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Detecting Drones Using Frequency Analysis

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***Abstract*—There has been an increase of drones in the skies over the last few years. This is due mostly to drone manufacturers developing cheap products for consumer use. This ease of availability and low cost, make it difficult for the government to provide oversite as they would over commercial airplanes. Drone pilots fly their drones into no-fly zones and areas where they should not. An attempt to force drone registration is a start, but hard to enforce. The problem this paper addresses is, when a drone pilot does fly into no-fly zone, how can it be detected using commercial off the shelf components and software.**

Keywords—Detecting drones, Frequency analysis

I. Introduction

There has been an increase of drones in the skies over the last few years. This is due mostly to drone manufacturers developing cheap products for consumer use. Availability and low cost make it difficult for the government to provide oversite as they would over commercial operations. For less than $800 (USD), a consumer can purchase a drone that can take video at 2.7k HD and has a 12MP camera with a three-axis gimbal mount [1].

Consumers purchase drones for various reasons. Some people purchase a drone out of curiosity. They are not quite sure what the hype is about and so they purchase one just to have it. Some people purchase them to do aerial tricks. Many drones are capable of doing air-acrobatics. No matter what the reason, drones are a popular gift for many children and adults.

Along with an increase in drone usage, comes an increase in drone incidents [2][1]. According to [1], drone operators have been behind many near collisions with aircraft in controlled air space.

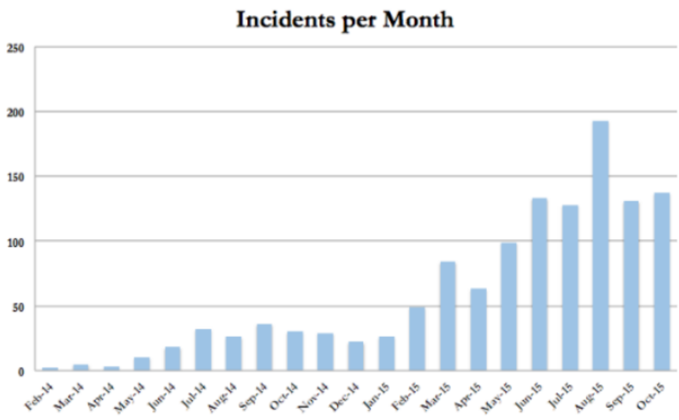
According to [4], drone growth is expected to rise significantly. The following chart shows worldwide drone sales by units sold through 2020.

Vehicle Type	2016	2017	2018	2019	2020
Hobby Aircraft	1.9	2.3	2.9	3.5	4.3
Commercial Use Aircraft	0.6	2.5	2.6	2.6	2.7
Total	**2.5**	**4.8**	**5.5**	**6.1**	**7.0**

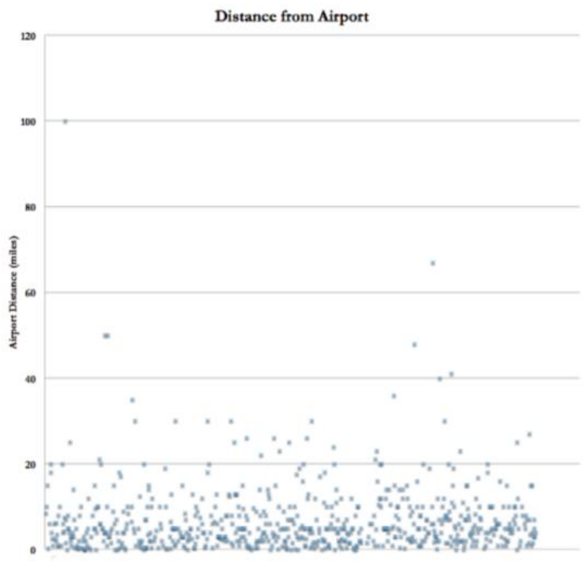
II. Current Problem

Drone pilots frequently fly into no-fly zones. According to [4], there have been numerous drone incidents where drones have flown into no-fly zones or near mid-air collisions. The question that law enforcement is trying to answer is how do we detect them?

In the following chart, [5] shows drone incidents from Feb 2014 to October 2015. Incidents include aircraft hits or near misses, drones coming in contacts with humans or buildings, and reports of drones involved in privacy incidents.



As we can see from the following chart, drones are mostly involved in incidents within 20 miles of an airport. The majority are within 5 miles. This is a concern since drones are not allowed to operate within 5 miles of an airport unless the drone operator has permission from the airport operator. In some areas such as Washington DC, the regulations are much stricter [6].



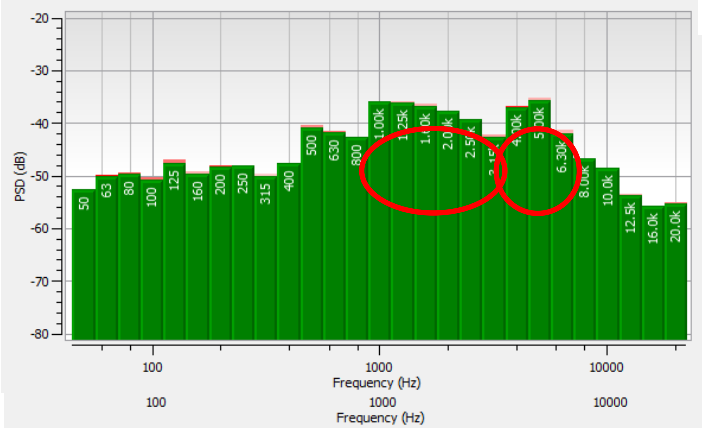
III. Solution

A drone, like any other machine, makes a sound. Sounds are not one frequency, but are made up of multiple frequencies. It is possible to fingerprint a drone by capturing its sound and looking at the multiple frequencies that are contained in it.

The sounds from three devices were analyzed, a drone, a lawn mower and a helicopter. First, the .WAV files were down loaded. For this research, Zapsplat was used to download the recordings of existing sounds since they were recorded with high quality [7]. The recordings were played and captured in Friture using a screen capture of the output. Friture shows the dynamic frequencies of each file as it plays. The screen captures were put into MSPaint to clean them up.

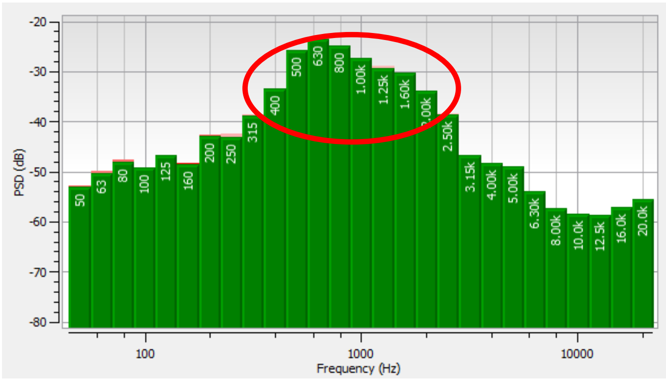
The frequencies were then analyzed to see if they could be uniquely identified. Friture was used to analyze the frequencies because it shows the data in multiple formats, a scope, 2D, FFT and octave spectrums [8]. For this paper, the octave spectrum option was used.

On the drone octave spectrum chart, we can see that frequencies in the 1- 2kHz and the 4-5KHz are the most prevalent for this drone. This is expected because a drone has a high pitch to it.



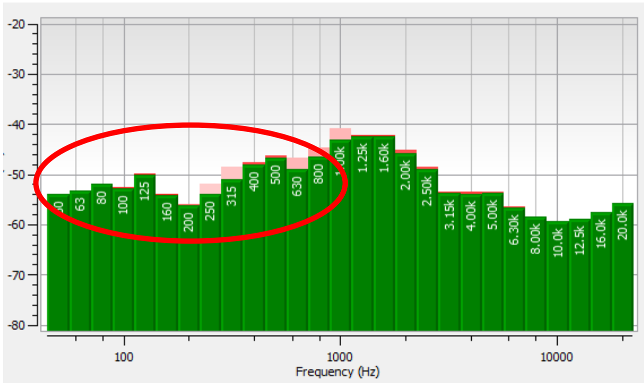
Drone

A lawn mower on the other hand should show stronger frequencies in the lower and middle range of the spectrum. We can see that the frequencies that were more prevalent in the drone octave spectrum chart are not in the lawn mower chart. The lawn mower has frequencies in the 400Hz-2kHz are more prevalent for the lawn mower.



Lawnmower

As a third example, a helicopter was analyzed. A helicopter has primary frequencies in the lower to middle end of the frequency range. The lawn mower has a lot of frequencies in the 50Hz – 800Hz frequency spectrum and very few in the higher ranges.



Helicopter

We can clearly see a difference in all three of the octave spectrum charts. Drones tend to have higher frequencies present in their sound spectrum, while lawn mowers and helicopters do not.

Keep in mind that not every drone, lawn mower or helicopter will create exactly the same frequency fingerprint as shown in this paper. However through analysis, there should be frequencies that distinguish them from each other.

IV. Preventative

As we have seen in [2], drones have been involved in accidents where people have been injured. It's not out of the realm of possibility that a drone could kill someone given the size and weight of the some of the commercial drones available to consumers.

Although it's not mandatory, a consumer can earn a drone pilot certificate. You can register for the Remote Pilot Certificate from the FAA and become certified to fly drones under the Small UAS Rule – Part 107 [9].

V. Conclusion

Drones are quickly filling the skies. Some pilots fly them into no-fly zones or restricted areas. Law enforcement is trying to figure out how to detect them.

Sounds are made up of a collection of frequencies. This paper has shown that is possible to use frequency analysis to detect a drone using COTS hardware and software. Drones emit specific frequencies when flown as opposed to other mechanical devices that have rotors such as helicopters or lawn mowers. These frequencies can be fingerprinted to discern a drone from a helicopter, lawn mower or any other device.

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