Automotive Lab: Angle of Arrival Estimation

Write your answers as a free style report (including equations, numerical answers, codes and plots where applicable)

Student (name and number): _____

Objective: This lab assignment consists of two main parts. In the first part which will be carried in the lab, students will execute and observe real-time data processing. In the second part, students implement MATLAB codes to apply and demonstrate the methods for the angle of arrival estimation on different data sets collected by an automotive radar.

Procedure: Student will visit the lab as a group (3 or 4 students). A short demonstration of automotive radar and data structure was provided to students. Following each group has chance to use their own radar set to observe an automotive radar in action by following Lab Manuals.

Total possible grade = 10

Please bring a USB Flash Drive to save your data.

Deliverables: Report that includes detailed explanation of assignments, figures and mathematical computations if needed. All Matlab codes.

Assignment 1) Visualization in Lab (2.0 points)

Use Lab Manual to control TI Visualization tool. Try the following configurations and write your observations as a free style report (take screenshots where possible to support your report).

a) Configure your plot Selection as follow; Scatter plot, Range Profiles, Noise Profile and Statistics are selected. Observe each plot and explain outputs (try different targets including moving and stationary). Observe target detection in scatter plot and range plot. Try to change CFAR range threshold under Real-Time Tuning, report your observations.
b) Using the same settings as in 1.a); Try “Romeve static clutter” under Real-Time Tuning --> Additional Algorithm Processing (try different targets including moving and stationary). Report your observation.
c) Observe range-Doppler and range-angle heatmaps once at a time. Try to use “Remove static clutter” and report your observation. Make comments on Doppler resolution and angle resolution? Which radar parameters effect those, can you change them?

d) Investigate the effect of radar settings by setting up your own radar parameters. Report your observations. Note down your settings and their effects. You can use screenshots to support your reports.
e) What are the main differences between lab 2-3 and 4. What did you observe new?

Assignment 2) Data Collection in Lab, Programming will be done as HW (3.0 points)

Set a target at the broadside of the radar (set azimuth and elevation angle to zero as much as possible. Note down the exact range of the target which is preferably between 2m to 3m). First, use the visualization tool to observe the angular response of the radar. Be sure it is good enough to calibrate the target. Ideally there shouldn't be any other target in the same range bins (discuss with instructors if needed). Collect data by following the steps in the Lab Manual. To start your implementation, you may use ReadData.m file.

Data to collect: a) $\theta_{az} = 0^\circ, \theta_{el} = 0^\circ$. b) $\theta_{az} = 30^\circ, \theta_{el} = 0^\circ$.

a) (1.5 points) Use your collected data and provided calibration coefficients. "CorrectionCoefficients.mat" file has 4 calibration coefficients which are numbered 1 through 4. Compute angle (response) plot for collected data by using each of these correction coefficients. Finally identify which correction coefficient belongs to your radar. Indicate your radar's sticker color in your report.

b) (1.5 points) This time use collected data to compute the array calibration coefficient by yourself. Plot theoretical array response (center frequency is 79GHz, inter-element spacing $d = \lambda/2$), uncalibrated data and calibrated data and make comments about your calibration coefficient, how well is it?

c) You can collect data at a different angle such as 30 degree and demonstrate that your calibration good for all angles.

Note that radar data for Assignments 3 and 4 were collected from a different automobile radar so the configuration of the radar is different than the Assignment 1 and 2. For Assignments 3 and 4. You will be giventhe radar settings inside the data.

Assignment 3) Programming, will be done as HW (3.0 points)

You are given a Matlab data named "*Assignment3*" which includes variables *CollectionA, CollectionB, CollectionC, CollectionD that represent observation of one target in different locations*. In addition to these, you will have Radar_settings Matlab struct where you can find information related to radar settings. The *Collection* variables are in two-dimensional array form which namely sensor by fast-time [12 x 1024]. To start your implementation, you may use Example.m file. Under these conditions please complete the following tasks.

a) (0.75 point) Plot angle vs range plot for all collections. (Set limits 0<range<10m, -90°<angle<90°)
   - Plot in Cartesian coordinates.
   - Plot in polar coordinates.
   - What are the range and angle of the target for all collections A, B, C and D?

b) (0.75 point) Plot 1D range cut of a selected data set (you may select the one whose angle closest to the broadside of radar).
   - Compute theoretical range resolution and compare with your plot. Is theoretical value matched with experiment?

c) (0.75 point) Plot 1D angle cuts with a target for all 4 data sets (fix the range where target is presented in every dataset).
   - Compute angular resolution theoretically and compare with your plot. Is theoretical value matched with experiment?

d) (0.75 point) Summarize your observations regarding to the range and angle resolutions. Are they always the same?

Assignment 4) Programming, will be done as HW (2.0 points)

You are given a Matlab data named "*Assignment4*" which includes Radar_settings Matlab structure where you can find information related to radar settings and variables *BS_TCR_0_5, BS_TCR_0_10, BS_TCR_0_15, BS_TCR_0_20*. These variables are two-dimensional array of received signals with dimensions namely sensor by fast-time (12 by 1024). In each of these data collections, there are multiple targets present in different locations. Under these conditions please complete the following tasks.

a) Plot angle vs range plot for all collections. (Set limits 0<range<10m, -90°<angle<90°)

b) (1.0 point) Plot 1D angle cut of all data sets (fix your range = 6.77m where multiple targets are present).
   - By observing your plot identify two possible targets.
   - Compute theoretical angle resolution.
   - In which data sets you can distinguish two targets and which you can't?

c) (1.0 point) Summarize your observations regarding to the angle resolution when multiple targets are present at same range.