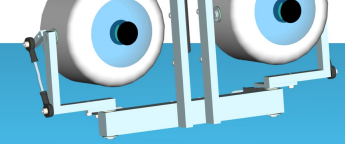


Cognitive Probabilistic Representation of Space for Mobile Robots

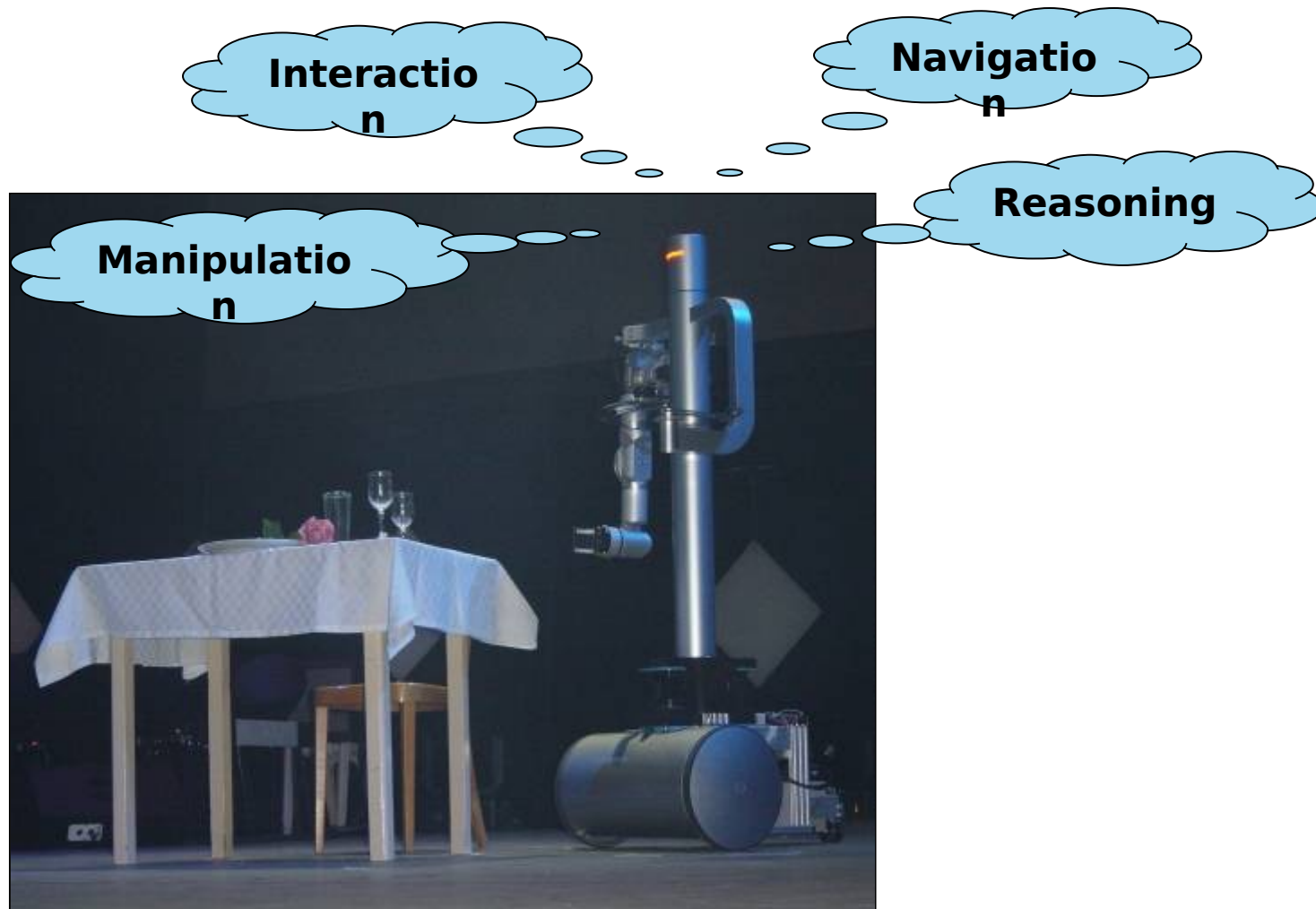
Shrihari Vasudevan, Stefan Gächter, and Roland
Siegwart

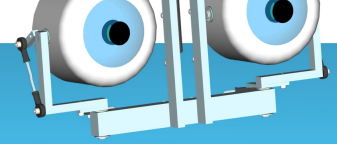
ETHZ-ASL

Robots@Home, May 2007



Motivation

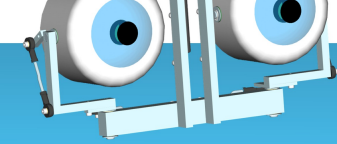




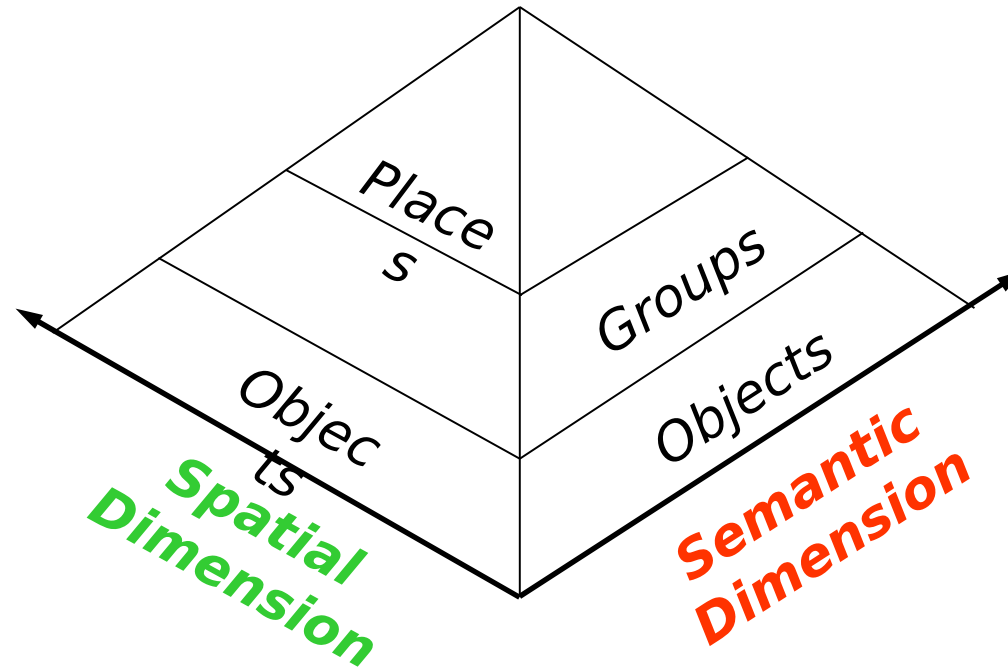
Motivation

Mapping

- **Robot mapping - well researched problem !**
 - Metric maps
 - Topological maps
 - Hybrid maps
- **Issues**
 - Only suited to robot navigation
 - Doesn't encode much or most of the semantics
 - Spatial awareness of robots - modest



Approach Overview



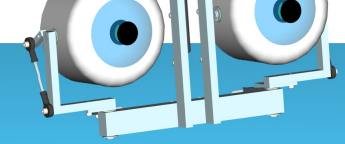
- **Spatial Dimension**

Places are formed as collections of groups of objects.

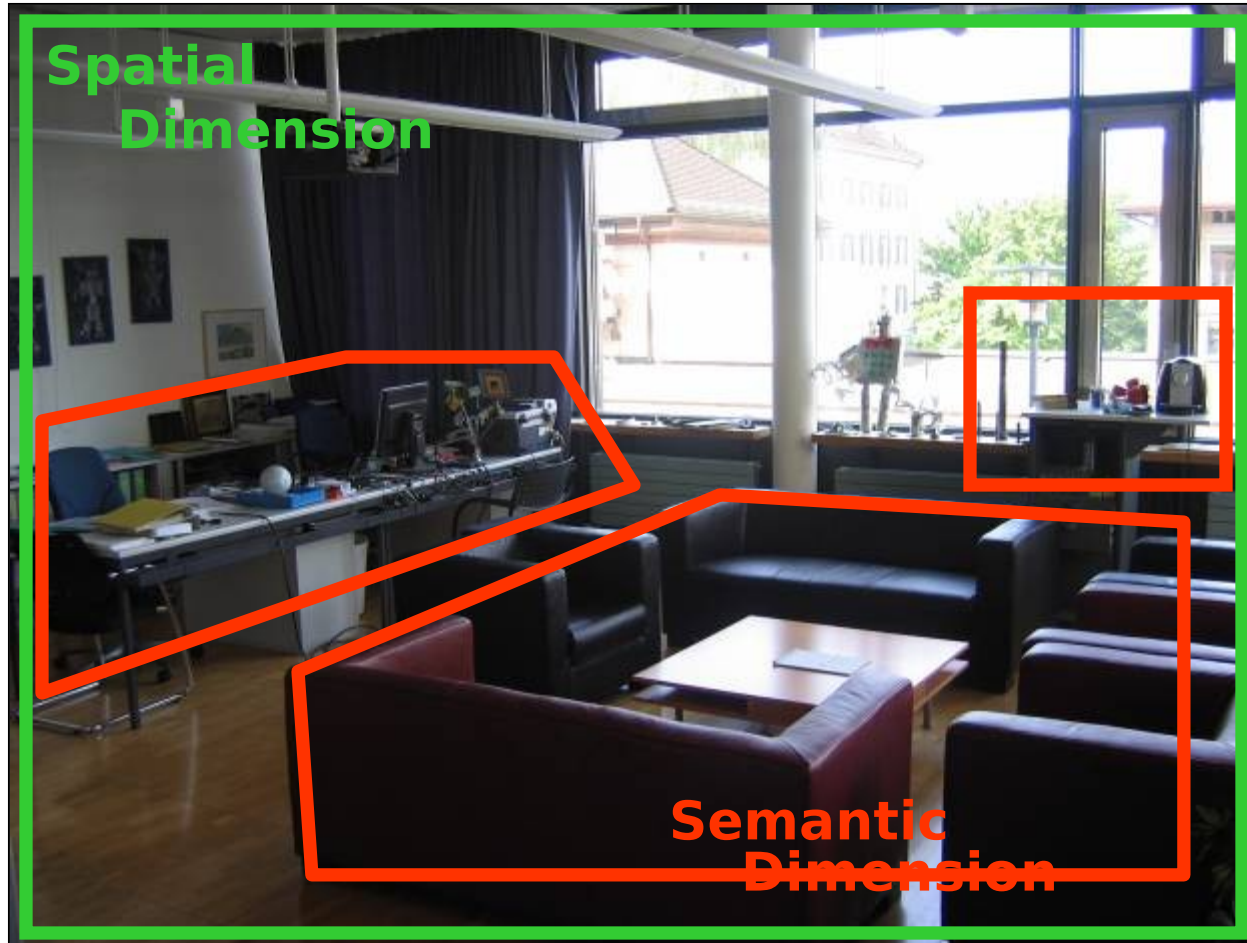
- **Semantic Dimension**

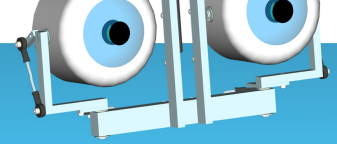
Groups are formed as a collection of objects, capturing their

semantics.
 Vasudevan, S., Gachter, S., Harati, A. and Siegwart R. (2007) A hierarchical Concept-oriented Representation for Spatial Cognition in Mobile Robots, Accepted for publication in the proceedings of the 50th Anniversary of Artificial Intelligence, Springer Lecture Notes in Artificial Intelligence (LNAI).



Approach Example



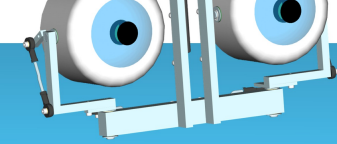


Implementation

Overview

- Object Recognition (SIFT), Door Detection (Line Extraction)
- Probabilistic Object Graph Based Representation
- Conceptualization
 - Bayesian network based conceptualization.
- Place classification
 - Bayesian incremental evidence accumulation.

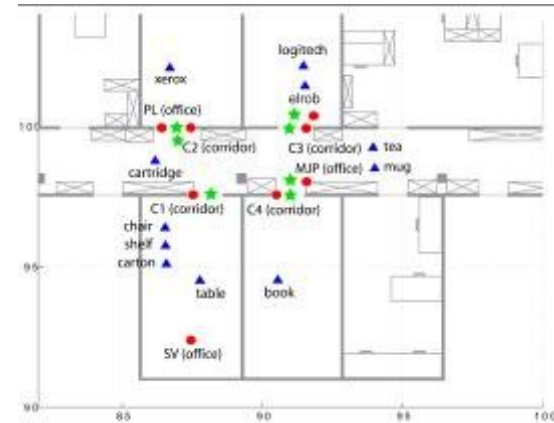
S. Vasudevan, S. Gachter, V.T. Nguyen and R. Siegwart, Cognitive Maps for Mobile Robots - An object based approach, Robotics and Autonomous Systems, Volume 55, Issue 5, From Sensors to Human Spatial Concepts, 31 May 2007, Pages 359-371.



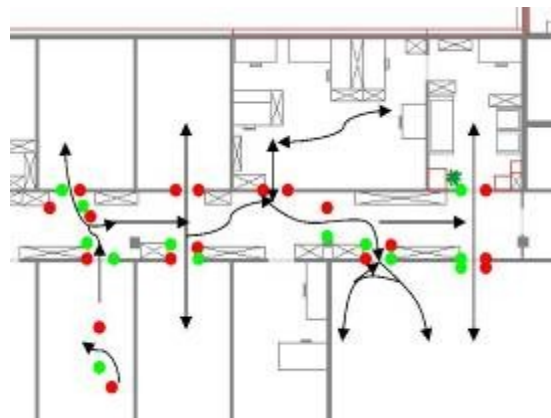
Implementation Mapping



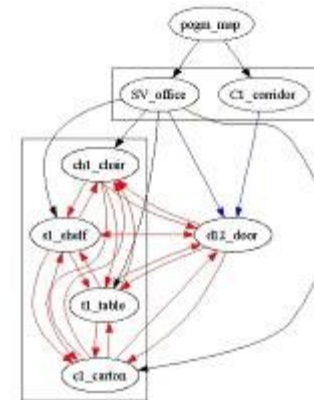
Object Recognition



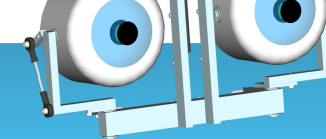
Object Map



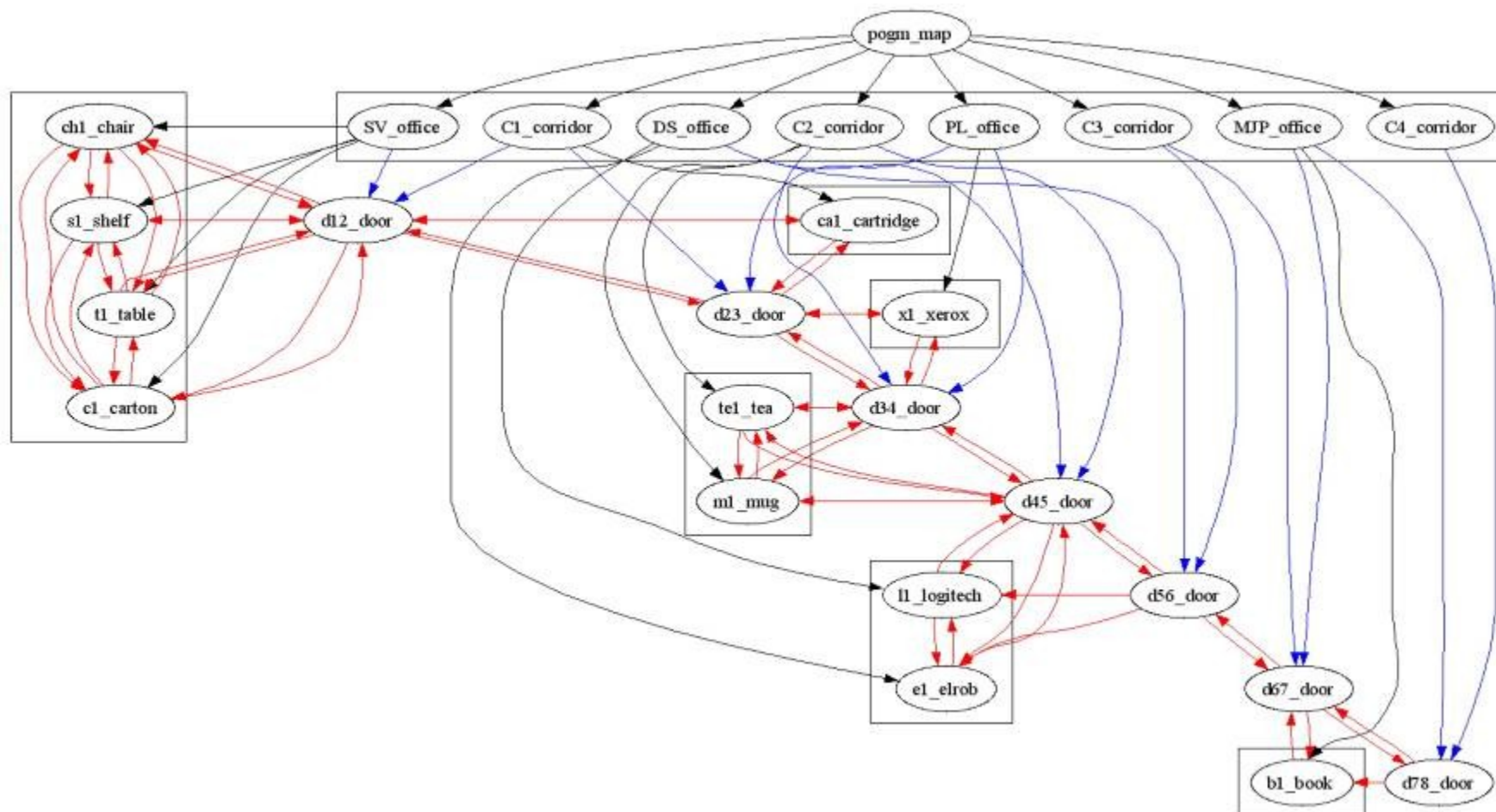
Door Detection



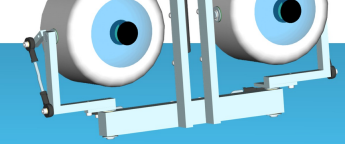
Object Graph



Implementation Representation

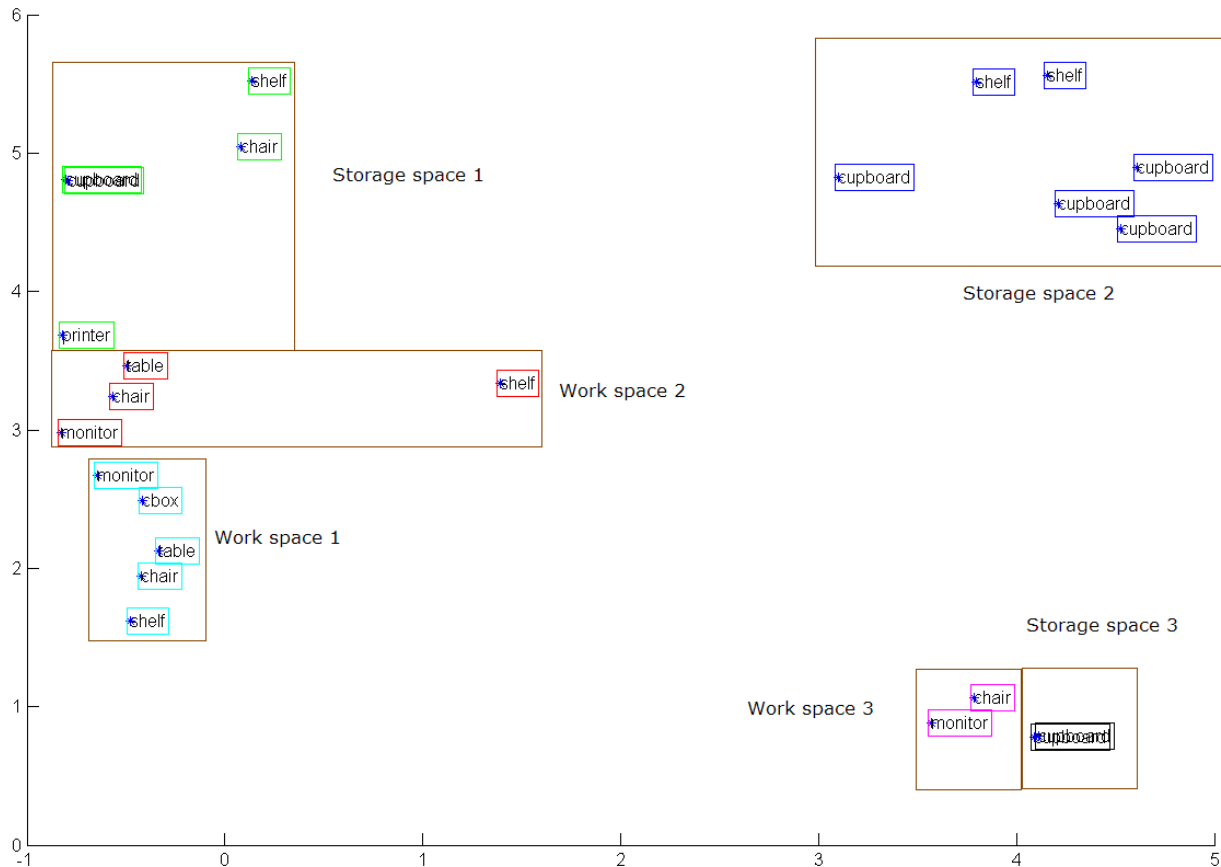


Hierarchical Representation

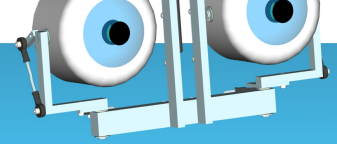


Implementation

Conceptualization



Identification of Groups



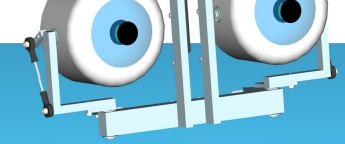
Validation

Overview

Human-Centered Experiments

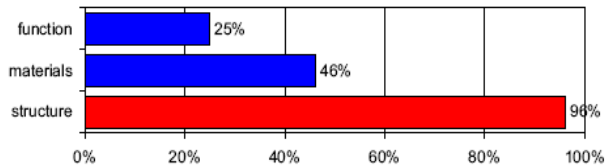
- Propose a human compatible representation of space
- Consistent link between robot sensory info and high level abstract concepts.
- User study with **52 people**
Tour in our labor premises.

Vasudevan, S., Gachter, S. and Siegwart, R. (2007) Cognitive Spatial Representations for Mobile Robots - Perspectives from a user study. In the proceedings of the IEEE International Conference on Robotics and Automation (ICRA) 2007 Workshop on Semantic Information in Robotics (SIR 2007), Rome, Italy.

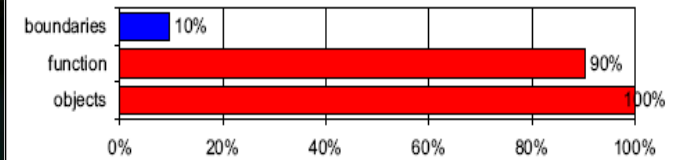


Validation

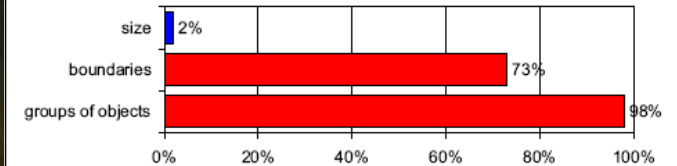
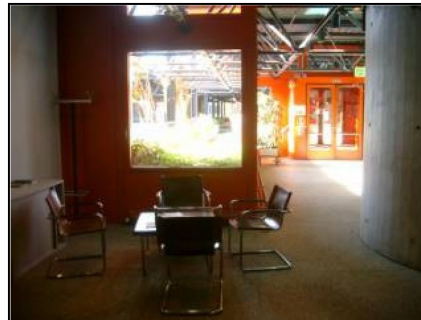
Objects, Places, and Groups



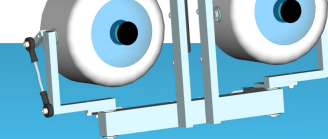
Representation
of Chair



Description of
Refreshment Room

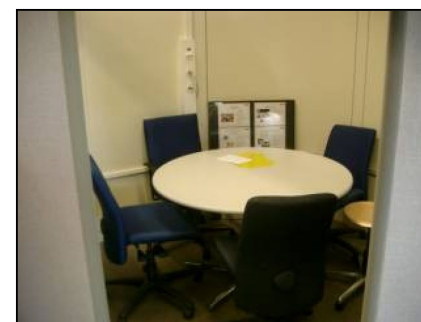
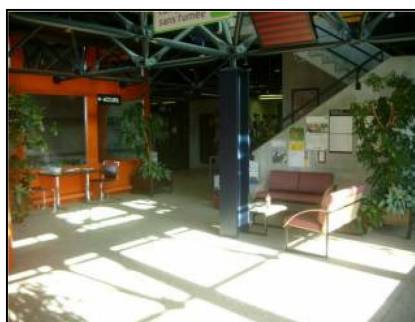
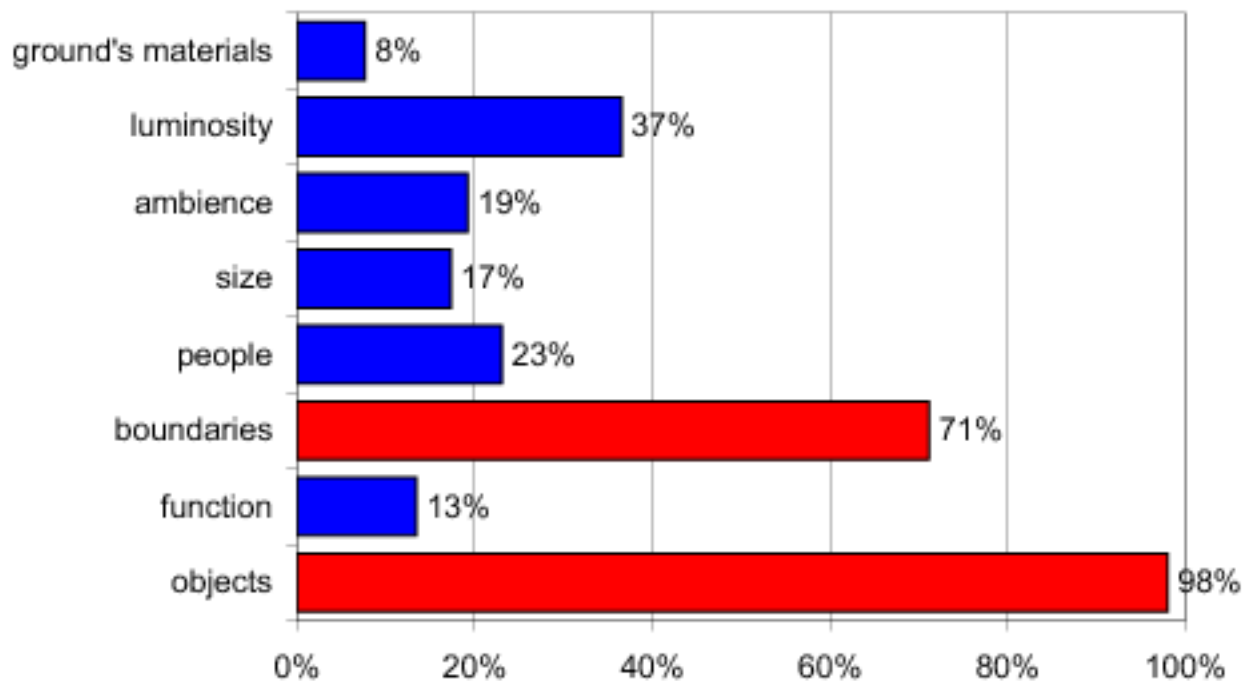


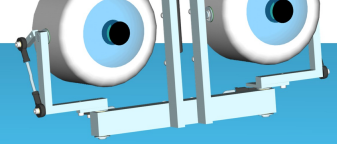
Zone Definition
of
Entrance Hall



Validation

Change of Places





Conclusion

- Human-compatible representation of space
 - Based on objects.
 - Hierarchical , probabilistic and concept oriented.
- Human-centered experiments to validate and enhance proposed representation.
- Robot-centered experiments to validate feasibility of proposed representation.