| Course Information | |
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| Course title | Signal Processing for Phased Array Radar |
| Semester | 110-2 |
| Designated for | COLLEGE OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE  GRADUATE INSTITUTE OF COMMUNICATION ENGINEERING |
| Instructor | YEN-MING HUANG |
| Curriculum Number | CommE5066 |
| Curriculum Identity Number | 942 U0800 |
| Credits | 3.0 |

| Course Syllabus | |
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| Course Description | Signal Processing for Phased Array Radar is a graduate-level course designed for students interested in modern radar systems widely used in vehicle networks, military applications, satellites, etc. A phased array, namely an electronically scanned array of antennas, can effectively produce beam patterns in different directions for signal transmission and reception without mechanical rotation of array antennas. A radar, i.e., radio detection and ranging, can be used for detection, tracking, and imaging of an object or physical phenomenon, in terms of range, velocity, angle, and radar cross section. Combining a phased array with a radar has been considered one of the most promising technologies in recent years for various new applications. With huge amounts of data continually obtained, Artificial Intelligence (AI) enables more accurate target prediction, better resource scheduling on multi-target tracking, modeling surrounding environment, etc.<br><br>To own in-depth knowledge of digital signal processing algorithms realized in phased array radar, in this course, we will study the following themes.<br>1. Introduction to Radar Systems and Applications<br>2. Fundamentals of Digital Signal Processing<br>3. Radar Signal Model and Range Equation<br>4. Threshold Detection of Fluctuating Targets<br>5. Matched Filtering and Pulse Waveforms |

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| | 6. Doppler Processing and Clutter Mitigation<br>7. Constant False Alarm Rate Detectors<br>8. Array Processing and Beamforming<br>9. Space-Time Adaptive Processing<br>10. Estimation of Target Parameters<br>11. Target Tracking With Data Association<br>12. Transceiver Front-end Non-ideal Effects<br>13. Channel Propagation and Target Models |
| Course Objective | The goal of this course is to introduce essential digital signal and data processing techniques for phased array radar systems. By taking this course, the students can<br>- understand the basic principles of radar,<br>- comprehend the commonly used signal and data processing algorithms at radar receivers, and<br>- explore advanced research topics in future radar transceivers.<br>In addition, by studying some selected papers and executing a term project in one semester, the students can<br>- be familiar with radar technology and its AI-based data usage,<br>- share their own opinions through oral presentations in classes, and<br>- actualize the interested algorithms by teamwork. |
| Course Requirement | Prerequisite:<br>- Linear Algebra<br>- Signal and System<br>- Principle of Communications<br>Preferable:<br>- Digital Signal Processing<br>- Digital Communications<br>- Detection and Estimation<br>- Adaptive Signal Processing<br>Skill:<br>- MATLAB (other programming languages are also okay)<br>- LaTeX (using the beamer template for preparing slides)<br>Study on Selected Papers or Book Chapters:<br>- Figuring out the system model and revealing the key proposed concepts<br>- Algorithm implementation and reconstruction of the simulation results |
| Office Hours | Appointment required. Note: Appointment by email. |
| References | Textbook:<br>- M. A. Richards, Fundamentals of Radar Signal Processing, 2nd edition, McGraw-Hill Education, 2014.<br>- M. A. Richards, J. A. Scheer, and W. A. Holm, Principles of Modern Radar: |

| | | Basic Principles, SciTech Publishing, 2010. |
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| | | - W. L. Melvin and J. A. Scheer, Principles of Modern Radar: Advanced Techniques, SciTech Publishing, 2013. |
| | | - T. W. Jeffrey, Phased-Array Radar Design: Application of Radar Fundamentals, SciTech Publishing, 2009. |
| | | - H. L. Van Trees, Optimum Array Processing: Part IV of Detection, Estimation, and Modulation Theory, John Wiley & Sons, Inc., 2002. |

| **Progress** | | |
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| Week | Date | Topic |
| Week 1 | 20220219 | Lecture 0: Course Information and Overview<br>Lecture 1: Introduction to Radar Systems and Applications |
| Week 2 | 20220226 | Lecture 2: Fundamentals of Digital Signal Processing |
| Week 3 | 20220305 | Lecture 3: Radar Signal Model and Range Equation |
| Week 4 | 20220312 | Lecture 4: Threshold Detection of Fluctuating Targets |
| Week 5 | 20220319 | Lecture 5: Matched Filtering and Pulse Waveforms |
| Week 6 | 20220326 | Lecture 6: Doppler Processing and Clutter Mitigation |
| Week 7 | 20220402 | Self-Study (No class)<br>Quiz 1 (at home) |
| Week 8 | 20220409 | Lecture 7: Constant False Alarm Rate Detectors |
| Week 9 | 20220416 | Lecture 8: Array Processing and Beamforming |
| Week 10 | 20220423 | Lecture 9: Space-Time Adaptive Processing |
| Week 11 | 20220430 | Lecture 10: Estimation of Target Parameters |
| Week 12 | 20220507 | Lecture 11: Target Tracking With Data Association |
| Week 13 | 20220514 | Lecture 12: Transceiver Front-end Non-ideal Effects |
| Week 14 | 20220521 | Self-Study (No class)<br>Quiz 2 (at home) |
| Week 15 | 20220528 | Lecture 13: Channel Propagation and Target Models |
| Week 16 | 20220604 | Self-Study (No class) |
| Week 17 | 20220611 | Term Project Presentation |

| Week 18 | 20220618 | Term Project Presentation |