# Learning and Teaching

(Based on Shoham and Leyton-Brown (2008). *Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations*, Cambridge.)

Leen-Kiat Soh

# Why Teaching? Is Learning Not Sufficient?

***Learning is to meet the needs of the learner agent***

***What about the needs of the teacher agent?***

**Learning is akin to ”search” for the best solutions, or best solution paths, from among many solutions and non-solutions. Approaching this search from both ends allows the process to be more timely, more targeted!**

# Introduction

- The capacity to learn is a key facet of **intelligent** behavior
- Learning is **complex**
  - the interaction between learning and teaching
  - the settings in which learning takes place and what constitutes learning in those settings
  - the learning of the other agents will be impacted by the learning performed by individual agents
  - the yardsticks by which to measure this or that theory of learning in multiagent systems

Recall the handout on Learning and Communication

# Introduction 2

- The **simultaneous** learning of the agents means that every learning rule leads to a dynamical system, and sometimes even very simple learning rules can lead to complex global behaviors of the system
- Moreover, in MAS, one *cannot* separate *learning* from *teaching*
  - when choosing a course of action, an agent must take into account not only what it has learned from other agents' past behavior, but also how **it wishes to influence their future behavior**

**Adversarial: A learns about B, B learns about A accordingly, how should each learn?**

**Non-Adversarial: A wants to teach B about X, B wants to learn from A about Y, what if X and Y are not the same thing?**

# Example | Stackelberg Game

Player 1 has a dominant strategy: **Play B**

| | Player 2 plays L | Player 2 plays R |
|---|---|---|
| Player 1 plays T | 1,0 | 3,2 |
| Player 1 plays B | 2,1 | 4,0 |

Nash equilibrium

- **Player 1 must teach player 2**
- **Why can't player 2 teach player 1?**
  - Who has a **dominant strategy**?
  - Is there a unique **Nash equilibrium**?

**Implications? What's the motivation of player 1? Why does player 1 believe that player 2 will learn to do what player 1 teaches?**

# Example | Pure Coordination Game

| | Driver 2 Left | Driver 2 Right |
|---|---|---|
| **Driver 1 Left** | 1,1 | 0,0 |
| **Driver 1 Right** | 0,0 | 1,1 |

- Which driver should be the teacher?
  - Either driver could be with equal success
  - **However**, if both decide to play teacher and happen to select **uncoordinated** actions (Left, Right) or (Right, Left) then the players will receive a payoff of zero forever
- *Is there a learning rule that will enable them to coordinate without an external designation of a teacher?*
  - Learning involves **choosing actions** and **updating beliefs**
  - In the abstract, **accumulating knowledge** **never hurts, since one can always ignore what has been learned**

# Example | Game of Chicken

| | Player 2 Yield | Player 2 Dare |
|---|---|---|
| **Player 1 Yield** | 2,2 | 1,3 |
| **Player 1 Dare** | 3,1 | 0,0 |

- The principle of the game is that while each player prefers not to yield to the other, the worst possible outcome occurs when both players do not yield
- *How to teach?*
- *Note*: The "**Watch out: I'm crazy**" policy
  - less knowledge is more, in terms of teaching the other player?

Does a player have any incentive for learning?

# Connection to MAS?

**For an agent to consider teaching, it needs to be able to understand that the learner agent will learn and will carry out what is taught once learned; Implications?**

**For an agent to consider teaching, since it is "effortful", it has to be worth it: the expected outcome to the agent is better than not teaching**

**Silly Question**: **Social media, such as Facebook, Twitter, Instagram, etc., is popular. What if Facebook had a new rule: If the average number of likes of a user's posts is below a certain threshold, then the user's monthly limit on number of posts is decreased. What would happen?**