

Engineering Notebook

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Senior Design - Autonomous Vehicle for Survival Detection: Communication Team

Fall 2024

Sprint 1:

9/19

Lit Review. All resources, citations, papers used in Lit Review are available on the team Github.

- a. Bibliography of references:

<https://docs.google.com/document/d/1N0dG5gglYNqAYxFy4Y3gFA8iJlVzb2reEV-PBrsleg/edit?tab=t.0>

Research on modulation

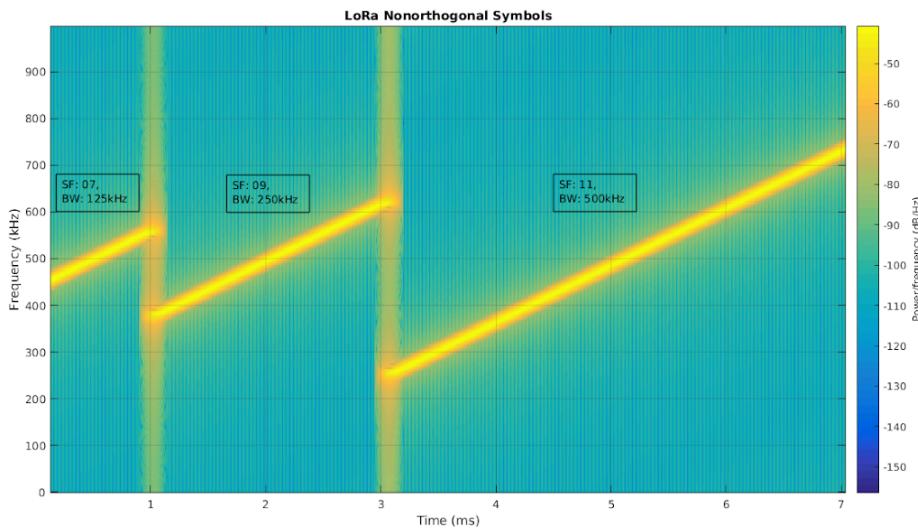
- a. Wifi using raspberry pi 2.4 GHz SoC is a viable option
- b. Backup option: Lora Communications
 - i. Proprietary radio communication (owned by Semtech); good for communicating at a long range, outdoors, in a place with limited access to WiFi, cellular, and other communications that require large infrastructure. Due to this, it is a good modulation technique to use for a disaster survival area, because it will be able to communicate over long distances in an area with little infrastructure available.

9/22

Research on radios

- c. RPi5 has 2.4 GHz WiFi SoC, added to parts list
- d. LoRa hat to place on top of RPi5's for LoRa communications
- e. Potential to use an SDR?

Example Lora Signal Plotted using MATLAB, with different Spreading Factors (7,9,11):



Sprint 2:

10/4

Additional research on LoRa

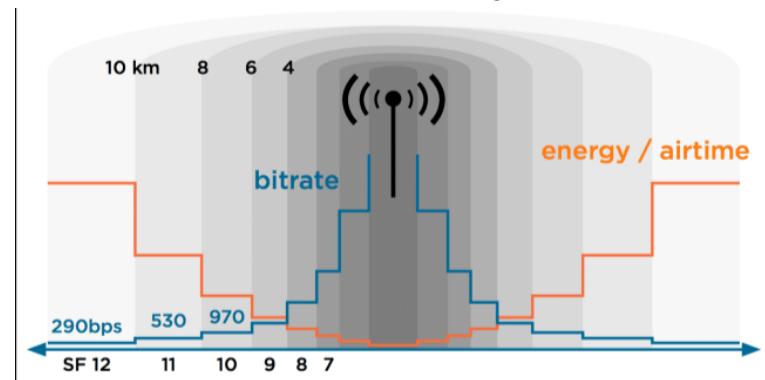
- a. LoRa contains spreading factors (SF) from 7-12. Only SF 7-10 is legal in North America due to restrictions.
 - i. We may want to use a higher SF (8,9, or 10) since we are simulating a disaster area. Higher spreading factor = slower data rate, but more reliable communication. LoRa with a SF of 12 can even be demodulated when the SNR is -20 dB! (that means the noise is 100x stronger than the signal power)
- b. LoRa communicates in ISM bands. We will have the option to use the S-band ISM band (preferred) or UHF ISM band.

10/7

Scope location for testing of rover

- c. LB 274 is inadequate. Why?: Indoors, small area, no terrain, too many people inside the room, tables are in the way
- d. Potential locations for testing:
 - i. If we must stay on campus, we could use one of the fields across the street or by O'connor dorms.
 - ii. Backyard (cookout) with testing rover movement and detection (preferred); required to take off campus

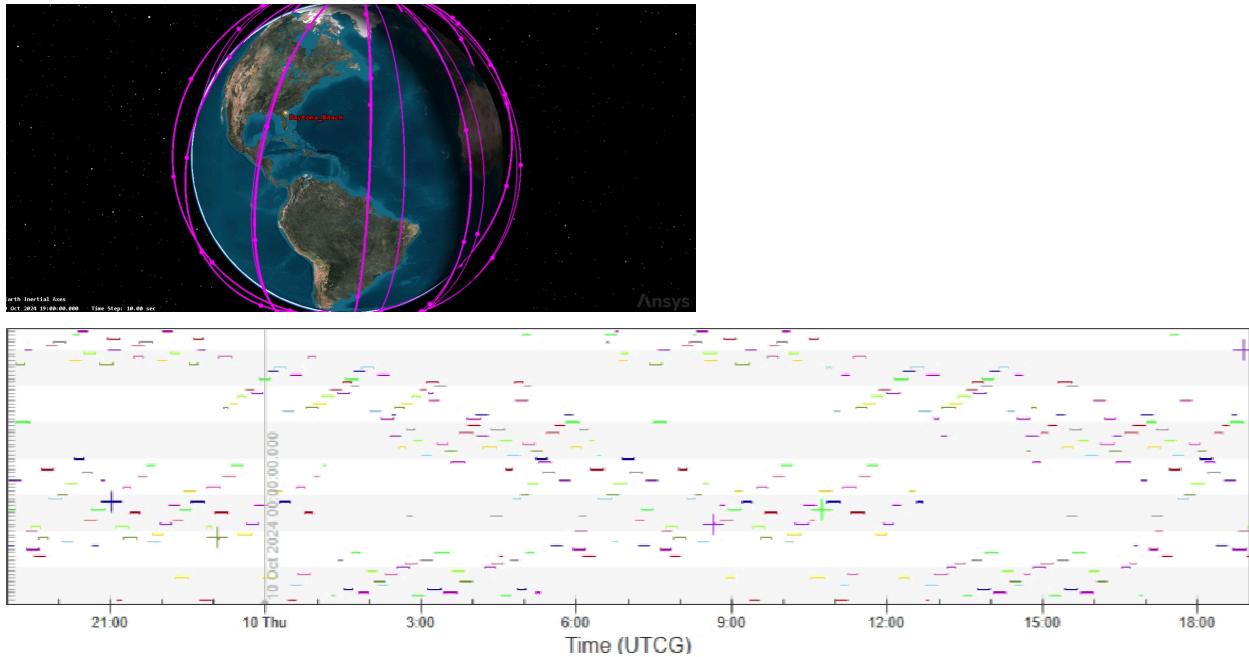
Illustration of different LoRa spreading factors data rate vs. time:



10/9

STK Sim

Our project got completely changed. It is now a requirement (?) to do satellite comms. So I made an STK simulation of both Iridium satellite constellation and Starlink satellite constellation to verify we have appropriate 24 hr coverage in the Daytona Beach area.



What this graph is showing: Each of the Iridium sats are on the left hand side. The lines are showing when each sat has access to the DB area. With a constellation of 80 satellites, we have full coverage to the Iridium constellation. The constellation is in LEO so we're only going to have a few minutes of coverage per satellite as you can see in the graph. However, with 80 satellites these add up to amount to a full coverage.

break for hurricane

Sprint 3:

10/16

1. Our project completely changed (again). It is no longer a requirement to do Sat Comms (?) so we will be using WiFi or LoRa as that is easier and makes more sense anyways.
 - a. Anyways we need to make a decision on the modulation. For now we will use WiFi because we are using 2 RPi5's to communicate. We will also have a LoRa hat as a backup, in case the project changes (again again) and we have to have a long range communication (WiFi is a LAN so not gonna work for long range).
2. Finalized parts list and sent to Dr. T. We will only have 2 radars so only 240 degrees coverage instead of 360.....
 - a. Still working with the hardware team to decide where we will mount it (high up on a pole, or in the front of the vehicle?)

fall break

10/24

Ground station decision.

- a. We're just going to have our own DIY ground station. We may need antennas to send/receive if the RPi5 or LoRa hat antenna isn't enough, but those can always be fabricated.
- b. The Micaplex has a GS which I use for research, if we needed to use it we could ask permissions from Dr. Rojas. However, this is unlikely because it would

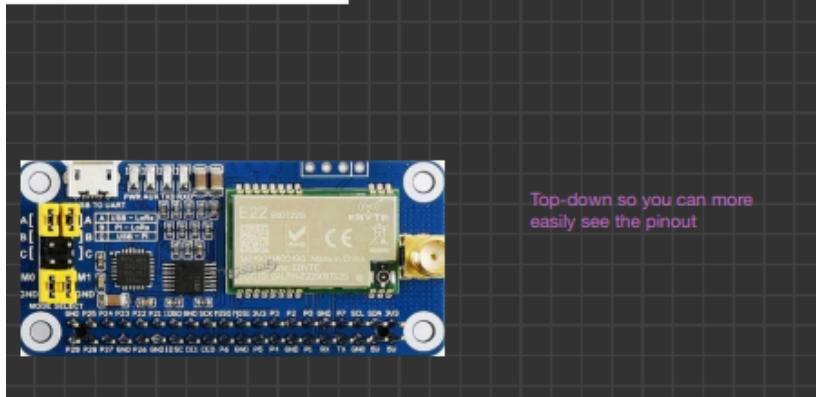
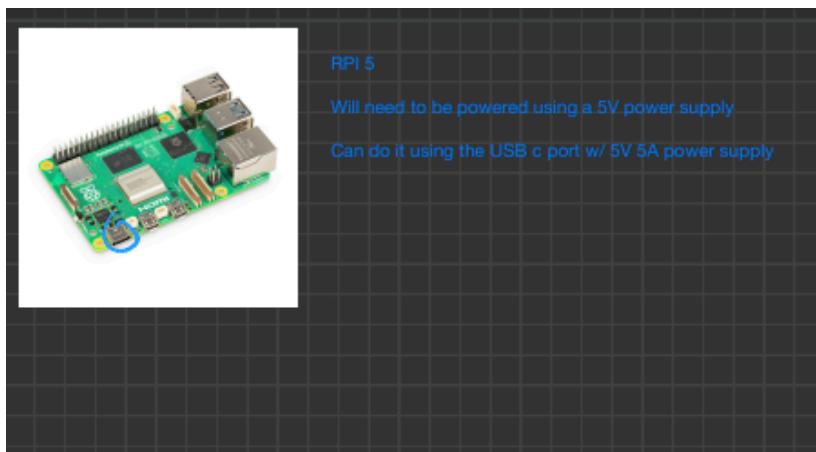
overcomplicate things, its ITAR, and also it was damaged in the hurricane so it will take some weeks to become operational again. It's just a backup option.

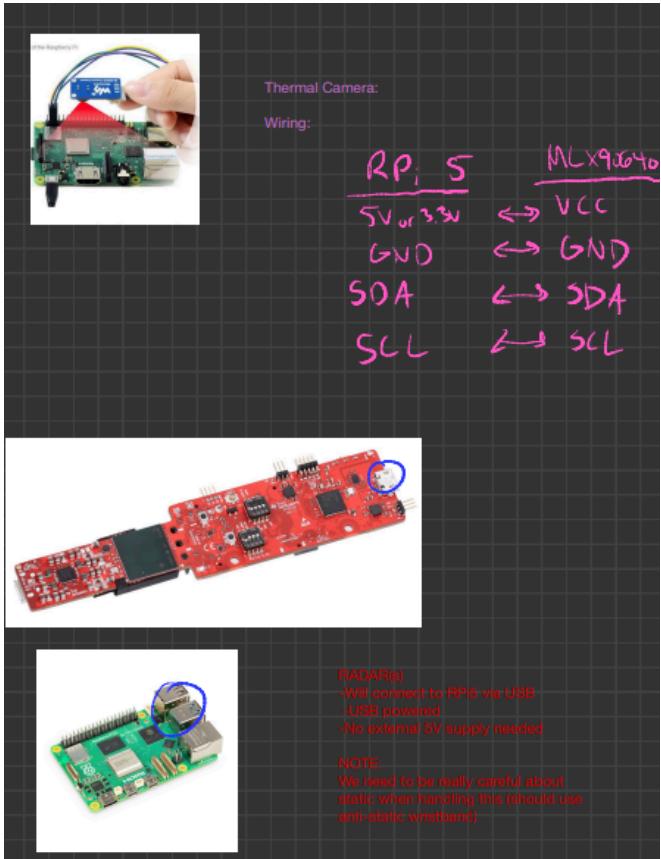
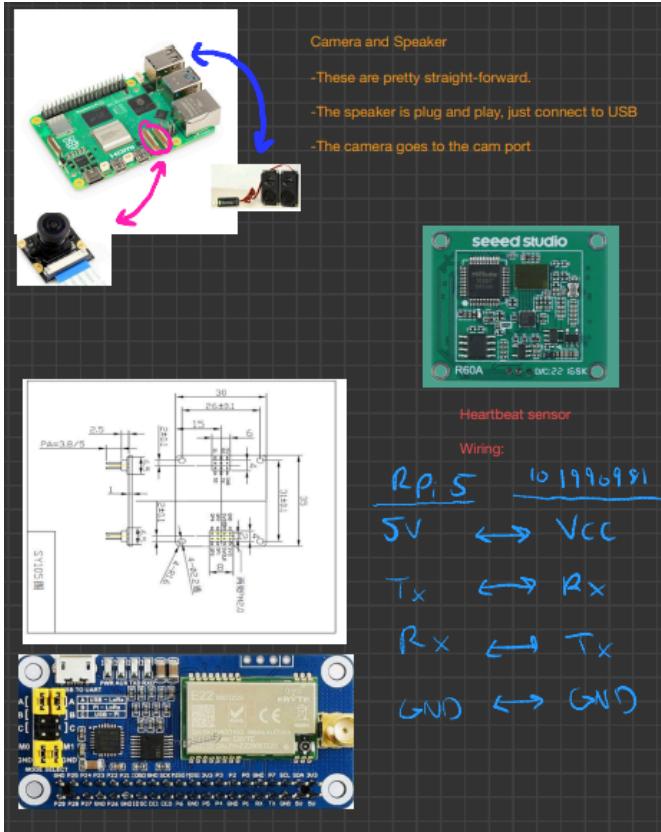
Sprint 4:

10/29: In this sprint we had a lot of documentation to do, so we worked on that a lot. We have the SRS and SDS. Today we worked on scrum and adding items to the backlog

10/31: I wrote requirements, mostly relating to the raspberry pi/LoRa, and the sensors. I wrote requirements relating to the hardware and communication interfaces. I also wrote requirements. I also wrote the related features section of the document.

11/5: I wrote out all the sensor components and all the wiring that needs to happen.





Sprint 5

11/12: Started to work on poster. Looked through EECS hallways at example posters. Used template from my old SRS poster. Took photos for the poster.



11/14:

Worked on MATLAB script of LoRa simulation in MATLAB. It simulates the Tx and Rx of a LoRa modulated signal.

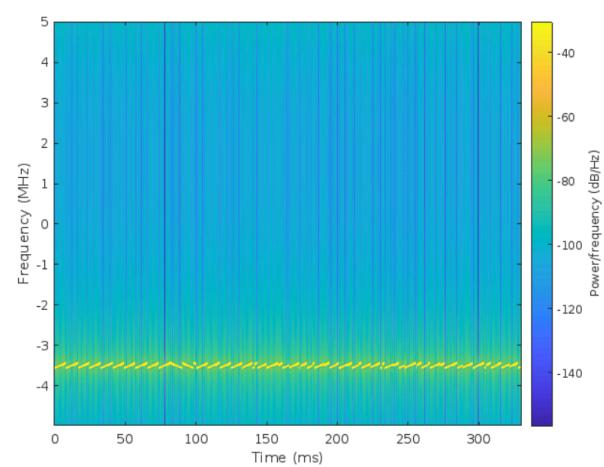
Example code and output:

```
clear
clc

SF = 10 ;
BW = 125e3 ;
fc = 915e6 ;
Power = 14 ;

message = "Hello World!" ;

%% Sampling
Fs = 10e6 ;
Fc = 921.5e6 ;
%% Transmit Signal
signalIQ = LoRa_Tx(message,BW,SF,Power,Fs,Fc - fc) ;
Sxx = 10^log10(cms(signalIQ).^2) ;
disp(['Transmit Power = ' num2str(Sxx) ' dBm'])
%% Plots
figure(1)
spectrogram(signalIQ,500,0,500,Fs,'yaxis','centered')
figure(2)
obw(signalIQ,Fs) ;
%% Received Signal
message_out = LoRa_Rx(signalIQ,BW,SF,2,Fs,Fc - fc) ;
%% Message Out
disp(['Message Received = ' char(message_out)])
```



11/19: Worked on diagram for hardware. Shows the connections of all the hardware components.

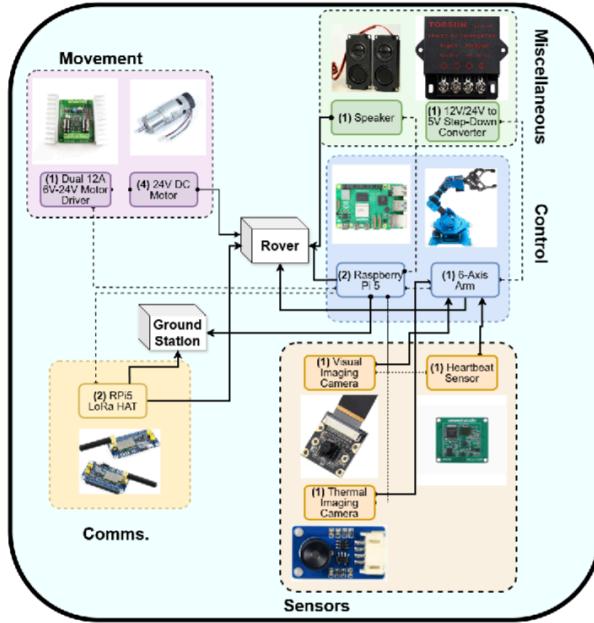


Figure 2. Hardware Architecture

We have all the components divided into categories: control, sensors, communications, movement, and other miscellaneous components. This shows how they all connect and interact with each other for the rover.

11/21: Made final edits to the poster and submitted it.

Sprint 6

11/26 - 12/2: Traveling for Thanksgiving Break

12/3: The semester is basically over... we just have a lot of things due.

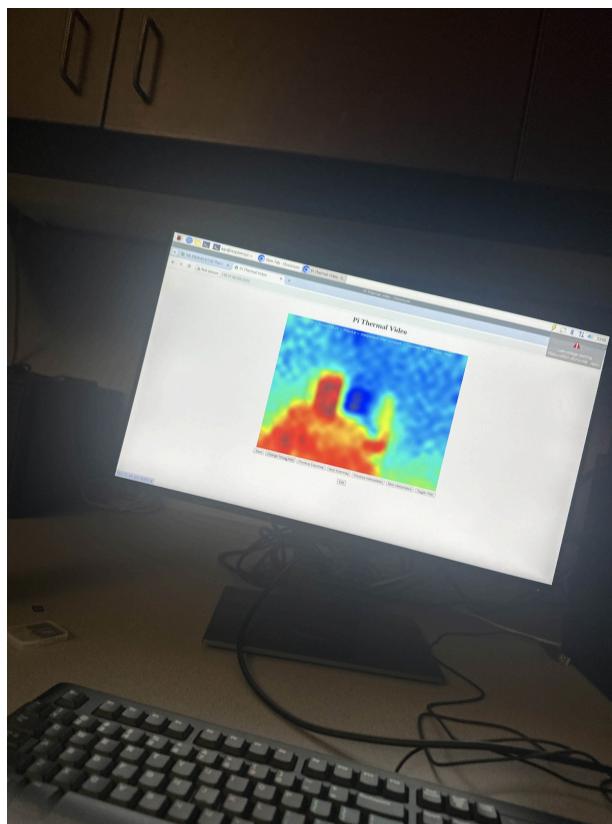
We made the slides and filmed our part of the 10 minute video, with an intro, conclusion and work done. 12/5 we will present the poster... overall much of this sprint was consumed by Thanksgiving break. Will start up again next semester.

12/5: Presented the poster; wrote test cases. Happy to be done

Sprint 7

1/9: Basically there was just a meeting for the class and the presentation by the professors. So we discussed things like, planning for this sprint and also the requirements of the SRS. There are new things we need to add in the SRS to appease ABET, so we will have to work that out and figure out how we are going to divide the sections between 9 people.

1/12: The thermal camera was working; we can stream it to a webpage (pictured below). We are now asking the software team to integrate it into their GUI.



1/14: We have mostly been working on the SRS, responding to Walter's critiques/comments about it. We want to make several revisions before the due date so that we can earn the most points possible.

1/16: We are trying to test the camera and make it work but it is not working. For some reason it doesn't interface well with the pi which is frustrating. If we spend too much more time on this we will consider ordering another camera. We are pondering this because it would be more cost-effective, taking into account the "cost" of time. Ordering another camera would be less than \$5 so it doesn't make sense to spend 10+ hrs doing this if we can just get a different one.

--3 day holiday for MLK day, I was traveling for 5 days---

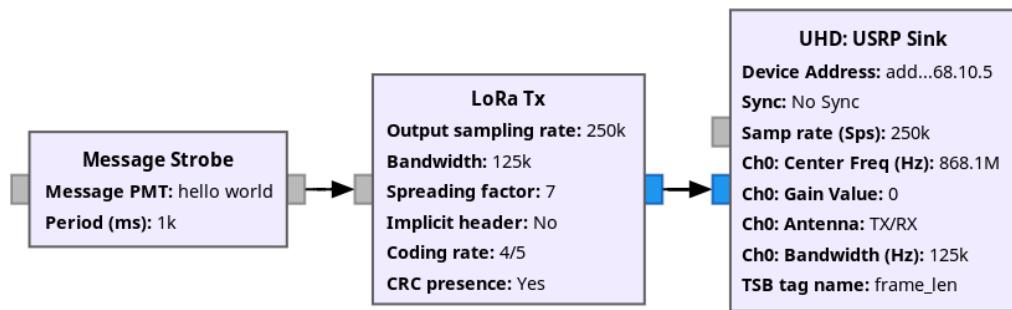
1/21: Over the holiday Alessia and George did a lot of work while I was skiing (I feel bad). So we spent a lot of today going over what they were able to accomplish. They showed me the speaker was working, and we played sounds to check. We also messed

around more with the camera and it just wasn't working. So we are going to order a new one that works better with the pi because it's really cheap.

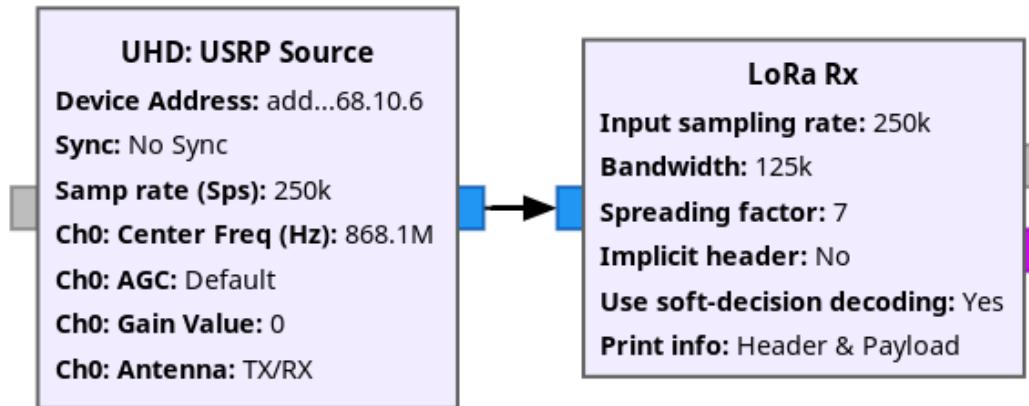
Sprint 8

1/23: I worked on GNU radio block diagram for LoRa modulation. It all works in my sim to code, mod, transmit, receive, demod, decode, in my simulation. Figuring out issue with pi with the USRP recognition. Block diagram:

Tx



Rx



1/26: Microphone testing, it works, we realized the speakers we got came with a built-in microphone which helps a lot because then we don't have another extra thing to plug in.



speaker/microphone

1/28: We decided and assigned the parts for the SRS. Mine was the social aspect/impact of our project. The hardware team is evaluating how this project would be done at a “real” company. George is doing the budget. The rest of us split up the writing part.

1/30: Heartbeat sensor testing, and now we are getting data, but it seems like random ASCII data and we don’t know what it means.

2/2: Wrote my part for the SRS for the extra part we got assigned.

2/3: Worked with Alessia on creating high level diagram for communications system for SDD.

2/4: Sprint planning, final review of SRS before submitting

Sprint 9

2/6: Began thinking about conference submission, and if we are doing a paper or a poster. We worked on troubleshooting the code for the heartbeat sensor.



Heartbeat sensor

2/9: Worked with George over weekend on WiFi communication so we can ensure it works (then switch to LoRa later) for the demo. We decided to do SSH because its easy, and we were able to transfer the file. So we will show it to the software team later this week.

2/11: Worked on the RADAR, found a linux code of the software we wanted to use (only runs on windows) so hopefully we can make that work.

2/13: We worked on showing SSH to the software team so they can send files and access the other pi to send commands/run code during the demo for Dr. T. Made changes to the poster to update it for the conference with our new results.



Autonomous Ground Vehicle for Real-Time Human Survival Detection

Introduction

In modern autonomous vehicle systems, detecting and classifying objects is important for managing safety and efficiency, especially in potentially dangerous situations. Thus, the Autonomous Ground Vehicle for Real-Time Human Survival Detection (AGV-HSD) is designed to locate and identify human survivors in disaster zones. The system addresses the need for accurate detection of survivors by asking for a vocal response and detecting heartbeat and body temperature. The lack of accurate detection systems in challenging environments prompted the need for a reliable and cost-effective AGV that provides precise identification of survivors, reduces misclassification, and speeds up rescue operations. This system could be beneficial in disaster zones, increasing rescue accuracy and response times, and avoiding human resources entering dangerous areas. The focus of the project is real-time human detection and communication with the Ground Station to perform safer and more efficient search and rescue operations.

Methodology

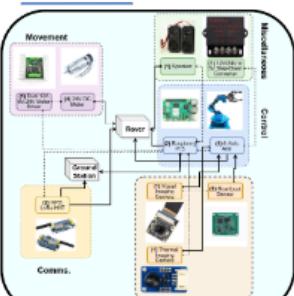


Figure 2. Hardware Architecture

Results (cont.)

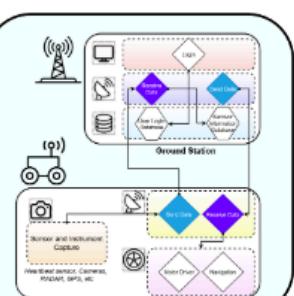


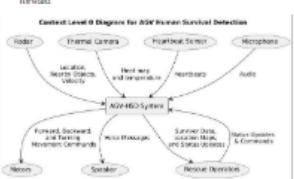
Figure 3. Software Architecture

Problem Statement

Develop a reliable, cost-effective autonomous ground vehicle (AGV) that accurately detects survivors and communicates with rescuers.

- 1. Be able to navigate in harsh environments
- 2. Communicate necessary data to the ground station
- 3. Map out the location of humans and instruct the AGV to move forward

Figure 1. AGV-HSD Context Diagram



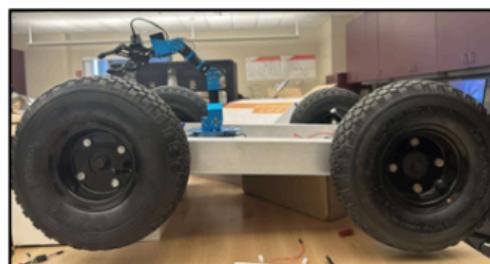
Conclusion

- We have developed a reliable, cost-effective, autonomous vehicle for survival detection.
- It can move autonomously or be remotely operated from a ground station.
- The communication and movement software is complete and functional.

Objectives

- Provide an autonomous system able to detect and locate survivors with minimal human intervention
- Detect humans through heartbeat, body temperature, and vocal responses
- Communicate with ground station to provide location of survivors to emergency services

Figure 4. Autonomous Ground Vehicle with Mechanical Arm



Future Work

- Mechanical enhancements to make the AGV more robust to water, rubble, and adverse environmental conditions.
- Add additional sensors for survivor and obstacle detection, such as LiDAR for obstacle detection or computer vision for survival detection.

Acknowledgements

We would like to acknowledge Dr. Majid Javidzadeh for being the product owner and mentor for this project. This project was funded by the Embry-Riddle Aeronautical University Electrical Engineering and Computer Science Department.

2/16: Alessia and I changed the poster and made the final submission to the ASEE regional conference.

2/18:

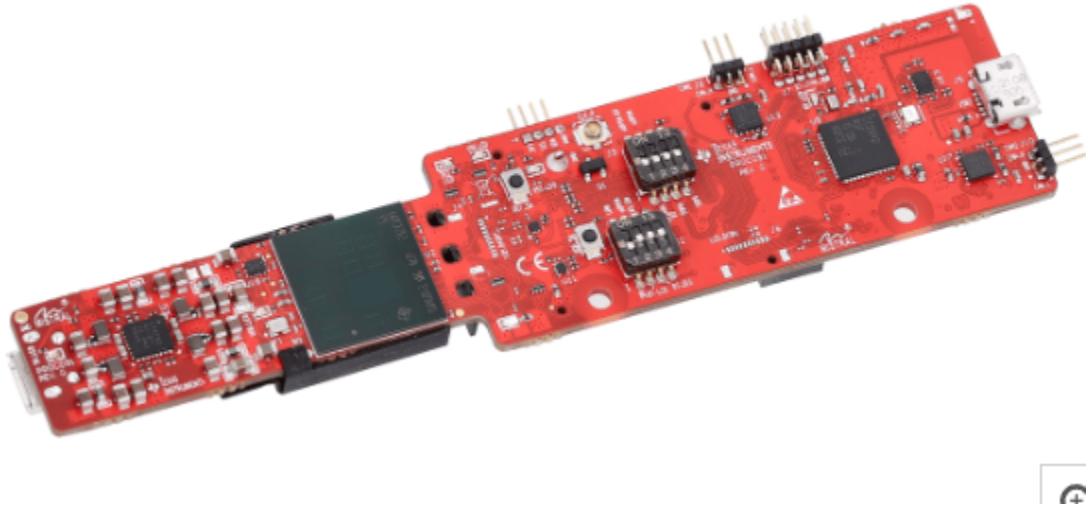
We worked on the RADAR and troubleshooting it. We are not sure if we need another piece or not to connect it via USB port/bluetooth, so we are looking into that.

Sprint 10

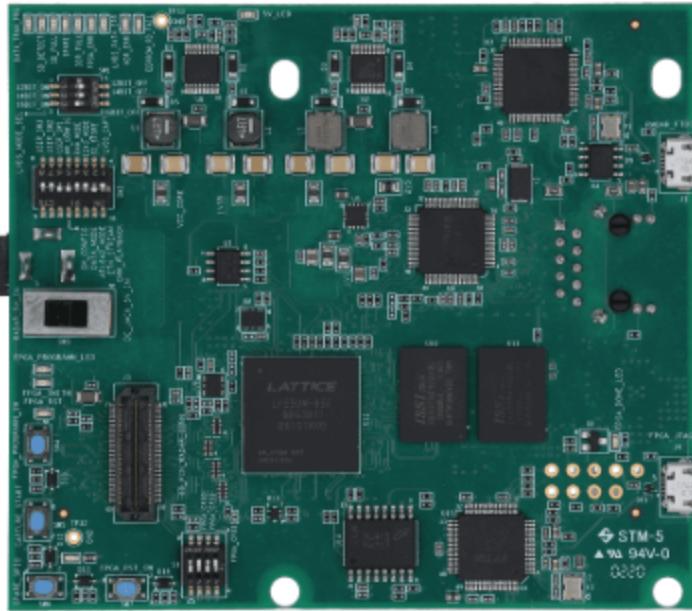
2/20:

We asked Dr. Butka about the radar (he recommended we buy this specific model). We aren't sure because although I've worked with this radar before, it was in conjunction with other boards. I have never used this one as a stand-alone module. So we are emailing him to ask for guidance.

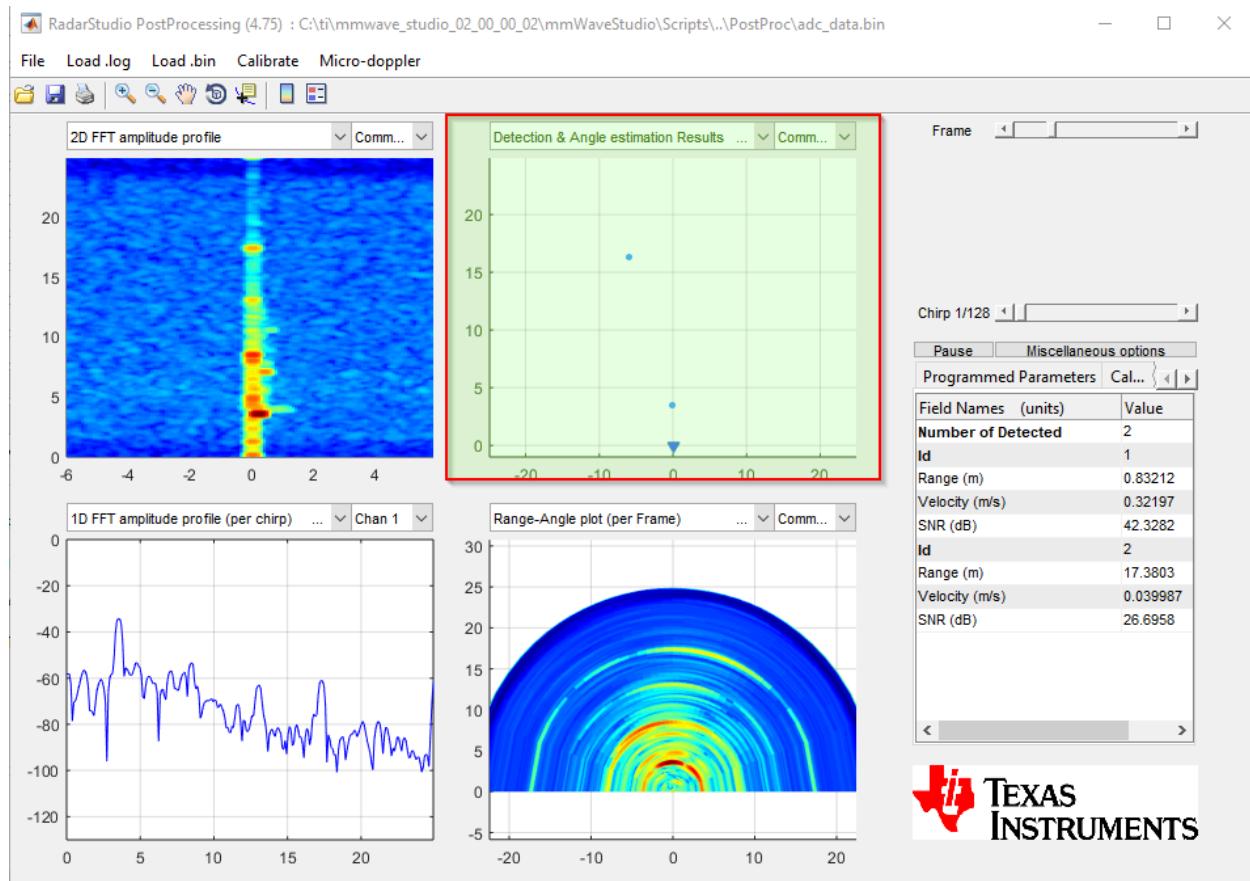
Stand-alone radar module:



Additional board im used to using:



2/25: Attempting to get radar working on Linux. First we are exploring the mmwave software downloadable from TI (shown below)

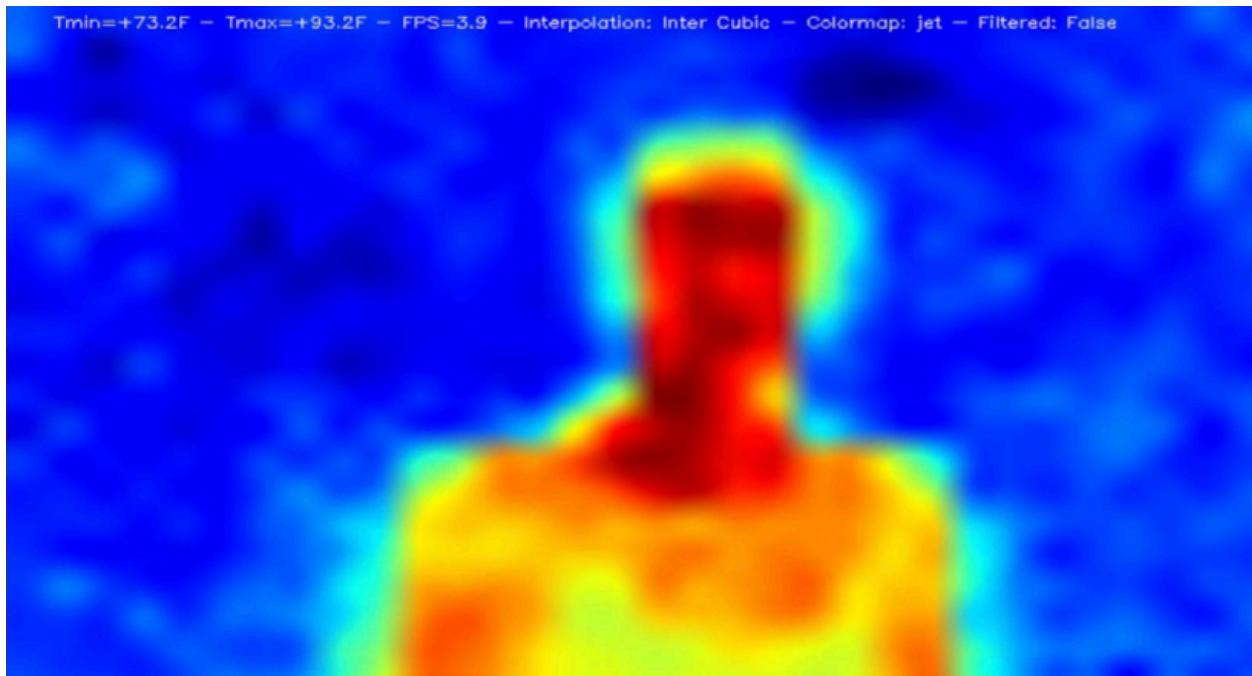


2/27: Troubleshooting on mmWave studio and trying to get it to connect to the RADAR. Its a really finicky software and TI is not a helpful company. They make it difficult to use on purpose to convince you to buy more hardware (which is not an option as it will cost upwards of \$400 for any additional board)

3/4: Meeting today with the team. We are doing more planning for the next sprint and adding things to the scrumwise. Since its going to be the spring break sprint we are seeing which is most important to add.

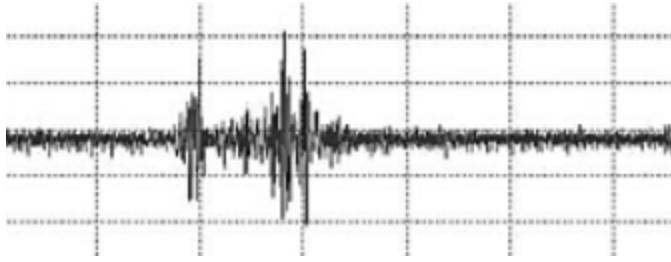
Sprint 11

3/6: Performing test cases related to each of the sensors to ensure they worked. We started with the heartbeat sensors and thermal camera. It is working to detect humans as shown below



March 8-16 SPRING BREAK No work performed

3/18: Integration of sensor (microphone and speaker) onto AGV for voice detection/recognition. Vocal recognition shows voice detection. The GUI looks similar to this:



3/20: Worked on the thermal camera to help software integrate it into GUI - bug fixes on the thermal camera data feed and tested under different lighting conditions to assure it did not have an affect on the data

Sprint 12

3/22: Trying a new RADAR software on the pi (shown below). Its pretty complicated and hard to use unfortunately

3/27: George and I are trying to load the demo configuration from the RADAR onto the software shown above. Waited for a 1 hour download of some needed software which took up most of the time

3/29: George and I worked on the SDK software but are still struggling. It seems to be something with the drivers, our computer can now recognize the RADAR is plugged in and powered but we cannot communicate with it due to driver issues.

4/1: Communication integration and test. Successfully integrated the communication system. The Pis could communicate over a P2P connection and could send data back and forth from the AGV to GS and back.

4/4: Had to help software team after the heartbeat sensor suddenly broke. We used a voltmeter and ohmmeter to check for shorts but there seemed to be none. It ended up being a software issue (George and Walter fixed it)

Sprint 13

***** I had eye surgery the week of April 7th and thus was not doing work from April 7 until April 14 *****

4/15: Work on test plan, editing based on Walter's comments. Adding A LOT of test cases, since last semester it was bad and we barely had any test cases.

4/17: Analyzing sample RADAR data that was given to me by a grad student of Dr. Rojas. It seems like the RADAR can parse its own data using the TI SDK software to give us the distance between the AGV and obstacle in meters.

4/22: Begin recording video, brainstorming ideas and discussing format and what we should demo and explain. Making powerpoint slides for the video.

4/23: Working on the video, recording audio and powerpoint slides explaining everything we've done. Demo-ing the sensors to show the robot detecting a survivor.

4/24: We are doing our final poster presentation and making the final changes to the video.