Senior Design Project in Electrical Engineering

VHF Hoax Detection Using the MUSIC Algorithm and Software Defined Radios

1/c Dahnyoung McGarry, 1/c Evan Truman

Advisors: Dr. Paul Crilly, Dr. Richard Hartnett, Dr. Ali Reza

Project Background

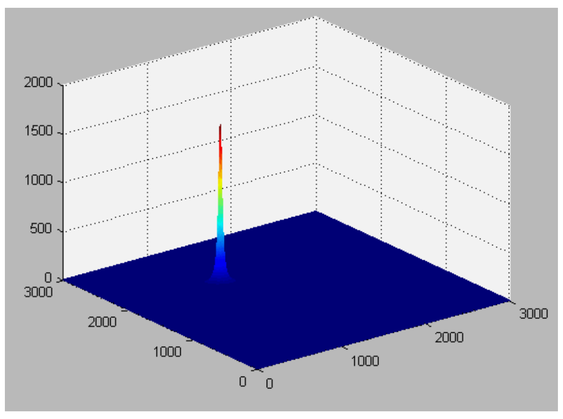
The purpose of this project is to pinpoint the locations of hoax callers by using multiple antenna arrays, software defined radios (SDRs), and the Multiple Signal Classification (MUSIC) algorithm, which literature deems as the optimal direction finding/source location method. If used in conjunction with broader direction finding systems, this project could theoretically pinpoint the location of a channel 16 (156.8 MHz) radio call to within meters. With that accuracy, the Coast Guard can prosecute hoax callers and combat a problem that has been plaguing the Coast Guard for years.

Software Defined Radio

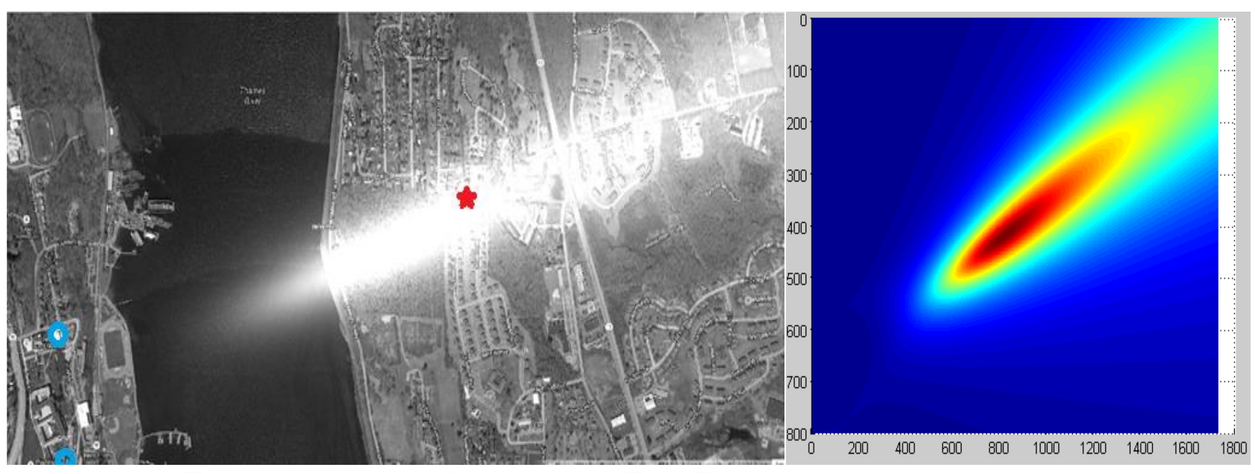
A Software Defined Radio is a programmable radio which we chose to act as a FM receiver. This receiver takes the incoming signals from the antennas and converts them into their in-phase and quadrature components, commonly known as I/Q data.

MUSIC Algorithm

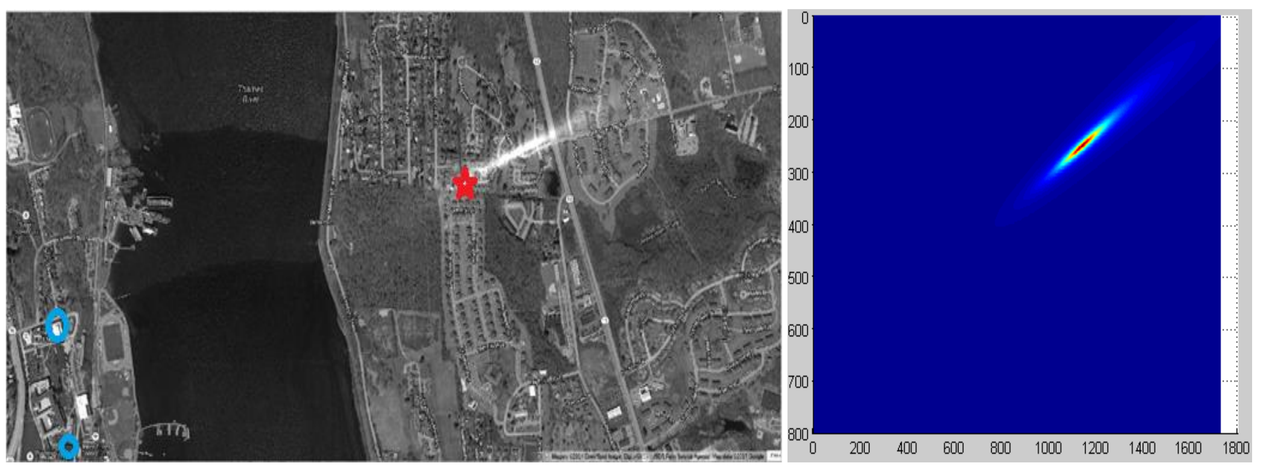
The MUSIC algorithm incorporates the location of the antennas as well as the I/Q data from each antenna to find a point on a grid that best satisfies the given information. This point represents the maximum likelihood that the transmitter is at the indicated location. This differs from other methods because the algorithm has a way of naturally weighing the importance of the antenna arrays in relation to the proposed location. A simulation of the algorithm is shown below.



Simulation of the MUSIC Algorithm



Actual Result from the Algorithm. Red X is the location of the source and the Blue O's are the location of the arrays.



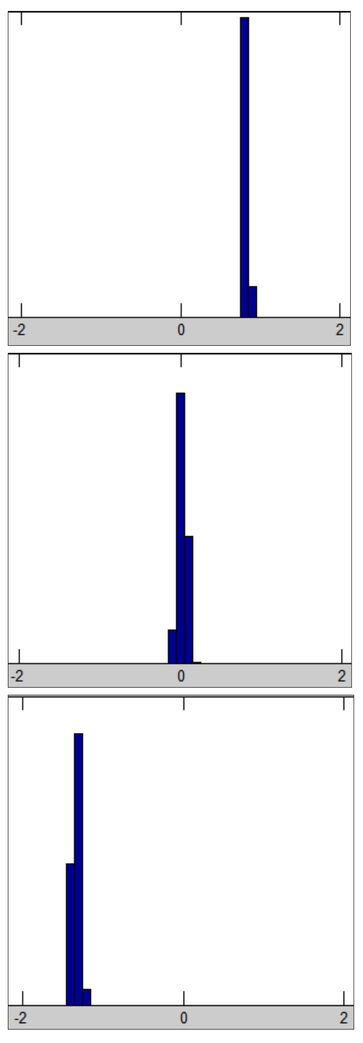
Theoretical Improved Results Correcting for Phase Variations

Results

In order to ensure that our antenna systems were working correctly, we attempted to calibrate them using the 99.5 MHz radio station . Since we knew the location of the station, we aligned each antenna array so that antennas were perpendicular to the incoming radio waves and received an expected zero phase delay between the antennas. We then did a controlled test by rotating the antennas and creating phase delays, and the results reflected the alterations (shown to the right). The figures above show the actual result and the theoretical improved result from correcting the phase variations. Currently we are conducting tests using a handheld VHF radio on channel 71, and the results look promising.

Antenna Setup

For the MUSIC algorithm to work there must be at least two antenna arrays each with a minimum of two antennas. The reason for this is because the data of interest is the delay in phase between the antennas in the array. We chose to use ground plane antennas because of their omnidirectional radiation pattern and because they were easy to build. A picture of one array is shown above.



Histograms reflecting the phase delays dictated by the antenna orientation