Humanoids 2005
Workshop on Cognitive Architecture

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Honda Research Institute Europe
2005

- HRE-G / FTR founded 1997
- HRI founded 2003 - 3 main projects
- flat project and research oriented hierarchy flexible organisation

**mission**

centre of excellence for Honda in the area of **intelligent systems technology**
with **core competence areas** in
- brain-like intelligence and cognitive systems
- evolutionary technology and learning

**3 pole network of responsibilities**

HRI-JP

HRI-US

HRI-EU

- BrainOS
- EBI
- EL
- TEC
Cognition & Architectures
Cognitive Systems’ Aspects

- Analytical point of view:
  - Understanding how natural cognitive systems work

- Synthetical point of view:
  - Construct artificial system with the cognitive performance of natural systems
  - Construct artificial systems which autonomously develop and learn from a simple to a complex system

- Understanding by synthesis

- Consequences for construction
  - Incremental systems architecture
  - Embodiment & situatedness
  - Minimal necessary overlap with biological model
Architectural aspect: Phenomenological

Space of phenomenological observable behavior of target entity

Direct transfer

Match of resulting observable behavior is perfect

Architecture of artifact

Decomposition by phenomenological means resulting in “behaviors”

Organization by phenomenological behaviors

Problem: artifacts do not necessarily shown sufficient cognitive performance like

- Learning and abstraction, robustness, association
- Transfer of solutions between different problem domains
Architectural aspect: Functional

Space of phenomenological observable behavior of target entity

Decomposition by phenomenological means resulting in “behaviors”

Evolution
Biology
Psychology

One source of inspiration only

Match of resulting observable behavior to target

Approach: devise an artifact that produces the desired observable behavior but that is no necessarily organized in terms of those targeted behavior.

- Quest for latent variables and control processes
- Towards non strict decomposition of architectures
Architectural aspect: Development

Space of phenomenological observable behavior of target entity

Initial phenomenology

Evolution, Biology, Psychology

Architecture of artifact

natural development

Match of resulting observable behavior to target

Approach: devise an artifact that has the minimum build in elements and processes to autonomously develop into a complex cognitive system

- Quest for initial architecture and development processes
Elements of cognitive architecture

- Commonly accepted elements / concepts of cognitive systems
- Need to combined to an architecture
- May need broad interfaces between elements for close interaction
BASS
Brain-like Active Sensing System

- Currently active vision system, prepared for speech
- Visual saliency, motion saliency selection, disparity saliency selection
- Visuomotor mapping and learning
- Nonlinear gaze control with memory
- Visual object recognition and learning
- Architecture biologically motivated
- General reusable elements
- Behavior determined by small set of variables that span the behavioral spectrum
Incremental systems

- BASS 1.0, 2004-03
  - Visuomotor learning
  - Interactive attention
  - Object recognition
- BASS 2.0, 2005-03
  - Interactive online learning with segmentation constraints
- BASS 2.5 (current state, see poster)
  - Interactive online learning without strong segmentation cues
- BASS 3.0, 2006-03
  - Stay tuned …
Incremental systems design works
  - 2004 -> 2005: additional modules and four extra communication lines
  - Implementation as ~150 modules mainly running asynchronously
  - System runs any time, please visit our lab and interact with the system live
WBM
Whole Body Motion generation and control

Whole body control for
  - Natural decomposition of body control problem
  - Flexible and Comprehensive control for integrated sensing and acting systems
  - Extension of working ranges
  - As good as possible solution

Representation of motion by targets points & control parameters

No single controllers for separate groups of DOF
Kinematic Robot Model

State vector $\mathbf{q}$ comprises
- joint angles
- heel and upper body coordinates

Task vector $\mathbf{x}$ may comprise
- hand positions
- hand and head attitudes
- other DOF

Motion decomposition
- “Hard” constrained task space motion (e.g. hand position)
- “Soft” null space motion (e.g. joint limit avoidance, comfortable posture, natural motion)
WBM 2005-03

- Systems runs in real-time onboard ASIMO
- No prerecorded trajectories
- Demo with hand position and attitudes & head attitude
- See poster for details
- System runs any time, please visit our lab and interact with the system live
Systems & Tools
Requirements

- Reliable distributed real-time processing
- Asynchronous & synchronous processing
- High bandwidth & short latency
- Incremental & flexible systems design and maintenance
- Maximum research support
- Long term perspective, i.e. independence of uncontrollable decisions
Cycle & Tools

1. Design: DTBOS design tool
2. Creation and Implementation:
   - Template Generators & Maintenance
   - Basic Libraries for sensing & acting
3. Compiling, Testing & Installation
   - Build & install system, compile environment
4. Running:
   - RTBOS: real-time networked middleware environment for LINUX, Solaris, VxWorks, Cygwin
   - CMBOS: control & monitor systems
5. Maintenance
   - Standard Versioning & Backup
Summary & Conclusion

- Overall systems architecture for real cognitive is extremely important
- Researching elements for cognitive architecture for sensing, acting, learning and decision making
- Providing environment for designing, implementing and maintaining large scale complex real-time systems

Thank you for your attention