15-494: Cognitive Robotics

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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 degress. 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

Tekkotsu features:

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

Your Code

Tekkotsu

OPEN-R

APERIOS

Linux or Mac OS
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

- 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

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