Robots as Computing Devices

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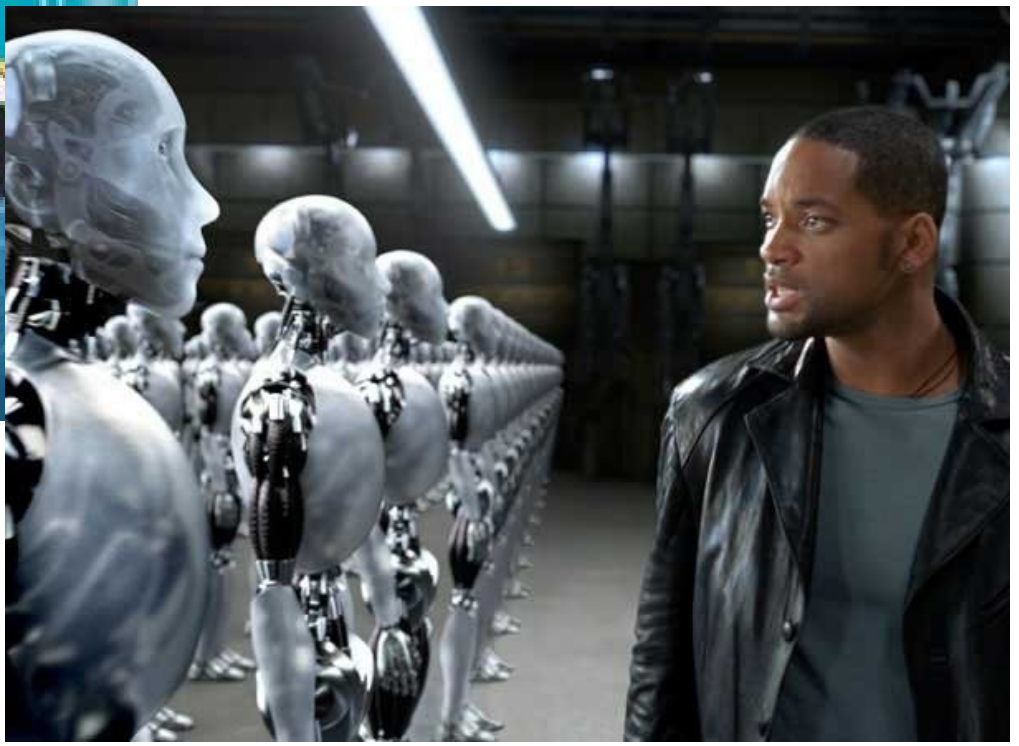
Shout-outs: Ethan Tira-Thompson & Glenn Nickens

Tekkotsu.org

The Robotic Future Is Unimaginable Today

The Jetsons cartoon

This isn't it.



Will Smith in “I, Robot”

Teaching the CS Side of Robotics

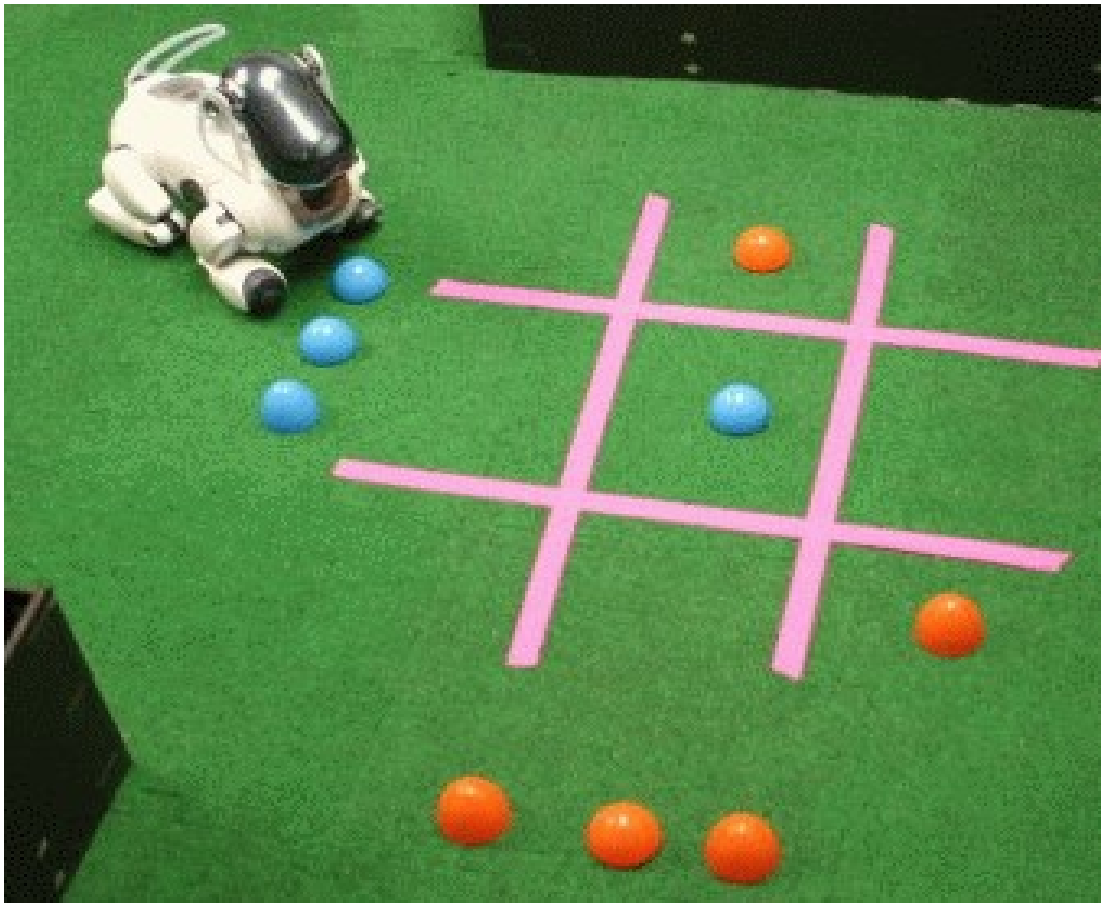
- What can we offer upper level CS undergrads in Robotics?
- There is lots of material we *could* be teaching:
  - Machine vision
  - Navigation, path planning (not just blob chasing)
  - Localization (particle filters)
  - Kinematics
  - Manipulation: grasp planning, path planning
  - Human-robot interaction (face and gesture recognition)
  - Inter-robot communication
- Why aren't we teaching this?
  - Inadequate platforms (poor sensors, not enough compute power)
  - Material needs to be made more accessible to undergraduates

Tekkotsu

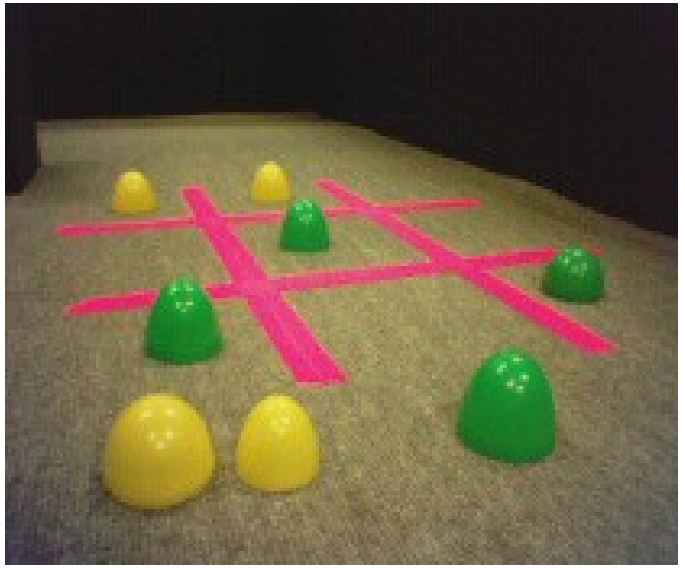
- Open source platform available from Tekkotsu.org
- Project started in 2003 on the Sony AIBO.
- Makes advanced robotics concepts accessible to undergrads.

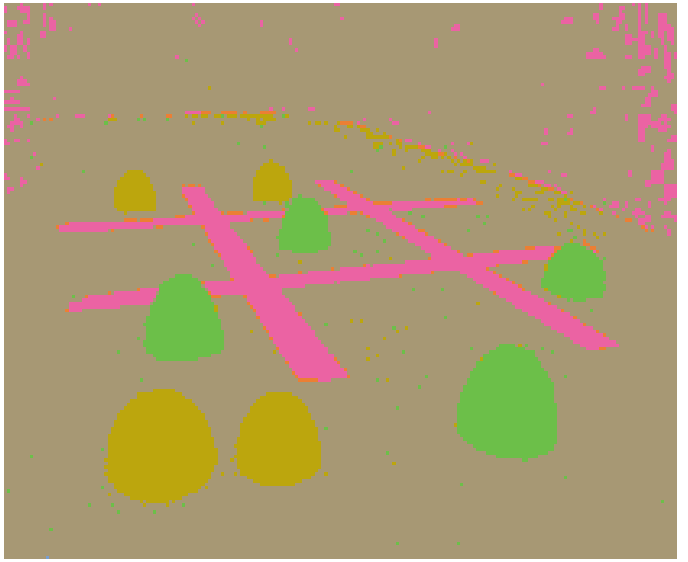
Primitives needed for tic-tac-toe

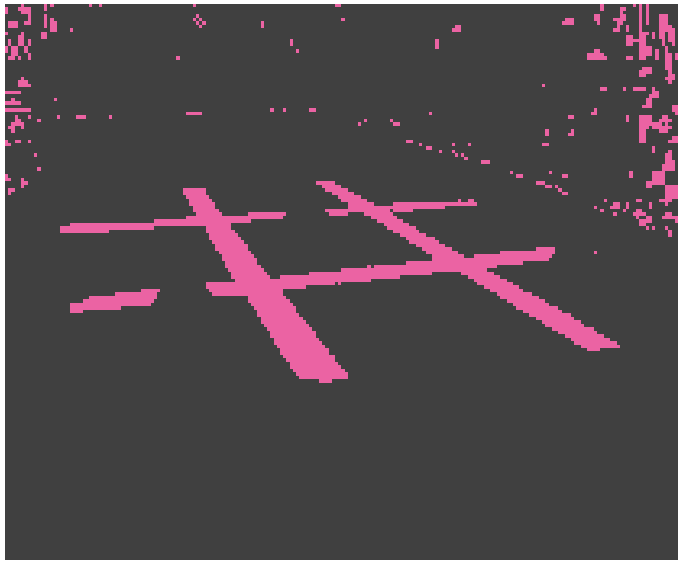
- See and understand the board (perception, mapping)
- Move the game pieces (manipulation)
- Take turns (control)

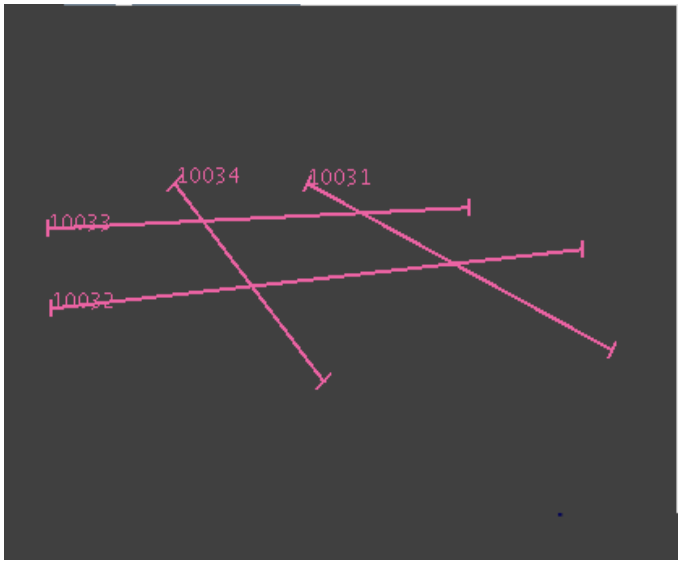


Visual Routines









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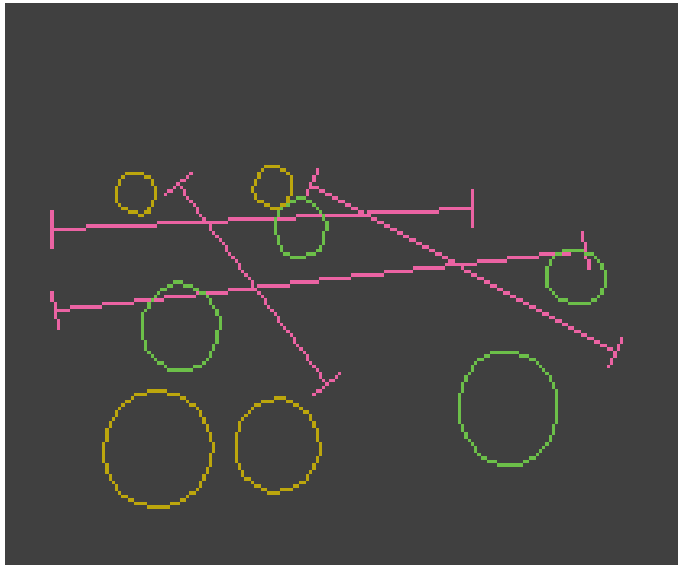
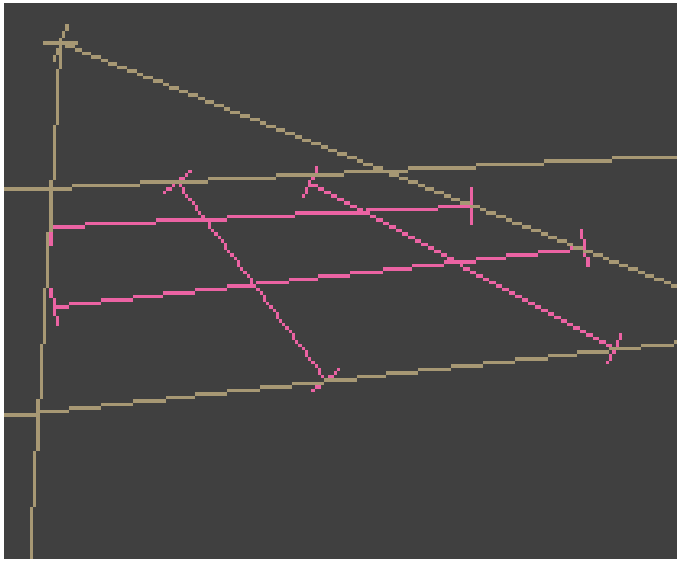
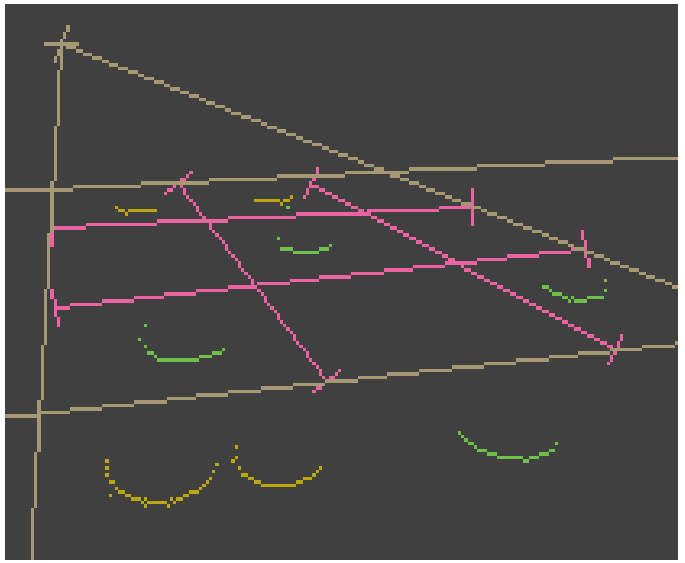
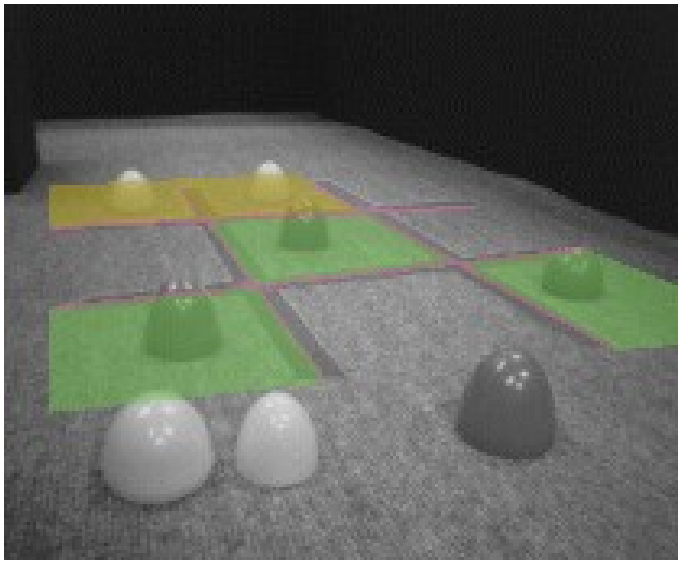
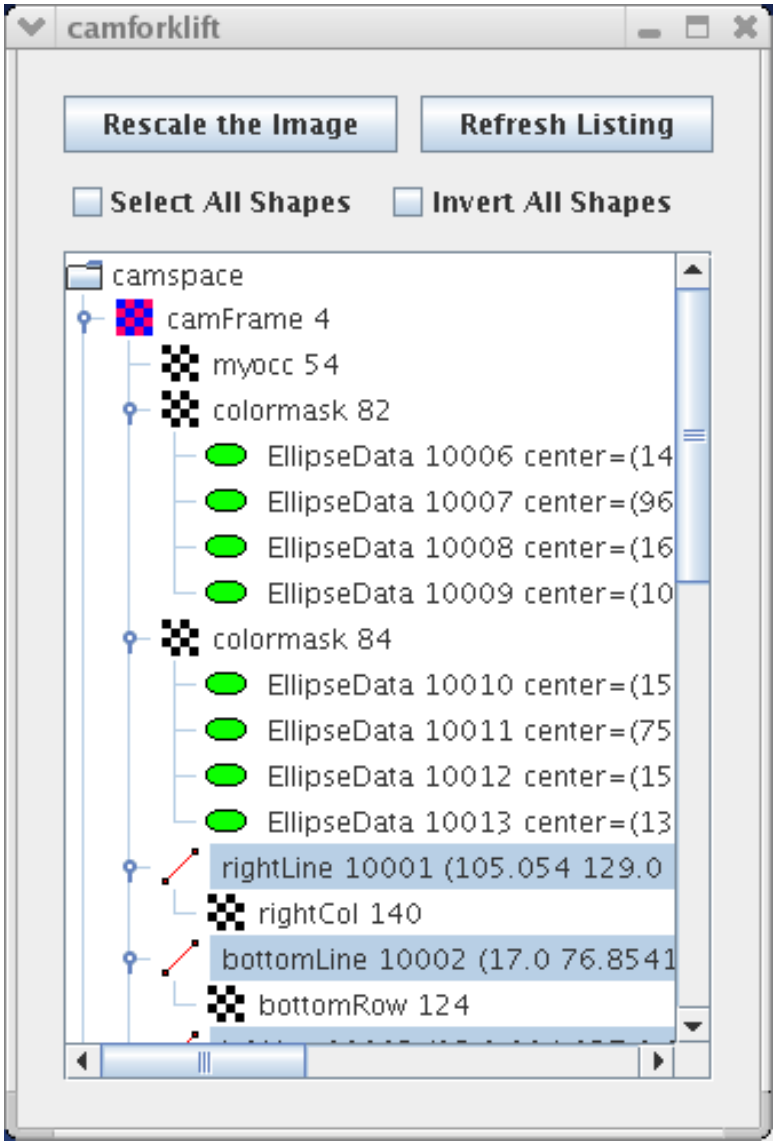


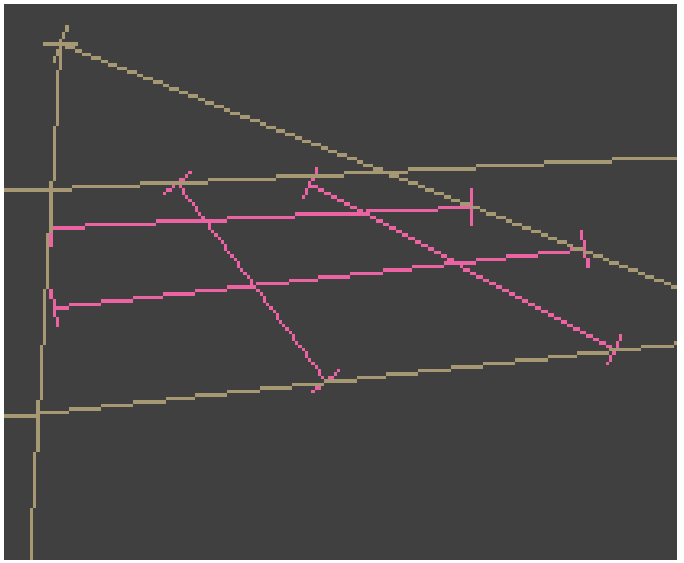






SketchGUI: see inside the robot's head





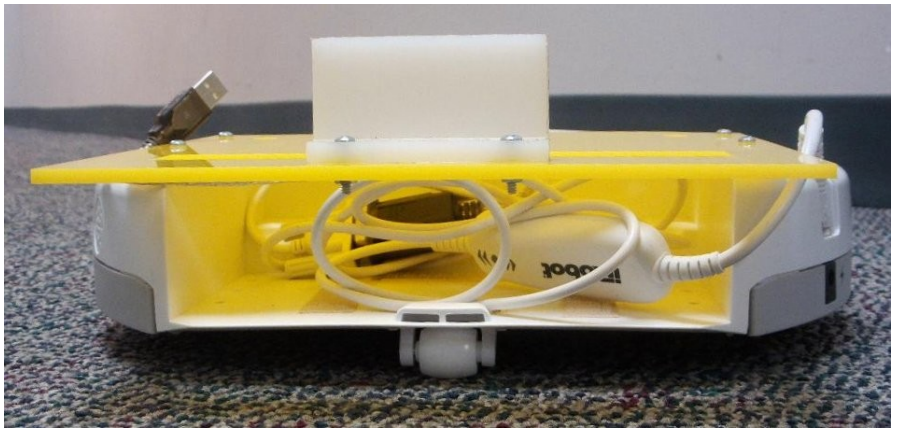
Raising the Bar for Educational Robots

Computer scientists shouldn't build robots!

Would you ask your CS1 students to build their own laptops?

Create/ASUS

- iRobot Create
- ASUS Eee 900 PC
  - Install Easy Peasy (Ubuntu)
- Mounting bracket
- Serial to USB cable
- Battery, charger



Parts: around $600.

Plans at Chiara-Robot.com/Create

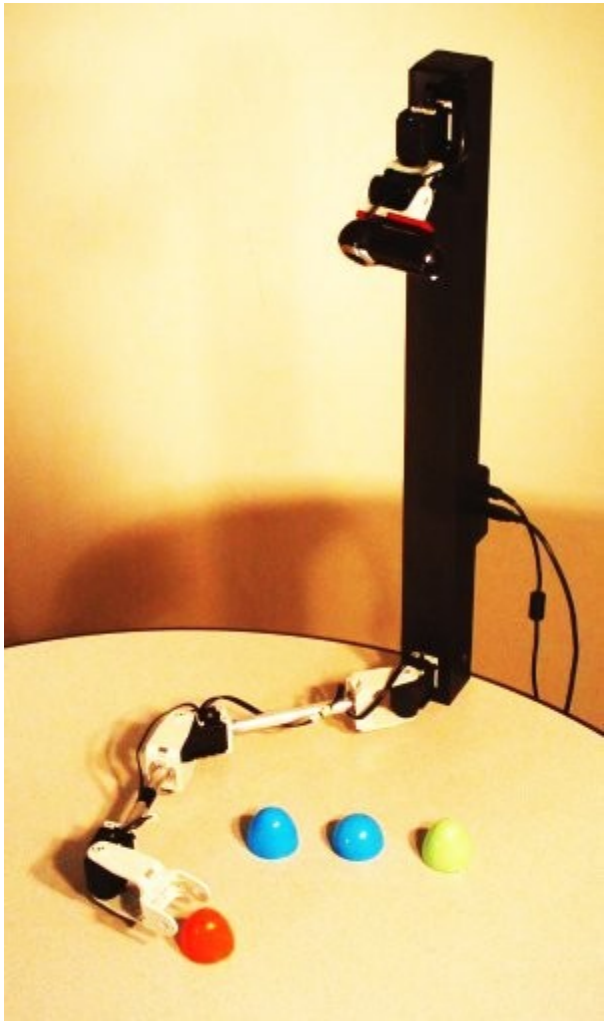
Retail from RoPro Design: $785.

Tekkotsu Planar Hand-Eye System

- Robotis Dynamixel AX-12 servos
- Three-link planar arm
- Logitech webcam on pan/tilt
- USB interface module
- Mast with C-clamp

Parts: ~ $600. Plans at
Chiara-Robot.com/HandEye

Fully assembled from RoPro: $995.



The Chiara Debuts at AAAI-08

- Pico-ITX processor:
  1 GHz, 1 GB, 80GB HD
  Ubuntu Linux
- 27 degrees of freedom:
  - 24 AX-12 digital servos
  - 3 analog microservos
  - 6-dof arm with gripper
- Logitech webcam, Robotis IR rangefinder
- Ethernet and WiFi
- Open source design

Chiara-Robot.com

2nd Place Award in the AAAI Mobile Robot Exhibition

Evolution of Tekkotsu Programming Model

- Arrays of pixels
- Dual-coding vision system: shape extraction (lines, ellipses, ...)
- MapBuilder
  - Handles occlusions
  - Get camera pose, transform line objects from camera space to egocentric (body-centered) space
- Pilot: use MapBuilder requests to locate landmarks for navigation
- Enhanced state machine formalism:
  - New shorthand notation compiles to C++; makes state machines much faster to write
  - Integrate map building into state machine programs

What Do Students Learn?

- Machine vision
- Serious C++ programming:
  - Templates, multiple inheritance, polymorphism, functors
- Advanced CS algorithms
  - Particle filters, RRTs (Rapidly-Exploring Random Trees), SIFT
  - Requires serious computer power
- Working with large software systems
  - Over 900 classes; 3500 pages of documentation (doxygen)
- Mathematical foundations
  - Coordinate systems, linear algebra, analytic geometry

What's Coming Up For 2009?

- Manipulation and grasp planner for the arm
- Navigation planner
- SIFT object recognition
- Text-to-speech (using the Mary package)
- Mirage simulator
- Next revision of the Chiara design

Tekkotsu Workshop At CMU

- Three-day hands-on Tekkotsu workshop for CS faculty
- Dates: July 21-23, 2009
- Place: Carnegie Mellon Pittsburgh, PA
- Funded by NSF
- Travel and accomodation paid for attendees
- Limited space available
- To apply: send CV to Dave Touretzky (dst@cs.cmu.edu)