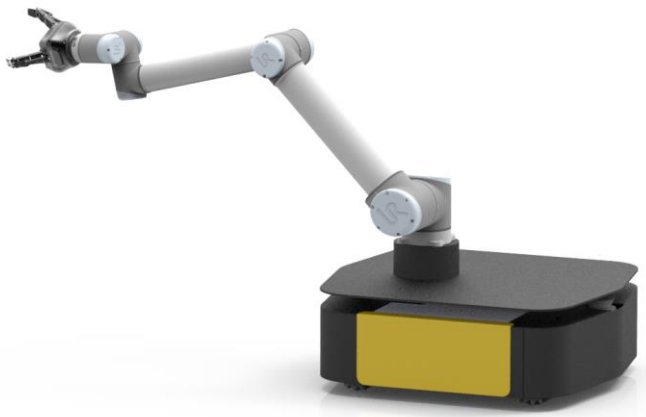
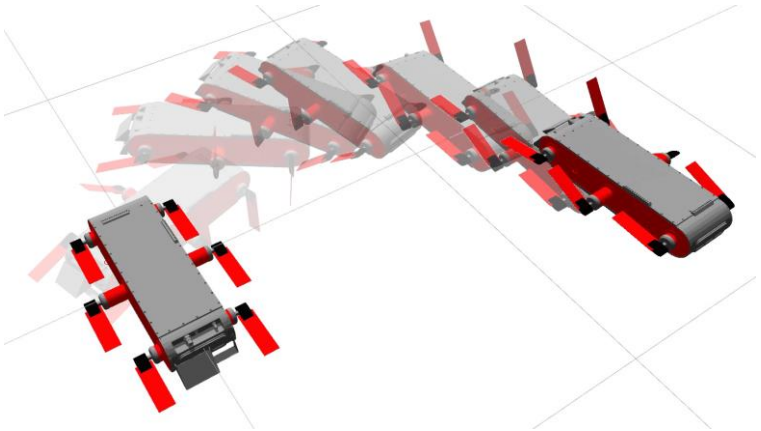




Welcome to Intelligent Robotics

McGill COMP 765

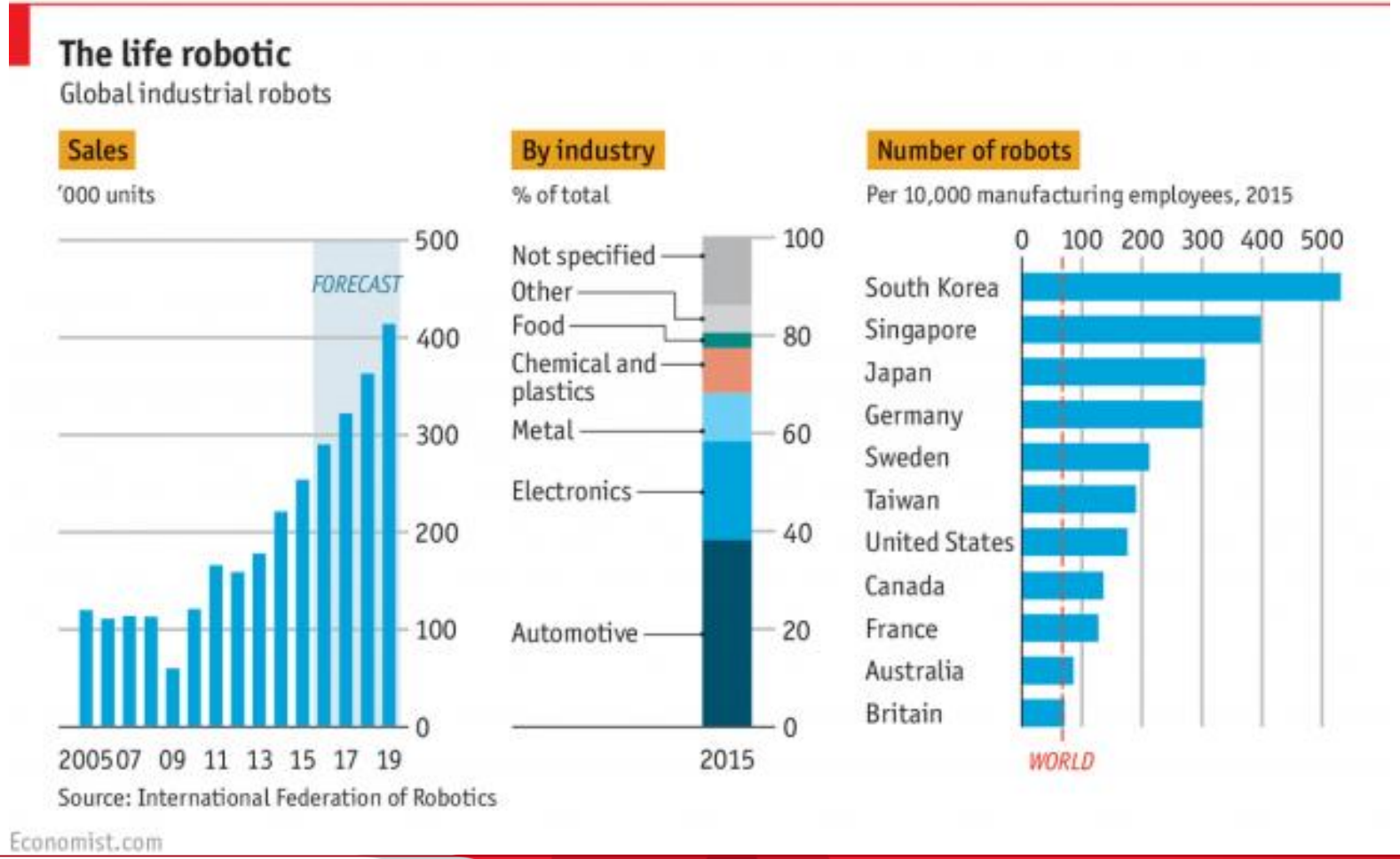
Sept 5th, 2017

Robotics Today

- The intersection of rocket science and machine learning
- A collaborative, team-oriented discipline practiced by children, high-school teams, DIY'ers, start-ups and the world's largest corporations
- A global industry predicted to become one of the largest sectors in the next decades
- Our best tool to explore space and to improve productivity globally

- ***Our main focus***: an active, growing research discipline that attempts to solve the problems introduced by the above needs

A quick tour: robotics industry



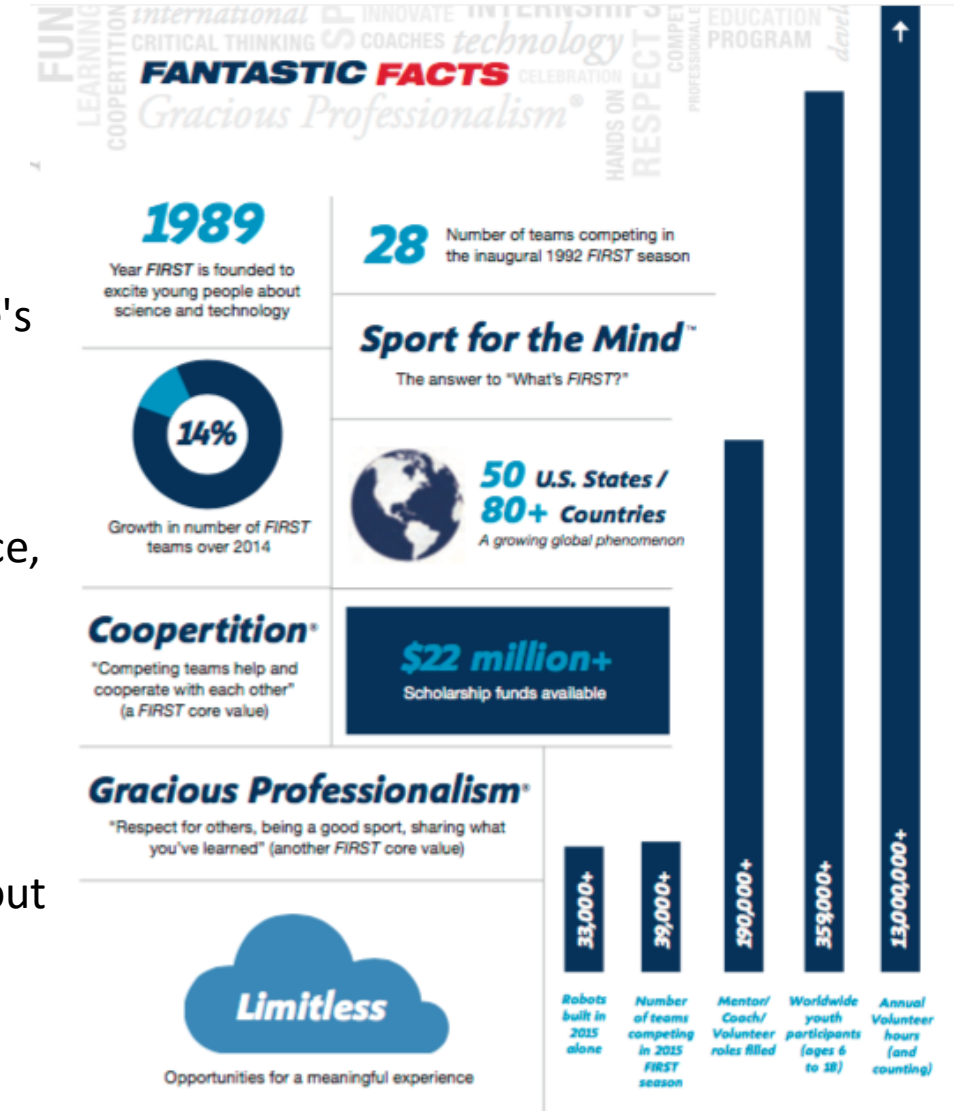
A quick tour: high school robotics

Founder:
Dean Kaman

*FIRST (***F**or **I**nspiration and **R**ecognition of **S**cience and **T**echnology) was founded in 1989 to inspire young people's interest and participation in science and technology. Based in Manchester, NH, the 501(c)(3) not-for-profit public charity designs accessible, innovative programs that motivate young people to pursue education and career opportunities in science, technology, engineering, and math, while building self-confidence, knowledge, and life skills.

FIRST is **More Than Robots.** *FIRST* participation is proven to encourage students to pursue education and careers in STEM-related fields, inspire them to become leaders and innovators, and enhance their 21 st century work-life skills. Read more about the Impact of *FIRST.*

2016 Finals Competition Video

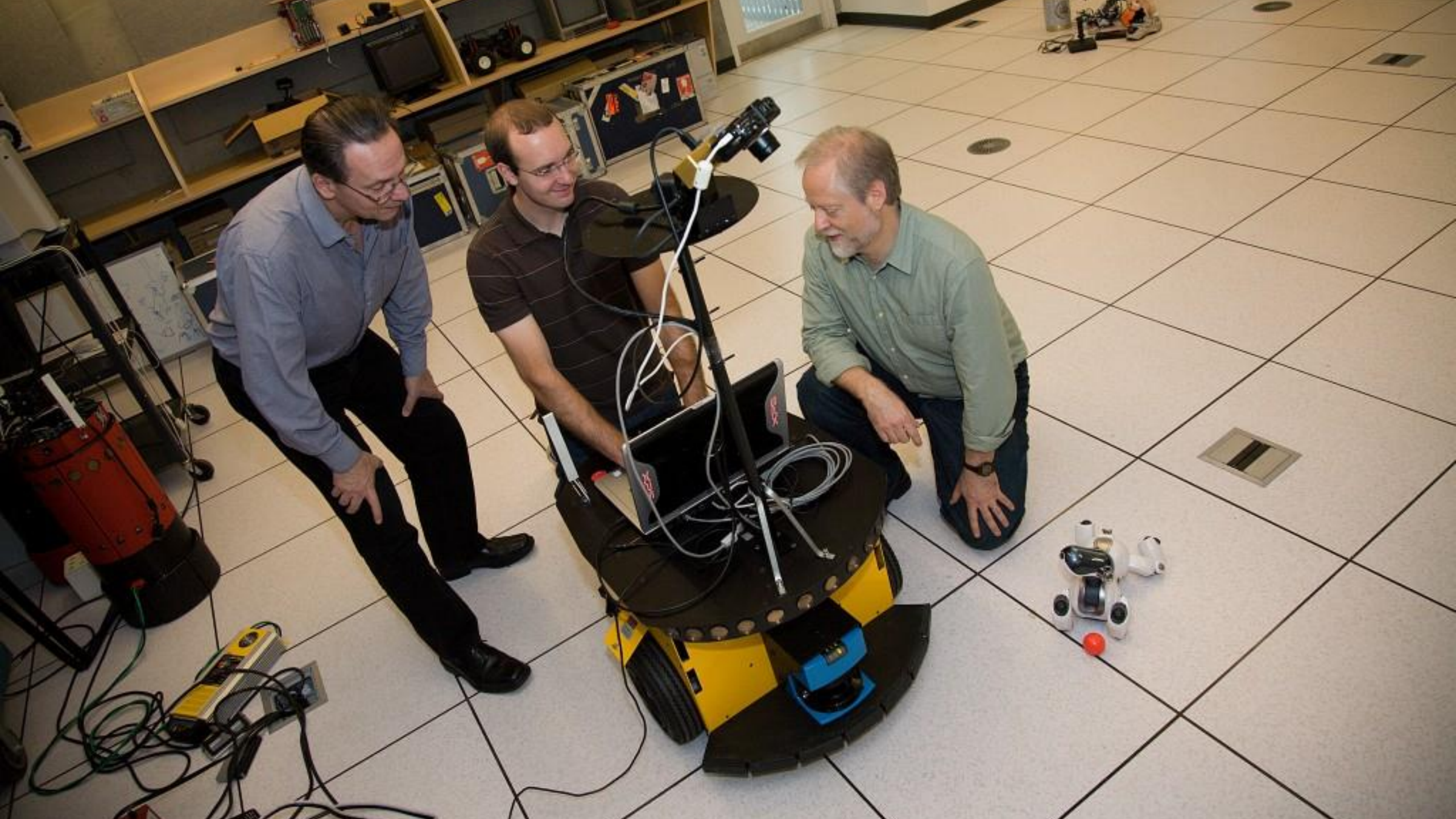



RoboCup 2015
CMDragons (4) vs. (0) MRL
x0.5 Replay


Inspired by XKCD (http://xkcd.com/149/)

Introductions

- I'm David Meger:
  - 3rd year as Professor at McGill
  - Co-Director of the Mobile Robotics Lab
  - Specialties are visual perception for robotics and robot systems that learn (some slides and highlights coming soon)
- I'm happy to meet you! Can you tell me:
  - If you have any previous robotics experience
  - What do you hope to learn in the course
  - Do you have any questions and concerns (can be postponed to the end of lecture if you want to wait and see)

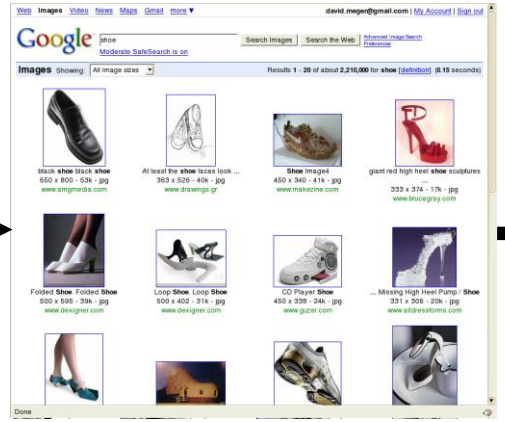


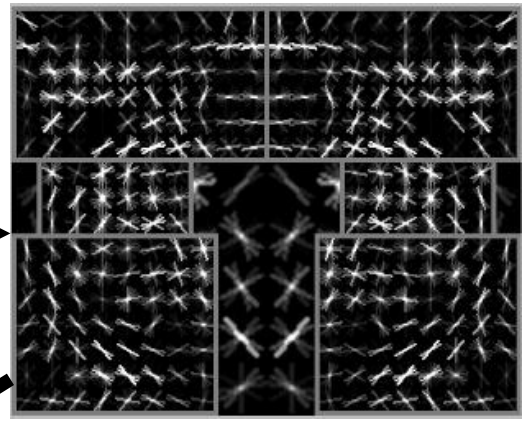
frying pan

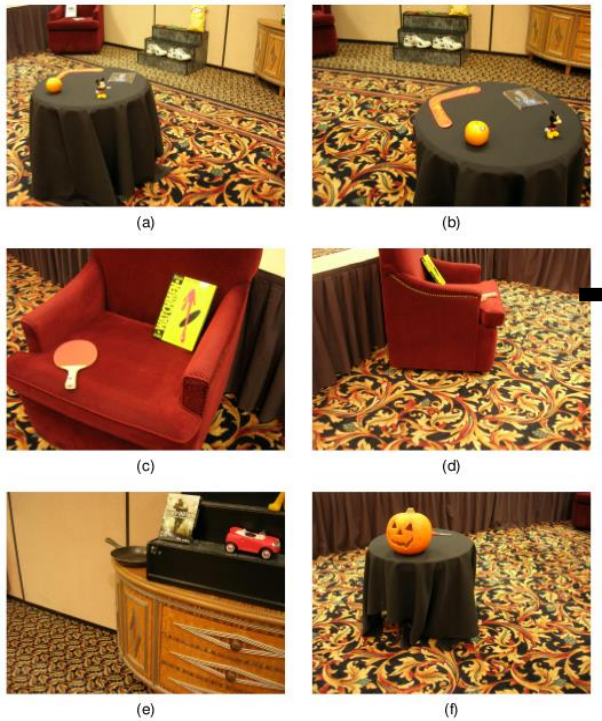
book

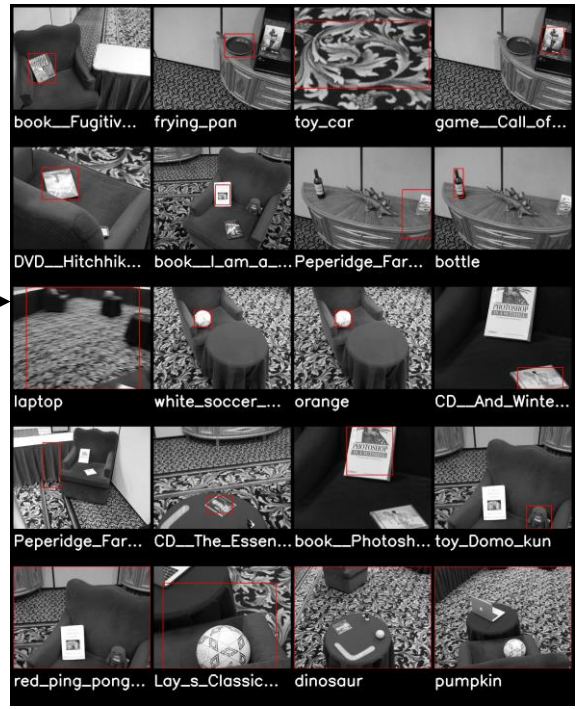
orange

...

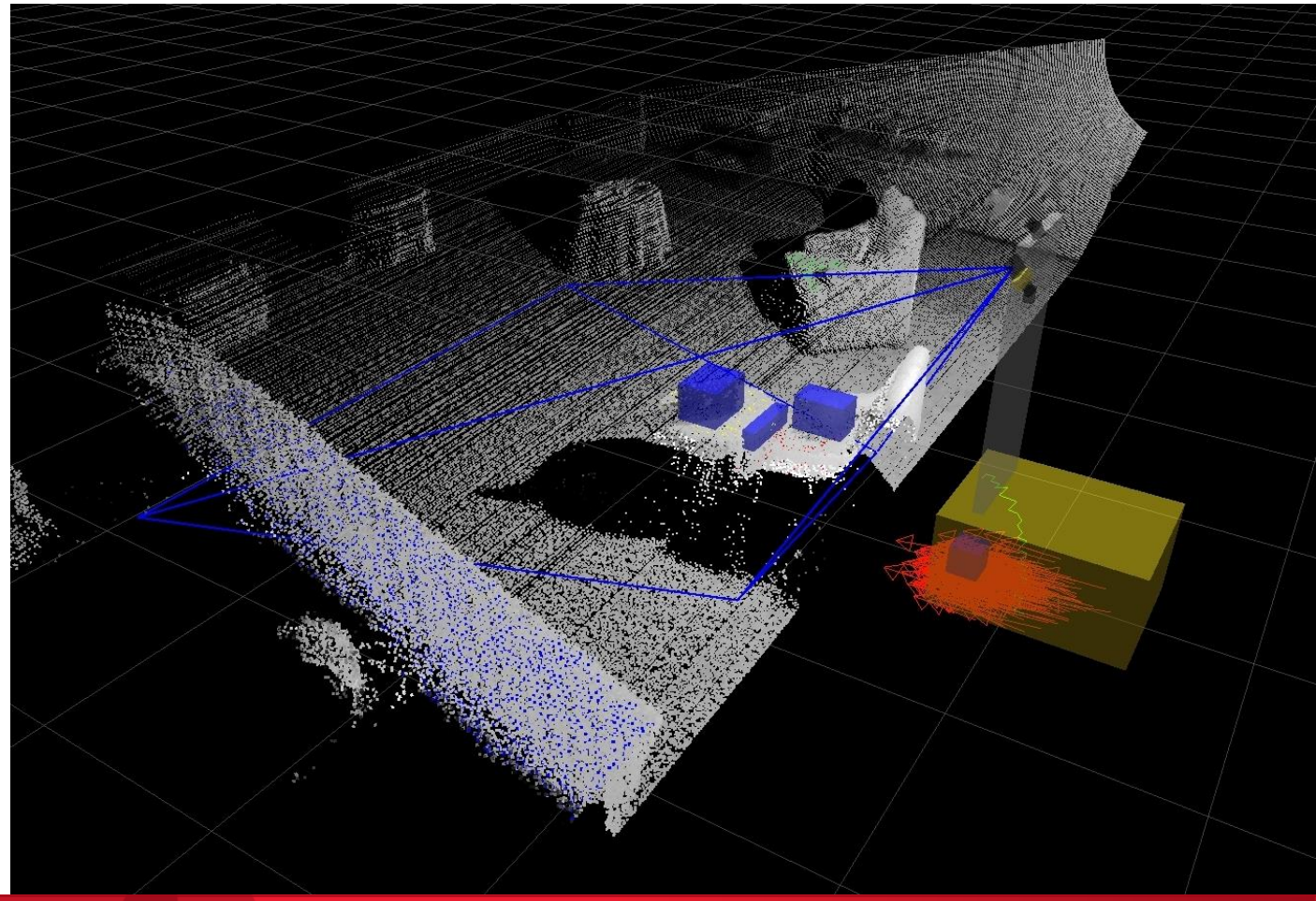








Curious George's view of the world

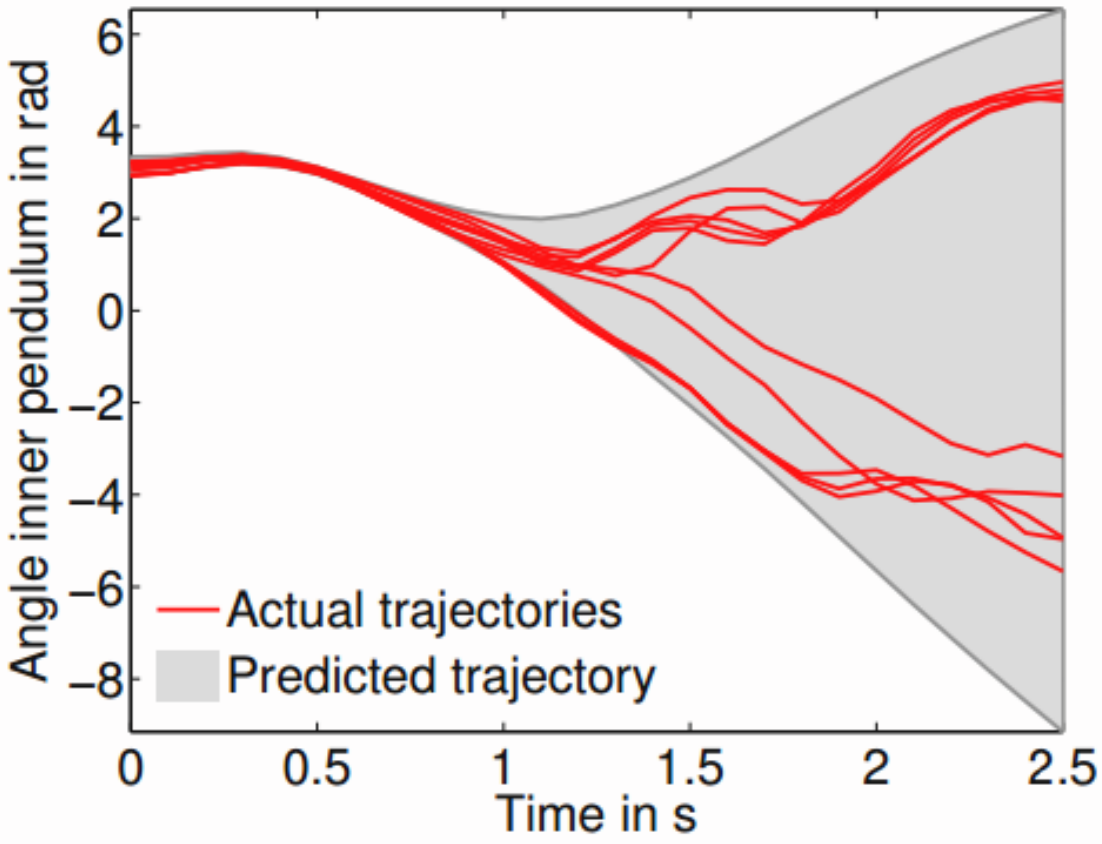


Learning Legged Swimming Gaits from Experience

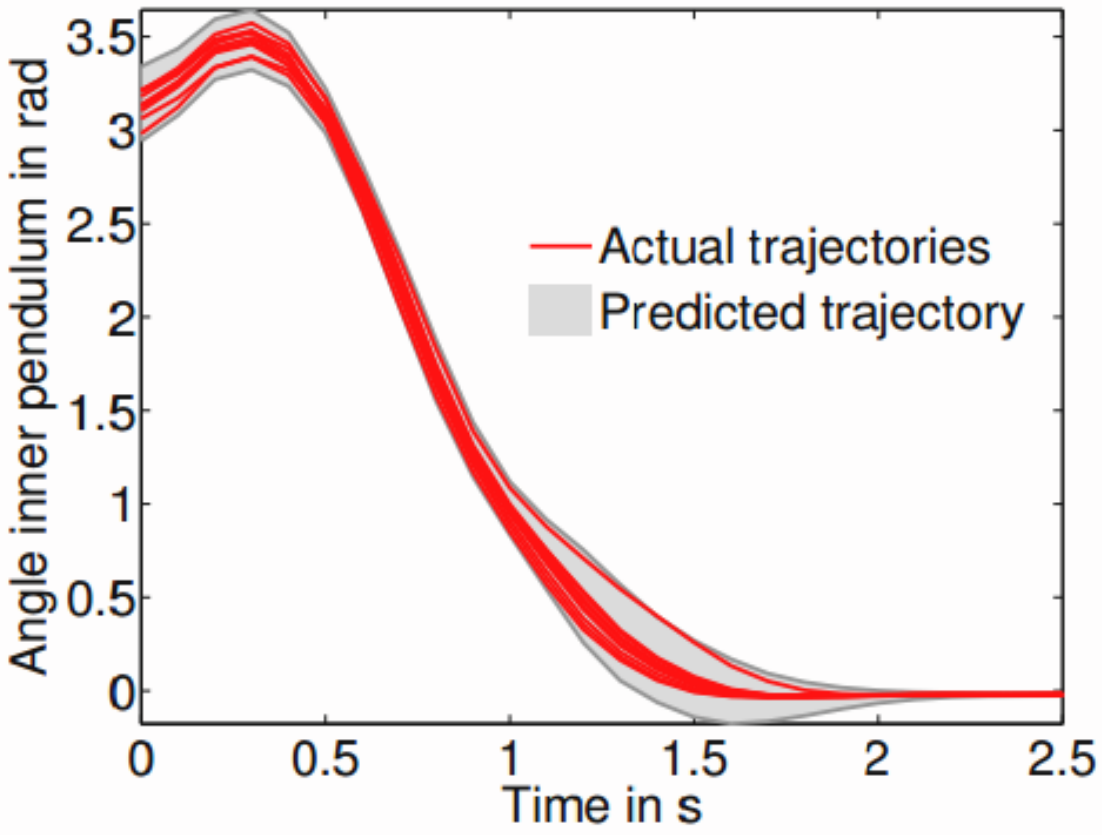
ICRA 2015 - Best Paper Award Nominee
http://www.cim.mcgill.ca/~dmeger/ICRA2015_GaitLearning/

David Meger, Juan Camilo Gamboa Higuera,
Anqi Xu, Philippe Giguere and Gregory Dudek

McGill University and Universite Laval



(a) Early stage of learning.

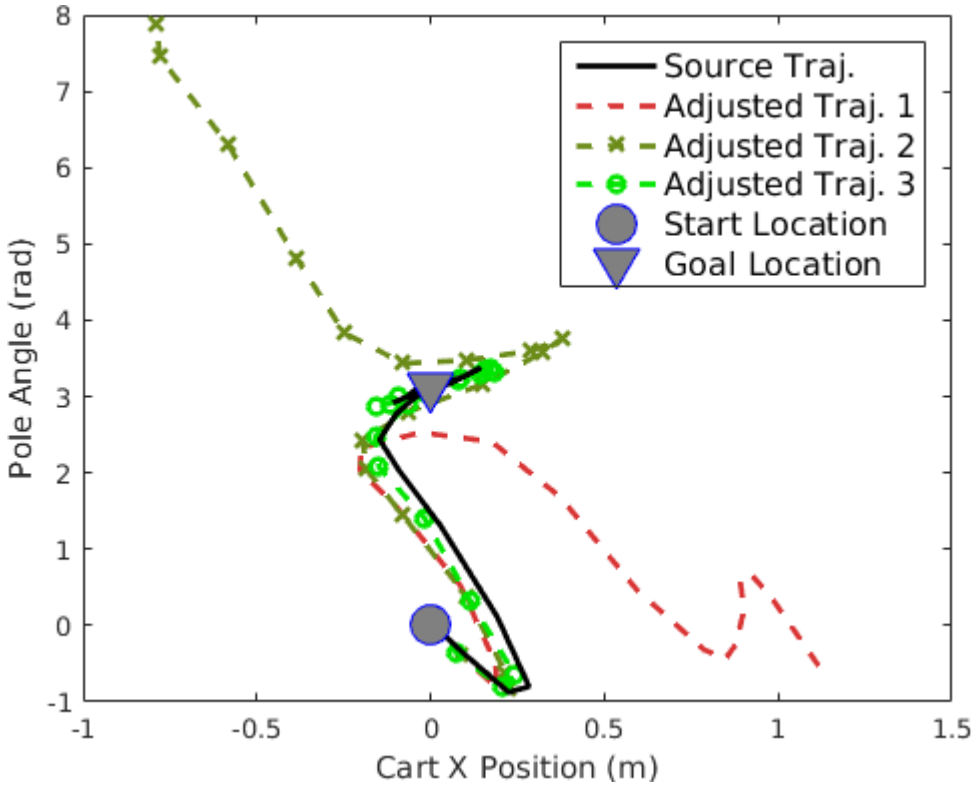


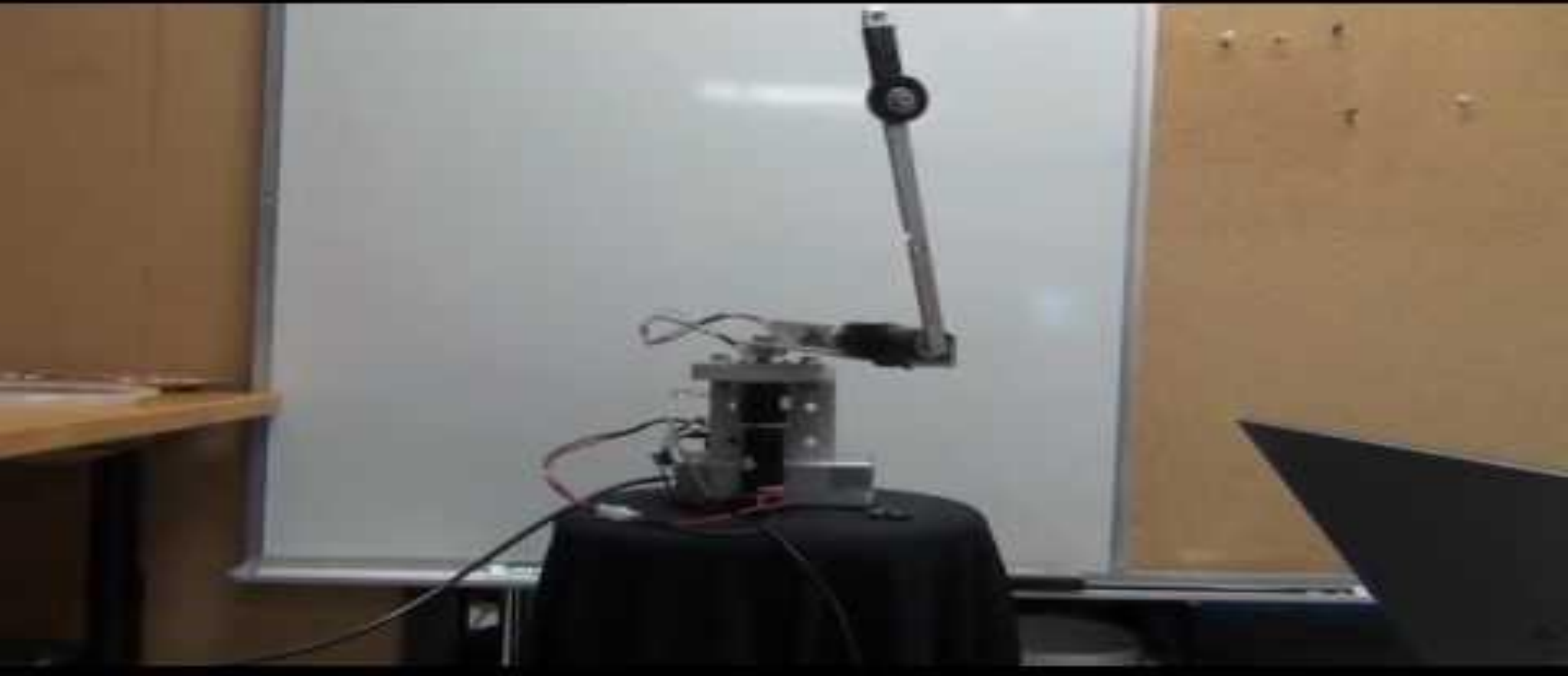
(b) After successful learning.

Adaptation to changes

Utilizing learned dynamics

- Dynamics model uncertainty allows detection of changes
- Rather than re-learning, attempt a "lazy" solution, minimally changing the previous model and controller





Course Plan

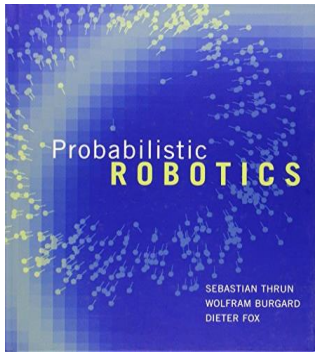
- Learning Outcomes:
  - Derive, analyze and compare important robotics algorithms
  - Familiarity with broad trends and ideas in current research
  - Ability to program for intelligent robots
  - Research experience in one focused project area
- Format:
  - My lectures cover history, important techniques and a snapshot of research
  - Associated assignments and exercises for practice
  - You give presentations on specific selected papers
  - Projects (single or group)

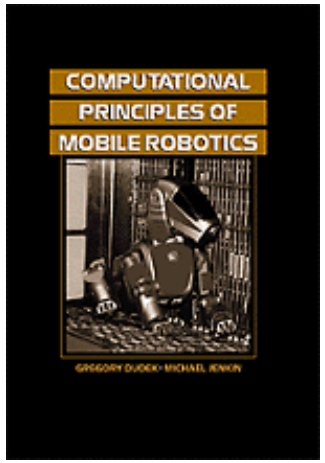
Topic Outline

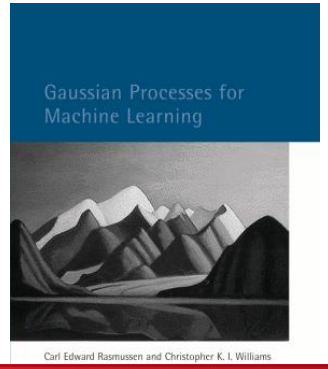
- The basic tools:
  - Spatial representations
  - Modeling motion and perception
  - Probabilistic State Estimation
  - Geometric motion planning
  - Classical control
  - Decision making under uncertainty
- Modern concepts and research:
  - Learning for robotics
  - Control using learned models
  - Learning from demonstration
  - Hierarchical planning systems
  - End-to-end learned systems
  - Cloud and collaborative robotics
  - Multi-robot teams
  - Human-robot teams
  - Safety in robotic intelligence

Textbooks and Resources

- Optional texts:
  - Probabilistic Robotics by Thrun, Burgard and Fox.
  - Computational Principles of Mobile Robotics: Dudek and Jenkins.
  - Gaussian Processes for Machine Learning: Rasmussen and Williams
- Most material online:
  - Required reading of recent papers
  - Robotics software package: mainly ROS
  - Simulated robots: Gazebo, OpenAI Roboschool and others
  - Datasets, project pages and robot-brains!





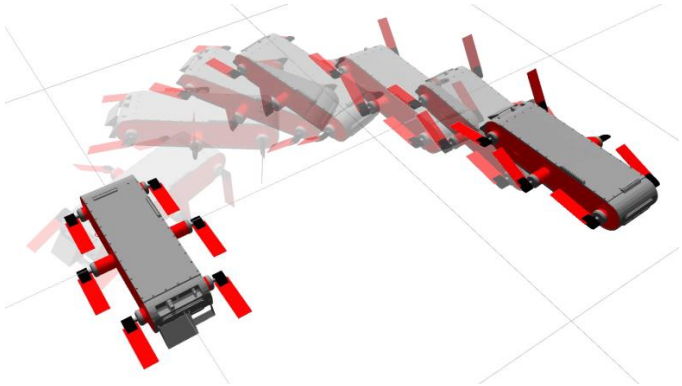


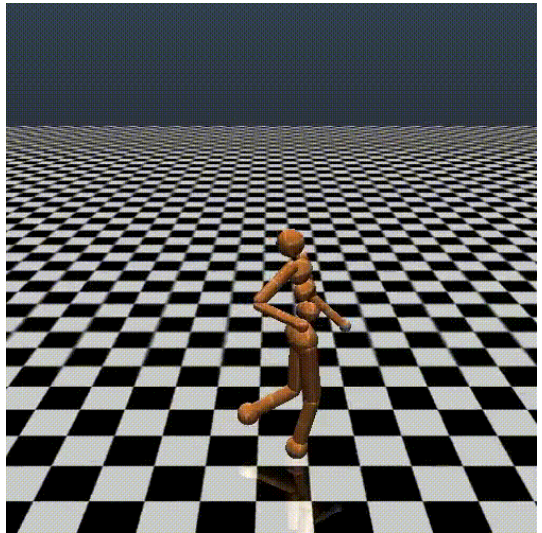
Assignments and Presentations

- 3 assignments:
  - I pick the problems: 1) Location Estimation; 2) Control With a Known Model; 3) Path Planning Under Uncertainty
  - You pick an algorithm: from class or another you find
  - Implement on a simulated robot: provided, that you find or build from scratch
  - Present your results as a write-up: It's about what you learned, not that your code must always work perfectly
- Present research papers:
  - Everyone will do 2 throughout the term. One from a required list and one that you pick as part of your project (to be continued…)

Access to simulators and robot hardware

- JACO Manipulator Robot
- Aqua Swimming Robot
- Husky Ground Robot
- Quadcopter Flying Robot
- Simple Walking Robot





Course Project

- The main focus of the last weeks of the course
- Select a recent research paper, or a group of related papers.
- Present to the class.
- Hands-on work with the paper's key technical points:
  - Experiment with their implementation
  - Re-implement in your own code
  - Perform the derivations from scratch
- Attempt a research extension
- Demos and discussions to end the term

Monday morning for a robot…

I am powered on and wonder **Where am I?** I wander for a bit, then form a **Plan Under Uncertainty** that will most likely for the kitchen. I know how to **Control** my arm to grab the coffee mug, and I can even refine my behavior once I hold it by quickly **Learning a Dynamics Model** - it's half full.

Now to make my delivery. My user is usually in the garage at this time of day, and so I **Plan a Geometric Path** though the house, navigate ther safely and put down the cup. I **Perceive Visually** that my user has purchased a new tool. After a few minutes, I have **Learned from Visual Demonstration** about how to use this, and feel ready to give it a try