15-494: Cognitive Robotics

Spring 2008

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Why is robot programming hard?

- It's done at too low a level:

  - Joint angles and motor torques instead of gestures and manipulation strategies

  - Pixels instead of objects

- It's like coding in assembly language, when what you really want is Java or Scheme or ALICE or Mathematica.

- Robots are stupid.

What Is this course about?

A new approach to programming robots:

- Borrowing ideas from cognitive science to make robots smarter

- Creating tools to make robot behavior *intuitive and transparent*

What if robots were smarter?

- Suppose robot could already see a bit, and navigate a bit, and manipulate objects.
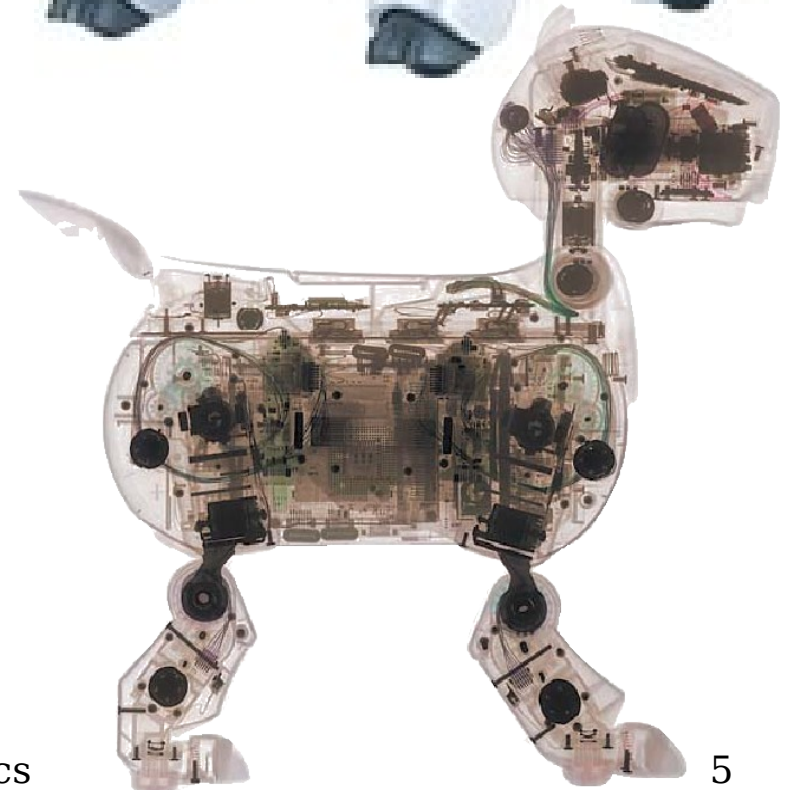
- What could you do with such a robot?

  We're going to find out!

- What primitives would allow you to easily program it to accomplish interesting tasks?

  Help us refine our design.

The AIBO ERS-7

- 576 MHz RISC processor

- 64 MB of RAM

- Programmed in C++

- Color camera: 208x160

- 18 degrees of freedom:
  - Four legs (3 degs. Each)
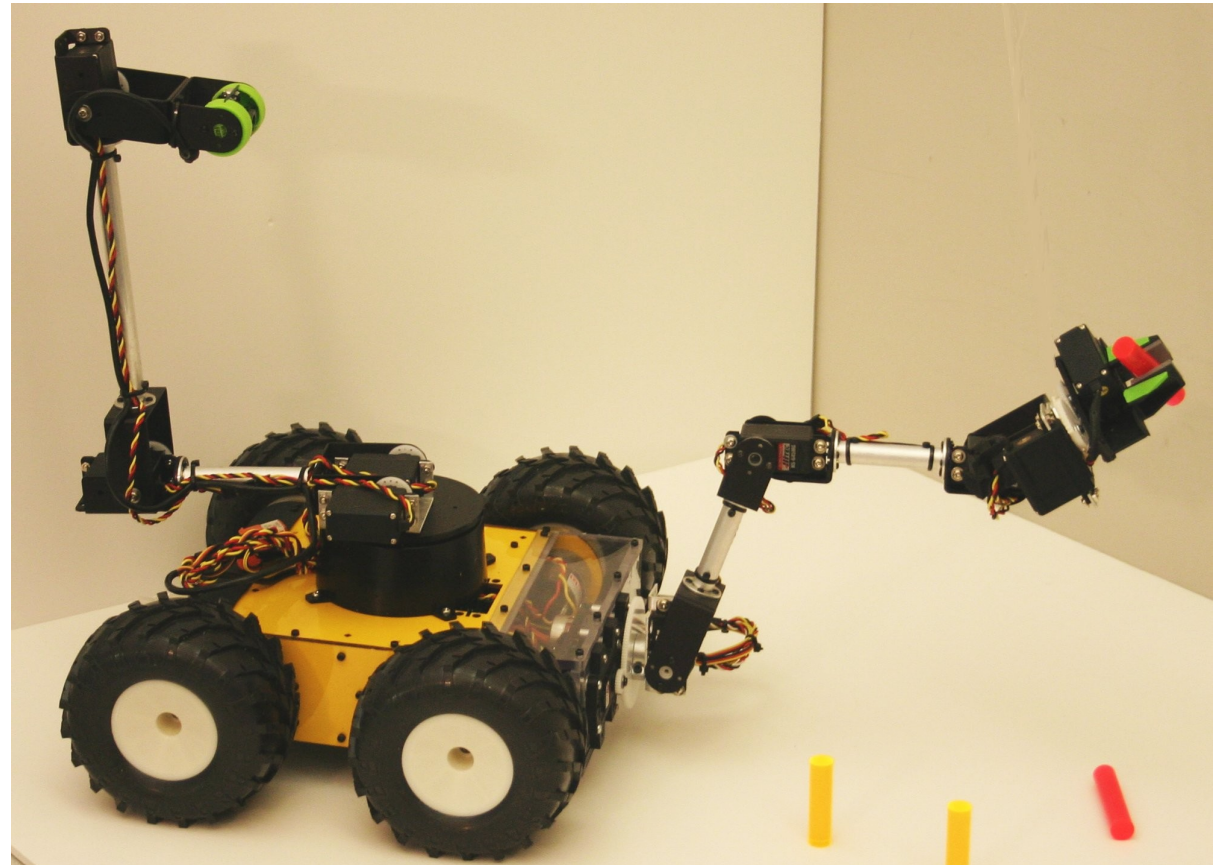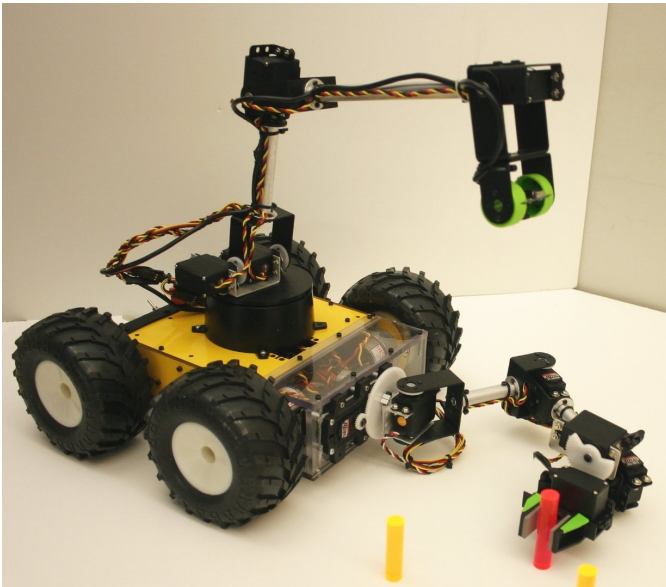 - Head (3), tail (2), mouth

- Wireless Ethernet

Other Platforms: Qwerk

- Qwerkbot+ developed by Illah Nourbakhsh at CMU.

- Uses Qwerk controller board from Charmed Labs.
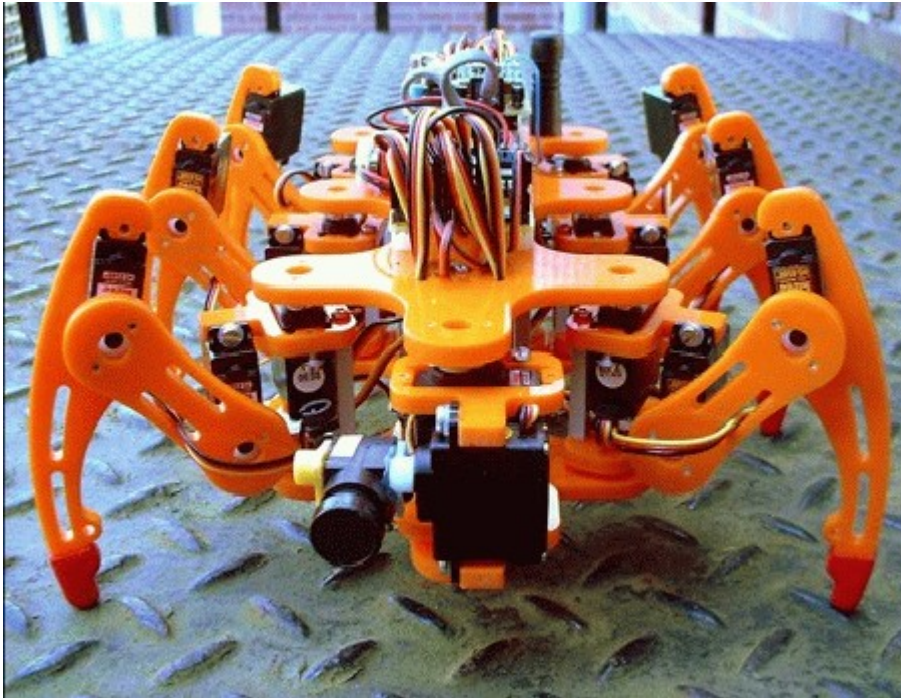
- Extensible! Add your own servos and sensors.

"Regis" Debuts at AAAI-07

- Modified Lynx Motion 4WD3 base, SES arms

- "Goose neck" webcam

- Crab arm w/gripper

- 600 MHz Gumstix processor

In Development: A Hexapod

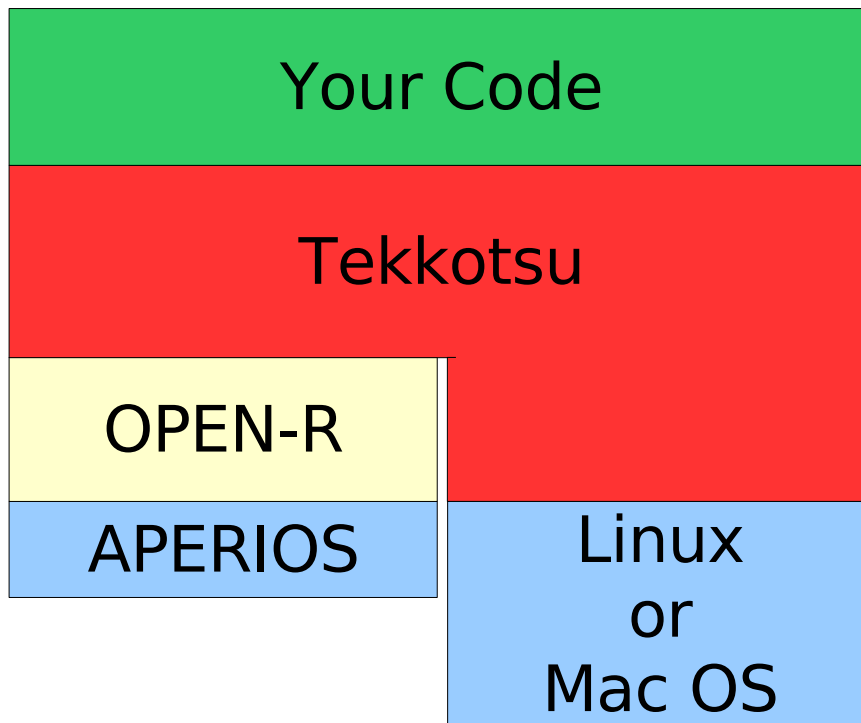MicroMagic Systems hexapod robots developed by Matt Denton.

Tekkotsu Means "Framework" in Japanese

(Literally "iron bones")

Tekkotsu.org

Your Code
Tekkotsu

OPEN-R
APERIOS

Linux
or
Mac OS

Tekkotsu features:

• Open source, LGPLed

• Event-based architecture

• Powerful GUI interface

• Documented with doxygen

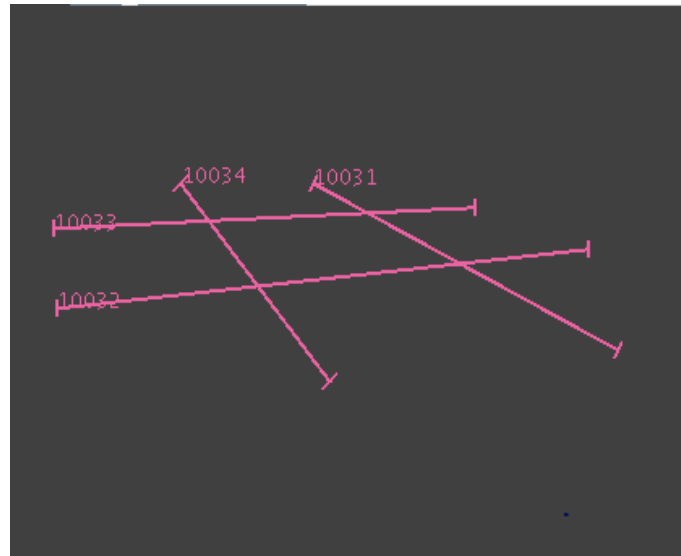• Extensive use of C++ templates,   inheritance, and operator
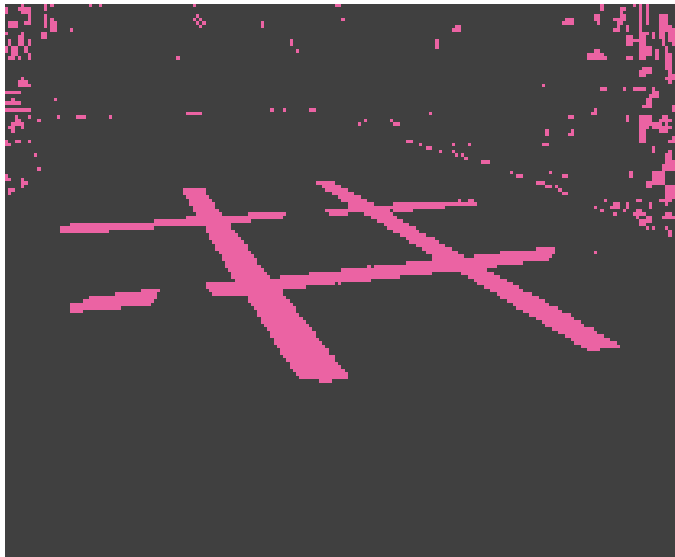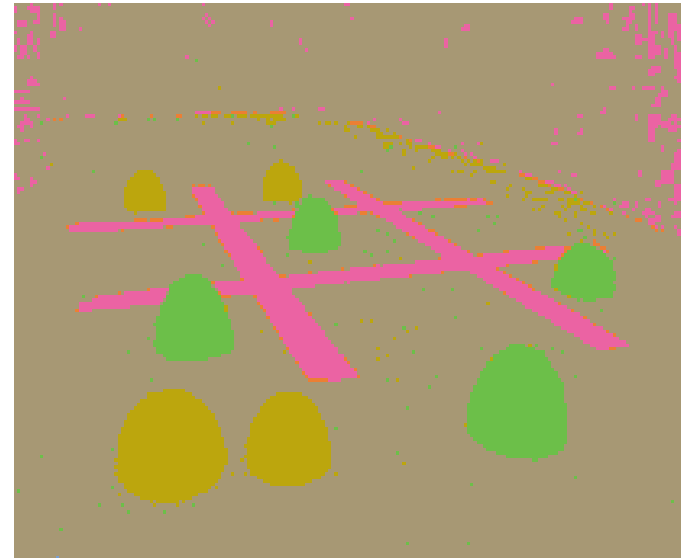   overloading
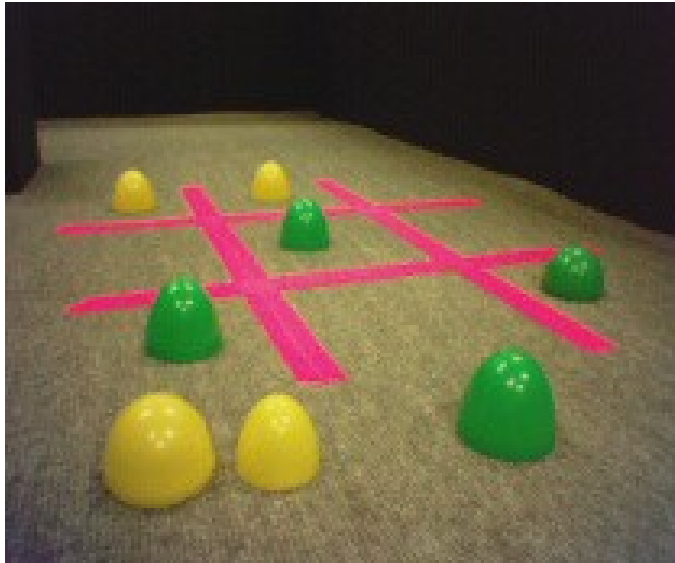
Primitives for Cognitive Robotics

- Perception: see shapes, objects
- Mapping: where are those objects?
- Localization: where am I?
- Navigation: go there
- Manipulation: put that there
- Control: what should I do now?
- Learning: how can I do better?
- Human-robot interaction: can we talk?
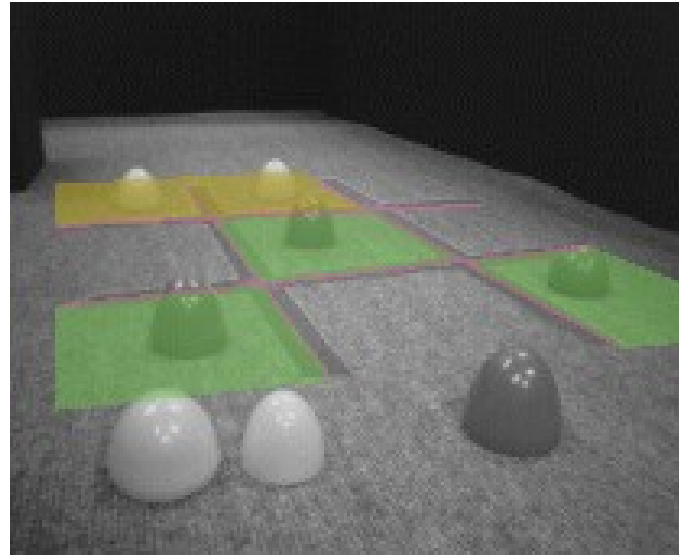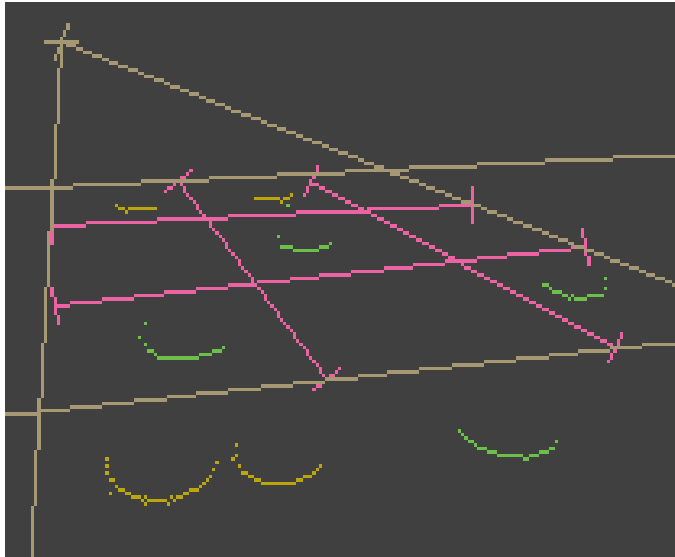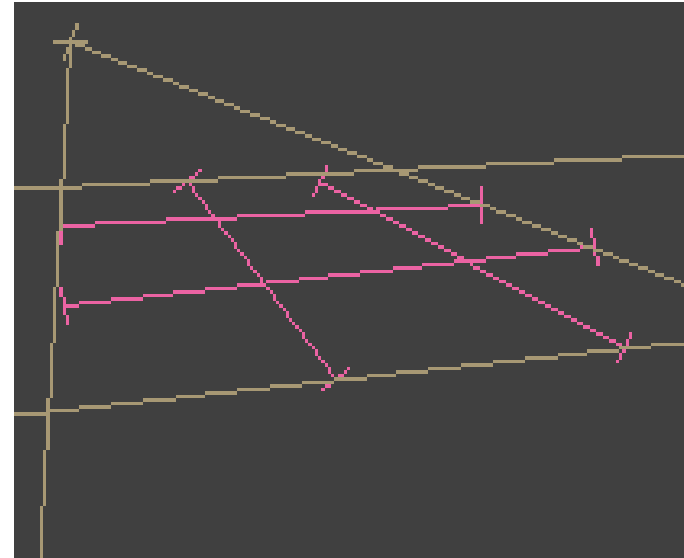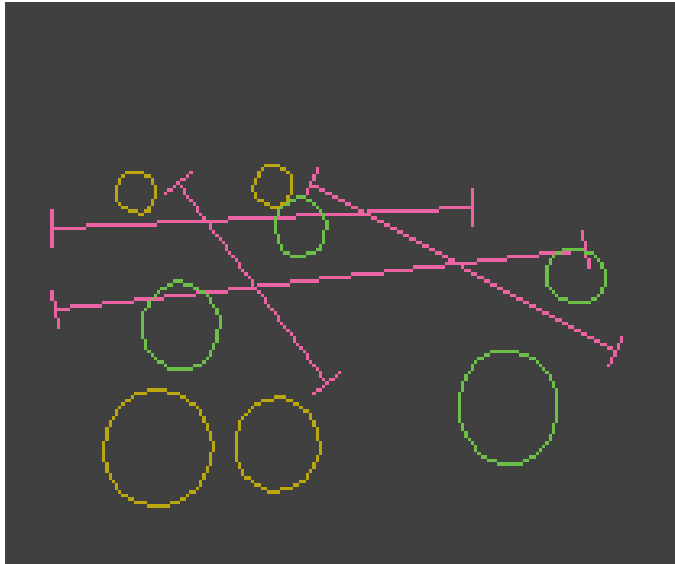
Primitives needed for tic-tac-toe

- See and understand the board (perception, mapping)

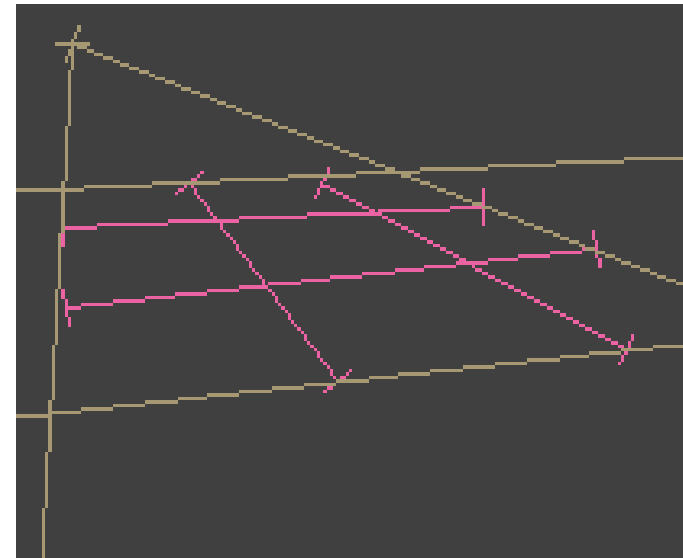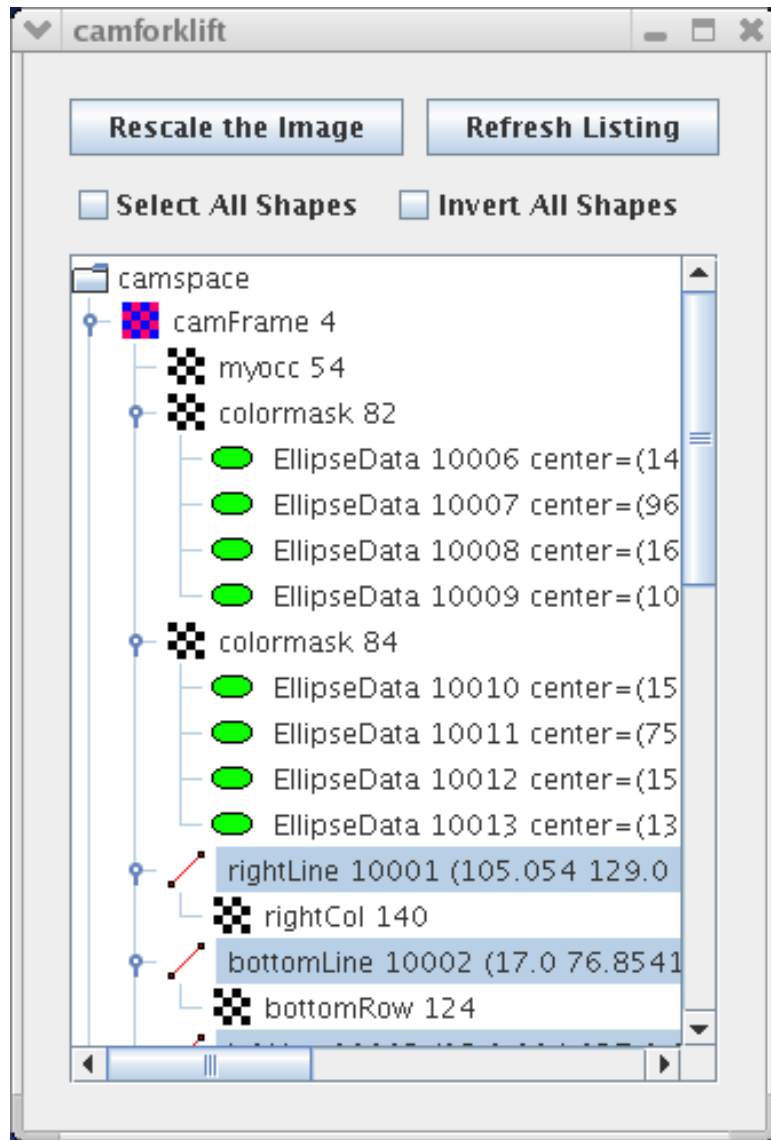- Move the game pieces (manipulation)

- Take turns (control)
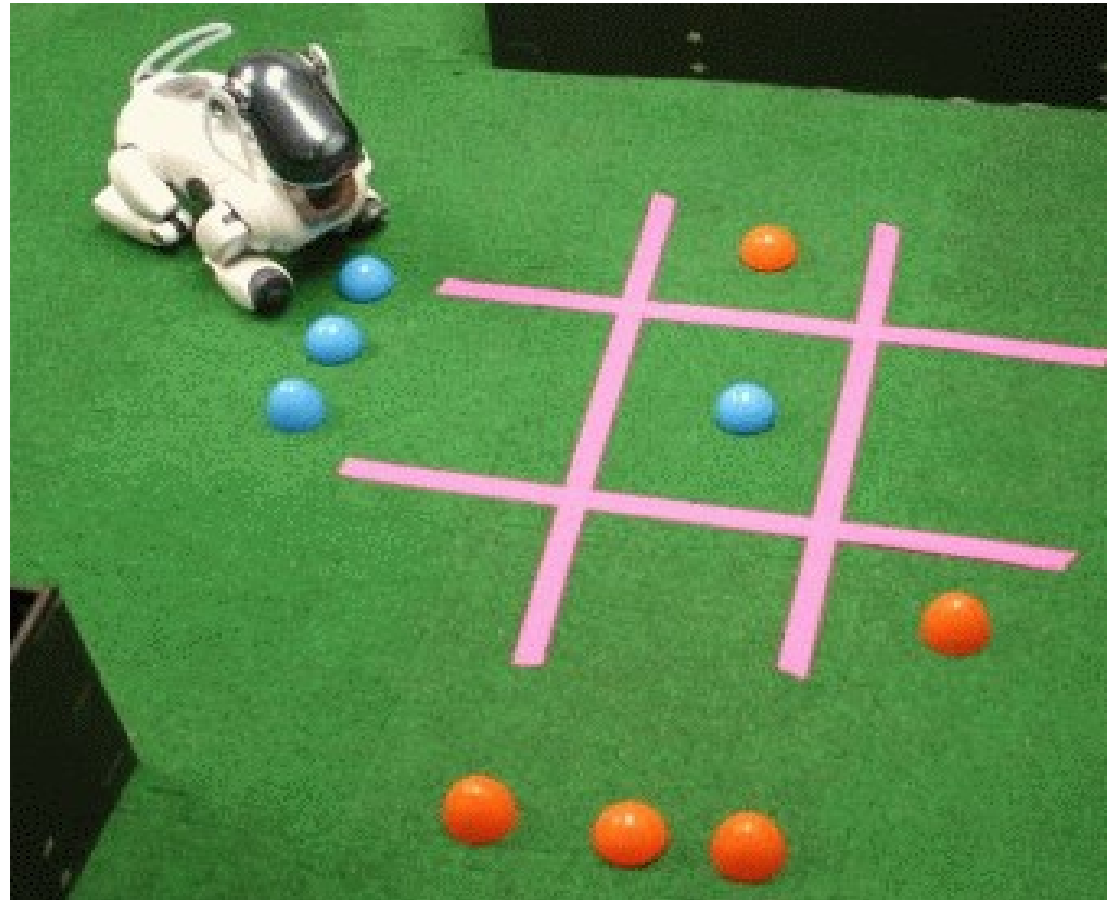
Visual Routines

Visual Routines

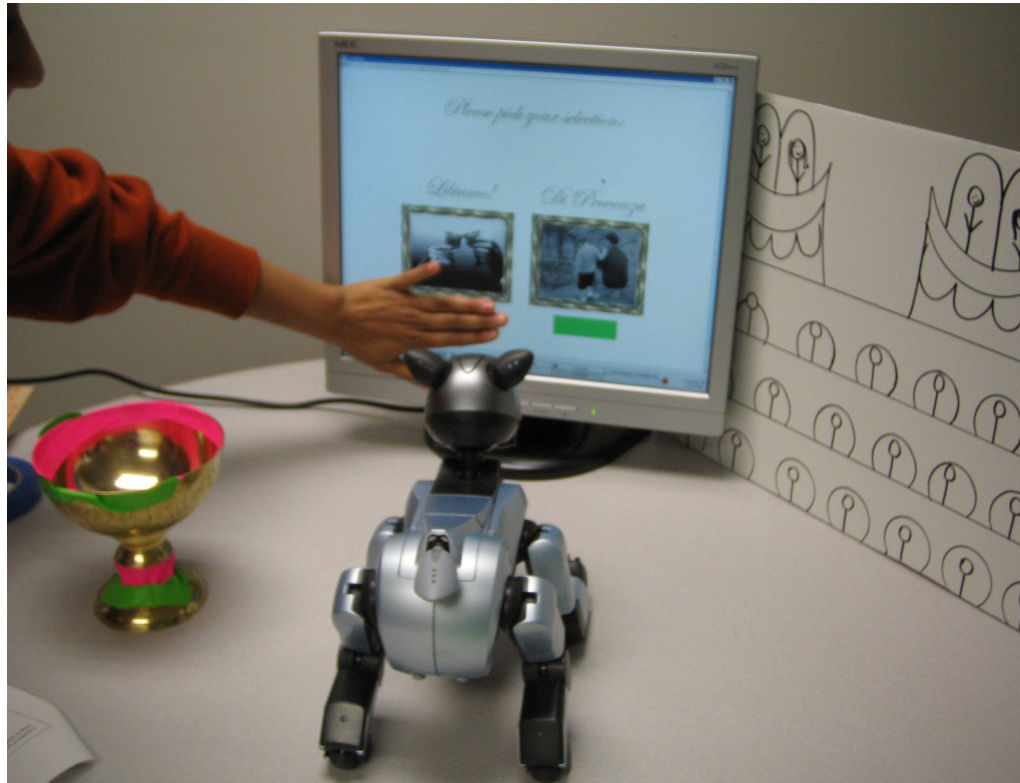# SketchGUI: see inside the robot's head

Transparency: Storyboard tool

Human-Robot Interaction

A duet from Verdi's *La Traviata*
(LookingGlass project by Kirtane & Libby)

Ideas from Cognitive Science?

- Visual routines, dual coding theory, gestalt perception, affordances, ...
- Active research area. You can help!
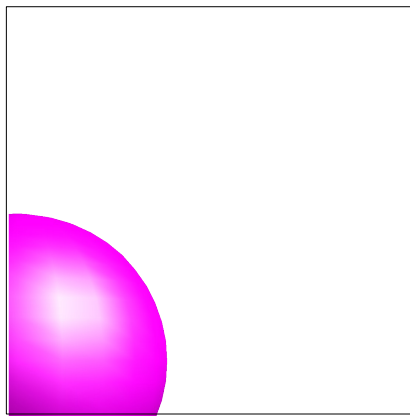
Camera view:
"I see a pink blob"
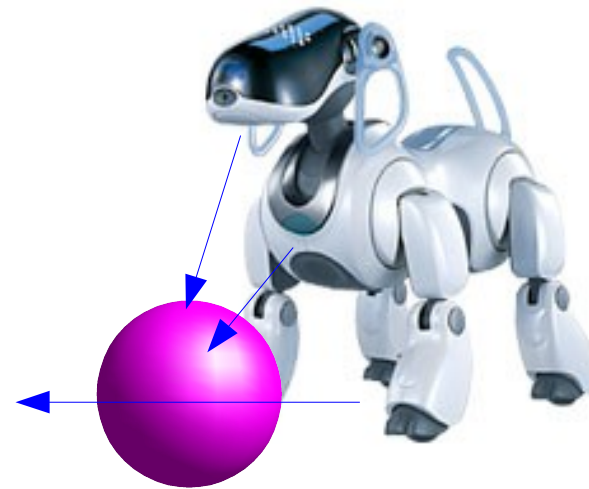
Affordances:
"I see something I can push"

Robot Learning

Implementing learning algs. on the robot:

    – TD learning for
       classical conditioning

Video
demos
from
Tekkotsu
web site
(Videos
and
Screen
Shots
section)

    – Two-armed bandit
       learning problem

New Features This Year

- Qwerk and Regis support

- Telepathy (inter-robot communication)

- Manipulation primitives for an arm

    – Zhengheng Go's senior thesis work

- SIFT object recognition

    – Xinghao Pan's senior thesis work

- New state machine parser

    – Dave Touretzky's Christmas break project

ARTSI Alliance

Monday, January 14th
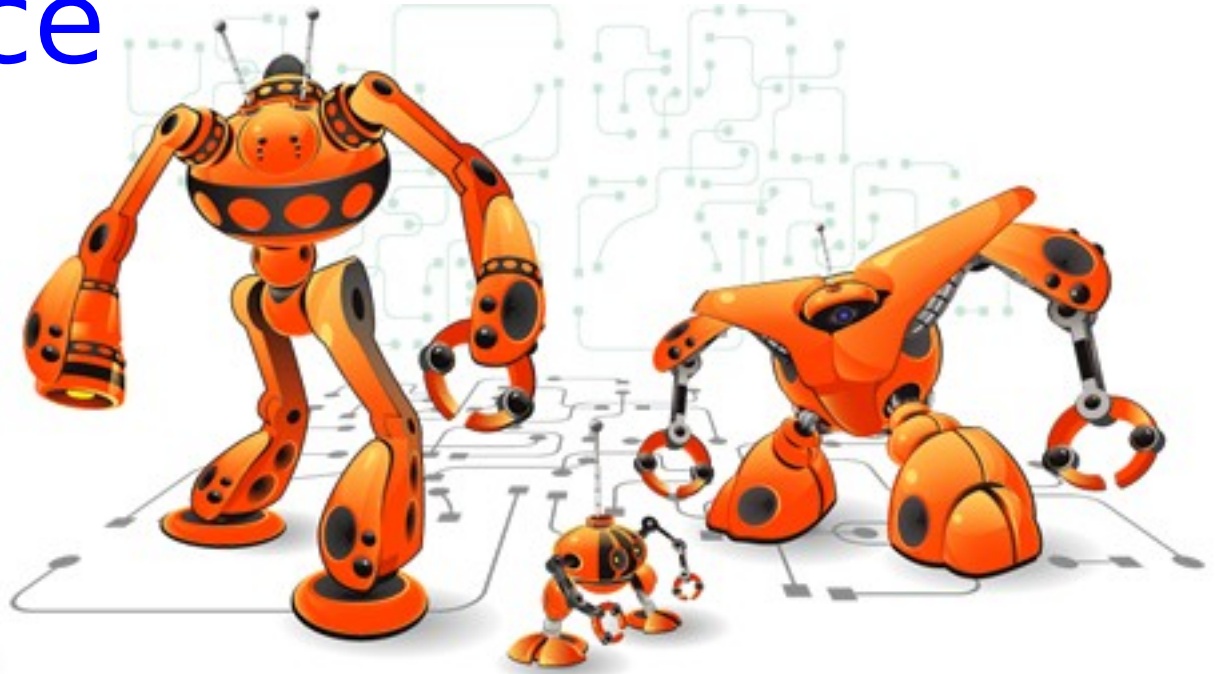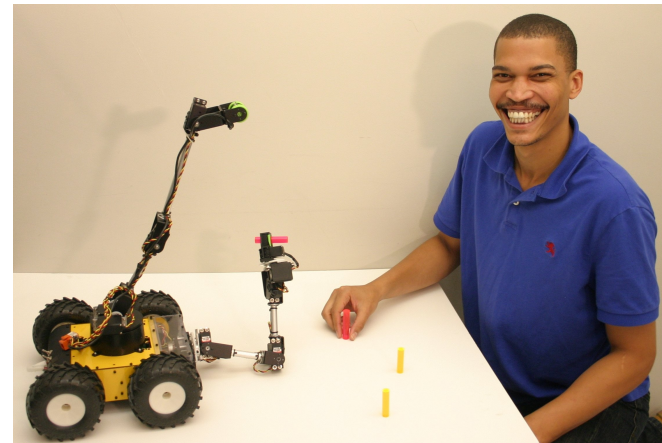Kick Off Event

artsi

Advancing Robotics Technology for Societal Impact

Course Administrative Stuff

- Times/Locations:
  - Mon / Wed 3:30 to 4:20 in Wean Hall 5320
  - Fri 3:00 to 4:20 in NSH 3206 (REL)
    REL = Robotics Education Lab

- Grading:
  - 25% homeworks and labs
  - 25% midterm exam
  - 25% final exam
  - 25% course project and presentation

Syllabus and Lecture Schedule

- The syllabus/lecture schedule is linked from the course home page:

  www.cs.cmu.edu/afs/cs/academic/class/15494-s08

- Check weekly for updates, links to readings, links to homeworks/labs.

- Some readings should be done before the lecture, some afterwards. Follow the order in the schedule.

- For Friday's lab: review the syllabus and check out Tekkotsu.org.

Teamwork

- You are permitted, but not required, to work in teams.

- A team may have at most 3 members.

- When handing in an assignment, only one copy need be handed in per team. Everyone's name should be on it.

Final Projects

- Proposal stage:

  - Pick something cool (we'll give suggestions); convince us that you can carry it off.

- Development stage:

  - We'll have project clinics to help you work on your projects.

- Presentation stage:

  - Develop a presentation and demo.
  - Public demonstrations on May 2, 2008