

CMPE58C: Sp. Tp. Mobile Location Tracking and Motion Sensing

Instructor: Can Tunca

Overview:

Smartphones are decorated with a variety of sensors and radio technologies that enable many interesting real-world applications. This course will specifically focus on mobile location tracking and selected topics regarding the ecosystem built around mobile location services. We will cover popular techniques and algorithms with an emphasis on how they can be used in an applied context. Topics include outdoor/indoor positioning, inertial sensors and pedestrian dead reckoning, sensor fusion, digital mapping, augmented reality and use of motion sensors for pervasive healthcare. To familiarize students on ongoing research and to allow them to apply the newly learned methods/skills on real problems, there will be paper presentations and a class project.

Outline:

1. Introduction and Course Overview
 - Brief history, use cases, challenges
2. Outdoor Positioning
 - GPS basics
 - Time-of-flight
 - Trilateration
3. Cellular Positioning
 - 5G positioning
 - Angle-of-arrival
 - Beamforming
 - Pico-cells, femto-cells
4. Radio-based Positioning
 - Radio fingerprinting
 - Bluetooth, WiFi, UWB
5. Inertial Sensor Basics
 - IMUs: Accelerometer, gyroscope, magnetometer
 - Sensor fusion basics (Bayesian filters)
 - Attitude (3D-orientation) estimation
 - Barometer, altitude tracking
6. Pedestrian Dead Reckoning
 - Human gait basics
 - Inertial navigation
 - Challenges: Sensor bias/noise, drift
7. Indoor Positioning
 - Combining different positioning schemes
 - Fusion: Linearized Kalman filters, particle filters

- Challenges, open problems
- 8. Mapping Basics
 - Digital maps: Considerations and challenges
 - Machine learning-based map digitization
 - Wayfinding and navigation
 - SLAM basics
- 9. Augmented Reality on Mobile Phones
 - AR basics
 - ARKit, ARCore
 - LIDAR
- 10. Case Study: Human Motion Tracking for Healthcare
 - Gait analysis basics
 - Fall risk assessment

Grading (tentative):

Paper Presentation	20%
Course Project	40%
Final Exam	40%

Paper Presentation:

Each student will be expected to review and present a recent paper on selected topics to grasp the state-of-the-art and open research problems.

Course Project:

In order to put the learnings in an applied context, the students will be expected to either develop a mobile application that tackles a problem related to mobile location tracking or motion sensors, or showcase a solution/analysis on pre-recorded mobile data. The students can come up with their own projects, but guidance will be provided if needed. Emphasis on literature survey and comparative performance evaluation will be given to familiarize the students on typical research processes. The project will be multi-phase:

- Project proposal (15-minute presentation and proposal document)
- Final presentation and demo
- Project report