Intelligent Robots Practice

Maps

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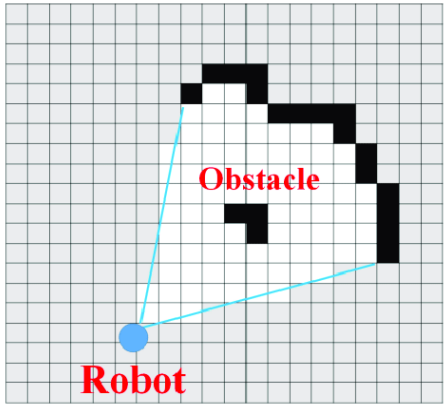
Introduction of maps

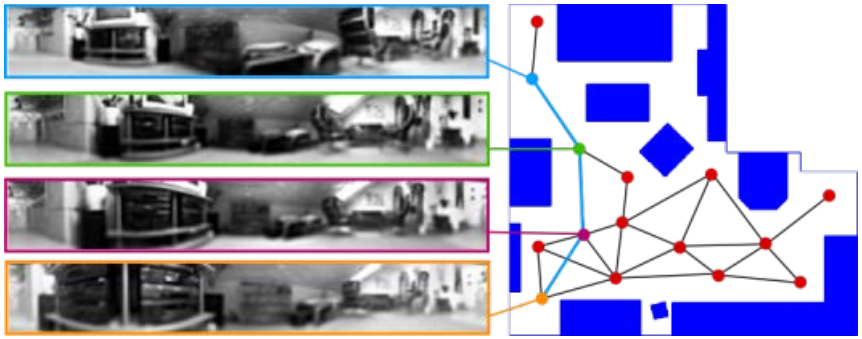
Introduction of maps

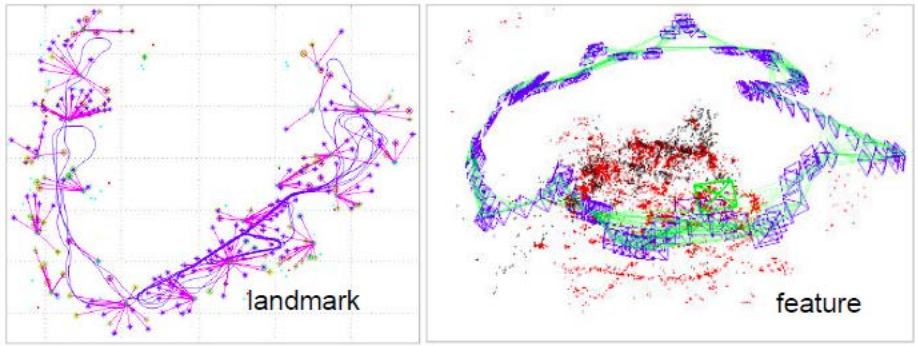
- Navigation problems
  - Where am I? → Localization
  - Where am I going? & How should I get there?→ Path planning, Obstacle avoidance
  - Final goal: to perform map building and localization simultaneously
    - → SLAM (Simultaneous Localization And Map building) or
  - Maps are used for environmental representation, localization, path planning.
  - Mapping and localization is a chicken-egg problem.

Introduction of maps

- Representation of Space
  - Types of maps
    - Grid maps: metric
    - Topological maps: non-metric
    - Feature maps: metric
      - The environment is modeled by a set of geometric primitives such as points, lines and arcs.







Grid based representation

Grid based representation

- Grid maps
  - Occupancy grid representation
    - Divides free space into a discrete 2D or 3D grid of cell
    - Each cell is assigned a single value between 0 and 1 to represent the probability that the cell is occupied, empty, and unknown.
      - (1: occupied, 0: empty, unknown: 0.5)
    - Bayesian probability model
      - The probability for each cell is updated as the new sensor data are available.

Grid based representation

- Grid maps
  - Uniform grids versus quadtree
    - Uniform grids
    - Decompose space into cells with uniform sizes.
    - Degree of occupancy at the sample grid: empty, full (or occupied), partially full
    - Advantages
      - Generality: no strong assumptions
    - Disadvantages
      - The resolution is limited by the cell size.
      - The representation is storage intensive even if much of the environment is empty or occupied.

Grid based representation

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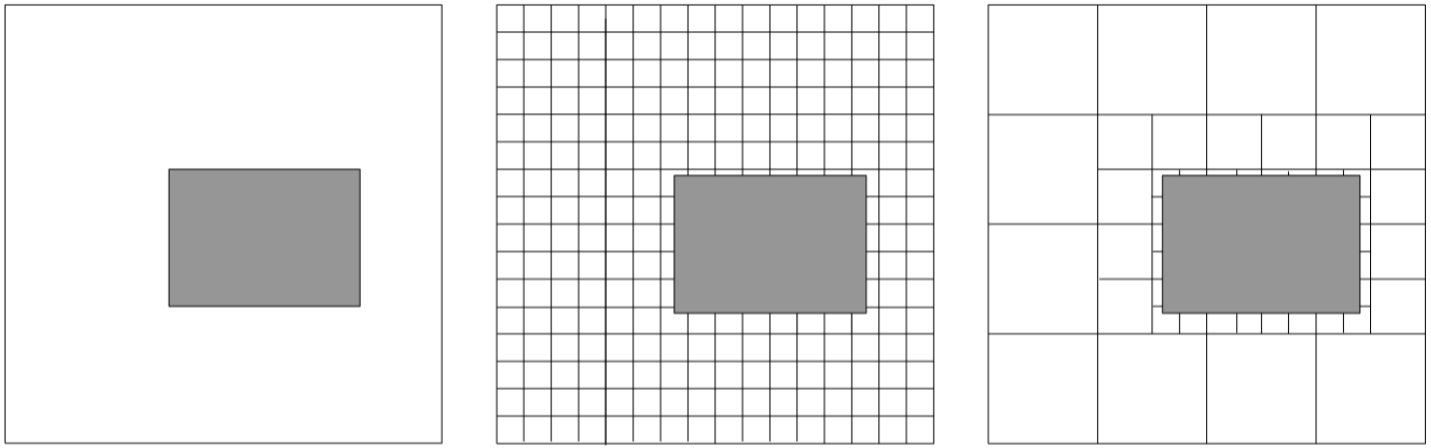
Grid based representation

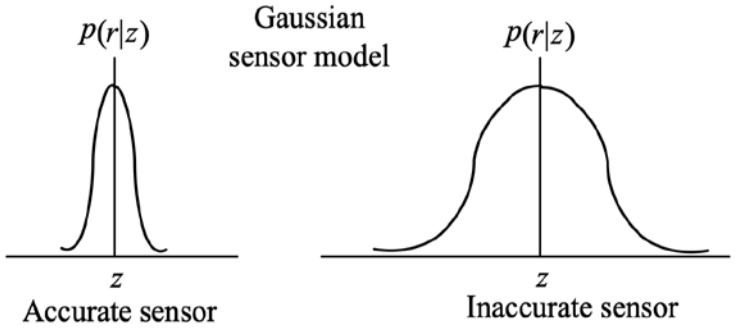
- Uniform grids versus quadtree
  - Quadtree
    - Cells that are not uniformly empty or full are subdivided into four equal subparts.
    - Subparts are subdivided in turn until either they are uniformly empty or full or the predetermined resolution limit is met.
    - Very suitable for the environments where most of space is free or occupied.



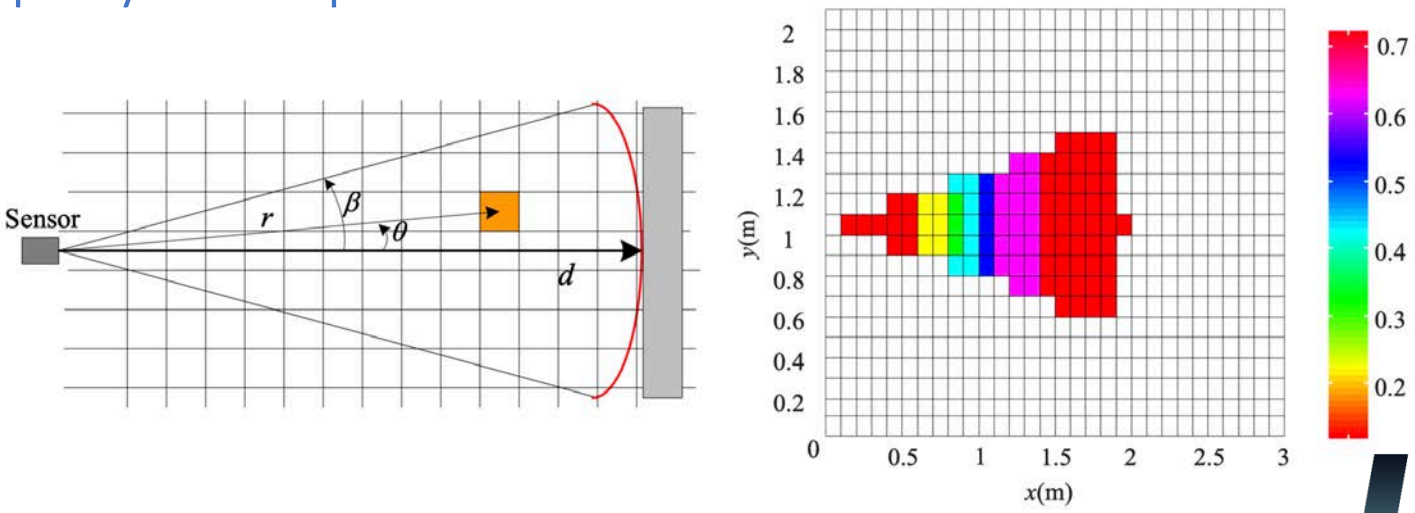
Sample environment Uniform grids Quadtree

Grid based representation

- Occupancy Grid Map using Sensor Model
  - Gaussian Sensor Model



  - Occupancy Grid Map



Grid based representation

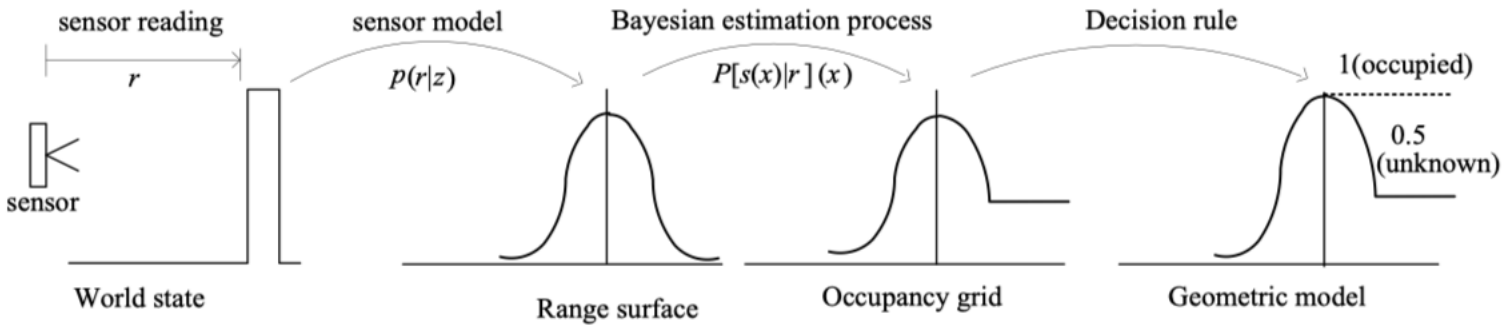
- Occupancy Grid Map using Sensor Model
  - Occupancy Grid Map
    - The occupancy probability is updated from the current occupancy probability of a cell and a new range data.
    - Bayesian update formula:

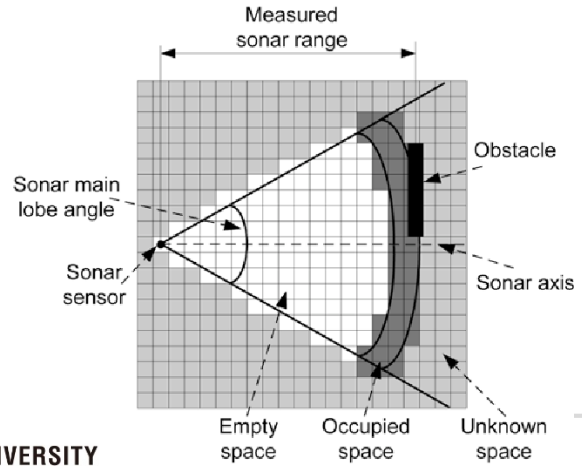
$$P[s(C_i) = OCC \mid \{r\}_{t+1}] = \frac{p[r_{t+1} \mid s(C_i) = OCC] \cdot P[s(C_i) = OCC \mid \{r\}_t]}{\sum_{s(C_i)} p[r_{t+1} \mid s(C_i)] \cdot P[s(C_i) \mid \{r\}_t]}$$

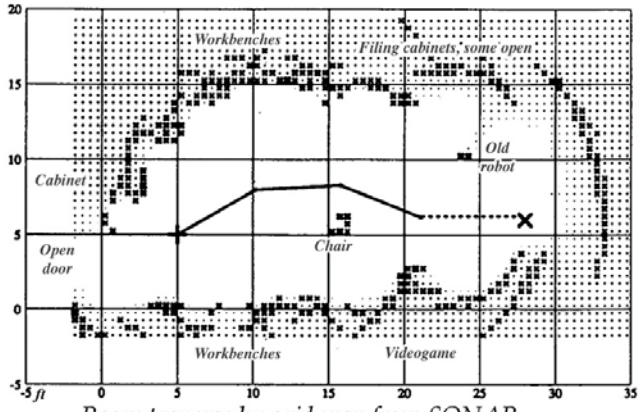
    - $\{r\}_t = \{r_1, r_2, \ldots, r_t\}$: range data up to time t
    - r_{t+1} : new range data
    - $s(C_i)$: state of cell C i

Grid based representation

- Occupancy Grid Map using Sensor Model
  - Occupancy Grid Map
    - Building of grid maps from sonar data
      - Estimation procedure of occupancy grid from sensor data







Room traverse by grid map from SONAR

Grid based representation

- Occupancy Grid Map
  - Advantages/disadvantages of grid maps
    - Advantages
      - Easy to build, represent, and maintain.
      - Recognition of places is non-ambiguous and view point independent.
      - Facilitates computation of the shortest paths.
    - Disadvantages
      - Planning is inefficient, space-consuming
        (resolution does not depend on complexity of the environment).
      - Requires accurate determination of the robot's position.
      - Poor interface for most symbolic problem solvers.
      - Requires a large amount of memory for the global grid map
        (This problem may not be serious for the local grid map.)

Topological Representation

Topological Representation

- Topological representation
  - An abstraction of the environment in terms of discrete places (i.e., nodes or vertices) with edges connecting them
  - Graph based representation: G = (N, E)
    - G: graph
    - N: a set of nodes (or vertices)
    - E: a set of edges (or arcs)
    - Nodes correspond to known landmarks and edges to the paths between them.
    - Non-metric representation
      - Exception: Edges may have length and orientation information.
    - Advantages
      - Compact (not storage intensive)