Rogue Radio Frequency (RF) Signal Detector

{ Edwin Torres, Sem Diaz and Matthew Scudder }   University of California, Riverside - EE Dept.

Objectives

The Rouge RF Signal Detector is designed to **locate, define, and report radio frequency power levels** given a general **predefined location**. This project utilizes the capabilities of the **Ettus E312 Universal Software Radio Peripheral** to accomplish its primary tasks. Mounted on an **Autel X-Star Premium quadcopter drone** with the capability of scanning an area that is originally determined by a predefined location. As the process of detection progresses and the location of the rouge RF becomes evident, the **search area is automatically reduced, shifted, and recalculated** based on the analysis results from its first or following flights. The analysis also provides a visual representation of its previous **trajectory path** along with a **heat map**, which clearly indicates the source of transmission and its power level.

Materials & Methods

USRP E312:

1. Converted raw GPS data into readable **latitude, longitude, and height** values.
2. Converted raw RSSI values into PSD samples by means of the periodogram approximation.
3. Parsed through the GPS and PSD data into a readable matrix text file.
4. Matrix file was extracted at base station for further processing.

USRP 2920:

Acted as our "Rogue Radio" that we needed to find. The 2920 was placed in a random location within our predefined area and output a sine wave signal at **450MHz**.

X-Star Drone:

Carried the E312 and flew the desired path.

Introduction

The U.S. Navy is a global fighting force that requires mission ready equipment. In order to succeed in this endeavour, it needs to resolve any problems that aim to hinder the mission. The purpose of this project is to **seek out rogue radio signals that are being transmitted in the field.** With this in mind, the idea of an autonomous signal detector drone was born. The opportunity to locate and neutralize this transmission with the minimum amount of boots on the ground is key to the future of the Navy's ability to handle missions in a rapidly changing world.

Results 2

After the first flight, the next search area is reduced by about **73%** and uploaded to the way point program; the drone flies the next path. It is found that the second flight comes within **0.3 m** of the rogue transmission. The area is further reduced if a more accurate location is required.

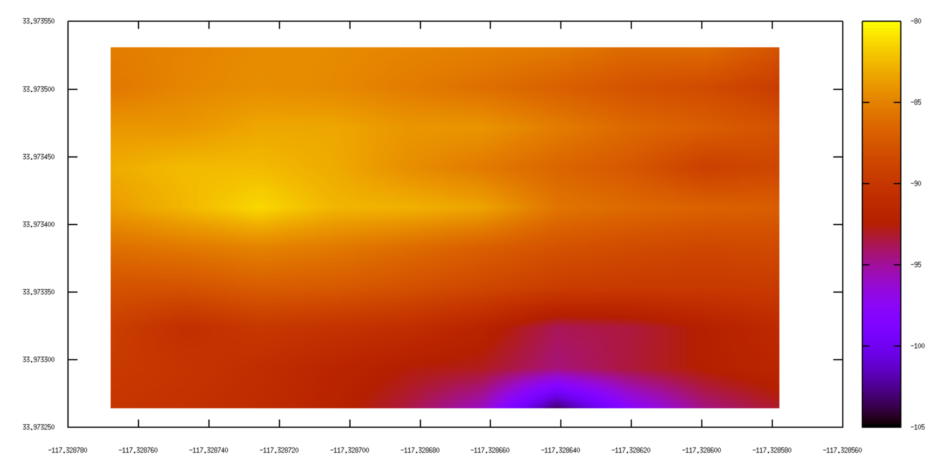

Figure 4: Heat Map - Second Flight

Figure 5: Flight Path - Second Flight

Results 1

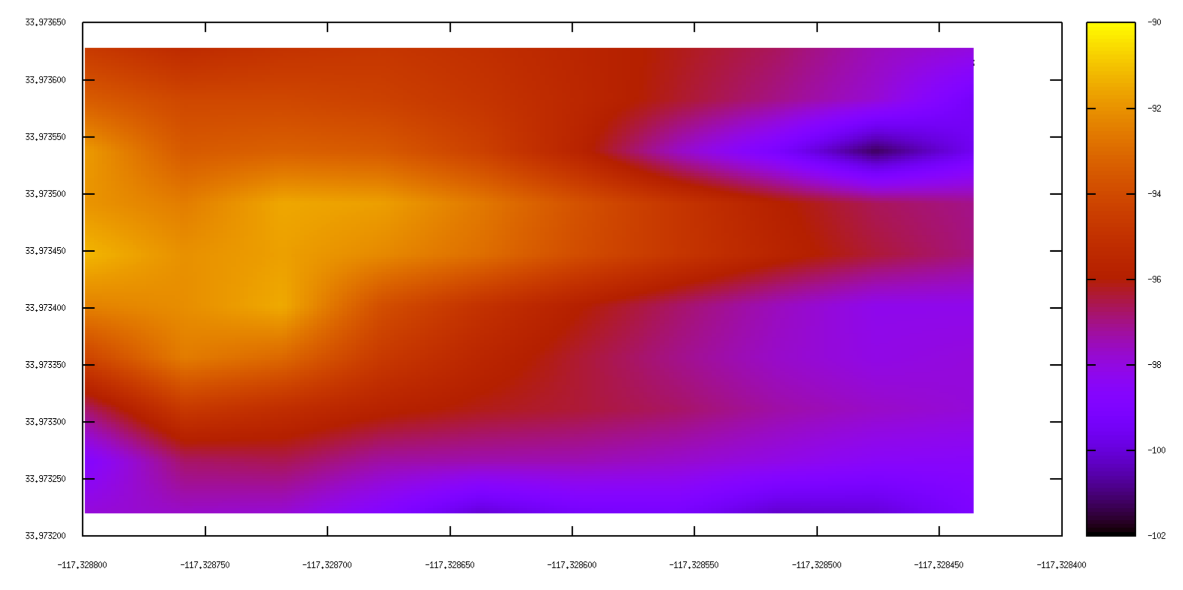

Figure 1: Heat map - First Flight

The flight path map was created using the latitude, longitude, and PSD matrix. For this graph, we plotted every instance of recorded data and highlighted the critical points. The colored points are the extremities of the flight path, the white points were calculated using the algorithm we came up with to find the new search area(with the white dot within that area being the max PSD) The outer box is the first search area, while the smaller box is the new redefined search area.

The heat map coordinates are recorded using a textbfGPS antenna along with a GPS module within the USRP E312 itself. The **Power Spectral Density** is also recorded within the USRP E312. For the PSD data, the RSSI levels are fed into the USRP's omnidirectional antenna and converted into PSD by means of the **periodogram** approximation. The **latitude**, **longitude**, and **PSD** are then stored in a matrix which are then plotted using gnuplot.

Figure 2: Flight Path - First Flight

Conclusion

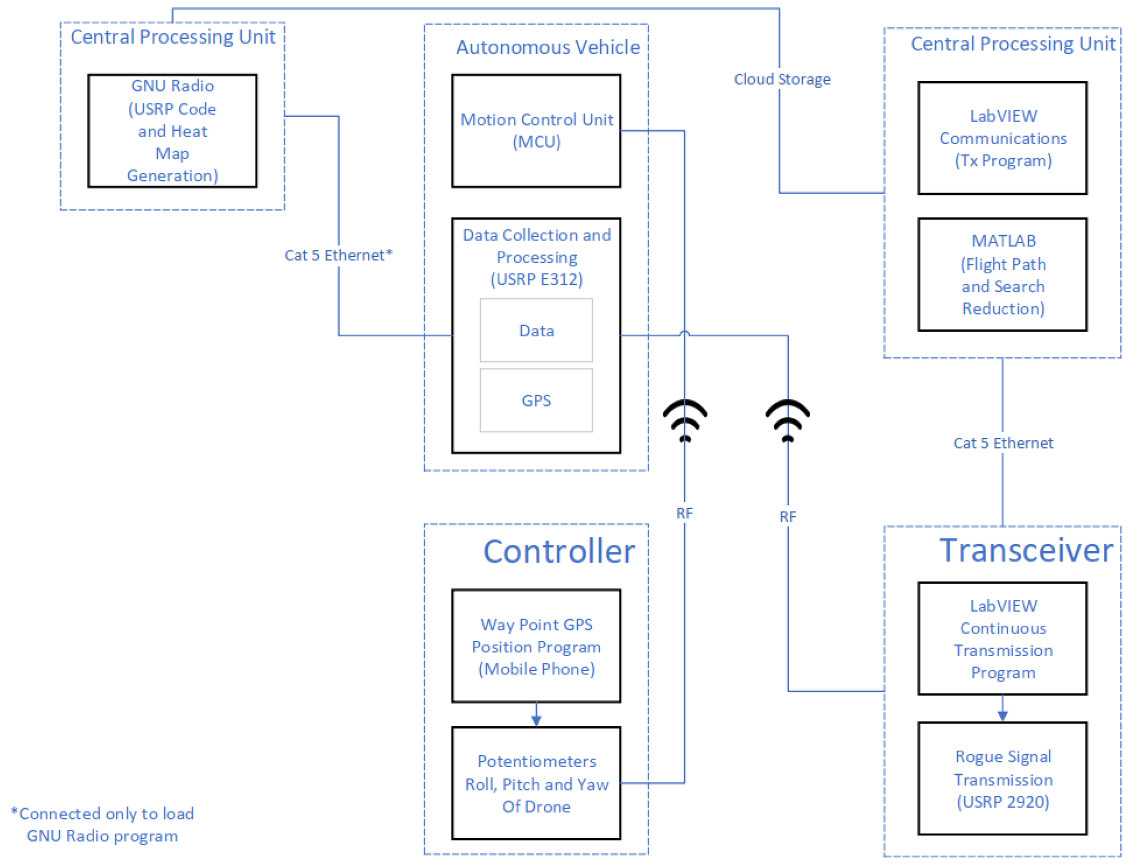

Figure 3: System Block Diagram

- By Loading the E312 on the drone, we scanned a predetermined area for PSD data and GPS coordinates, then converted the data into a heat map and found the next search area (reduced by 73%) and located the 2920 to within 0.3m (after 2 flight path iterations).
- With MATLAB, GNU Radio, and GNU Plot, data from the E312 was extracted and converted to a heat map and path trajectory map. The trajectory map gives us the next search area and also points out the highest PSD location recorded.

References

[1] G. Buttazzo C. Di Franco. Coverage path planning for uavs photogrammetry with energy and resolution constraints. *J Intell Robot Systems*, pages 446–462, 2016.

[2] Z. Bar-Yehuda. Zoharby - plot google map. *GitHub*, 2019.

Future Research

In the future, we plan to take this project and incorporate live data feedback. We can use WiFi, Bluetooth, and even RF demodulation to send data to and from the USRP and base station.

Having a means of communication between the drone and base station would greatly enhance the usability of this product and therefore become easier to operate along with instant information.

Contact Information

Email Edwin: etorr039@ucr.edu
Email Matthew: matthewfscudder@gmail.com
Email Sem: sdiaz020@ucr.edu