CS6650 HOMEWORK II

Android-based GNSS Measurements

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1. LOCATIONS

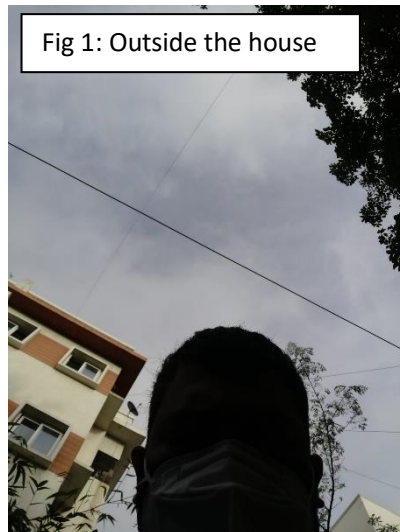**IMAGES FROM KK NAGAR, CHENNAI**

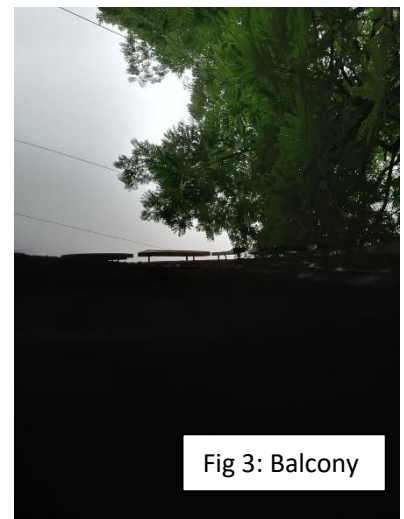Fig 1: Outside the house

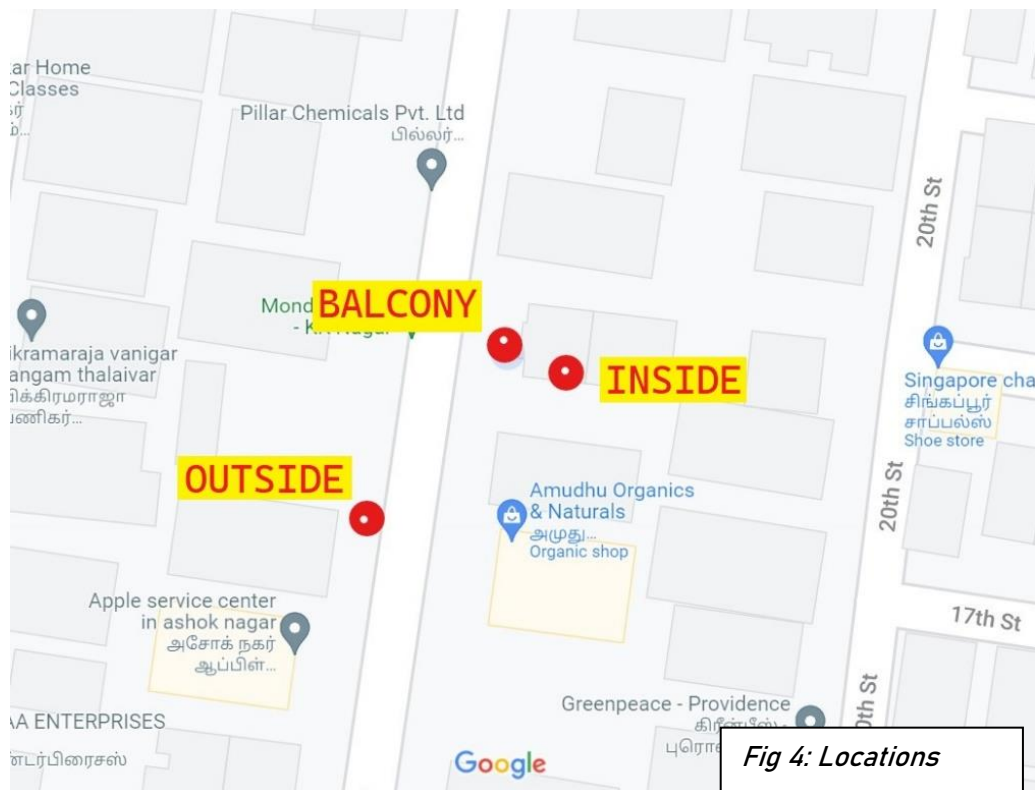Fig 2: Inside the house


Fig 3: Balcony

Fig 4: Locations

2. ERRORS

LOCATION	MEAN COORDINATES	MEAN ERROR (meters)	ERROR VARIANCE (meters)
OUTSIDE	[13.041906395270273, 80.19956583108106]	0.031335658284732844	0.0002932762001711339
BALCONY	[13.042322594964032, 80.19952895863308]	0.7710878790376084	19.62760738751255
INSIDE	[13.042178818518515, 80.1996418]	8.281005133706566	44.2093306224494

Table 0: Location and error
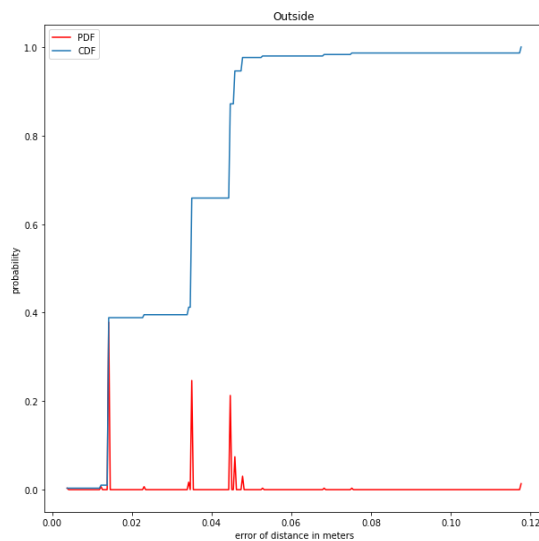
Fig 5: Outside error CDF
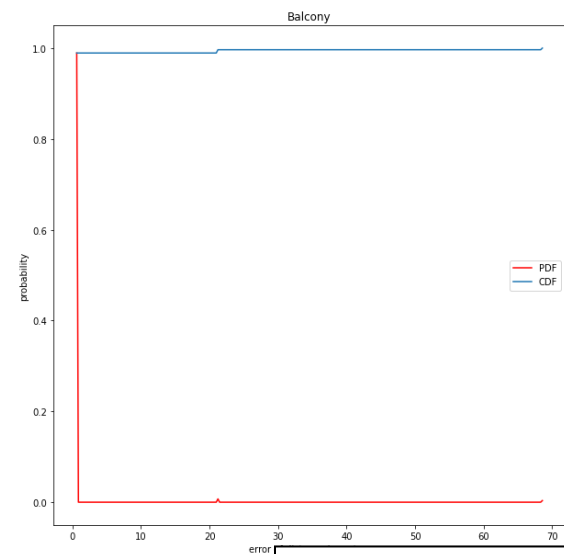

Fig 6: Balcony error CDF
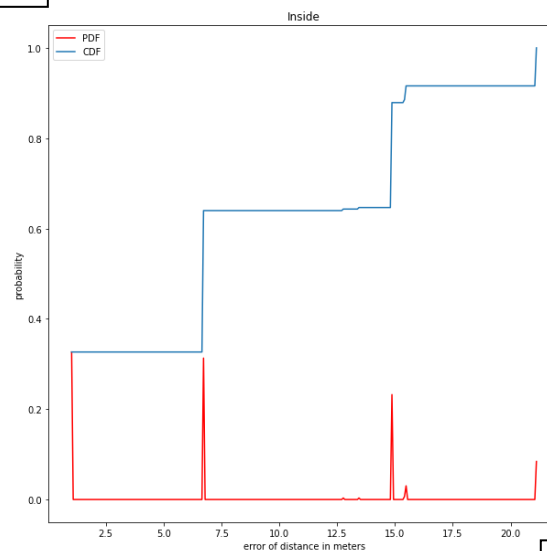
Fig 7: Inside error CDF

We note that

- Mean error decreases as the exposure to sky increases. (Table 0)
- Variance of the error increases as the exposure to sky is reduced. (Table 0)
- Error at which CDF approaches 1 decreases as the exposure to sky increases. (Fig 5,6,7)
- With the increase in exposure to the sky, the errors reduce by orders of 10 (Table 0)

3. SOME SCATTERPLOTS

Table 1: Scatterplots

LOCATION	#SATS	ERROR VS # SATELLITES	ERROR VS MEAN SNR
INSIDE	9		
BALCONY	9		
OUTSIDE	12		
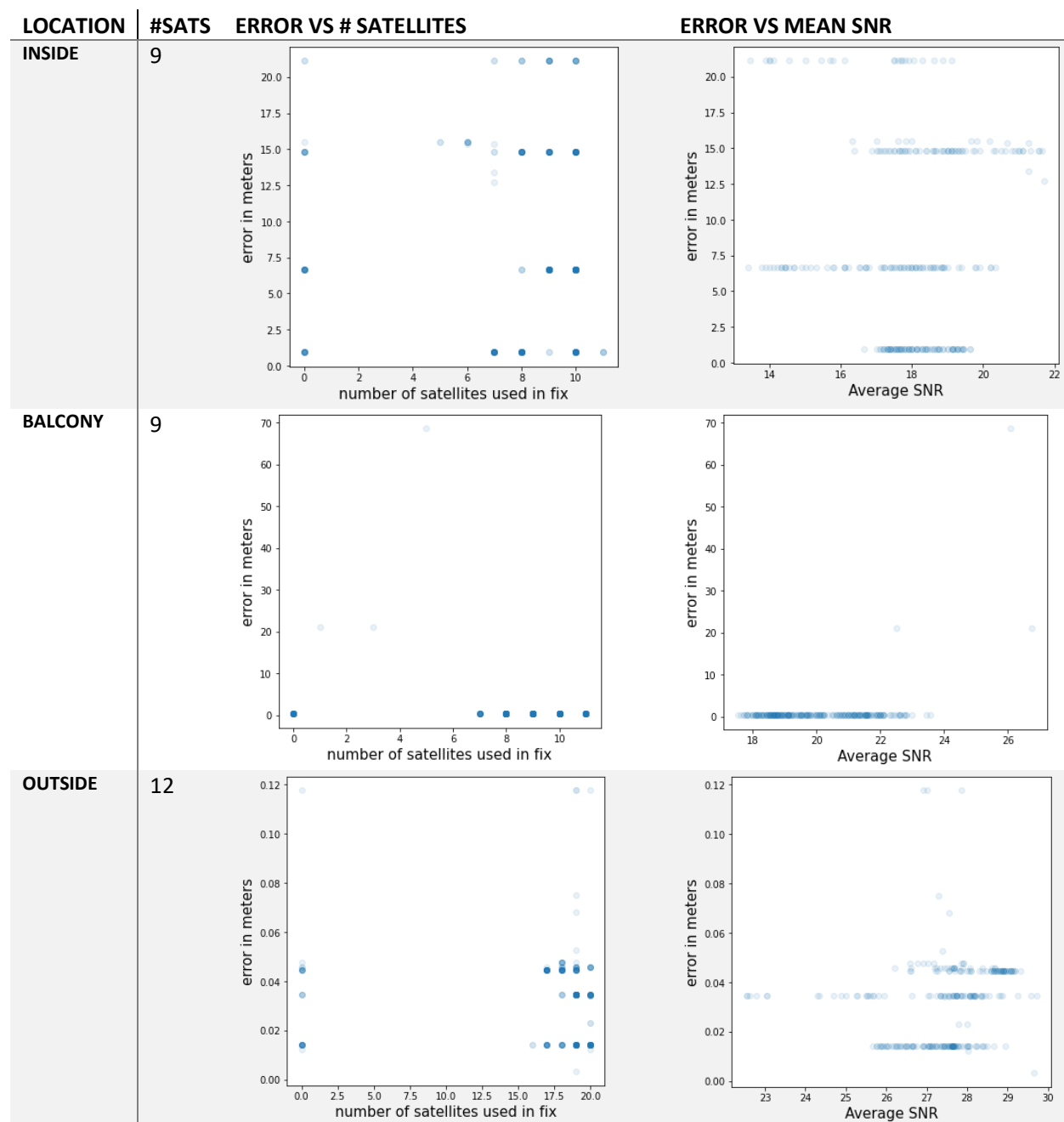
A clear correlation cannot be identified from any of these plots. This may be due to the current bad weather in Chennai.

| LOCATION	CORR (#SAT, errors)	CORR (SNR, errors)
inside	0.04711268328397208	0.003471931118734638
balcony	-0.11428933268346592	0.22744824279195308
outside	-0.032694855083967876	0.3325697429749448

Table 2: Correlation

4. SATELLITES: SIGNAL AND POSITION

OUTSIDE

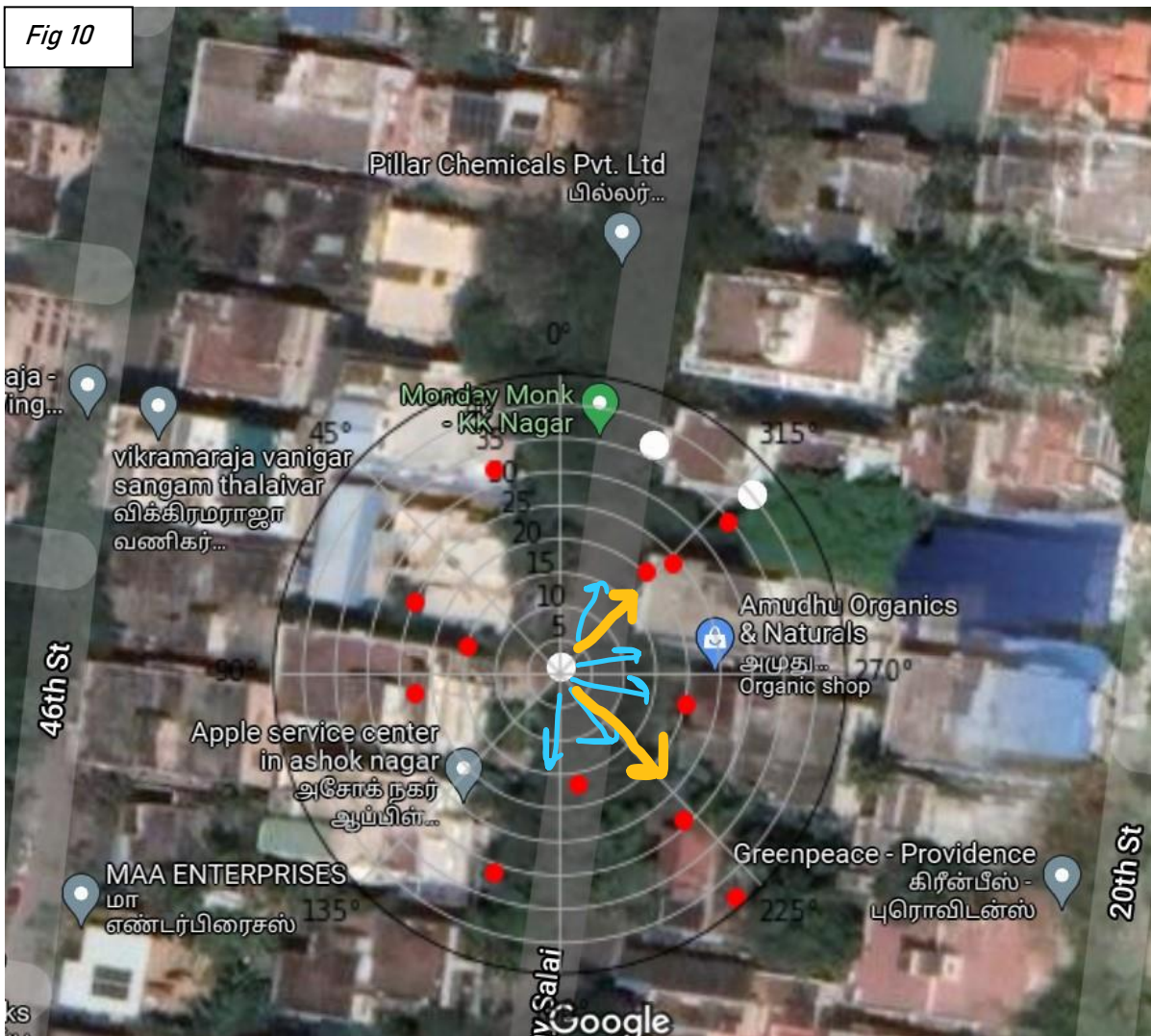| Svid	Average Cn0DbHz	Average AzimuthDegrees	Average ElevationDegrees
2	19.957746	102.362077	9.249789
5	20.434146	40.789659	11.360146
10	22.799320	263.025952	22.785476
12	16.498182	170.264655	8.923273
13	23.911864	46.600780	24.987390
15	34.385135	48.952601	56.073243
18	32.182432	341.334020	31.589493
23	25.044218	295.508980	42.557279
24	28.912162	138.392297	22.396318
25	31.331081	199.064020	21.666250
26	15.006329	286.034557	6.552342
29	43.189189	140.445135	85.262872

Table 3: Outside satellite data
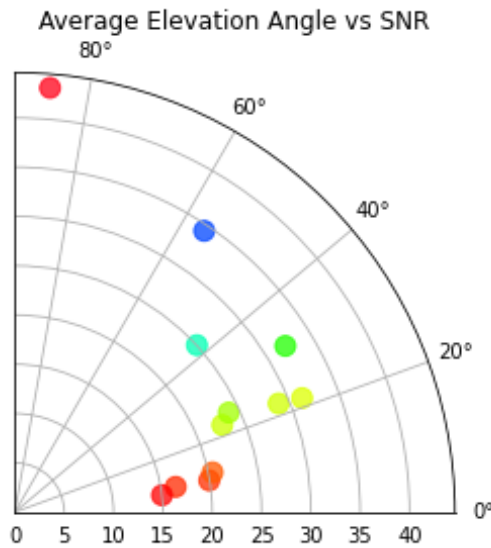
Fig 8: OUTSIDE

"Average Elevation" (0, 90 degrees) with "Average SNR"
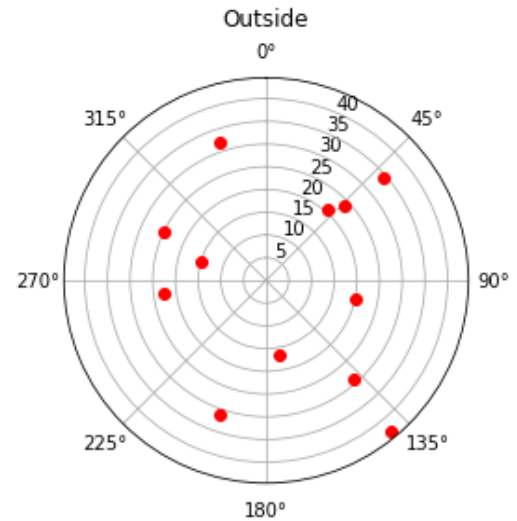
Fig 9: OUTSIDE
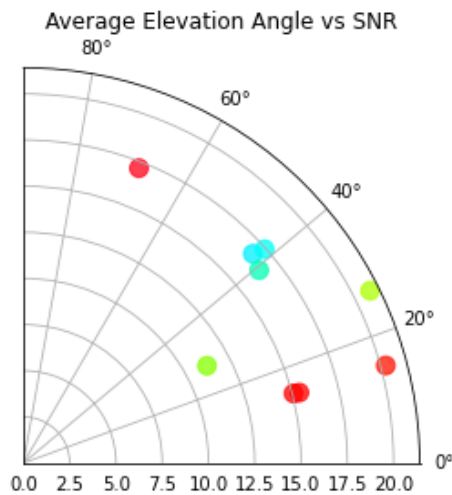
"Average Azimuth" (0 - 360 degrees) with "Average SNR"

Fig 10

INSIDE

Svid	Average Cn0DbHz	Average AzimuthDegrees	Average ElevationDegrees
10	20.929530	278.672886	26.477617
13	15.388889	39.224778	14.357556
15	16.796748	37.745610	42.440569
18	16.473214	354.698839	39.354464
23	17.437710	315.779091	41.623704
24	11.230769	124.670385	27.966538
25	15.074627	188.080821	14.478134
29	17.147287	168.363837	68.652093
32	20.280702	212.515018	15.099193

Table 4: Inside satellite data

Average Elevation Angle vs SNR
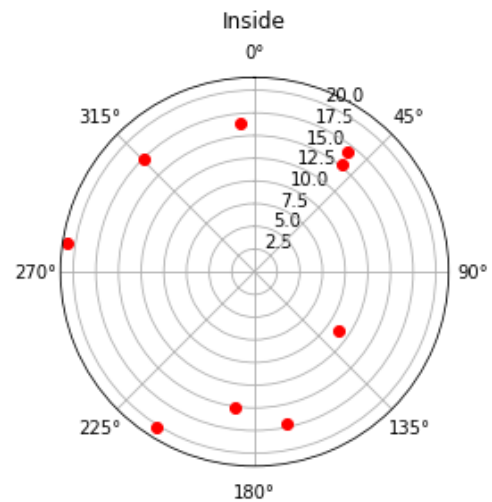

Inside

Fig 11: INSIDE

"Average Elevation" (0, 90 degrees)
with "Average SNR"

Fig 12: INSIDE
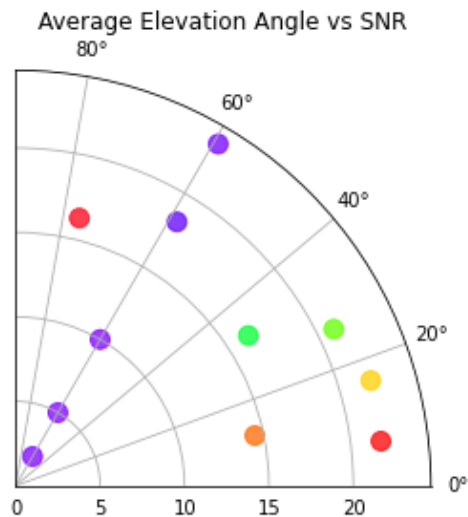
"Average Azimuth" (0 - 360 degrees)
with "Average SNR"

Fig 13

BALCONY

Svid	Average Cn0DbHz	Average AzimuthDegrees	Average ElevationDegrees
1	2.000000	90.000000	60.000000
4	16.289474	104.028991	76.617588
7	21.000000	325.432069	26.212759
8	18.310078	82.539729	58.558333
9	23.519713	331.128495	59.330287
11	10.000000	90.000000	60.000000
14	21.940559	243.350769	16.505734
17	5.000000	90.000000	60.000000
22	14.472222	171.020463	11.855648
27	16.402174	52.903043	32.843533
30	21.795455	301.920136	6.952682

Table 5 Balcony satellite data

Average Elevation Angle vs SNR
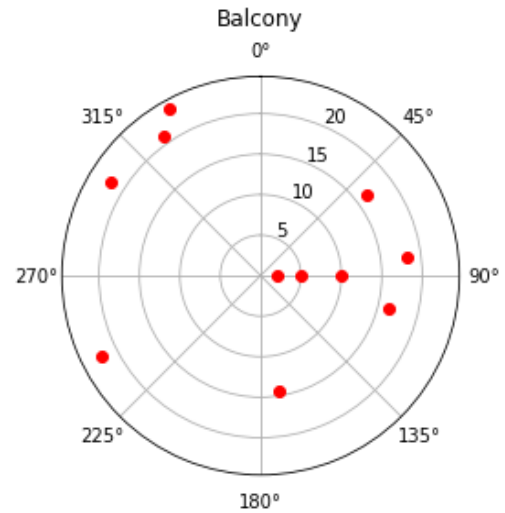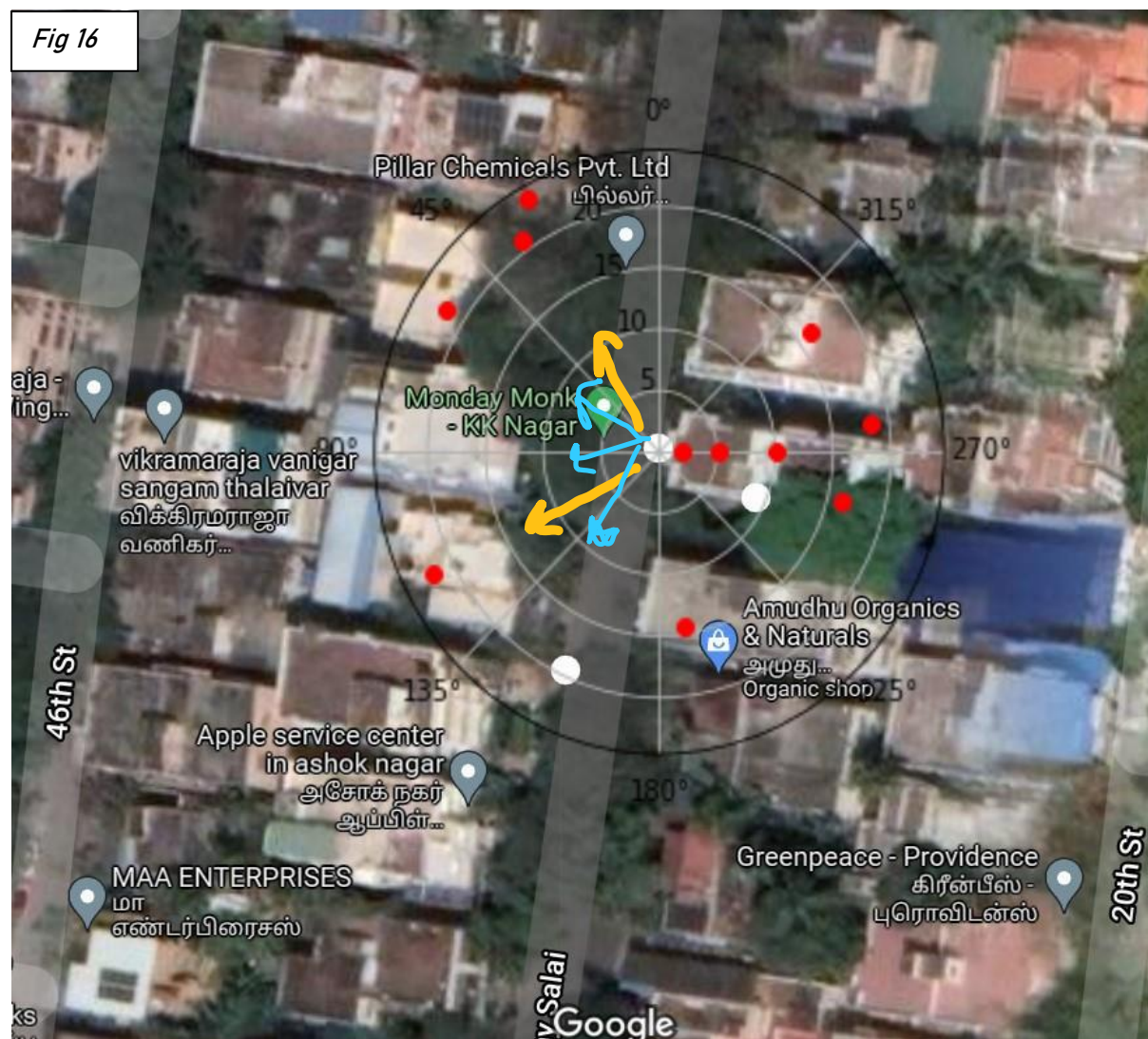
Fig 14: BALCONY

"Average Elevation" (0, 90 degrees) with "Average SNR"

Balcony

Fig 15: BALCONY

"Average Azimuth" (0 - 360 degrees) with "Average SNR"

Fig 16

5. INTERPRETING SATELLITE DATA

In the Average SNR with Average Azimuth plots (fig 10,13,16):

- The white dots are the locations of phone where logs were recorded.
- The red dots represent the average SNR at different directions from the phone.
- The blue lines span the directions of clear sky from the location of phone.
- The yellow lines represent the directions of peaks of average SNR.
- All the map images are aligned with top of page as North

We observe that:

- Peaks of SNR are in general aligned towards the direction of open sky
- This is best seen in the 'inside' case where in the window direction is packed between the SNR peaks
- In the 'balcony' case, a huge span to the west is exposed to the sky, and consequently, we observe high SNR along the west.

6. DETAILS

- **SMART PHONE USED:** Version: v3.0.0.10 Platform: 10 Manufacturer: HUAWEI Model: STK-L22
- Experiment performed from KK Nagar, Chennai – 600078
- Data was collected from 3 pointes labelled as 'outside', 'balcony' and 'inside' as shown in fig 4
- Exposure to sky: outside > balcony > inside (as suggested by fig 1,2,3)
- Each log was collected for exactly 5 minutes.
- The outside and inside cases were collected between 7 AM and 8 AM, and the balcony log was collected at 6 PM of 6th November, 2021.
- The location was surrounded with a canopy of trees, which could have been of considerable disturbance in the balcony and inside cases.
- The outside case was made sure to be away from the canopy and directly under the sky.
- The weather during the time of experiment was mildly cloudy. The next day, Chennai had intense rain.
- Special thanks to Nithin Uppalapati (EE18B035) for the discussions and comments.

7. REFERENCES

- sklearn.metrics.pairwise.haversine_distances — scikit-learn 1.0.1 documentation
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- https://www.geeksforgeeks.org/how-to-calculate-and-plot-a-cumulative-distribution-function-with-matplotlib-in-python/
- https://stackoverflow.com/questions/30328646/python-pandas-group-by-in-group-by-and-average