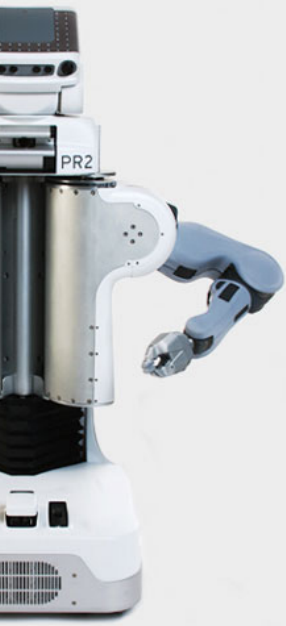

AI & Robotics: Lab Course

Introduction

Marc Toussaint
Technical University of Berlin
Summer 2020

Short Bio

- Stations
  - Since 2012 Prof. @ U Stuttgart, introductury teaching (AI, ML, Robotics)
  - 2017/18: 1yr MIT sabbatical, 3 months manager at Amazon
  - PhD in Evolutionary Algorithms(!) and Neural Networks(!)
  - After that: Doing ”proper things”: PostDoc in ML in Edinburgh
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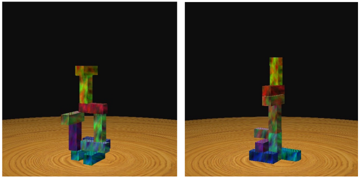
- Research:
  - Naively: What’s going on when we think? (representations, computations)
    - Probabilistic Inference, Decision Theory, Markov Decision Processes, Reinforcement Learning, POMDPs, factored and relational representations in all these
  - Later: Consider much more the REAL world
    - representations & abstractions for the real world
    - ROBOTICS, control, motion, MANIPULATION
    - General Purpose Physical Reasoning:
      Reason about anything doable in a Newtonian world

Physical Reasoning & Manipulation



Battaglia, Hamrick & Tenenbaum, PNAS'13

(Wolfgang Köhler, 1917)

- What are computational models for physical reasoning?
- Reason about anything doable in a Newtonian world

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- Physical Reasoning is under-researched
  - Lots of methodologies for physical modelling, but not reasoning
  - Focus of main-stream RL: specific skills $\rightarrow$ generalization to anything conceivable in a Newtonian world
  - Robotics: task and motion planning
  - Cognitive Science needs models

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- Core challenge in robotics

Inverting Physics

- In analogy to inverting graphics
  Given desired outcomes, what inputs do we have to send to physics?

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- Differentiable Physics:
  - Todorov: A convex, smooth and invertible contact model for trajectory optimization. ICRA'11
  - de Avila Belbute-Peres & Kolter: A Modular Differentiable [..] Physics Engine. NIPS'17 workshop
  - Mordatch et al: Discovery of complex behaviors through contact-invariant optimization. TOG'12
  - Note: Local(!) differentiation through KKT conditions of constrained optimization

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- *Gradients are powerful, but can they alone solve our problem?*
  - would contradict known complexity of task and motion planning
  - 'zero gradients' or local optima
  - discrete decisions translate to *combinatorics of local optima*

vids

- Describing Physics For Physical Reasoning: Force-based Sequential Manipulation Planning
  https://www.youtube.com/watch?v=YxKuVit_23E
- Differentiable Physics and Stable Modes for Tool-Use and Manipulation Planning https://www.youtube.com/watch?v=-L4tCIGXKBE
- More
  https://www.youtube.com/channel/UC9ANVqaEC0iM9aZr88sHK3A

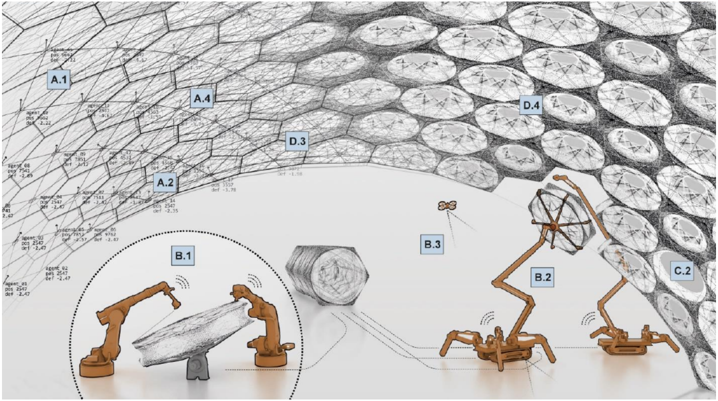
Planning → Execution

- So far, LGP only describes how to compute plans – execution of these plans is a different beast

- → *Learning to Execute Plans*

IntCDC

- Excellence Cluster in Integrated Computational Design and Construction



Questions?

Official Module Description

- Learning Outcomes:
  - The students can program robotics systems to perform object manipulation tasks. To this end, they can integrate basic methodologies covered by other introductory courses, in particular motion generation and perception, potentially also machine learning, task planning, and mobile navigation.
- Content:
  - In this practical lab course students will directly work with robotic systems. The major time is spend on practically solving (coding) a series of problems, with direct supervision by the instructor during the session. In some lectures the instructor introduces basic concepts. The series of problems includes, for instance,
    - generation of basic motion on the robot system,
    - leveraging state-of-the-art motion planning and optimization,
    - perceiving objects and mapping them into virtual representations,
    - pointing to, grasping, and pushing objects,
    - realizing longer manipulation sequences,

    and a more involed project at the end. Students are expected to work also offline, as homework, on these problems.

Official Module Description

- Desirable prerequisites for participation in the courses: Students should have
  - in depth knowledge in robotics (passed a robotics course)
  - basic knowledge in AI and machine learning
  - ADDED: good programming skills in python, perhaps C++, familiarity with git

  If these prerequisits are not met, the iunstructor needs to approve participation

- 180h (6LP)

- Portfolio examination:
  - Implementation and documentation: 25%, written, throughout the course
  - Practical tasks: 50%, practical, about 4 tasks throughout the course
  - Presentation of the solutions and a final project: 25%, oral, 5-10 minutes per week, plus 30 minutes final presentation

- This module is used in the following module lists:

Organization

- See `https://www.user.tu-berlin.de/mtoussai/new-at-tu-berlin.html`

- Tutors (contact them via slack)
  - Jung-Su Ha (PostDoc)
  - Ingmar Schubert (1yr PhD)

- Group work
  - 2-3 people
  - collaborate on exercises and project

Course Webpage with Instructions

- https://marctoussaint.github.io/robotics-course/
- https://github.com/MarcToussaint/robotics-course