Department of Electrical Engineering

Radar Remote Sensing Group

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EEE5105F FUNDAMENTALS OF RADAR SIGNAL PROCESSING

1 Prerequisites

This course requires students to have a good background in Mathematics, Physics, and computer programming, probably at an Honours Level (4 years of study). In addition, it is highly recommended that the student should have completed an introductory course in Radar Systems (such as EEE5104F/S), or have had practical exposure to radar systems in the work place, or as part of an undergraduate course in Radar Systems.

Students must be proficient in tools such as Octave, MathCad, Mathematica, Simulink/Matlab, spreadsheets (OpenOffice, Excel), as they are used extensively in the analysis and design examples. Students will use the tools most familiar to themselves.

2 Course Format and Dates

The course is given in a five day, intensive format, followed by a further four tutorial and seminar sessions over the weeks following the intensive session. These sessions are based on problem sets which the student must attempt in order to gain benefit from the seminars. In addition, students may book appointments with the Course Convener and the Tutor.

The course Calendar is the governing document for planning: please monitor it frequently.

https://sites.google.com/site/radarmasters/schedule

Course interaction is via the UCT Vula System. You will have access to this information once you have registered for the course. It is important that you provide your preferred email address (one that it checked frequently) for your Vula registration.

3 Staff

Convener	Dr. Amit K Mishra	UCT	amit.mishra@uct.ac.za
Lecturer:	Dr. Amit K Mishra	UCT	amit.mishra@uct.ac.za

Tutor: Roaldje Nadjiasngar UCT neddje(a)gmail.com

4 Course description:

This course presents the principles and techniques fundamental to the operation of the signal processing found in a radar system. The course follows the recommended text book very closely. Specific course topics include:

4.1Fundamentals for Radar Signals & Signal Processing

Radar range equation; RCS statistics; Data cube; Sampling and Quantisation; Review Fourier Analysis and the Z-Transform; Digital Filtering and Random Signals and signal integration; Correlation and Matched Filters

4.2Threshold Detection of Radar Targets

Detections strategies and optimal detectors; Statistical models for noise and target RCS, threshold detection.

4.3Constant False Alarm Rate Detectors

CFAR Detectors, including Cell Averaging; Robust CFAR and comparisons

4.4Doppler Processing

Doppler and the Pulsed Radar; Moving Target Indication, pulse doppler;Clutter mapping, pulse pair processing

4.5Radar Measurements

Radar signal model and accuracy of measurements; Parameter Estimation: Range; Parameter estimation: phase, doppler and range rate.; RCS estimation and angle measurements, coordinate systems.

4.6Radar Tracking Algorithms

Basic tracking, kinematic motion; Measurement models and radar track filtering.; Measurement-to-track data association and track performance assessment.

4.7Fundamentals of Pulse Compression Waveforms

Matched filters for pulse compression and range resolution; Straddle loss; Pulse compression waveforms, compression gain, LFM; Matched filter implementation, range sidelobe reduction

Ambiguity Functions and LFM Summary; Phase-coded waveforms, biphase; Polyphase codes, summary

4.8Overview of Radar Imaging

General imaging considerations and resolution/sampling; Data collection and image formation.

Image phenomenology and summary

5 Learning outcomes:

Having successfully completed this course, students should be able to:

5.1Knowledge Base:

- Understand the design and processing of signals to be able to execute the fundamental operation of radar to measure distance, angle, velocity, using a modulated carrier;
- Describe the key techniques for extracting moving targets from clutter;
- Be able to identify which kind of signal processing is best for a particular application;
- Understand the operation of basic imaging radar;
- Understand the basics of target tracking.

5.2Engineering ability:

- Specify the properties of important signal processing blocks in a radar;
- Model radar signal processing using appropriate mathematical and computational techniques;
- Be able to gauge the amount of processing required to implement a radar signal processor.

5.3Practical skills:

- Implement radar signal processing mathematically;
- Simulate all or part of a radar signal processor system using computer software;
- Predict performance of processing blocks using mathematics and / or simulation.

6 Textbook[1]

"Principles of Modern Radar" Volume 1, Ed. Richards, Scheer and Holm, Scitech Publishing, 2010

"Fundamentals of Radar Signal Processing", Mark A. Richards, McGraw-Hill, New York, 2005

Lectures will be closely following the text-books. Both being by the same authors, are 99% identical. You can follow any one of them or any other classic RSP type book.

Slides will be uploaded on Vula.

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[1] We acknowledge Prof. Richards for sharing with us the images from the second textbook.

7 Lecture Programme

Table 1: EEE5105F Fundamentals of Radar Signal Processing 2012 Programme (topics expanded below)

Time	12/04/16	12/04/17	12/04/18	12/04/19	12/04/20
08h00	Overview	Signal model	Pulse compression	Estimation	Tracking
09h00	Student-presentations	Signal model	Doppler processing	Radar Imaging	Tracking
10h00	Student-presentations	Signal model	Doppler processing	Radar Imaging	Tracking
11h00	Tea	Tea	Tea	Tea	Tea
11h30	Student-presentations	Radar waveform	Detection	Radar Imaging	Tracking
12h30	Lunch	Lunch	Lunch	Lunch	Lunch
13h30	Radar blocks	Ambiguity function	Detection	Radar Imaging	Tracking
14h30	Signal model	Ambiguity function	CFAR	Radar Imaging	Tracking
15h30	Signal model	Pulse compression	CFAR	Radar Imaging	Conclude
16h30	Tea	Tea	CFAR	Tea	
17h00	Signal model	Pulse compression	Estimation	Radar Imaging	
18h00	Close	Close	Break	Close	

8 Drill Problems, Simulation Assignments & Term Project

Students are expected to complete four sets of Drill Problems and five sets of simulation assignments, handed out after the intensive lecture period. Students will be provided with at least 5 seminar opportunities of about an hour each with the lecturer, convener and tutors, and will be expected to attend 4 out of the 5 seminars. The student's solutions to the problem set must be submitted on Vula before the start of the seminar. The seminars will be carried out with access by Skype for students off campus after the lecture session. For bandwidth reasons, the number of parallel sessions will have to be limited. For example, all students resident in the same city will be expected to attend at a common venue, and students will have to organise their own venue and projection facilities. Screen sharing will be enabled, but it is unlikely that video will be supported, again due to bandwidth limitations. Within reason, and with prior arrangement, students can approach the tutor / and / or the lecturer for help with problem sets.

Assignment submission should consist of a report (preferably written using Latex or LYX) with the following components:

- problem statement
- approach or preliminary calculations
- results (with graphs or tables)
- discussion (if any) on the results
- appendix giving the code for the assignment (code should be
- properly commented and written in C/Matlab/Octave)

Term project will be a small piece of independent work to be carried out by individual students. Students are expected to choose an advanced topic in the field of Radar signal processing with consultation to the convenor and try to repeat the results shown in them. Project work will be evaluated based on a project report to be submitted by the student.

9 Course Assessment and Examination

The assessment of this course will be as per follows:

Item	Student hours needed (total = 200)	% of total marks
Start of the course presentation	15 (approximately 2 days)	10
Simulation based assignments	5x4 = 20	5x3=15
Term project	30	20
End of term examination (2 hour exam)	2 + 18 = 20	55

The examination is open book, i.e. students can bring books and printed materials to the examination venue. However they need to show the books to the invigilator before the start of the exam. Students may write the examination in their home location, provided satisfactory supervision of the examination can be arranged in good time.

10 Course Load

Class hours = 7x5 = 35 Hrs

Tutorial questions and revision = 4x7.5 = 30 Hrs

Total = 15 + 20 + 30 + 20 + 35 + 30 = 150 Hr