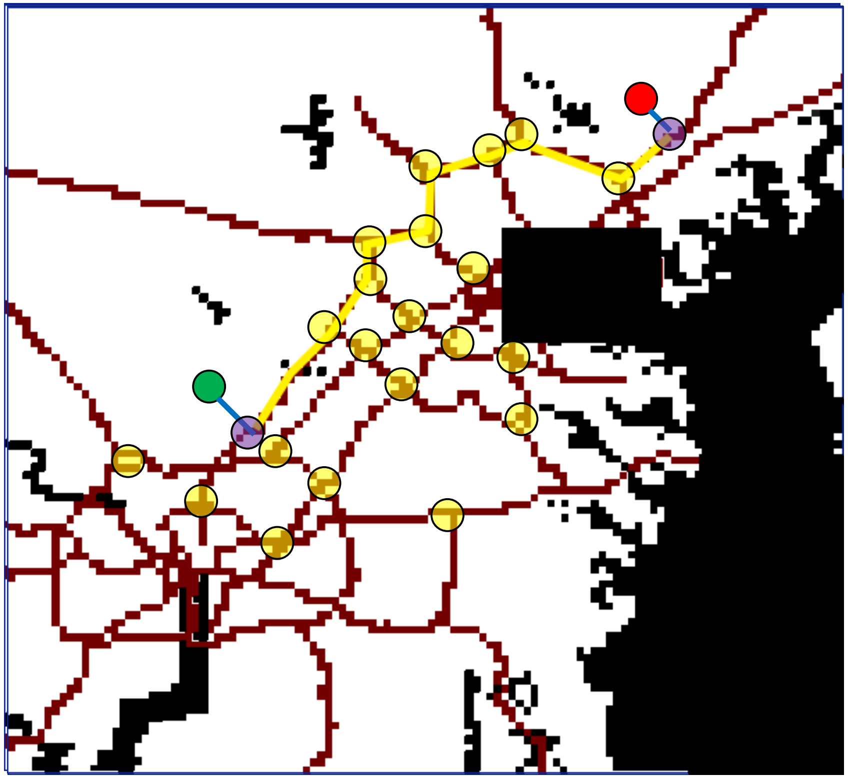
Road Map Methods

Including material from Howie Choset

The Basic Idea

- Capture the connectivity of Q_{free} by a graph or network of paths.



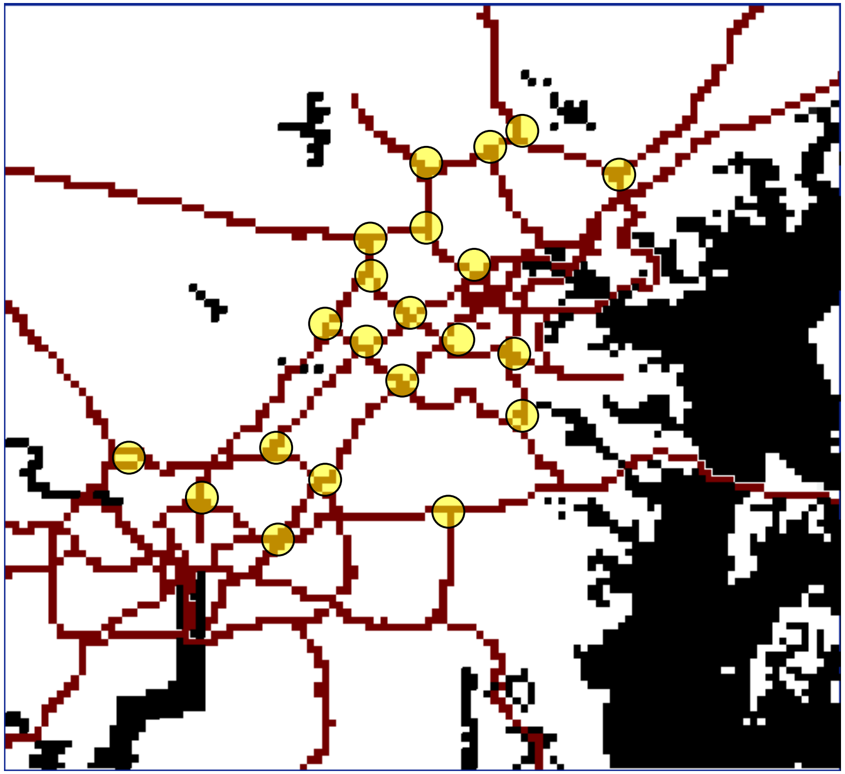
RoadMap Definition

- A roadmap, RM, is a set of ***trajectories*** (i.e. $f(t, \boldsymbol{q}_A, \boldsymbol{q}_B)$) such that for all $\boldsymbol{q}_{start} \in Q_{free}$ and $\boldsymbol{q}_{goal} \in Q_{free}$ can be connected by a path:

- The three ingredients of a roadmap
  - **Accessibility:** There is a path from $\boldsymbol{q}_{start} \in Q_{free}$ to some $\boldsymbol{q}' \in RM$
  - **Departability:** There is a path from some $\boldsymbol{q}'' \in RM$ to $q_{goal} \in Q_{free}$
  - **Connectivity:** there exists a path in RM between q' and q''

RoadMap Path Planning

1. Build the roadmap
   a) nodes are points in Q_{free} or its boundary
   b) two nodes are connected by an edge if there is a free path between them (i.e. $f(t, \boldsymbol{q}_A, \boldsymbol{q}_B)$)
2. Connect $\boldsymbol{q}_{\text{start}}$ and $\boldsymbol{q}_{\text{goal}}$ points to the road map at point q' and q'', respectively
3. Find a path on the roadmap between q' and q''. The result is a path in Q_{free} from start to goal

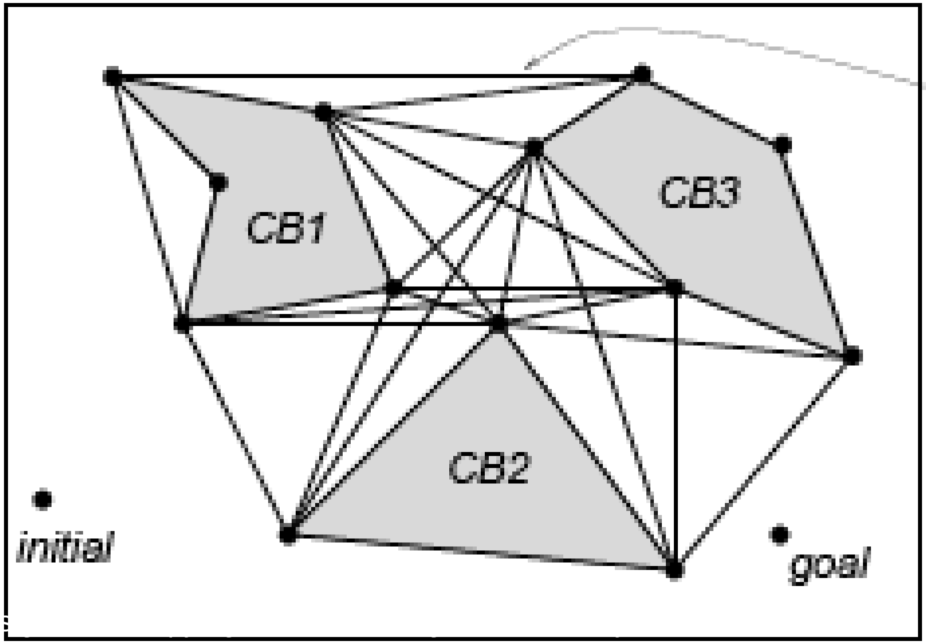


Overview

- Deterministic methods
  - ✓ Some need to represent Q_{free}, and some don't.
  - ✓ are complete
  - ✓ are complexity-limited to simple (e.g. low-dimensional) problems
    - example: Canny's Silhouette method (5.5)
      - – applies to general problems
      - – is singly exponential in dimension of the problem

Visibility Graph methods

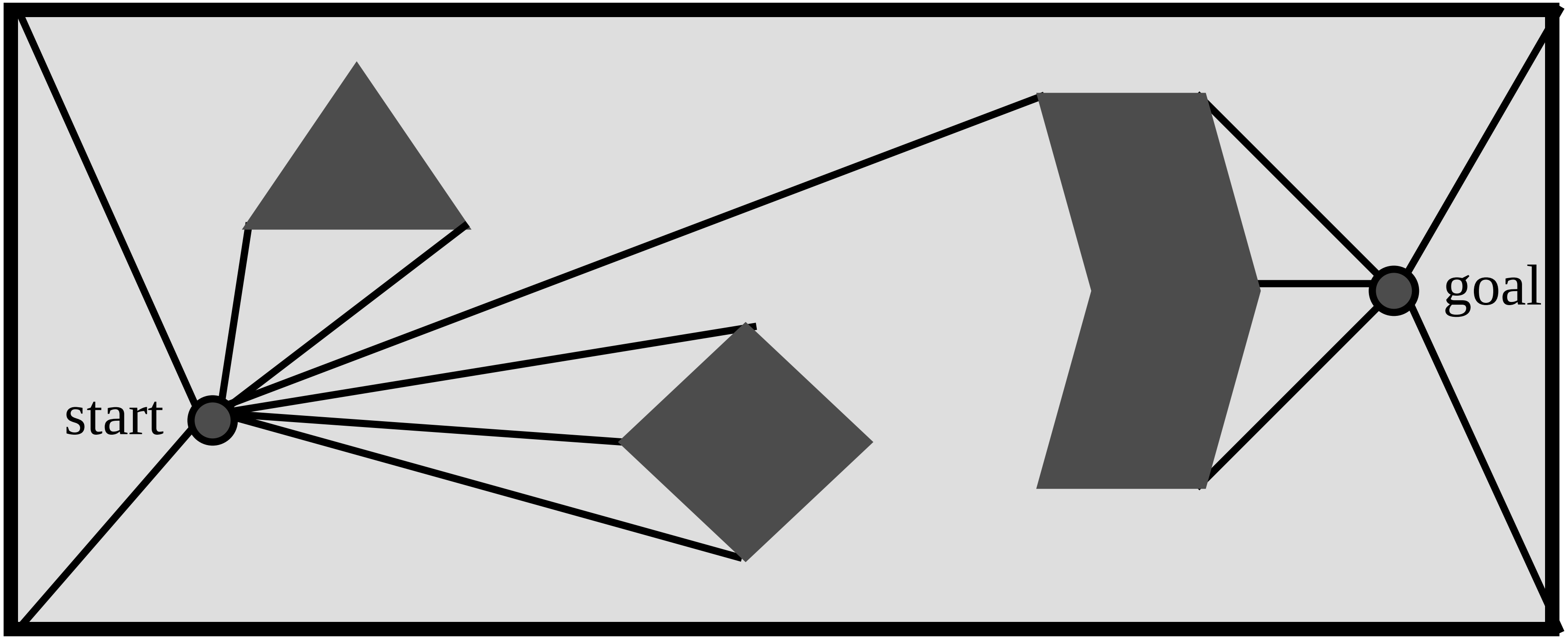
- Defined for polygonal obstacles
- Nodes correspond to vertices of obstacles
- Nodes are connected if
  - they are already connected by an edge on an obstacle
  - the line segment joining them is in free space
- Not only is there a path on this roadmap, but it is the *shortest* path
- If we include the start and goal nodes, they are automatically connected
- Algorithms for constructing them can be efficient
  - $O(n^3)$ brute force



Visibility Graph in Action

1. Draw lines of sight from the start and goal to all “visible” vertices and corners of the world.

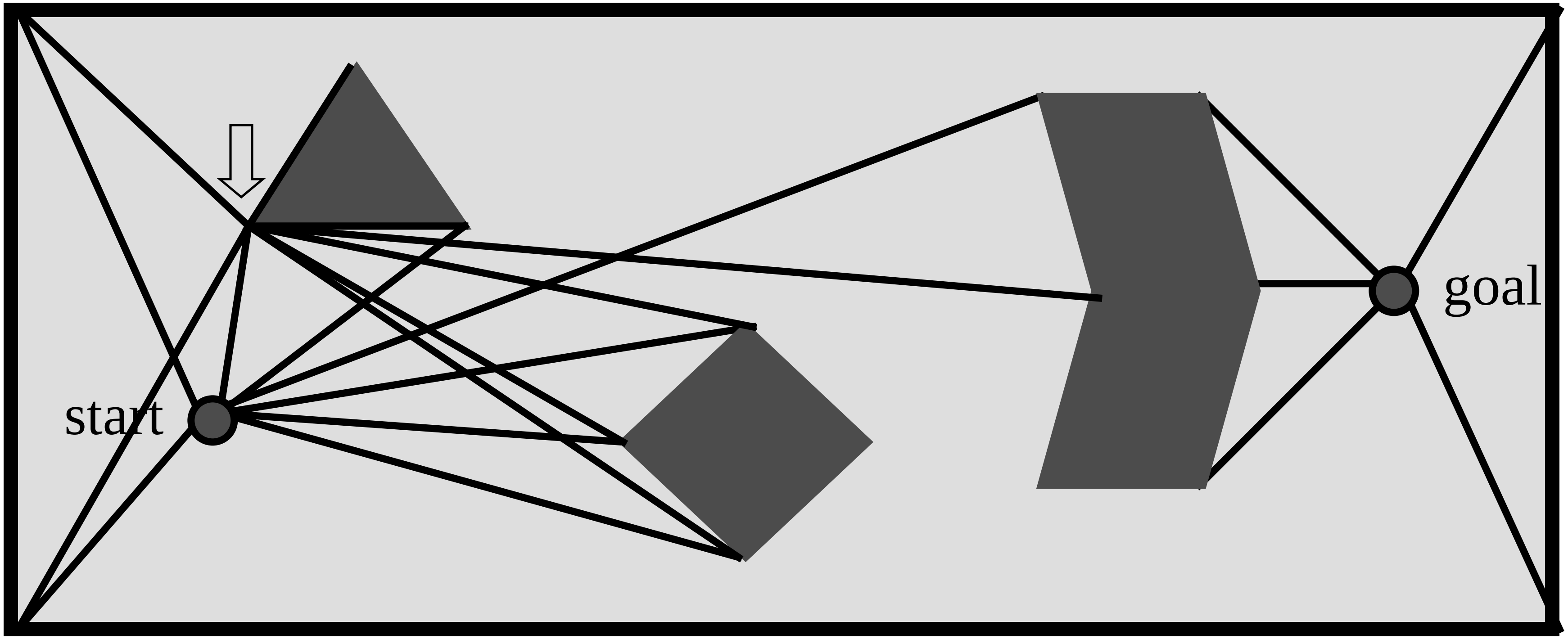
$$e_{ij} \neq \emptyset \iff sv_i + (1-s)v_j \in \mathrm{cl}(Q_{\mathrm{free}}) \quad \forall s \in (0,1)$$



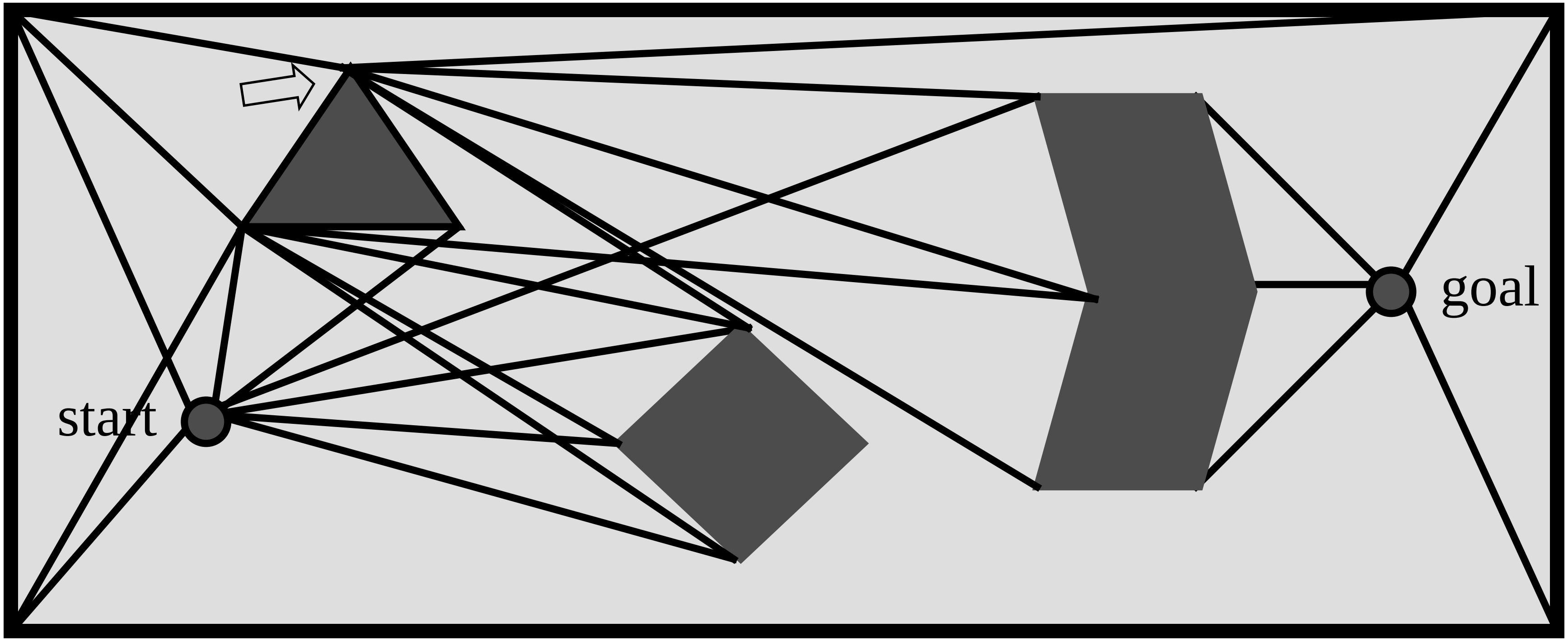
Visibility Graph in Action

2. Second, draw lines of sight from every vertex of every obstacle like before. Remember lines along edges are also lines of sight.

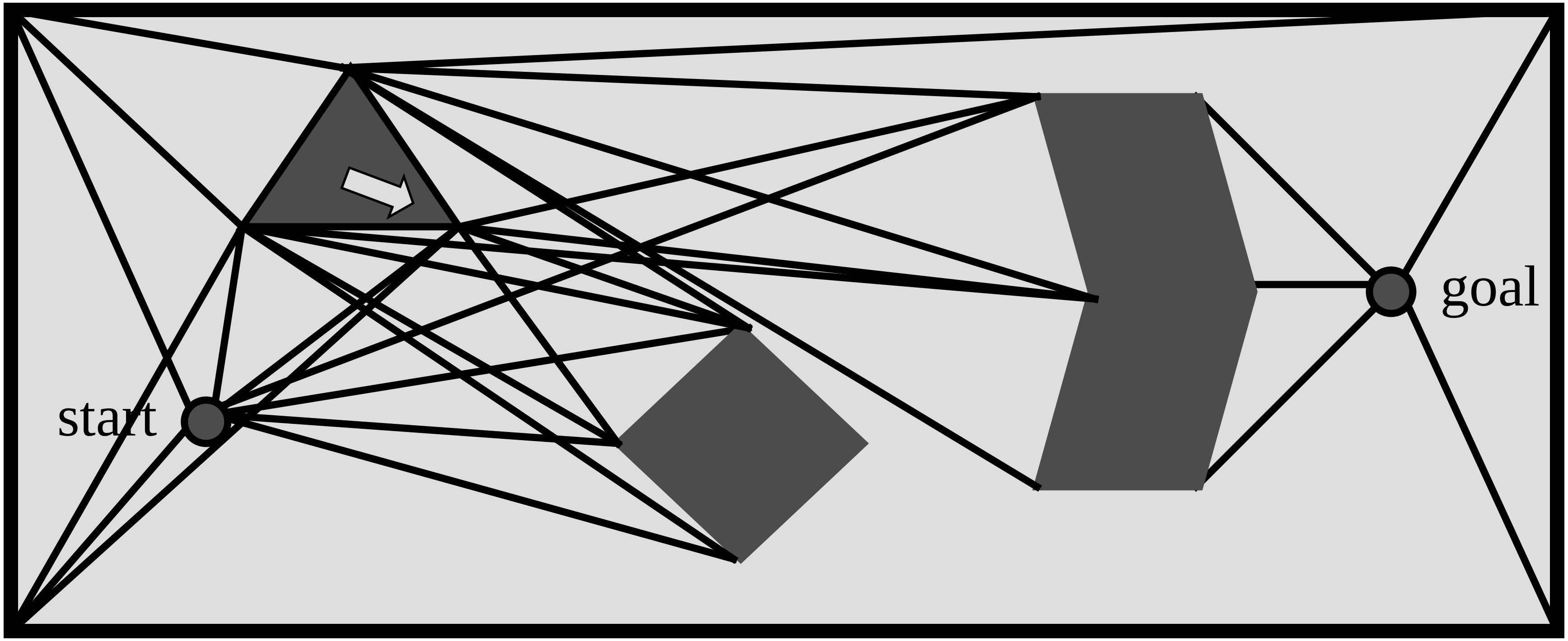
$$e_{ij} \neq \emptyset \iff sv_i + (1-s)v_j \in \mathrm{cl}(Q_{\mathrm{free}}) \quad \forall s \in (0,1)$$



Visibility Graph in Action



The Visibility Graph in Action (Part 4)



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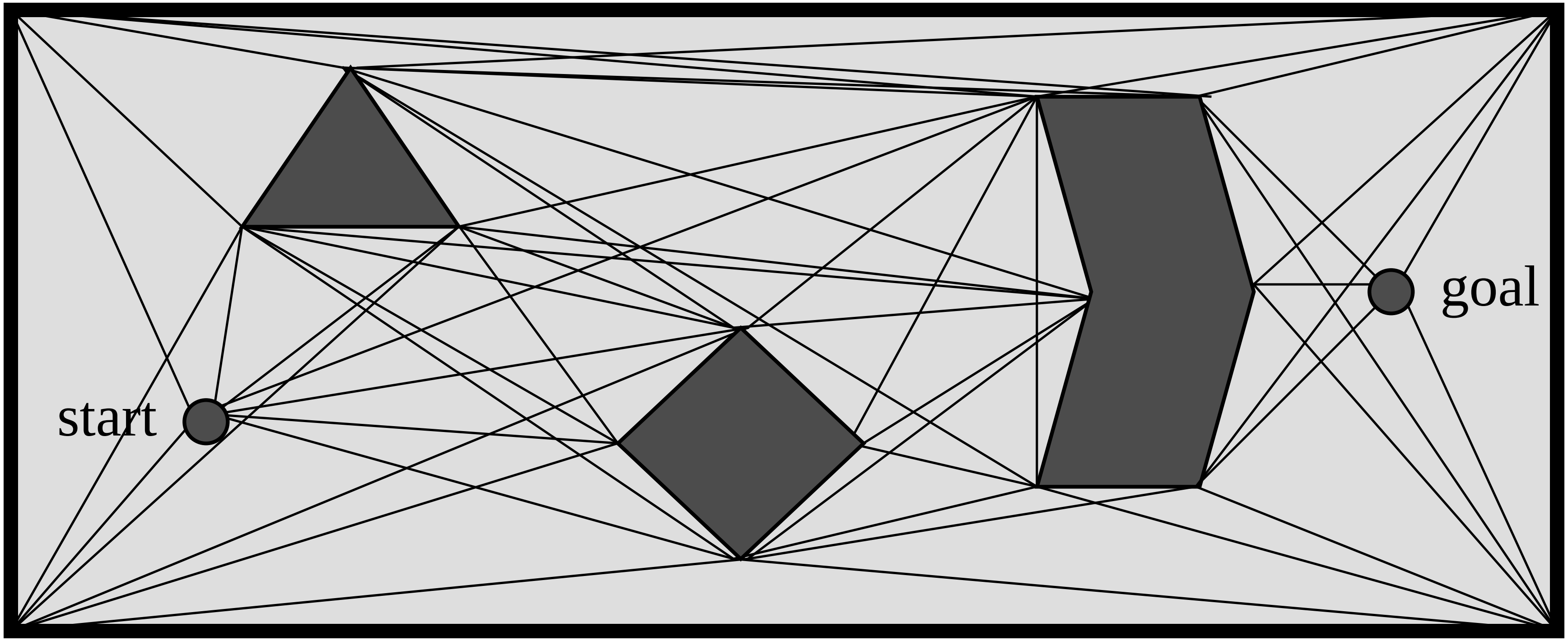
Visibility Graph in Action

- Repeat until you're done.



Visibility Graphs

- Find a path in the graph.
  - Bread first, depth first, Dijkstra's, etc.