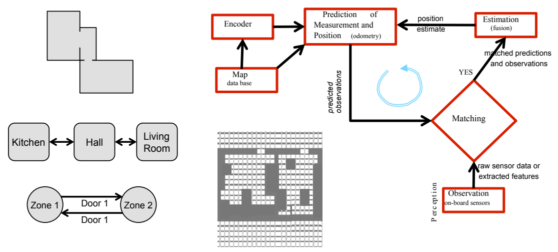
Map Representations 2 Probabilistic Localization I



Previously and Now

Done:

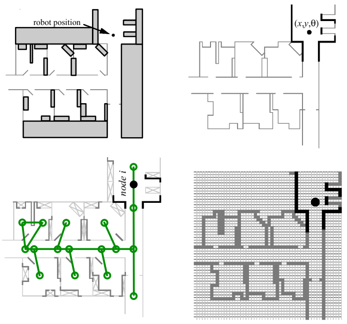
- All about kinematics
- All about transforms
- Localization
- Location error
- Movement error
- Behavior-based navigation
- Belief representations
- Map representations

Yet to come:

- More representation
- Probabilistic localization
- Cognition and control
- HRI
- Maze event!

Representations So Far

- Polygonal
- Line
- Topological
- Discretized

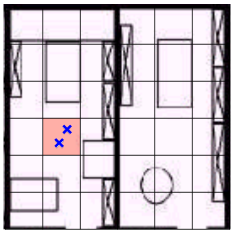


How To Build Maps

- All of these map representations are simplifications of reality
  - Easier to store
  - More intuitive (sometimes)
  - Faster to use computationally
- Simplified maps still derived from sensor data
- How do we get from rich sensor data to representations?

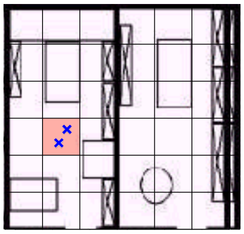
Decomposing Maps

- For both topo and discretized, we need a **map decomposition**
  - Break the map into areas we care about (cells)
- Important warning: In cell decompositions, → **every point in a cell is the same as every other** ←
- Why?



Decomposing Maps: Why?

- For navigation, we mostly care about "free" (traversable) space.
- Say I want to get to the door.
  - Who cares if I'm here or here?
  - Movement isn't infinitely precise.
- If that's not precise enough, we need a different **decomposition**.
- So let's look a a few choices…



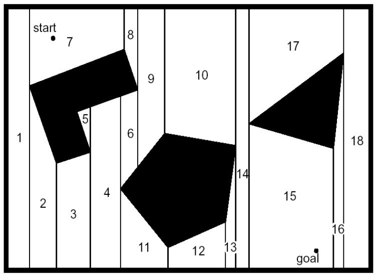
Exact Cell Decomposition

- Subdivide a map into blocks of free space
  - Find vertices of objects in area
  - Break up map so all vertices bound cells

Idea:

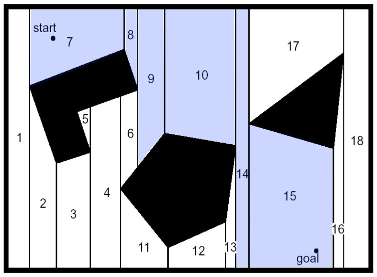
- It matters how a robot can traverse free cells
- Exact position doesn't matter

Exact Cell Decomposition



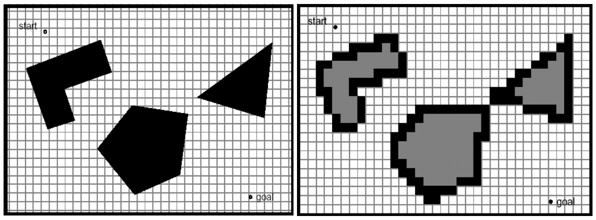
Navigation through Exact Cells

- Sequence: 7, 8, 9, 10, 14, 15



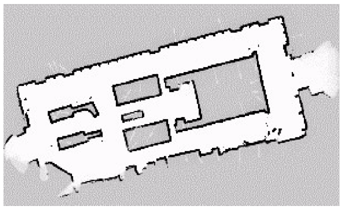
Fixed Cell Decomposition

- Use a fixed size grid overlaid on space
- Problem: Narrow passages disappear!



Tiny Fixed Cells

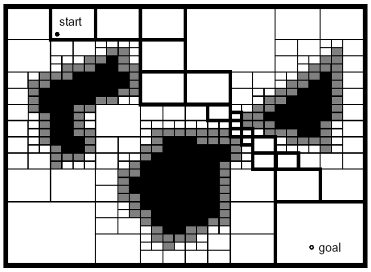
- Fixed cell decomposition – Example with very small cells
- Expensive
  - Reduces some of the efficiency of decomposed maps



Courtesy of S. Thrun

Adaptive Cell Decomposition

- Use the size cell you need to represent features



Topo Decomposition

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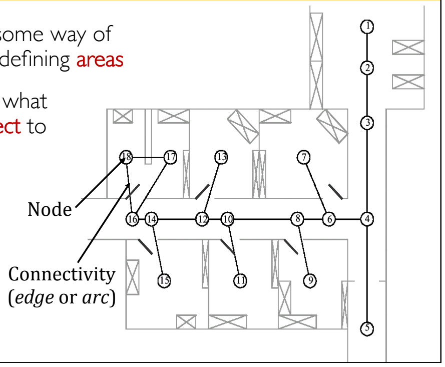
- Must have some way of identifying/ defining areas
- Must know what areas connect to create arcs
- Must know what node robot is in



Occupancy Grid

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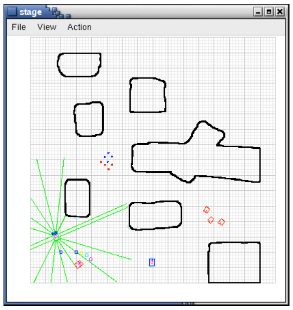
- Each grid cell is marked as occupied or unoccupied
- Robot is in known area in grid
- Generally created on the fly from range sensing data



Representation Review

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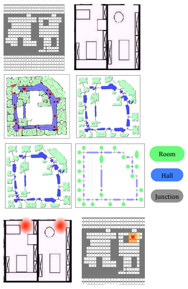
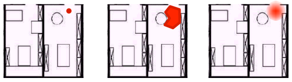
- Characterizing maps
  - Discrete vs. continuous
  - Geometric vs. topological
  - Semantically labeled vs. unlabeled
- Characterizing beliefs (location)
  - Discrete vs. continuous
  - Single vs. multiple hypothesis
  - Point, bounding box, probability function





Map Representation Review

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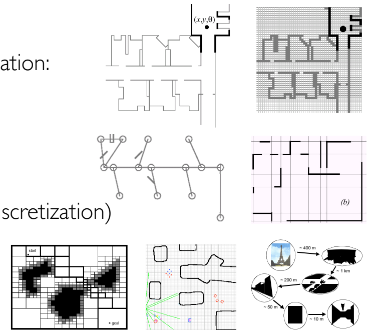
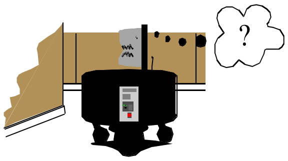
- Precision
- Types of representation:
  - Continuous line
  - Grid
  - Topological
  - Line extraction
- Decomposition (discretization)
  - Grid-based
  - Topological



Probability & Localization

where am I (most likely)?



Current Challenges

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- Real world is dynamic
  - People move, couches move, walls move…
- Perception is still a major challenge
  - Error prone, extraction of useful information can be difficult
- Traversal of open space is critical
- How to build up topology (boundaries of nodes)
- Sensor fusion
- So, represent map and belief state probabilistically

Probabilistic Map-Based Localization

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- Given: A mobile robot moving in known environment
  - Starts from a known location and tracks location using odometry
  - After a while robot is very uncertain of its position

➔ Update using an observation of the environment

- Observation gives:
  - An estimate of robot position…
  - Which can then be fused with odometric estimation…
  - To get best possible update of robot's actual position.

Probabilistic Localization (2)

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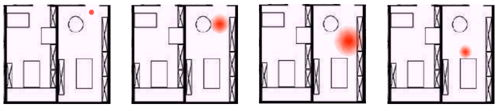
- Mobile robot moving in known environment
  1. Starts from known location
  2. Keeps track (maintains a belief) using odometry
  3. Over time, uncertainty about position grows

  ➔ Observe environment for new estimate

  4. Fuse estimate with odometric estimation to give…
  5. Best possible belief update

Prediction (action) update

Perception (measurement, correction) update



Map-Based Localization

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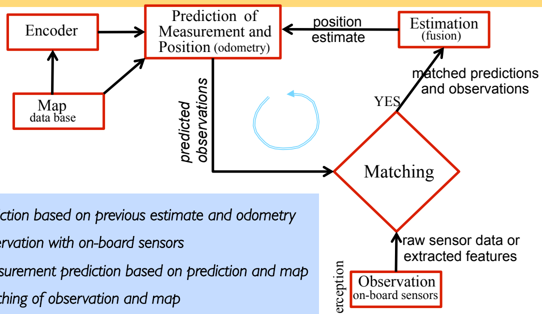
Encoder
Prediction of Measurement and Position (odometry)
position estimate
Estimation (fusion)
Map data base
predicted observations
matched predictions and observations
YES
Matching
raw sensor data or extracted features
Observation on-board sensors
Perception

1. Prediction based on previous estimate and odometry

2. Observation with on-board sensors

3. Measurement prediction based on prediction and map

4. Matching of observation and map

*5. Estimation * position update (posteriori position)*