COMPUTATIONAL APPLICATIONS TO POLICY AND STRATEGY (CAPS)

Session 1 – Introduction to CAPS

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Outline

1. Admin
2. About CAPS
3. Game Theory, Games and AI
4. StarCraft II
5. AI Policy and AI Strategy
6. Required Software

Workshop Information

- Six sessions from TBA to TBA
- Friday 4:00 to 5:00 pm
- Website (GitHub): https://git.io/fAaJn
- Group: TBA
- Contact me: lklenne1@jhu.edu

Core Resources

> Readings and additional learning resources on our GitHub: https://git.io/fAaJn

Goals

> Leverage state of the art research on AI gameplay to explore in open-ended manner how computational methods can advance IR research
> Cover a lot of ground fast to provide you with a valuable short project and a personal website that augment your SAIS portfolio
> Python is a tool not the primary object of learning itself
> All of the sessions are prepared but we maximize value by working as a team

Workshop Overview

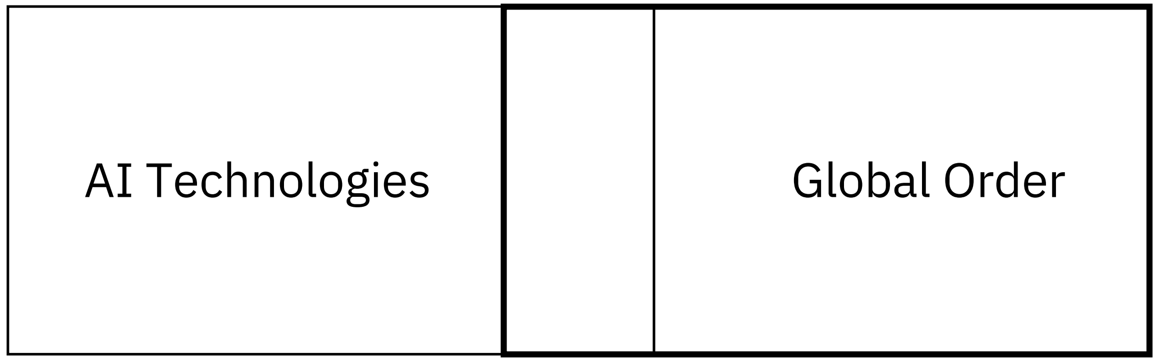
> Session 1: Introduction to CAPS and background on AI and games
> Session 2: Primer on Python
> Session 3: StarCraft II recap and building a rule-based bot
> Session 4: Introduction to basic AI and building a learning-based bot
> Session 5: Game data mining and discussion of AI Policy and Strategy
> Session 6: Creating and hosting a free personal website through GitHub

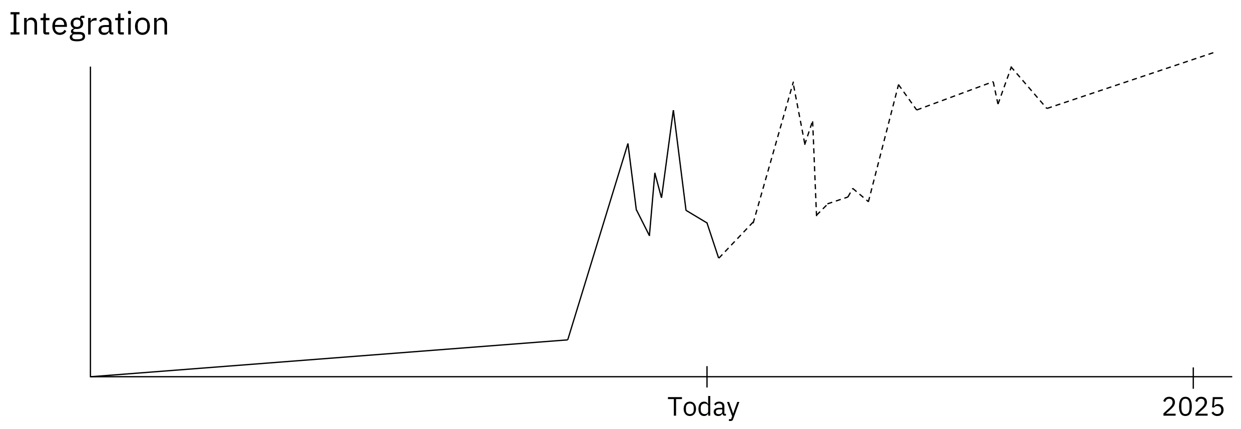
About CAPS

> How can computational methods advance our understanding and practice of international relations?

> Why is it necessary that the IR community at large engages with emerging technologies such as AI?

The Intersection of AI and IR





What are the Consequences?

"The Age of Reason originated the thoughts and actions that shaped the contemporary world order. But that order is now in upheaval amid a new, even more sweeping technological revolution whose consequences we have failed to fully reckon with, and whose culmination may be <u>a world relying on machines powered by data and algorithms and ungoverned by ethical or philosophical norms</u>."

- Henry Kissinger, *How the Enlightenment Ends* (June 2018)

How Companies React

"The only way through our "Crisis of Trust" is adopting a set of core values that allows us to navigate these complex times. We are now all stewards of the ethical & humane use of tech."

- Mark Benioff, CEO Salesforce, Tweet (09/10/2018)

"I think one of the only 'arms races' AI people are excited about is the emerging competition between AI research labs to staff up meaningful policy organizations."

- Jack Clark, Policy Lead OpenAI, Tweet (11/10/2018)

Who is in the AI/IR Market?

AI + AI Policy Labs

DeepMind

OpenAI

Venture and Partnerships

DEFENSE INNOVATION UNIT

PARTNERSHIP ON AI

Applications

Palantir

Hala Systems Inc.

PRIMER

AI Policy Research

Future of Humanity Institute
UNIVERSITY OF OXFORD

DARPA

Oxford Digital Diplomacy Research Group

External Stakeholders

UNDP

facebook

salesforce

Reassessing the Consequences

- Do you think Kissinger‘s prediction is right?
- What might be reasons to disagree with it?

Defining AI

> Russel and Norvig (1995)

a. Systems that think like humans
b. Systems that think rationally
c. Systems that act like humans
d. Systems that act rationally

> Obstacles

a. How do humans solve problems?
b. How to formalize uncertain knowledge?
c. How to successfully pass the Turing Test?
d. How to always do the right thing?

The Rational Agent Approach

> Properties

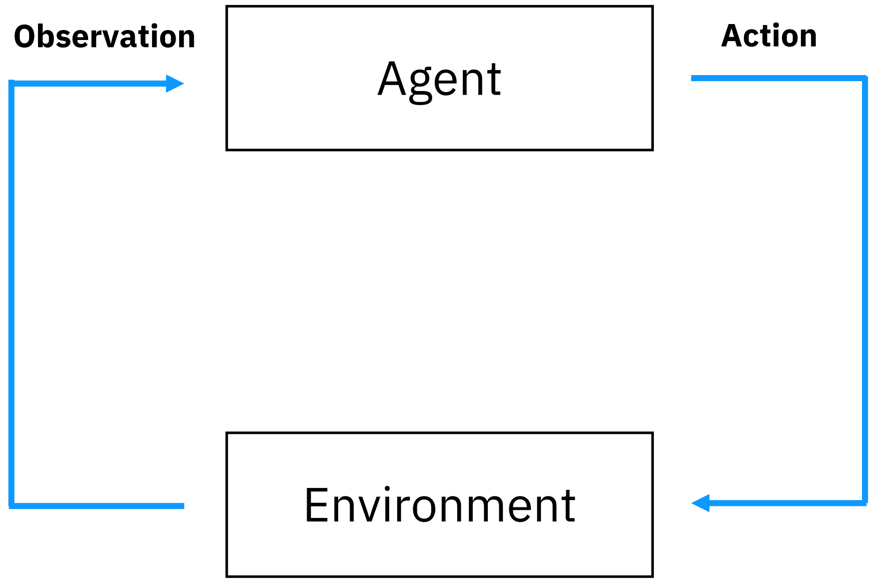
a. Rational agency does not necessarily depend on correct inference
b. Standard for rationality is clearly defined and completely general
c. Limited rationality: can‘t always do the right thing in complicated environments

> Advantages

a. Allows easy comparison between AI and non-AI agents
b. Familiar from game theory and easily relatable to gameplay

Agents Interact with Environments

> General



> Prisoner's Dilemma

P1 \ P2	Cooperate	Defect
Cooperate	(3,3)	(0,5)
Defect	(5,0)	(1,1)

Prisoner’s Dilemma – Agent

Properties of the PD agent	
Behavior	Maximize rewards
Lifetime	1 action
Personality	Homogenous
Memory	No memory
Strategies	Defector, Cooperator, Random, TFT, …

Prisoner's Dilemma – Environment

Properties of the PD environment	
Type	Game theory, non-zero sum
Gameplay	Turntaking
Action space	2 = Cooperate, Defect
Environment states	4 = CC, CD, DC, DD
Rule of transition between states	Discrete, based on the agents' actions
Rewards assigned to each state	3/3, 5/0, 0/5, 1/1
Reward horizon	Instantaneous
Mode of information	Perfect Information
Mode of action	Simultaneous

An Interim Conclusion

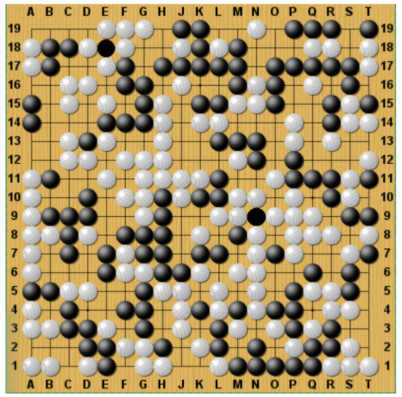
> Intelligent agents are conditioned by their environment

> Consider the environment before you consider the agent

> Games provide powerful, scalable environments

Games and AI

- Two contemporary milestones in AI gameplay



- 1997 Deep Blue beats Garry Kasparov
- Algorithm: Alpha-Beta Search
- Approach: Brute force

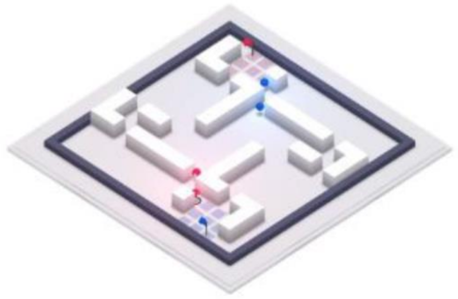
- 2016 AlphaGo beats Lee Sedol
- Algorithm: Hybrid (Neural nets, MCTS)
- Approach: Deep learning

Video Games

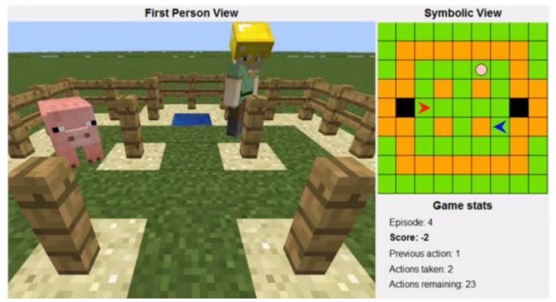
- Computationally more complex than Chess and Go
  - Multi-objective tasks to reach goal
  - Multiple dissimilar units
  - Partial information
  - Long time horizons
  - Continuous action space and environment
- Require teamplay, depending on the type of game
  - Learning cooperation and teamplay is a paradigm shift for agents
  - Opens a host of real-world applications

Recent AI Advances in Video Games

> 2013 Atari DQN
> DeepMind
> Non-cooperative



> 2018 Quake III Arena CTF
> DeepMind
> Hybrid



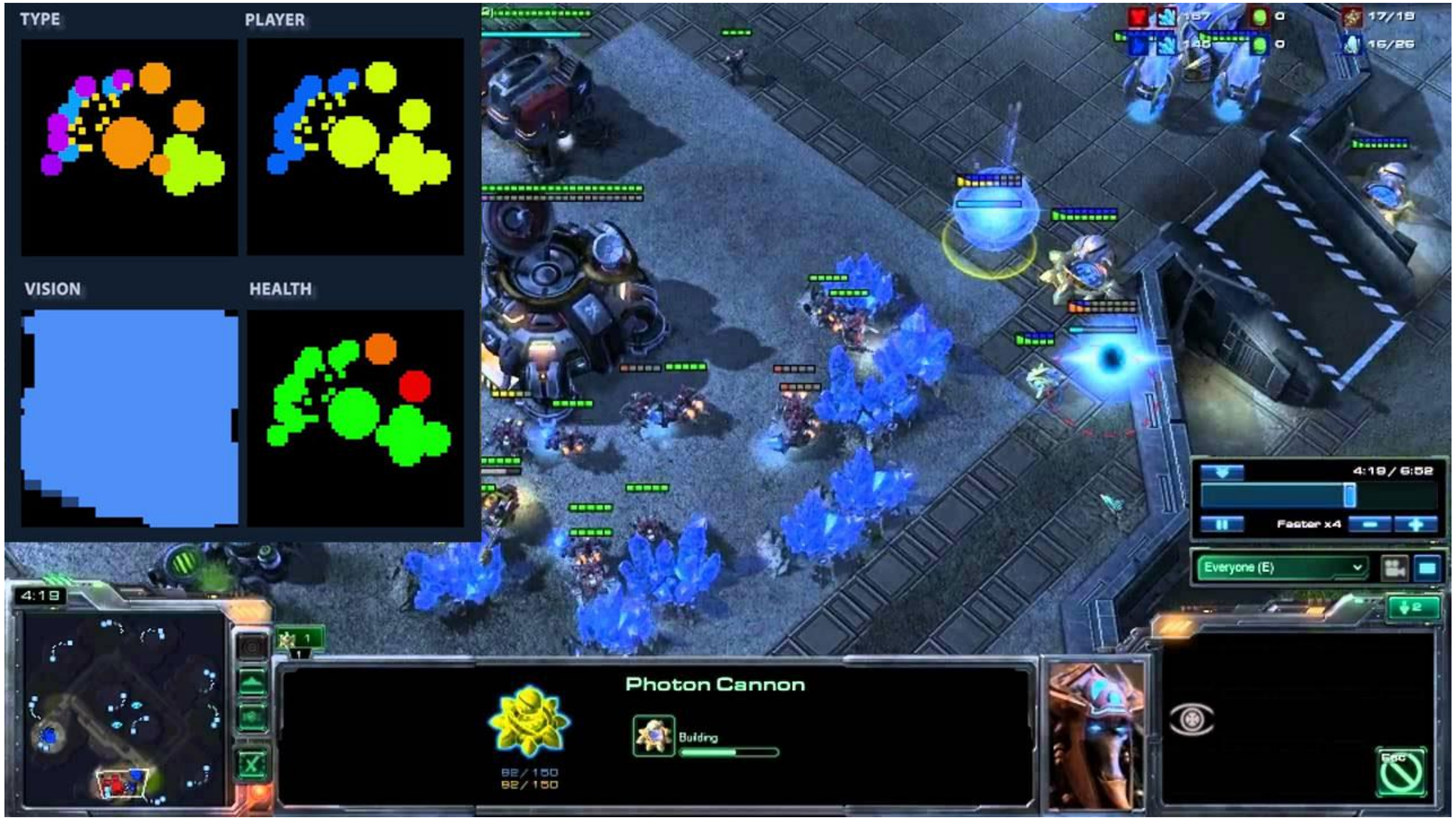
Game stats
Episode: 4
Score: -2
Previous action: 1
Actions taken: 2
Actions remaining: 23

> 2015 Malmo Minecraft
> Microsoft
> Cooperative

OpenAI
Five

> 2018 Five Dota
> OpenAI
> Hybrid

Enter StarCraft II



Screenshot from DeepMind’s pysc2 API

Python for StarCraft II

- 2017: release of the pysc2 and python-sc2 API libraries for StarCraft II
- pysc2 (DeepMind)
  - Vinyals, O., et al. 2017. *StarCraft II: A New Challenge For Reinforcement Learning*
  - Geared towards building advanced reinforcement learning agents
- python-sc2 (Dentosal)
  - Geared towards ease of use for building both rule-based and AI agents

A Basic StarCraft II Agent

- ‘Worker rush’
- Simple example of a rule-based agent < 20 lines of code
- Take everything you have at time t_0 and attack the enemy

- At t_0:
  - Select all workers w_0
  - Send w_0 to attack enemy start location

Code for Worker Rush

> Taken from https://github.com/Dentosal/python-sc2#example

```python
import sc2
from sc2 import run_game, maps, Race, Difficulty
from sc2.player import Bot, Computer


class WorkerRushBot(sc2.BotAI):
    async def on_step(self, iteration):
        if iteration == 0:
            for worker in self.workers:
                await self.do(worker.attack(self.enemy_start_locations[0]))


run_game(maps.get("Simple128"), [
    Bot(Race.Protoss, WorkerRushBot()),
    Computer(Race.Teran, Difficulty.Easy)
    ], realtime = False)
```

StarCraft II – Agent

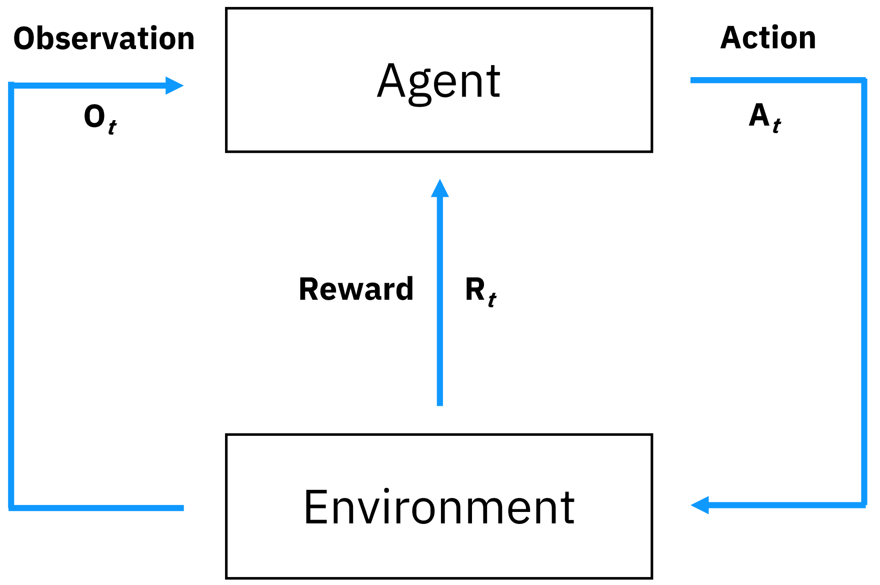
Properties of the SCII agent	
Behavior	Win game
Lifetime	Until defeat
Personality	Asymmetric, 3 different races, multiple 100s of units
Memory	Depends
Strategies	Balance resource management, expanding vs. defense

StarCraft II – Environment

Properties of the SCII environment	
Type	Real-time strategy (RTS) game
Gameplay	Fast paced micro-actions and need for high-level planning
Action space*	10^8, need for hierarchical actions
Environment states**	$10^{1,685}$
Rule of transition between states	Continuous, based on the agents' actions
Rewards assigned to each state	Unknown
Reward horizon	Long pay-off = strats more important than micro
Mode of information	Fog of war = imperfect information
Mode of action	Simultaneous

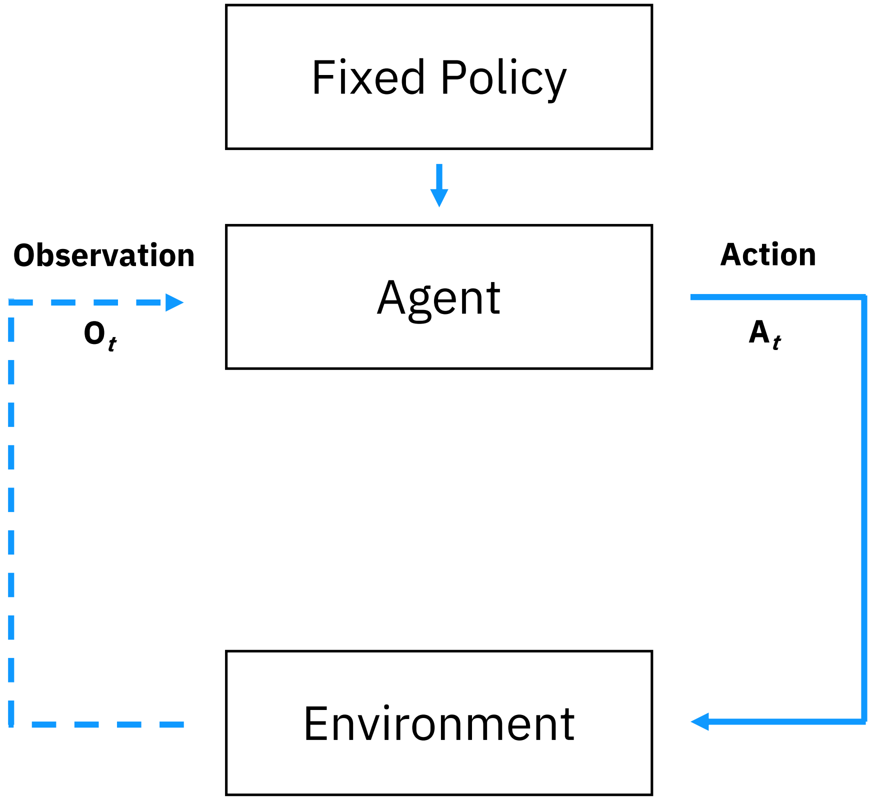
* Vinyals, O., et al. 2017. *StarCraft II: A New Challenge for Reinforcement Learning.* https://arxiv.org/abs/1708.04782
** Estimated for StarCraft Brood Wars. Usunier, N., et al. 2016. *Episodic Exploration for Deep Deterministic Policies: An Application to StarCraft Micromanagement Tasks.* https://arxiv.org/abs/1609.02993

Agent-Environment Loop 1



- At each step t the agent
  a. Exectues action A_t
  b. Receives observation O_t
  c. Receives scalar rewar R_t
- The environment
  a. Reveives action A_t
  b. Emits observation O_{t+1}
  c. Emits scalar reward R_{t+1}
- *t* increments at environment step

Agent-Environment Loop 2



> At each step t the agent
  a. Exectues action A_t based on fixed policy
  b. Receives observation O_t
> The environment
  a. Reveives action A_t
  b. Emits observation O_{t+1}
> *t* increments at environment step
> Observations restricted by fixed policy

Differences between Loop 1 and Loop 2

- Loop 1
  a. Reward enables utility max.
  b. Utility max. enables learning
  c. Learning enables dynamic actions
  d. Dynamic actions enable adaption
  e. **AI** (reinforcement learning)

- Loop 2
  a. No reward, hence no utility
  b. No utility, hence no learning
  c. No learning, hence static actions
  d. Static actions, hence no adaption
  e. **Rule-based**

Respective Pros and Cons

> Loop 1
  a. Accommodates complex actions
  b. Requires meaningful rewards
  c. Underperforms in ‘mute’ env.
  d. Weakly predictable actions

> Loop 2
  a. Complexity constrained by coded rules
  b. Does not depend on rewards
  c. Constant actions across environments
  d. 100% predictable actions

> In theory, AI > rule-based. In practice, heavily dependend on environment.

Hard Trade-Offs

- > Assuming that you have only limited knowledge about the environment and only one shot at success, which approach would you chose? Why?
- > Would your answer change if you had more than one shot at success?

Framing the Trade-Offs

- The global implementation of AI brings about a host of questions
- AI Policy and AI Strategy have emerged as fields to provide answers
- **AI Policy**
  - Analysis and practive of societal decision-making about AI
- **AI Strategy**
  - Long-term conceptual analysis of AI developements
- While IR is recoginzed as a valuable discipline, the community has yet to leverage its potential.

Challenge

> We need to integrate both the computational tools and the debate on implementing AI into IR thinking

> What are useful points of contact between AI and IR?

> Where do you see overlap and potential for applications?

Summary

> AI is having an increasing impact on the global order

> Stakeholders are looking for meaningful ways to respond

> Clear definitions of AI are needed to mitigate uncertainty

> The rational actor approach to AI offers high explanatory power

> Games and game theory can be used to develop AI agents

> Current video games present highly complex challenges for AI

> One of the games with the most strategic depth is StarCraft II

> Two Python APIs allow building AI and rule-based agents for StarCraft II

> The IR community needs to integrate these tools into its thinking and practice

Required Software

- For next week you only need Pyhton. We will install more stuff along the way.
- Python 3.6.6
  - https://www.python.org/downloads/release/python-366/
- Python-sc2
  - via command line: pip install sc2
- StarCraft II (free to play)
  - https://us.battle.net/account/download/
  - This will take some time so best to do it at home
- StarCraft II maps
  - https://github.com/Blizzard/s2client-proto#map-packs
  - Once installed, extract the maps as subdirectories into StarCraft II's map directory
  - Do this after you have installed StarCraft II