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**	**多智能体系统 Multi-Agent Systems**
2.	**授课院系 Originating Department**	计算机科学与工程系 Department of Computer Science and Engineering
3.	**课程编号 Course Code**	CS325
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**	秋季 Fall
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）**	程然，副教授，计算机科学与工程系，chengr@sustech.edu.cn Ran Cheng, Associate professor, Department of Computer Science and Engineering, chengr@sustech.edu.cn
9.	**实验员/助教、所属学系、联系方式 Tutor/TA(s), Contact**	郑博文（计算机科学与工程系）：bowen.zheng@protonmail.com 孙克斌（计算机科学与工程系）：12232432@mail.sustech.edu.cn 王力爽（计算机科学与工程系）：11911012@mail.sustech.edu.cn 李浩 （计算机科学与工程系）：12132340@mail.sustech.edu.cn
10.	**选课人数限额(可不填) Maximum Enrolment （Optional）**	50

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	CS203 数据结构与算法分析				
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 designed to bridge foundational theories and advanced methodologies within the field of Multi-Agent Systems (MAS), with a strong emphasis on their intersection with Artificial Intelligence (AI). It aims to provide a comprehensive understanding that encompasses both the traditional elements of MAS and the innovative AI practices shaping the future of this dynamic field. The objectives are fourfold:

- **Comprehensive Understanding of MAS and AI Integration:** Students will gain an in-depth knowledge of MAS, covering its core principles, architectures, and interaction models, while integrating AI concepts such as machine learning, reasoning, and intelligent behavior. The course will delve into how AI enriches MAS, focusing on agent communication, coordination, cooperation, and the intelligent architectures that underpin agent-based systems.

- **Competition/Cooperative Behaviors in Intelligent Agents:** The course will explore the dynamics of competitive and cooperative behaviors among intelligent agents within MAS. It will examine how AI-driven agents can effectively negotiate, collaborate, and compete to achieve individual and collective goals. The curriculum will include studies on game theory, social choice theory, and AI mechanisms that drive successful agent interactions and conflict resolutions in competitive and cooperative settings.

- **MAS for Intelligent Optimization:** The course will provide practical experience in applying AI-enhanced MAS to complex problem-solving scenarios, particularly in the realm of intelligent optimization. Students will learn to implement and utilize optimization algorithms such as Particle Swarm Optimization (PSO) and Ant Colony Optimization (ACO) within a multi-agent framework, demonstrating how AI principles can be used to optimize these processes.

- **MAS for Intelligent Decision-making:** A significant focus will be placed on exploring and mastering advanced AI strategies for optimization and control within MAS. This includes deep dives into neuroevolutionary algorithms like NeuroEvolution of Augmenting Topologies (NEAT) and Genetic Programming (GP), understanding how these AI-driven methods can be used to evolve agent behaviors in complex environments. Students will investigate how these advanced AI methodologies can be seamlessly integrated into MAS to enhance performance, adaptability, and efficiency in various tasks.

这门课程旨在桥接多智能体系统（MAS）领域的基础理论和高级方法论，并且强调其与人工智能（AI）的交叉。课程目标是提供一个全面的理解，涵盖了 MAS 的传统元素以及塑造这一动态领域未来的创新 AI 实践。课程目标四个方面如下：

- **MAS 概念的理解及其与 AI 的关联：**学生将深入了解 MAS，包括其核心原则、架构和交互模型，并融入 AI 的概念，如机器学习、推理和智能行为。课程将深入探讨 AI 如何丰富 MAS，重点关注智能体通信、协调、合作以及支撑基于智能体系统的智能架构。

- **智能代理的竞争/合作行为：**课程将探索 MAS 中智能代理的竞争和合作行为动态。它将研究由 AI 驱动的代理如何有效地进行协商、合作和竞争，以实现个体和集体目标。课程内容将包括对博弈论、社会选择理论以及推动竞争和合作设置中成功代理交互和冲突解决的 AI 机制的研究。

- **面向智能优化的 MAS：**课程将提供在复杂问题解决场景中应用 AI 增强 MAS 的实践经验，特别是在智能优化领域。学生将学习在多智能体框架内实施和利用诸如粒子群优化（PSO）和蚁群优化（ACO）之类的优化算法，展示如何使用 AI 原则来优化这些过程。

- **面向智能决策的 MAS：**课程将重点探索和掌握 MAS 中优化和控制的高级 AI 策略。这包括深入研究如神经进化算法 NEAT（NeuroEvolution of Augmenting Topologies）和遗传编程（GP），理解这些 AI 驱动的方法如何用于在复杂环境中进化代理行为。学生将研究如何将这些高级 AI 方法无缝集成到 MAS 中，以提高各种任务中的性能、适应性和效率。

16. 预达学习成果 Learning Outcomes

- **Mastery of MAS and AI Integration:** Students will have a comprehensive understanding of the integration between Multi-Agent Systems (MAS) and Artificial Intelligence (AI), encompassing core principles, architectures, and interaction models of MAS, along with machine learning, reasoning, and intelligent behavior in AI. They will be able to identify and analyze how these two fields complement each other to advance the development of intelligent systems.
- **Analysis and Application of Competitive/Cooperative Behaviors:** Students will be able to analyze and apply competitive and cooperative behaviors of intelligent agents, understanding how to achieve effective agent negotiation, collaboration, and competition through AI mechanisms. They will learn to use game theory and social choice theory to design and optimize agent interactions and conflict resolution strategies within MAS.
- **Design and Implementation of Intelligent Optimization Algorithms:** Students will gain practical skills in implementing and utilizing intelligent optimization algorithms, such as Particle Swarm Optimization (PSO) and Ant Colony Optimization (ACO), within a MAS framework to solve complex optimization problems. They will master how to integrate AI principles with MAS techniques to enhance the efficiency and effectiveness of the problem-solving process.
- **Design and Implementation of Intelligent Decision-making Systems:** Students will be capable of designing and evaluating MAS decision-making systems that incorporate advanced AI strategies, such as NeuroEvolution of Augmenting Topologies (NEAT) and Genetic Programming (GP). They will understand how these algorithms facilitate the evolution of agent behavior in complex environments and will be able to integrate these methods to improve the performance, adaptability, and efficiency of MAS.
- **掌握 MAS 和 AI 的集成知识：**学生能够全面理解多智能体系统（MAS）和人工智能（AI）的集成，包括 MAS 的核心原则、架构、交互模型以及 AI 的机器学习、推理和智能行为技术。学生将能够识别和分析这两个领域如何互相强化，以促进智能系统的发展。
- **分析和应用竞争/合作行为：**学生能够分析和应用智能代理的竞争和合作行为，理解如何通过 AI 机制实现有效的代理协商、合作和竞争。学生将学会如何运用博弈论和社会选择理论来设计和优化 MAS 中的代理交互和冲突解决策略。
- **设计和实现智能优化算法：**学生将具备在 MAS 框架内实施和利用智能优化算法（如 PSO 和 ACO）的实践技能，能够将这些算法应用于解决复杂的优化问题。学生将掌握如何结合 AI 原则和 MAS 技术来提高问题解决过程的效率和效果。
- **设计和实现智能决策系统：**学生能够设计和评估采用高级 AI 策略（如 NEAT 和 GP）的 MAS 决策系统。学生将深入理解这些算法如何促进复杂环境中的代理行为进化，并能够集成这些方法来增强 MAS 的性能、适应性和效率。

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.)

Week 1-2: Foundations of Multi-Agent Systems

- Overview of MAS: Definitions, architectures, types of agents
- Basic principles of agent communication, coordination, and cooperation
- **Lab:** Setting up MAS environments and initial simulations, Design and simulation of basic agent architectures

Week 3-6: Swarm Intelligence in MAS

- Introduction to swarm intelligence: PSO and ACO
- Application of swarm intelligence for numerical optimization
- **Lab:** Implementing PSO and ACO for optimization tasks

Week 7-10: Neuroevolution in MAS

- Introduction to neuroevolution and its role in enhancing agent intelligence and adaptability.
- Exploring the integration of neuroevolutionary algorithms like NEAT for dynamic decision-making and problem-solving.
- **Lab:** Implementing neuroevolutionary algorithms in MAS to evolve agent behaviors and strategies for complex tasks.

Week 10-14: MAS for Decision-making

- Basics of decision-making in MAS
- Introduction to neuroevolution (NEAT) and genetic programming (GP) for control tasks
- **Lab:** Implementing basic control tasks using MAS and neuroevolution

Week 15-16: Project Development and Presentation

- Students develop their own MAS project integrating numerical optimization and decision-making
- Final presentations and course wrap-up
- **Lab:** Course project

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

Textbook: An Introduction to MultiAgent Systems - Second Edition. Michael Wooldridge (Wiley, 2009)

Supplementary Readings:

Kacprzyk, Janusz, and Witold Pedrycz, eds. Springer handbook of computational intelligence. Springer, 2015.

Stanley, Kenneth O., et al. "Designing neural networks through neuroevolution." Nature Machine Intelligence 1.1 (2019): 24-35.

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		10%		
课堂表现 Class Performance				
小测验				

Quiz				
课程项目 Projects				
平时作业 Assignments		30%		
期中考试 Mid-Term Test				
期末考试 Final Exam		30%		
期末报告 Final Presentation		30%		
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**
☐ B. 二级记分制（通过/不通过） **Pass/Fail 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

教学负责人签字：
日期：