Smart Sensing for Internet of Things: Assignment 2

Rishika Varma K

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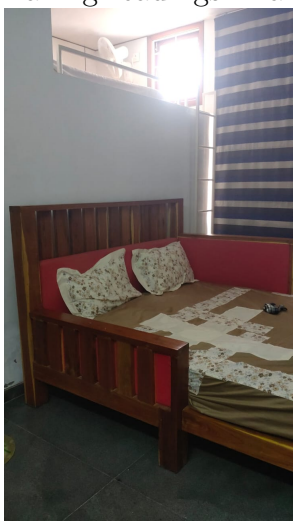
Introduction

This assignment is involved in analysing of the Android GNSS measurements in various circumstances namely, under the open sky with maximum direct exposure, near a window with reduced exposure to the sky and inside the house with no direct exposure to the sky to observe the variation in aspects like number of satellites, direction of signal(Azimuth) from a satellite, Snr, etc. Using the hardware of the smartphone, and tapping into signals from various satellite constellations. For this experiment, the GNSSlogger App was used to log the various specifications and appropriately analyse the results with respect to various aspects.

1 Photos of locations

1.1 Inside

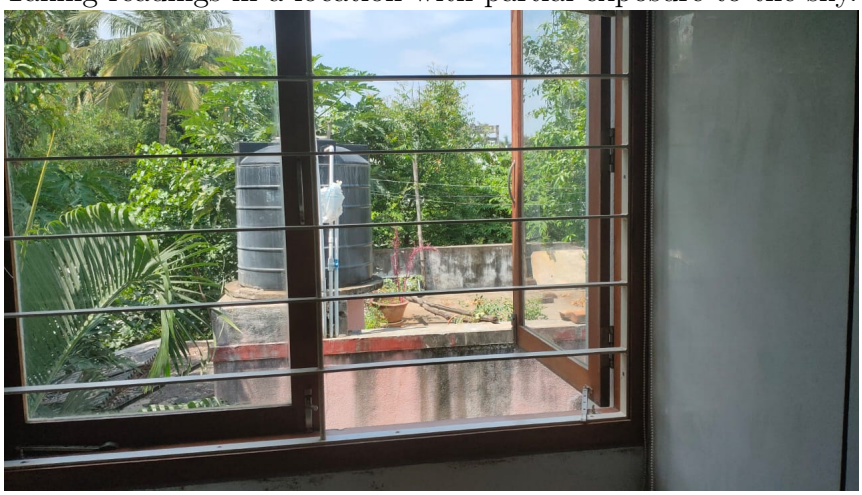
Taking readings in a location with the lowest exposure to the sky possible.



As can be seen from the picture, the only direct exposure to the sky is from the small sky light near the ceiling. (Reading was taken with the phone on the bed).

1.2 Near window

Taking readings in a location with partial exposure to the sky.



Here there is partial exposure to the sky through the window. (Reading was taken with the phone kept a few inches inside the room from the window sill).

1.3 Outside

Taking readings in a location with direct exposure from the sky.

Here the phone is kept directly under the sky and the reading is taken.

2 Mean location and error

The mean location is calculated from taking the appropriate value (index 2 and 3) from all the fix GPS entries and taking their mean. The error is then calculated from this mean and each of the values using haversine distance.

The mean location in latitude and longitude (Groundtruth location) for the 3 locations, the corresponding CDF plots of the errors and the variance of the same are as follows

2.1 Inside

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Mean latitude: 11.960344858092485
Mean longitude: 79.80877466849711
Variance of Haversine Error: 0.0027259965386369238
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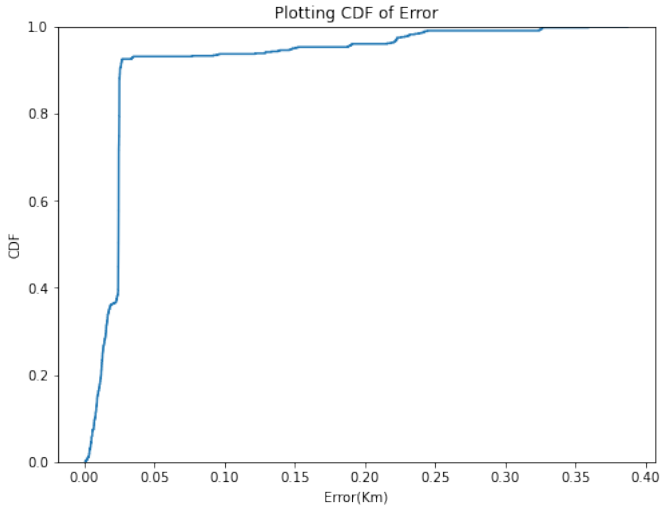
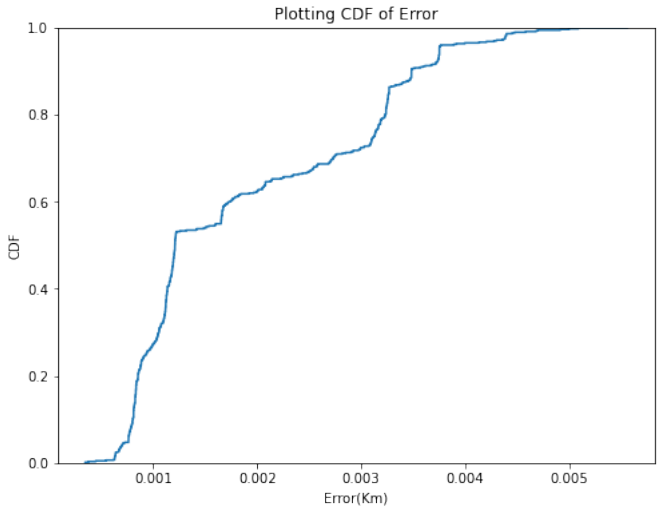


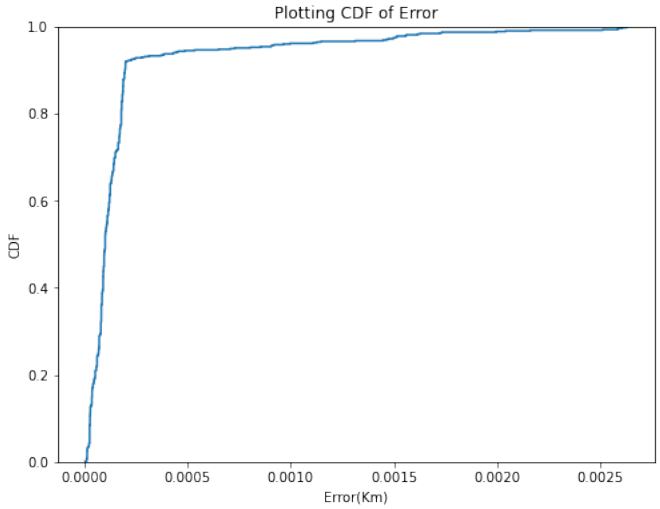
2.2 Near window

Mean latitude: 11.960525609640523
Mean longitude: 79.80863583447713
Variance of Haversine Error: 1.3176916561216906e-06



2.3 Outside

Mean latitude: 11.960423988519638
Mean longitude: 79.80869082567976
Variance of Haversine Error: 1.2867163284611862e-07



Variance observation

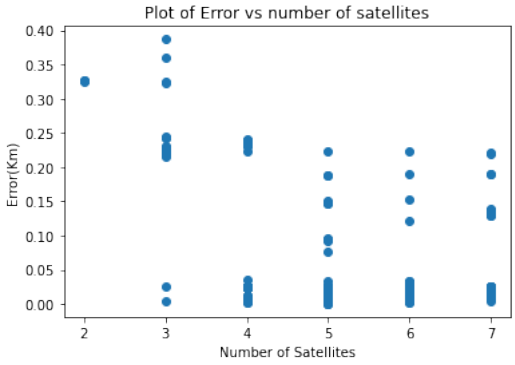
Variance as seen from the values above decreases with increase in exposure to the sky. The reading taken inside has the highest variance whereas the remaining values are much lesser comparatively. The reading taken outside has the least variance. This seems intuitive as with direct exposure, most satellites have similar access and so the reading is not hindered for some of the satellites due to obstructions resulting in similar error values. Thus variance is lesser when exposure to sky is better.

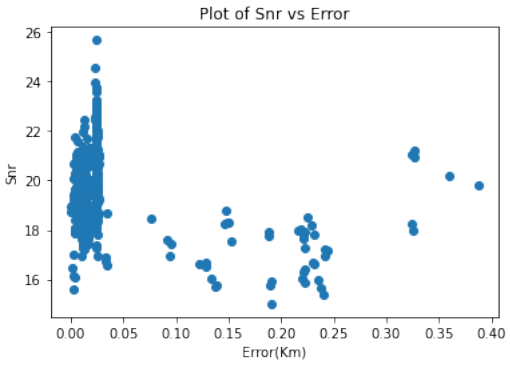
3 Status entry analysis

The number of satellites was calculated by adding the UsedInFix(index 10) entry in all the status lines before a particular fix line. An array of number of satellites corresponding to each fix entry was maintained. Similarly average snr of all the snr values (index 7) of the status entries before a fix entry is maintained as an array in the same way. Using these arrays, the error vs number of satellites and error vs average snr are plotted as scatter plots. The median number of satellites is also found from this. These values and plots for each log file are as follows:

3.1 Inside

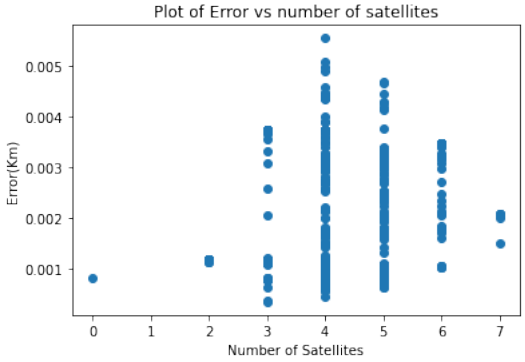
Median of number of satellites: 6.0

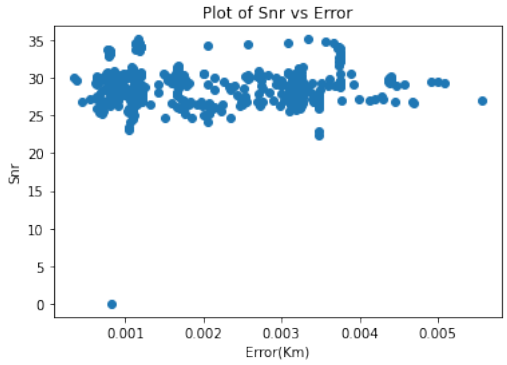




3.2 Near Window

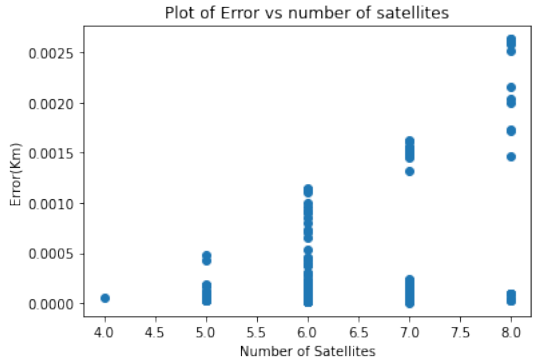
Median of number of satellites: 4.0

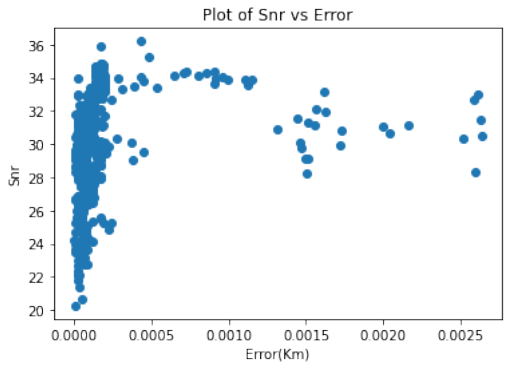




3.3 Outside

Median of number of satellites: 6.0





Error to number of satellites correlation observation

The number of satellites used for the inside and near window cases ranged from 2 to 7 but for the outside case it ranged from 4 to 8. Many of the points correspond to mid number of satellites i.e, in the plot, there are more points in the middle of the graph. For the outside plot, maximum error occurs for the points with maximum number of satellites. This shows that when

exposure to sky is optimal, more input results in wider variation resulting in higher error. Here the necessary and sufficient number of satellites appears to be 6 as the error value is low and number of such points are high. In the inside plot, error value is higher for the points with 3 satellites implying that with very low sky visibility, 3 satellite information is insufficient for proper conclusion of location. Here, for number of satellites values beyond 3, the error values are similarly distributed which means that 4 satellites is sufficient information and anything above that will not change the result by much. For the near window plot most of the points have 4 satellites. This may be because the partial exposure to the sky resulted in 4 particular satellites information as more accessible and thus more points are of this type.

Error to Snr correlation observation

The first observation that can be seen is that the values of snr on average increases with increase in exposure to the sky. Intuitively, this makes sense as the signal strength will be better with better exposure to the sky. Comparatively, the density of points is greater in the area with lesser error and greater snr value. This can be explained as if snr value is high, noise is lesser which means error is lower. Thus points of this form will be high. In both the inside and outside plots most of the points cluster together in the lesser error region. In the partial visibility plot the points are more evenly distributed over all error values in the range. The variance of snr in the partial visibility plot is lesser with most points having similar values. The maximum of error values also decreases with increase in visibility of sky which is also expected.

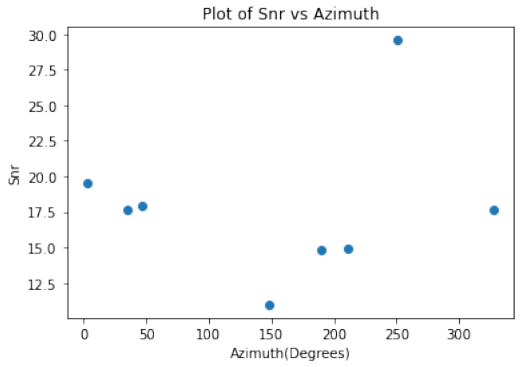
4 Satellite characteristic analysis

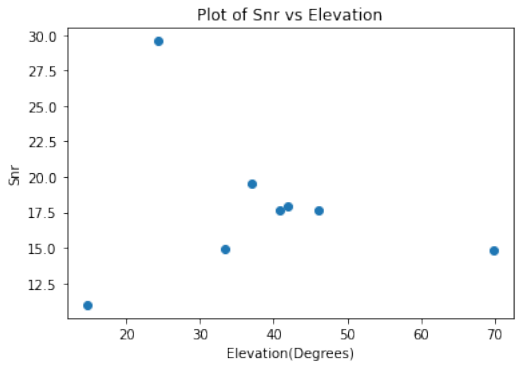
For each svid that is used for the fix entry, the values of snr (index 7), azimuth (index 8) and elevation (index 9) are collected and the average is found to give the corresponding means for each svid. These values are tabulated. These values are used to plot the average azimuth vs average snr and average elevation vs average snr plots. The tables and plots for each location are as follows:

4.1 Inside

Svid	Azimuth	Elevation	Snr
6	189.718	69.8793	14.8192

7	148.333	14.6667	10.9778
13	250.87	24.3685	29.5796
14	46.9519	42	17.932
19	327.814	46.1343	17.694
28	35.4223	40.8516	17.6601
17	2.66461	37.0572	19.5
2	211.269	33.3819	14.9266

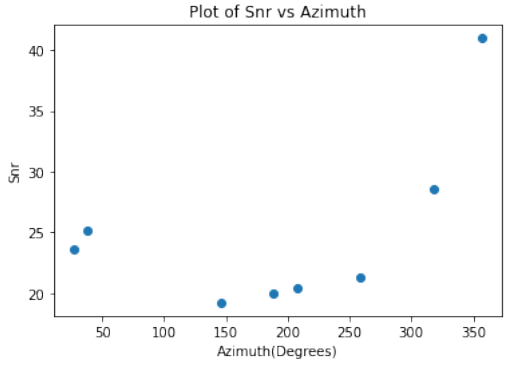


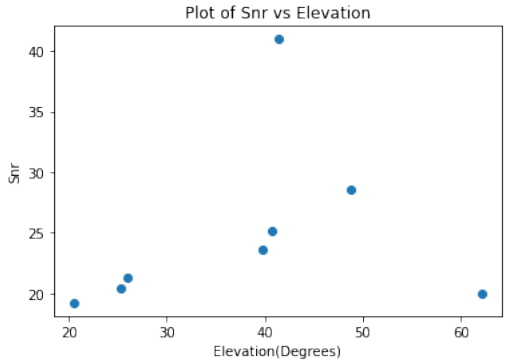


4.2 Near Window

Svid	Azimuth	Elevation	Snr
2	208	25.25	20.4375

14	37.7146	40.751	25.2032
17	356.466	41.3584	40.9925
19	317.64	48.7774	28.5856
13	258.842	26	21.3236
7	146.364	20.5341	19.2068
28	27.2654	39.7202	23.5609
6	188	62.1042	19.9625

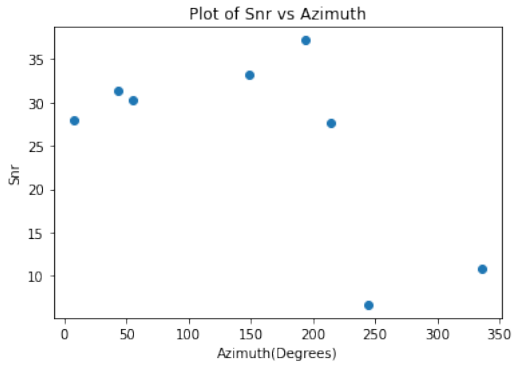


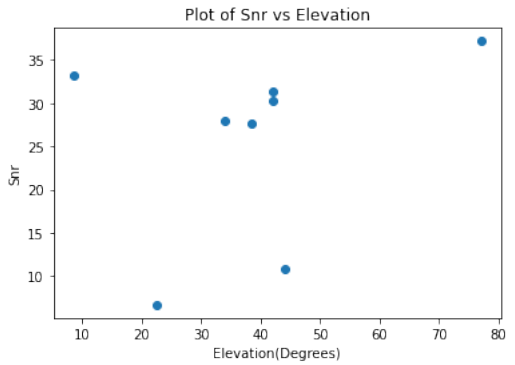


4.3 Outside

Svid	Azimuth	Elevation	Snr
2	214.372	38.5778	27.5949

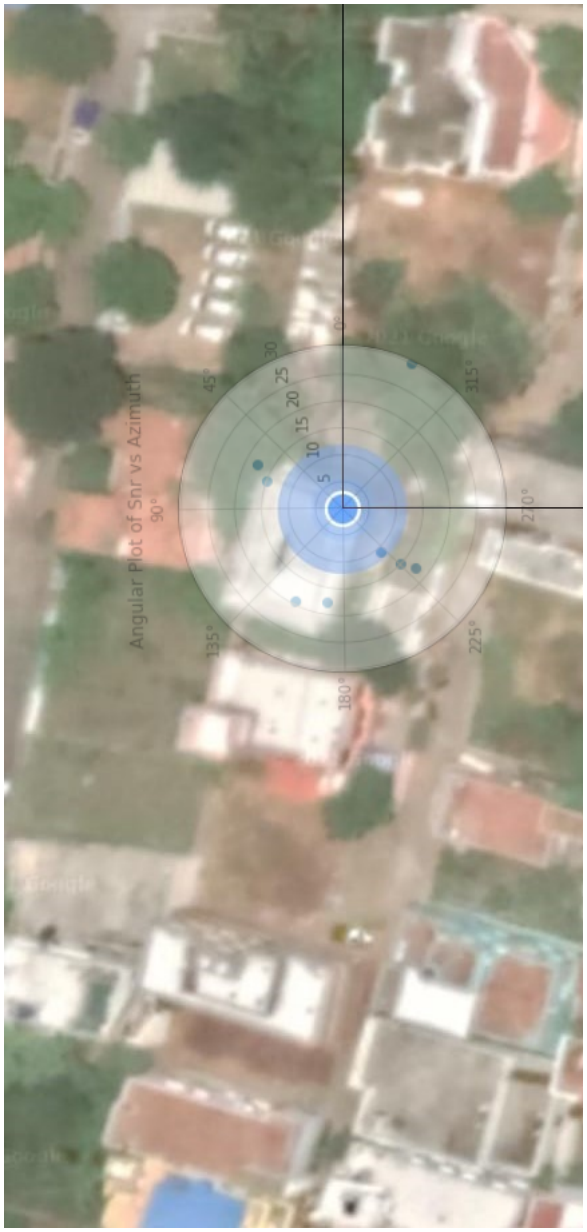
6	194.314	77.0529	37.1752
7	149	8.60817	33.1772
13	244.511	22.4889	6.66
14	54.858	42	30.3197
17	8.12044	33.9873	28.012
19	335.26	44.1345	10.743
28	43.2161	42	31.3549





5 Polar Snr plot with aerial view of landscape

5.1 Inside



5.2 Near Window

5.3 Outside

Observations

In the first figure which corresponds to inside, the maximum snr appears in 2 directions and these are in the direction of the window and skylight present in the room. The signal from other directions is much more feeble.In the other directions there is less snr in some directions with less obstructions whereas in other directions there is no signal due to obstructions like trees

and neighbouring buildings.

In the second figure which corresponds to near window, snr is generally higher in the points in the direction of the window which is north (0_o azimuth) In the remaining directions, it mostly corresponds to the obstructions present in the path. The highest snr however is not directly in the direction of the window and this can be explained because although the window is towards the north, the visibility of the sky from the window is more than just 1 particular direction.

In the third figure which corresponds to outside, as the visibility of the sky is optimal, we can clearly see that almost all the points are towards north due to much more open area whereas in the lower part of the circle there are hardly any points due to there being a large building directly beside. The points in the 270 degree area also have much better snr as the reading was taken in a open balcony kind of area and so in the opposite direction, the signal was obstructed by the house.

References

https://datavizpyr.com/ecdf-plot-with-seaborn-in-python/