A Multimodal Attention Mechanism for Autonomous Mobile Robotics

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CAOS
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Introduction (I)

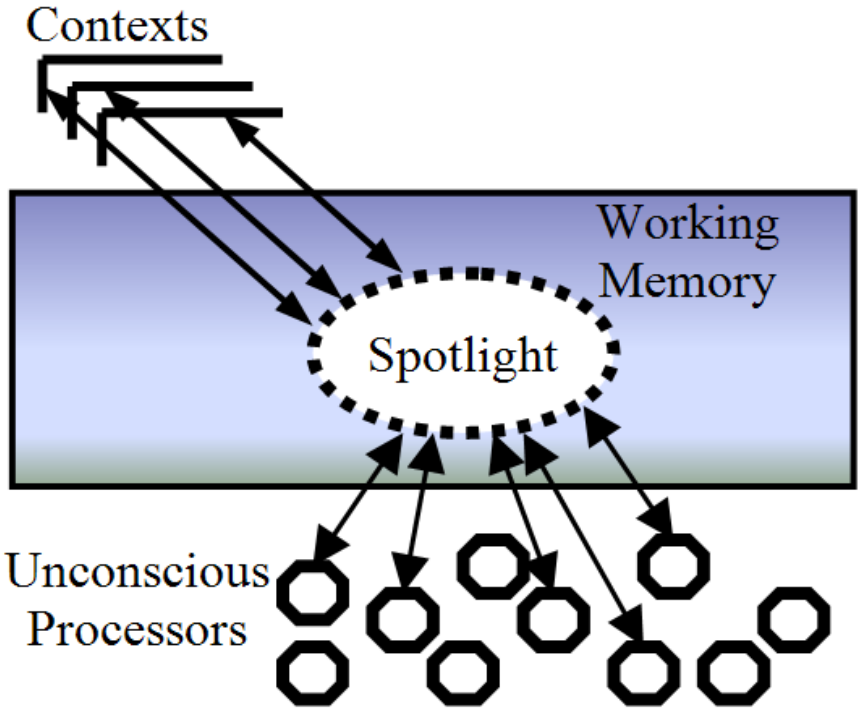
- **An attention mechanism is required in:**
  - Complex and dynamic environments.
- Considering all available sensory information is:
  - Extremely expensive.
  - Unnecessary.
- Considering all physically plausible behaviors is:
  - Not adaptive to the current situation.
  - Not oriented to the current mission.
  - Unnecessary.

Introduction (II)

- **Filtering relevant information.**
  - But, what does *relevant* mean?
  - Useful for the mission and adapted to the current environment.
    - This imply *integrated multimodal* attention.

Attentional Contexts (I)

- Inspired in the concept of context defined in the Global Workspace Theory (Baars 1993).



Attentional Contexts (II)

- *Simple Percepts* are minimal (monomodal) information units.
- *Sensory Contexts* define sets of percepts:
  - Complex multimodal percepts.
- *Behavioral Contexts* define sets of actions:
  - Complex behaviors.

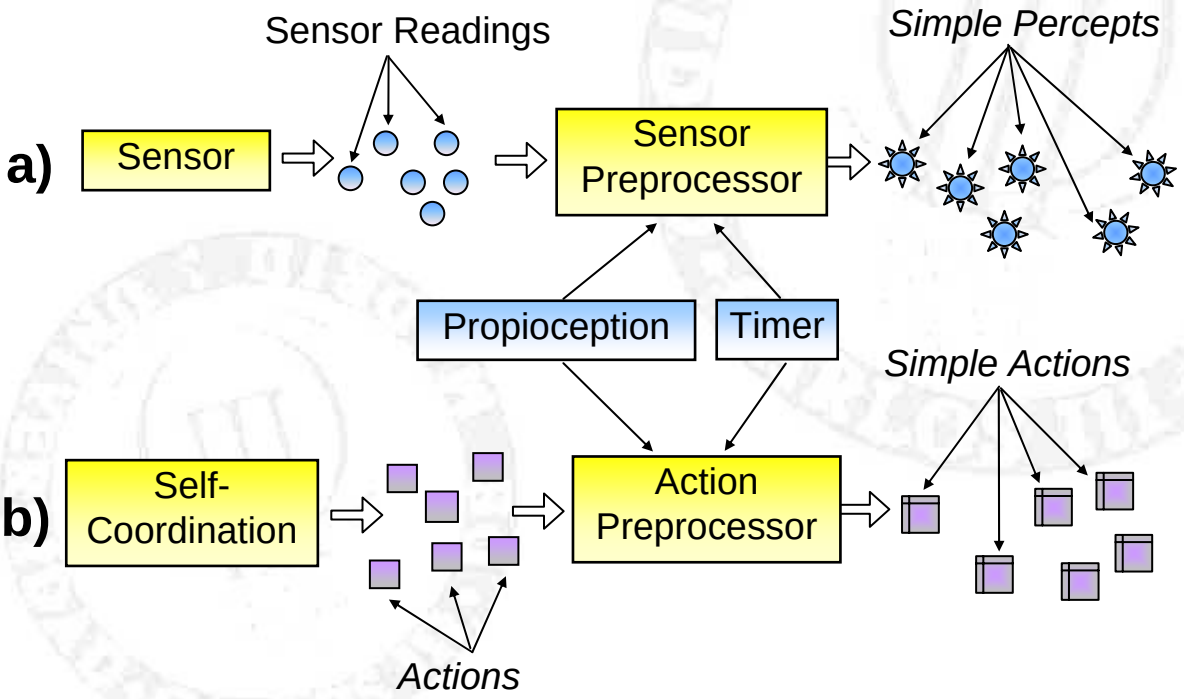
- Both sensory and behavioral contexts need to be dynamically generated.

Attentional Contexts (III)

- Context Criteria / Context Formation
  - Calculate the degree of relation between potential elements of a context.
  - Basic criteria for context formation:
    - Time
      - Stimulus perception timestamp.
    - Location
      - Relative position of objects.

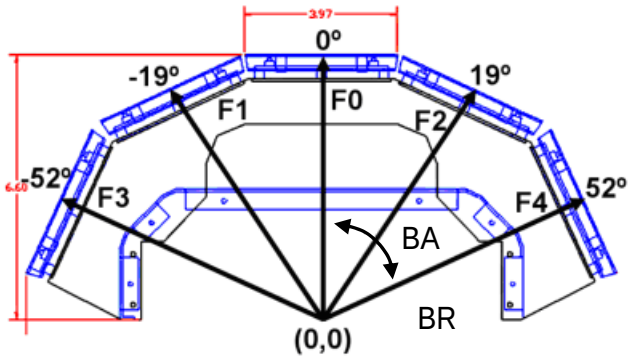
Simple Percepts (I)

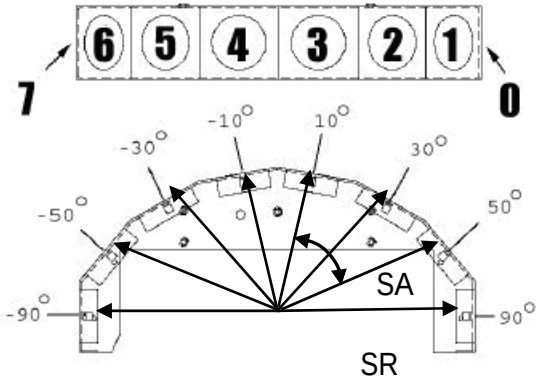
- Percepts and actions are decorated with timestamps and *J*-Indexes



Simple Percepts (II)

- Calculation of J-Indexes



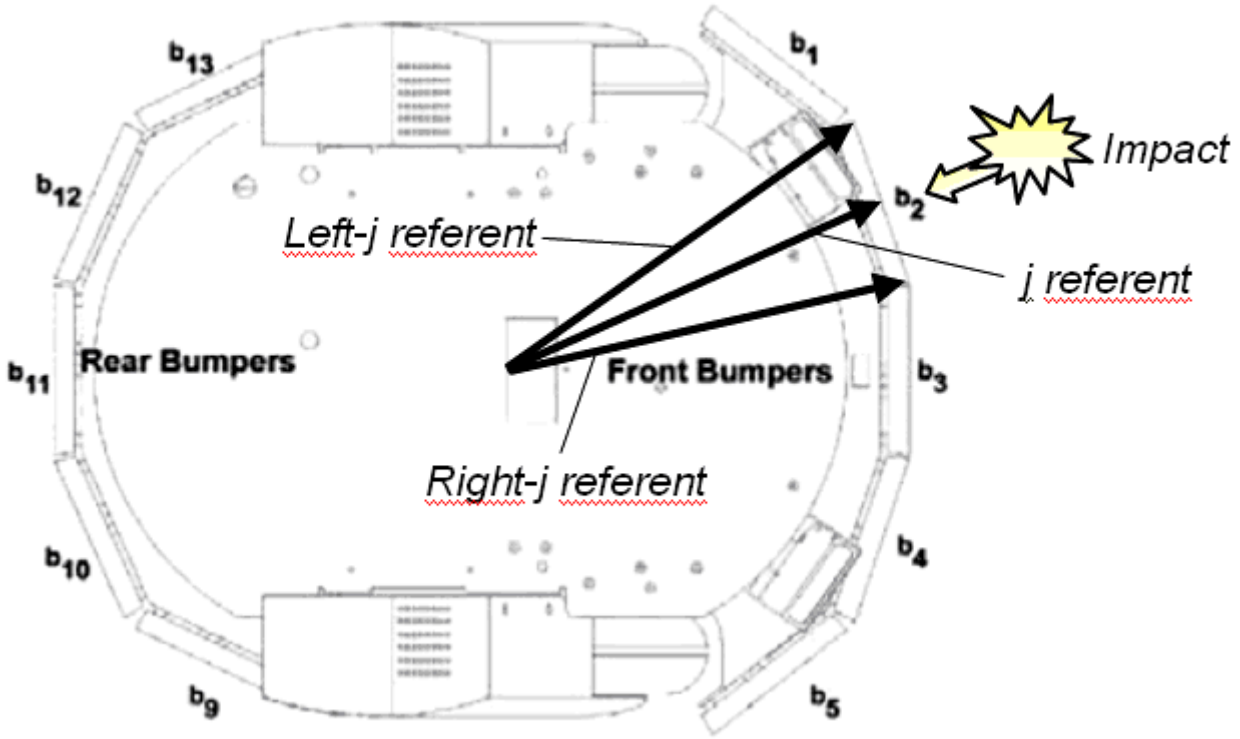


$$j=(X,Y,Z)=\begin{pmatrix} BR*Cos(BA), \\ BH, \\ BR*Sin(BA) \end{pmatrix}$$

$$j=(X,Y,Z)=\begin{pmatrix} (R+SR)*Cos(SA), \\ SH, \\ (R+SR)*Sin(SA) \end{pmatrix}$$

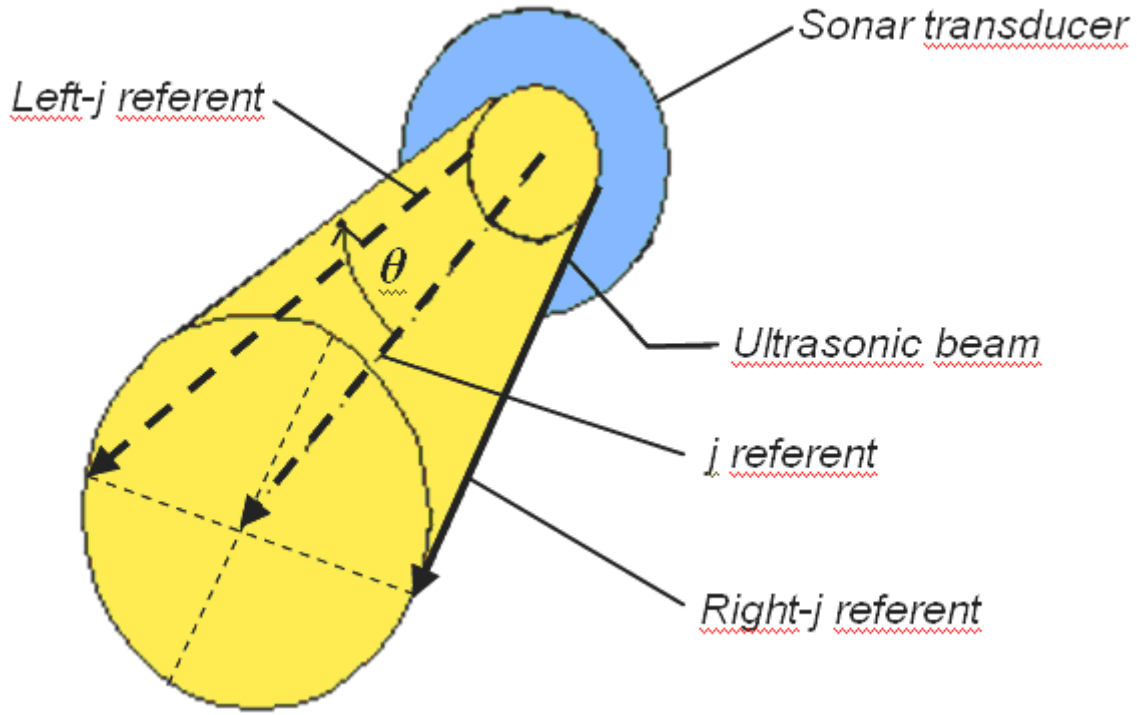
Simple Percepts (III)

- *J* –Referent vectors

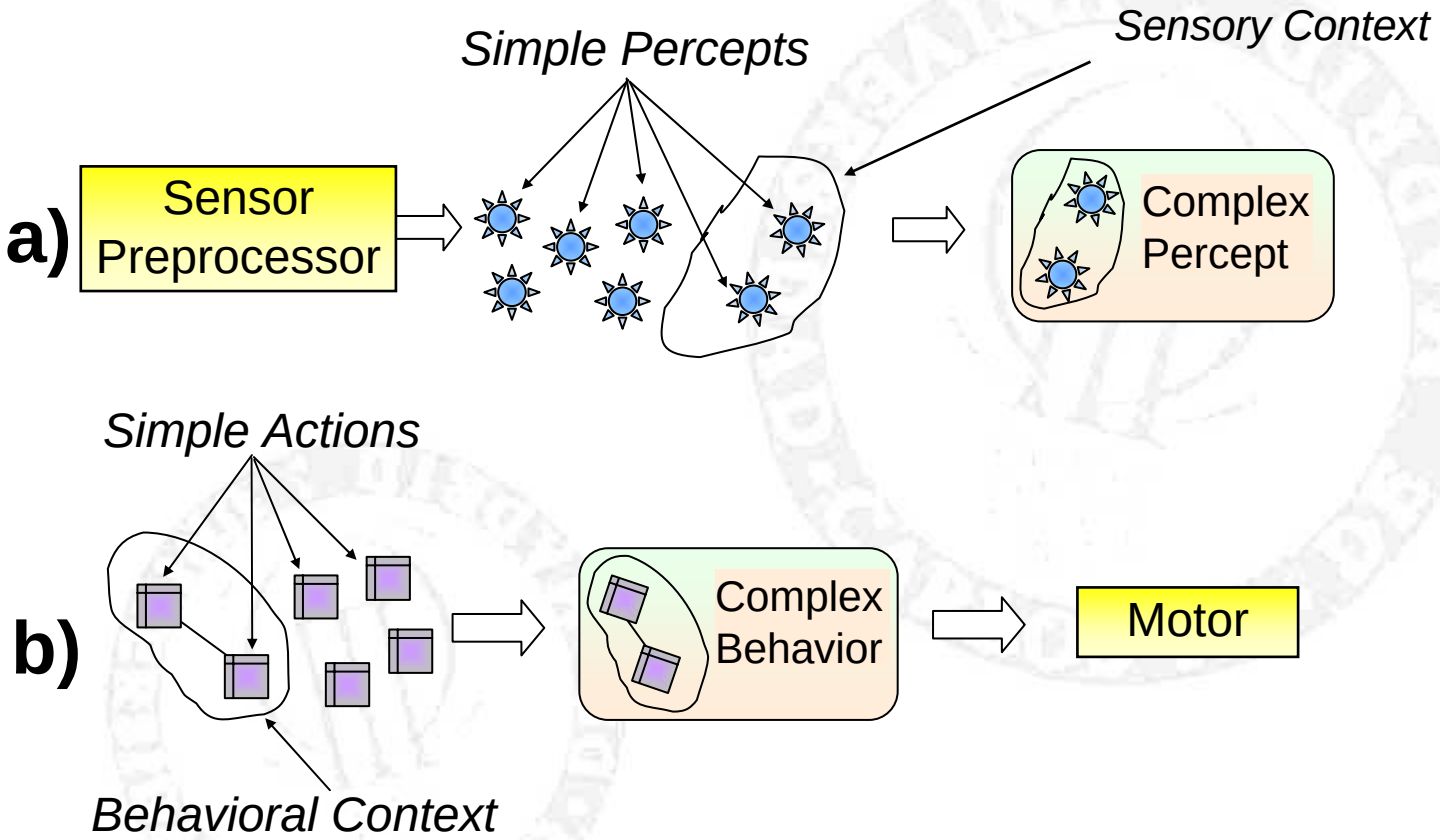


Simple Percepts (IV)

- *J*–Referent vectors

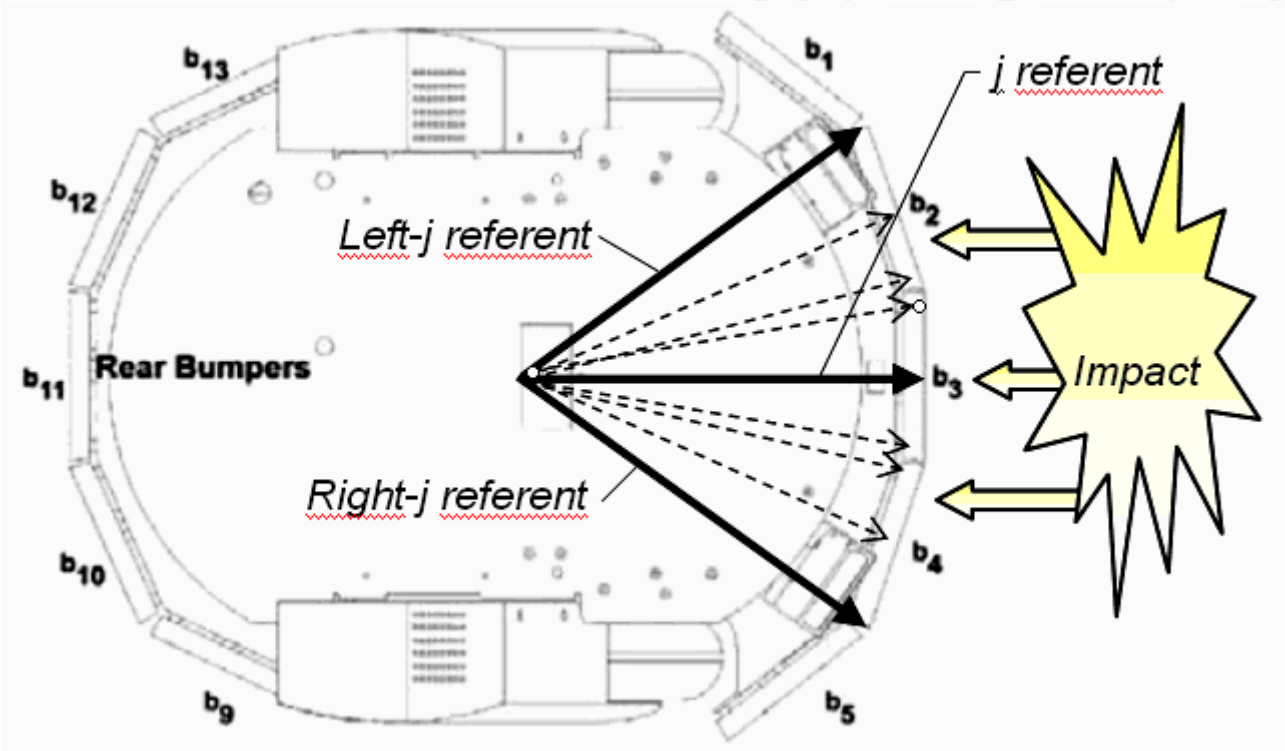


Complex Percepts (I)



Multimodal Integration (I)

- Monomodal Context Formation



Multimodal Integration (II)

- Multimodal Context Formation
  - All percepts can be compared using contextualization criteria (time and location) independently of their modality.

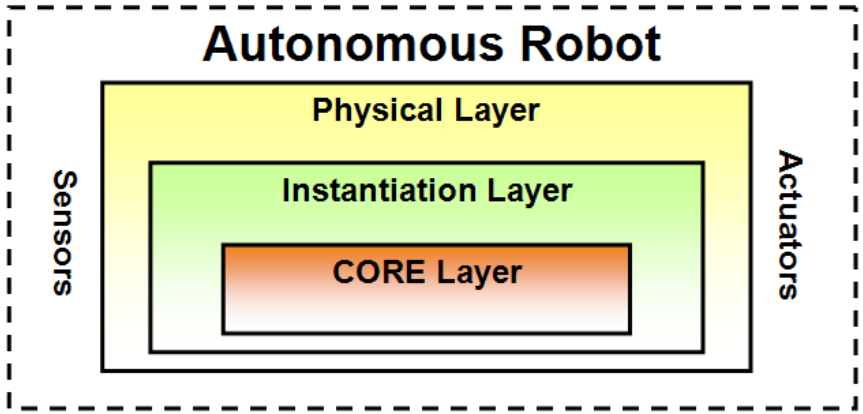
- Contexts have meanings:
  - *"All objects within the reach of the robot".*
  - *"All events that took place between five and ten minutes ago".*

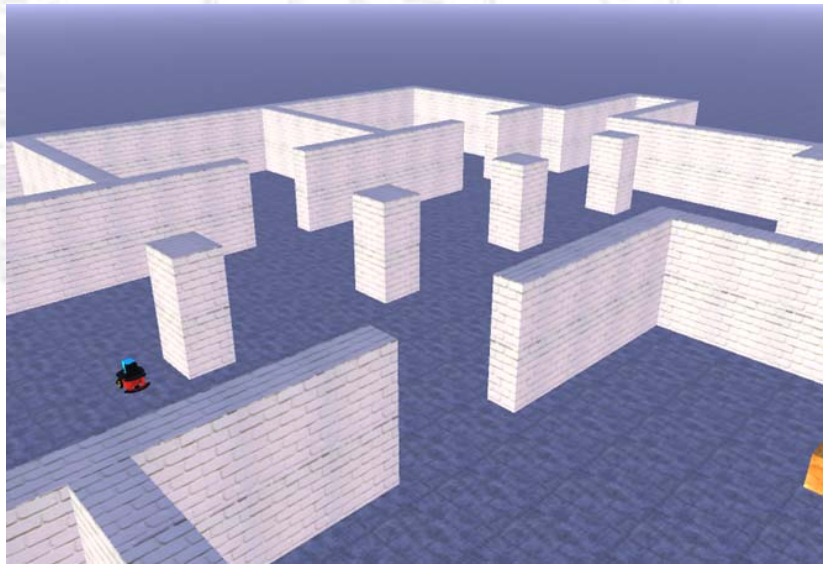
Multimodal Integration (III)

- Contradictory sensor data:
  - Build significant complex percepts out of conflicting simple percepts.
  - For example: Sonar fails to detect a sharp corner.
    - Ultrasonic beams are diverted.
    - But, bumpers notify obstacle simple percepts.
    - Bumper contacts have more confidence than sonar measurements.

Attention to Mapping (I)

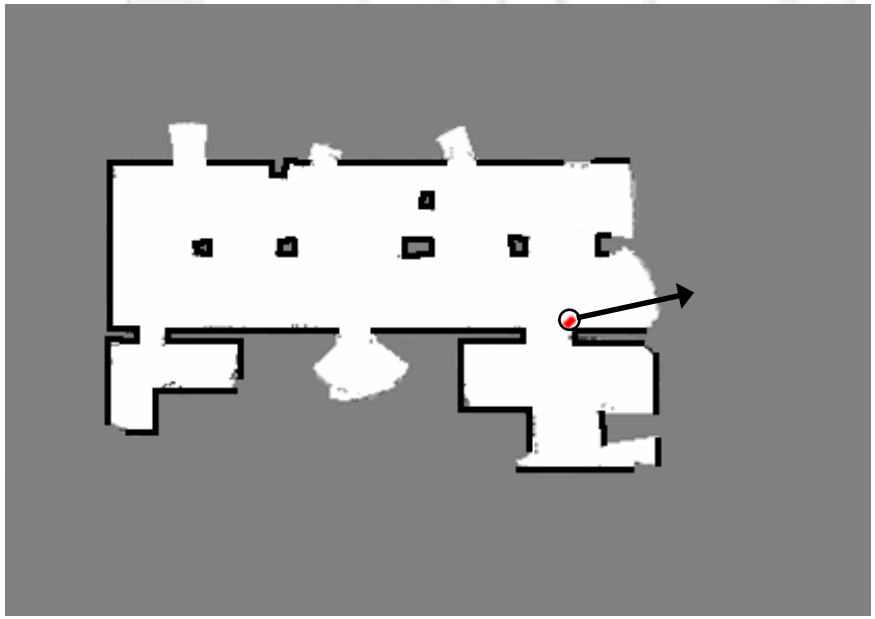
- Attention mechanism integrated in a cognitive control architecture.





Attention to Mapping (II)

- Specific “wall” and “open space” contexts are defined based on sonar single percepts.
  - Also RoI context is defined.
  - Global reference system.

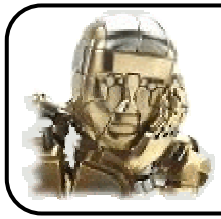


Conclusions and Future Work

- A method has been proposed for integrating multimodal attention in a cognitive architecture.
  - Tested against the unknown environment mapping problem.

- Future Work:
  - Add more complex attentional contexts for other problem domains.
  - Integrate LRF.
  - Integrate with SLAM for imperfect odometry.

Thank you



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