Cognitive Primitives for Mobile Robots

Development with the Tekkotsu framework

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What is Tekkotsu?

• Development framework for robotic applications
  • Handles common tasks to avoid reinvention
  • Provides libraries of utility code with integrated interfaces to speed new development
  • Increase communication and code reuse by providing a common platform between groups
  • Enable high level robotics education
What is Tekkotsu?
What is Tekkotsu?

- Written in C++
- Event-based architecture
- Extensive use of templates and inheritance
- High performance, real time
- Open Source - LGPL
- See Tekkotsu.org for code and documentation
Why AIBO?

- AIBO is currently a unique platform
  - Highly articulated (18 joints)
  - Significant processing power
    - 576 MHz MIPS, 64MB RAM
  - Lots of sensors (Color camera, 3 IR range-finders, 3-axis accelerometer, stereo microphones, array of buttons)
  - 802.11b wireless ethernet
  - Small, light - “desktop” development
  - Affordable! $1799 before 6% academic discount

ERS-7 Sample Camera Image
Interactions Between Robotics and Cognitive Science

- Cognitive Scientists can explore practical applications of their ideas
- Roboticists can draw new inspiration from cognitive theories
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Primitives for Cognitive Robotics

- Perception (Vision)
- Mapping
- Manipulation
- Control (state machines, subsumption, etc.)
- Attention
- Learning
- Human-Robot Interaction
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Touchstone Task: Tic-Tac-Toe
Primitives for Cognitive Robotics

- Perception

Primitives for Cognitive Robotics

• Perception

• Visual Routines [S. Ullman, Cognition, 1984]
Primitives for Cognitive Robotics

- Perception

Primitives for Cognitive Robotics

• Perception

• Dual Coding Theory [Paivio, Mental Representations, 1986]
Primitives for Cognitive Robotics

• Perception

• Dual Coding Theory [Paivio, Mental Representations, 1986]
Primitives for Cognitive Robotics

- Perception

- Mapping and Navigation

![Diagram showing different spaces and transformations](image)
Primitives for Cognitive Robotics

• Perceiving objects in terms of the actions that can be performed upon them (door knob/grab twist)

• Affordances [J.J. Gibson, The Theory of Affordances, 1977]
Current Development

• Manipulation Engine

• Point of contact

• Type of contact (ballistic impact, steady pressure, rolling swipe, etc.)

• Path to follow

• Type of visual monitoring

• Motion constraints (e.g. areas or objects to avoid)
Future Primitives

• Planning: a higher level approach to control structure
  • Attentional control: where should the AlBO be looking now?
  • Learning: we would like to support experimentation with different learning architectures, such as SOAR or ACT-R

• Modeling human POV (Schultz)
  • Stay for the next talk! :)
Teaching Robot Programming

- We’re creating a cognitive robotics course to be taught in January 2006
- Focusing on teaching robotic programming at a high level using the cognitive primitives described in this talk
AIBO Home Movies

- Training XOR using a variant of Temporal Difference Learning

Movie Clip available from:
http://www-2.cs.cmu.edu/~tekkotsu/Samples.html#TD-learning_XOR
AIBO Home Movies

• k-Armed Bandit (exploration vs. exploitation)
• Just a homework assignment ;-)

Movie Clip available from:
http://www-2.cs.cmu.edu/~tekkotsu/Samples.html#k-Armed_Bandit
Thanks!

Questions?