ECE 579 Global Navigation Satellite Systems

Spring 2023

Time: Wednesday 4:00-6:15PM
Location: ENGR E104
Credit Hours: 3
Office hours: TBD
Instructor: Jian Yao, 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 and other international GNSS, and applications of GNSS. Students will learn to use originally collected GNSS data to compute receiver position, velocity, and time.

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 the collected raw GNSS receiver 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.
9. Design and implement high accuracy position systems such as wide-area and local-area differential GPS.

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: Analyze the real GNSS-receiver data; RINEX data format
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 152/162/163/164 with C or better.

Assignments

There will be ~10 assignments. These assignments will need to be turned in for grades.

Final Project

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

Exams

There will be one written midterm exam.

Grading Policy

Assignments	50%
Final project	25%
Midterm exam	25%
Total	100%

Letter grades are supposed to be assigned according to the following distribution, though some adjustments might be made under scrutiny:

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

Honor Code

This course follows the CSU honor code (https://tilt.colostate.edu/integrity/pledge/). For assignments and final project, students need to indicate what help they get from other students or online resources, if there is. An honest statement is more important than a beautiful assignment/project result.