Mini Hack 2 - Writeup

Adolfo Roquero, Leticia Schettino, Kobi Green

February 2022

[Section 1]

Q1) Discuss with you team about why the WiFi channel phase varies. Include these details in the writeup.

The wifi phase channel is changing because the robot is moving. The phase is directly proportional to the distance traveled, so as the robot is moving around with the transmitter the phase will vary.

Task 1

Q2) Discuss with you team about why the AOA profiles are different. Can you guess how the TX nodes are positioned around the RX robot?

The AOA profiles are different since the location of each transmitter with respect to the robot is different as well as due to noise in the measurements.

- tx2 - We can estimate that it is behind and to the left since the highest peak in the AOA profile is at 120 degrees (azimuth)
- tx3 - We can estimate that it is to the right and in front of the robot since the highest peak in the AOA profile is at -30 degrees (azimuth).
- tx4 - We can estimate that it is behind the robot since the highest peak in the AOA profile was at -180 degrees (azimuth)

Figure 1: TX 2: profile generated for sample data

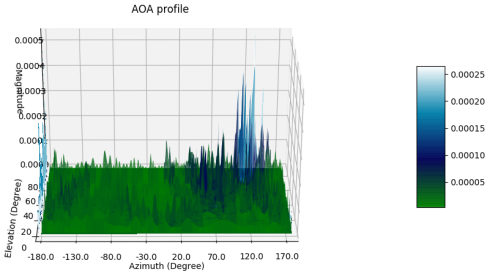


Figure 2: TX 3: profile generated for sample data

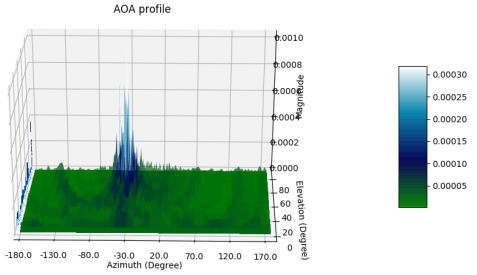
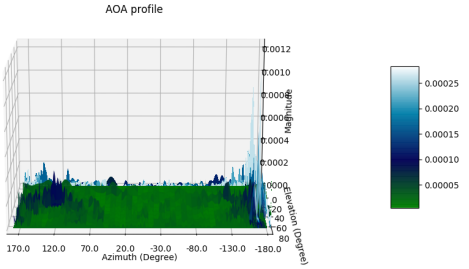


Figure 3: TX 4: profile generated for sample data



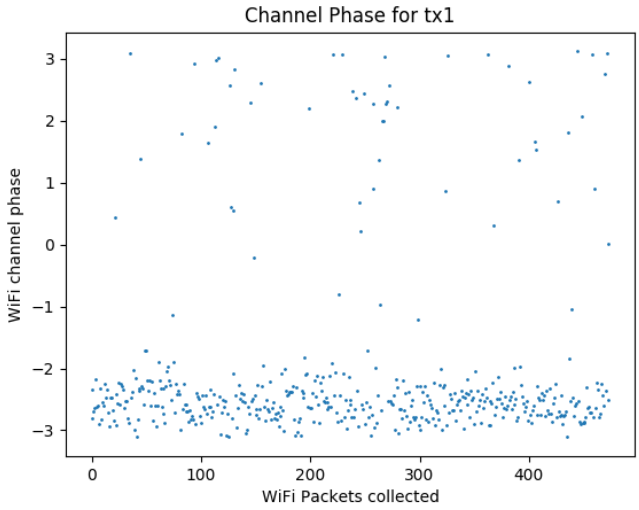
[Section 3]

Q3) Show the above the output on both the robot (configured in section 2) and the TX node, to the TFs to confirm that the WiFi driver has been configured correctly. Also show that you can login to the robot and TX node without password. Add the details of the channel you used and the 'Frequency' value in your wirteup.

Channel used was 108, packet length of 63 and the frequency 5.54 GZ.

[Section 4]

Figure 4: Python test 1: plot of Wifi data



Q4) Discuss with your team as to why there is a difference between this plot vs the one you saw in the first section. Essentially, why the WiFi channel phase does not vary.

We expect to see a straight band of data packets on this plot because the robot is no longer moving. Since the robot is no longer moving the wifi channel phase will not change dramatically because the distance is the same. Most of the variations we see are due to noise.

Task 2

Figure 5: Data collected with ts = 3

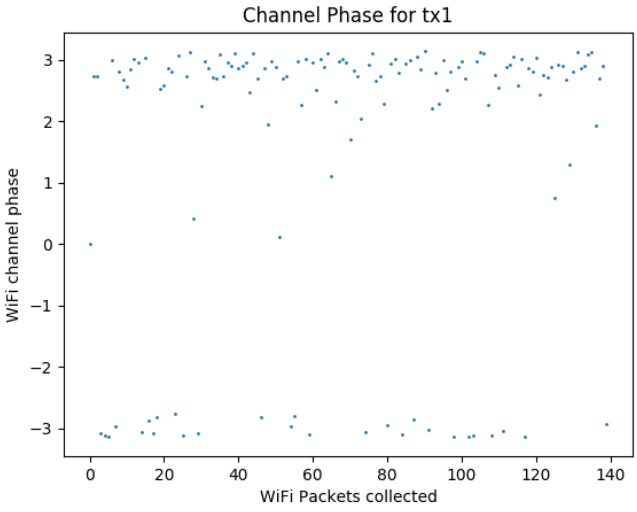


Figure 6: Data collected with ts = 7

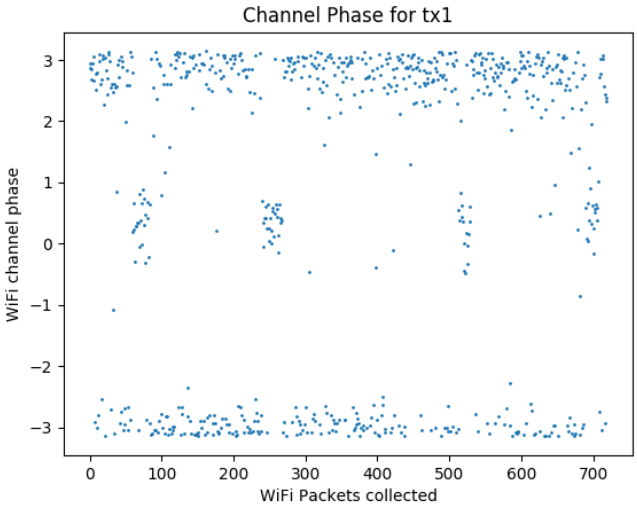
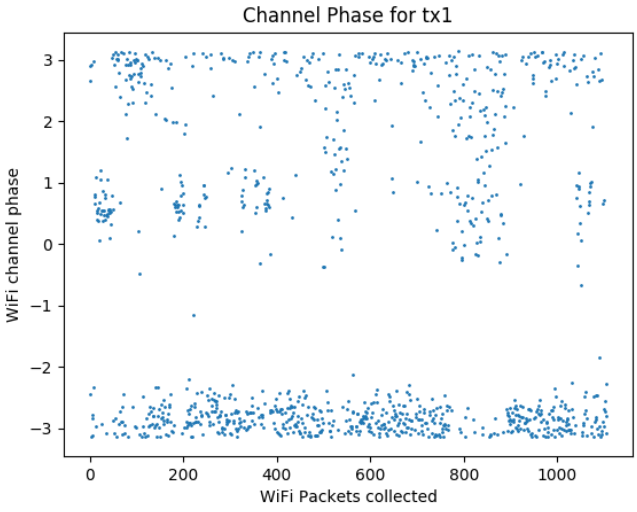


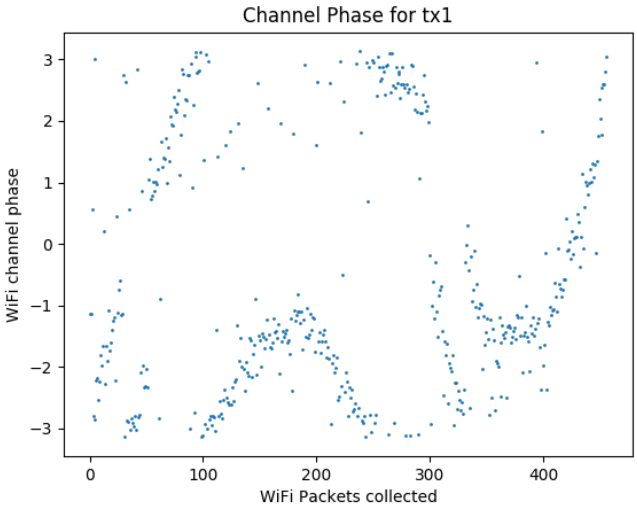
Figure 7: Data collected with ts = 10



One of the first differences we observe between the three plots is that there are a lot more points for ts = 7 compared to ts = 3 and similarly for ts = 10 compared to ts = 7. This is due to the fact that when the ts is higher, the robot will collect data for a longer amount of time. Therefore, since there are more observations we see a slightly different pattern in the bands, even though the robot is still in all of the cases. It is worth noting that the quality of the AOA profile will also change depending on the number of packets, which is why we would want to have relatively higher values for the ts.

[Section 5]

Figure 8: Section 5 experiment: Python test 2



Q5) Discuss with your team as to why there is a difference between this plot vs the one you saw in the previous section.

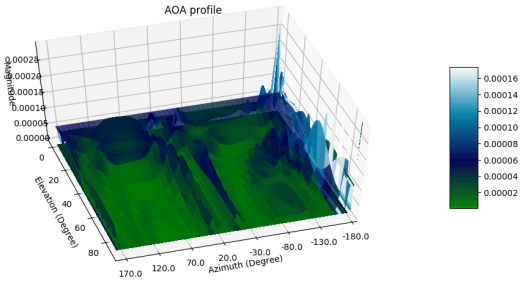
Since the robot is now turning in place, the phase plot no longer shows a horizontal band, which was the case in the previous plots, but has this shape.

[Section 6]

Q6) Discuss among yourselves what the profile means.

The main information we can extract from the profile below is the angular direction of arrival which is given by the maximum peak in the AOA profile.

Figure 9: Section 6 experiment: Python test 2 - collecting new data



In this case, because the main peak occurs around the -180^{o} azimuth, we can estimate that the transmitter is directly behind the robot. The second thing we can discuss about the profile is that there is noise in the measurements, especially due to the reflection of the Wifi signal on the ground and the objects in the room. When there is significant reflection of the signal due to other objects in the room we get multi-path in the profile. It is worth noting that due to noise and the amount of reflection the profiles are unique fingerprints.

Task 3

Task 3.1 - Generate multiple profiles. Note that the Angle-of-Arrival will be with respect to the current "heading" of the robot. Make sure to save 2 plots using screen-capture and include in your writeup.

Figure 10: Task 3.1 - profile 1

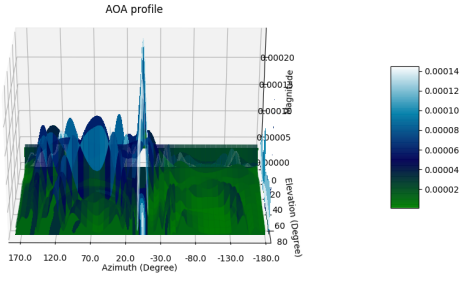
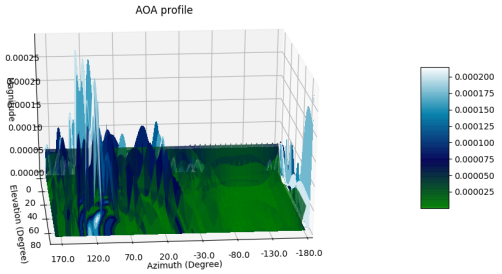


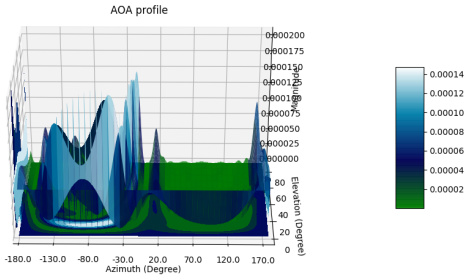
Figure 11: Task 3.1 - profile 2



Task 3.2 - Move the robot to a different location (need to restart the driver) and generate the profile. Does the AOA change? Add this plot in the writeup.

The AOA profile changes after moving the robot to a different location, which is expected since now the transmitter is in a different position in relation to the robot and the objects in the room will cause the reflections to be different as well.

Figure 12: Task 3.2 - profile from different location

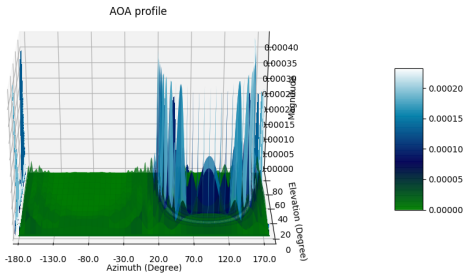


Task 3.3 - 3. Move the robot linearly and check the profile. How is it different? **Include an answer of this question and one accompanying plot in the writeup.**

When the robot moves linearly instead of rotating in place we are tracing a different geometry of the antenna array (linear vs circular). The different shape in the antenna array will lead to a different AOA output where you have am-

biguity in regards to what the maximum peak is located and therefore cannot properly identify the angular direction the signal is coming from. After talking to Ninad to try to understand what causes this, it seems to be the case that the linear antenna array computes only between the 0 and 180 in azimuth angle which generates this mirrored image.

Figure 13: Task 3.3 - profile moving the robot linearly



Task 4: use the T265 tracking camera instead of the odometer

Get the profile for tracking camera. Compare the AOA profile from tracking camera and the odom. Is there a difference? Include an answer of this question and one accompanying plot in the writeup.

Both of the profiles look very similar. We would expect some change between the two profiles since there is probably a difference due to noise on how each of the sensors is measuring the linear displacement of the robot. It might be the case that we are seeing this close similarity between the two AOA profiles because the displacement is very small.

Figure 14: Task 4 - profile using T265