Radar Processing Project

Due 08/16

1 Description

The final course project is designed to give you hands-on experience working with real radar data. You will be given sample radar signals and will be asked to determine the speed of a target. If a target's velocity vector has some portion in the direction of the radar sensor/antenna, a (Doppler) shift in frequency with respect of the original transmitted frequency occurs. Your task will be to identify the speed of the target by using Fourier analysis techniques. Your solution should load a sample radar file, perform appropriate signal processing and Fourier analysis to determine the most prominent target (if one can be found).

The main emphasis of the project will be the design and development of radar analysis and software processing systems using a computational tool such as Matlab. The project should be completed individually. Each student must submit a project report summarizing findings at the completion of the course.

2 Report

At the completion of the project, a report must be generated to describe the project and summarize the findings. The project report should be approximately 4-6 pages and contain the following sections:

1. Abstract - This brief summary of the project purpose presents a general overview of the project topic and solution.
2. Description - The project description provides and introduction to the project topic and expands upon the abstract. This section completely explains the specifications of the project: e.g. the objectives, functionality, and components used.
3. Implementation - The project implementation provides the details on how the specified problem was solved. This implementation will include the software packages and libraries utilized, your programming methodology, efforts to optimize the project code, and any difficulties encountered while implementing the design.
4. Experimental evaluation - The experimental section describes how the project program performance was evaluated. This section should provide examples that highlight the input/output relationships of your system and how the results can be observed and confirmed. Be sure to clearly present the findings for each experiment in an easy to read format (e.g. a Table).
5. Summary - The conclusion of the report should provide a summary of the project aim and results as well as highlight both what was learned working on the project and what further directions would improve the project.

3 Deadlines and Deliverables

The following highlight the important dates and items to be submitted for the project. The project will be worth 30% of your final grade. Final hard copy version of the report (4-6 pages including figures/tables) along with an electronic submission including the report and code should made by August 16.

References

You are able to use whatever programming language is most natural but we highly recommend using Matlab (available at UNLV computer labs). For those without easy access to Matlab you can try to use Octave (the open source Matlab clone) or Python with NumPy/SciPy.

1. `https://www.mathworks.com/academia/student_version.html`
2. `https://www.gnu.org/software/octave/`
3. `https://www.scipy.org/`
4. `https://www.numpy.org/`

4 Part 1: Radar Pulsed Operation

Determine the key pulsed Radar parameters from Table 2 by looking at the transmit waveform of a stationary, ground-based, pulsed Doppler Radar. Use the "pulsetrain**X**.csv" file [link], where **X** is the file identifier you were assigned (Table 4). Note: each file is different so be sure to submit results only from the file you have been assigned. Keep in mind that any DC offset present in the data will result in a spike in the Fourier transform at 0 Hz. Be sure to filter this out if you automate your maximum return detection. Below are some formulas and constants of interest.

$$c = 3 \times 10^8 \text{ m/s}$$

$$R_{u,simple} = \frac{c}{2 \times PRF} \qquad \text{Duty Cycle} = \frac{\tau}{T}$$

$$R_{u,accurate} = \frac{C \times (PRI - \tau)}{2} \qquad PRF = \frac{1}{PRI}$$

Table 1: Pulsetrain File Assignment

Last	First	**X**	Last	First	**X**
Abraha	Yared	4	Alcaraz	Oliver	5
Clark	Jamie	1	Hickson	Shane	2
Hightower	Cliff	3	Hudson	Cody	1
Landers	Ryan	4	Matienzo	Edgar	5
McDonald	Tate	3	Ojito-Palma	Carlos	3
Shreiar	Daniel	1	Smith	Kyle	2

Table 2: Waveform Parameters

Parameter	Value	Unit
Radio/Carrier frequency (f_c)		MHz/GHz (include in answer)
Pulse width (τ)		µs
Receive Time		µs
PRI (T)		µs
PRF (f_r)		kHz
Duty factor/cycle		%
Maximum Unambiguous Range (simple)		m
Maximum Unambiguous Range (accurate)		m
Maximum Unambiguous Doppler		Hz

5 Part 2: Video Signal Analysis

Consider the "video_signal**X**.xlsx" file [link] which contains sampled video data received from a Radar of various moving targets. The Radar that created these is the continuous wave radar operating at 3 GHz which was demonstrated in class. The Radar system itself was stationary while taking measurements. The return was sampled at 1 kHz after the down conversion in frequency was performed.

Use the Fourier transform to determine the dominant frequency component. Fix the axis of the spectrum to be between 0 and 500 Hz since the data was sampled at 1 KHz which means a maximum of 500 Hz is discernible due to the Nyquist Theorem. Populate Table 3 based on your assigned file.

Below are some formulas of interest:

$$f_d = \frac{2V_t}{\lambda}.$$

Table 3: Received Echo/Waveform Target Information

Parameter	Value	Unit
Radio/Carrier frequency (f_c)		MHz/GHz
Maximum Doppler Frequency		Hz
Maximum Target Speed		m/s

Table 4: Video Signal File Assignment

Last	First	**X**	Last	First	**X**
Abraha	Yared	2	Alcaraz	Oliver	1
Clark	Jamie	2	Hickson	Shane	3
Hightower	Cliff	4	Hudson	Cody	9
Landers	Ryan	5	Matienzo	Edgar	6
McDonald	Tate	8	Ojito-Palma	Carlos	1
Shreiar	Daniel	7	Smith	Kyle	10