15-494/694: Cognitive Robotics

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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
Visual Routines
SketchGUI: see inside the robot's head
Transparency: Storyboard tool
Mirage Simulator
Tekkotsu Means “Framework” in Japanese

(Literally “iron bones”)

Tekkotsu features:
- Open source, LGPLed
- Event-based architecture
- Powerful GUI interface
- Documented with doxygen
- Extensive use of C++ templates, multiple inheritance, and polymorphism

Tekkotsu.org
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

- Two-armed bandit learning problem

Video demos from Tekkotsu Robotics channel on YouTube
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
Chiaras Play Chess at AAAI-2010
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
Chiara Mantis
ARTSI Alliance

See ARTSIAlliance.org

Advancing Robotics Technology for Societal Impact
Demo Videos

Mirage Stack Topple and
52 views
2 months ago

Denavit-Hartenbee 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.