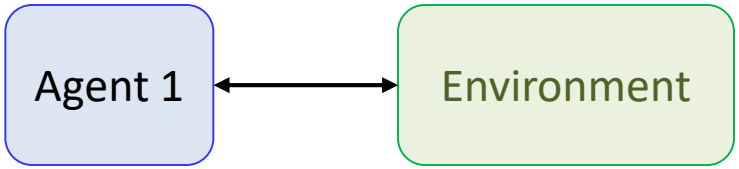
Lecture 14. Learning in games

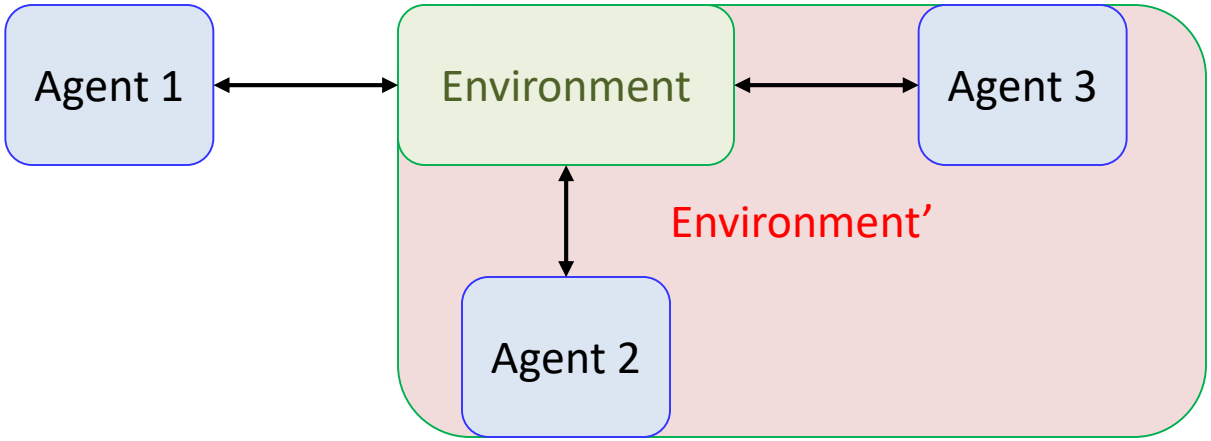
- We concentrate on techniques drawn primarily from two disciplines
  - Artificial intelligence
  - game theory

The integrations between learning and teaching



- Most work in **artificial intelligence** concerns the learning performed by an individual agent
  - The goal is to design an agent that learns to function successfully in an environment that is
    - unknown
    - (potentially) changing as the agent is learning

The integrations between learning and teaching



- **Multiagent setting** adds additional complexities
  - Environment contains other agents
    - Environment is changing as other agents are learning
    - Environment is changing depending on other agents' actions
    - ➢ *The learning of the other agents will be impacted by the learning performed by our protagonist*

The simultaneous learning of the agents means that every learning rule leads to a dynamical system

The integrations between learning and teaching

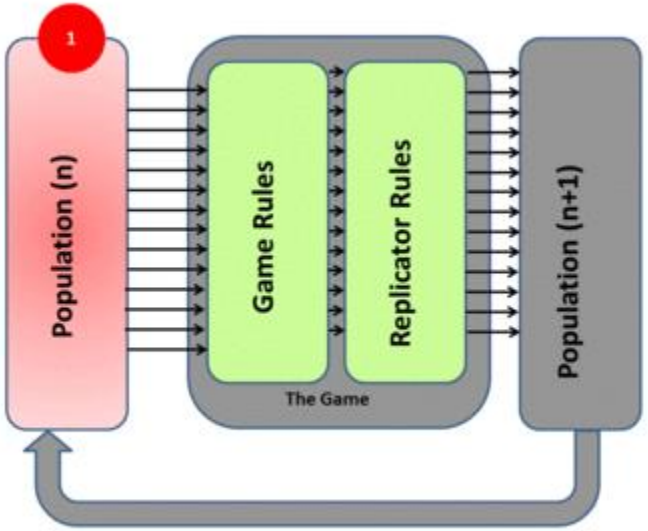
	L	R
T	$1, 0$	$3, 2$
B	$2, 1$	$4, 0$

Stackelberg game

- Player 1 (the row player) has a dominant strategy, namely B.
- (B, L) is the unique Nash equilibrium of the game
  - ✓ If player 1 were to play B repeatedly, it is reasonable to expect that player 2 would always respond with L.
- What will happen if player 1 chooses to play T?
  - Then, player 2's best response would be R, yielding player 1 a payoff of 3 (>2 for Nash)
- In a single-stage game it would be hard for player 1 to convince player 2 that he (player 1) will play T, since it is a strictly dominated strategy.1
- However, in a repeated-game setting, player 1 could repeatedly play T; presumably, after a while player 2, if he has any sense at all, would get the message and start responding with R.

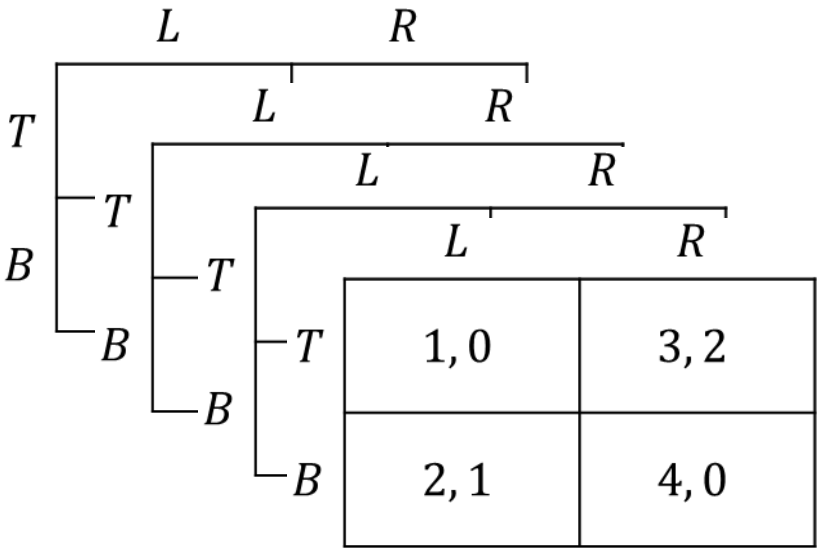
Player 1's role is a teacher, trying to modifying player 2's strategy

1. Evolutionary game



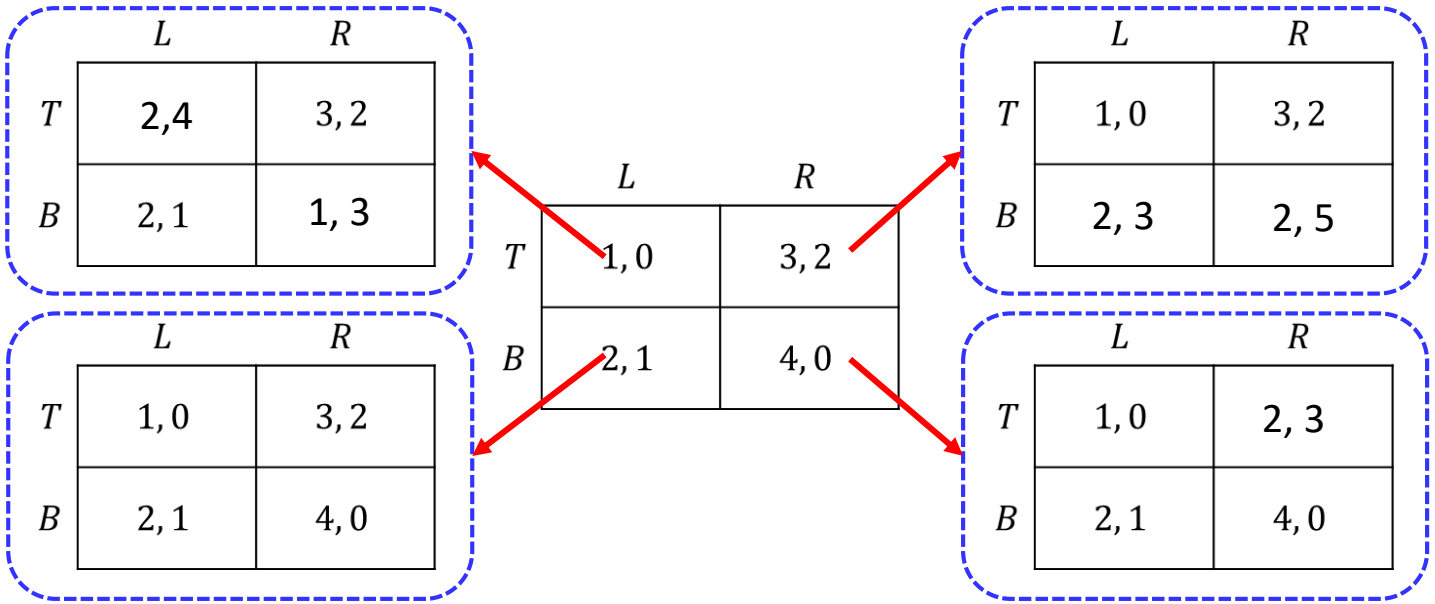
- Evolutionary game is for modeling large populations
  - Largely inspired by evolutionary biology
  - Consist of a large number of players, who repeatedly paly a given game among themselves

2. Repeated (Matrix) game



- Repeated game is used for learning setting because
  - Each time the same players are involved
  - Each time the same game is played
- The experience so far → a strategy for selecting future action
  - Tit-for-Tat and Triger strategies in repeated PD game
  - A more general strategies can be obtained

3. Stochastic game



- Stochastic game is a moral general setting where learning is taking place
  - The game transits to another game depending on the joint actions by agents
  - Same players and same actions sets are used through games
- Most of the techniques discussed in the context of repeated games are applicable more generally to stochastic games
  - ✓ specific results obtained for repeated games do not always generalize.

What constitutes learning?

Additional aspects for repeated and stochastic games

	Opponent's strategy unknown
Game is known	Need to learn only opponents' strategies
Game is unknown	Need to learn both the payoffs and opponents' strategies (e.g., Multiagents reinforcement learning)

Learning in game: Descriptive theories

- **Descriptive theories** attempt to study the way learning takes place in real life usually by people, but sometimes by other entities such as organizations or animal species.
    - the goal here is to show experimentally that a certain model of learning agrees with behavior (typically, in laboratory experiments) and then to identify interesting properties of the formal model.
- The ideal descriptive theory would have:

Property (Realism)

There should be a good match between the formal theory and the natural phenomenon being studied.

Property (Convergence)

The formal theory should exhibit interesting behavioral properties, in particular convergence of the strategy profile being played to some solution concept (e.g., equilibrium) of the game being played.

Learning in game: Perspective theories

- **Prescriptive theories** ask how agents—people, programs, or otherwise—should learn:
  - Concentrate strategic normative theories, in which individual agents ae self-motivated

Property (Safety)

A learning rule is safe if it guarantees the agent at least learning rule its maxmin payoff, or "security value." (Recall that this is the payoff the agent can guarantee to himself regardless of the strategies adopted by the opponents

Property (Rationality)

A learning rule is rational if whenever the opponent learning rule settles on a stationary strategy of the stage game (i.e., the opponent adopts the same mixed strategy each time, regardless of the past), the agent settles on a best response to that strategy.