

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?

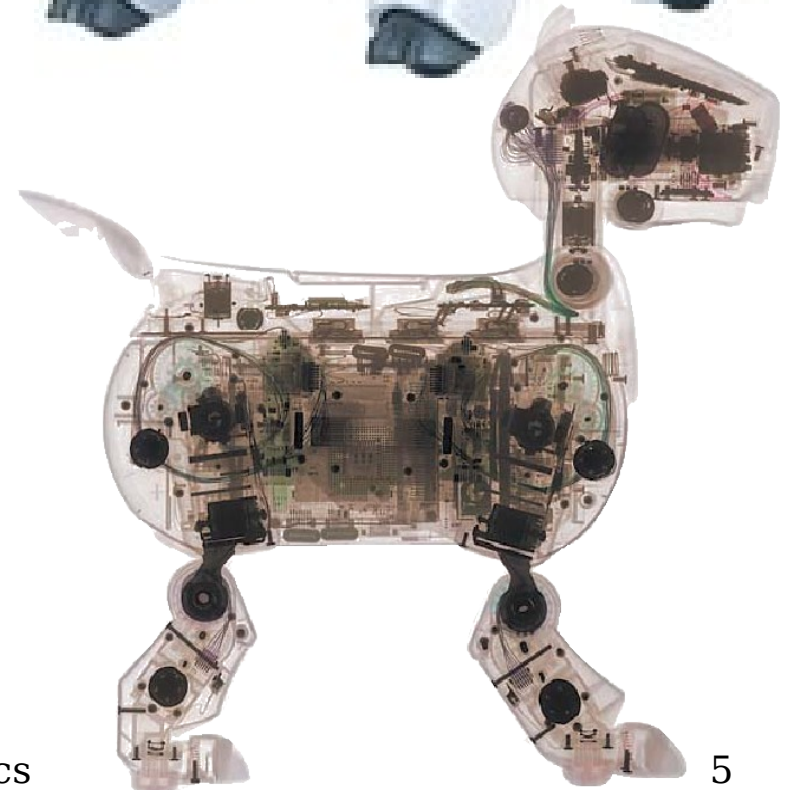
We're going to find out!

- 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



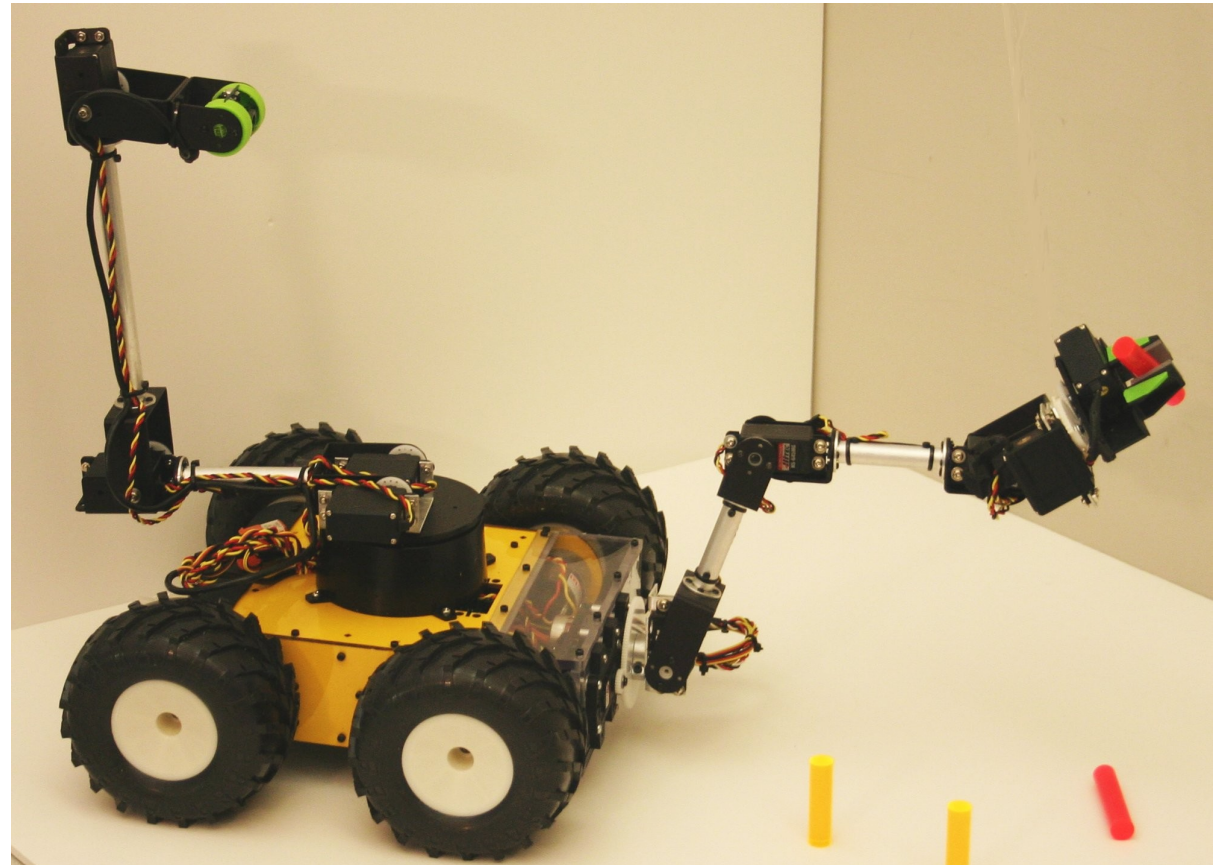
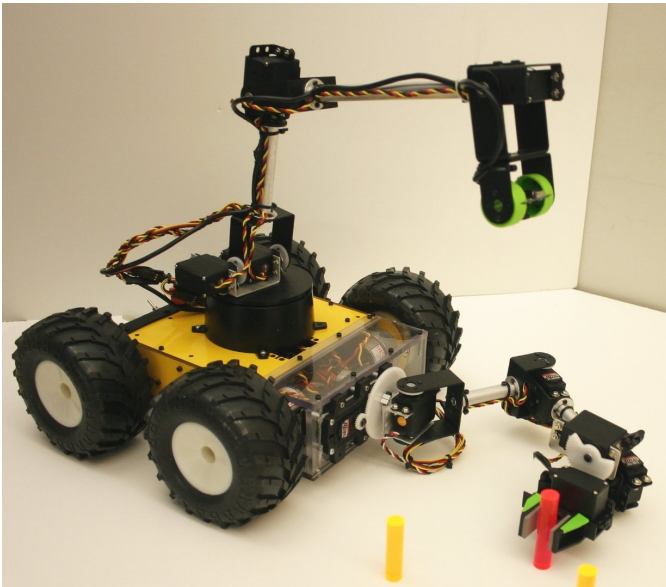
Other Platforms: Qwerk

- Qwerkkbot+ developed by Illah Nourbakhsh at CMU.
- Uses Qwerk controller board from Charmed Labs.
- Extensible! Add your own servos and sensors.

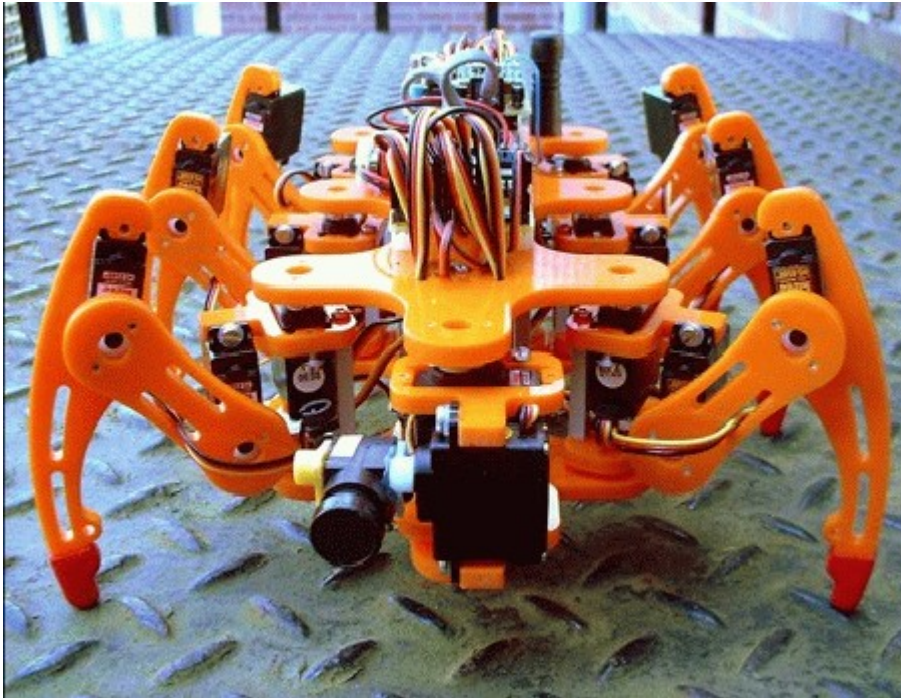


“Regis” Debuts at AAAI-07

- 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.

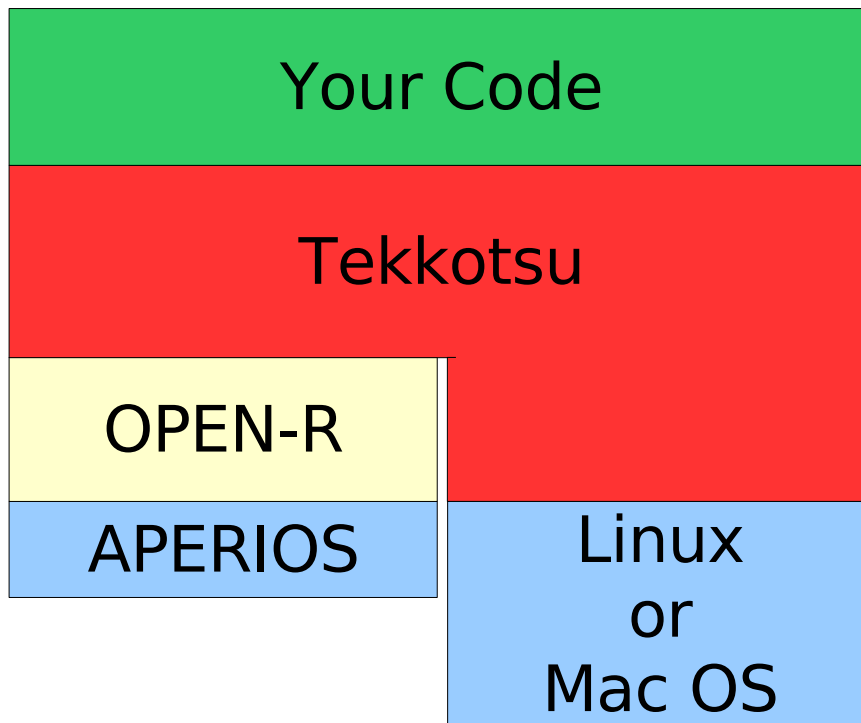


Tekkotsu Means “Framework” in Japanese

(Literally “iron bones”)



Tekkotsu.org



Tekkotsu features:

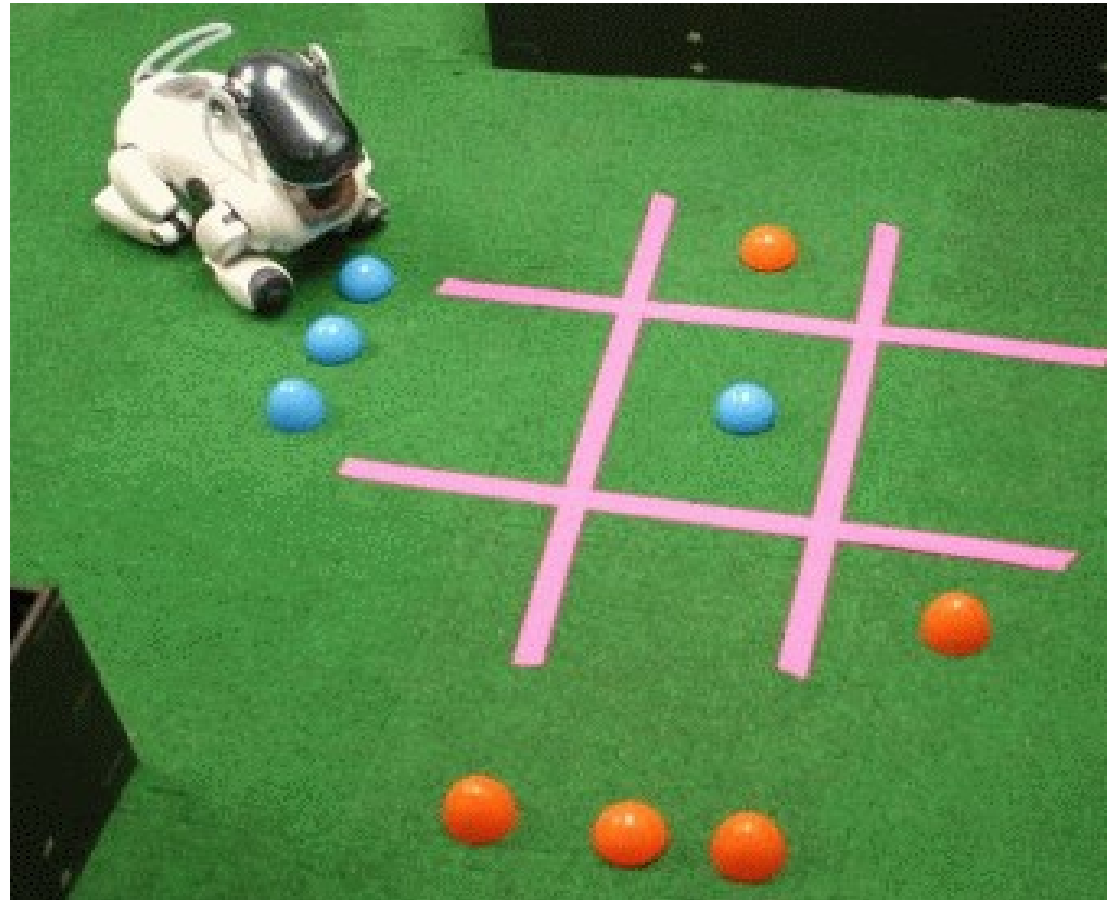
- Open source, LGPLed
- Event-based architecture
- Powerful GUI interface
- Documented with doxygen
- Extensive use of C++ templates, inheritance, and operator overloading

Primitives for Cognitive Robotics

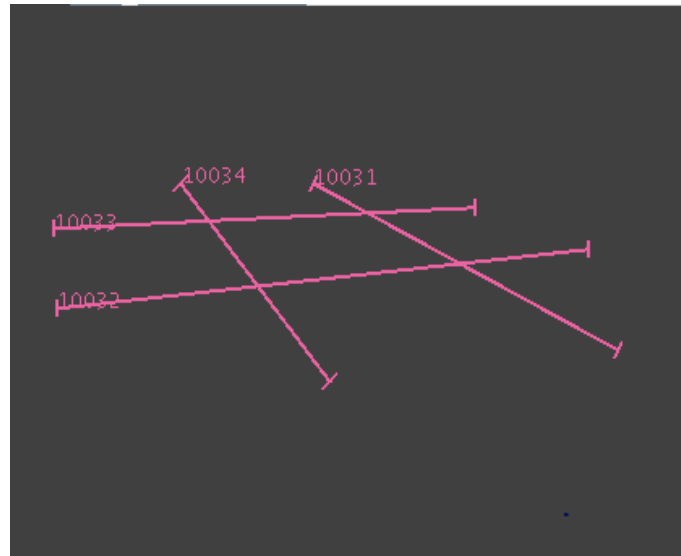
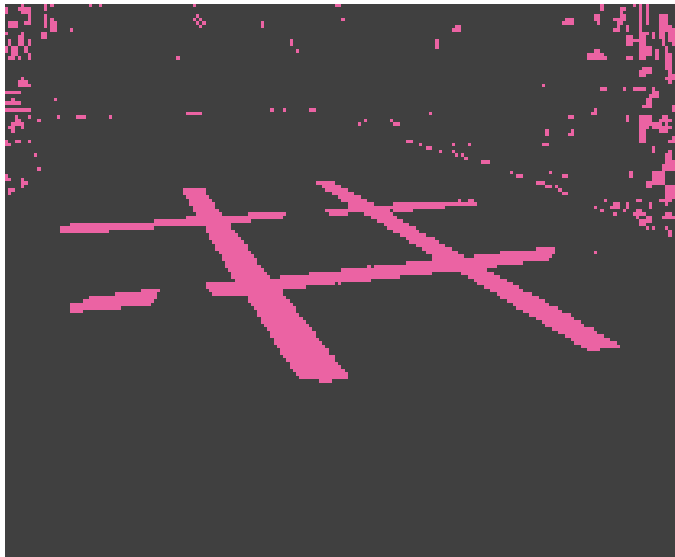
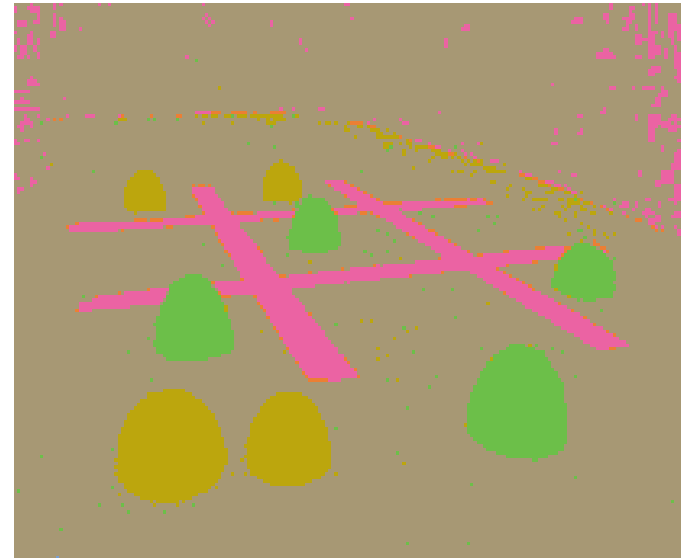
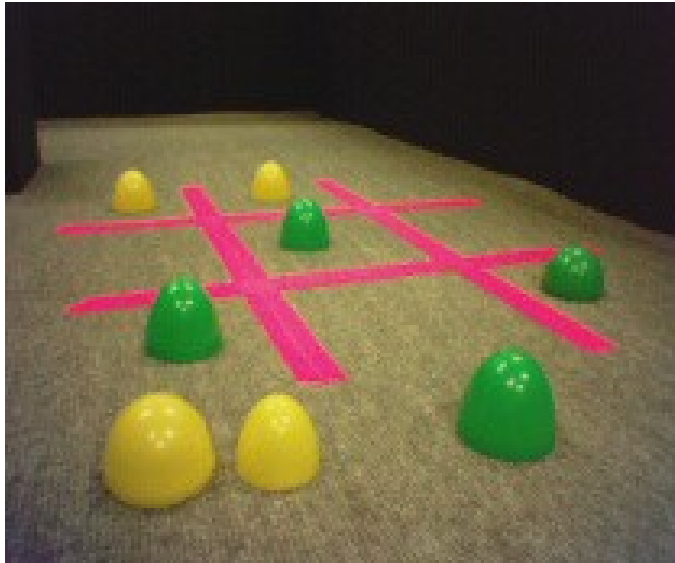
- **Perception**: see shapes, objects
- **Mapping**: where are those objects?
- **Localization**: where am I?
- **Navigation**: go there
- **Manipulation**: put that there
- **Control**: what should I do now?
- **Learning**: how can I do better?
- **Human-robot interaction**: can we talk?

Primitives needed for tic-tac-toe

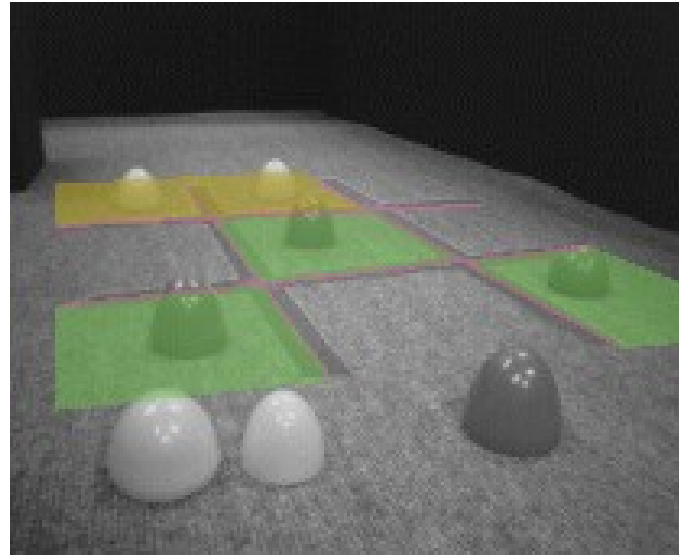
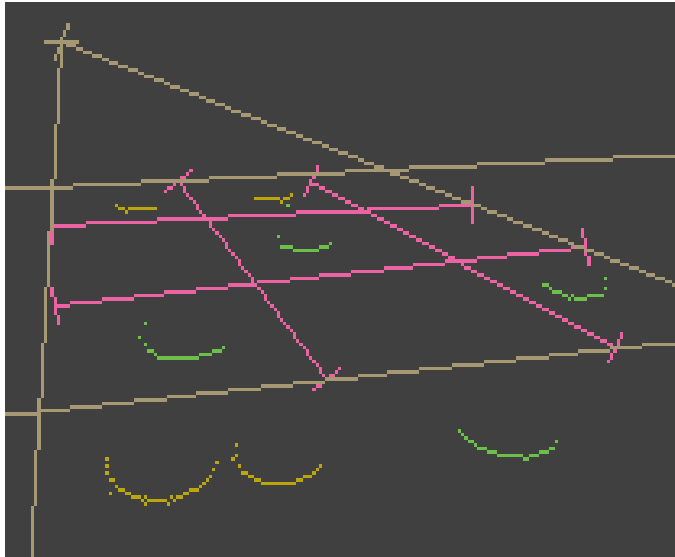
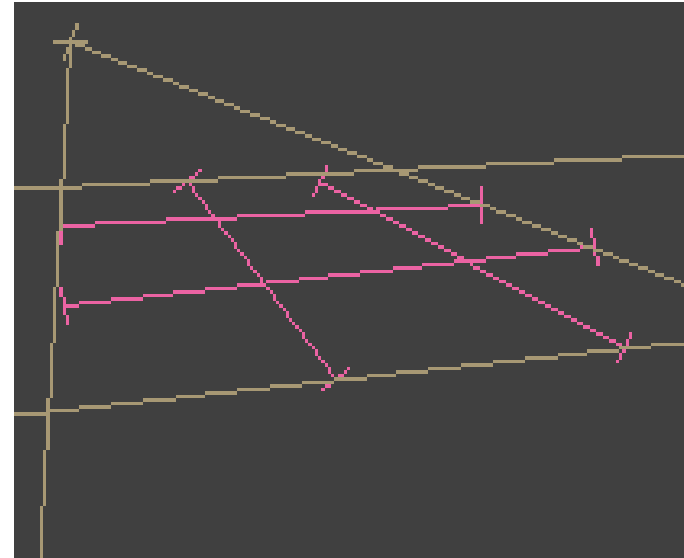
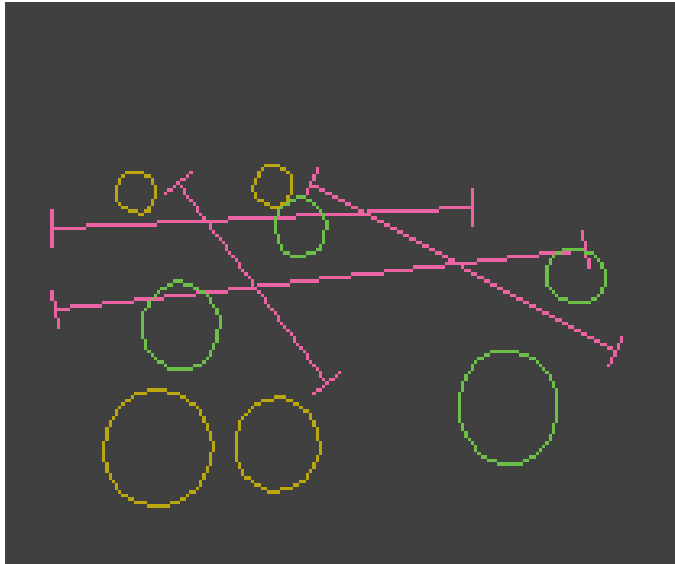
- See and understand the board
(perception, mapping)
- Move the game pieces
(manipulation)
- Take turns
(control)



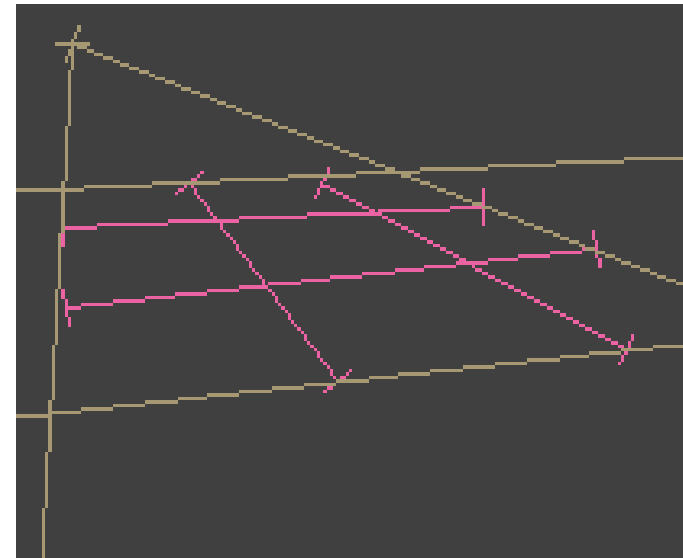
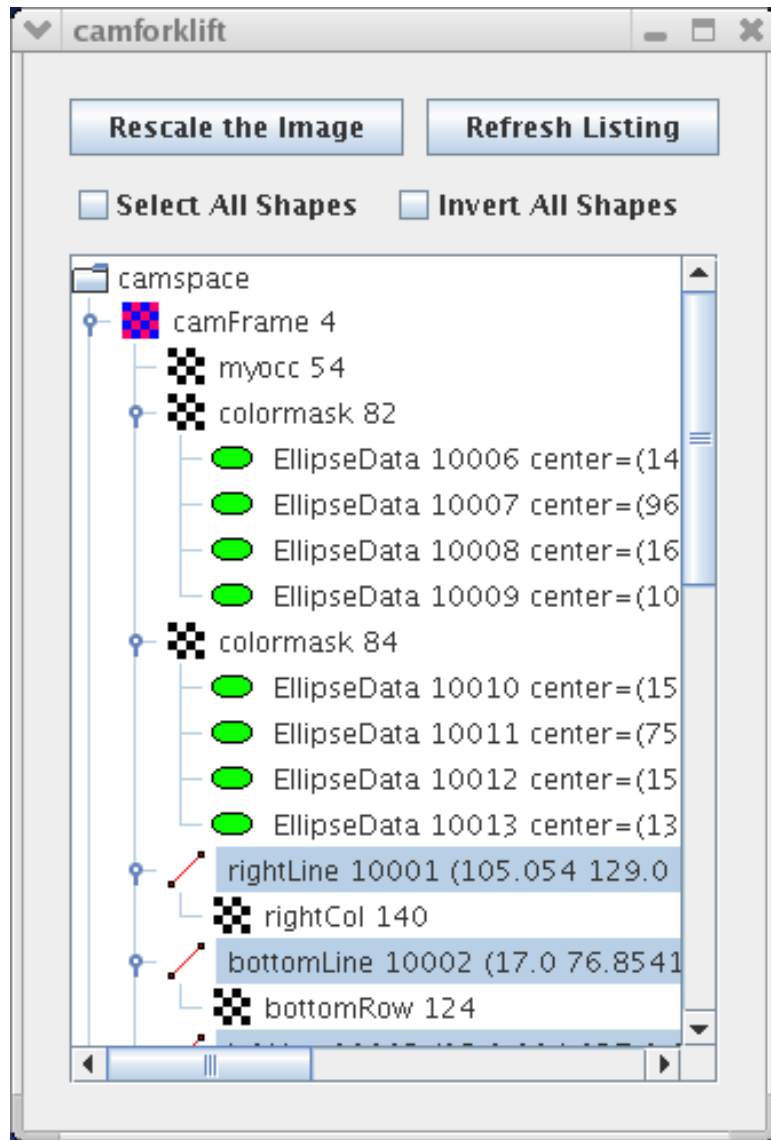
Visual Routines



Visual Routines



SketchGUI: see inside the robot's head

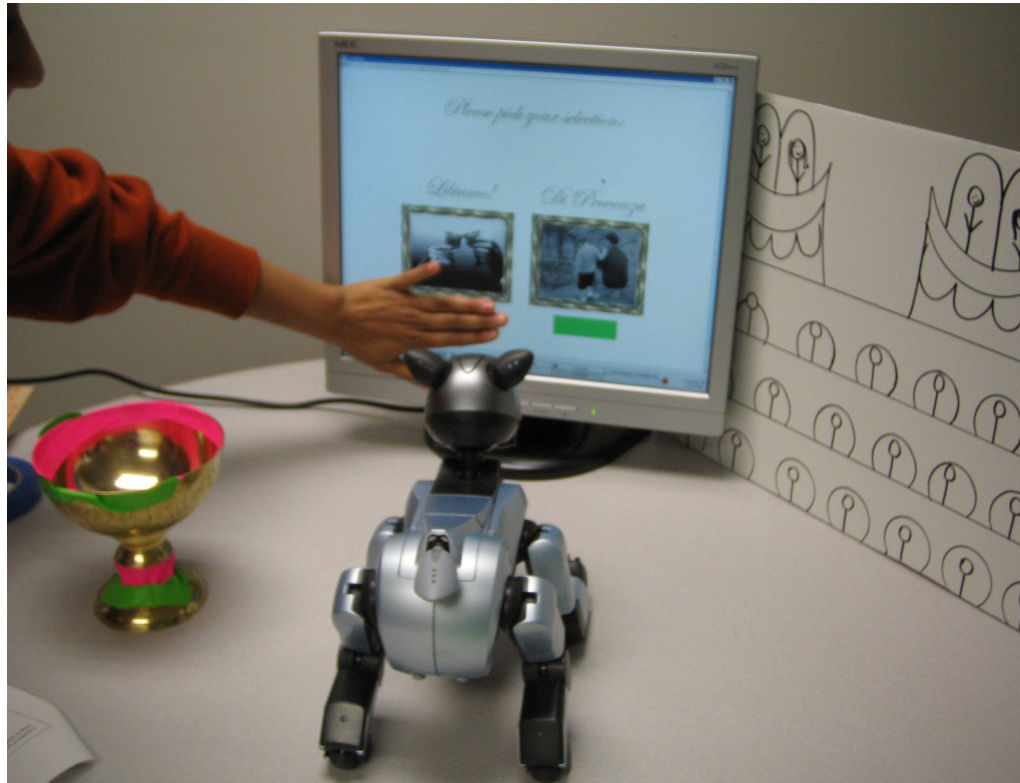


Transparency: Storyboard tool

The screenshot displays the Tekkatsu Viewer application, which is used for visualizing and interacting with a state machine model. The interface is divided into several panels:

- Top Panel:** Contains a menu bar (File, Edit, Window) and a toolbar. The main area shows a state machine diagram with nodes like 'Pink', 'Follow', 'Sit', 'Sound', 'Down', 'Sniff', 'Up', 'Punch', 'Look', and 'Funny'. A 'Time' node is also present. The 'Host' is set to 'localhost' and the 'Port' is '10080'. The 'Name' is 'Explore State Machine'. Buttons for 'Download Model', 'New Trace', and a refresh icon are visible.
- Right Panel (Properties):** Shows the 'Runtime View' properties for the current selection (46.875s). It lists the following states and transitions:
 - Up:** activate at: 43.002s, deactivate at: 47.0s, type: state
 - Up->PunchLock:** fire at: 47.001s, type: transition
 - Punch:** activate at: 47.002s, deactivate at: 51.002s, type: state
 - Look:** activate at: 47.002s, deactivate at: 59.002s, type: state
- Bottom Panel (Storyboard):** A timeline view showing the sequence of events. The timeline has a scale from 0 to 60 seconds. The storyboard shows a sequence of actions: 'Funny', 'Pink', 'Follow', 'Sit', 'Sound', 'Down', 'Sniff', 'Up', 'Punch', and 'Look'. A red vertical line indicates the current time position.
- Bottom Right Panel (Image Preview):** A 3D rendering of a virtual environment with a green floor and a black background. It shows a yellow sphere, a pink sphere, and a pink bone-like object.

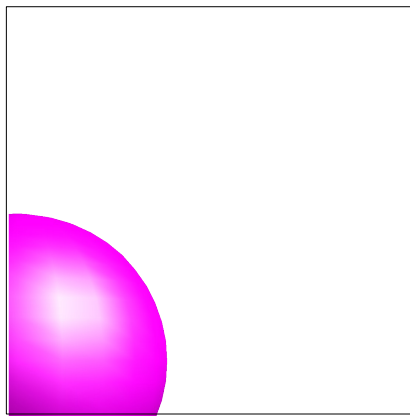
Human-Robot Interaction



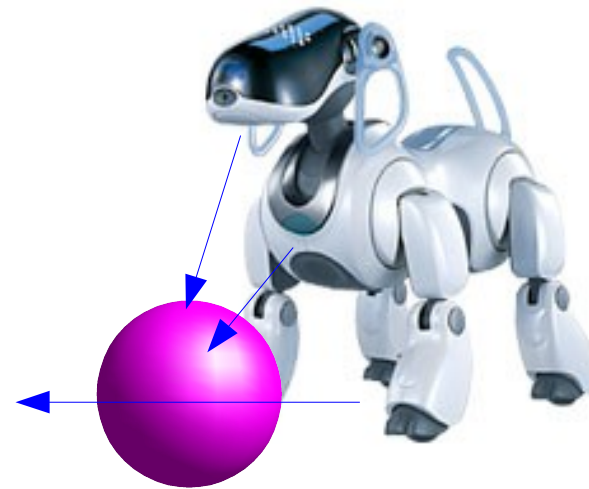
A duet from Verdi's *La Traviata*
(LookingGlass project by Kirtane & Libby)

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
- Two-armed bandit learning problem



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

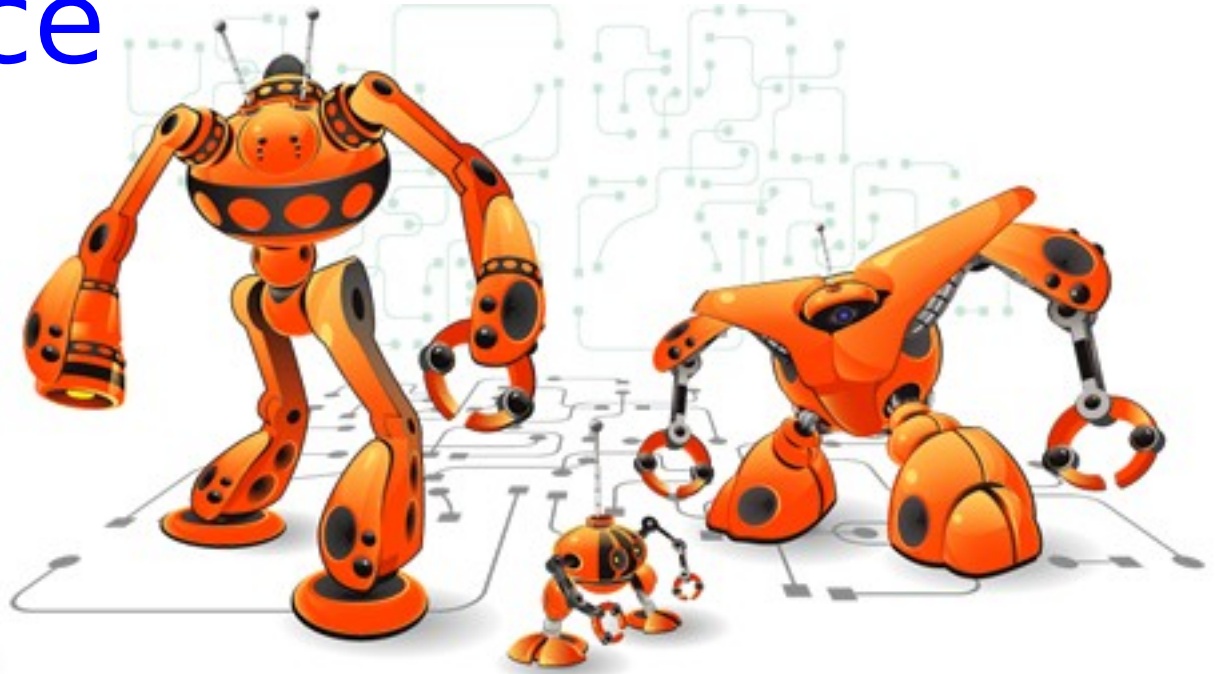
New Features This Year

- 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

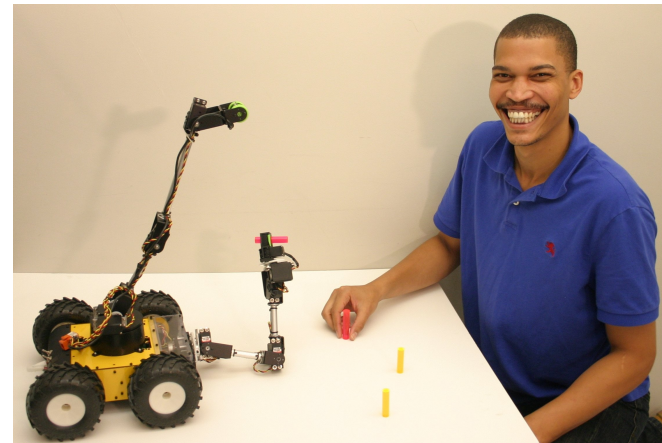
ARTSI Alliance

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