课程大纲
COURSE SYLLABUS

课程代码/名称 **Course Code/Title**	**Intelligent Sensing Systems in Mobile Robots** **移动机器人的智能感知系统**
课程性质 **Compulsory/Elective**	Elective
课程学分/学时 **Course Credit/Hours**	3 (32 Lecture Hours and 32 Lab Hours)
授课语言 **Teaching Language**	English
授课教师 **Instructor(s)**	Dr. Xiaoping Hong, School of System Design and Intelligent Manufacturing (SDIM)
先修要求 **Pre-requisites**	Required: Electronics EE104 or SDIM242 or equivalent, Computer Programming: CS102A/B or equivalent Preferred: Optics PHY307/EE210 or equivalent, Signal EE205 or equivalent

教学目标
Course Objectives

Objectives:
The advance of sensing system is bringing significant revolution to the field of robotics. The course will try to give the students an up-to-date overview of the mobile robots and the related sensory systems, their respective working principles, and higher-level applications. This class will expose the students to the cutting-edge development of today's autonomous mobile robots including both the sensors and the algorithms. We will cover state sensors such as GPS, IMU and GNSS, vision sensors such as optical principles in cameras, RGB cameras and different types of advanced cameras, and advanced sensors such as LiDARs, millimeter-waves radars, advanced ultrasonic sensors. We will also cover mathematical models and algorithms such as probabilistic approach of sensor signal, Kalman filter and other robotic algorithms, computer vision and deep learning, localization, mapping and SLAM (Simultaneous Localization And Mapping).

Learning Outcomes:
1. Students will gain working knowledge of 1. Robot basics. 2. Low level sensory systems, their principles and engineering methods. 3. High level sensing algorithms. 4. Use of sensing systems in moving robots.
2. Students will learn how to execute a complete project, through problem formulation, implementation, verification and time management.
3. Students will gain teamwork experience through group project.
4. Students will gain scientific writing and presentation skills through report, presentation and video clips.
5. Students will gain open source repository experience. (GitHub)

教学方法
Teaching Methods

Teaching
Lectures. Lectures provide motivations and overall understanding of the sensor principles and algorithms.
Student literature research. Papers, books and references will be delivered in class.
Project-based learning.

Project Details
Student will be required to form groups and construct a robotic system to perform certain tasks. This system needs to have justifiable motivations. Example tasks are the following (difficulty in ascending order).

Tracking/Motion from A to B (Deliver goods from A to B)
Obstacle detection and avoidance (Pedestrian safety for example)
Object classification with camera and/or lidar (Identify cars and parking lots to manage campus parking)
Localization and mapping (build a map around the campus for digital management)
Autonomous navigation with all the above (An autonomous AGV good for all of the tasks above)

教学内容
Course Contents

Section 1	**Introduction to Robotics and Sensing Systems (Week 1, 2)** • Project introduction • Architectural view of a mobile robot system • Overview of sensors and background of robotic sensing • Building blocks of robotic sensing • Introduction to sensors
Section 2	**State Estimation (Week 3, 4, 5)** • Introduction of state sensors (GNSS, IMU, barometer, UWB) • Probabilistic and Bayesian approach to sensor signal processing, • Bayesian filter, particle filter, Kalman filter and extensions, • Other topics
Section 3	**Cameras and Computer Vision (Week 6, 7, 8, 9)** • Cameras, working principles and different types (e.g. event camera, stereo vision cameras, structured light cameras, IR camera etc) • Intro to computer vision (conventional vs deep learning) • Other topics • Project mini-presentation (Week 7)
Section 4	**Advanced Sensors and Sensor Fusion (Week 10, 11, 12)** • Ultrasonic sensors • LiDAR and time-of-flight sensors • Millimeter-wave sensors • Sensor calibration and sensor fusion
Section 5	**Localization and Mapping (Week 13, 14, 15)** • Introduction to localization • Introduction to mapping • Introduction to SLAM
Section 6	**Final presentation and Report (Week 16)**

课程考核
Course Assessment

The evaluation will be based on the project presentation and report. Project and presentation can be done in groups, but the report should be worked out by each student independently.

Each student needs to deliver a group mini-presentation (10%), group final presentation (30%), an individual report (50%), a GitHub repository (5%) and a 2-min video clip (5%) about the constructed system. From training perspectives, the breakdown of the score will be from hardworking and teamworking (20%), the ideas (20%), proposed specs and system architecture (20%), results (10%), discussion and prospects (30%). The grade will be scaled with project difficulty and innovativeness. The final grade will be higher if the students could demonstrate use of more knowledge and skills learned in this class. Original and innovative ideas are appreciated.

教材及其它参考资料
Textbook and Supplementary Readings

Lecture Notes
Probabilistic Robotics (2005) by Sebastian Thrun, Wolfram Burgard, Dieter Fox

Other references will be delivered in class