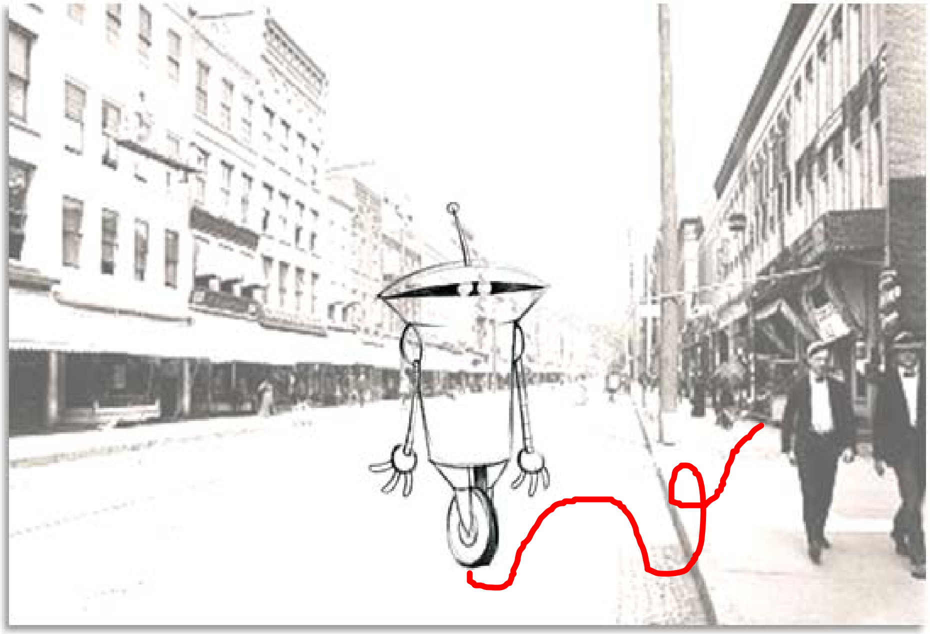
Lecture 16: Motion planning (Navigation functions and roadmaps)



Topics:

- Navigation functions - example
- Cell decomposition
- Roadmaps

Reading:

- Choset: 4.6,5,6
- LaValle: 6
- E. Rimon, D. Koditschek *Exact Robot Navigation Using Artificial Potential Functions,* IEEE Transactions on Robotics and Automation, Vol 8, No 5, Oct 1992

Motion planning

Given: q_{goal}

ability to track $q_{1:t}$

sometimes: map, q_0

Find: $u_{1:t}$ s.t. $q_t = q_{goal}$

Assuming:
in this class

static map

holonomic

$\dot{q} = v$

2D

Navigation Functions

$$\varphi_{sphere} = \frac{d(q, q_{goal})^2}{\left[d(q, q_{goal})^{2k} + \lambda \beta(q)\right]^{1/k}}$$

λ, k

Star to sphere transformation:

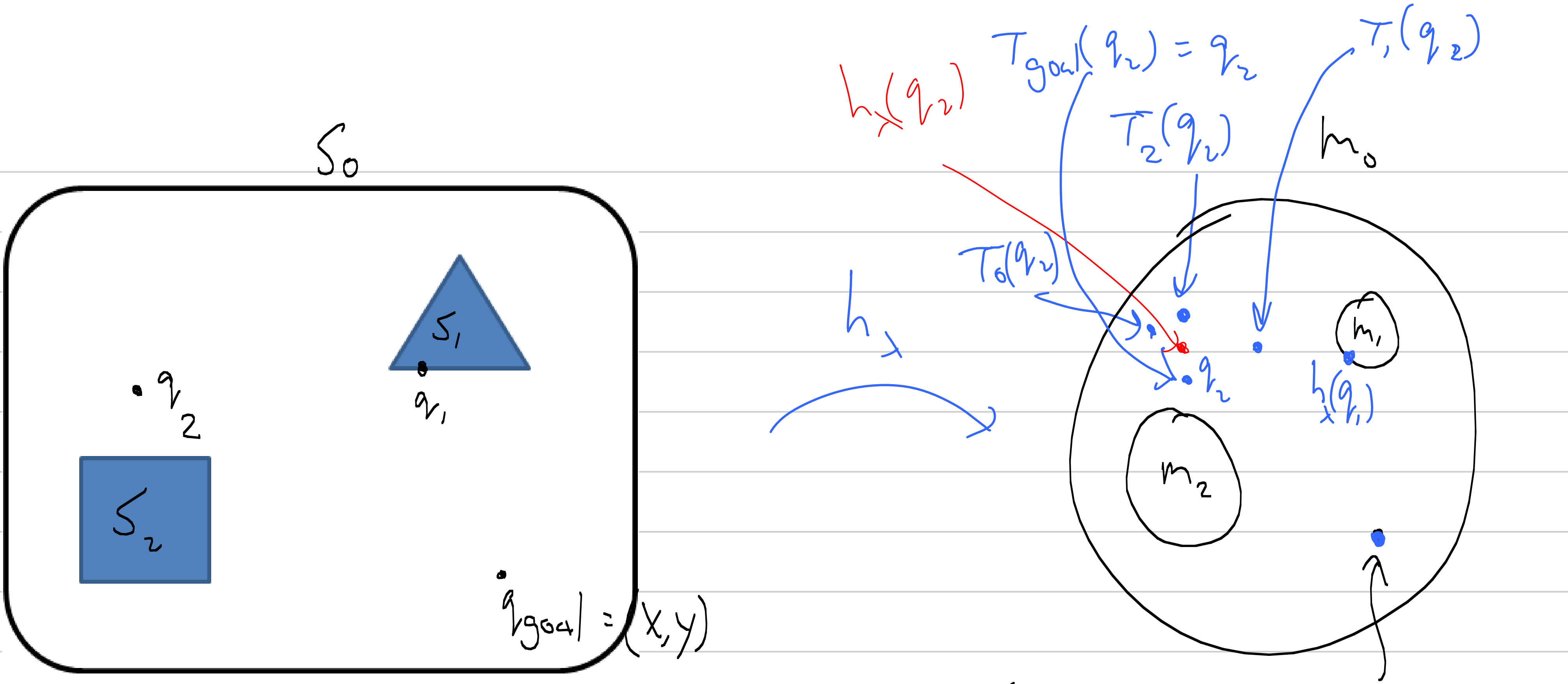
$$h_\lambda(q) = s_{goal}(q, \lambda) \cdot T_{goal}(q) + \sum_{i=0}^{m} s_i(q, \lambda) \cdot T_i(q)$$

where

$$s_i(q, \lambda) = \frac{\gamma_k(q) \cdot \bar{\beta}_i(q)}{\gamma_k(q) \bar{\beta}_i(q) + \lambda \beta_i(q)}$$

$$T_i(q) = (1 + \beta_i(q))^{1/2} \cdot \frac{\rho_i}{d(q, q_i)} (q - q_i) + p_i$$

$$s_{goal}(q, \lambda) = 1 - \sum_{i=0}^{m} s_i(q, \lambda) \qquad T_{goal}(q) = q$$

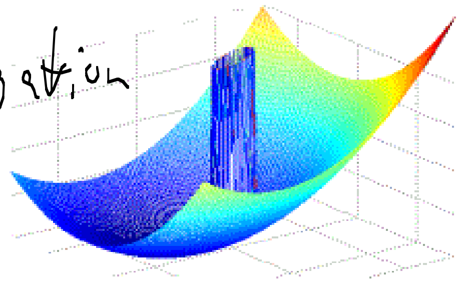


$$\varphi_{star}(q_{goal}) = 0 \text{ ``by definition''} = \varphi_{sphere}(h_\lambda(q_{goal})) = h_\lambda(q_{goal}) = (x,y)$$

$$\varphi_{sphere}(q_{goal})$$

$$\varphi_{star}(q_1) = \varphi_{sphere}(h_\lambda(q_1)) = \varphi_{sphere}(T_1(q_1)) = 1$$

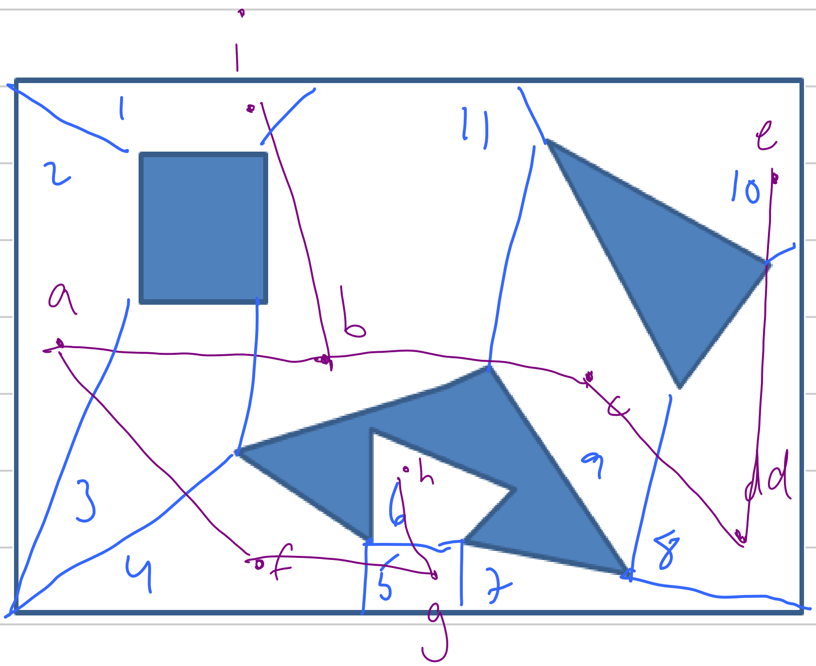
$$\varphi_{star}(q_2) = \varphi_{sphere}(h_\lambda(q_2))$$

Localization		Motion Planning
Dead Reckoning	"Missing info"	
grid	"Discrete"	Cell decomposition, Roadmaps.
KF / EKF	"Continuous"	potential / navigation functions 
PF	"Samples"	

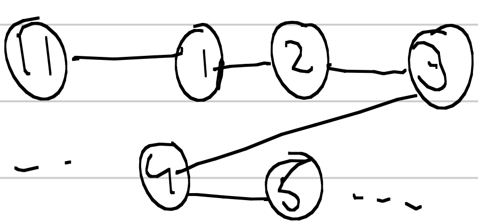
Discrete abstraction: Create graph G, search over graph

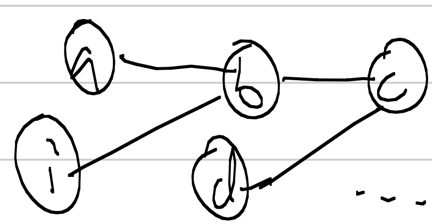
graph $G = (V, E)$ $\quad$ V are nodes, E edges

$e_{ij} = (v_i, v_j) \in E$



	Cell decomposition	Roadmap
V	Cells	Point in Q_{free}
E	Adjacency	paths in Q_{free} between nodes in V





Cell decomposition

triangulation, etc...

- Trapezoidal Decomposition

Idea: Grow vertical lines at each vertex until you hit an obstacle