IE481& IE801
Special Topics in Industrial Engineering I & II
(Game Theory with Engineering Applications)

Instructor

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Office hours: Tue/Th: 1:00-3:00 pm (other times are available by appointment by email)

Time/Location

Time: Tue/Th from 10:30 – 12:00 pm
Location : (E2) Industrial Engineering & Management Bldg., #1120

Course TA

TBD

Prerequisites

- IE331 Operations Research I or similar courses
- IE332 Operations Research II or similar courses
- IE481 Data-driven decision making and control (recommended if you are undergraduate)

Textbook

Yoav Shoham and Kevin Leyton-Brown, *Multiagent Systems*, Cambridge, 2009

References

- Steven Tadelis, Game Theory: An Introduction, Princeton
- Howard M. Schwartz, *Multi-Agent Machine Learning, Wiley*
- Dario Bauso, Game Theory with Engineering Applications, Siam

Overview

As an engineering system becomes highly complicated and distributed, it becomes challenging to understand the behavior of the system and operate the system efficiently. Multi-agent system modeling is a useful tool to model the complex and collective behavior of the target system by independently modeling the subsystems (agents) that comprise the whole system.

The control problem of a multi-agent system has drawn much attention in the past years, due to the practical and potential applications in robots formation, distributed control, resource management, collaborative decision-making systems and data mining. A multi-agent system is composed of a set of independent agents that interact with each other in a shared stochastic environment. Since the agents in multi-agent system lack full information of dynamic environment and other agents' strategies, learning decision-making strategy (policy), in a multi-agent system is much more challenging than in a single agent system.

This course provides an essential and fundamental knowledge required for understanding multiagent systems and deriving decision-making strategies. The two primary subjects of the course are (1) game theory and (2) data-driven decision-making (e.g., machine learning and reinforcement learning). This course first provides an overview of game theory in both modeling and computational perspectives. Based upon analytical framework, the course will discuss how learning concepts can be used with game-theory modeling technique to derive the optimum operational strategies for a multi-agent system. Specifically, this course discusses the learning in a repeated-static game and Stochastic game.

The final goal of the course is to provide the foundation of modeling and computation for multi-agent reinforcement learning algorithms, i.e., Nash-Q learning, Correlated Q-learning, Minmax Q-learning, and Team Q-learning.

As examples, this course provides various applications in a smart-grid system, i.e., energy storage control, demand response, energy trading.

Objectives

- Understand various modeling approaches in game theory
- Understand data-driven decision making and control approaches
- Understand how learning concepts can be employed in game theory modeling
- Understand the concept of multi-agent reinforcement learning
- Formulate real-world problems with multiple decision makers using game theory
- find solutions using both game theory modeling techniques and learning concepts

Topics (tentative)

1. Static Games of Complete Information
2. Dynamic Games of Complete Information
3. Static Game of Incomplete Information
4. Dynamic Games of Incomplete Information
5. Learning in Repeated Game
6. Learning Stochastic Games (Multi Agent Reinforcement Learning)
7. Optimal Control and Differential Game (if time allows)

Evaluations(tentative)

- 4 sets of homework (20%)
- Midterm exam (40%)
- Final project (30%)
- Class Participation (10%)

Projects

The objective of the project is to encourage students to define their own problems of interests and formulate them in a formal mathematical way. The topic should be related to the general theme of the course. As part of the project you should:

- *formulate* a target problem
- *apply* a decision making methodology to solve the formulated problem
- *analyze* and *interpret* the results obtained
- *present* the result and derived insights to other people