15-494/694: Cognitive Robotics

Spring 2015

Professor:
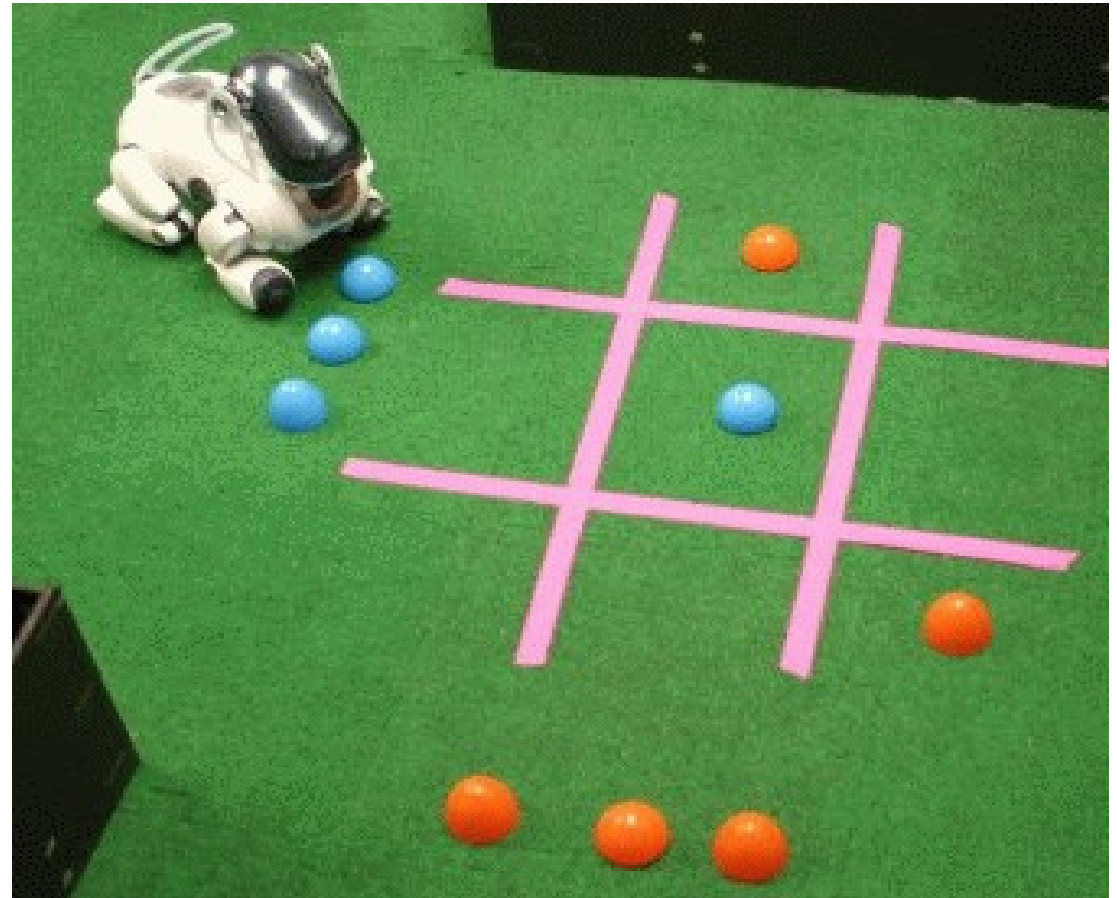 Dave Touretzky
  GHC 9013
  x8-7561

dst@cs.cmu.edu

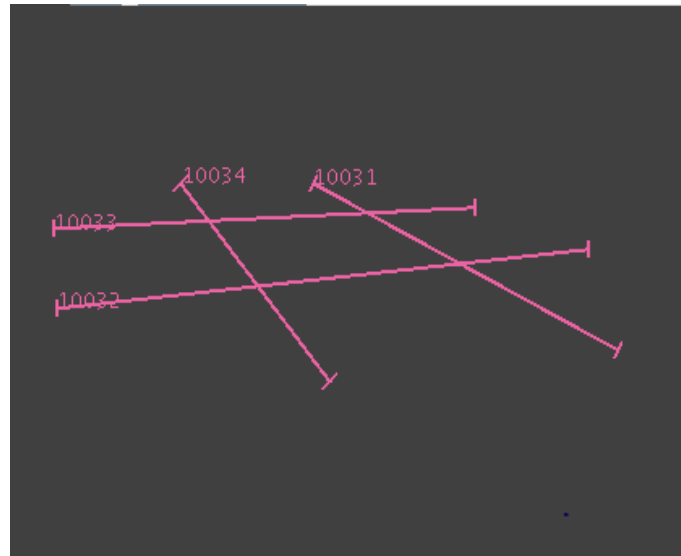# What Was This Course About?

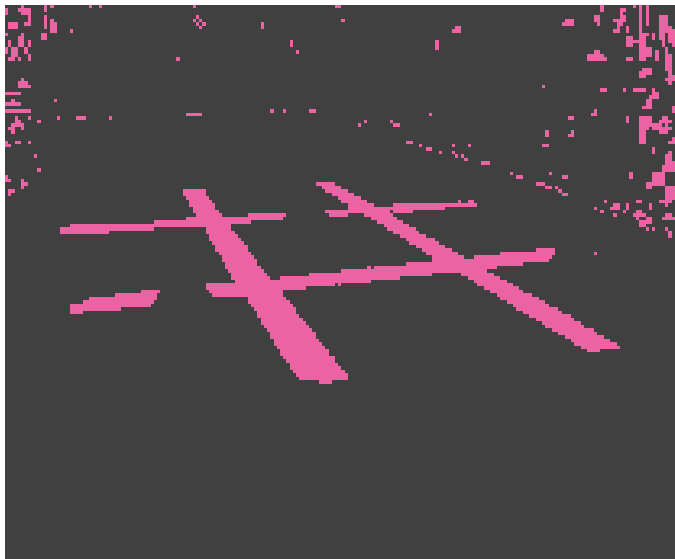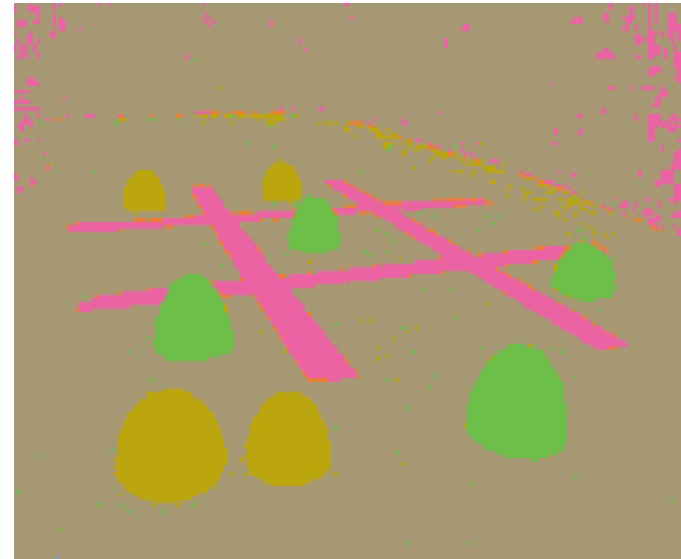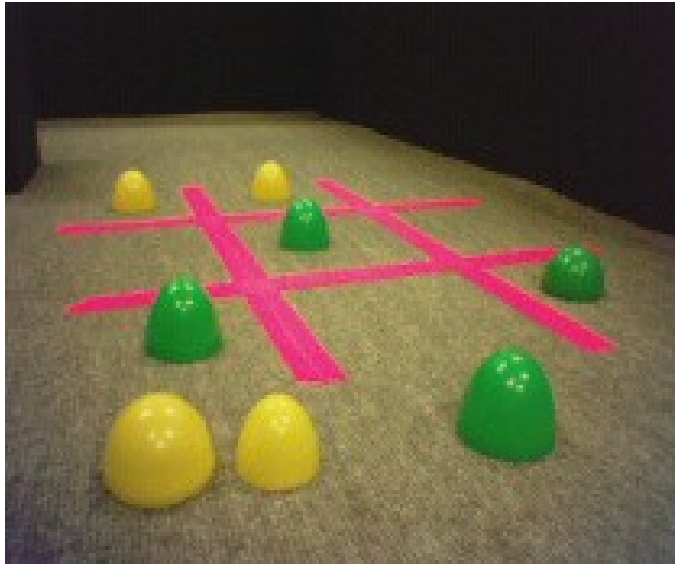A new approach to programming robots:

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

- Borrowing ideas from cognitive science to make robots smarter.

- Building the infrastructure to teach "ten big ideas in robotics".
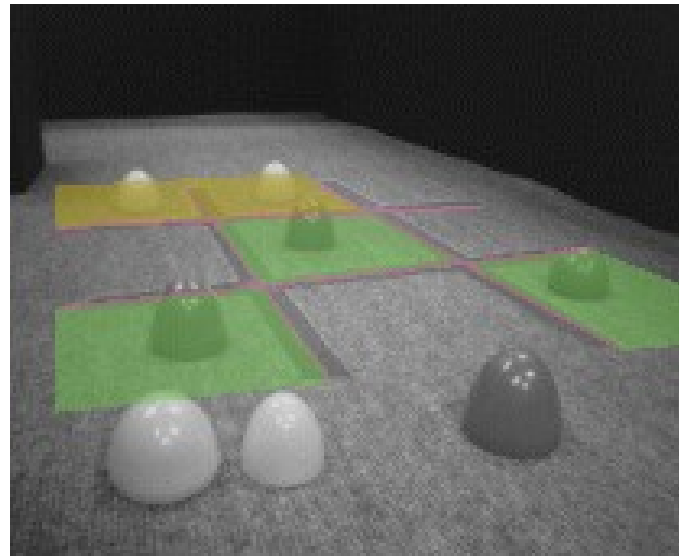
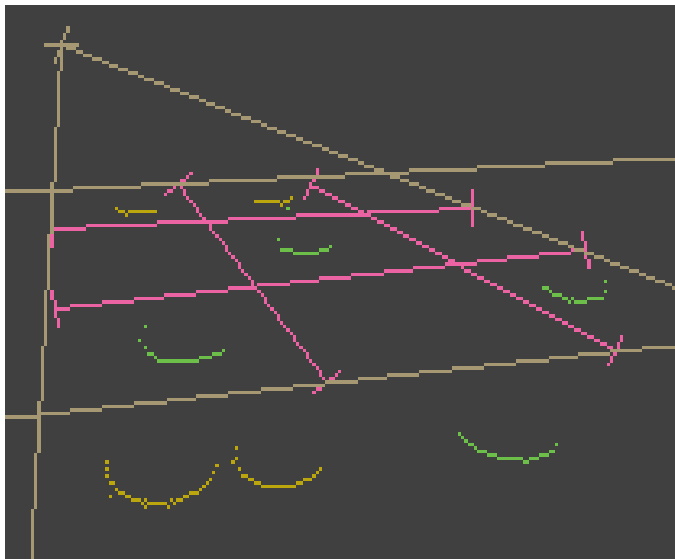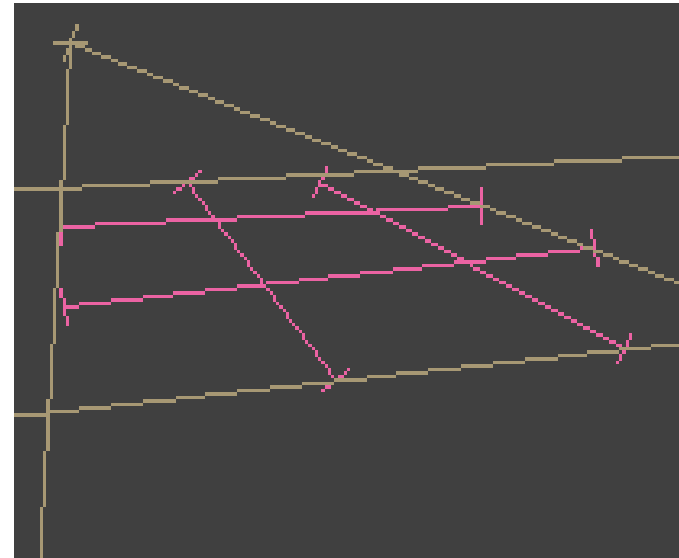# Primitives needed for tic-tac-toe

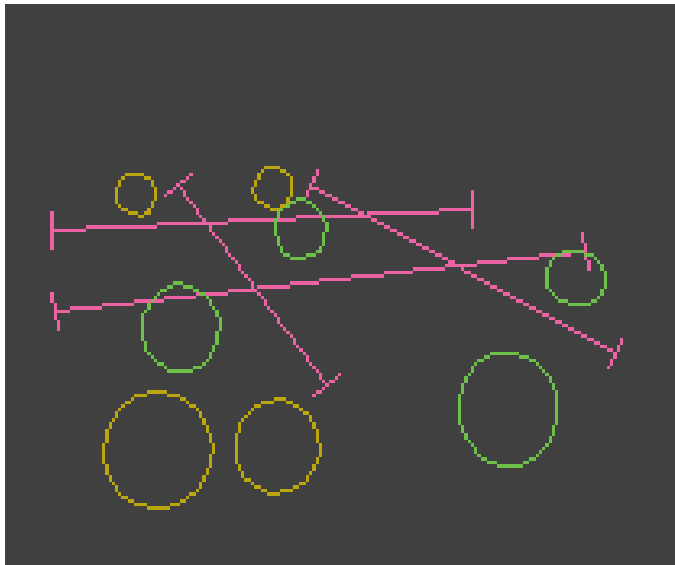- See and understand the board (perception, mapping)

- Move the game pieces (manipulation)

- Take turns (control)

Visual Routines

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Visual Routines

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SketchGUI: see inside the robot's head
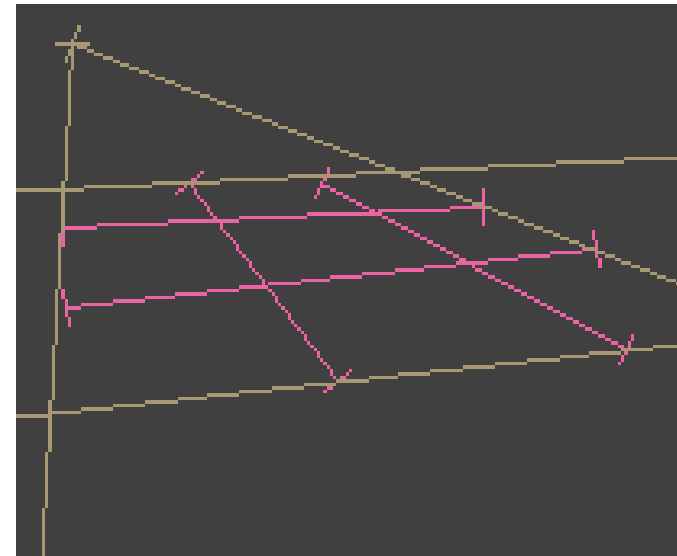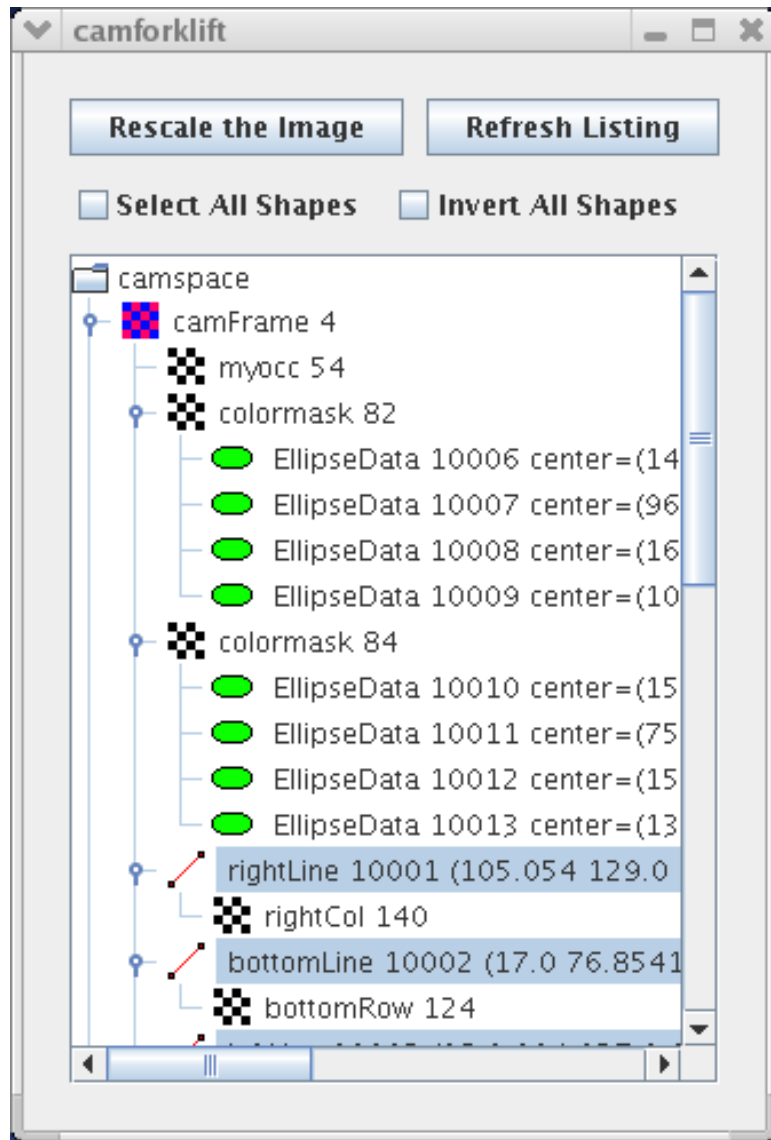
Transparency: Storyboard tool

Mirage Simulator

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Tekkotsu Means "Framework" in Japanese

(Literally "iron bones")

Tekkotsu.org

Your Code
Tekkotsu

OPEN-R	Tekkotsu
APERIOS	Linux or Mac OS
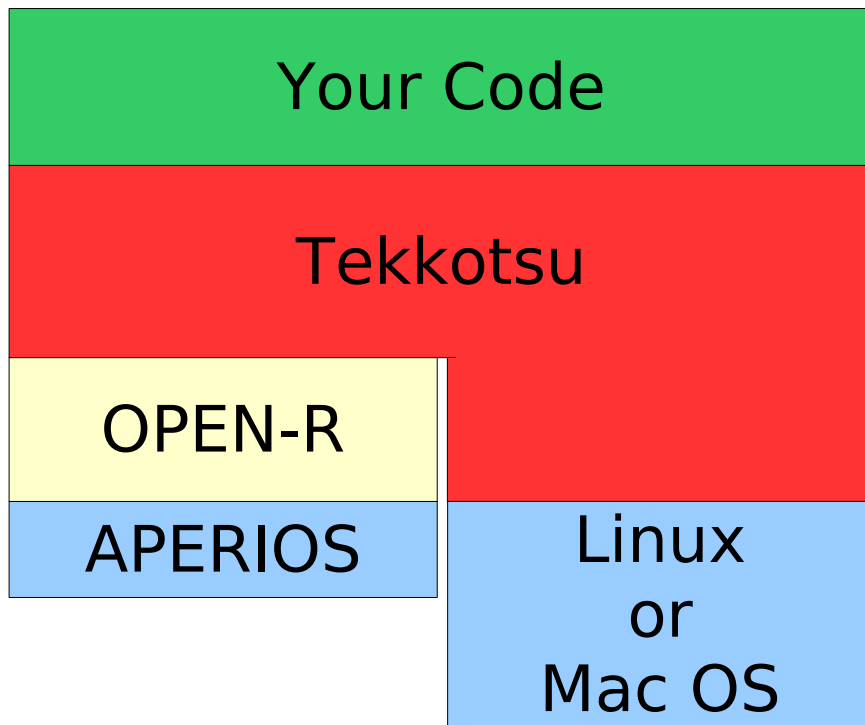
Tekkotsu features:

• Open source, LGPLed

• Event-based architecture

• Powerful GUI interface

• Documented with doxygen

• Extensive use of C++ templates, multiple inheritance, and polymorphism

The Tekkotsu "Crew"

- MapBuilder does vision and maintains local and world maps.

- Lookout moves the head and controls the sensor package.

- Pilot is responsible for navigation and localization.

- Grasper controls the arm and is responsible for manipulation.

Tekkotsu vs. ROS

- **Unified** framework for perception, navigation, and manipulation

- **Single** address space model simplifies coding & debugging

- Designed for **education**

- Emphasis on **orthogonality** of components: "mix and match"

- **Multi**-process approach good for scalability (but with some costs)

- Designed for **research**

Early Days: 2006 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
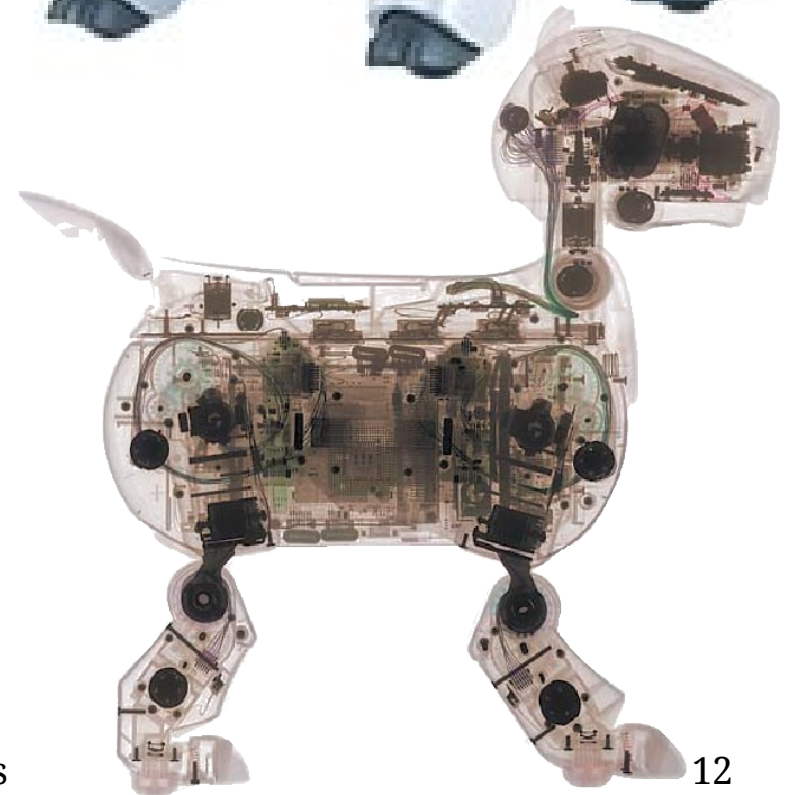
Robot Learning

Implementing learning algs. on the robot:

- – TD learning for classical conditioning

Video demos from Tekkotsu Robotics channel on YouTube

- – Two-armed bandit learning problem

The Chiara Debuts at AAAI-08

- Pico-ITX processor:
  1 GHz, 1 GB, 80GB HD
  Ubuntu Linux

- 27 degrees of freedom:

  - 24 digital servos

  - 3 analog microservos

  - 6-dof arm with
    gripper

- Logitech webcam,
  Robotis IR rangefinder

- Ethernet and WiFi

- Open source, GPLed
  design

Gamma Series Chiara (2009)
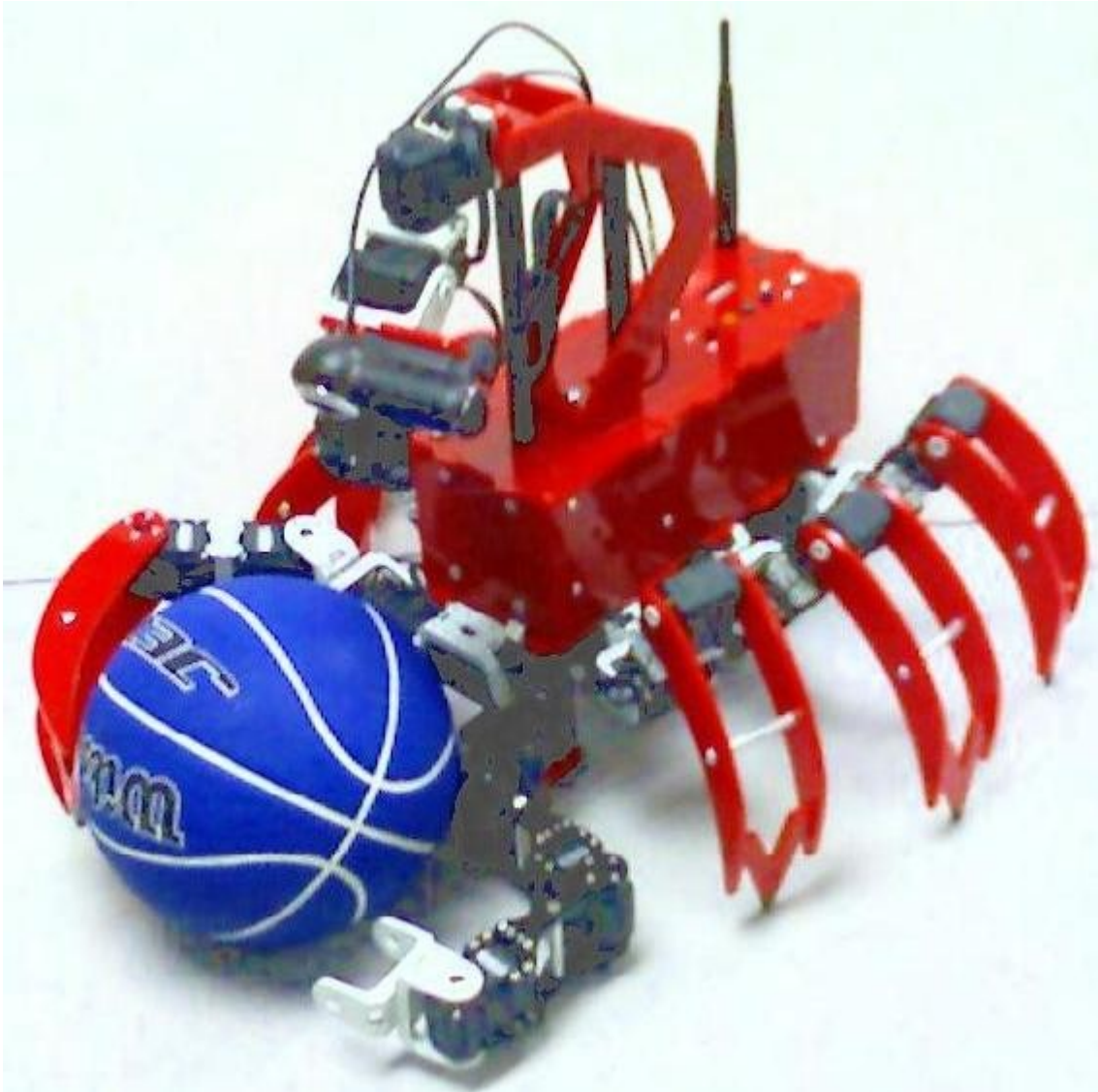
- 21 built

- Fixed gripper (c-bracket)

See demo videos at
Chiara-Robot.org
or directly at
youtube.com/TekkotsuRobotics

Delta Series Mockup

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Chiaras Play Chess at AAAI-2010

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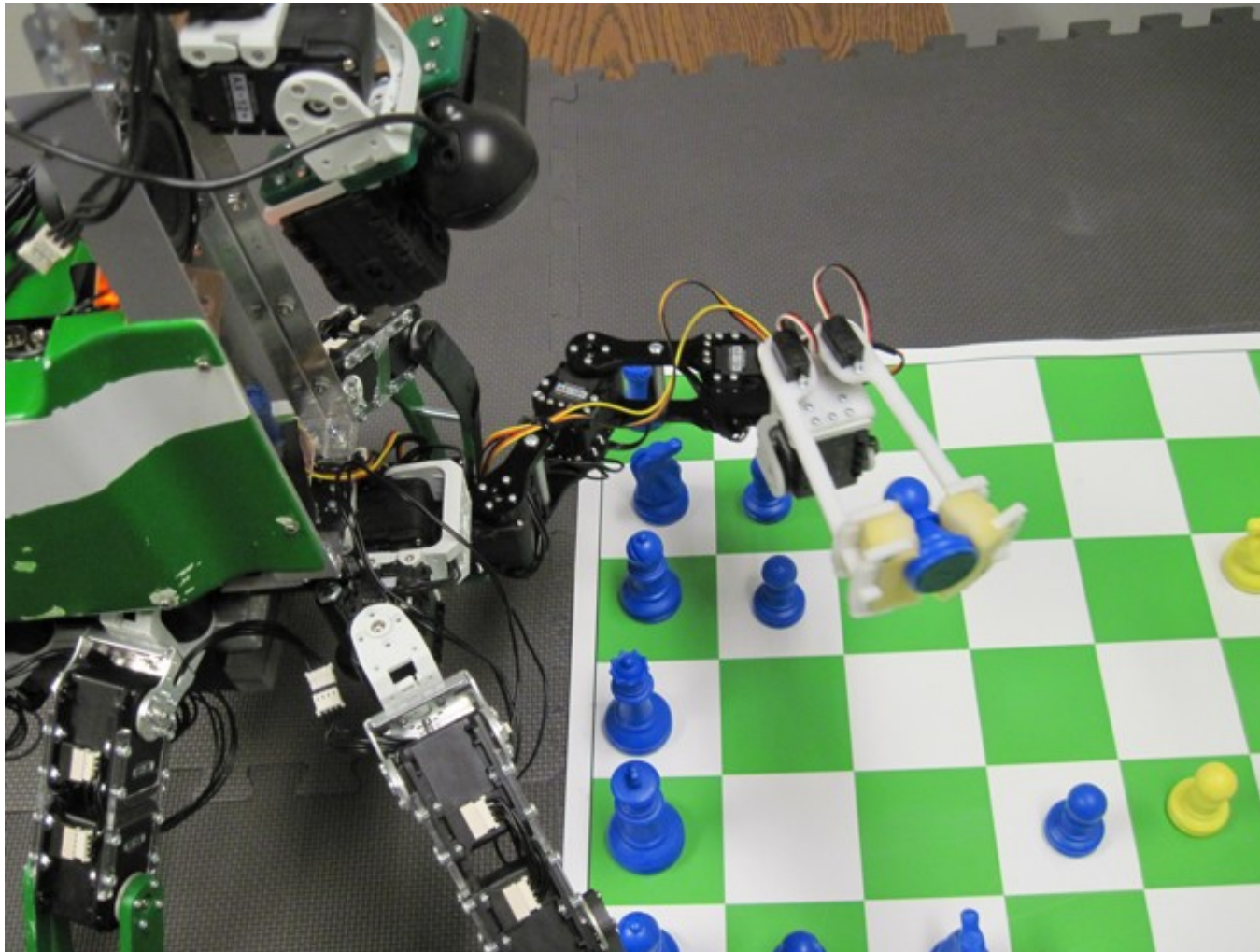
Chiara Playing *"Ode to Joy"*

Demo by high school student Ashwin Iyengar, August 2010.

Tekkotsu Planar Hand-Eye System

- 3-dof planar arm

- Logitech webcam on a pan/tilt mount

- Connects to a PC via USB

- Many variations possible:

Zhengheng Gho's gripper

Jonathan Coens' 8-dof "tentacle"

Calliope5KP

Calliope2SP

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Chiara Mantis

ARTSI Alliance

See ARTSIAlliance.org

artsi

Advancing Robotics Technology for Societal Impact

Demo Videos

Mirage Stack Topple and
52 views
2 months ago

Denavit-Hartenber Reference Frame
1,163 views
2 months ago

Mirage Camera Simulation
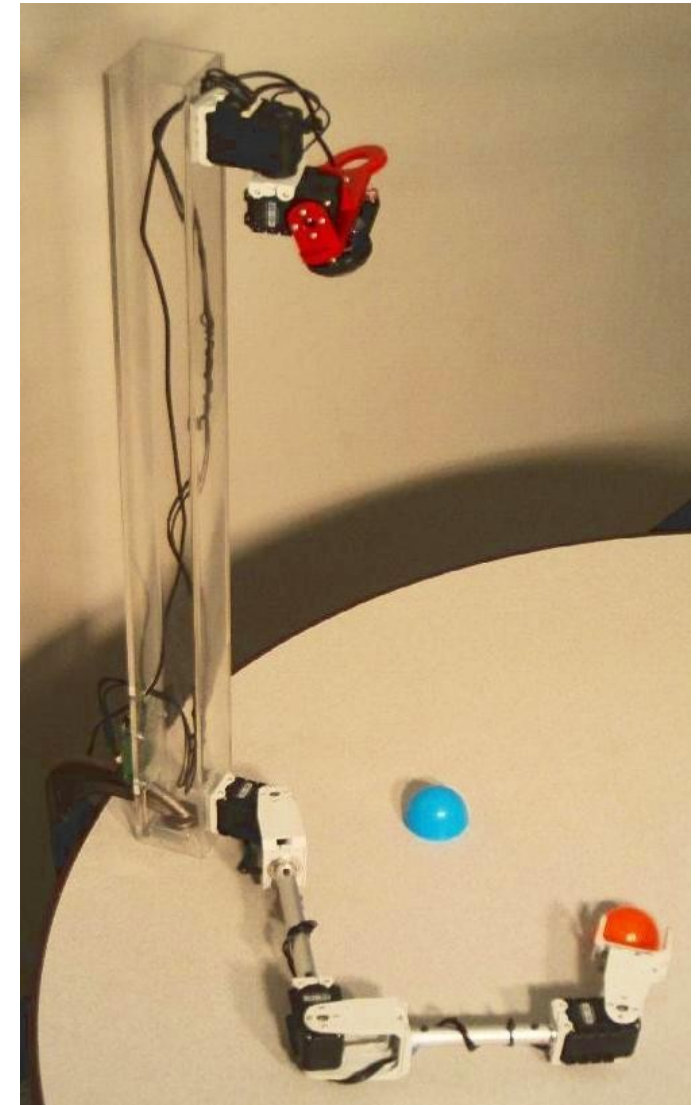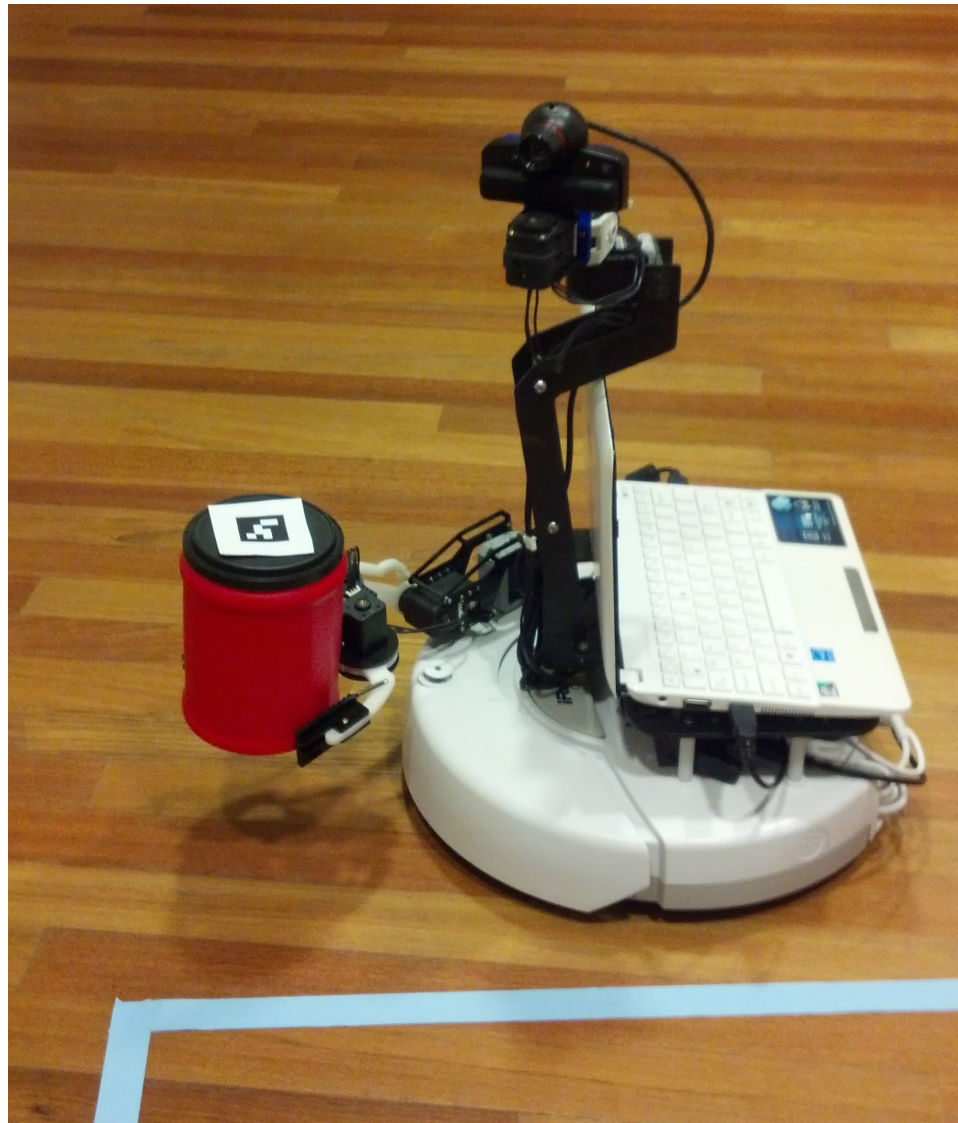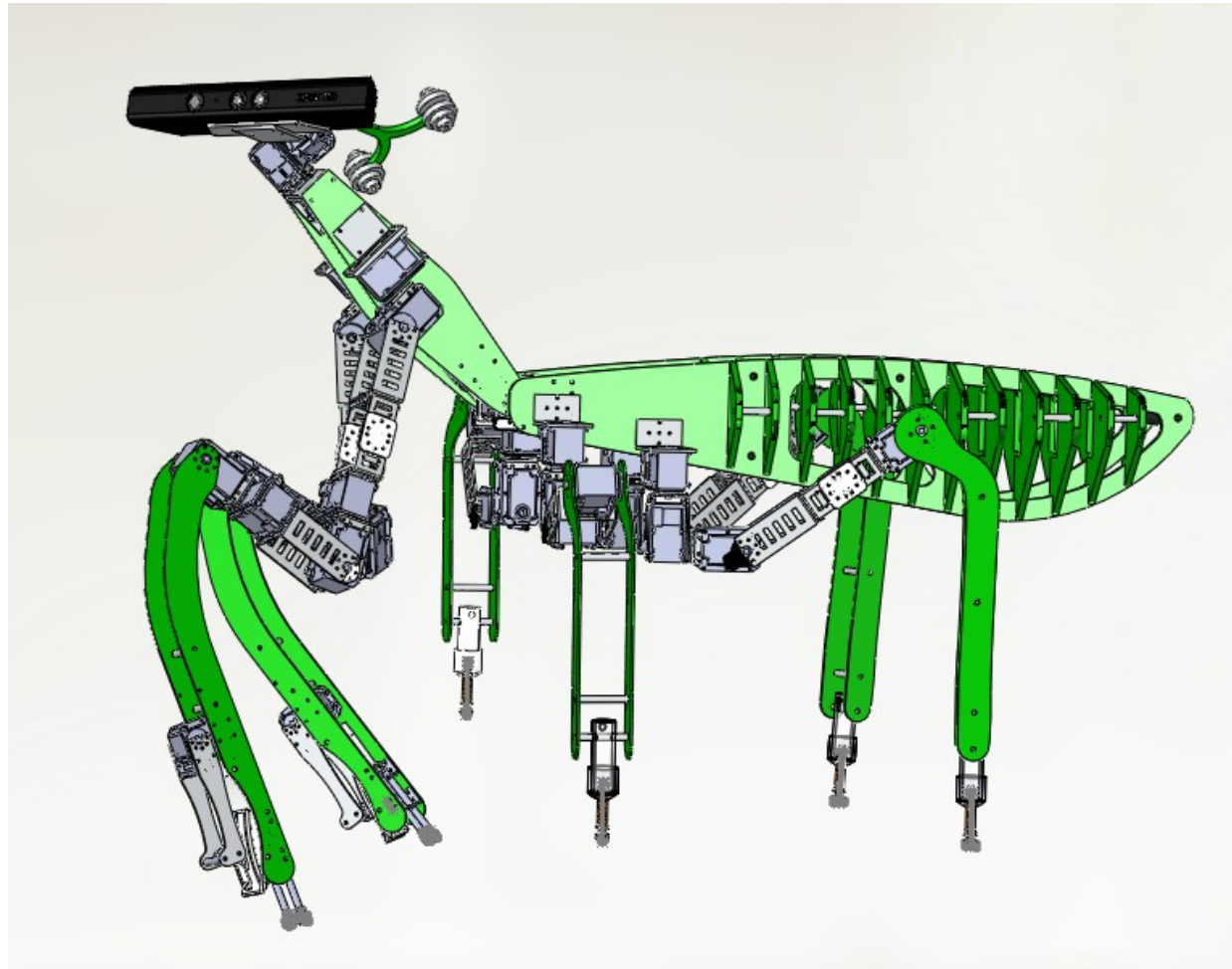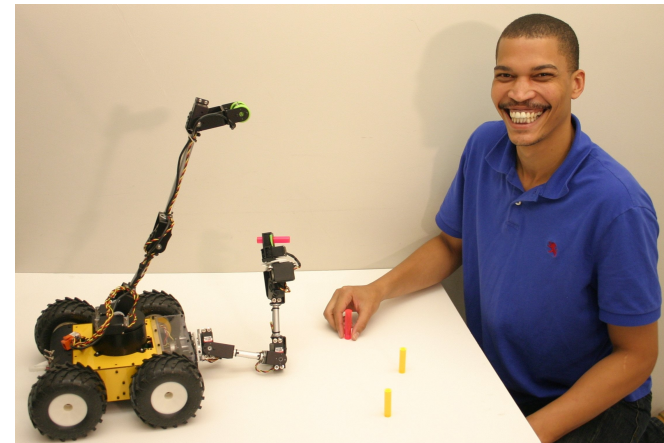149 views
4 months ago

Chiara Maze Wander
97 views
5 months ago

Mirage HandEye Physics Demo
545 views
5 months ago

Chiara Robot: Ultimate Chase
183 views
5 months ago

Chiara Stanky Leg Dance
62 views
5 months ago

Chiara Robot Fetching An
95 views
5 months ago

Frustrated Chiara Robot at
143 views
5 months ago

Sherene Campbell's
43 views
5 months ago

Andrew's Leap: Chiara Rocks
64 views
5 months ago

Andrew's Leap: Chiara Dance
22 views
5 months ago

Tekkotsu Arm Path Planning
160 views
6 months ago

Chiara Robot pincer usage
187 views
6 months ago

Chiara walking in Mirage simulator
205 views
7 months ago

Chiara IR rangefinder demo
187 views
8 months ago

Chiara depth from stereo
4,914 views
8 months ago

Chiara robot rolling a ball
836 views
8 months ago

Goals For This Semester (1)

- Develop a successor to the Calliope2SP as a common platform for robotics research and education:

  - Open source

  - Cost under $1,000

  - Manipulation: gripper plus paddles

  - Compelling demos

  - Both Tekkotsu and ROS support

Goals For This Semester (2)

- Kodu Robots: The Next Generation of Robotic Toys

  - Kodu programming language implemented on top of Tekkotsu

  - Robot "characters" (shells/costumes) built on top of the Calliope2SP

  - Interact via table and game controller

  - Multi-robot and human-robot interaction

  - Create mock-ups and demo videos to sell the idea.

Course Administrative Stuff

- Times/Locations:

  - Mon / Wed 3:30 to 4:20 in GHC 4211

  - Fri 3:00 to 4:20 in NSH 3206 (REL)
    REL = Robotics Education Lab

- Course home page:
  http://www.cs.cmu.edu/afs/cs/academic/class/15494-s15

- Tekkotsu wiki: http://wiki.Tekkotsu.org

Tekkotsu On Your Laptop

- If you run Linux on your laptop:

  – You can install Tekkotsu directly. See wiki.tekkotsu.org for instructions.

- For Windows users:

  – The Tekkotsu Flash Drive is a bootable flash drive with Ubuntu 14.04, Tekkotsu, and Mirage pre-installed.

  – See the Tekkotsu wiki for instructions for creating a Tekkotsu Flash Drive; ask me for help if you need it.