ECE 580C5 Global Navigation Satellite Systems

Spring 2022

Time: Monday and Wednesday 4:00-5:15PM
Location: Engineering D 102
Credit Hours: 3
Office hours: Flexible, send an email to schedule a meeting
Instructor: Yajing Liu, Electrical and Computer Engineering
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Course Description:

This course provides a fundamental understanding of Global Navigation Satellite Systems (GNSS), including GNSS satellite constellations, satellite orbits, ground monitoring stations functions, GNSS receivers, GNSS measurement errors and correction techniques, recent advancements in GPS (Global Positioning System) and other international GNSS, and applications of GNSS. Students will learn to use a variety of GNSS receivers to collect data, to compute receiver position, velocity, and time, and to analyze GNSS data.

Objectives:

At the completion of this course, the students will be able to:

1. Apply knowledge and skills acquired from calculus, linear algebra, mechanics, and electromagnetics to the analysis of radio navigation systems and principals.
2. Implement navigation solutions based on time-of-arrival, time-difference-of-arrival, and Doppler measurement methods.
3. Understand the three segments of satellite navigation systems, their functions, inter-connections, and key characteristics.
4. Design and implement algorithms to compute satellite orbit using almanac and ephemeris information.
5. Use both consumer and high-end GPS receivers to collect raw measurement data for post-processing and analysis.
6. Design and implement algorithms to characterize various satellite range measurement errors and to mitigate the errors.
7. Implement linear model to solve range measurement equations to obtain receiver position, velocity, and time (PVT) solutions.
8. Analyze satellite geometry contribution to PVT solution errors.

Topics Covered:

Week 1: History of navigation and radio navigation techniques
Week 2: GPS system architecture
Week 3: GPS signal structures
Week 4: Reference systems, coordinate frames, and conversion algorithms
Week 5: Time standard and GPS time

Week 6: GPS orbits and satellite position determination
Week 7: GNSS measurement models
Week 8: GNSS signal propagation errors and mitigations: ionosphere
Week 9: GNSS signal propagation errors and mitigations: troposphere
Week 10: Multipath and receiver noise effects
Week 11: Linear model for position, velocity, and time computation
Week 12: Precise position using carrier phase measurements
Week 13: Working with GNSS receivers to collect and analyze data
Week 14: GPS modernization and the next generation GPS
Week 15: International GNSS: GLONASS, Galileo, and Beidou

Required Textbook:

Global Positioning System, Signals, Measurements, and Performance, by Pratap Misra and Per Enge, Revised 2nd edition, Ganga-Jamuna Press, 2011

Prerequisite: ECE 311, MATH 261, PH 142, and CS 160 with C or better.

Assignments

Homework + projects

Final Project

There will be one final individual project. Student will collect raw GPS receiver measurements and ephemeris over extended time period; design a complete navigation signal process algorithm to compute receiver position, time, and velocity with high accuracy.

Grading Policy

Homework + projects	40%
Midterm	30%
Final Project	30%
Total	100%

Letter grades are assigned according to the following distribution:

A	[90, 100]
B	[80, 90)
C	[70, 80)
D	[60, 70)
F	[0, 60)