Robot Motion Planning

Classic Path Planning Algorithms

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Outline

- **Roadmap**
  Represent the connectivity of the free space by 1-D Curves
- **Cell Decomposition**
  Decompose the free space into simple cells and represent the connectivity of the free space by adjacency graph of these cells
- **Potential Field**
  Define a potential function over the free space that has a global minimum at the goal and follow the steepest descent of the potential function

Roadmaps

- construct a `map` once and then use that map to plan subsequent paths more quickly
- Topological maps aim at representing environments with graphlike structures
- **Roadmaps** are a type of topological map embedded in free space where each node corresponds to a specific location and an edge corresponds to a path between neighboring locations

find path from q_{start} to roadmap $\rightarrow$ traverse roadmap to vicinity of goal $\rightarrow$ find path from roadmap to the q_{goal}

Definition

A union of one-dimensional curves is a roadmap RM if for all q_{start} and q_{goal} in $\mathcal{Q}_{free}$ that can be connected by a path, the following properties hold:

1. **Accessibility**: there exists a path from $q_{start} \in \mathcal{Q}_{free}$ to some $q'_{start} \in RM$,
2. **Departability**: there exists a path from some $q'_{goal} \in RM$ to $q_{goal} \in \mathcal{Q}_{free}$, and
3. **Connectivity**: there exists a path in RM between q'_{start} and q'_{goal} .

Visibility Graph

Assume a polygonal configuration space with obstacles approximated as polygons, with the nodes v_i of the graph consisting of q_{start}, q_{goal} and all obstacle vertices

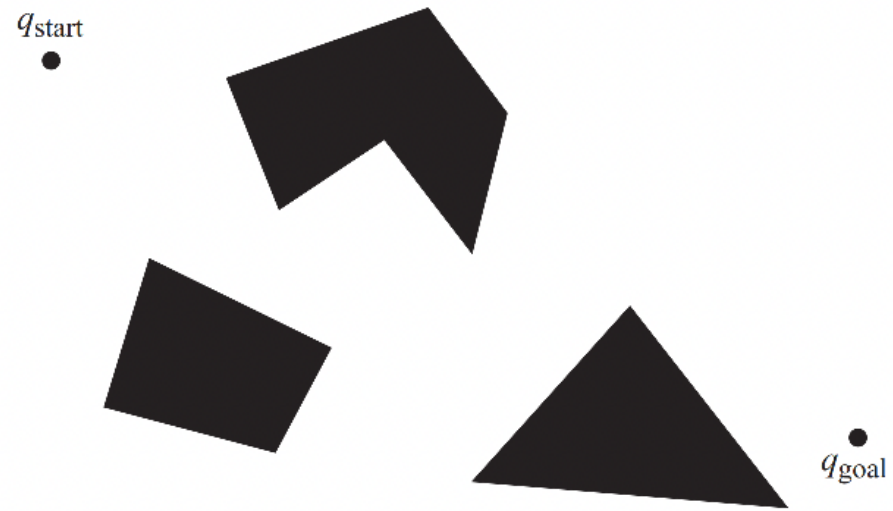

Figure: A polygonal config space with start and goal

Visibility Graph

The graph edges e_{ij} are straight-line segments that connect two line-of-sight nodes v_i and v_j

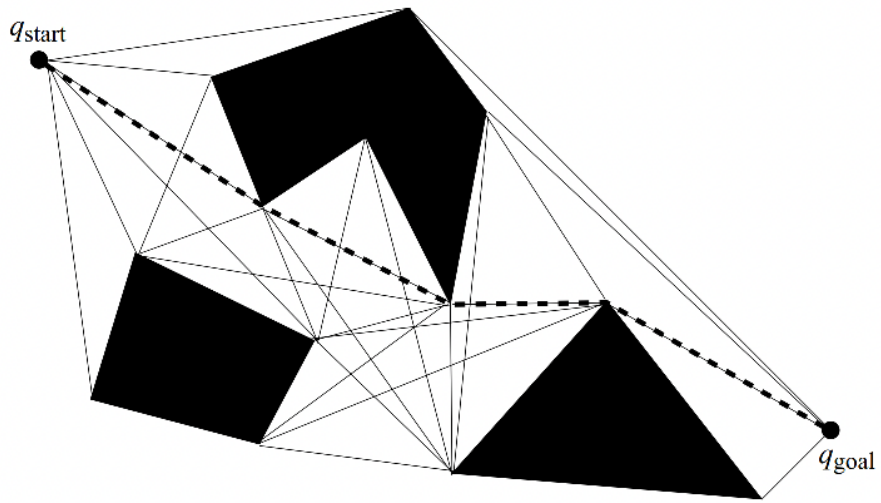

Figure: The Visibility graph

Reduced Visibility Graph

the visibility graph has many needless edges. The use of supporting and separating lines can reduce the number of edges.

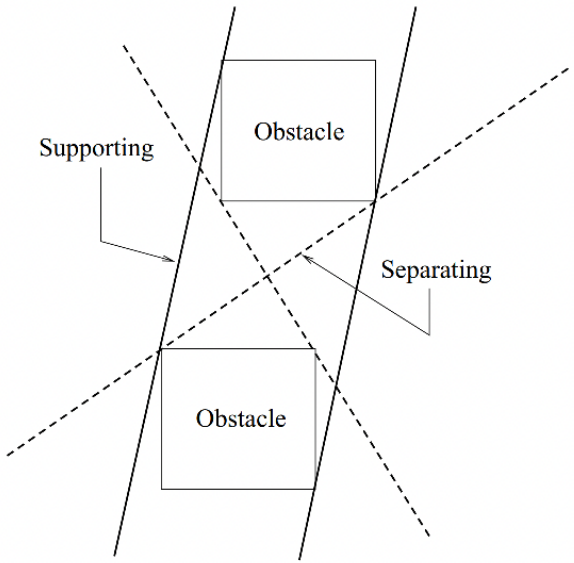

Figure: Supporting and Separating Line Segments

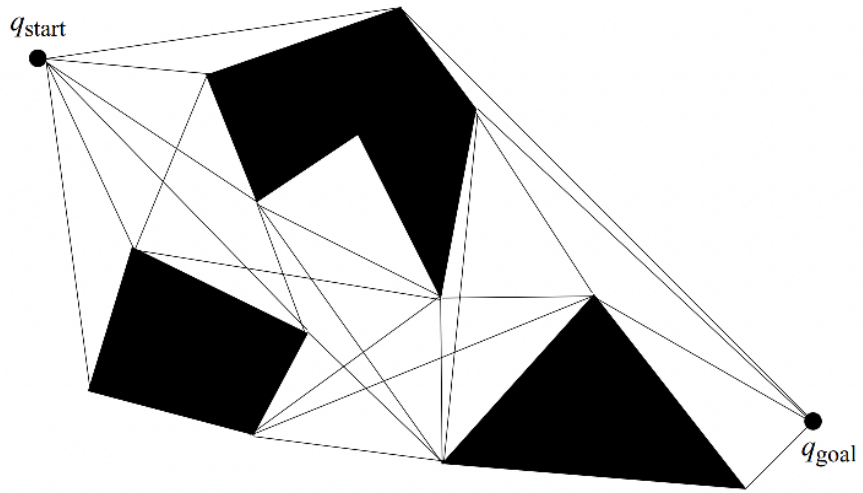

Figure: Reduced Visibility graph

Rotational Plane Sweep Algorithm

Generalized Voronoi Diagrams

The **Generalized Voronoi Diagram** (**GVD**) is the set of points where the distance to the two closest obstacles is the same.

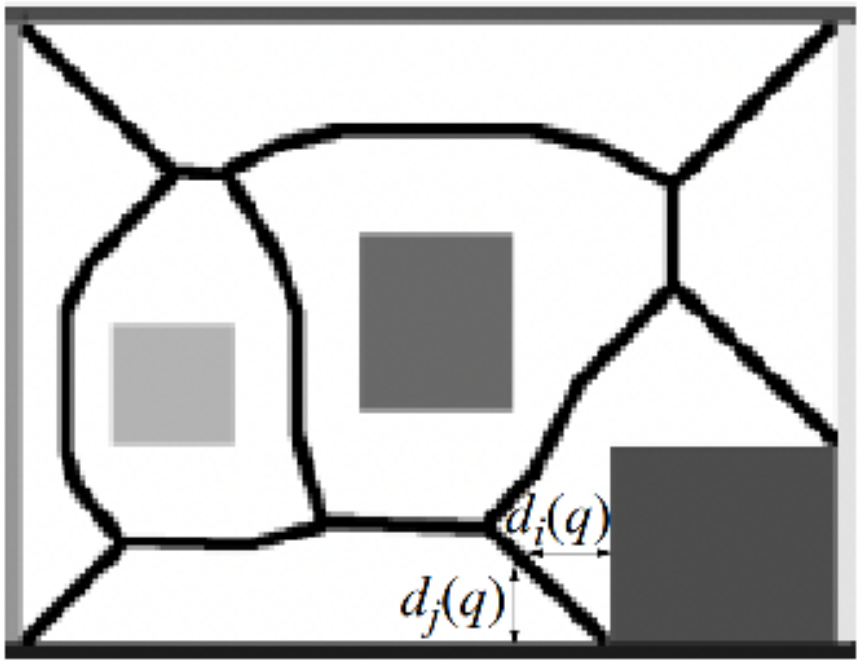

Figure: Voronoi Diagram

Construction of the GVD

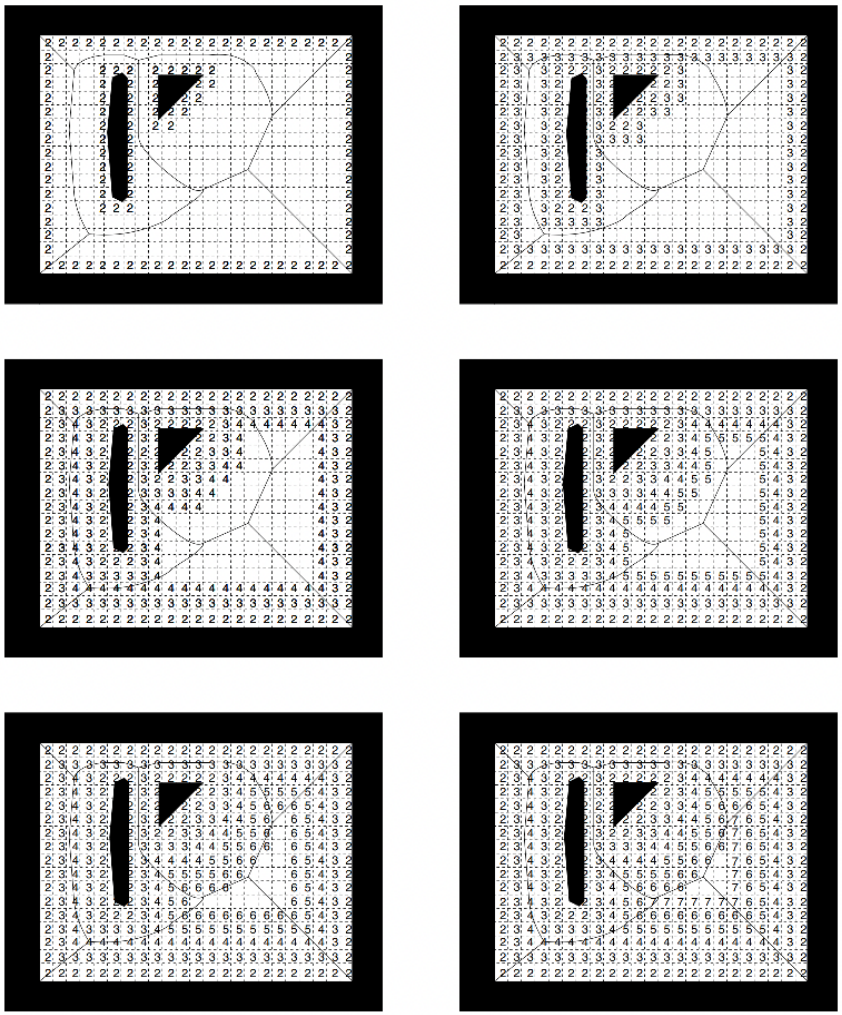

Figure: The **Brushfire algorithm** uses a grid to approximate distance