COMP 551: Advanced Robotics Lab

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63
open source
hardware
Micro SD
IR
Beacon
Expansion
R
G
B
Heartbeat
System
Charge
Power
IR0
IR1
IR2
IR3
IR4
IR5
IR6
IR7
T0
T2
T3
T4
T5
T6
FL
FR
BL
BR
RST
QEI0A
QEI0B
PWM0A
PWM0B
GND
3.3V
VBAT
RX
TX

Course Overview

Learn key concepts of distributed robotic systems

- Sensing/control
- Communication
- Consensus
- State estimation

Implement these concepts on real robots

- This is a Lab course
- With lots of software to write and algorithms to implement
- Python for the first lab, then C for the remaining labs

Course Overview

Course Un-Topics

Algorithmic Robotics

- For that, take COMP 450, “Algorithmic Robotics”
- I will keep the math and theory and proofs to a minimum

Manipulation and Control

- For that, take MECH 498, “Introduction to Robotics”

AI and Machine Learning

- Comp 441, Artificial Intelligence
- ELEC 631, Reinforcement Learning

Staff

Prof. James McLurkin

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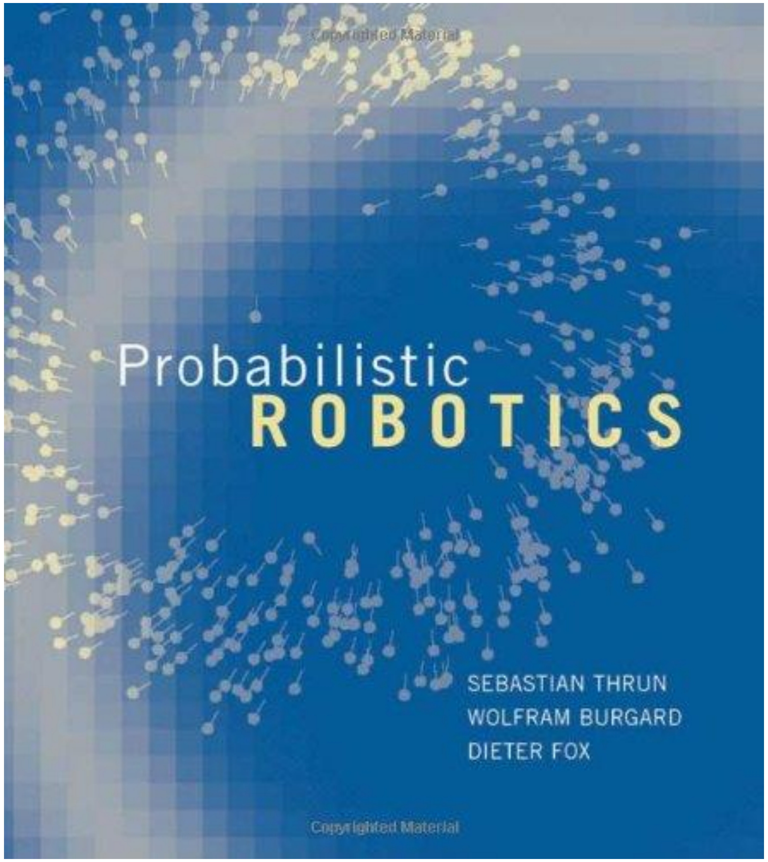
A Book

Not required for the course, might be helpful for the final project

The bibliographic notes are very nice



Grading

This is a lab course:

- Lab Set 1: 20%
- Lab Set 2: 20%
- Lab Set 3: 30%
- Lab Set 4: 30%

The labs will take considerable time

- Start early
- Ask lots of questions

No final

No homework

Collaboration

We will all have to work together

- Solve the challenging problems
- Share experiment design

Submit one code per lab team

- Your code will be written collaboratively

Hand in one report per person

- One or two pages, max
- Tell us what your group design is…
- Tell us what <u>you</u> did

Lab Topics

Lab 1:

- Robot Software Architecture,
- Pose Estimation,
- Behavior-based control

Lab 2:

- Sensors and feedback
- Communications,

Lab 3

- Distributed algorithms,
- Multi-robot configuration control.

Lab 4:

- State Estimation, EKF or Particle Filter

Topics Overview

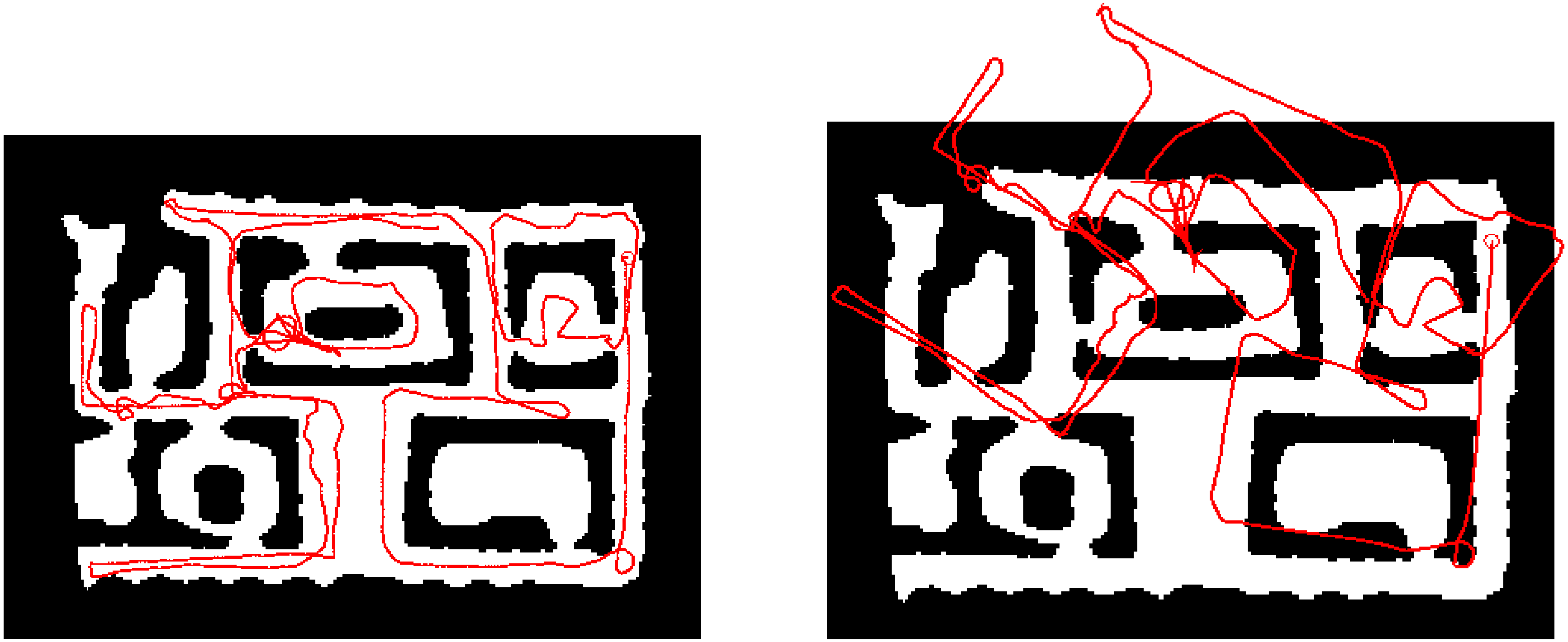
Basic Robotics

Robot Architecture, Odometry

Multi-threaded software design

Odometry-based pose measurement

Data visualization



Feedback Control

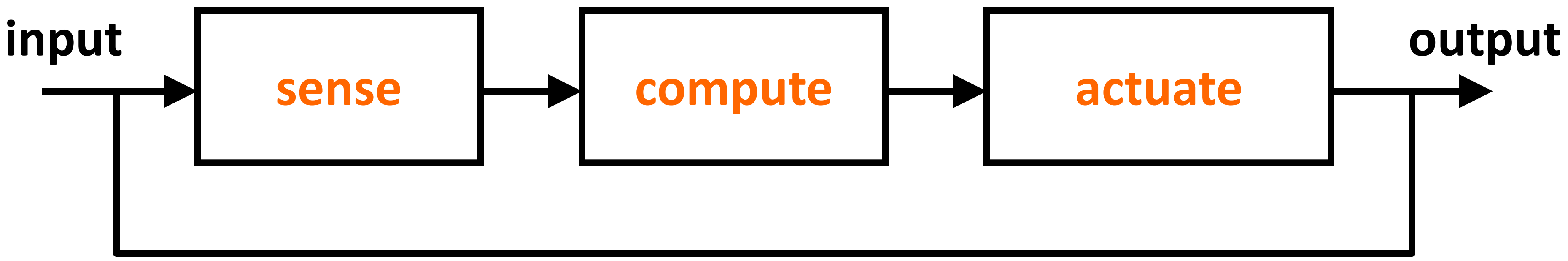
Feedback Control

This is one of the most common system diagrams

We will be using it extensively in this course

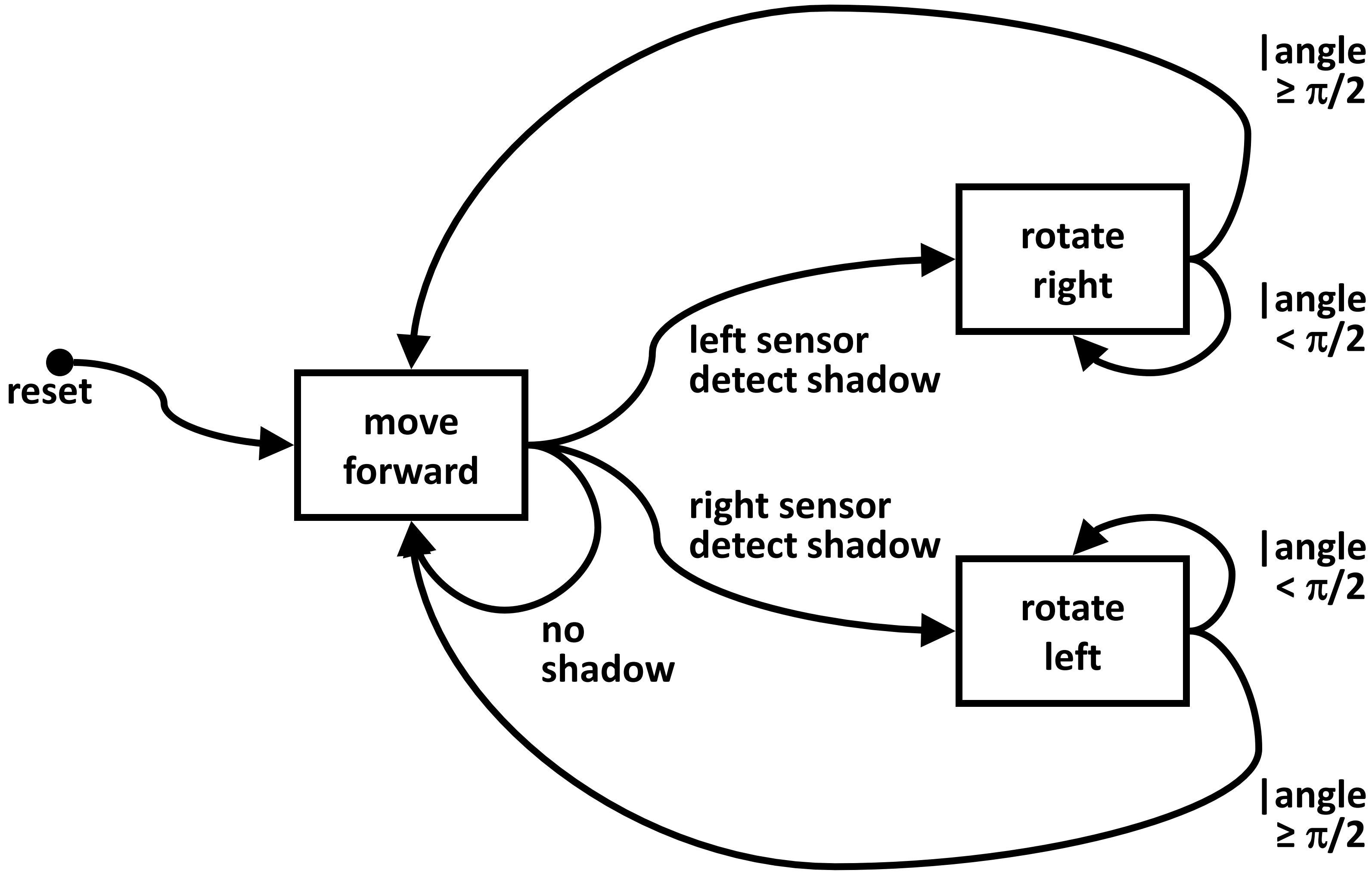
This is a feedback system. The output “feeds back” to the input.

This is also a control loop. (Because it controls and it loops)



Deterministic Robot Control Algorithms

An Example FSM: Wall detection



[Review dark avoid code in editor]

Behavior-Based Control

A behavior is a small program (or finite-state machine) that reads the sensors and controls the robot

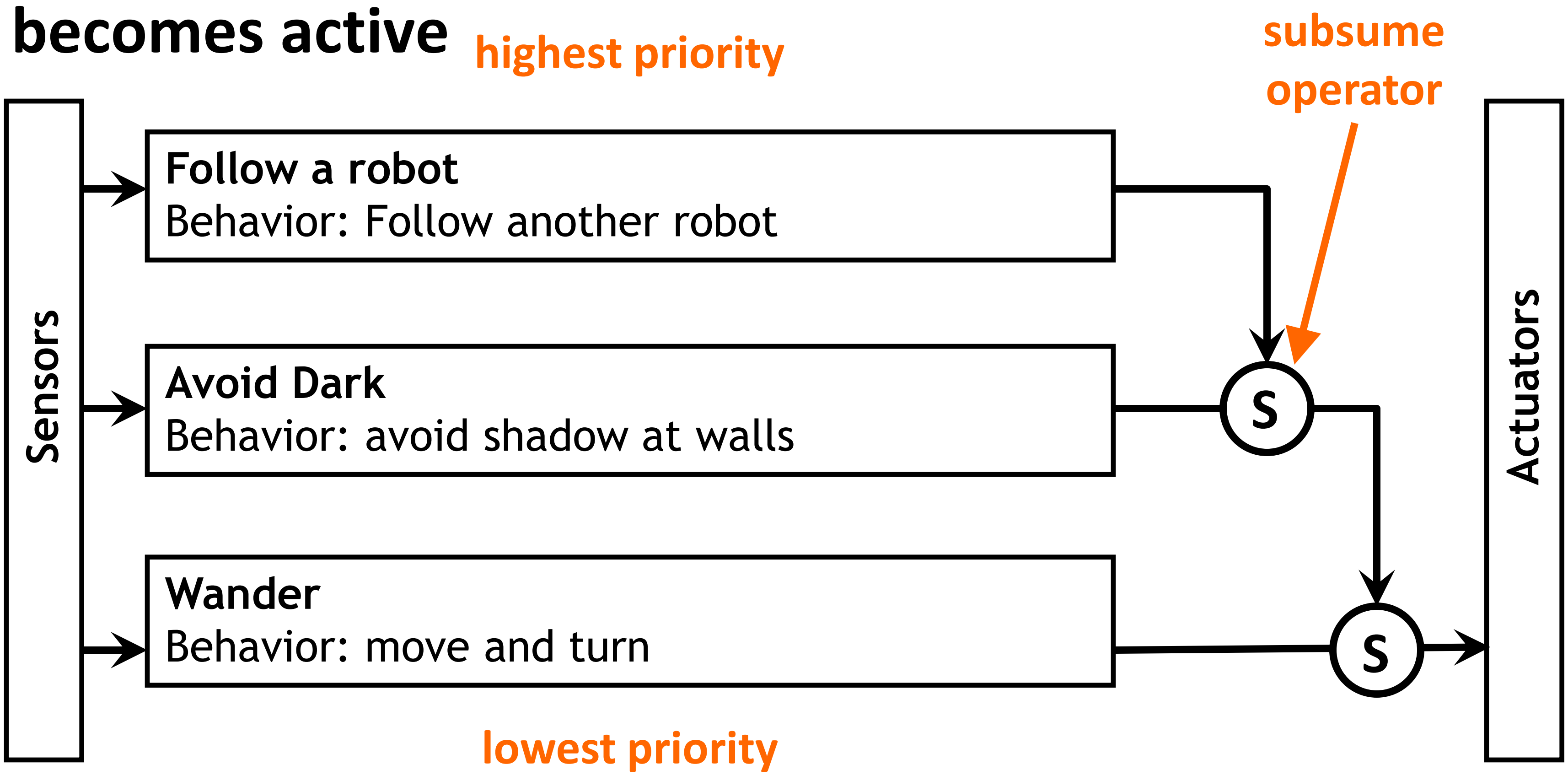
- Each behavior only does ***one simple*** thing
- Each behavior has access to all the sensors of the robot and produces motor outputs (tv, rv)

Only one behavior can be active at a time

- There is a *prioritization* of behaviors
- More important ones override, or ***subsume***, less important ones

Combining Behaviors

We combine behaviors by overriding, or *subsuming* lower-priority behaviors if a higher-priority behavior becomes active



Probabilistic Robotics

Uncertainty

What is my sensor telling me?

How can I extract perception from sensing?

How can I produce optimal estimates?

Is my sensor even working?

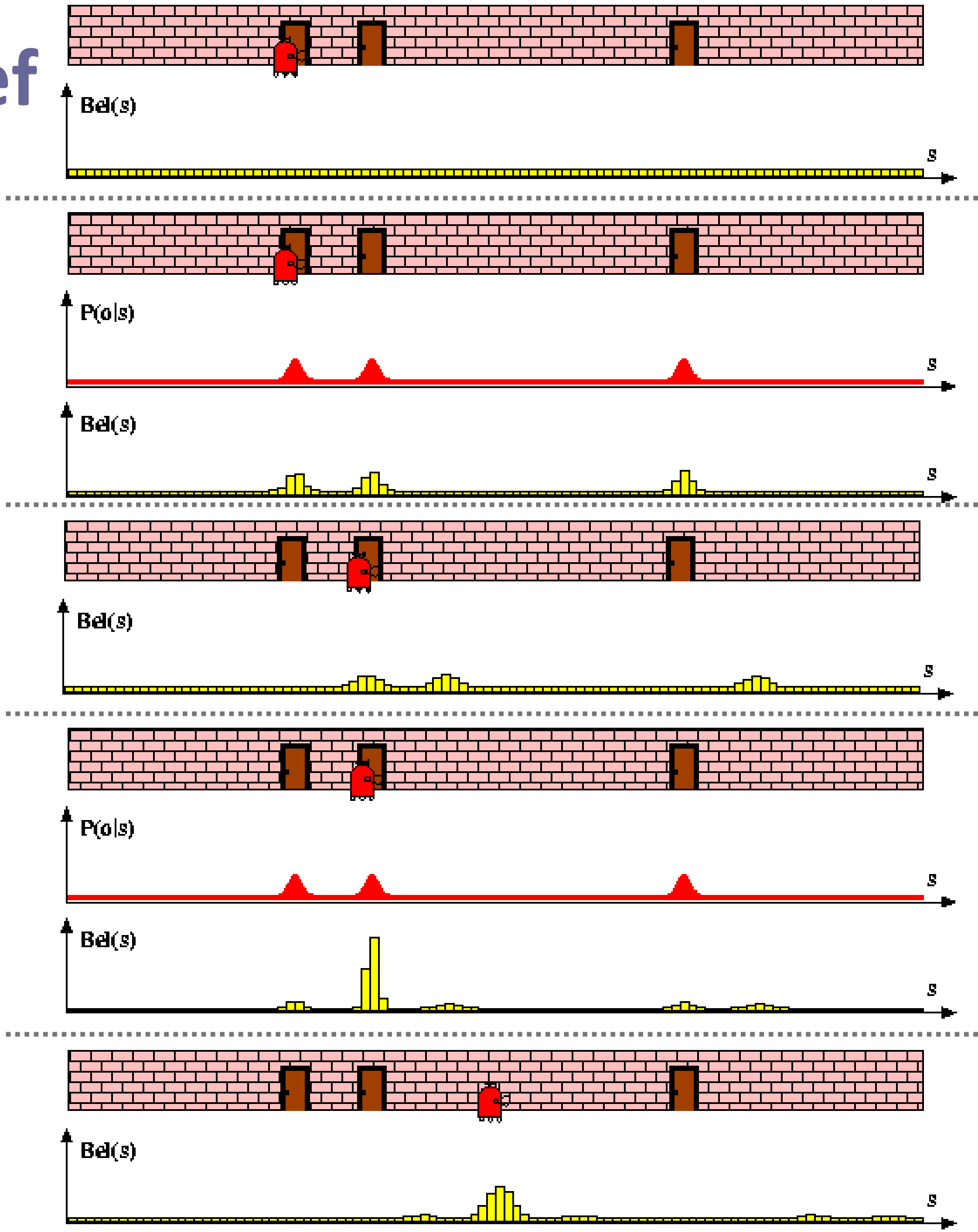
Where am I?

Sensing and Belief

s is the state of the robot, in this case, position

Bel(*s*) is the robot's *belief* about where it is.

P(o|*s*) is the probability of the sensor observation *given* the state of the robot.



A Brief, Abridged, somewhat biased, History of Robotics

Pop Quiz!

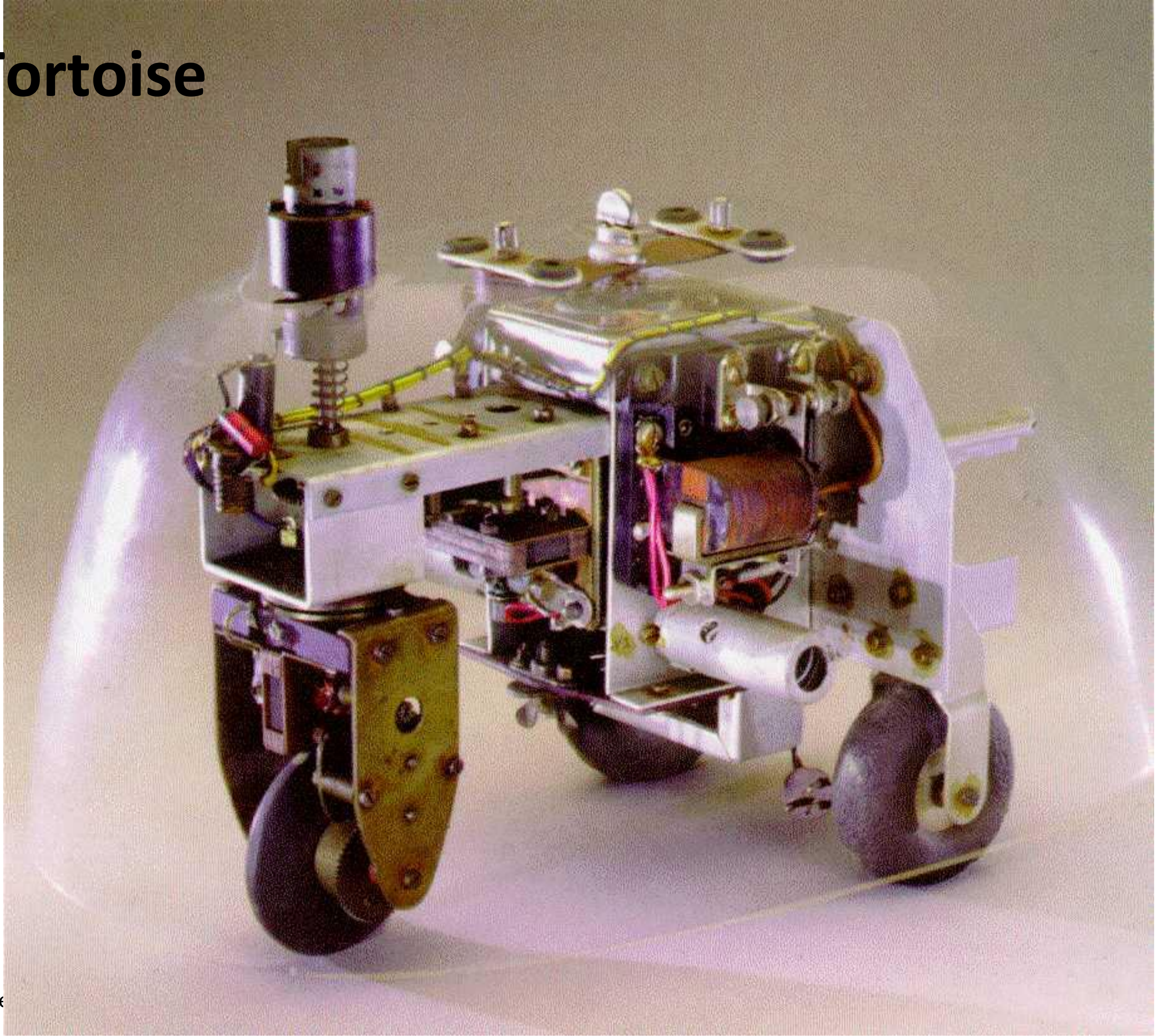
Name the Robot (1pt)

Name the creator/company/school (2pts)

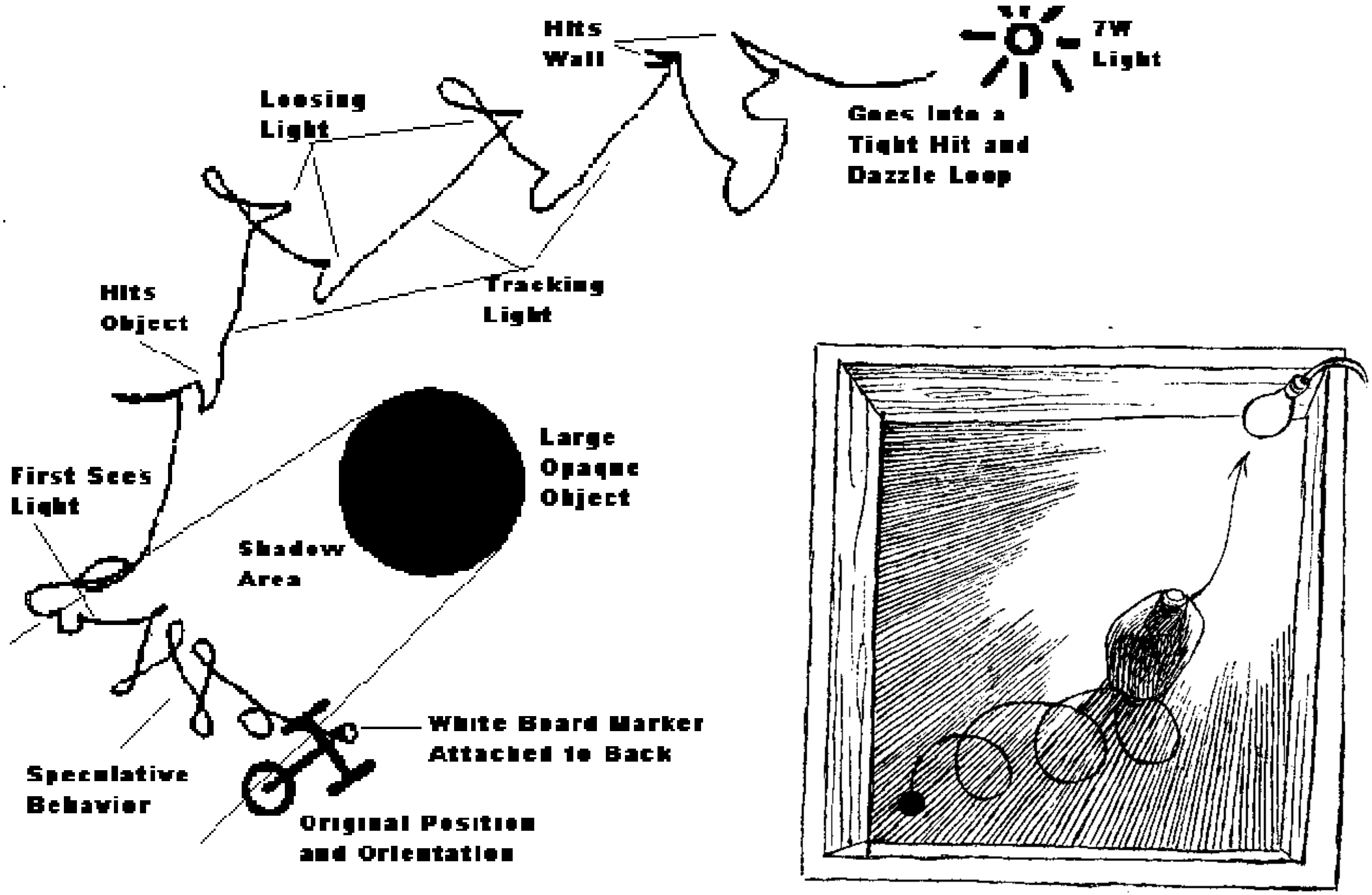
Explain the significance (3pts)

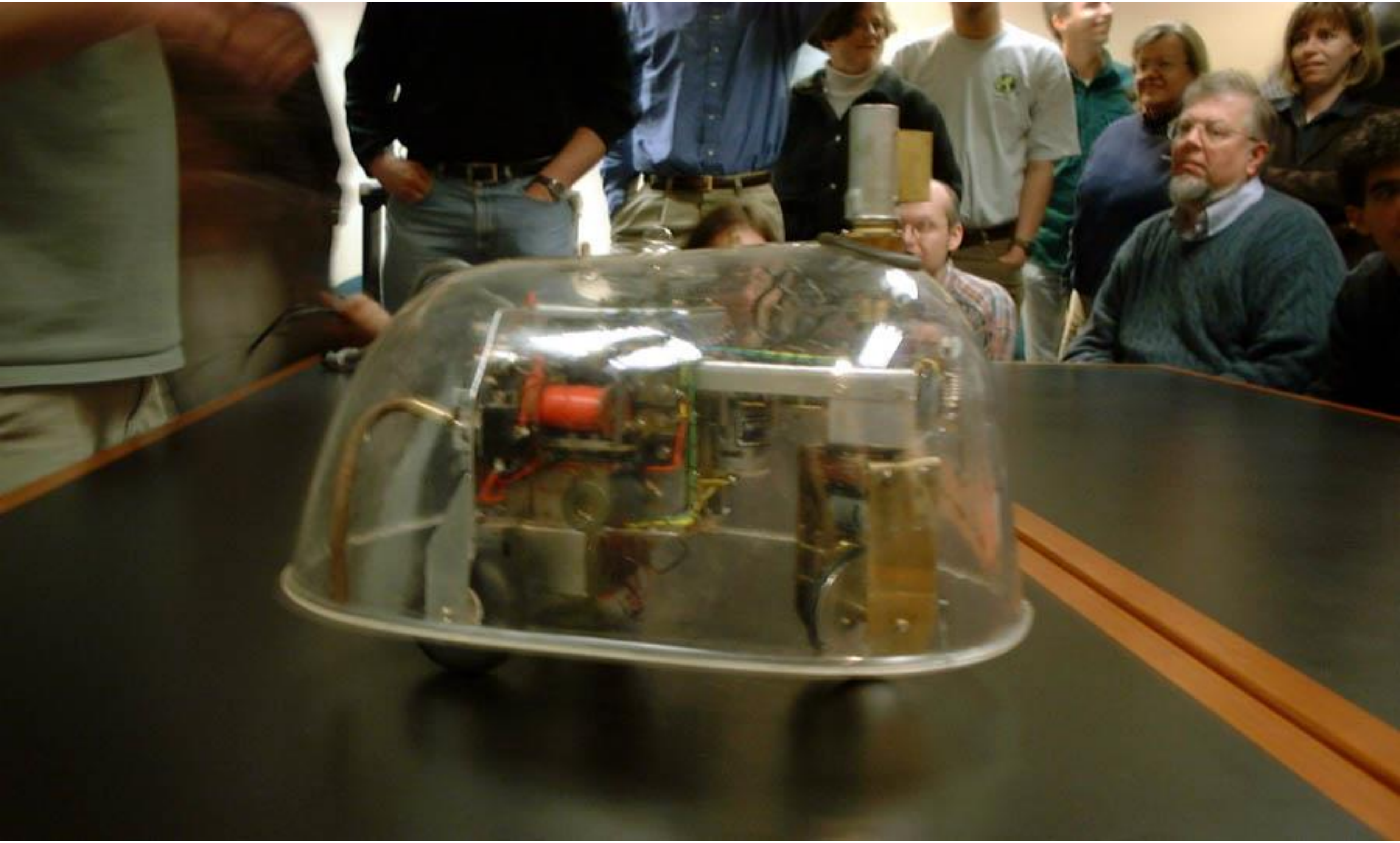
Winner gets to select from these fine prizes…

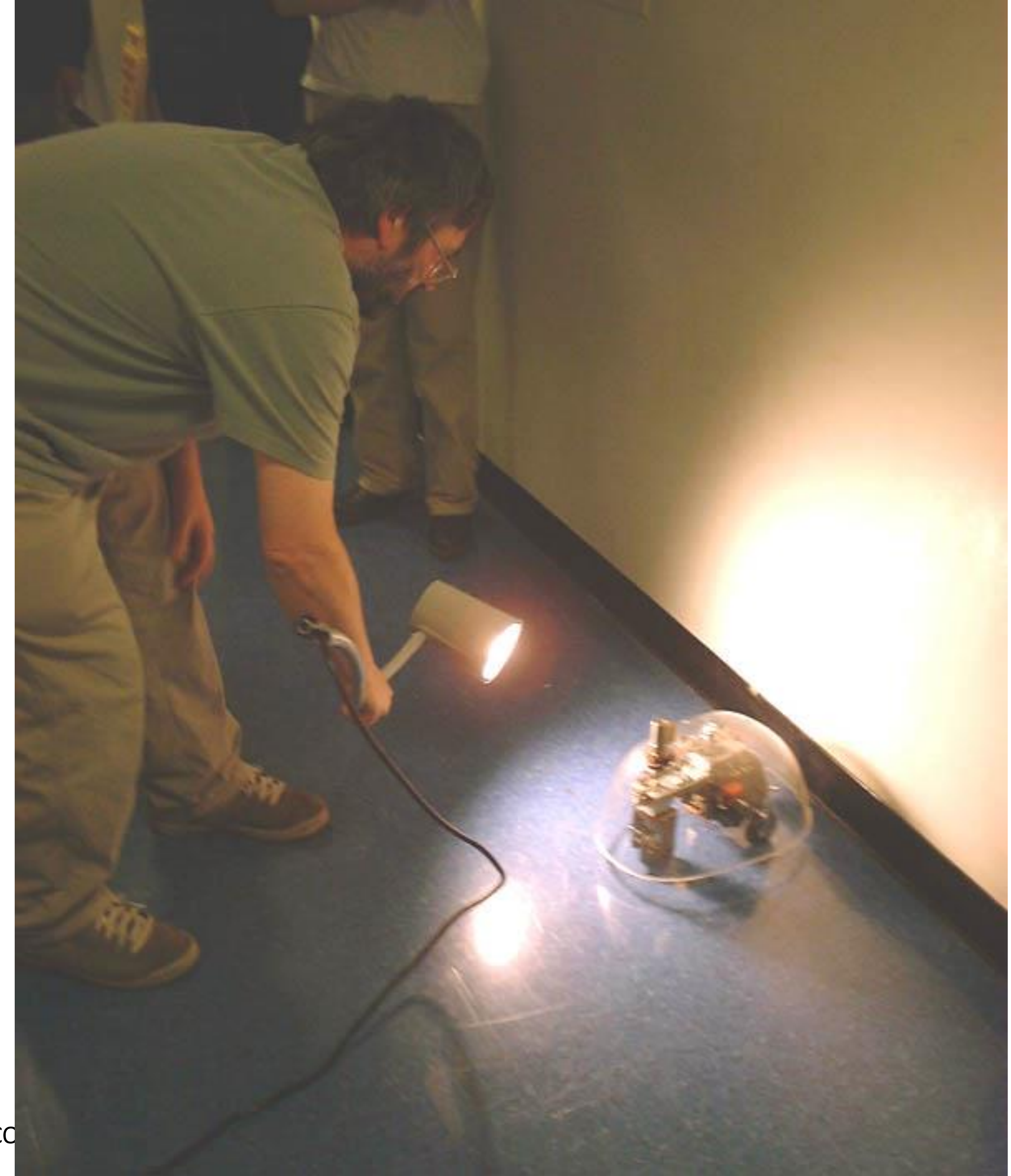
Tortoise

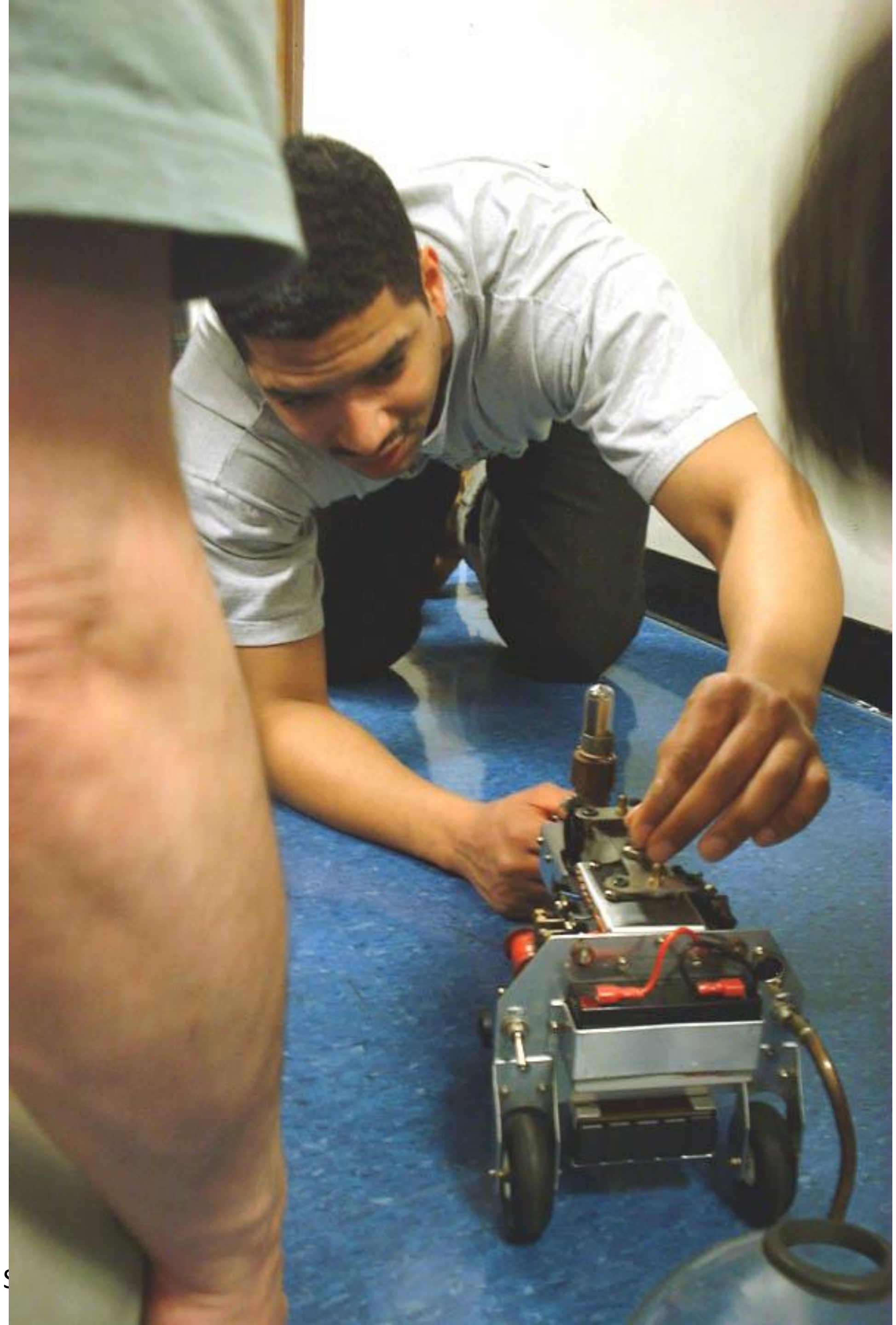


Tortoise Behaviors

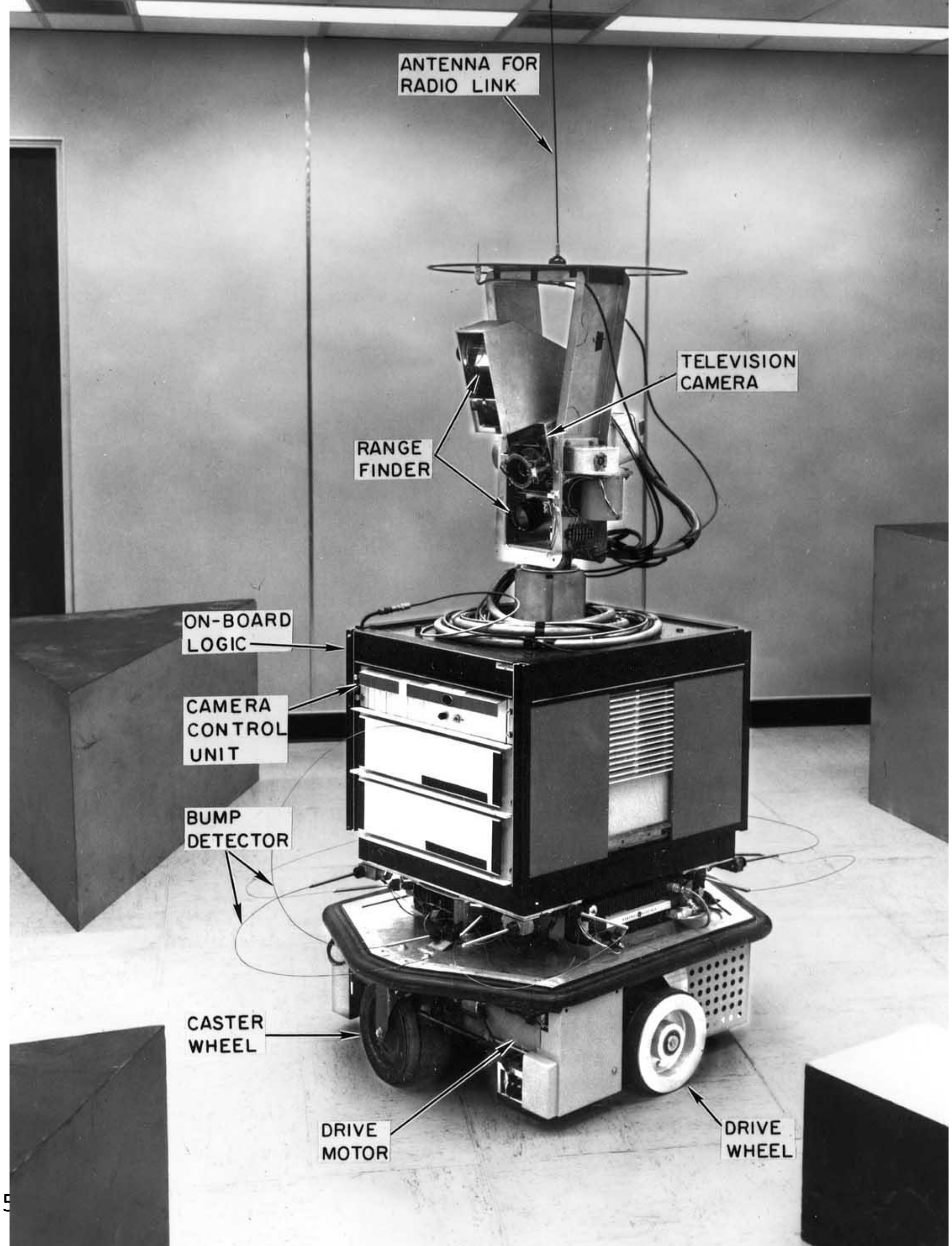






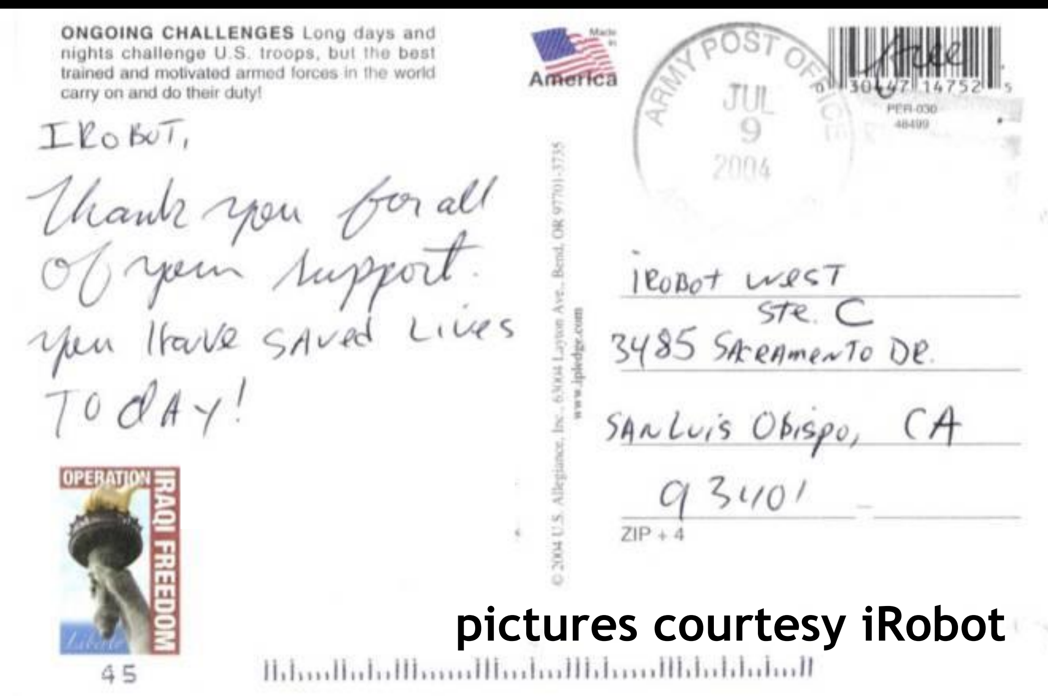


Shakey


ANTENNA FOR RADIO LINK
TELEVISION CAMERA
RANGE FINDER
ON-BOARD LOGIC
CAMERA CONTROL UNIT
BUMP DETECTOR
CASTER WHEEL
DRIVE MOTOR
DRIVE WHEEL

Genghis

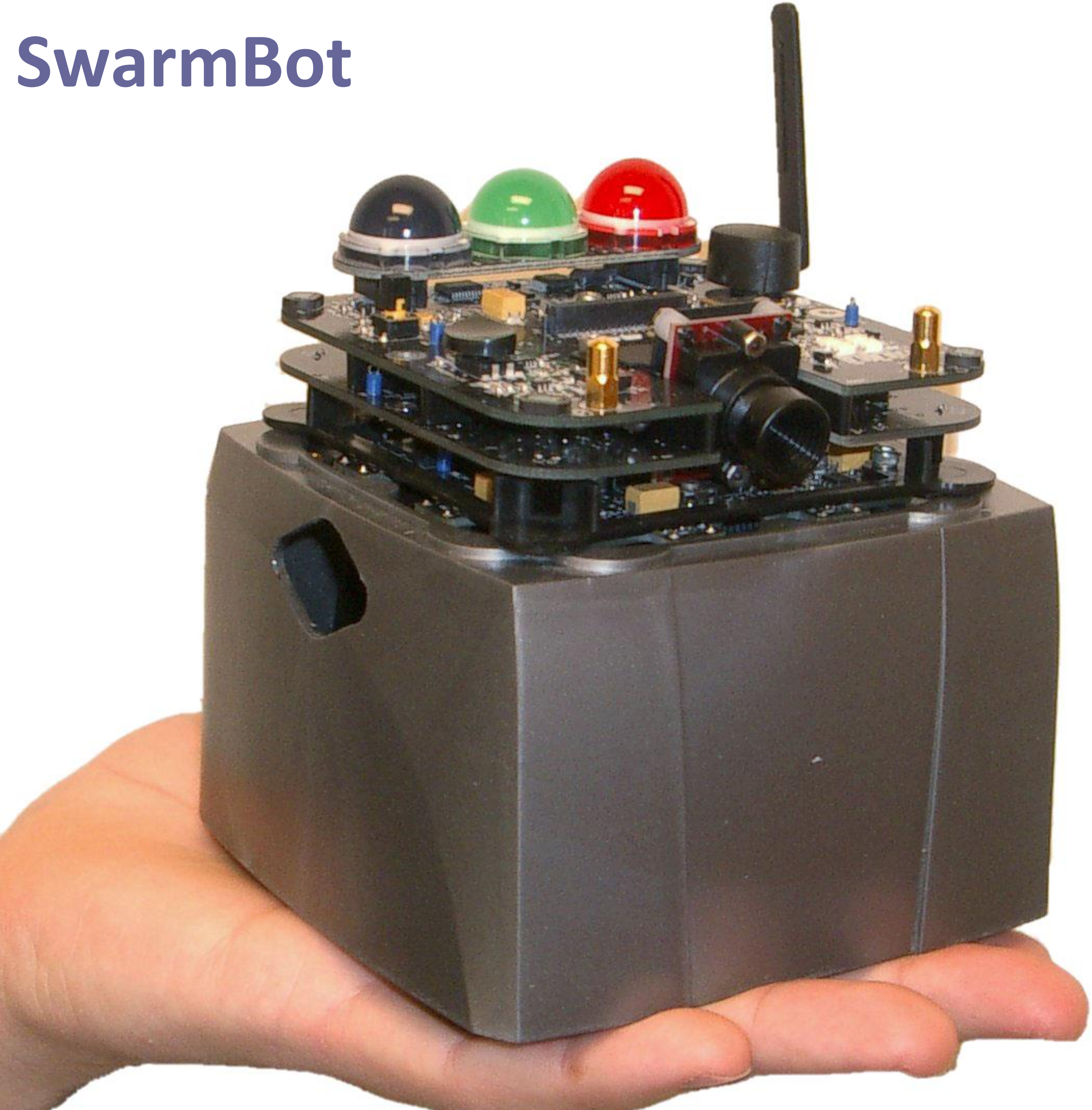
PackBot



pictures courtesy iRobot

NASA’s Spirit and Opportunity

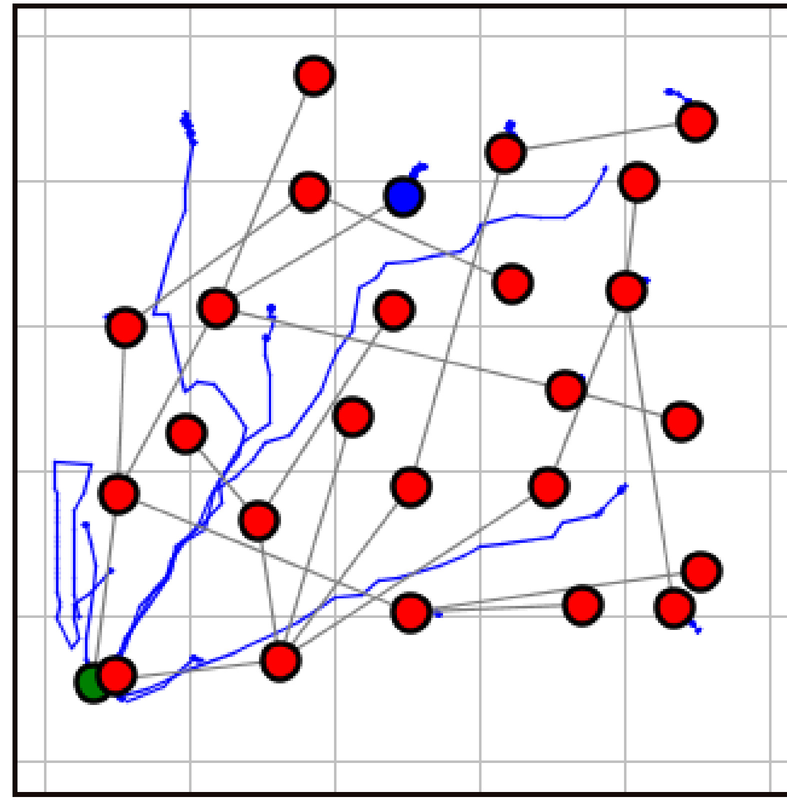
SwarmBot



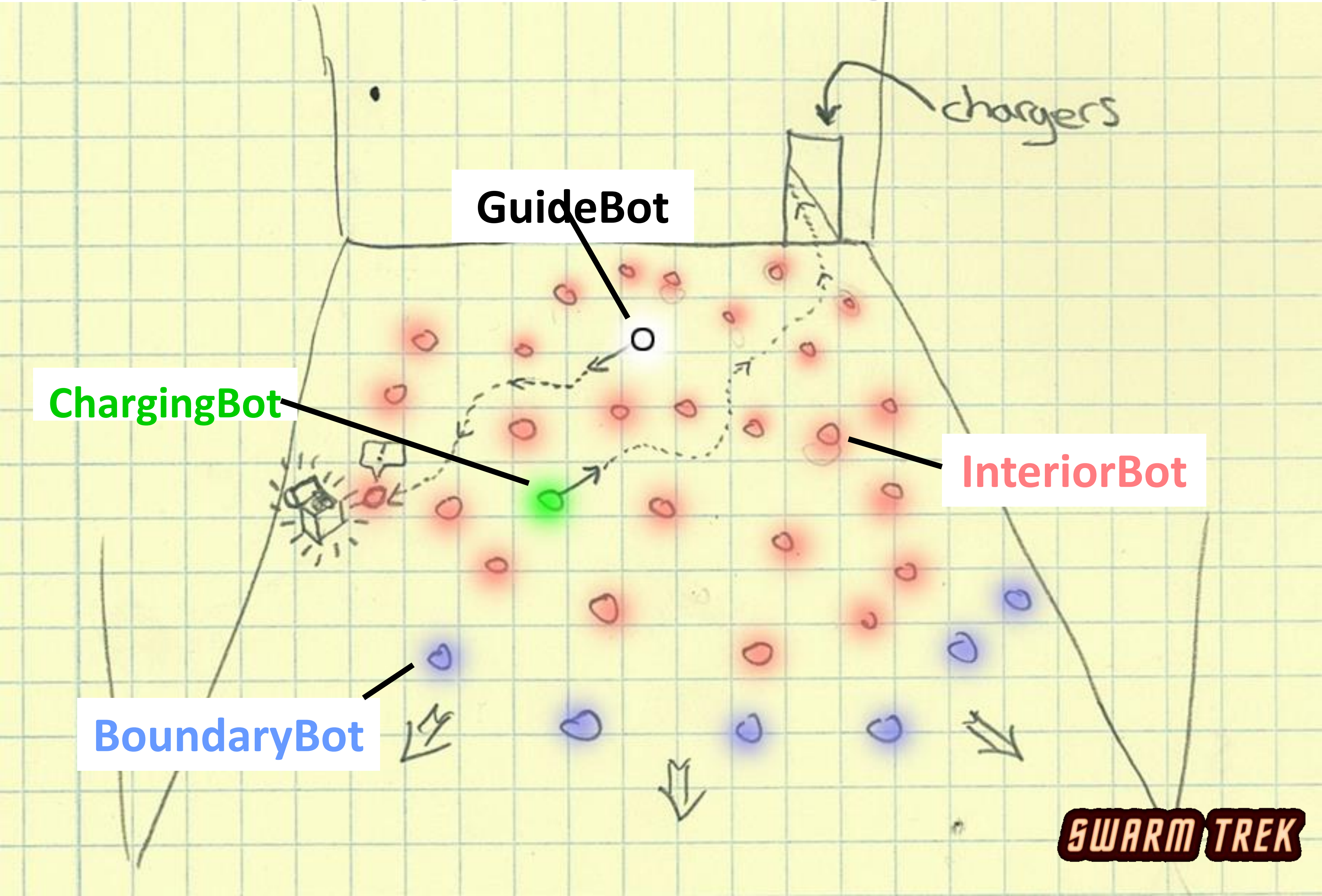
Message Speed

Broadcast Tree Navigation

Purpose: To guide a robot from anywhere in the configuration to the root robot



An Example Application: Building Search



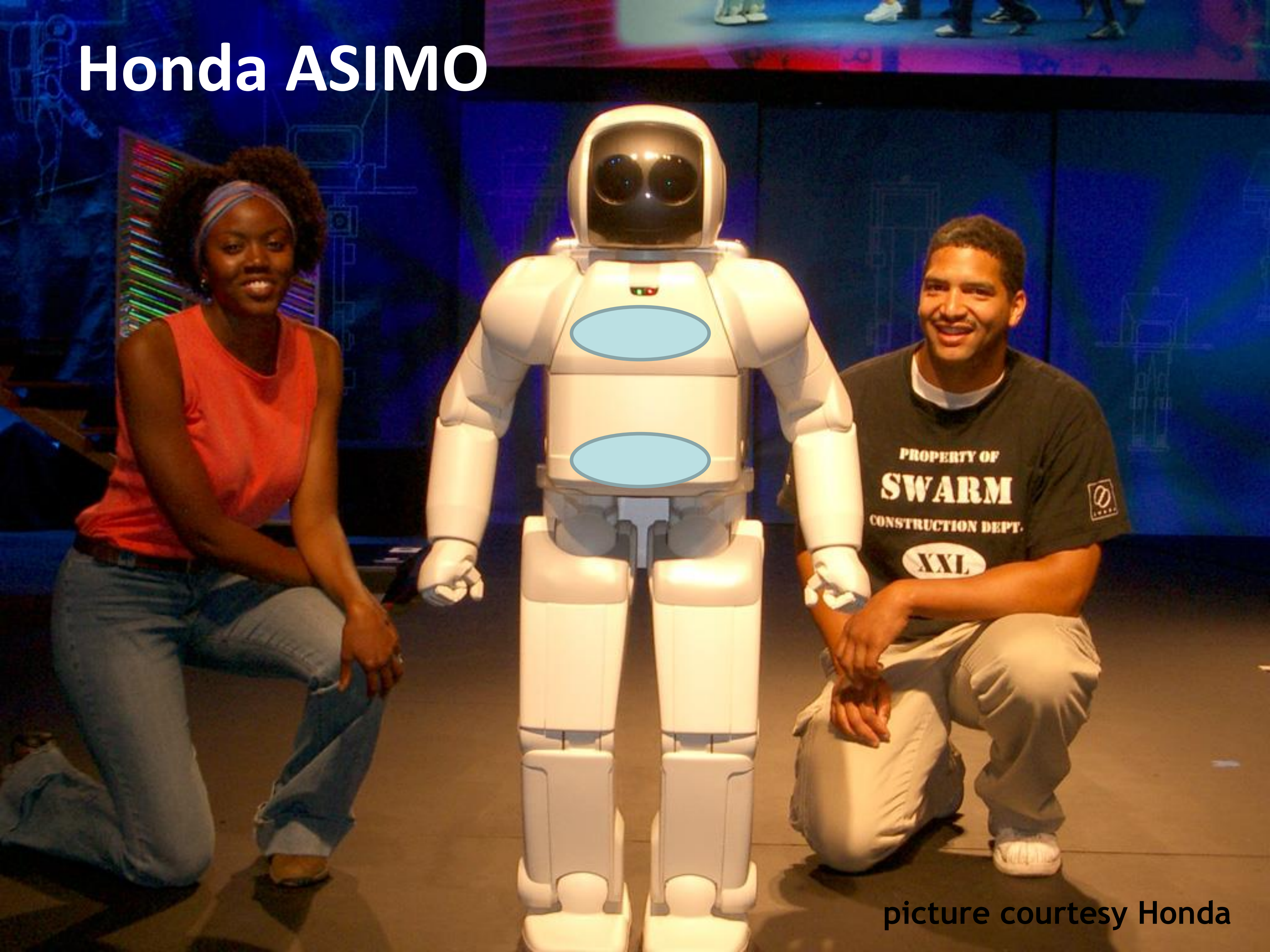

Thu Jan 29 18:49:06 2004


Thu Jan 29 13:15:44 2004

iRobot Roomba

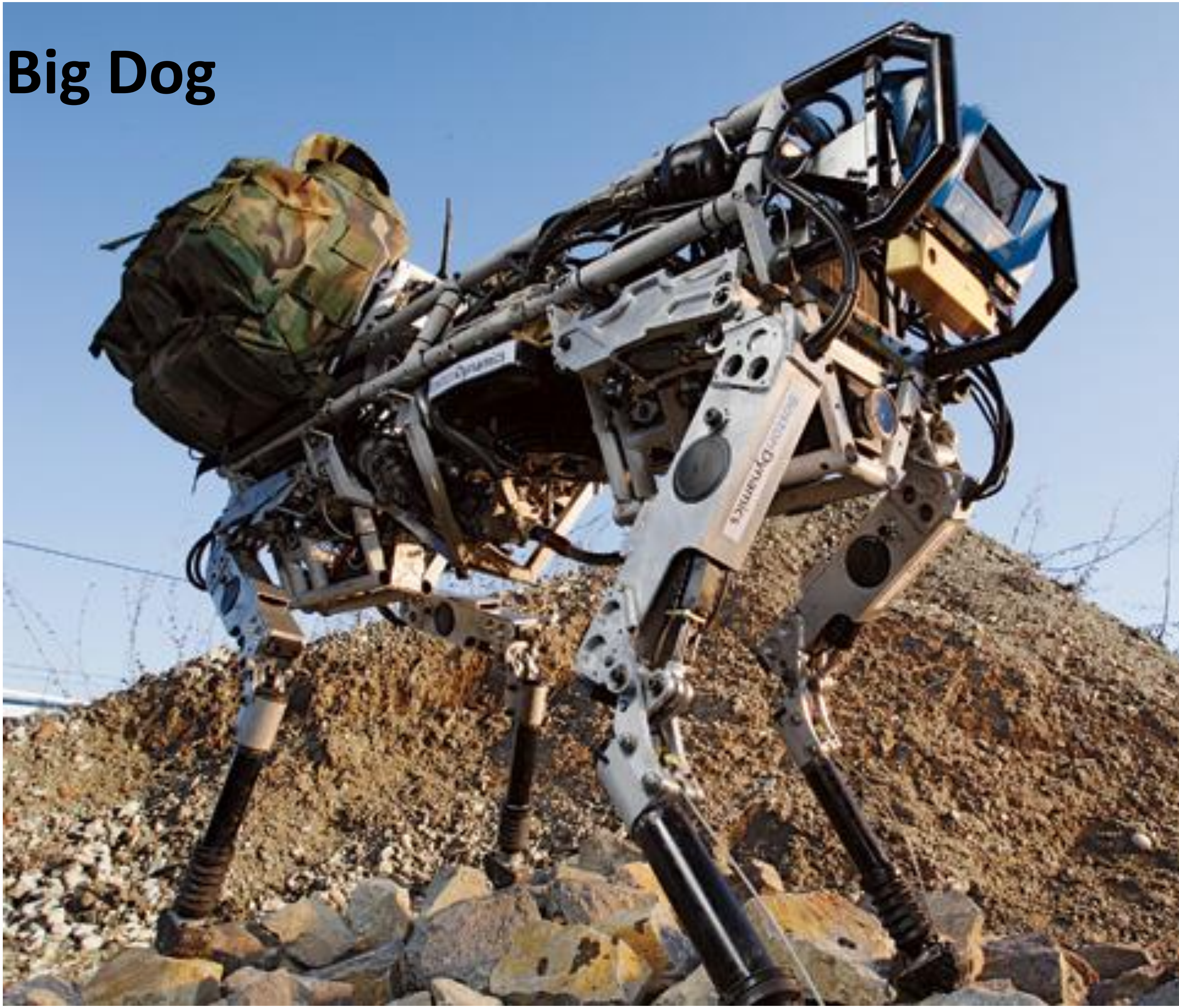
Kiva Systems

Honda ASIMO



picture courtesy Honda

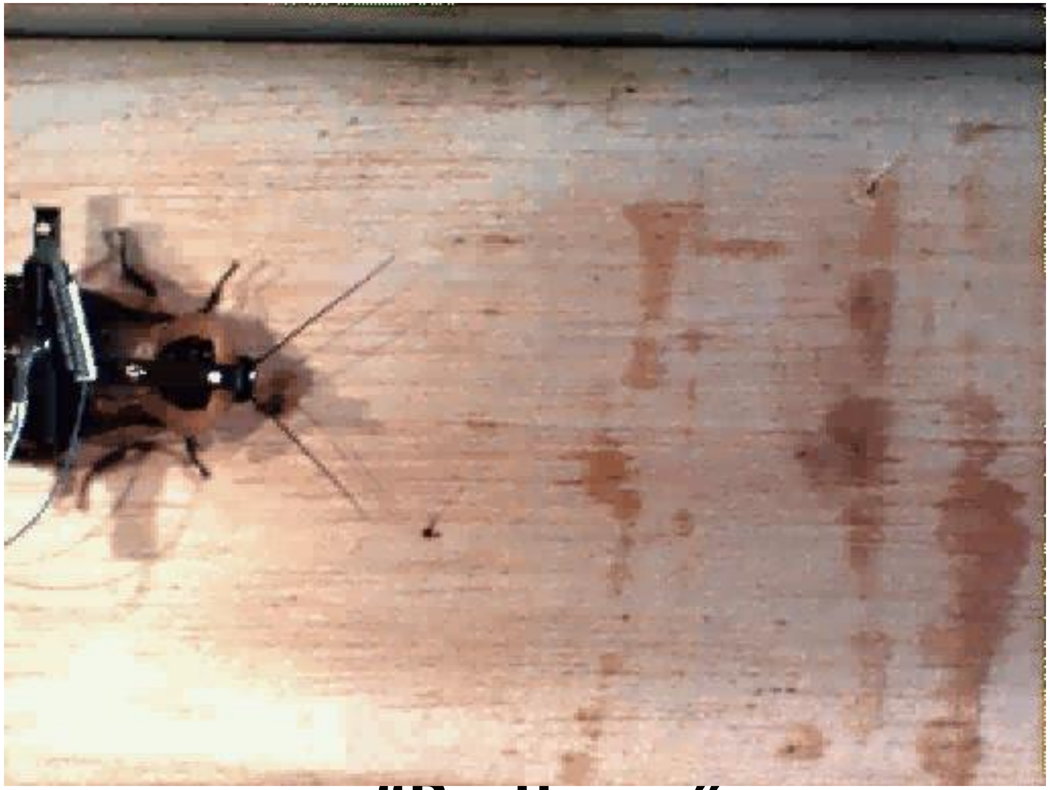
Big Dog



Disturbance Rejection: Artificial System

“Big Dog”, www.bostondynamics.com

Disturbance Rejection: Natural System



"Preflexes"

(Recovery in ~27ms!)

Jindrich, D. L. and Full, R. J. (2002). Dynamic stabilization of rapid hexapedal locomotion. Journal of Experimental Biology. 205,2803-2823. (Video and picture courtesy Devin Jindrich)

Stanley


accelerometers mounted above
the rear axle provide detailed
orientation data in "6D."
Light Detection and Ranging
Five LIDAR units at various angles
bounce laser beams off rotating
mirrors to create a 3D map of ter-
rain up to about 100 ft. away.
Color Video
A video camera scouts drive-
able road up to 160 ft. ahead,
identifies distant obstacles.
Red Bull
Red Bull
android

Job Selection

The Big Sort

Broad group

Need to know what you guys can do

Lots of Jobs for the Honary TAs

sysadmin

- Administer the git back-end server

web master

- update website

blog masters

- make blog entries

lab experts

- Help get the labs setup

Robot Demo!