IS THIS SIM A DRONE?

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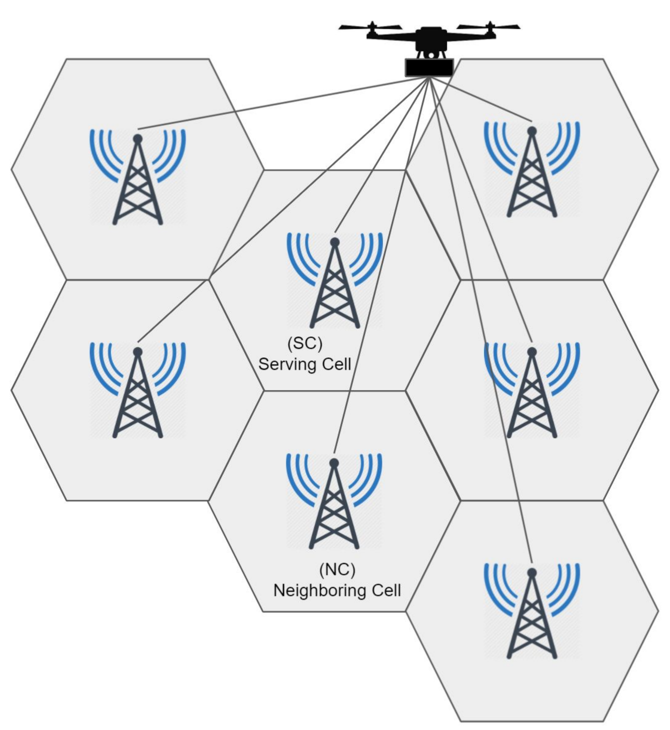
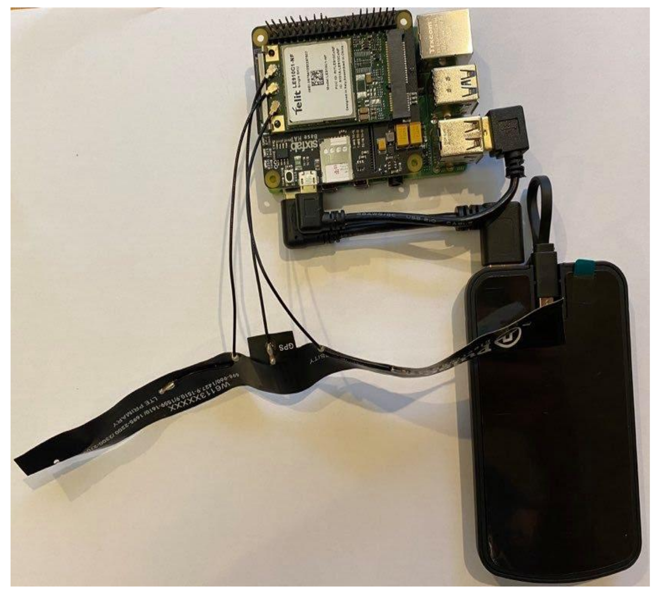
SIM Card Usage in Drones

- SIM card usage in drones is increasingly popular because it provides rangier connection than Wi-Fi or Bluetooth.
- The problem with this trend is that Base Station antennas are optimized for terrestrial coverage and drone SIM usage can cause interference as well as expose networks to security issues
- Technology exists to accommodate for SIM usage in a drone, i.e., telecom providers offer drone-specific data plans.
- T-Mobile needs a way to identify customers using SIM cards on cellular data plans to connect those clients to the appropriate technology for their needs.



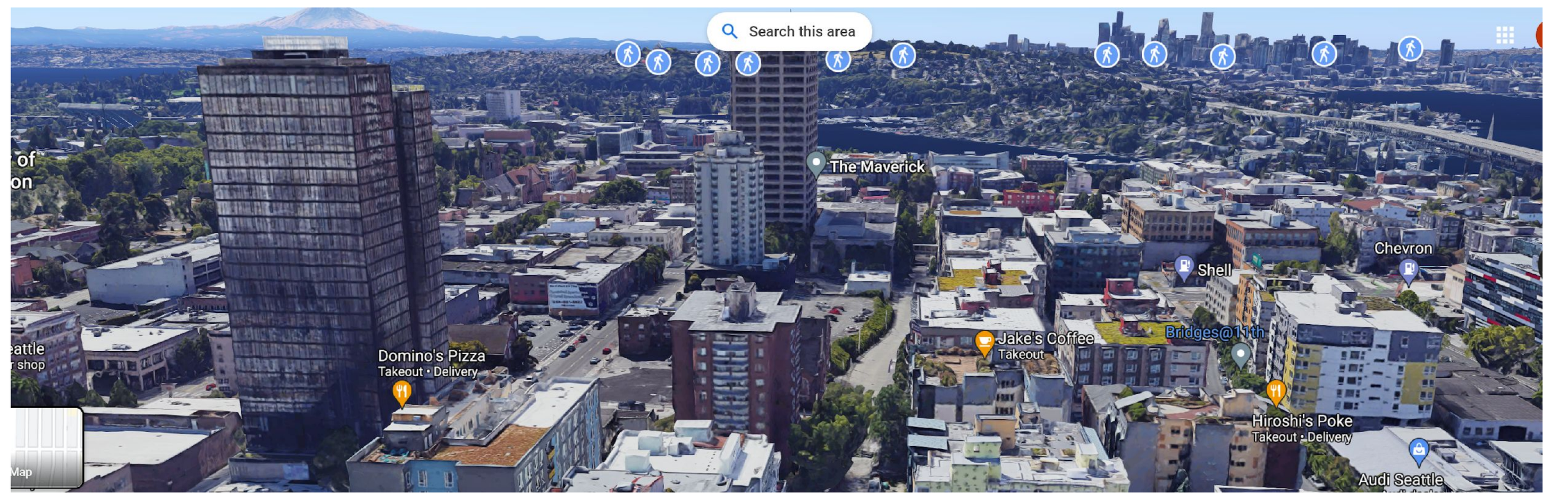
Raspberry Pi – IoT Hat

- To collect cellular data, a Raspberry Pi 4 was fitted with a Raspberry Pi 3G/4G & LTE Base IoT (Internet of Things) Hat from Sixfab
- The IoT attachment was fitted with a Telit LE910C1 LTE module and a T-Mobile SIM card to create a cellular connection
- The portable hardware setup shown below (with a portable battery and antennas attached) runs a Python script which collects a suite of cellular data parameters every 15 seconds
- The hardware can be mounted to a drone or used as a handheld device to collect data on the ground level



Data Collection Scenarios

- Two types of data need to be taken: data at high-altitude in open-air, i.e., drone data, and data in as many other scenarios as possible
- Thus far, drone data has been collected from open-air rooftops at altitudes greater than 20 meters above the ground
- Non-drone data has been collected inside buildings at ground level, outside at ground-level, and inside buildings at altitudes of 20 meters above ground or greater
- The tower on the left of the foreground of the photo below shows a site where data was collected



Differentiators: Signal Power and Signal Quality

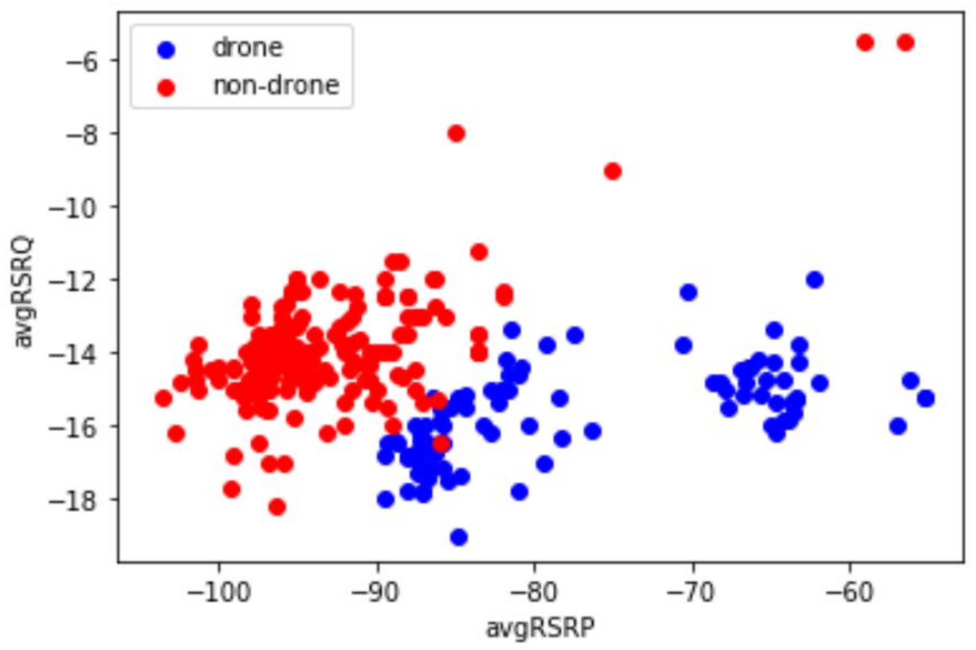
- The scatterplot below shows data points from field testing where blue points mark data taken on open-air rooftops and red points mark all other collection scenarios
- The scatterplot shows a clear differentiation in signal behavior in the two scenarios

Average RSRP

- RSRP – Reference Signal Received Power
- The average signal power of all the connections between the SIM and nearby towers
- Signal power is higher at higher altitudes and is degraded by building material

Average RSRQ

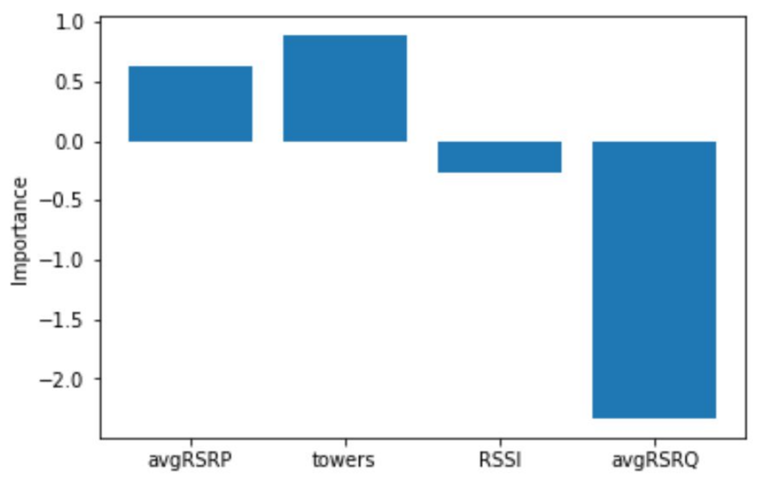
- RSRQ – Reference Signal Received Quality
- The average signal quality of all the connections between the SIM and nearby towers
- RSRQ = (N * RSRP) / RSSI



Logistic Regression Algorithm

- Logistic Regression takes both categorical and numerical data as independent, input data, and outputs a categorical classification as an output based of a simple mathematical model
- Our Logistic Regression model was able to correctly classify data as drone or non-drone in over 98% of test data
- Successful classifications depended on avgRSRP and number of connected towers, while RSSI and avgRSRQ were not very useful in classifications
- Collected data was split 80/20 between training and testing

```
Accuracy: 0.9818181818181818
Precision: 0.95
Recall: 1.0
```



Decision Tree Algorithm

```
Accuracy: 0.9636363636363636
Precision: 0.9047619047619048
Recall: 1.0
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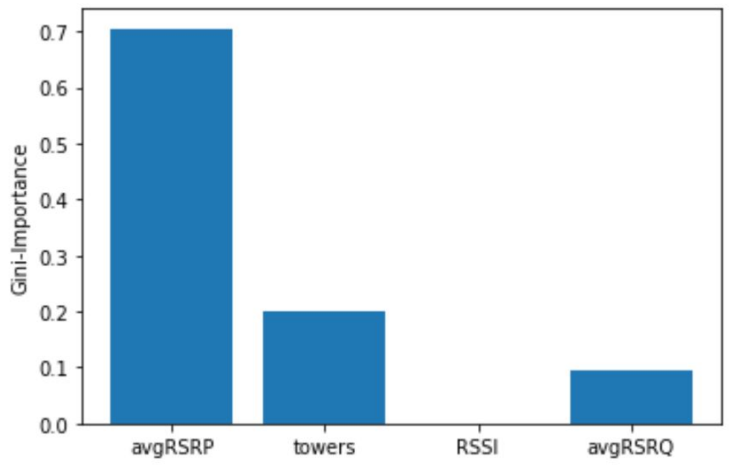

- The Decision Tree Algorithm uses complex algorithms to create simple decision rules to split, and then classify the input data
- While the Decision Tree Algorithm performed slightly worse than the Logistic Regression algorithm, it still had an accuracy above 96%
- Similarly to the Logistic Regression model, number of towers and average RSRP among connected towers were important classification factors
- Collected data was split 80/20 between training and testing

Future Work, References, and Acknowledgments

- The accuracy of our models both exceeded our goal of 85% classification (based on our limited, gathered data)
- Gathering large datasets with a real drone is our next goal
- Using positional characteristics may differentiate between a SIM on an open-air high-altitude rooftop and a SIM in a drone
- More scenarios need to be tested, e.g., rural areas, vehicles, etc. to ensure model accuracy

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Citations

[1] *Google Maps U District Skyline Screenshot*. Google Maps.

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