ARTIFICIAL INTELLIGENCE

Master degree

2023/2024

Ivan Bratko

TEACHERS

- Lectures

  Ivan Bratko

- Practical work

  Aleksander Sadikov, Jure Žabkar

TIME TABLE

- Thursdays 14 – 17h, P22

STUDENTS' BACKGROUND?

- Course Introduction to AI? (Osnove umetne inteligence)
- Problem solving and search in AI?
- Planning in AI (STRIPS-like problem definition, means-ends)?
- Machine learning?

CONTENTS

- This course requires some knowledge from the course Introduction to AI

- Therefore the contents is organized as:

  - Quick coverage of prerequisites
  - Proper (new) topics

INTRODUCTORY CONTENTS:

Quick repetition of some topics from course Introduction to AI

- Basic search techniques: uninformed techniques, heuristic search, algorithms A* and IDA*

- Basic planning methods (total-order planning): STRIPS-like definition of planning domain, basic means-ends planning, regression planning

CONTENTS:

Proper new topics

- **Advanced heuristic search techniques:**

  space-efficient algorithm RBFS (Recursive Best First Search),

  real-time problem solving (algorithms RTA*, LRTA*)
- **Reinforcement learning**
- **Partial-order planning methods:**

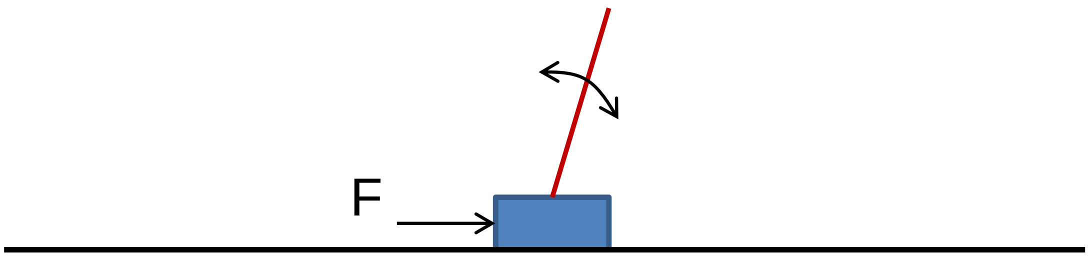
  POP algorithm; planning as constraint satisfaction: GRAPHLAN
- **Qualitative reasoning, modelling and learning**
- **Learning in logic (inductive logic programming, ILP)**

PREVIEW OF SOME TOPICS

REINFORCEMENT LEARNING (RL)

- **RL is a very popular learning setting**
- **Applicable to dynamic environments**
- **It is about making *sequences* of decisions**
- **Distinguishing feature: “delayed reward”**
- **Famous successes: AlphaGo, AlphaZero**

A CLASSICAL EXAMPLE: POLE-CART



- Control force F = +1 or -1 (bang-bang regime)
- Mathematical model of pole-cart assumed not available
- Task 1: Find control F in time to avoid pole falling
- Task 2: Find control F in time to move cart from start to goal position while avoiding pole falling
- Note: feedback only occurs when pole falls, or cart at goal
- This is very late, “delayed reward”, this makes problem hard
- How is this stated formally in RL?
- Reinforcement learning is **the** method for this

OTHER EXAMPLES OF REINFORCEMENT LEARNING TASKS

- Balancing double or triple pendulum (cart and triple pole)
- Acrobot, mountain car, pendulim, HalfCheetah (Open AI Gym)
- Learn to fly a helicopter or quadcopter
- Exploring maze-like environments
- Playing complex games: total reward (success) only known at end of game

DEMOs

- http://www.youtube.com/watch?v=a4c7AwHFkT8

  Classic control of inverted pendulum (Enfield)
- http://www.youtube.com/watch?v=Lt-KLtkDlh8

  RL learning to swing up pole on cart (Martin Riedmiller)
- https://www.youtube.com/watch?v=EwrQEsFmL4E

  (New version of mechanism, balancing on two connected wheels)
- https://www.youtube.com/watch?v=FeCwtvrD76I

  (Acrobot controller)
- http://www.youtube.com/watch?v=cyN-CRNrb3E&feature=related

  (Triple pendulum, acrobot-like)
- hhttp://www.youtube.com/watch?v=f6GpehgzY4w&feature=related

  (Flying inverted pendulum)
- https://www.youtube.com/watch?v=3CR5y8qZf0Y

  (Flying ball juggling)

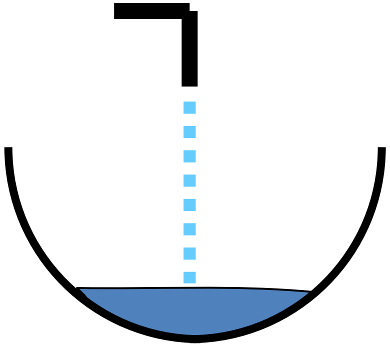
QUALITATIVE REASONING, A PREVIEW

- Here, we want to reason about physical systems without use of numbers

- That is, reason **qualitatively** rather than quantitatively

Bath tub example

- What will happen?



Amount A of water will keep increasing,
so will level L,
until the level reaches the top.

Qualitative reasoning

- Why model qualitatively? Advantages: Can use rather simple, abstract models, only knowing approximate relations
- How can the computer reason with qualitative models, without numbers, in the style of **common sense**?
- Qualitative reasoning about static and dynamic systems
- QSIM algorithm for qualitative simulation
- Qualitative models are easier to learn than quantitative models

INDUCTIVE LOGIC PROGRAMMING, ILP

- Machine learning in logic, program synthesis
- E.g.

  Positive examples of sorting:

  [2,1,3] → [1,2,3],

  ...

  Negative examples:

  [2,1] → [5],

  [2,1,3] → [2,3,1],

  ...

  ILP constructs a sorting program, e.g. quicksort
- ILP can use, in principle, general **background knowledge** (knowledge known prior to learning)

STUDENT'S PROJECT

- Projects in selected topics, e.g.:
  - reinforcement learning by a robot
  - reinforcement learning to play a video game, e.g. angry birds
  - robot task planning
  - typing by looking (with eye tracker)
  - control by thinking (EEG)
  - ...
- Project: condition for admission to exam; may also earn bonus for exam

- Required: report, presentation

- Projects can be individual or in teams (encouraged)