1. Enhance the feature set!
   - Move from low-level features such as lines, corners etc. to high-level ones such as objects, doors and walls.

2. Graph based representation
   - Develop a representation that encodes space in terms of objects and spatial relationships between them.
   - Represent relationships using a metric basis.

3. Abstract space to develop the hierarchical representation
   - Develop a mapping from sensory abstractions to increasingly abstract concepts - both spatial and semantic.
   - Semantic abstractions (groups): capture spatial semantics (common purpose, functionality or due to spatial arrangement) between a cluster of objects.
   - Spatial abstractions (places): collection of groups of objects, formed due to the occurrence of boundary elements such as doors and walls.

Our Work
Hierarchical Probabilistic Representation of Space

Motivation
Cognitive Robot Companions of the future

Cognitive Robot Companions of the future
- Navigation
- Manipulation
- Interaction
- Reasoning

Objects and relative spatial information between them

REPRESENTATION FOR ROBOT
Hierarchical Probabilistic Representation of Space

Objectives
- Perception
  - High level features like objects, doors and walls.
- Representation / Mapping
  - Hierarchical Cognitive Probabilistic representation of space based on high-level features - human compatible representation of space.
- Cognition (probabilistic methods for cognitive competences)
  - Conceptualization of places.
  - Place Classification
  - Place recognition
- User Studies (Cognitive Validation of thesis)

Approach

From Objects to Places

Overview of Conceptualization Methods

- Supervised, exemplar based learning
- Bayes Net Classifiers
- Likelihood model based on M1 through M4
- Used for Conceptualization and Place Classification
- Place Recognition using Graph Matching

Preliminary Results

Stereo - SIFT Object recognition
Laser - Door detection
Object based map

From Objects to CONCEPTS to Places

Conceptualization of an office based on the objects identified.
Objects are clustered and identified as groups which in turn are used to infer the place.
This leads to a concept-oriented (semantically enriched) representation of space.