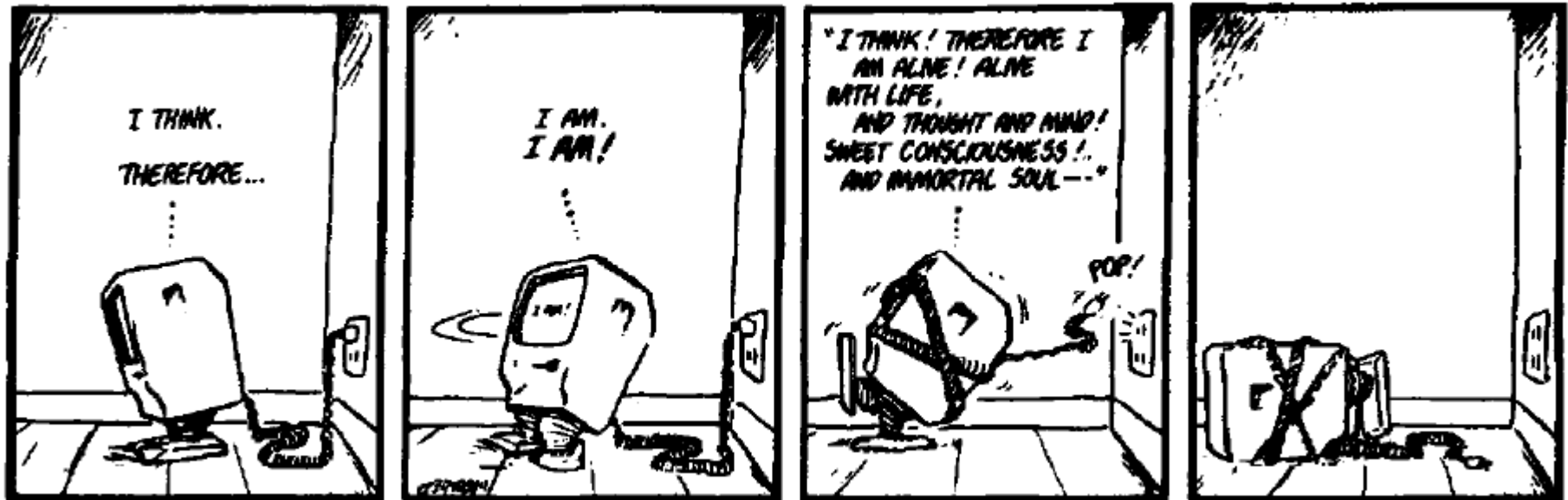


Cognition and Control





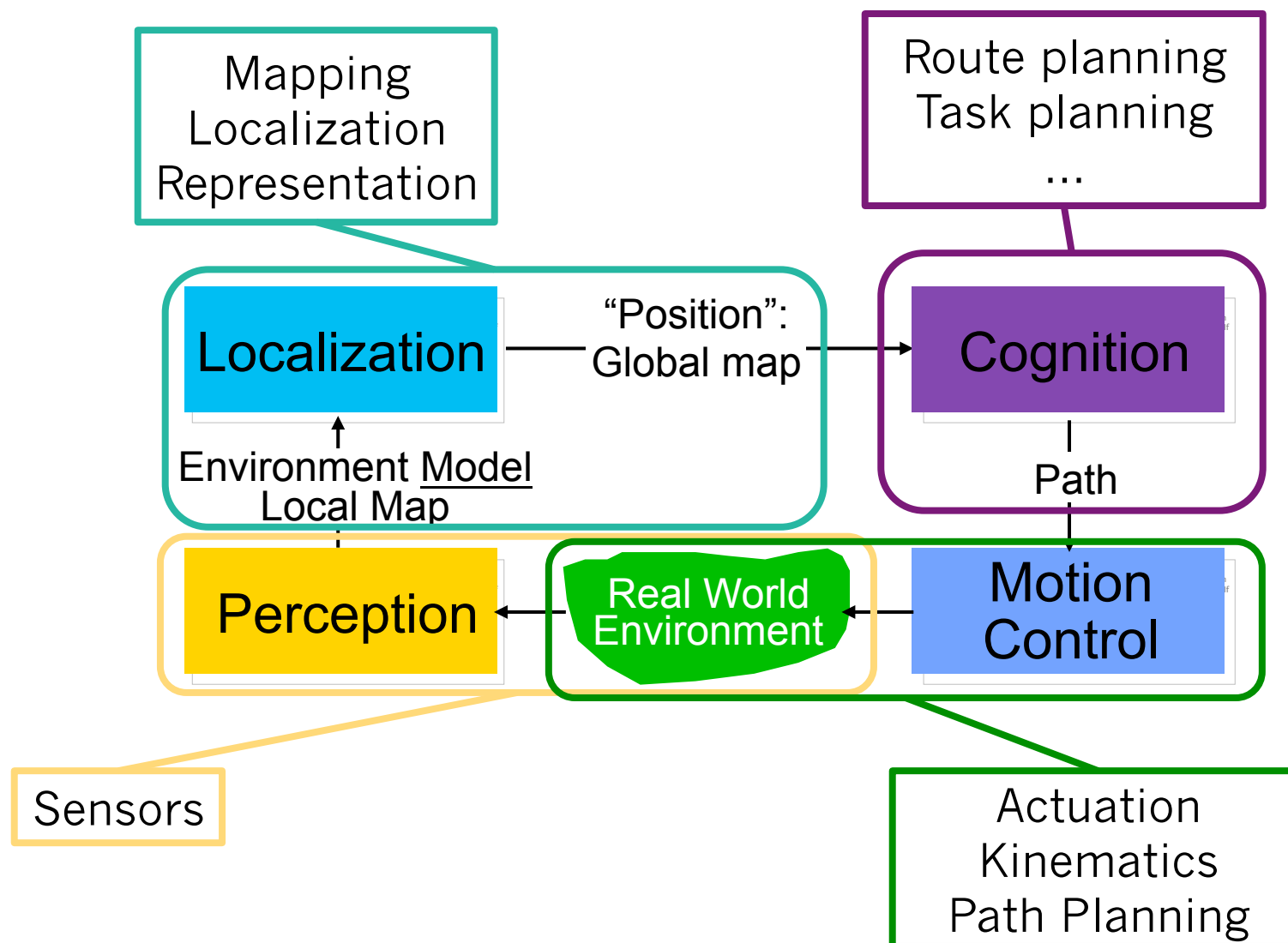
Bookkeeping

2

- ◆ Quiz 4
 - ◆ Was this week
 - ◆ That is terrible, so it will be next week
- ◆ Artificial intelligence (class)
- ◆ Next Reading:
 - ◆ One of:
 - ◆ <https://www.ted.com/topics/robots>
- ◆ And post about it on Piazza!

Cognition and Mobility

3



What Is Autonomy?

4

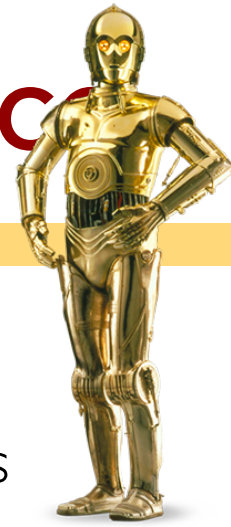
- ◆ Autonomous robots...
 - ◆ Perform their tasks in the world by themselves
 - ◆ Do not require human control / intervention
 - ◆ Learn about their environment and tasks
 - ◆ Avoid damage (to themselves, people, property)
 - ◆ Adapt to changing situations
 - ◆ Make and execute decisions
 - ◆ Possess some degree of self-sufficiency
- ◆ Intelligently and safely perform tasks
- ◆ Without direct human control

All of
these?

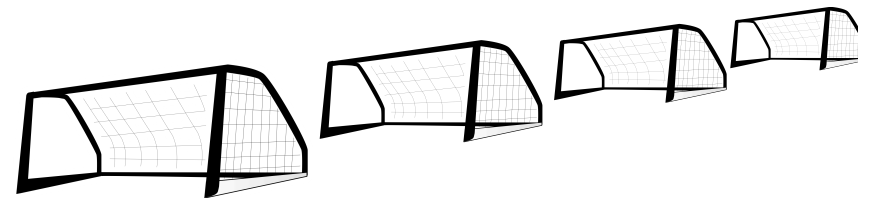


Artificial Intelligence

5



- ◆ Key types
 - ◆ Strong AI: mental/thought capabilities equal to (or better than) human
 - ◆ Weak (bounded) AI: intelligent actions or reasoning in some limited situations
- ◆ These are problematic
 - ◆ How do we measure it?
 - ◆ What's an 'intelligent action'?
 - ◆ In practice, 'previously human only'
 - ◆ Is there something ineffable missing?
- ◆ How does it change when it's a robot?



Autonomous Task Performance



6

- ◆ Many subtasks
 - ◆ Understanding and modeling of the **mechanism**
 - ◆ Kinematics, dynamics, odometry
 - ◆ Reliable control of actuators
 - ◆ Understanding and modeling the **environment**
 - ◆ Integration of sensors
 - ◆ Understanding and modeling the **task**
 - ◆ Generation of task-specific motions
 - ◆ Creation of flexible control policies, new situations
- ◆ Coping with noise and uncertainty
- ◆ Probably physical tasks!



Intelligent Action Needs...

7

- ◆ Knowledge Representation
- ◆ Search
- ◆ Planning
- ◆ Learning
- ◆ Inference

DARPA Grand Challenge 1



8





DGC 1 Challenges

9

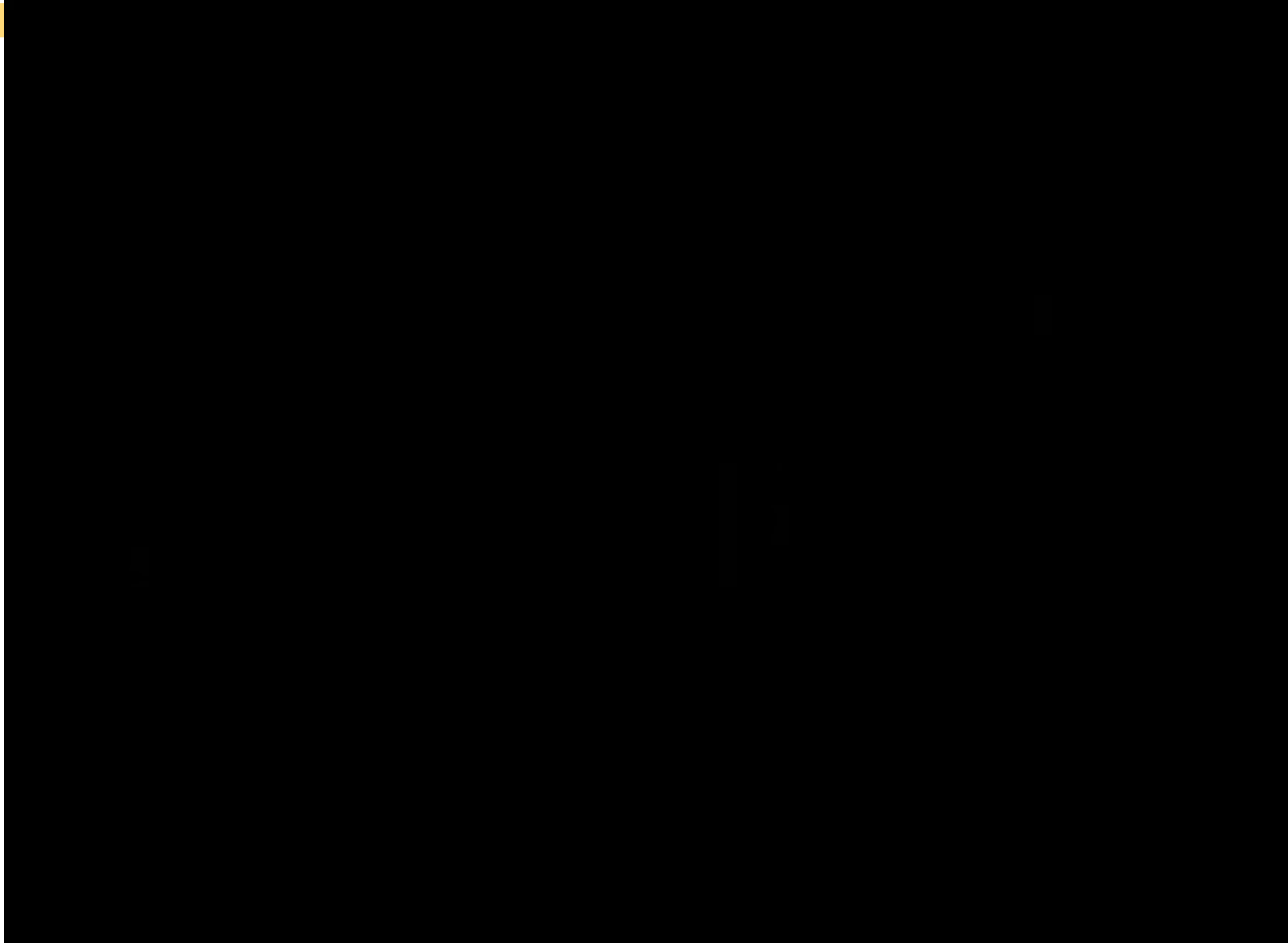
- ◆ Localization
 - ◆ But not mapping
- ◆ Sensor management
 - ◆ What sensors?
 - ◆ Where's the road?
- ◆ Narrow pass
 - ◆ Switchbacks, turns
 - ◆ Tunnels
- ◆ Actuator management

- ✓ Knowledge Representation
- ✓ Search
- ✓ Planning
- ✗ Learning
- ✗ Inference

DARPA Grand Challenge 2



10





DGC 2 Challenges

11

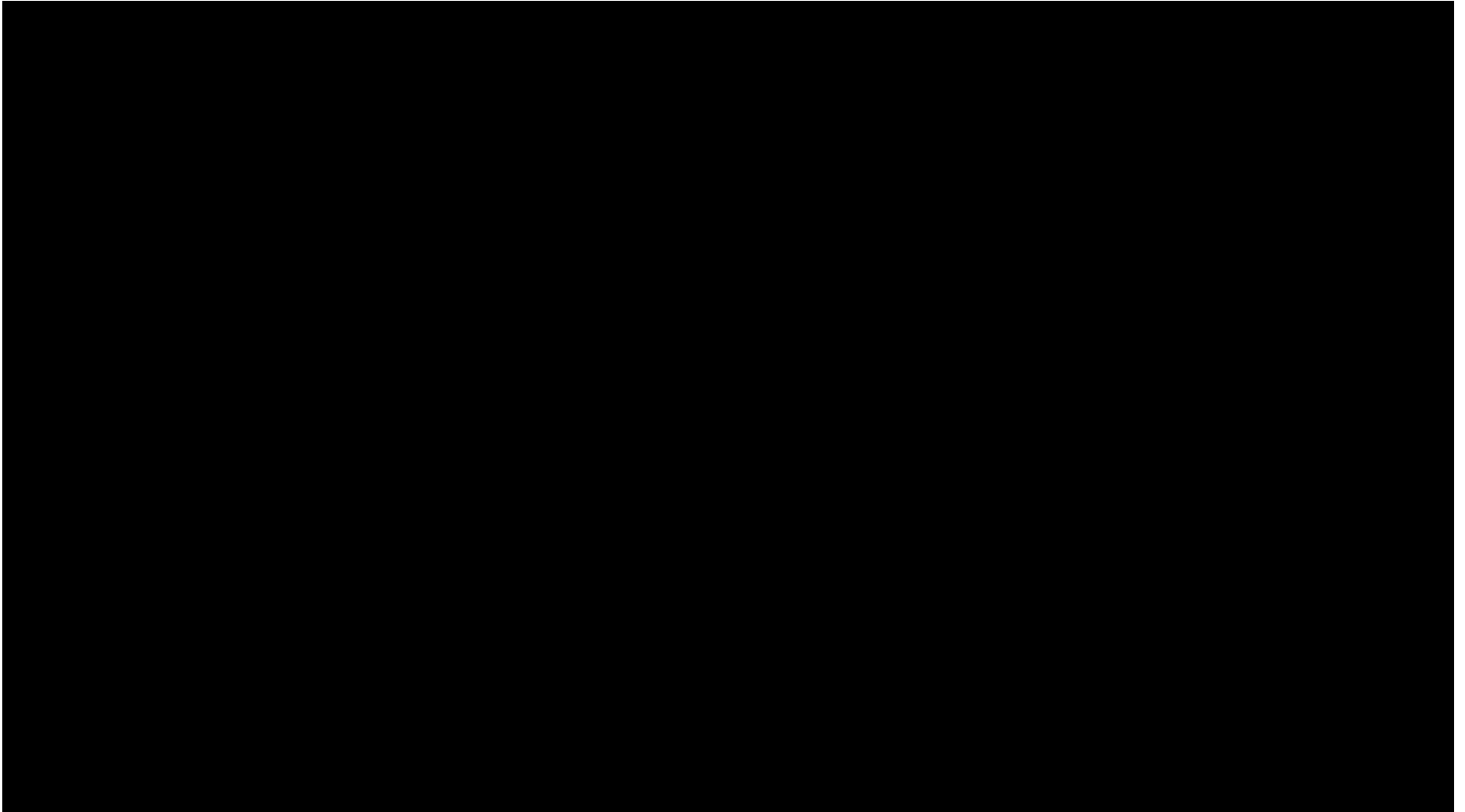
- ◆ All of the above, plus...
- ◆ Visual parsing of traffic elements
 - ◆ Sensing + Knowledge
- ◆ Awareness of other cars
 - ◆ Sensing + Planning
- ◆ Non-3D-guided tasks
- ◆ Faster speeds
- ◆ Safety

- ✓ Knowledge Representation
- ✓ Search
- ✓ Planning
- ✗ Learning
- ✓ Inference



Google Self-Driving Car

12





Google Challenges

13

- ◆ All of the above, plus...
- ◆ Sublimely oblivious drivers
- ◆ Full-speed actuator management
- ◆ Legal management
- ◆ Ethical management

- ✓ Knowledge Representation
- ✓ Search
- ✓ Planning
- ? Learning
- ✓ Inference



DARPA Robot Challenge 1

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DRC 1 Challenges

15

- ◆ All of the above, plus...
- ◆ Non-designed environment
 - ◆ Balancing
 - ◆ (Much) harder actuation
 - ◆ Bipedal motion
- ◆ Yet more sensor hassles
- ◆ Weight, power
- ◆ Manipulation
 - ◆ !!!

- ✓ Knowledge Representation
- ✓ Search
- ✓ Planning
- ✓ Learning
- ✓ Inference
- ✗ Autonomy

DRC 1

16



Robocup

17





Robocup

18

- ◆ All of the above, plus...
- ◆ Object interaction
 - ◆ Balls, walls, ...
- ◆ Deliberately difficult goal task
 - ◆ Streets designed for easy driving
 - ◆ S&R not designed
- ◆ Enormous robot design space
- ◆ Antagonistic agents

- ✓ Knowledge Representation
- ✓ Search
- ✓ Planning
- ✓ Learning
- ✓ Inference
- ✓ Autonomy



Other Robot Tasks



IN COLLABORATION WITH
Nonlinear Systems Laboratory MIT
& ALDEBARAN Robotics



Gambit: An Autonomous Chess-Playing Robotic System

C. Matuszek, B. Mayton, R. Aimi, M. P. Deisenroth, L. Bo,
R. Chu, M. Kung, L. LeGrand, J. R. Smith, D. Fox



University of Washington



Intel Labs Seattle



Alum Labs

**Cloth Grasp Point Detection
based on Multiple-View Geometric Cues
with Application to Robotic Towel Folding**

Jeremy Maitin-Shepard
Marco Cusumano-Towner
Jinna Lei
Pieter Abbeel

Department of Electrical Engineering and Computer Science
University of California, Berkeley

International Conference on Robotics and Automation, 2010



Intelligent Action Needs...

20

- ◆ Knowledge Representation
- ◆ Search
- ◆ Planning
- ◆ Learning
- ◆ Inference



Other Robot Tasks

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