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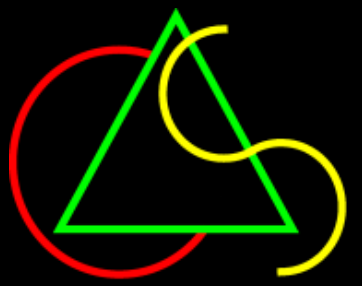

Centre for Autonomous Systems

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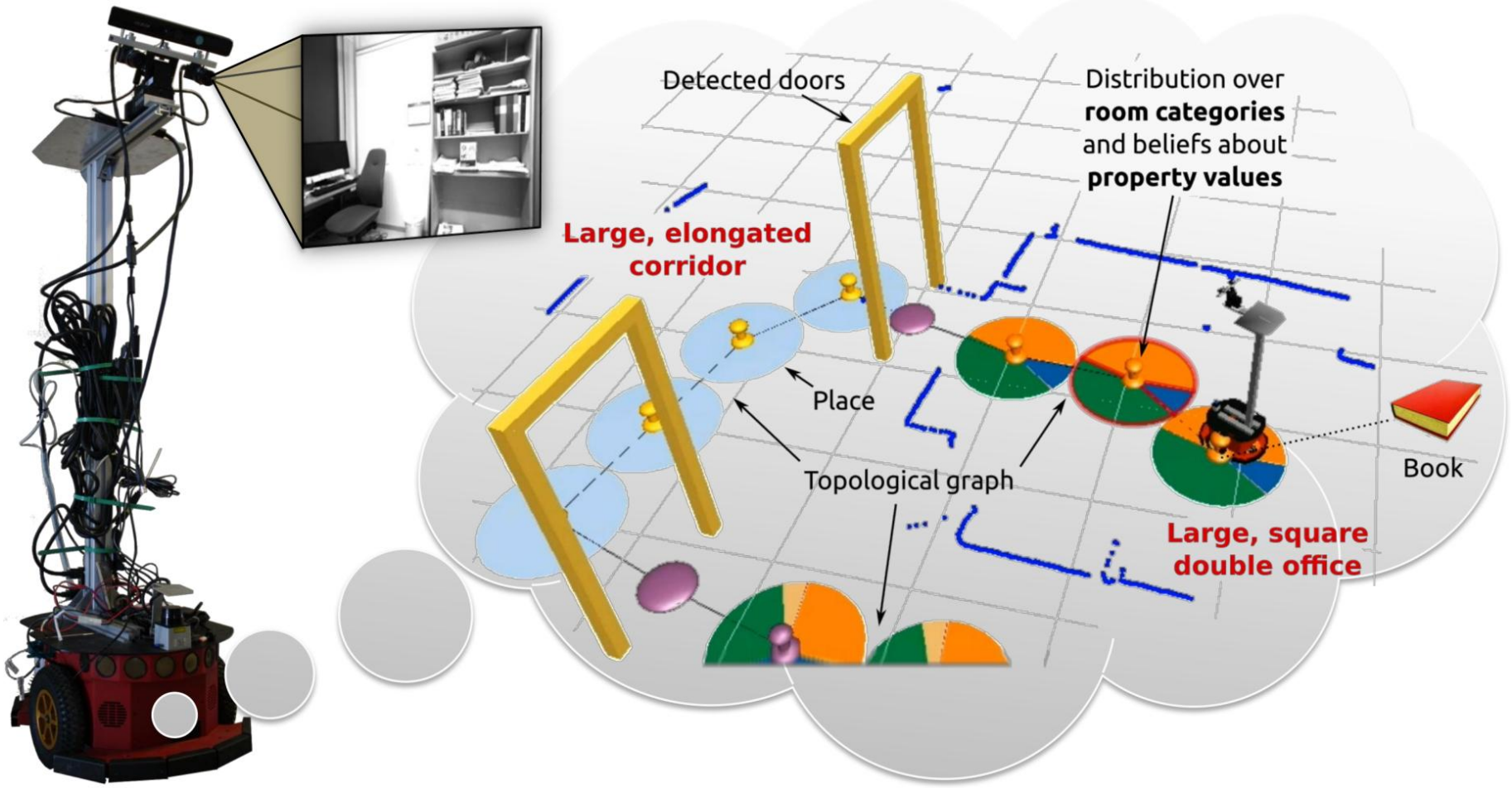
Large-scale Semantic Mapping and Reasoning with Heterogeneous Modalities

http://www.pronobis.pro

Semantic Mapping and Reasoning



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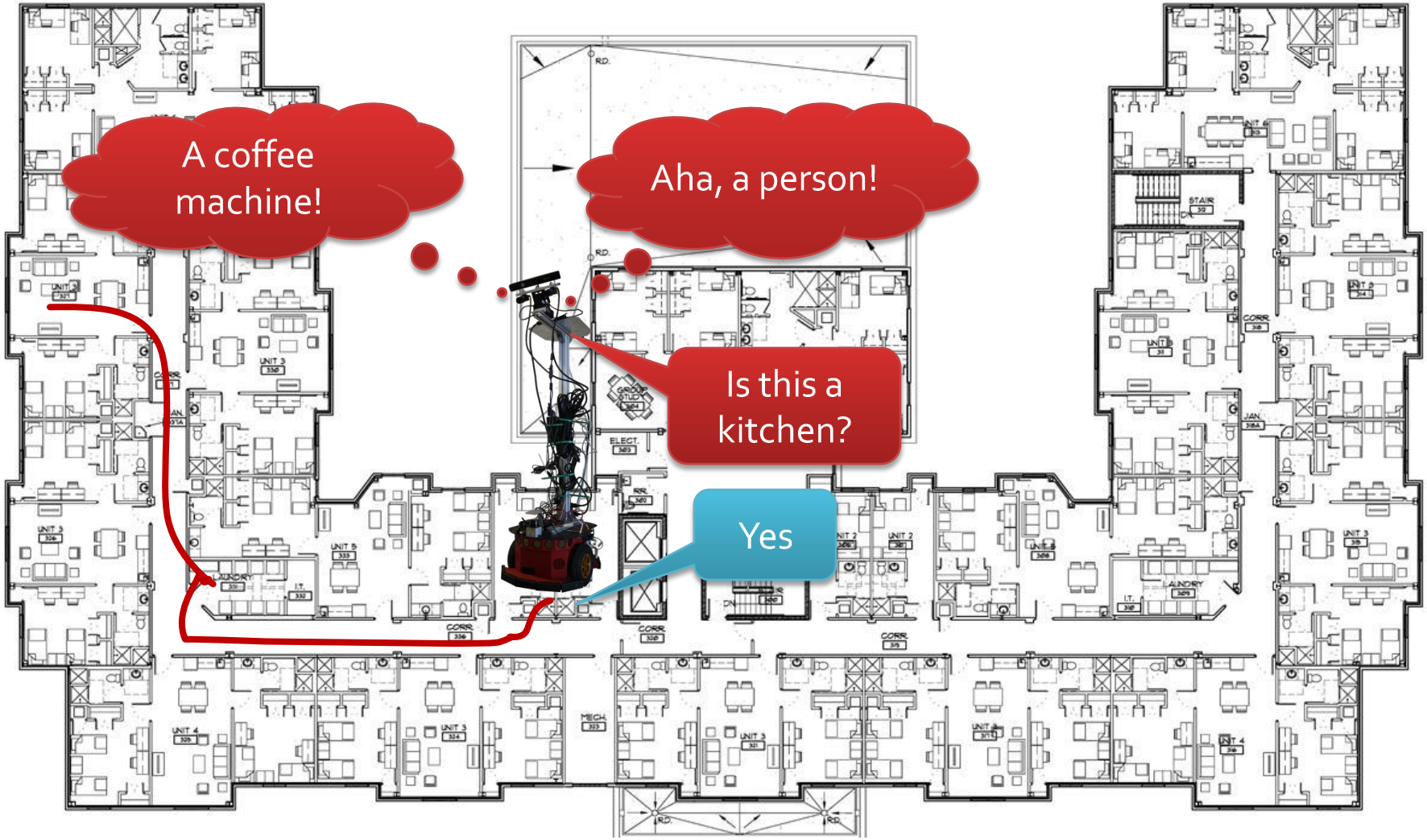

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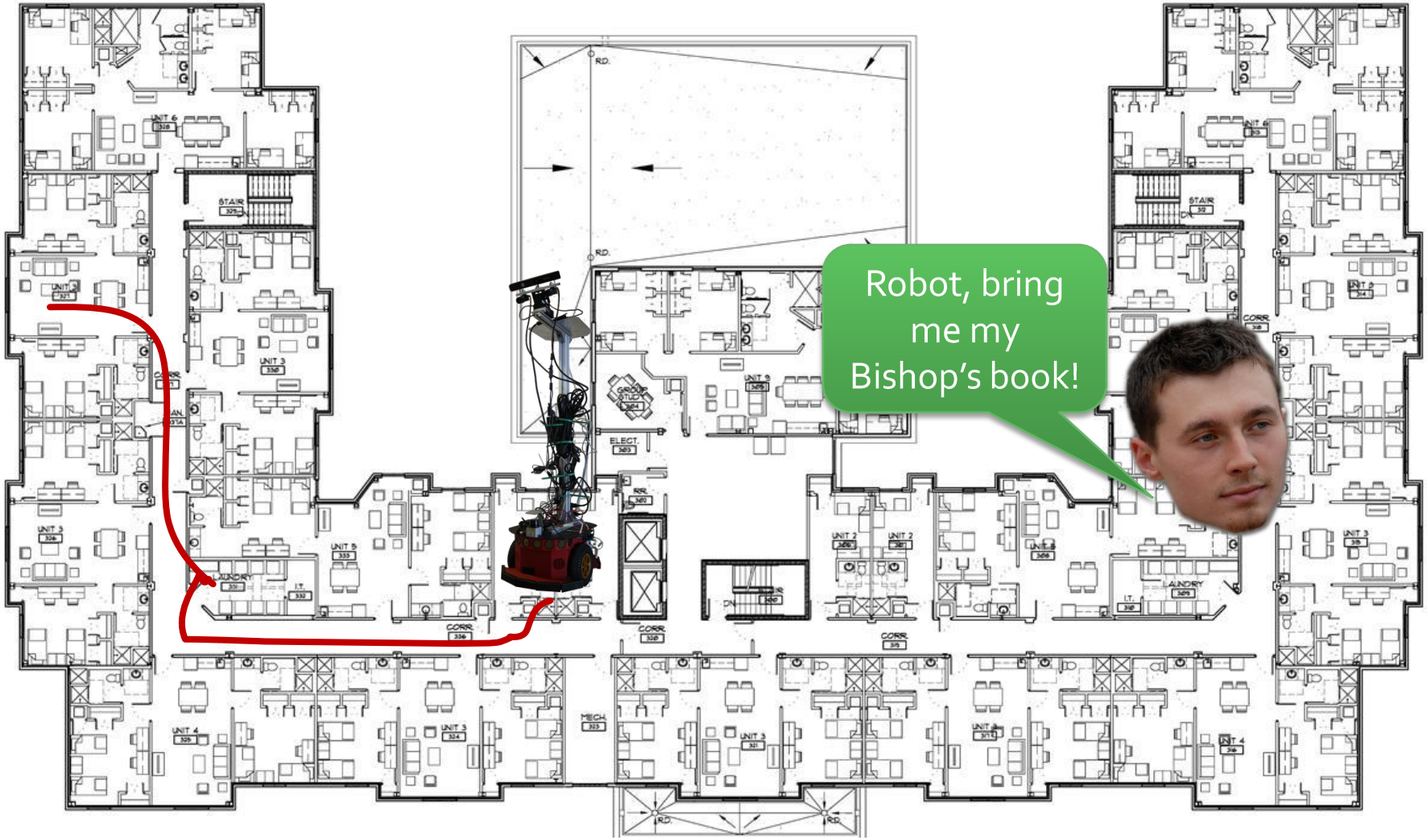

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Characteristics of the Problem

- Challenges
  - Perception
  - Scalability
  - Acquisition of concepts
  - Modeling uncertainty

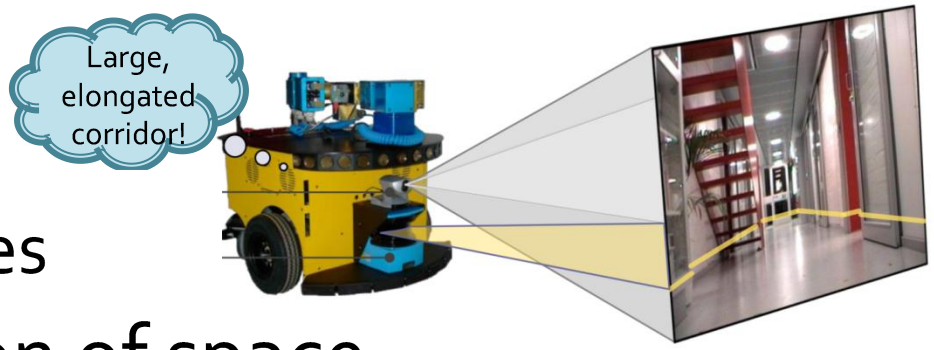




- Opportunities
  - Indoor spaces share structure
  - Multiple source of semantic information
  - Plenty of human knowledge sources

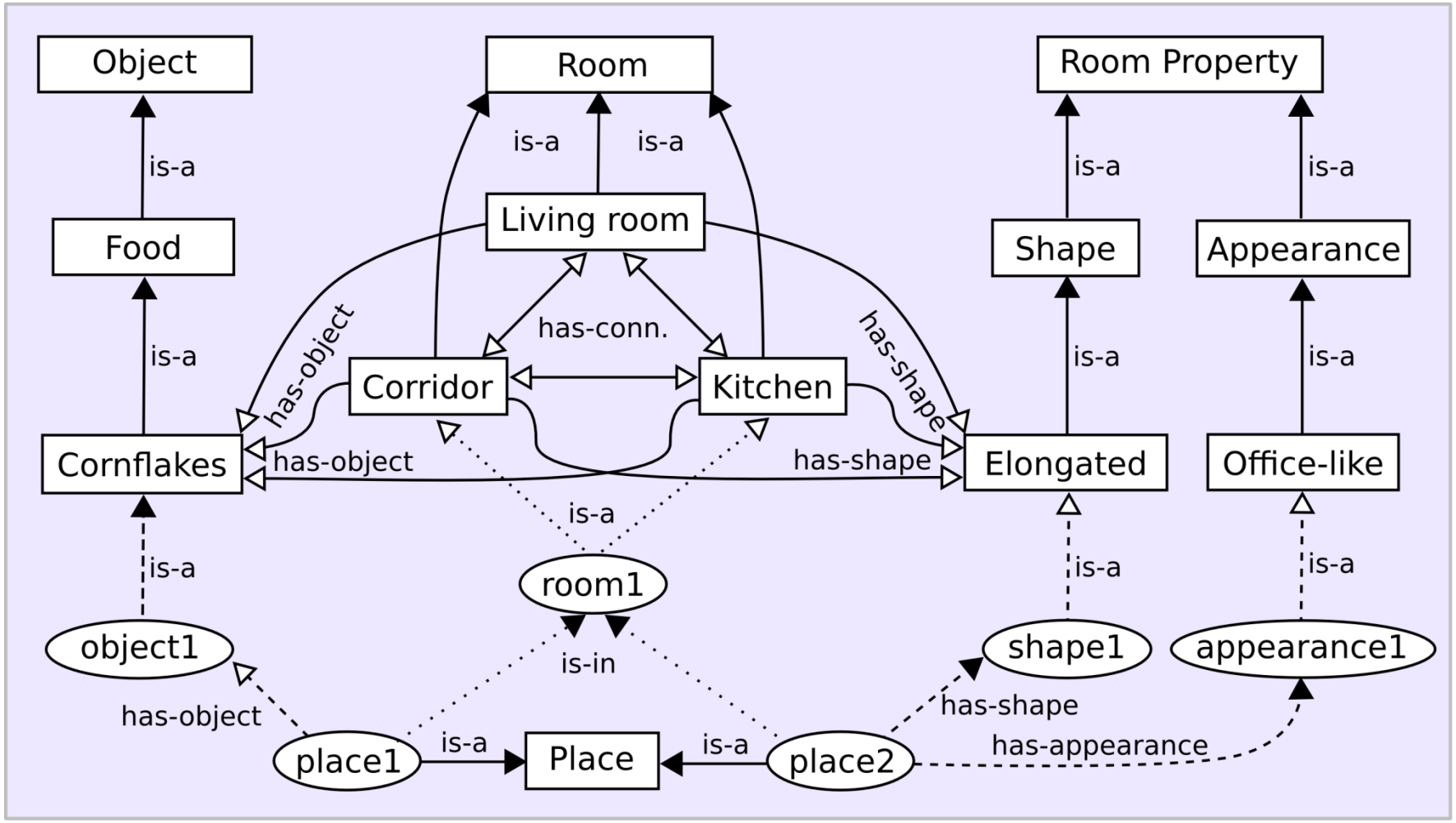
Our Approach

- Hierarchical, property-based architecture
  - Places have properties
  - Room categories modeled using properties



- Fine-grained description of space
- Integration of heterogeneous modalities
  - Appearance, geometry, objects, topology, dialogue
- Discriminative and generative models
  - Robustness for high-dimensional data
  - Probabilistic conceptual reasoning
- Common-sense knowledge from the Web

Conceptual Map



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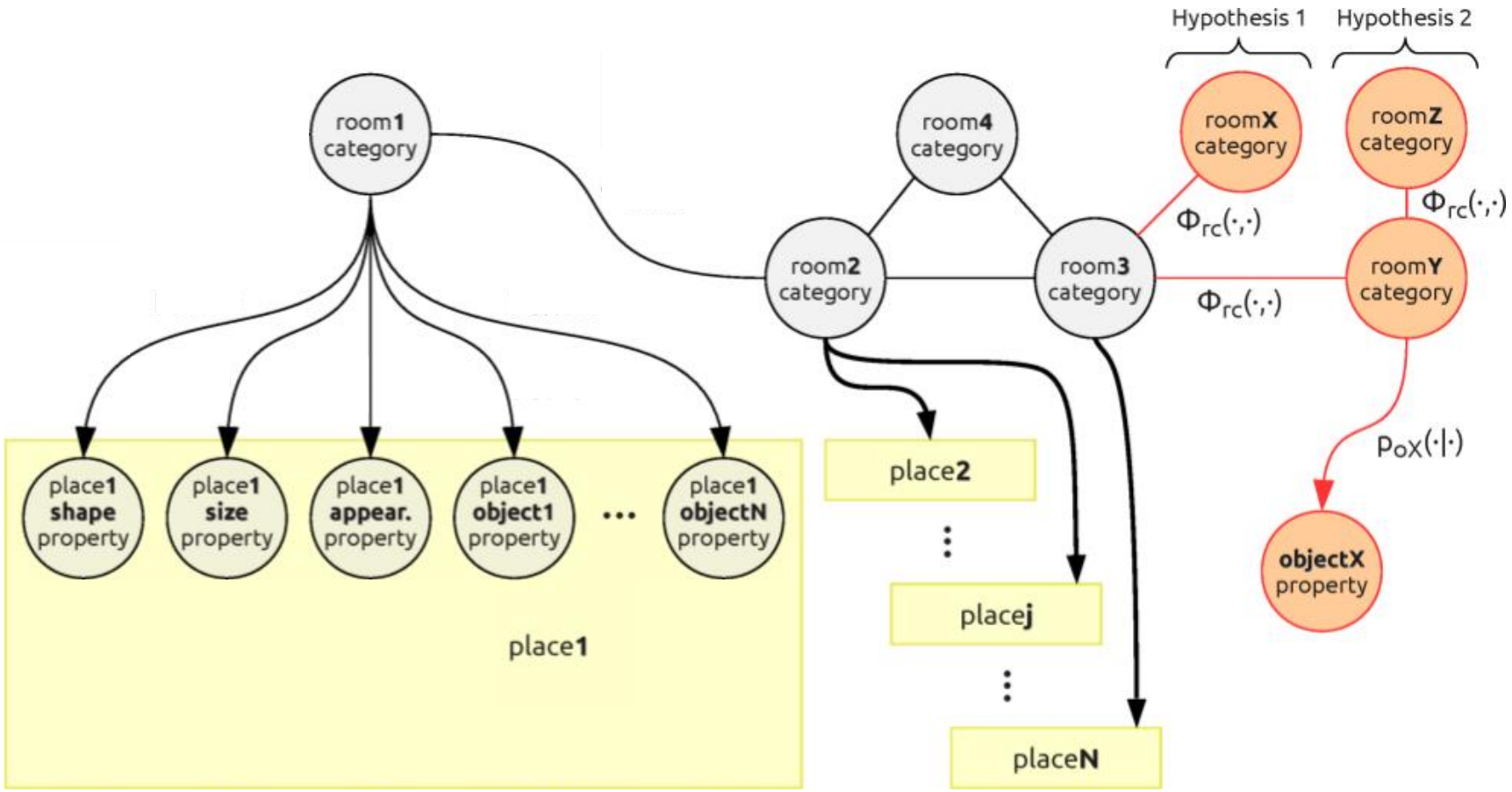
Probabilistic Reasoning

- Probabilistic graphical model: chain graph



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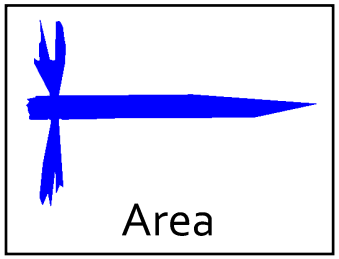
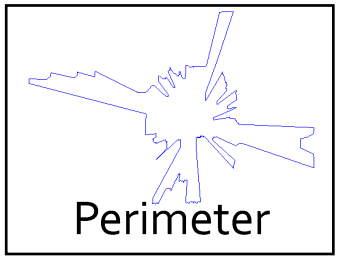
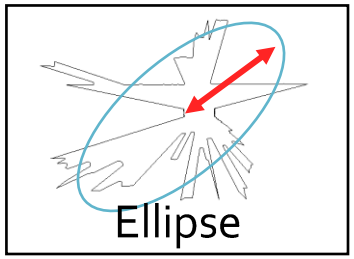
Property Models

- Geometrical properties

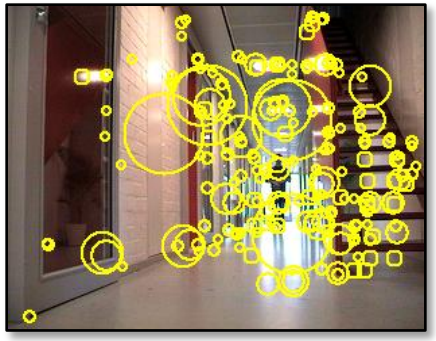




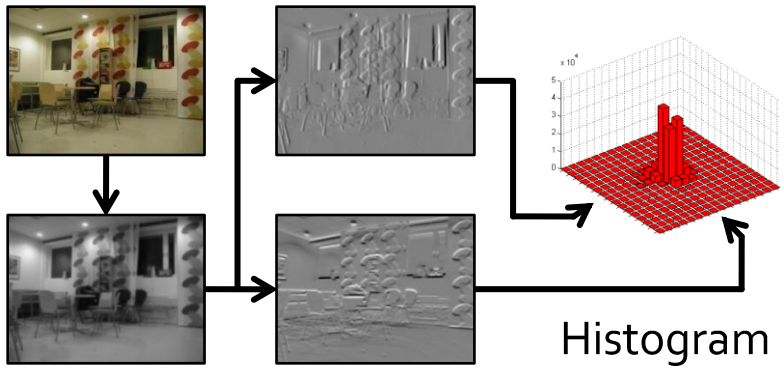


...

- Appearance properties



Local Features – Bag-of-words (SURF)



Global Features - CRFH

- Object properties, landmark properties
  - BLORT [Mörwald et al.'10], template-based door detector

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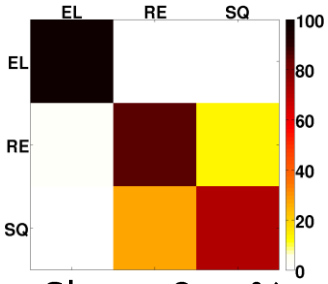
COLD-Stockholm Database

- 47 rooms, 4 floors
- 7 appearance categories
  3 room shapes, 3 sizes
- Varying illumination (daylight/night)

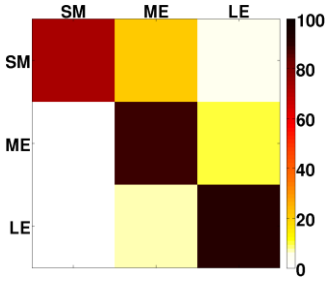
http://www.pronobis.pro/data/cold-stockholm

Property Model Evaluation

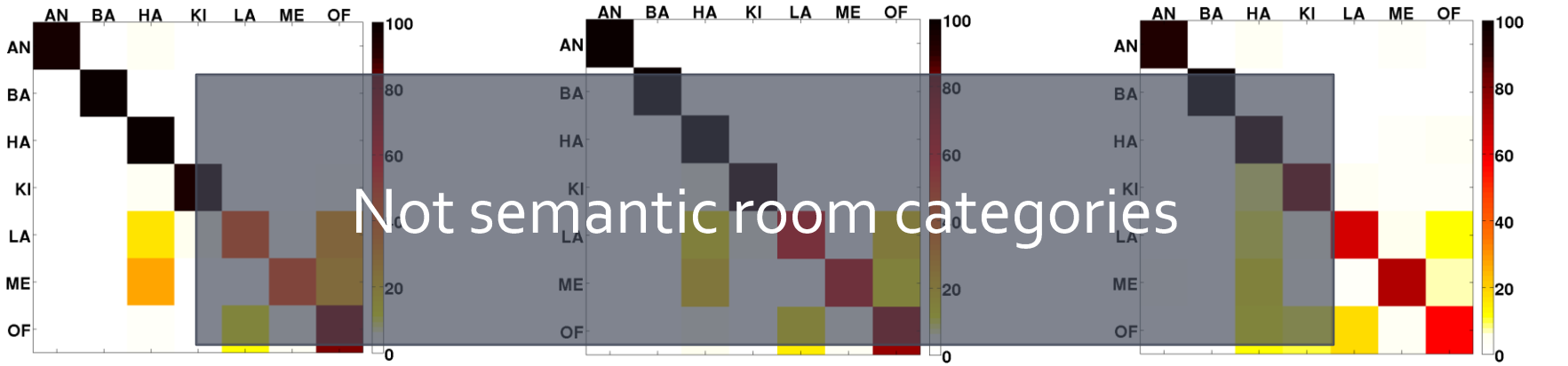
- Evaluated independently
  - In unseen environments (different floors of a building)
  - Across illumination settings



Shape 84.9%



Size 84.5%



Appearance CRFH 80.5%

Appearance SURF 79.9%

Appearance CRFH+SURF 84.9%

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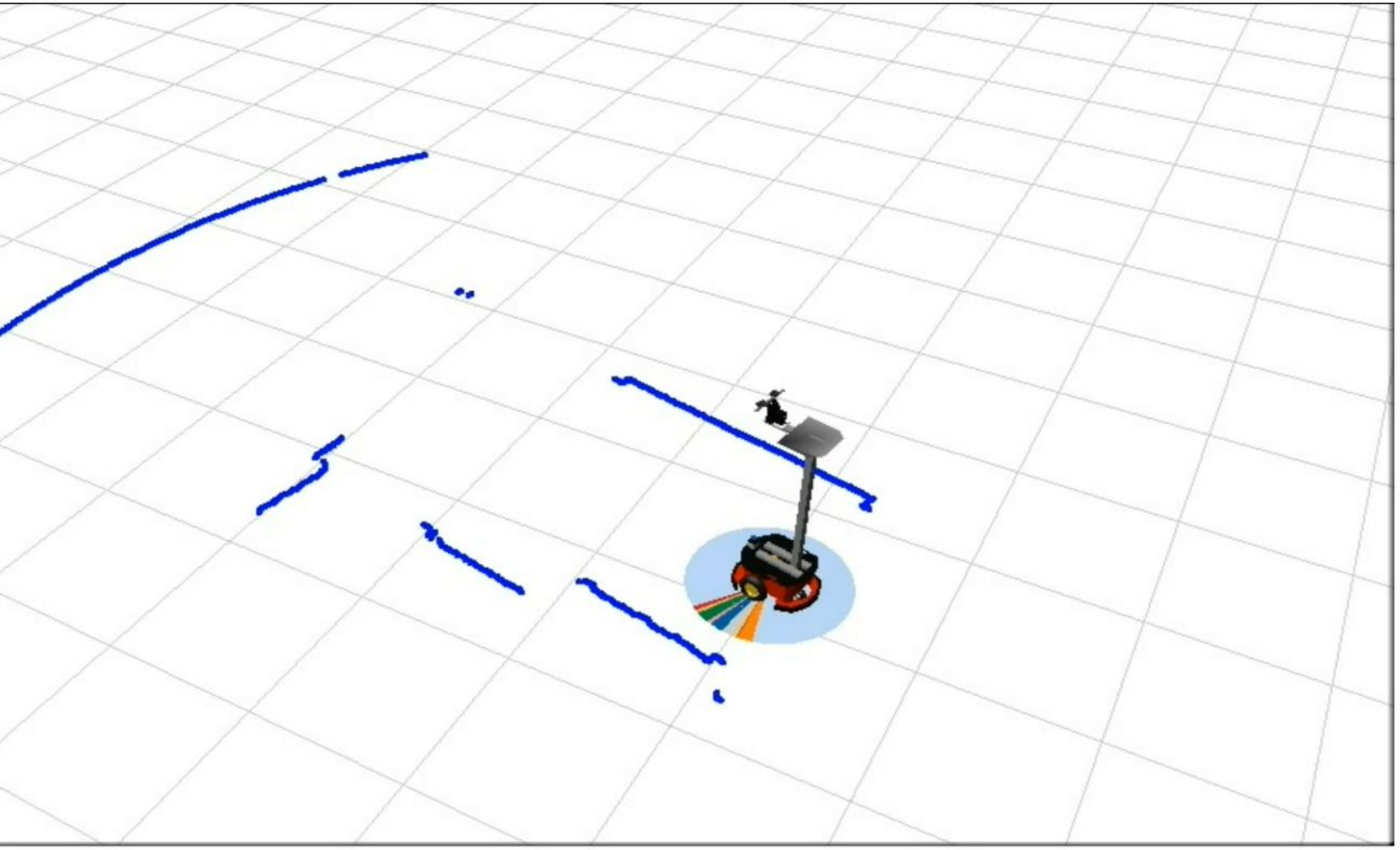
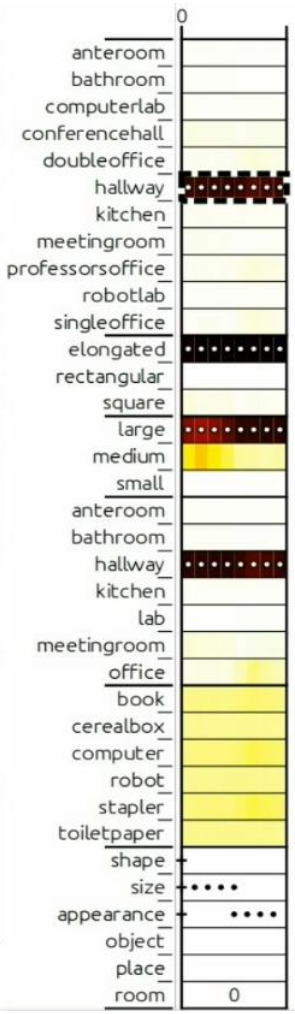
Semantic Mapping in Action





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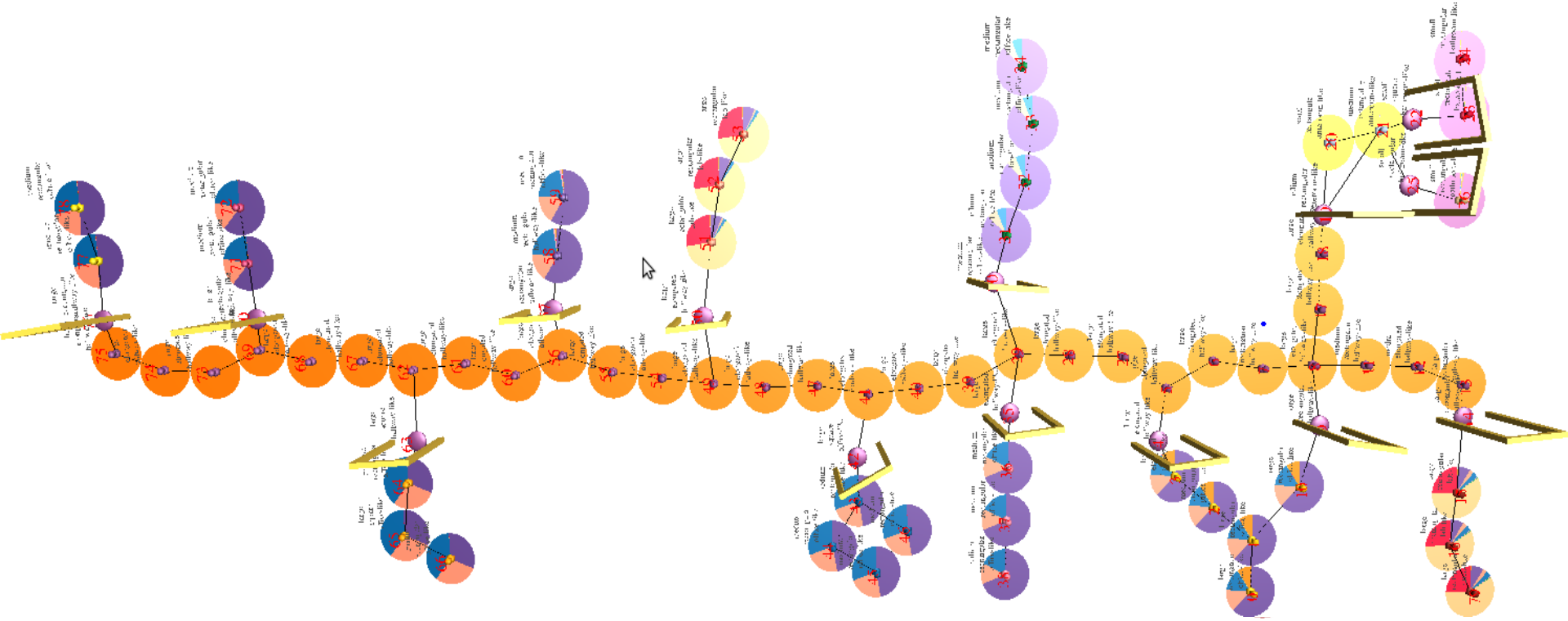
Results: Semantic Maps



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Conclusions

- Real-time, large-scale semantic mapping system
  - Hierarchical, property-based architecture
  - Multiple heterogeneous sources of information
  - Probabilistic concept modeling and reasoning

- Integrated into object search system
  - [Aydemir et al., ECMR'11, T-RO (in submission)]
  - Conceptual map represents belief state for DT planner
  - Using our semantic map leads to:
    - More efficient search strategy
    - More human-like behavior