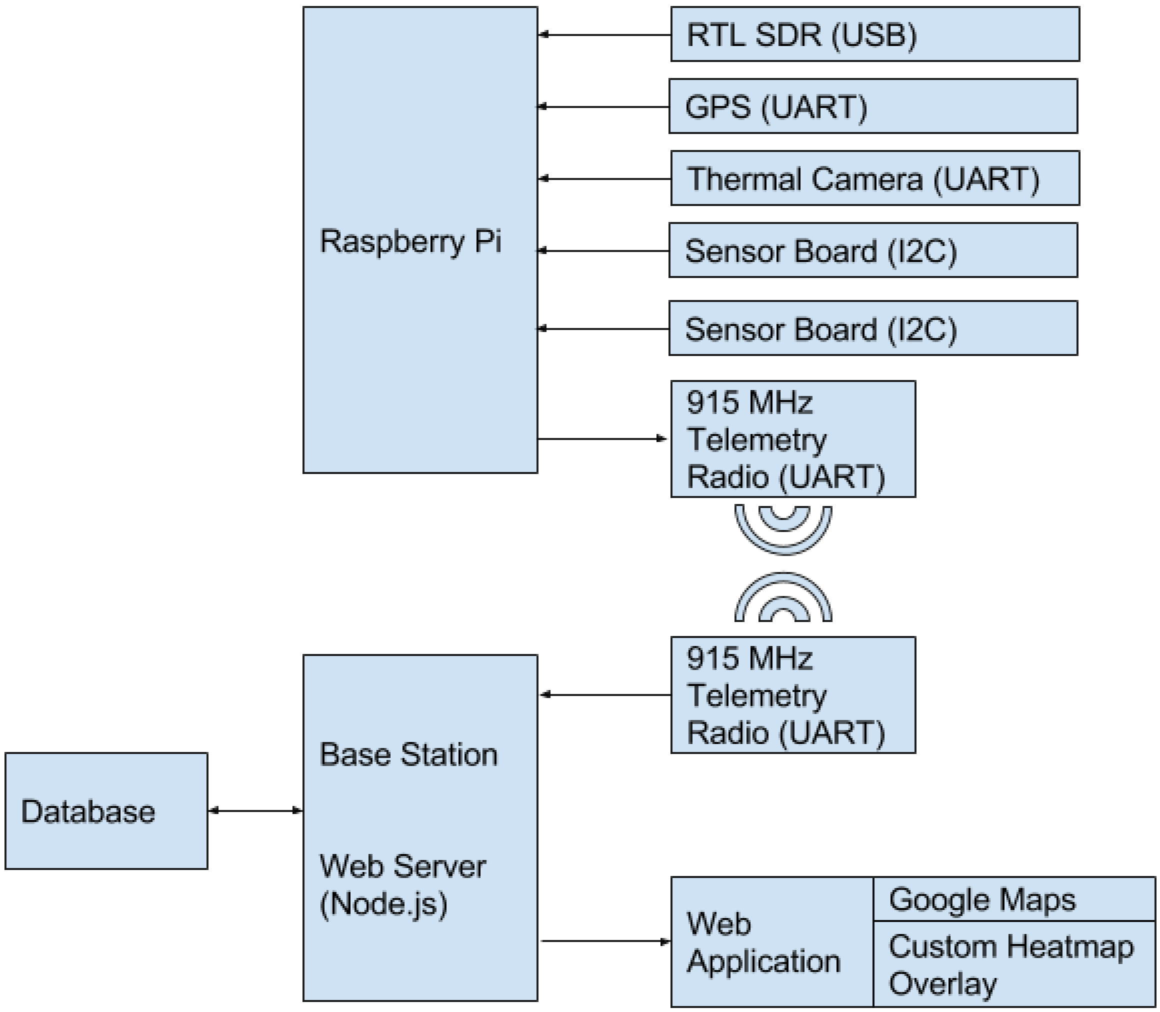
3.1 Previous work/literature

Nothing has been done that is exactly like our project but there are some previous projects that share a great deal of similarities with our work. For example: Bomb-sniffing drones that are being used to detect nuclear bombs;[1] several websites and blogs dedicated to telemetry with drones;[2] and tracking cell phone Wi-Fi signals has been explored to help businesses gain foot traffic statistics of their customers.[3]

3.2 Proposed System Block diagram

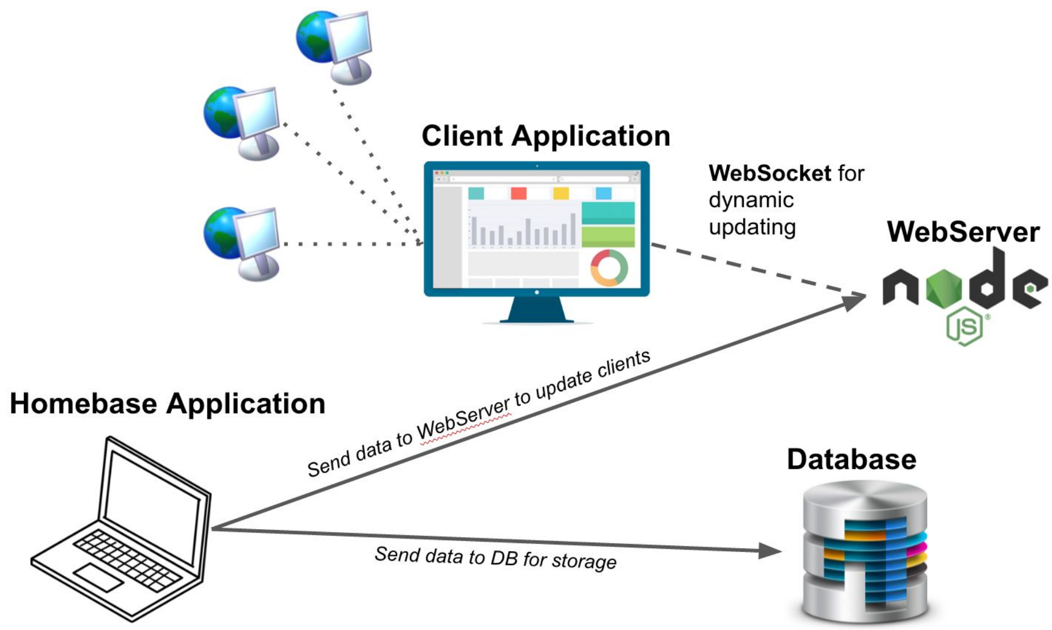
In sections 3.2.1 and 3.2.2, we have our two system design diagrams. We have divided our project into separate systems, one for our drone / hardware and one for our high level software application.

3.2.1 Drone / Hardware System Design



3.2.2 Software System Design

We will have a web based application that will allow clients to see real-time data that is being gathered by the drone. Our web application will use Google Maps to generate a heat map to give clients a visual representation of where survivor hot spots could possibly be. We will also be transmitting live thermal video from our drone, which will also be displayed on the web application. There will also be a raw data console, where a user can see the flow of the raw data into the application.



Our front end, client side application will be written using a combination of JavaScript and HTML5. We will use Node.JS as our WebServer, since it is a great option when dealing with real time data feeds. We will also be using WebSocket's for dynamically updating our client side UI.

We will also have a homebase application which will run on a user's laptop. This application will be linked to the drone and will take in the drones input through a telemetry link. This homebase application will send the drone data to a database for long term storage and then send it to our WebServer through REST calls in order to update our clients.

3.3 Assessment of Proposed methods

We have decided to divide the project up into four parts and have each member specialize in one section of our project. We will communicate and discuss our individual proposed methods.

3.3.1 Hardware Proposed Methods

Our initial challenge for hardware was to find a configuration that allowed us to prove as many design concepts as possible in our project given funding constraints. We decided to remove all flying components from the project (for now) to simplify it and focus on what matters.

We are using a Raspberry Pi as our field data collection unit. We will collect from a thermal camera, traditional camera, GPS, and software defined radio. The initial challenge will be to establish connectivity with each of these components as they all use different protocols. We will use the software development kits available for each of these components to speed up our development time.

Once we have data streams coming from our components, to the Pi, we will need a way to get that data back to base. We will package the data into a single stream for transfer to the base station. Since we still do plan on mounting this system to a drone, we will be using a protocol called MAVLink which is designed for data transfer to and from autonomous vehicles.

We will be using existing implementations of this protocol to create our own that can be interfaced with by all of our sensor boards. That application will then communicate with the 915MHz Telemetry Radios.

At the base station, we will have another implementation of the MAVLink protocol to decode the packets being received from the base station 915 MHz telemetry radio. What the base station will do with this data will be discussed in other sections of this document.

3.3.2 Software Proposed Methods

Initially there were several different proposed software solutions that we considered implementing for this project. We considered creating a desktop application, as we had experience in creating large desktop platforms. We thought that limiting our project to computers, however, would not be practical, as most users would want to access this information from a variety of places. We considered creating an mobile Android / IOS application, as it seemed logically that search and rescue users would be moving around, making a mobile application a great fit. However, we figured why limit our application by developing natively for mobile. We eventually settled on creating a web based application, as mobile devices, tablets and desktops can all access this tool. It also gives our group a chance to work with some new technologies and develop for a wider range of clients.

3.4 Validation

We will test each component individually to ensure isolated functionality throughout the project, then combine all parts into the mount to test cooperation between components. Initially we will measure the thermal camera's detection on ourselves (with and without obstructions.) The next items for testing are the cell phone radio frequency location detection, paired with wifi request detection. Following the previous tests, testing the Pi to base station transmission will be of paramount importance. The server and application will be tested throughout their creation. We will build a unit testing platform that will test the functionality of our code. We will also create a test of automated functional tests that will allow us to simulate user interactions. This can be done through the use of Selenium. We will also use mock data to verify our system works as intended.

4 Project Requirements/Specifications

4.1 FUNCTIONAL

The ability to locate cell phone radio frequencies is central to the success of this project. Radio sniffing capabilities will pinpoint locations and numbers of persons in affected areas after a natural disaster. Phones of potential survivors (with WI-FI enabled) should connect to the spoofed router on board the quadcopter. Thermal images must be taken and be tied to specific GPS locations using the Raspberry Pi's GPS. The Raspberry Pi must package and send information back to the base station, which will parse the data for use in the application. Base station application will display locations of phone signal clusters, WI-FI connections, and thermal images on google maps.

4.2 NON-FUNCTIONAL

The weight of the mount must not greatly inhibit the flight of the drone. If drone flight is inhibited the effectiveness of the end product is greatly reduced. The drone must transmit data back with delay less than one second and packet loss less than 2.5%. The vast majority of the data must reach its destination quickly in order to display accurate results to first responders. Drone must move slowly enough to capture many images from thermal camera. Our camera operates at 8fps, we will have to investigate a methods to increase the resolution.

5 Challenges

Hardware Challenges

The challenges the hardware will pose to our project are tied to the requirements. These challenges will range from ensuring the proper weight of the mounted equipment does not exceed the maximum load of the drone to ensuring proper packaging of the data on the Pi for sending to the base. The weight balancing for proper drone flight, not just heaviness, but where the weight is carried will be an interesting challenge to tackle. Another difficulty will be maintaining a quality telemetry connection to the drone at long distances. These are not all of the problems we will encounter, but the obvious ones that we can foresee.

Software Challenges

Web development can always produce some strange issues. None of our team members have ever worked with Node.JS or WebSockets in a large application, so this will be new territory for us.

Reading serial data from our drone will also be something that only one of our team members has familiarity with, so the rest of our team will need to quickly get up to speed with that pattern of data flow.

6 Timeline

Gantt Chart

6.1 First Semester

Blake Skaja:

- Web Application
    - Google Maps API - generate heatmaps
    - Setup Webserver using Node.js
    - Update clients via Websockets
    - Display console of incoming data
    - Display thermal camera images
    - Choose timeframe for the heatmap display
    - Pull data from DB into our Web Application
- Database
    - Decide on module
    - Set up database
    - Have access from Web Application to our database

Jarid Ingebrand

- Thermal Camera
    - Capture images from the camera
    - Save the images to the disk
    - Calculate camera position and orientation
    - Detect the number of survivors in each image
- RGB Camera
    - Capture images from the camera
    - Send images back to the base server

Mark Rusciano

- Raspberry Pi
    - Implement MAVLink protocol to transfer data back to base
    - Establish UART link to telemetry radio
    - Store high resolution data logs of all incoming data

    - Correlate all sensor data with GPS Coordinates, potentially interpolating between refresh intervals.
- Telemetry Radio
    - Range test telemetry radio
    - Create chart of bandwidth/distance values to assist Jarid in determining how much we need to compress the thermal and conventional images.
- Software Defined Radio
    - Programmatically determine signal strengths of key frequencies from SDR
    - Interface SDR data to MAVLink transponder

Collin Farrell

- Create software for interacting with hardware
    - GSM Patch antenna: tuning to a specific frequency emitted by cell phones(TBD)
    - wi-fi: offer connectivity to nearby, wi-fi enabled devices and obtain location
    - Bluetooth: offer connectivity to nearby, Bluetooth enabled devices
- Programmatically read locations of devices based on the three parameters listed above

6.2 Second Semester

Blake Skaja:

- Homebase
    - Read in data from telemetry
    - Build useful modules for storing data
    - Send data to webserver and database

Jarid Ingebrand:

- Thermal Camera
    - Improve algorithm
    - Improve accuracy
    - Send as much data as possible back to base
- Build quadcopter
    - Attach sensors
    - Collect data
    - Analyze data

Mark Rusciano:

- Drone
    - Determine parts/payload/efficiency requirements
    - Create purchase proposal
    - Assemble drone
    - Move existing MAVLink transponder code to flight controller
- Base Station
    - Assist in implementing custom MAVLink packets at the base station

Collin Farrell:

- Drone
    - Assist with MAVlink data transfer and assembly.
    - Assemble on mount: GSM Patch antenna
    - weight balancing for quadcopter

7 Conclusions

Our plan is to divide the project into 4 manageable sections. Each team member is the owner of that section and all changes and decisions must be communicated through them. We will discuss these decisions as a group and decide on the best course of action for the team. This method will allow us to track changes to our project and insure that we are always on the same page.

Our project consists of two parts: 1) The sensor array and base station, 2) The quadcopter and autonomous functions. First semester we will work almost entirely on the first part of this project. We will build a full integrated data collection platform that can be easily mounted on a drone. This sensor array will collect thermal data, cell signals, WiFi signals, and rgb images. We will use this data to estimate how many survivors are in the area.

8 References

1. http://www.ibtimes.co.uk/bomb-sniffing-drones-uavs-carry-nuclear-weapon-detection-sensors-1556679
2. http://diydrones.com/profiles/blog/list?tag=telemetry
3. https://www.technologyreview.com/s/509771/startup-lets-retail-stores-track-shoppers-as-websites-do/
4. https://developers.google.com/maps/
5. https://nodejs.org/en/
6. https://www.npmjs.com/package/nodejs-websocket

9 Appendices

If you have any large graphs, tables, or similar that does not directly pertain to the problem but helps support it, include that here. You may also include your Gantt chart over here.