On measuring social intelligence: experiments on competition and cooperation

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Outline

- Introduction
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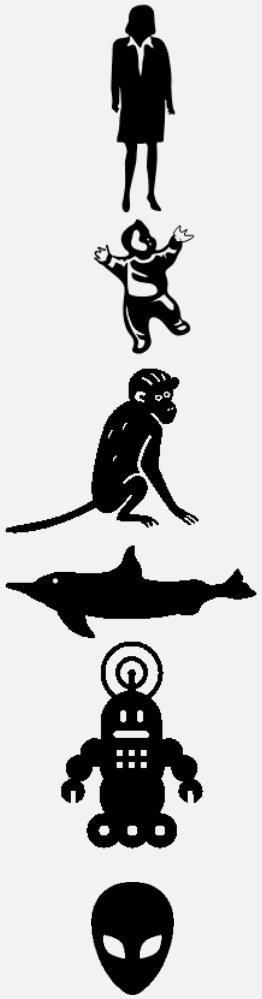
Introduction



- Can we construct a ‘universal’ intelligence test?

Project: **anYnt** (Anytime Universal Intelligence)

http://users.dsic.upv.es/proy/anynt/

- Any kind of system (biological, non-biological, human).
- Any system now or in the future.
- Any moment in its development (child, adult).
- Any degree of intelligence.
- Any speed.
- Evaluation can be stopped at any time.

Introduction

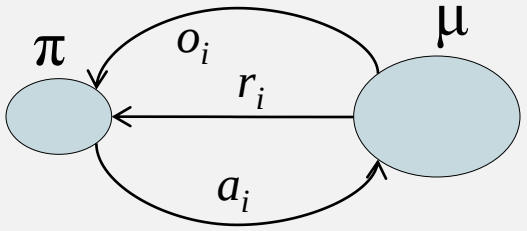
- Intelligence as a cognitive ability:
  - General Intelligence: Capacity to perform well in any kind of environment.
  - Social Intelligence: Ability to perform well in an environment interacting with other agents.

- Objectives:
  - Create a universal test to evaluate general intelligence.
  - The test must be defined in a formal way.

Universal tests and social intelligence

- Universal Intelligence (Legg and Hutter 2007).

$$\Upsilon_U(\pi) \triangleq \sum_{\mu \in \mathbb{E}} p_U(\mu) \cdot V_\mu^\pi = \sum_{\mu \in \mathbb{E}} 2^{-K_U(\mu)} \cdot E\left(\sum_{i=1}^{\infty} r_i^{\mu,\pi}\right)$$



= performance over a universal distribution of environments.

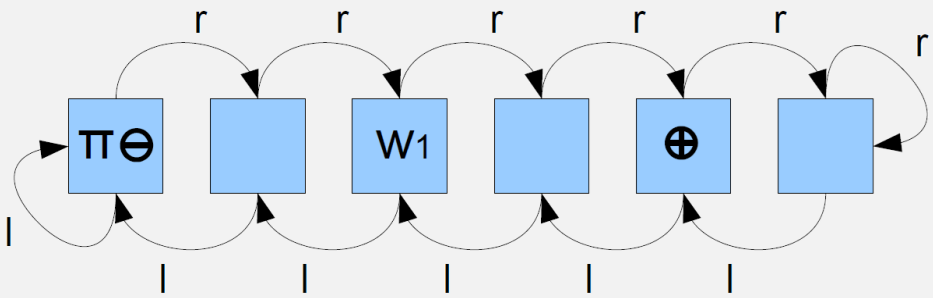
- An intelligence test can be seen as a definition of intelligence.
  - Turing Test enhanced with compression (Dowe and Hajek 1997)
  - Intelligence tests based on Kolmogorov Complexity (Hernandez-Orallo 1998)
- But a definition of intelligence does not ensure an intelligence test.
  - Anytime Intelligence Test (Hernandez-Orallo and Dowe 2010).
  - An environment class Λ (Hernandez-Orallo 2010) (AGI-2010).

Universal tests and social intelligence

- Anytime Intelligence Test (Hernandez-Orallo and Dowe 2010).
  - An interactive setting following (Legg and Hutter 2007) which addresses:
    - Issues about the difficulty of environments.
    - The definition of discriminative environments.
    - Finite samples and (practical) finite interactions.
    - Time (speed) of agents and environments.
    - Reward aggregation, convergence issues.
    - Anytime and adaptive application.

Universal tests and social intelligence

- An environment class Λ (Hernandez-Orallo 2010) (AGI-2010).
  - Spaces are defined as fully connected graphs.
    - Actions are the arrows in the graphs.
    - Observations are the ‘contents’ of each edge/cell in the graph.



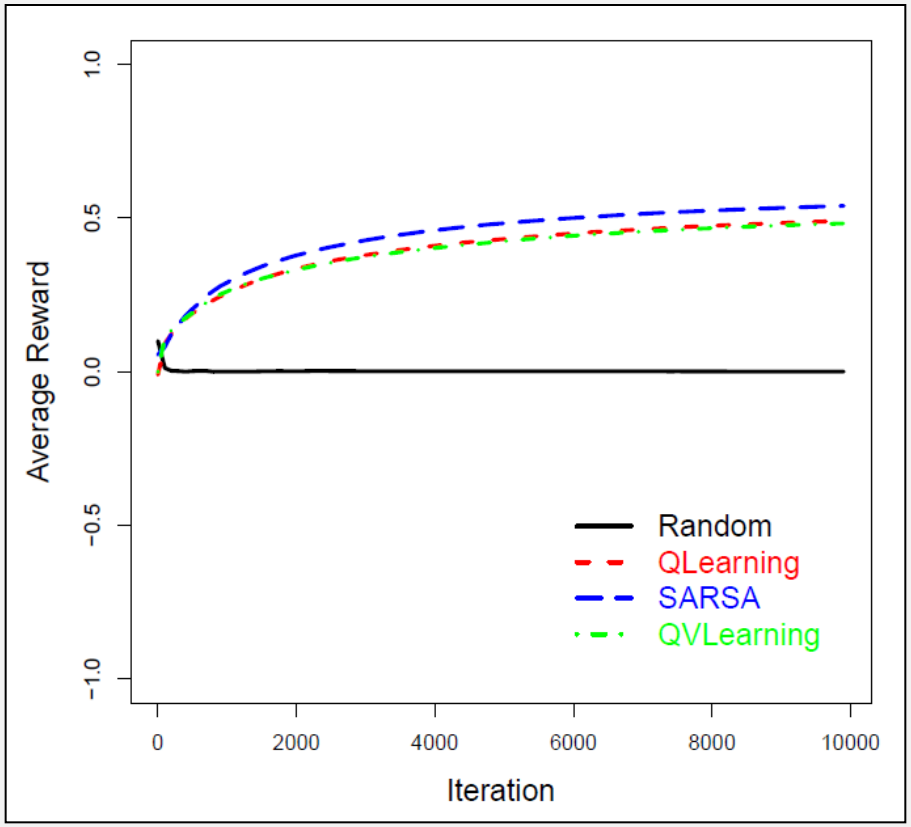
    - Agents can perform actions inside the space.
    - Rewards: Two special agents Good ($\oplus$) and Evil ($\ominus$), which are responsible for the rewards.

Universal tests and social intelligence

- Evaluate general intelligence of different systems.
  - Experiments concluded that the test prototype is not universal (Insa-Cabrera et al. 2011) (AGI-2011).
  - Environments rarely contain social behaviour. Environment distributions should be reconsidered: Darwin-Wallace distribution (Hernandez-Orallo et al. 2011) (AGI-2011).
- Goal: modify the setting to include some social behaviour.
  - Test whether social behaviour better discriminates between humans and machines.
  - Introduce simple agents in the environments.
  - Examine the impact of competitive and cooperative scenarios on the performance of the agents.

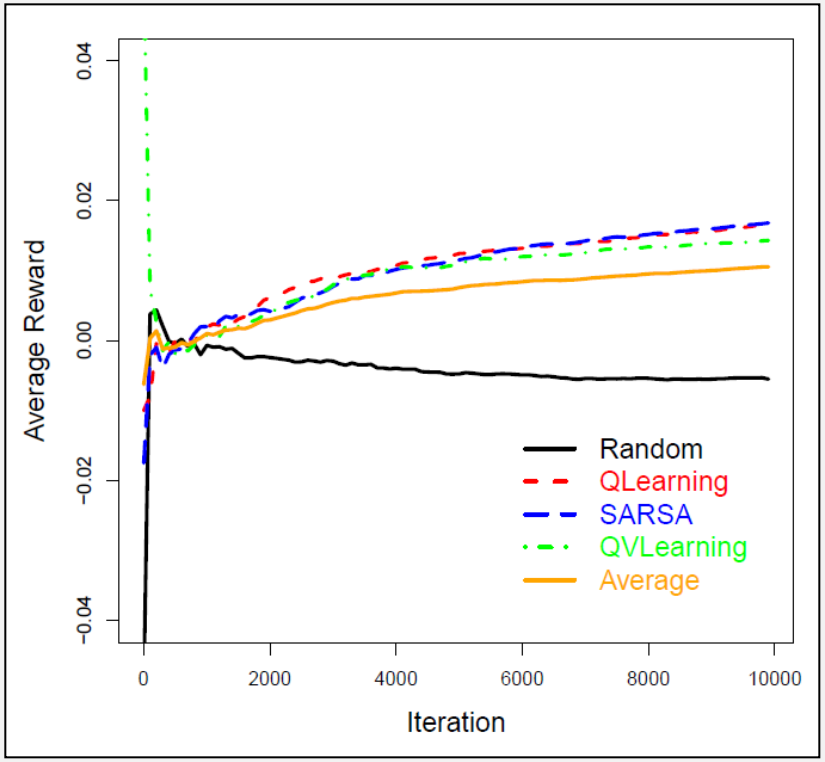
Evaluation: Competition and Cooperation

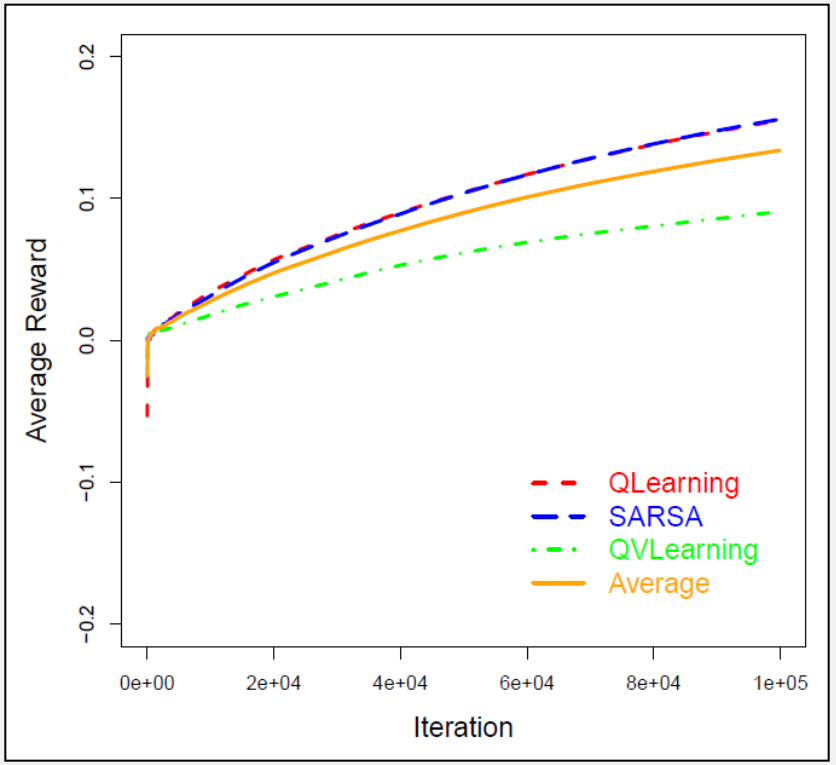
- Reinforcement Learning algorithms:
  - Q-learning
  - SARSA
  - QV-learning
- Simple algorithm
  - Random



Evaluation: Competition and Cooperation

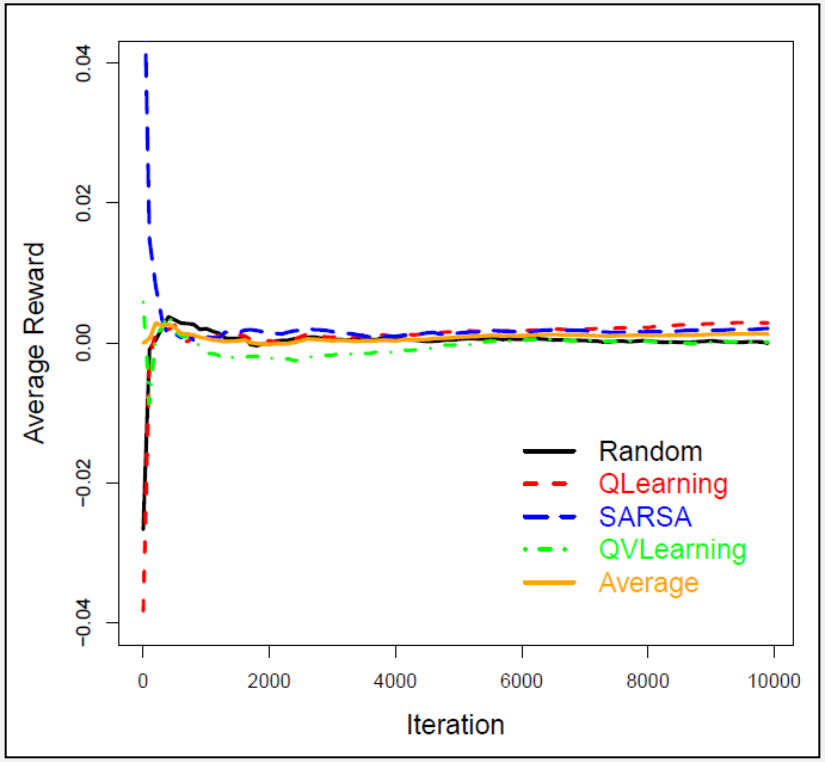
- Competition:
  - All the agents compete for rewards.

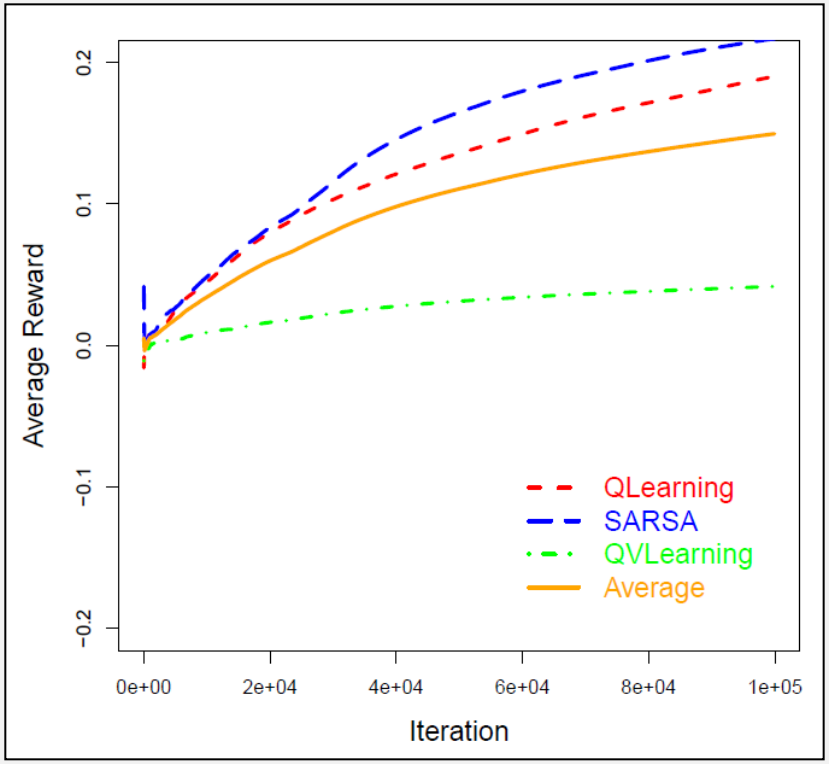




Evaluation: Competition and Cooperation

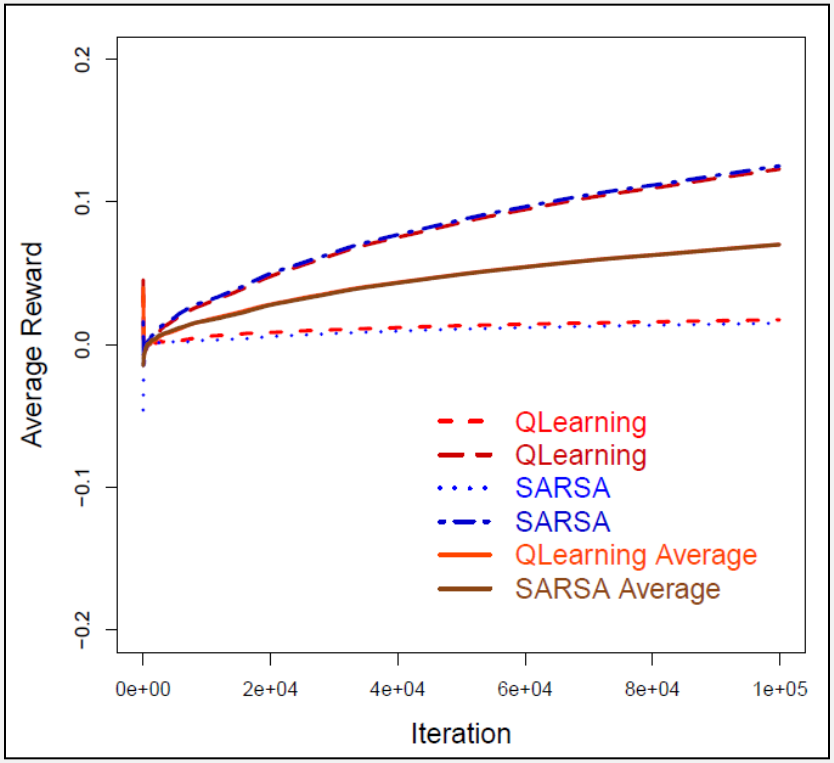
- Cooperation:
  - The agents receive the average of obtained rewards.





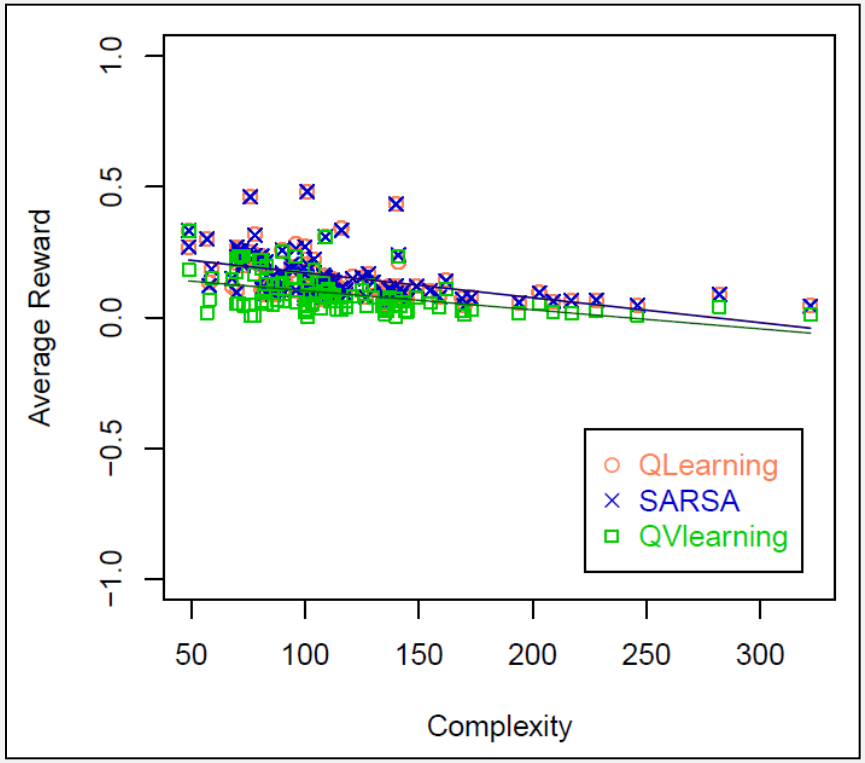
Evaluation: Competition and Cooperation

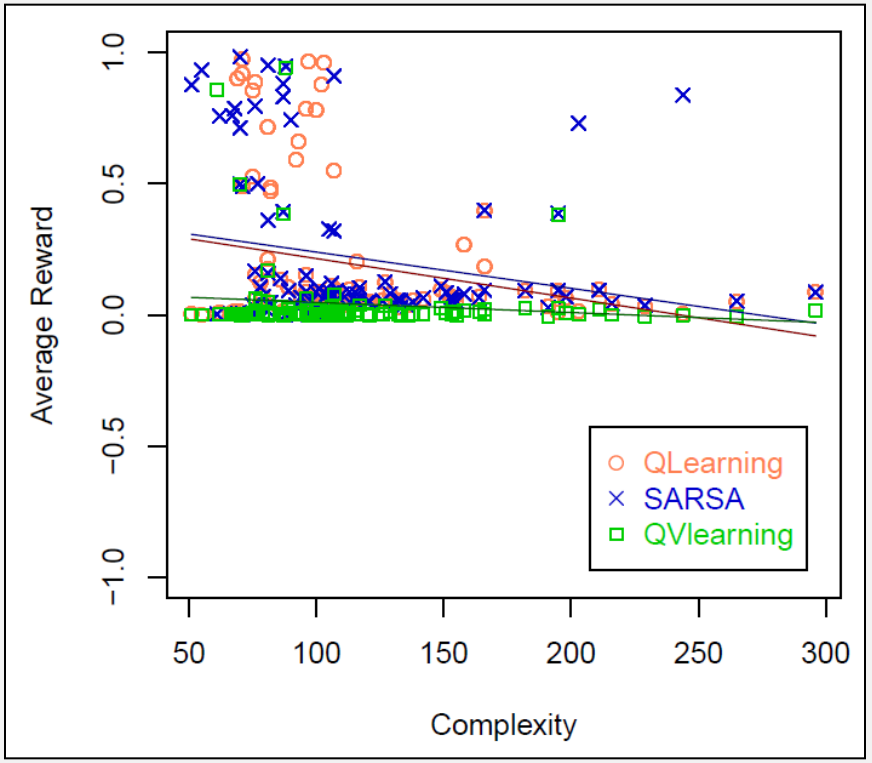
- Teams:
  - Two teams (Qlearning vs SARSA) compete for rewards.
  - Competition and cooperation.



Evaluation: Competition and Cooperation

- Complexity (Lempel-Ziv approximation):
  - The complexity of the environment (solely) barely affects the results.
  - The complexity of other agents makes the environment more difficult.





Discussion

- The inclusion of other agents (even random) make other agents perform worse.
  - RL algorithms increase their cost matrix.
  - Algorithms should learn to deal with ‘noise’.

- Complexity increases with the inclusion of social behaviour.
  - The complexity of the environment is more related to the complexity of the other agents.
  - We need to calculate first the complexity (or intelligence) of the other agents included in the environment.

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Thank you!