课程大纲
COURSE SYLLABUS

1.	**课程代码/名称** **Course Code/Title**	**自主机器人系统 Autonomous Robotic Systems**
2.	**课程性质** **Compulsory/Elective**	专业选修课 Major Elective Courses
3.	**课程学分/学时** **Course Credit/Hours**	3/48
4.	**授课语言** **Teaching Language**	中英双语 English & Chinese
5.	**授课教师** **Instructor(s)**	贾振中，助理教授，机械与能源工程系， Email: jiazz@sustc.edu.cn Zhenzhong Jia, Assistant Professor, Department of Mechanical and Energy Engineering, Email: jiazz@sustech.edu.cn
6.	**是否面向本科生开放** **Open to undergraduates or not**	是 Yes
7.	**先修要求** **Pre-requisites**	MA107A 线性代数 A、 MA212 概率论与数理统计；学生需熟练掌握程序设计。另建议学生先修 ME339 机器人与视觉感知：基本原理及算法（此项为非强制要求） MA107A Linear Algebra A, MA212 Probability and Statistics; students should be fluent with computer programming. It is recommended to take ME339 Robotics and Visual Perception: Fundamentals and Algorithms (optional, not a strict requirement).
8.	**教学目标** **Course Objectives**	
	（如面向本科生开放，请注明区分内容。 If the course is open to undergraduates, please indicate the difference.） 随着机器人和人工智能技术的迅猛发展，机器人迅速发展到能在我们日常生活环境中执行挑战性任务的日益复杂的机器。本课程的目的在于：为学生提供能在复杂环境中自主运行的机器人系统的基本概念和算法。本课程将着重介绍自主机器人系统所涉及的机器人移动概念、运动学建模、导航、环境感知、基于概率地图的定位与建图、运动规划与操作等方面的基本概念和基础算法，帮助学生了解智能驾驶、自主移动和操作等方面的核心问题、经典算法和发展趋势，为学生开展自主机器人系统的研究奠定基础。对于研究生和本科生，本课程所需要掌握内容相同，**但对研究生理解问题的深度以及解题难度上要求更高**。 With the development of robotics and artificial intelligence technologies, robots are rapidly evolving to increasingly complex machines capable of performing challenging tasks in our daily environment. The objective of this course is to prepare students with basic concepts and algorithms required to develop mobile robotic systems that act autonomously in complex environments. The main emphasis is put on locomotion concepts, kinematics, navigation, environment perception, probabilistic map-based localization and mapping, motion planning, and manipulation. This course aims to help students to understand key issues, classical algorithms, and development trends in intelligent driving, autonomous mobility and manipulation, thereby laying foundations for future researches on autonomous robotic systems. Both graduate students and undergraduate students will learn the same materials, however, this course will have **higher standards for graduate students** for deeper understanding of fundamental problems and more difficult homework.	
9.	**教学方法** **Teaching Methods**	

（如面向本科生开放，请注明区分内容。 If the course is open to undergraduates, please indicate the difference.）
教室讲授，使用多媒体授课，进行案例解析，并设置课程报告环节，
Class room lecture, applying multimedia, case and reference study, course project (writing report + oral presentation)

对本科生和研究生使用相同方法，不同评估标准（课后作业和课程项目难度和要求不同）。
Use the same teaching method for both undergraduate and graduate students, but with different assessment criteria (different requirements in homework and course projects).

10. 教学内容
Course Contents
（如面向本科生开放，请注明区分内容。 If the course is open to undergraduates, please indicate the difference.）
对本科生和研究生采用相同内容，要求掌握程度不同(作业和课程项目难度要求不同)。
Using the same course contents for both undergraduate and graduate students, but the requirements for the assignments and course projects will be different, especially in difficulty.

Section 1 (2 credits)	课程导论及动机——为什么学习自主机器人系统 Introduction and Motivation – why study this course?
Section 2 (4 credits)	移动概念及关键问题 腿式、轮式、飞行移动机器人 Locomotion concepts and key problems Legged, wheeled, and flying mobile robots
Section 3 (4 credits)	移动机器人运动学：模型和约束，机动性/移动性能，工作空间，运动控制 Kinematics of mobile robots: Modeling and constraints, mobility, workspace, motion control
Section 4 (3 credits)	感知-1：传感器，计算机视觉与图像处理基础 Perception-I: sensors, fundamentals of computer vision and image processing
Section 5 (3 credits)	感知-2：图像处理基础，特征提取，位置识别，基于距离传感信息（激光、超声）的特征提取 Perception-II: fundamentals image processing, feature extraction, place recognition, feature extraction based on range data (laser, ultrasound)
Section 6 (2 credits)	定位-1：挑战，基于定位的导航与编程求解对比，信任度的表示方法，地图表示方法 Localization-I: challenges, localization-based navigation vs programmed solutions, belief and map representations
Section 7 (2 credits)	定位-2：基于概率地图的定位，定位系统实例 Localization-II: probabilistic map-based localization, localization system examples
Section 8 (3credits)	同步定位与建图-1：引言，问题描述，数学定义，扩展卡尔曼滤波（EKF） SLAM-I: introduction, problem formulation, mathematical definitions, extended Kalman filters
Section 9 (3 credits)	同步定位与建图-2：EKF SLAM，视觉 SLAM，基于图形的 SLAM，粒子滤波 SLAM SLAM-II: EKF SLAM, visual SLAM, graph-based SLAM, particle filter SLAM

	Section 10 (4 credits)	同步定位与建图-3：软件，公开难题，近期研究进展与未来发展方向 SLAM-III: software, open challenges, recent progress and future directions
	Section 11 (6credits)	规划与导航：导航能力（规划与反应），路径规划，避障，导航与控制的体系结构 Planning and navigation: competences of planning (reactive and planning), path planning, obstacle avoidance, navigation and control architectures
	Section 12 (12 credits)	自主机器人系统实战，项目答辩 Autonomous robotic systems – hands on trainings, Course project presentation

11. 课程考核
Course Assessment

①考核形式 Form of examination：Assessment

②分数构成 grading policy：a.出勤 Attendance 5%; b.课堂表现 Class performance 10%; c.课程项目 Projects 45%; d.平时作业 Assignments 40%

③如面向本科生开放，请注明区分内容。 If the course is open to undergraduates, please indicate the difference.）

本科生考核分数构成如下 Grading policy for ：

a.出勤 Attendance 5%; b.课堂表现 Class performance 10%; c.课程项目 Projects 35%; d.平时作业 Assignments 50%

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

[1] Roland Siegwart, Illan R. Nourbakhsh, and Davide Scaramuzza. Introduction to Autonomous Mobile Robots (second edition), MIT Press, 2011. 【教材/Textbook】
[2] Spyros G. Tzafestas. Introduction to Mobile Robot Control. Elsevier, 2014（注：中文版拟于 2020 年秋季推出）
[3] Roland Siegwart 等著，李人厚、宋青松译. 《自主移动机器人导论》（第二版），西安交通大学出版社，2012.
[4] Alonzo Kelly, Mobile Robotics: Mathematics, Models, and Methods, Cambridge University Press, 2013.
[5] Alonzo Kelly 著，王巍等译. 《移动机器人学：数学基础、模型构建及实现方法》，机械工业出版社，2020.