Humanoids 2005
Workshop on Cognitive Architecture

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HONDA
The Power of Dreams

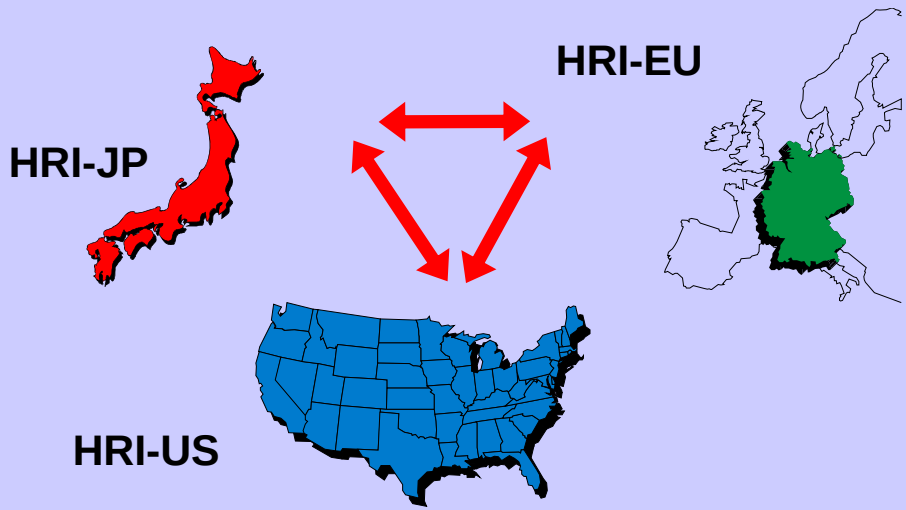
Honda Research Institute Europe
2005

- 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 — BrainOS — EBI
  - evolutionary technology and learning — EL→TEC

- *3 pole network of responsibilities*



Cognition & Architectures

Cognitive Systems' Aspects

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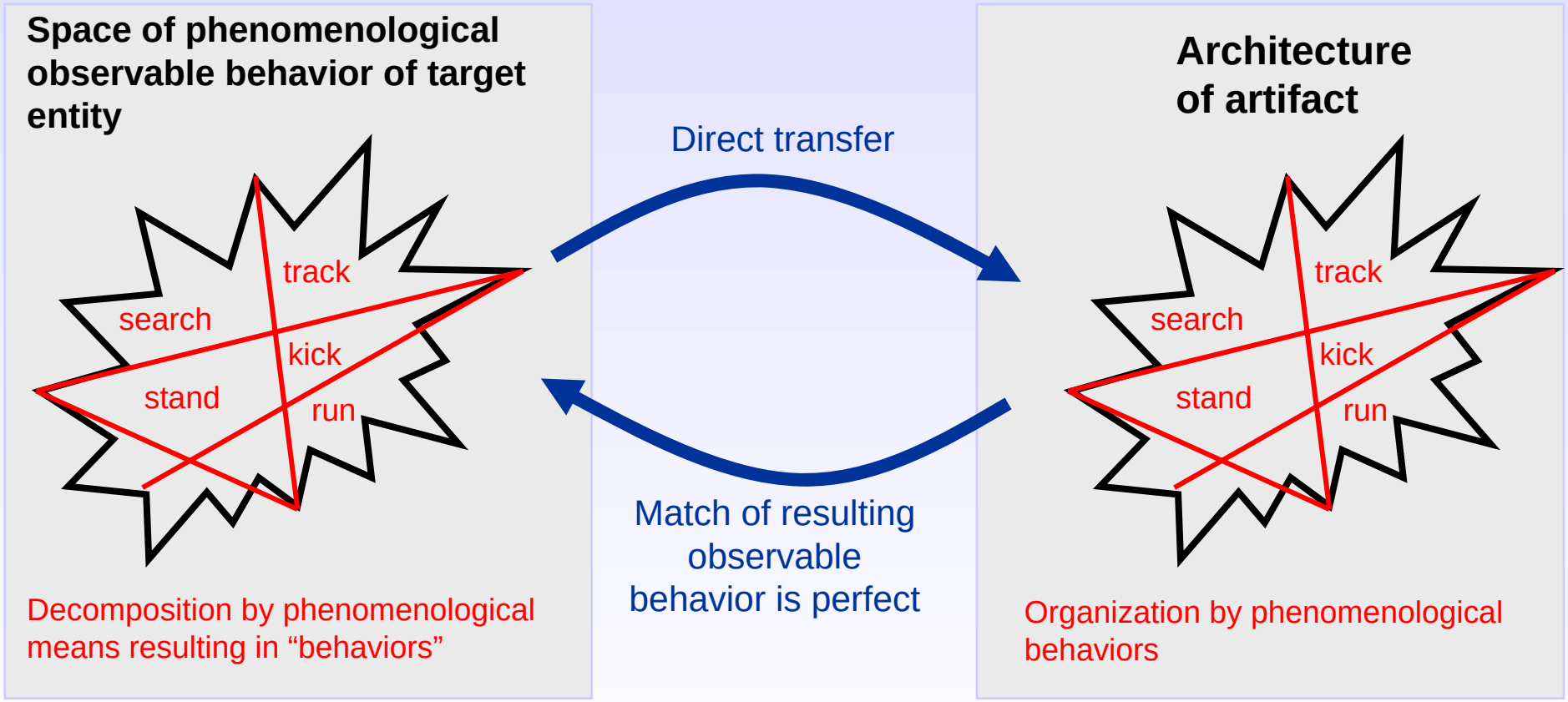
- Analytical point of view:
  - Understanding how natural cognitive systems work
- Synthetical point of view:
  - Construct artificial system with the cognitive **performance** of natural systems
  - Construct artificial systems which autonomously **develop** and **learn** from a simple to a complex system
- Understanding by synthesis
- Consequences for construction
  - Incremental systems architecture
  - Embodiment & situatedness
  - Minimal necessary overlap with biological model

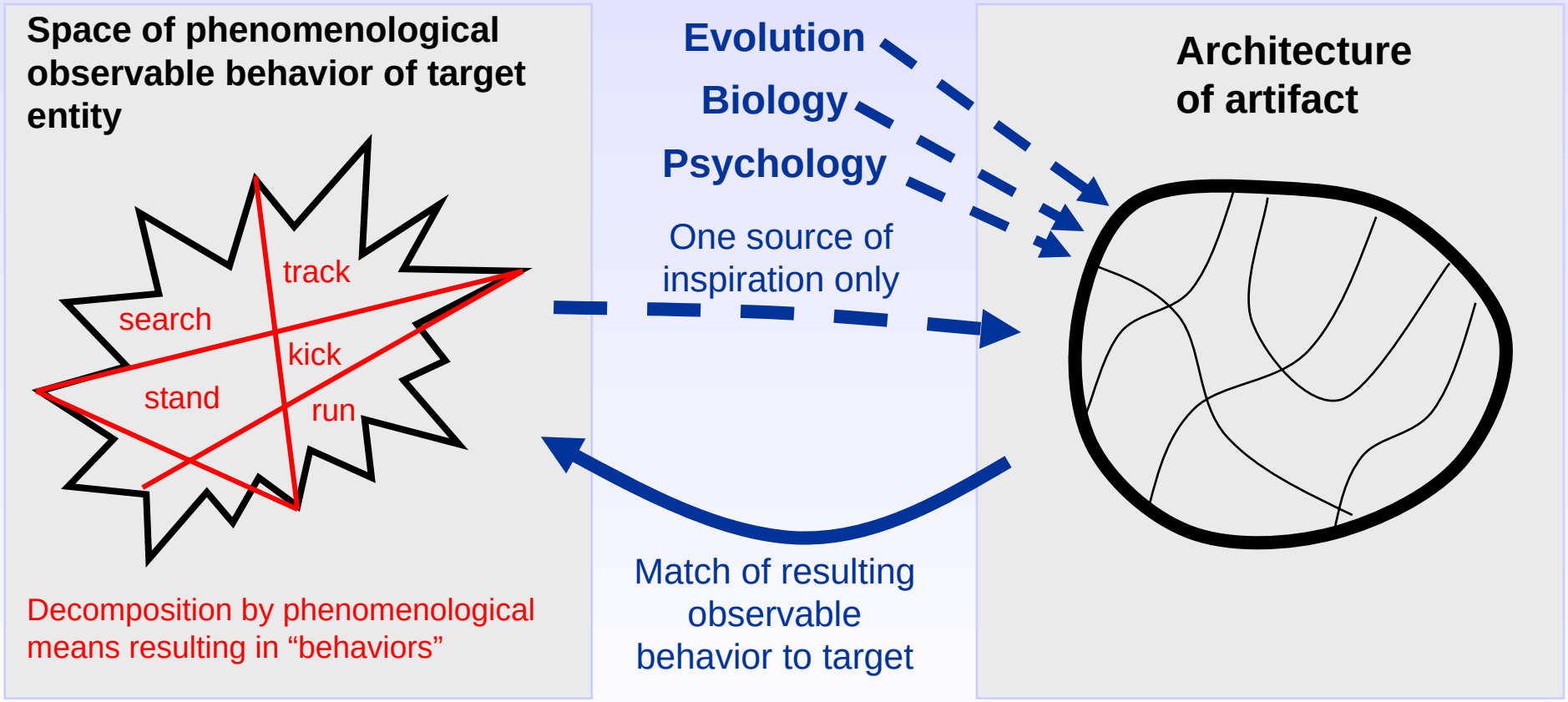
Architectural aspect: Phenomenological



Problem: artifacts do not necessarily shown sufficient cognitive performance like

- Learning and abstraction, robustness, association
- Transfer of solutions between different problem domains

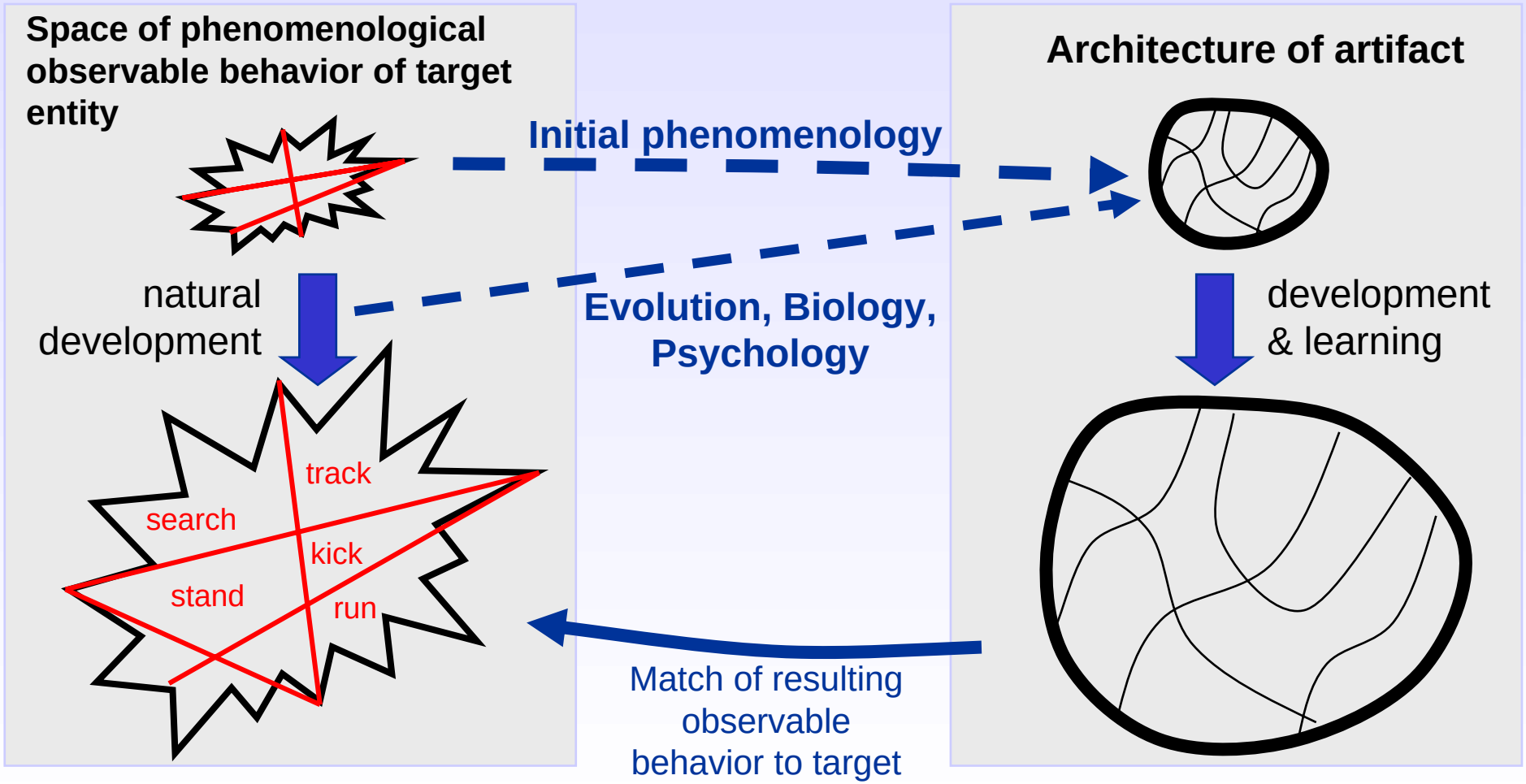
Architectural aspect: Functional



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



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

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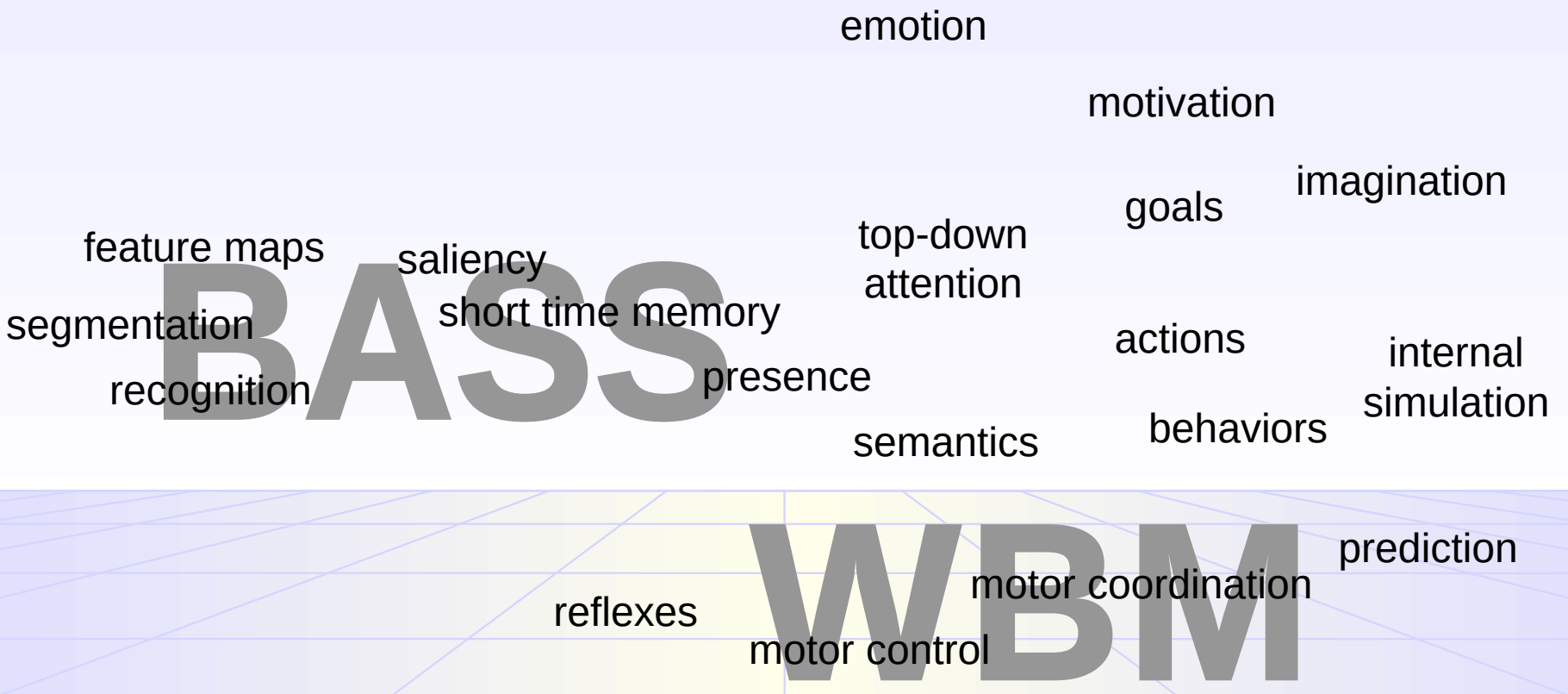
- Commonly accepted elements / concepts of cognitive systems
- Need to combined to an architecture
- May need broad interfaces between elements for close interaction



BASS

BASS

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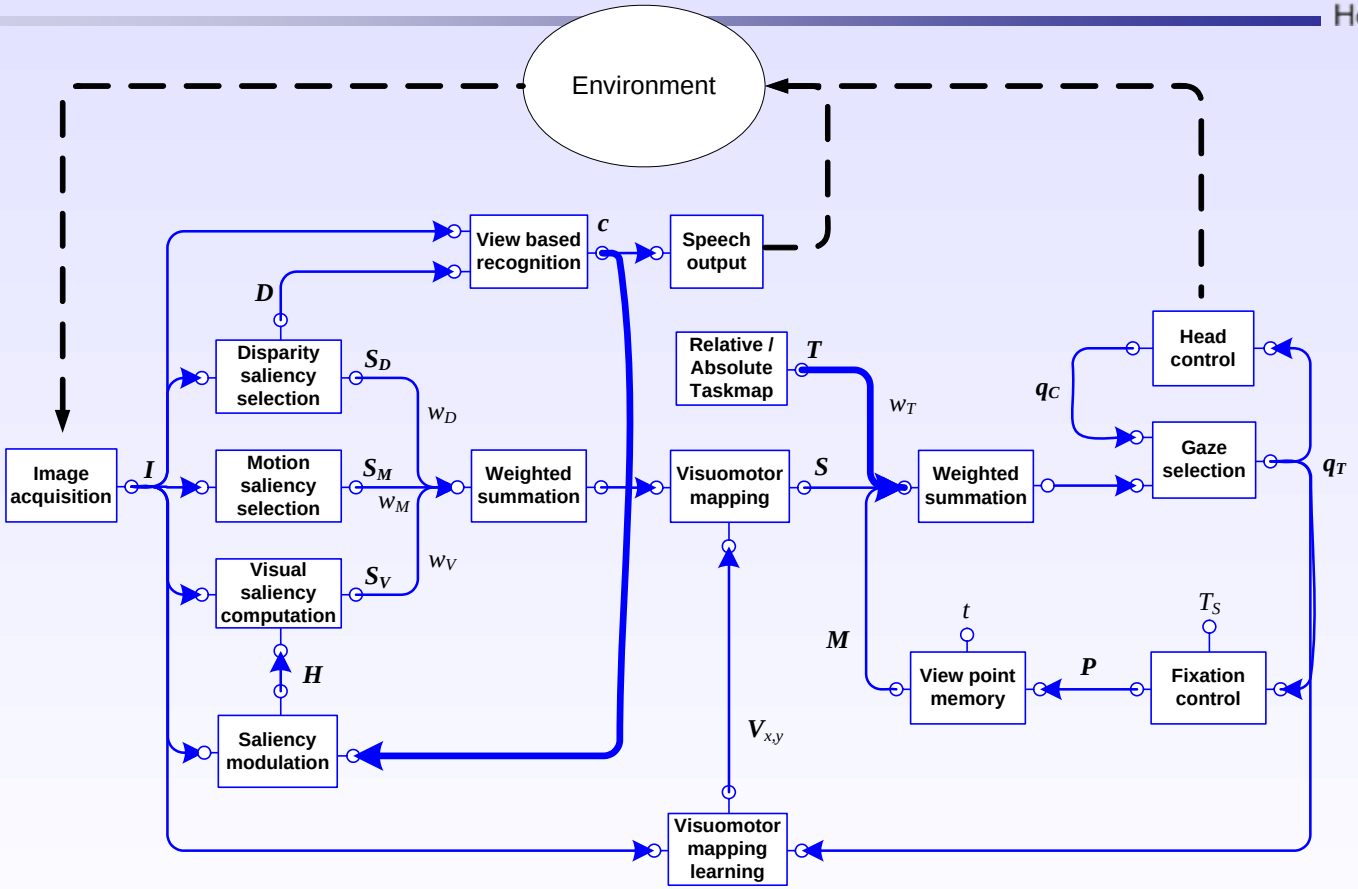
- Brain-like Active Sensing System
  - Currently active vision system, prepared for speech
  - Visual saliency, motion saliency selection, disparity saliency selection
  - Visuomotor mapping and learning
  - Nonlinear gaze control with memory
  - Visual object recognition and learning

BASS: Overall architecture

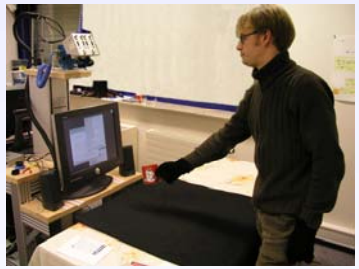


- Architecture biologically motivated
- General reusable elements
- Behavior determined by small set of variables that span the behavioral spectrum

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 ...

Comments on BASS

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- 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

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 **q** comprises

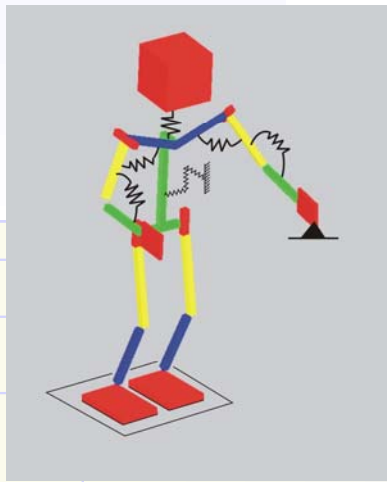
- joint angles
- heel and upper body coordinates

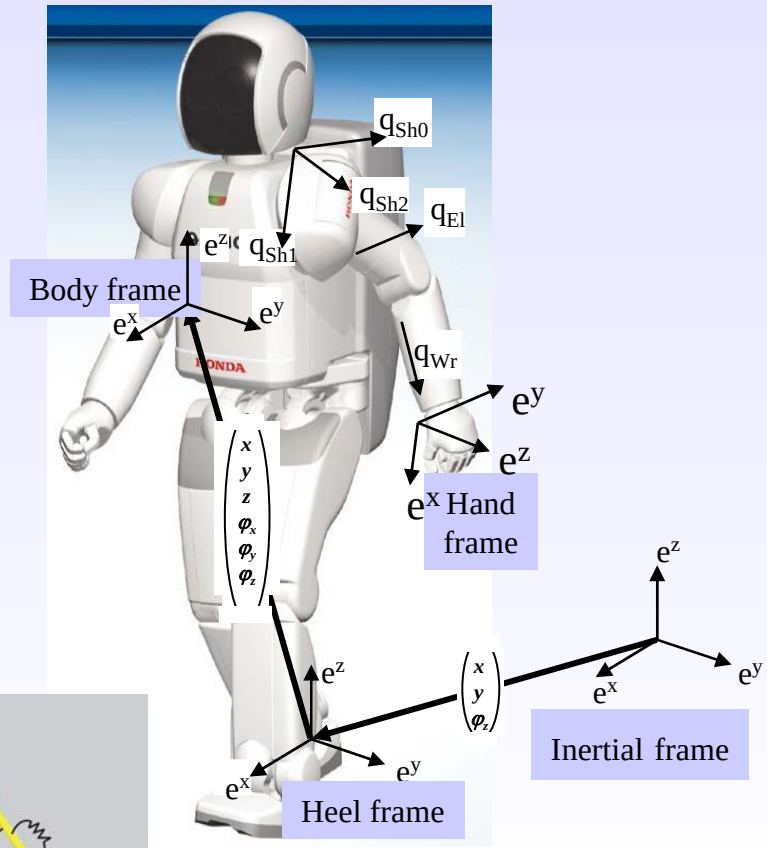
Task vector **x** may comprise

- 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)



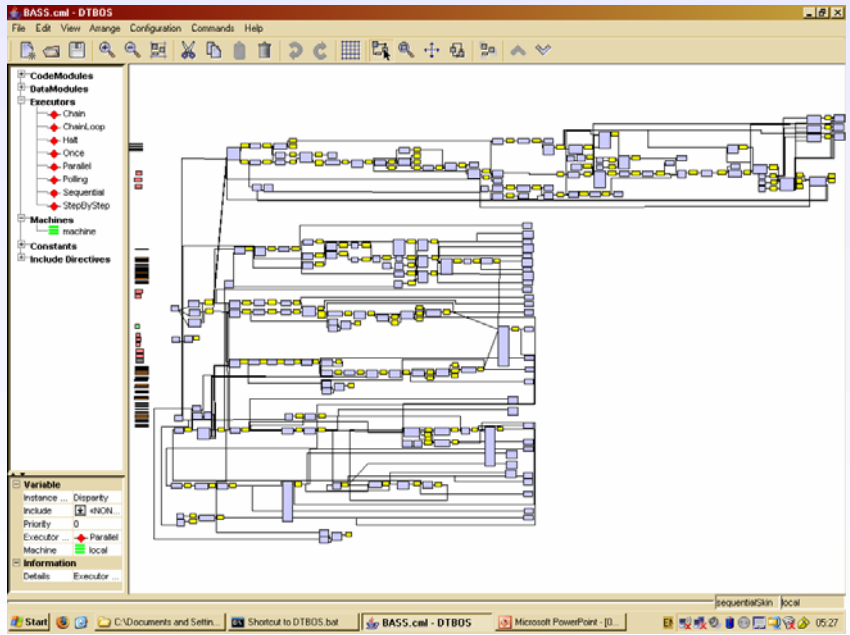


WBM state

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

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- 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

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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

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- 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