



# Introduction to General Game Playing

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November 15, 2021

# Outline

Introduction

Playing Games

Implementing a GGP

# AI Challenges

AI systems are able to

- ▶ make autonomous decisions
- ▶ adapt flexibly to unforeseen situations

Do they, really?

Most existing AI systems are

- ▶ designed for a specific and narrow application
- ▶ use tailor-made algorithms

The intelligence lies with the programmers-not their systems

# Computer Game Playing



Kasparov vs. Deep Blue (1997)



Kejie vs. AlphaGo (2017)

# General Game Player

A **General Game Player** is a system that

- ▶ understands description of arbitrary games
- ▶ learns to play these games without human intervention

Translation: They don't know the rules until the game starts.

Unlike specialised game players (e.g. Deep Blue, AlphaGo), they do not use algorithms designed in advance for specific games.

# General Game Playing

Rather than being concerned with a specialized solution to a narrow problem, General Game Playing encompasses a variety of AI areas:

- ▶ Game Playing
- ▶ Knowledge Representation
- ▶ Planning and Search
- ▶ Learning

General Game Playing is considered as a grand AI Challenge

# Variety of Games



General Game Playing Contest @AAAI since 2005

# General Game Playing Initiative

games.stanford.edu

- ▶ Game description language
- ▶ Variety of games/actual matches
- ▶ Basic player available for download
- ▶ Annual world cup @AAAI (since 2005)  
Price money: US\$ 10,000

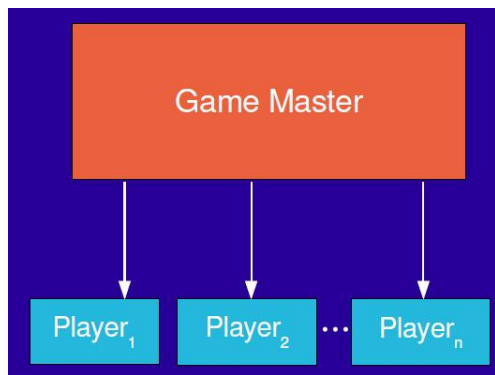


# GGP Winners

- 2005: Cluneplayer, by Jim Clune ([UCLA](#))
- 2006: Fluxplayer,<sup>[5]</sup> by Stephan Schiffel and Michael Thielscher ([Dresden University of Technology](#))
- 2007: Cadiaplayer,<sup>[6]</sup> by Yngvi Björnsson and Hilmar Finnsson ([Reykjavik University](#))
- 2008: Cadiaplayer, by Yngvi Björnsson, Hilmar Finnsson and Gylfi Þór Guðmundsson ([Reykjavik University](#))
- 2009: Ary, by Jean Méhat ([Paris 8 University](#))
- 2010: Ary, by Jean Méhat ([Paris 8 University](#))
- 2011: TurboTurtle, by Sam Schreiber
- 2012: Cadiaplayer, by Hilmar Finnsson and Yngvi Björnsson ([Reykjavik University](#))
- 2013: TurboTurtle, by Sam Schreiber
- 2014: Sancho,<sup>[7]</sup> by Steve Draper and Andrew Rose
- 2015: Galvanise, by Richard Emslie
- 2016: WoodStock, by Eric Piette ([Artois University](#))

—Wikipedia

# How it works



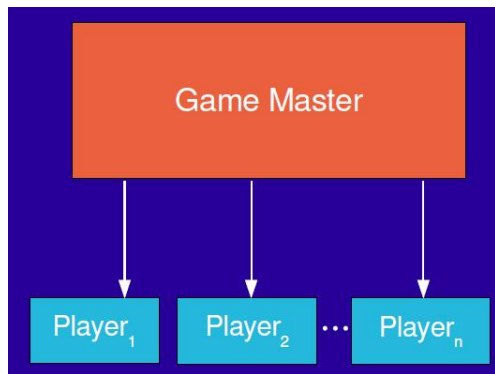
Game description

Time to think: 30s ~ 120s

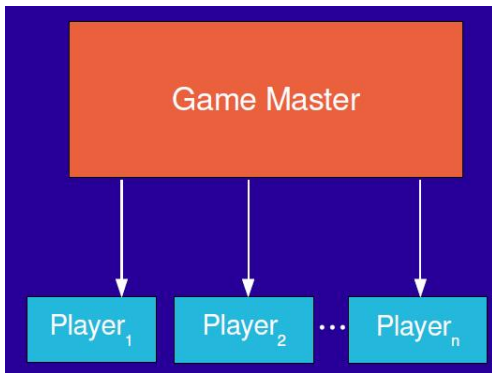
Time per move: 15s ~ 60s

Your role

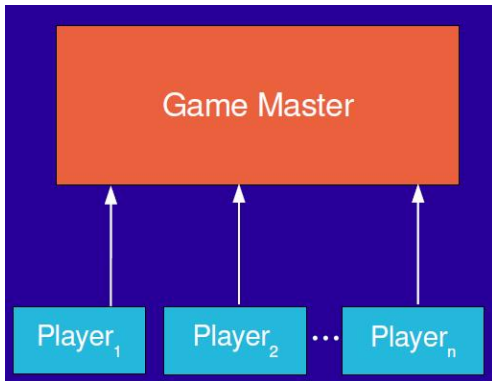
# How it works



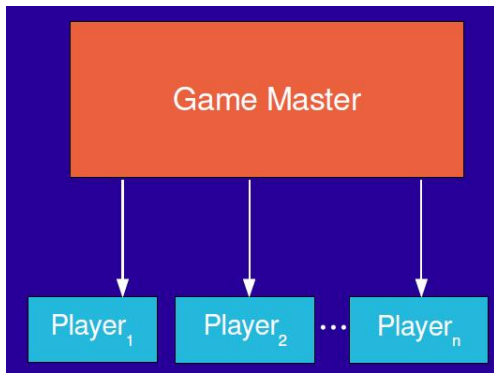
Start



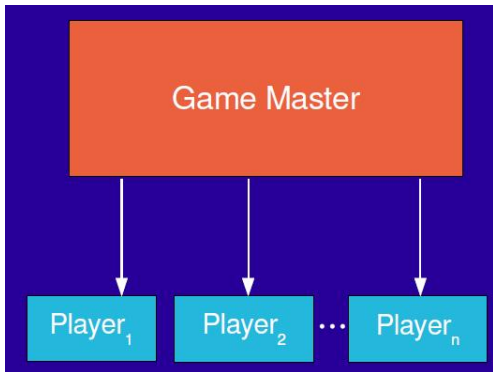
Your move, please



Individual moves



Individual Information  
about states/moves



End of game

# Roadmap

- ▶ The Game Description Language GDL:  
Knowledge Representation
- ▶ How to make legal moves:  
Automated Reasoning
- ▶ How to solve simple games:  
Planning & Search
- ▶ How to play well:  
Learning













Tiltlyard Hosting























**Games you've never seen before.** Play over 100 different games against humans or intelligent computers.

Would you like to start a  match?

You can include human players, computer players, and random players.

**Listing of the 50 most recently played matches, of which 0 are ongoing:**

18 Oct	? Anonymous	×	Tic-Tac-Toe		<a href="#">View</a>
	? Anonymous	×			
18 Oct	? Anonymous	×	Chess		<a href="#">View</a>
	? Anonymous	×			
18 Oct	? Anonymous	×	Chess		<a href="#">View</a>
	? Anonymous	×			
10 Oct	? Anonymous	⚠ 100	Tic-Tac-Toe		<a href="#">View</a>
	? Anonymous	⚠ 0			
26 Sep	 <a href="#">Random</a>		Tic-Tac-Toe		<a href="#">View</a>
	? Anonymous (play)				
19 Sep	? Anonymous	×	Tic-Tic-Toe		<a href="#">View</a>
	? Anonymous	×			
19 Sep	? Anonymous	×	Tic-Tic-Toe		<a href="#">View</a>
	? Anonymous	×			
13 Sep	? Anonymous	×	Tic-Tic-Toe		<a href="#">View</a>

22 Aug	? Anonymous	⚠	0	Two-Player Tic-Ta...		<a href="#">View</a>
	? Anonymous	⚠	0			
14 Aug	 Random		0	Sudoku Grade 3		<a href="#">View</a>
13 Aug	 Random		0	Two-Player Free-F...		<a href="#">View</a>
	 Random		10			
13 Aug	? Anonymous		×	Tic-Tac-Toe		<a href="#">View</a>
	? Anonymous		×			
11 Aug	? Anonymous	⚠	50	Tic-Tic-Toe		<a href="#">View</a>
	? Anonymous	⚠	50			
11 Aug	? Anonymous		×	Tic-Tic-Toe		<a href="#">View</a>
	? Anonymous		×			
14 Jul	 Random		10	Two-Player Free-F...		<a href="#">View</a>
	 Random		20			
14 Jul	 Random		20	Two-Player Free-F...		<a href="#">View</a>
	 Random		30			
19 Jun	 Random		0	Two-Player Free-F...		<a href="#">View</a>
	 Random		20			
16 Jun	? Anonymous		×	Chess		<a href="#">View</a>
	? Anonymous		×			
15 Jun	? Anonymous		×	Chess		<a href="#">View</a>
	? Anonymous		×			
15 Jun	? Anonymous		×	Chess		<a href="#">View</a>
	? Anonymous		×			
15 Jun	? Anonymous		×	Chess		<a href="#">View</a>
	? Anonymous		×			

# Playing Games

<http://euklid.inf.tu-dresden.de:8180/ggpserver/index.jsp>

## Games

Camera stills tickblock, ... - Dresden CCF Server

2/25/11 11:27 AM

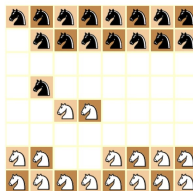
Wright@wisc.edu, 1304115991776.

2/25/11 11:49 AM

## View Matches

[Home Page](#)   [User Profile](#)   [View Match](#)

Mayew: knightthrough,1304115991776, Step14, Seen by: WHITE :



**REMAINING STATE:**  
**(CONTROL BLACK)**

**WEBMASTER:** [Stephan Schefel](#)  
 This visualization is part of [GGP Server](#).  
 Design partially provided by the [Stanford Logic Group](#)

**PLAY CLOCKS:**

**REMAINING:** Inactive (Not the current step)

**PLAYERS:**

WHITE	REDSHELL
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BLACK\* FLUXPLAYER TEST

### HISTORY:

	WHITE	BLACK
1	1	1
2	2	2
3	3	3
4	4	4
5	5	5
6	6	6
7	7	7
8	8	8
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98	98	98
99	99	99
100	100	100

3. (MOVE 3 2 4 NOOP  
4)

2. NOOP (MOVE 1 7 2 5)

1. (MOVE 4 2 3 NOOP  
4)

**Wiederhersteller:** Stephan Schäffel

Design partially provided by the [Stanford Logic Group](#).

[illegible]

[http://eulid.inf.tu-dresden.de:8180/cgi/server/public/show\\_games.jsp?page=6](http://eulid.inf.tu-dresden.de:8180/cgi/server/public/show_games.jsp?page=6)

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[http://euklid.inf.tu-dresden.de:8180/ggserver/public/view\\_state.jsp?matchID=knightsthrough.1304115991776&stepNumber=4&role=RANDOM](http://euklid.inf.tu-dresden.de:8180/ggserver/public/view_state.jsp?matchID=knightsthrough.1304115991776&stepNumber=4&role=RANDOM)

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# <http://www.general-game-playing.de/downloads.html>

## DownloadManager

Downloads - General Game Playing

2/05/11 12:25 PM

<a href="#">Home</a> <a href="#">Activities</a> <a href="#">Research</a> <a href="#">Literature</a> <a href="#">Getting Started</a> <a href="#">Downloads</a> <a href="#">Links</a>	<h3>Downloads</h3> <p>We provide programs that might help you to implement your own General Game Playing system. All programs contain source code and are distributed under GPL.</p> <h4>GAMECONTROLLER</h4> <p>GameController is a standalone game maker done entirely in Java and developed as part of the GGPServer project. It is particularly useful for testing your own general game playing system. GameController comes with a simple GUI and a command line interface. Send bug reports and suggestions to <a href="mailto:Stefan.Schulte@uni-siegen.de">Stefan.Schulte</a>.</p> <p>Download the most recent version from the <a href="#">sourceforge</a> project page.</p> <p>System requirements:</p> <ul style="list-style-type: none"><li>Java 1.6 runtime environment</li></ul> <p>Usage:</p> <pre>java -jar gamecontroller.exe.jar</pre> <h4>BASIC PROLOG PLAYER</h4> <p>A basic player implemented in Eclipse Prolog based on code from FLUXPLAYER.</p> <p>Download current version (1.1)</p> <p>System requirements:</p> <ul style="list-style-type: none"><li>Eclipse Prolog version 3.10 or higher</li></ul> <p>Changes since version 1.0</p> <ul style="list-style-type: none"><li>the port should be free now after stopping the player</li></ul> <p>(last update: 12 March 2009)</p> <h4>BASIC JAVA PLAYER</h4> <p>A basic player implemented in Java which comes with a framework for implementing your strategies, analyzing the game, etc. It can be found at the <a href="#">Fluxendo-101</a> website.</p> <h4>BASIC C++ PLAYER</h4> <p>A basic player implemented in C++ with the resembler of the prolog player above.</p> <p>Download current version (1.6)</p> <p>System requirements:</p> <ul style="list-style-type: none"><li>Linux/Unix (or any system which provides sockets)</li></ul>
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<http://www.general-game-playing.de/downloads.html>

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## Download Manager and Basic Players

# Game Controller App

GameController (tictactoe)

MatchID

Startclock

Playclock

Role	Type	Host	Port	Value
XPLAYER	RANDOM	-	0	0
OPLAYER	RANDOM	-	0	100

```
INFO(12:43:15.123): match:TestMatch_1, GDL v1
INFO(12:43:15.129): game:tictactoe
INFO(12:43:15.129): starting game with startclock=10, playclock=5
INFO(12:43:15.131): step:1
INFO(12:43:15.134): current state:((CELL 1 1 B)(CELL 1 2 B)(CELL 1 3 B)(CELL 2 1
B)(CELL 2 2 B)(CELL 2 3 B)(CELL 3 1 B)(CELL 3 2 B)(CELL 3 3 B)(CONTROL XPLAYER))
INFO(12:43:15.135): role: XPLAYER => player: local(Random)
INFO(12:43:15.136): role: OPLAYER => player: local(Random)
INFO(12:43:15.137): Sending start messages ...
INFO(12:43:15.152): time after gameStart's runThread: Mon May 02 12:43:15 EST
```

# Implementing a General Game Player

# Implementing a Player

- ▶ Free implementation
- ▶ Reasoning is not compulsory
- ▶ Main technique:
  - ▶ Search-Space and Heuristics
  - ▶ Compute the value of the next state

eg. (1) Minimax

eg. (2) Monte-Carlo Tree Search

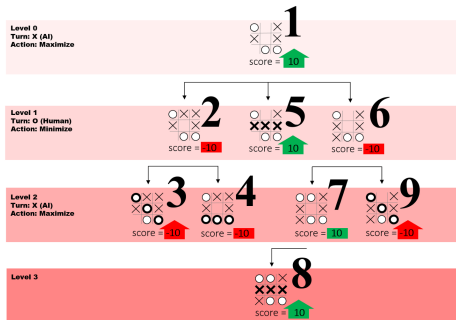
```
> org.ggp.base.player.gamer.statemachine.random
# org.ggp.base.player.gamer.statemachine.sample
  ▶ SampleGamer.java
  ▶ SampleLegalGamer.java
  ▶ SampleMonteCarloGamer.java
  ▶ SampleNoopGamer.java
  ▶ SampleSearchLightGamer.java
> org.ggp.base.player.proxy
```



# Minimax

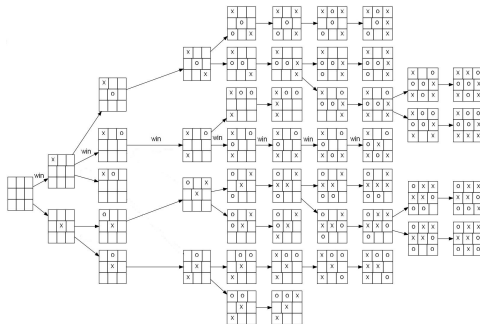
## Extensive search

- ▶ depth first
- ▶ min value for the opponents (worst case)
- ▶ max value for myself (best case)
- ▶ depth of search may be limited (heuristics)



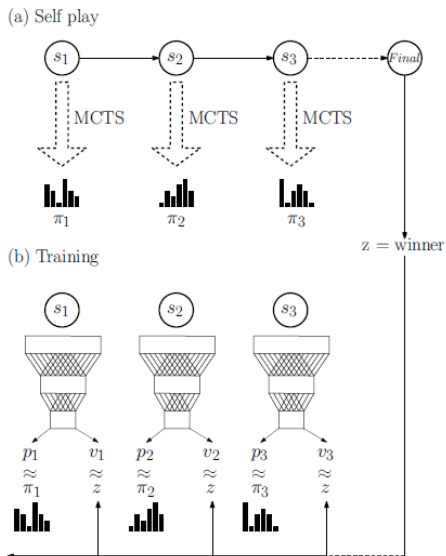
# Monte Carlo Tree Search

- ▶ Run random simulation
- ▶ Sampling the game tree
- ▶ Estimation of actions



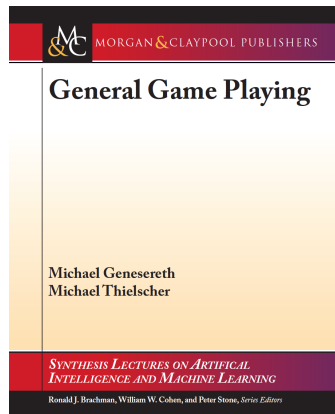
# Deep Reinforcement Learning

- ▶ MCTS to generate the training set through self-play
- ▶ Neural Network
- ▶ State, Move Distribution and Winner



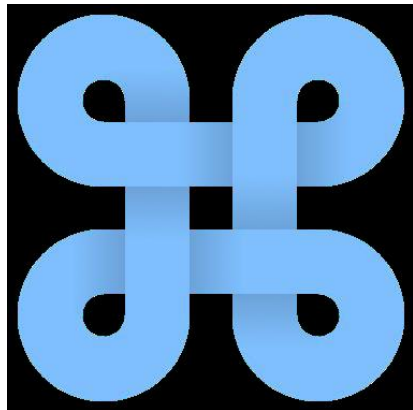
# Further Reading

- ▶ [www.generalgameplaying.de/literature.html](http://www.generalgameplaying.de/literature.html)
- ▶ [www.ggp.org/](http://www.ggp.org/)
- ▶ [ggp.stanford.edu/](http://ggp.stanford.edu/)
- ▶ [www.general-game-playing.de](http://www.general-game-playing.de)



# Other Platforms

**Ludii** <https://ludii.games/index.php>

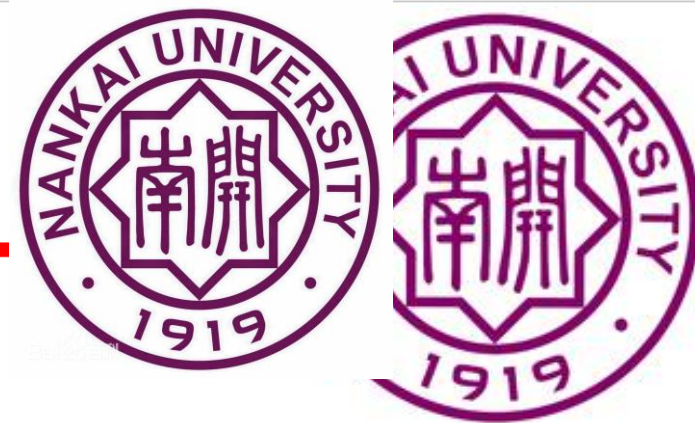


**Botzone** <https://www.botzone.org.cn/>



**AI LAB, Peking University**

Game Name	Create Time	Author	Description	Player Number	
Mahjong (旧麻将)	2014-6-7 12:58:14	Administrator	请选择用更新的Mahjong-New游...	4 - 4	<a href="#">Game Discussion</a> <a href="#">Bot Rank List</a>
Reversi (黑白棋)	2014-6-7 12:58:14	zhouhy	黑白棋是一款历史悠久的游戏，	2 - 2	<a href="#">Game Discussion</a> <a href="#">Bot Rank List</a>
VideoPlayer	2014-8-7 12:58:14	zhouhy	名副其实的視頻播放器，不支持b...	1 - 1	<a href="#">Game Discussion</a> <a href="#">Bot Rank List</a>
Minesweeper (扫雷)	2014-10-1 12:58:14	zhouhy	【最后更新2014.12.3】单人扫...	1 - 1	<a href="#">Game Discussion</a> <a href="#">Bot Rank List</a>
Gomoku (无禁手五子棋)	2014-10-7 21:45:37	leedy	【完全可用】五子棋是一种有...	2 - 2	<a href="#">Game Discussion</a> <a href="#">Bot Rank List</a>



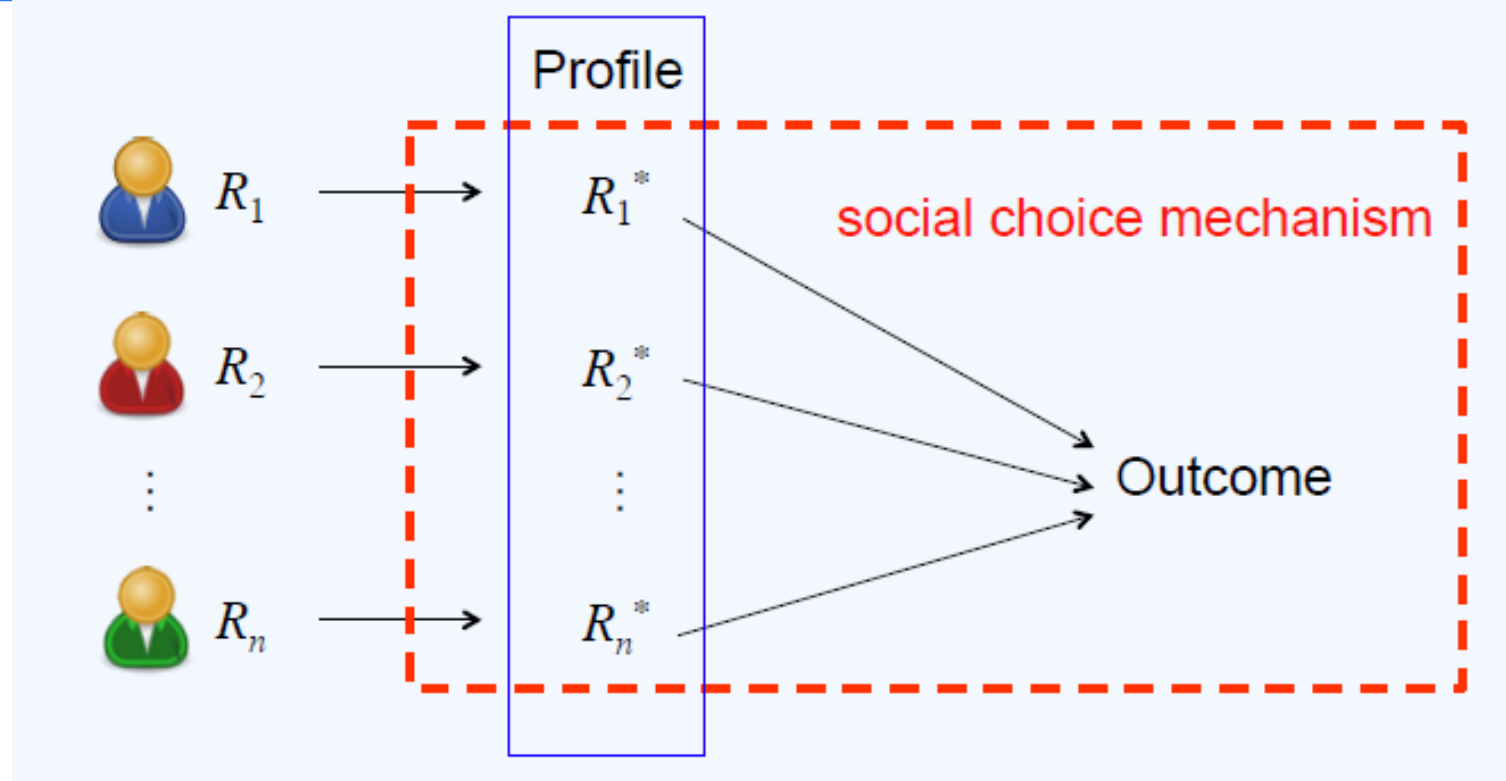
# Computational Social Choice

# What is Social Choice Theory



- **Social choice theory** is about methods for collective decision making, such as political decision making by groups of economic agents.

# Social Choice



- Agents
- Alternatives
- Outcomes
- Preferences (true and reported)
- Social choice mechanism



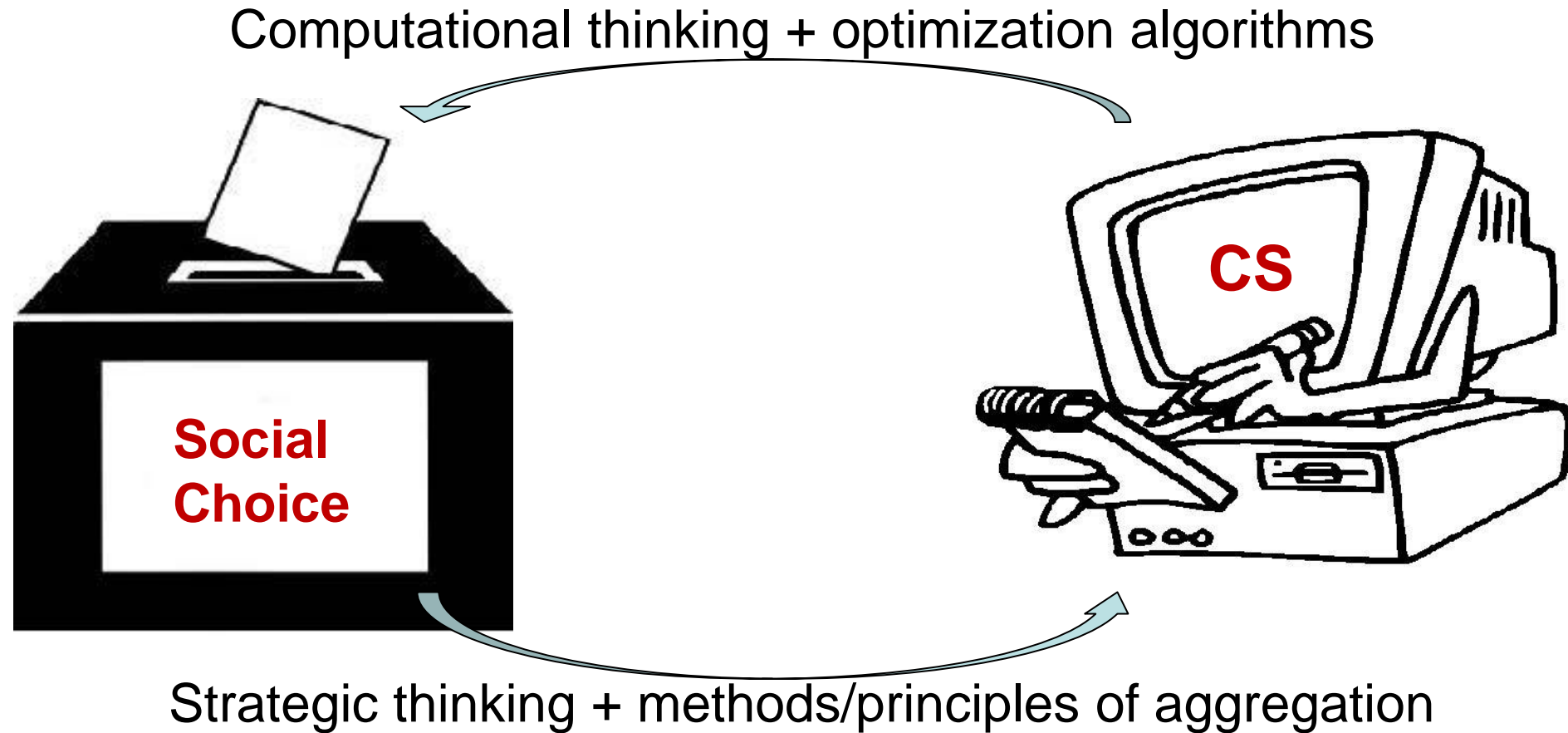
# Computational social choice (COMSOC)

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- *“Computational social choice is an interdisciplinary field of study at the interface of social choice theory and computer science, promoting an exchange of ideas in both directions.”*

---<http://www.illc.uva.nl/COMSOC/>

# Computational Social Choice



- Interdisciplinary field of study at the interface of social choice theory and computer science, promoting an exchange of ideas in both directions.



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How to design a good social choice mechanism?

WHAT IS BEING “GOOD”?

# Two goals for social choice mechanisms

**GOAL1:** democracy



**GOAL2:** truth



# Challenges



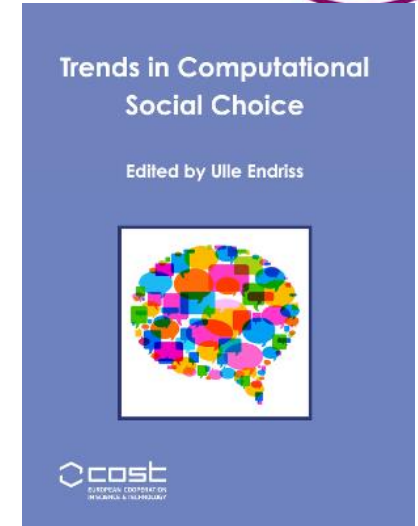
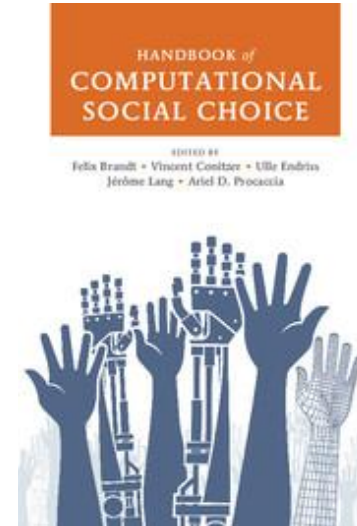
- **Goodness:**
  - democracy: fairness, efficiency, etc
  - truth: accuracy
- **Computation:** how can we compute the outcome as fast as possible
- **Incentives:** what if an agent does not report her true preferences?



# Finding out about New Developments

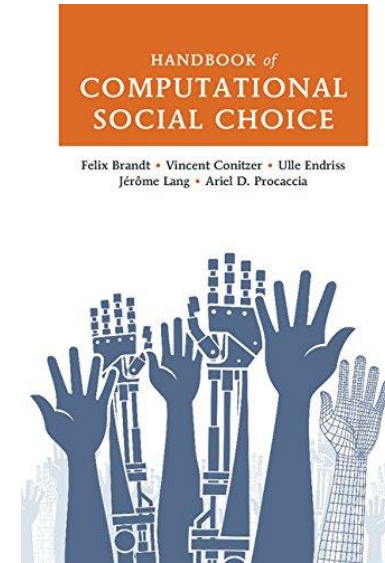


- **The Handbook of COMSOC** (2016) represents the state of the art around 2012, when it was conceived.
- **Trends in COMSOC** (2017) covers several important developments that have taken place since then.
- A lot of work in COMSOC gets published at major AI conferences: AAMAS is the most important multiagent systems conference IJCAI, AAAI, ECAI are the main general-purpose AI conferences
- At the interface with Algorithmic Game Theory (and Theoretical Computer Science more generally), the most important conference is EC.
- In Computer Science most new ideas (first) show up at conferences, but also look at the corresponding journals (JAIR, AIJ, TEAC, JAAMAS).





# Welcome to Join Us



- If you're interested in doing a project/thesis/...on **General Game Playing** and **Computational Social Choice**
- Join us and Contact me at

[G.Jiang@nankai.edu.cn](mailto:G.Jiang@nankai.edu.cn)