What is game theory?

How do we study it?

Where is research headed?

What?

The study of interacting decision makers

Economy

Biology

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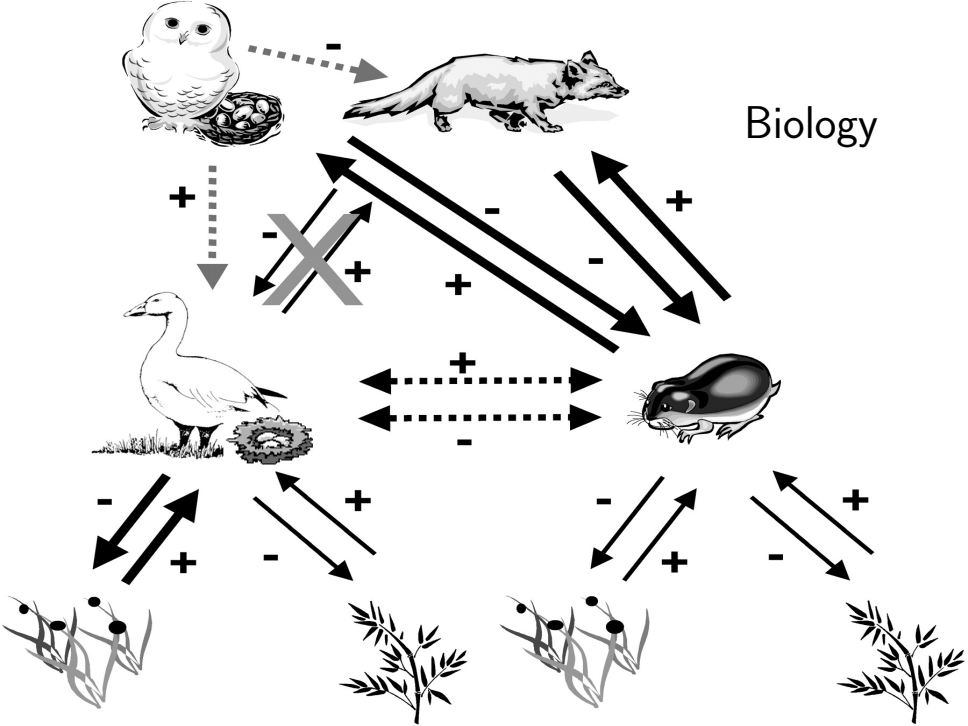
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Birthday: Month: Day: Year:

Why do I need to provide this?

Sign Up

Sociology

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Computer
Science

Engineering

Different agendas

What?

- study of interacting decision makers
- interdisciplinary field
- different agendas

How?

Decision maker

- choices, C
- preferences, $\succeq$
  utility function, $u : C \to \mathbb{R}$

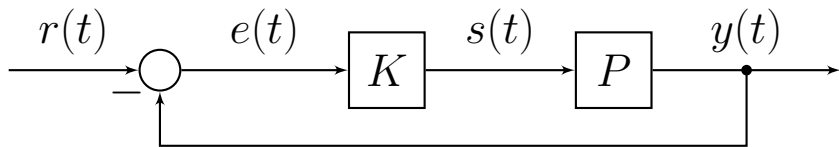$$c_1 \succeq c_2 \iff u(c_1) \geq u(c_2)$$

$C = \{L, R\}$

$u : C \to \mathbb{R}$
$\quad L \mapsto 0$
$\quad R \mapsto 1$

	u
L	0
R	1

- $C = \{\text{stabilizing controller } K\}$
- $u(K) = -\tau_r(K)$

Optimality

Decision maker:

- choices, C
- utility function, u

Goal of decision maker:

$$\max_{c \in C} u(c)$$

Game Theory

- players, $\{i\}$
- choices for player i, C_i
- joint choices, $C = \prod_i C_i$
  $c \in C = (c_i, c_{-i})$
- utility function for player i, $u_i : C \to \mathbb{R}$

Optimality?

Goal of decision maker i:

$$\max_{c \in C} u_i(c_i, c_{-i}) \left(\neq \max_{c \in C} u_i(c_i) \right)$$

Example: Prisoner's dilemma

	C	D
C	$2, 2$	$-1, 3$
D	$3, -1$	$0, 0$

Best response, $\mathsf{BR}_i : C_{-i} \rightrightarrows C_i$

- $\mathsf{BR}_1(C) = \{D\}, \mathsf{BR}_1(D) = \{D\}$
- $\mathsf{BR}_2(C) = \{D\}, \mathsf{BR}_2(D) = \{D\}$

Nash equilibrium

$a^* = (a_i^*, a_{-i}^*)$ is a Nash equilibrium:

- $\forall i$, a_i^* is a best response to a_{-i}^*
- no unilateral deviation is profitable
- $\forall i$, $\forall a_i \in A_i$,

$$u_i(a_i^*, a_{-i}^*) \geq u_i(a_i, a_{-i}^*)$$

Existence of Nash equilibria

Every n-player game has a Nash equilibrium.

Extensions

- history-dependent strategy
- imperfect information
- cooperation
- large populations

Back to the agendas
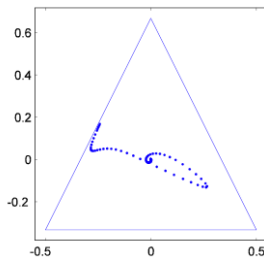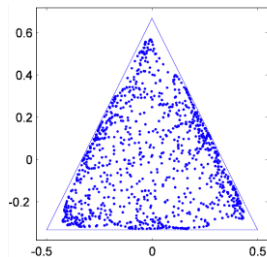
- descriptive
- predictive
- manipulative

How?

- interacting decision maker
- best response
- Nash equilibrium

Where?

Learning

Controls $\Rightarrow$ Game Theory:

- ▶ stability and robustness
- ▶ derivative control

Decentralized control

Game Theory $\Rightarrow$ Controls:

- network formation
- communication limitations

Dynamic Games

- network security
- learning in repeated games

Where?

- learning
- decentralized control
- dynamic games

Questions?

Comments?