Drone Detection through Acoustic Signal Processing

Khushboo Patel, Lynette Ramirez

Space Trajectories & Applications Research

Introduction

Audio signal processing enables for the development of a drone detection algorithm to improve national security.

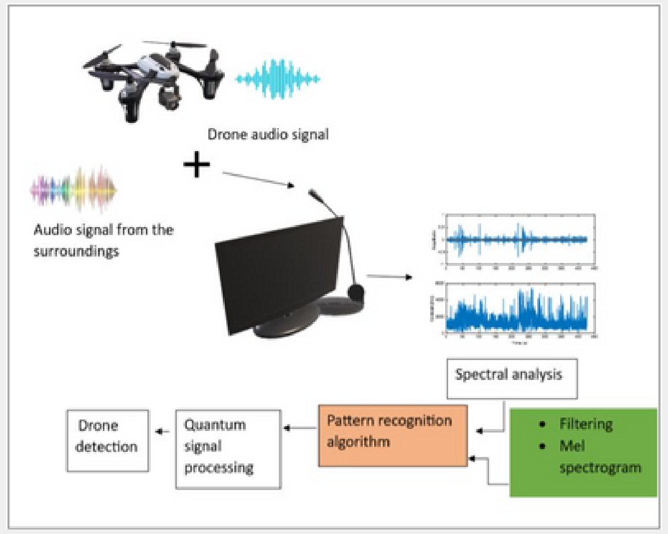
Modern Drone Detection Technologies

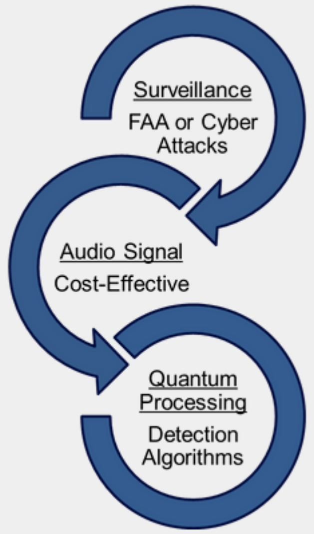
Method	Pros	Cons
Radar Frequency	• Resistant to weather conditions • High resolution range	• Most likely to lose drone's path due to vehicle size
Radio Frequency	• High detection range for flight path	• Can only monitor drones that use communication channels
Visual/Optical Sensing	• Cameras cost-effective • clear visual when in line-of-sight	• Weather conditions can obstruct visual • Require verification by a person • Limited detection range
Audio Signal Processing	• All type of drones can be monitored • High detection range • Audio sensors cost-effective	• Measured audio signals not fully resistant to outside noise ✓ Algorithm can be trained to filter outside noise

Objective

- Extract the drone's audio signal through spectral descriptors to then be used for the development of pattern recognition algorithm.
- Report on limitations for pattern recognition algorithm for ranging operation frequency & background noise levels
- Compare audio signal processing methods
  - i. Support Vector Machine for pattern classification
  - ii. Quantum Signal Processing, using Shor's & Grover's algorithm

Methodology





Initial Results

I.) Spectral Descriptors

Drone Analysis: 1m alt for Flight

Conditional Statistics: based on Drone operation recordings in a closed environment. Divided into three phases of operation as follows:

i. Take off
ii. Steady Hover
iii. Landing

Pattern Recognition: Use conditional statistics to verify the presence & phase in the operation.

Test the algorithm: Implement similar frequencies during operation recordings to test the pattern recognition algorithm.

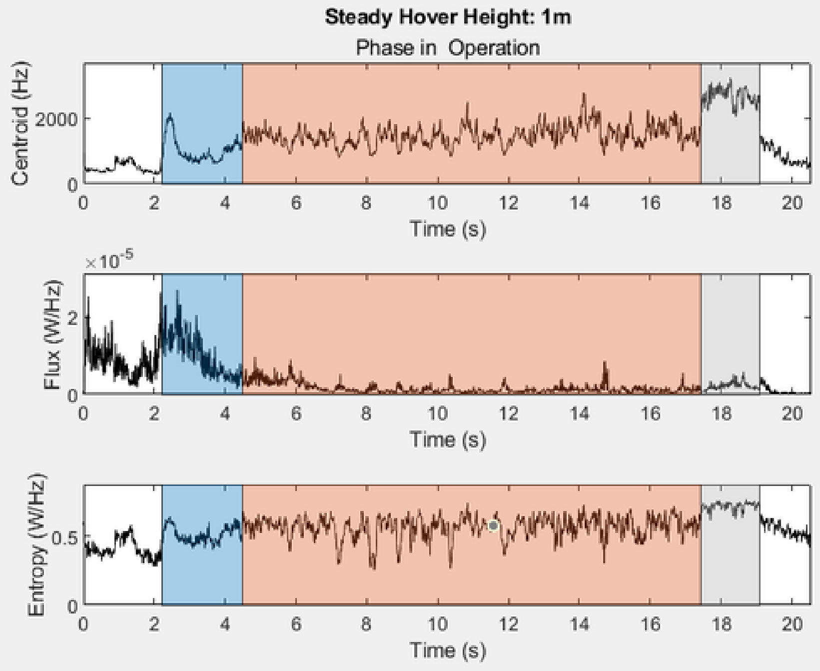


Figure 1: Pattern of Drone operation using spectral centroid, flux, & entropy.

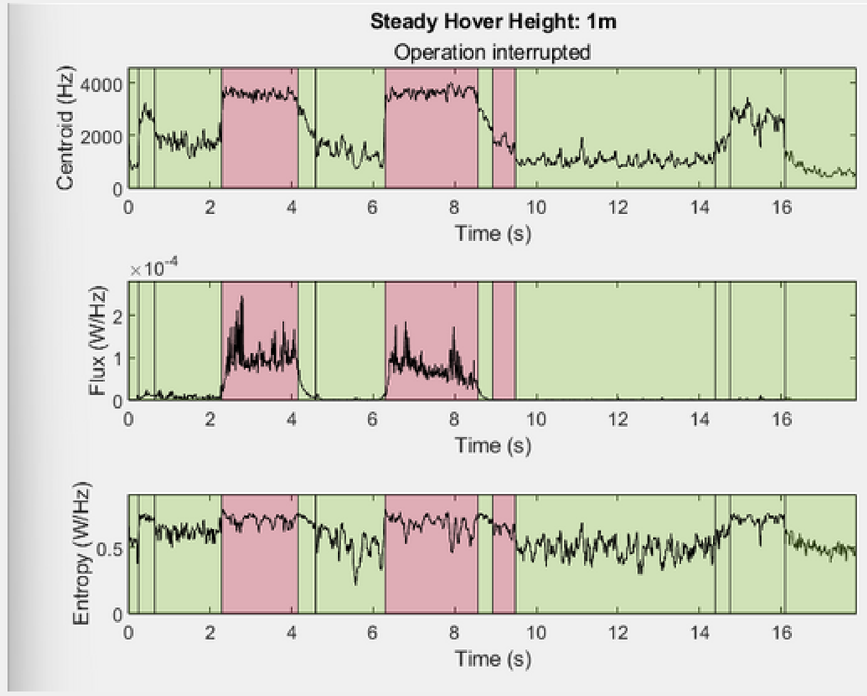
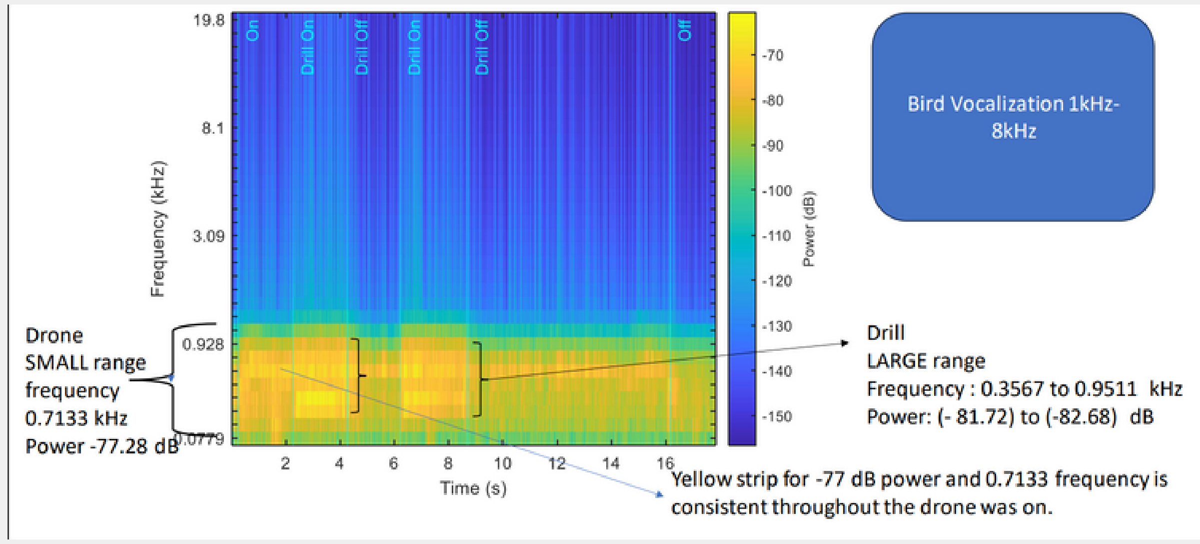


Figure 2: Pattern of Drone operation with imposed interruption of similar frequency (Drill). Testing pattern recognition in accordance to phases in operation.

Operation Phase	Time Section #	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Turn On	0%	16.5%	0%	2.8%	7.9%	2%	0%	1.6%	5.6%	0%	0%	0.1%	3.3%	0%
	Steady Hover	8.3%	1.4%	89.1%	0%	0%	98.0%	8.3%	0%	0%	99.6%	25.6%	10.4%	1.3%	0%
	Turn Off	0%	0%	0%	4.2%	0%	0%	0%	4.2%	0%	0%	1.4%	3.8%	11.2%	6.9%
	Total %	8.3%	17.9%	89.1%	7.0%	7.9%	100.0%	8.3%	5.8%	5.6%	99.6%	27.0%	14.3%	15.8%	6.9%

II. Mel Spectrogram



III. Support Vector Machine