课程详述

COURSE SPECIFICATION

以下课程信息可能根据实际授课需要或在课程检讨之后产生变动。如对课程有任何疑问，请联系授课教师。

The course information as follows may be subject to change, either during the session because of unforeseen circumstances, or following review of the course at the end of the session. Queries about the course should be directed to the course instructor.

1.	**课程名称 Course Title**	**协作机器人学习** **Collaborative Robot Learning**
2.	**授课院系** **Originating Department**	机械与能源工程系 Department of Mechanical and Energy Engineering
3.	**课程编号** **Course Code**	ME336
4.	**课程学分 Credit Value**	3
5.	**课程类别** **Course Type**	专业选修课 Major Elective Courses
6.	**授课学期** **Semester**	春季 Spring
7.	**授课语言** **Teaching Language**	英文 English
8.	**授课教师、所属学系、联系方式（如属团队授课，请列明其他授课教师）** **Instructor(s), Affiliation& Contact （For team teaching, please list all instructors）**	宋超阳，机械与能源工程系，songcy@sustech.edu.cn Song Chaoyang, Department of Mechanical and Energy Engineering, songcy@sustech.edu.cn
9.	**实验员/助教、所属学系、联系方式** **Tutor/TA(s), Contact**	待公布 To be announced
10.	**选课人数限额(可不填)** **Maximum Enrolment （Optional）**	

11. 授课方式 Delivery Method	讲授 Lectures	习题/辅导/讨论 Tutorials	实验/实习 Lab/Practical	其它(请具体注明) Other（Please specify）	总学时 Total
学时数 Credit Hours	32		32		64

12. 先修课程、其它学习要求 Pre-requisites or Other Academic Requirements	ME306 机器人基础 Fundamentals of Robotics
13. 后续课程、其它学习规划 Courses for which this course is a pre-requisite	
14. 其它要求修读本课程的学系 Cross-listing Dept.	

教学大纲及教学日历 SYLLABUS

15. 教学目标 Course Objectives

This course is intended for students advancing in the study of robotic engineering. The focus is on the problems of how a robot can learn to perceive the physical world well enough to act in it and make reliable plans. Subjects covered by this course include robotic collaboration, kinematics, Robot Operating System (ROS), robotic vision, calibration, RGB-D sensing, object recognition, artificial intelligence (AI) and deep learning (DL). Specific projects will be carried out throughout this course regarding the simulation of robot picking using fundamental kinematics and robot vision, an AI robot to play tic-tac-toe game, and a DL robot to play arcade claw game.

- To teach students how to conduct the basic kinematic formulation of a robotic system in simulation.
- To teach students how to use robotic vision, including algorithm, hardware, and software, in simulation.
- To teach students how to program artificial intelligence into a robot hardware performing interactive tasks.
- To teach students how to use deep learning methods to program a robot hardware to perform advanced tasks.
- To reinforce students' team skills through various team project, including problem formulation, problem solutions and written reporting of results.

To reinforce students' visualization and hands-on skills through project virtual prototyping and/or physical construction exercises.

16. 预达学习成果 Learning Outcomes

As an elective course for robotic engineering major, this course lays the foundation for students to use widely adopted Robot Operating System (ROS) to perform advanced robot control including basic mathematical formulation, hardware usage, and intelligence integration. The following learning outcomes are expected for students taking this course:

- Given functional and environmental requirement, utilize concepts generation methods within a team setting to achieve a consensus for a robot design concept.
- Design and develop functional robot programs from the perspectives of function, hardware,

algorithm, and physical environment.
- Apply basics of disciplines including mechanical engineering, electrical engineering, applied mathematics, computer science to understand the use of robots in action.
- Communicate engineering decisions, justification for those decisions, designs, programming, and test results in multi-media presentation and report writing.

17. **课程内容及教学日历 （如授课语言以英文为主，则课程内容介绍可以用英文；如团队教学或模块教学，教学日历须注明主讲人）**
Course Contents (in Parts/Chapters/Sections/Weeks. Please notify name of instructor for course section(s), if this is a team teaching or module course.)

Course & Lab Structure	Hours	Teaching Content
Lecture Section 1: Course Introduction • Robotic Collaboration • Robot Learning • Industrial Robot	4	This section aims at an introduction to the concept of robots in industrial applications and its academic research, focusing on the state-of-the-art development and its root in learning, specially the collaboration between robots and human operators. [Key concepts] industrial robot, learning algorithms, human-robot collaboration. [Learning Challenge] the challenges in using robots for industrial applications and why it is difficult to program them with intelligence.
Lecture Section 2: Kinematics & ROS • Kinematics I & ROS I • Kinematics II & ROS II	6	This section aims at building the fundamental mathematics widely adopted in robotic modelling and analysis, and how they are translated in the simulation environment of ROS to consolidate the understanding of the robotic form and functionality. [Key Concepts] kinematics, dynamics, motion planning, ROS. [Learning Challenge] forward and inverse kinematic derivation of any serial robot arm and the use of ROS
Lab Project 1: Simulate picking using kinematics	6	This project aims at an integrated adoption of the robotic mathematics in a common picking tasks, how to analyse, model and program the robot in simulation, and why such simulations are so important in learning robotics. [Key Concepts] robot picking, kinematic formulation, moveit. [Learning Challenge] the translation of equations in a simulated environment to use ROS for specific tasks.
Lecture Section 3: Robotic Vision • Robotic Vision & Calibration • RGB-D /	6	This section aims at introducing the use of perception in robotic tasks, why they are so important in high level applications, what are the key concepts related and how to simulate them in ROS.

Segmentation / Filter		[Key Concepts] robotic vision, camera basics, perception [Learning Challenge] the various technical details in camera vision and how they can be translated in robotics
Lab Project 2: Simulate picking using robotic vision	6	This project aims at the use of robotic vision to guide the control of the robot in simulation in reaction to the physical environment, which serves as a continuation of the previous project. Both projects together serve as a preparation for the follow-up training before using the real robot. [Key Concepts] rviz, camera calibration, motion planning. [Learning Challenge] the simulation of vision in robotics and its integration with a robotic system
Lecture Section 4: Artificial Intelligence • Intelligent Agents • Adversarial Search	6	This section aims at an introduction to the basic concepts in artificial intelligence and basic algorithms for interactive tasks, such as games, with a special focus on its application in robotic tasks. [Key Concepts] intelligence, search algorithm, agents. [Learning Challenge] programming of an AI algorithm for interactive tasks.
Lab Project 3: Program an AI robot to play Tic-Tac-Toe game	6	This lab aims at an integration of an AI algorithm for robotics, where a physical robot is to be connected and programmed to physically interact with the external environment in a simple game task. [Key Concepts] hardware, search algorithm, integration. [Learning Challenge] connect and program a real robot for motion planning with vision, and interact with human using intelligence.
Lecture Section 5: Deep Learning • Deep Neural Network • Convolutional Neural Network	6	This section aims at the introduction to the basic concepts in deep learning where an end-to-end solution is used to program the robots with learning capability. [Key Concepts] neural network, deep learning, CNN. [Learning Challenge] the use of tensorflow to program a CNN for deep learning tasks
Lab Project 4: Program a DL robot to play arcade claw game	6	This lab aims at the integration of CNN in a robotic task to autonomously interact with the physical environment using deep learning techniques. [Key Concepts] tensorflow, robot learning architecture.

		[Learning Challenge] design and deploy a deep learning algorithm in robotic hardware to perform learning tasks
Lecture Section 6: Special Topics • Robotic Standards • Final Presentation	4	This section aims at a review of the non-technical issues related to the adoption of robotics in industry and research, which are critically important to the development of robotics in learning. [Key Concepts] industrial standards, safety, ethical concerns. [Learning Challenge] the non-technical side of robotic technology in industrialization and frontier research.
Lab Project 5: Autonomous Robot Manipulation Competition	8	This project aims at the development of a robot manipulation task designed by the students to achieve physical interactions with the external environment. [Key Concepts] system integration, design and deployment. [Learning Challenge] competitive robot learning task design for manipulation and interaction.

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

Required:

- A Mathematical Introduction to Robotic Manipulation by Richard M. Murray, Zexiang Li, and S. Shankar Sastry.

Optional:

- Mastering ROS for Robotics Programming by Lentin Joseph
- Introduction to Robotics – Mechanics and Control (4th Edition) by John Craig.
- Robotics, Vision & Control - Fundamental Algorithms in MATLAB® by Peter Corke.
- Artificial Intelligence – A Modern Approach (3rd Edition) by Stuart Russel, and Peter Norvig.

课程评估 ASSESSMENT

19.

评估形式 Type of Assessment	评估时间 Time	占考试总成绩百分比 % of final score	违纪处罚 Penalty	备注 Notes
出勤 Attendance				
课堂表现 Class Performance		10		Team-wise peer marking
小测验 Quiz				
课程项目 Projects		90		60%: project marking - 15% per project for the first four projects, including 10% code submission and 5% video presentation. 30%: final project marking, including - 10% final paper - 10% final video demo - 5% final poster

				- 5% code submission
平时作业 **Assignments**				
期中考试 **Mid-Term Test**				
期末考试 **Final Exam**				
期末报告 **Final Presentation**				
其它（可根据需要改写以上评估方式） **Others (The above may be modified as necessary)**				

20. 记分方式 **GRADING SYSTEM**

☐ A. 十三级等级制 **Letter Grading**

课程审批 REVIEW AND APPROVAL

21. **本课程设置已经过以下责任人/委员会审议通过**
This Course has been approved by the following person or committee of authority
