Active Memory Architectures for Cognitive Systems

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Introduction

Building cognitive systems that emerge from the interplay of diverse modules developed by different experts demands for an appropriate integration architecture. Beyond functional assets which are essentials for many cognitive systems, we also want to address the social complexity of collaborative research. Our ongoing work is aimed to provide a solid foundation for the construction of artificial cognitive processing schemes. We present the Active Memory concept on the crossroads of middleware technologies, enterprise integration patterns, and cognitive architectures, resembling several essentials of cognitive systems.

Motivations for Integration

- Demonstrate scientific progress in real-world scenarios
- Combine individual capabilities to emergent systems
- Prototype novel application domains
- Narrow gap between cognitive processing models and real-world systems

Essential Features of Modular Cognitive Systems

Models · Time · Parallelism · Asynchronicity · Self-Awareness · Relations · Redundancy · Uncertainty · Memory · Learning · Relevance · Synchronization · Sequencing · ???

Dynamic Representations

Information-oriented encoding in XML document models

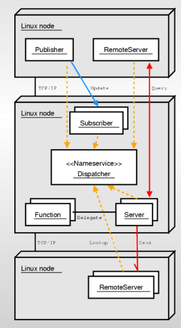
```
<OBJECT>
  <CLASS>Cup</CLASS>
  <REGION>
    <CENTER x="367" y="285"/>
    <RECTANGLE
          x="335" y="245"
          w="65" h="80"/>
  </REGION>
  <HYPOTHESIS>
    <TIMESTAMPS>
      <CREATED value="34525"/>
      <UPDATED value="34565"/>
    </TIMESTAMPS>
    <RATING>
      <RELIABILITY value="0.6"/>
    </RATING>
  </HYPOTHESIS>
</OBJECT>
```

- extensible units of information are self-descriptive XML documents
- which may link sub-symbolic data
- common meta-information deals with Time, Space and Uncertainty
- open to all memory processes

Information Flow

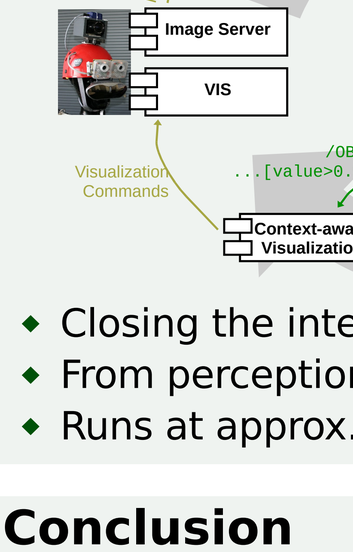
Data- and Event-Driven Integration Middleware

- dynamic interaction patterns
- asynchronous parallel processing
- content-based routing of information
- introspection of interactions



Memory

Active Memory Server + Forgetting / Compacting

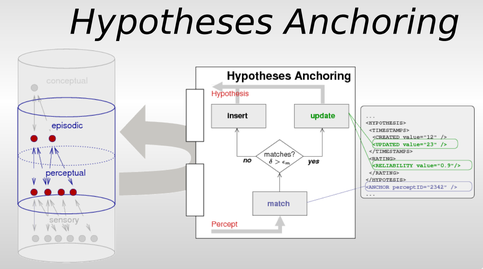


- allows memorization, recalling and forgetting of variable structures
- repository allows symbolic and sub-symbolic data
- memory instances vary in temporal behavior

Information Fusion

Hypotheses Anchoring

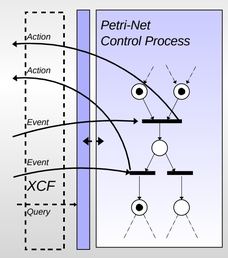
- multi-modal fusion processes
- consolidation of perception
- temporal integration



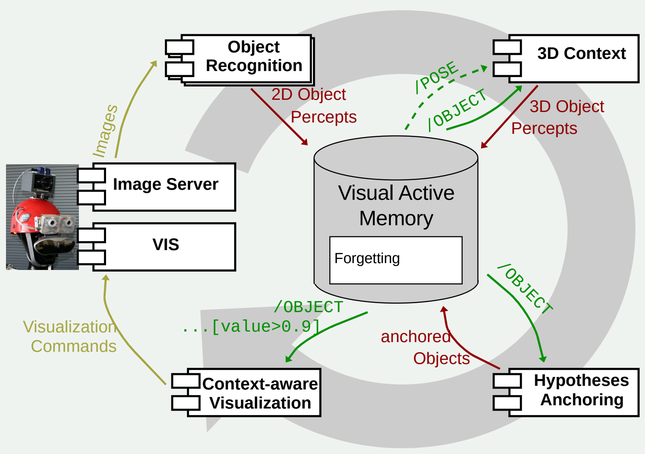
Coordination

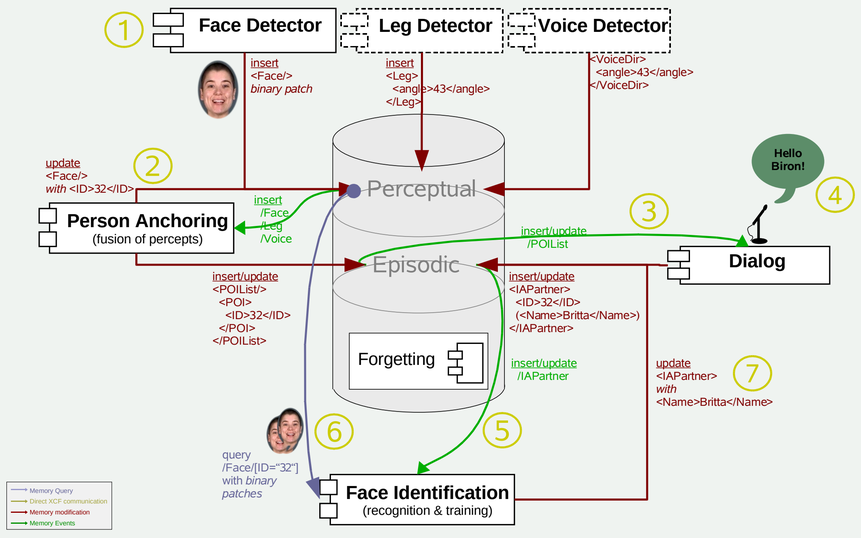
AM Petri-Net Engine

- perception/action coupling
- task and state knowledge
- dynamic re-configuration
- coupled to memory instances
- models stored in long-term memory



Exemplary Use Cases





- Closing the interaction loop
- From perception to visual feedback
- Runs at approx. 10Hz
- Face identification of tracked interaction partner
- Learning from memory content

Realized Interactive Systems

- Humanoid Robot
- Bi-manual Actions
- AR Assistant System
- Mediated Embodiment
- Robot Companion
- "Home-Tour"-Scenario

Conclusion

- Our vision is to embed interactive cognitive systems in the real-world
- Cognitive architectures should take up cognitive systems essentials
- The Active Memory Architecture aims at supporting a broad subset of these
- Several systems already apply the Active Memory architecture concept

Open Questions

- How to control complex dynamic relations of information in a memory?
- What are further essentials of cognitive systems that need to be addressed by integration architectures?
- How do these further essentials affect the design of the architecture infrastructure?
- What level of "cognitive conformity"?

References

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