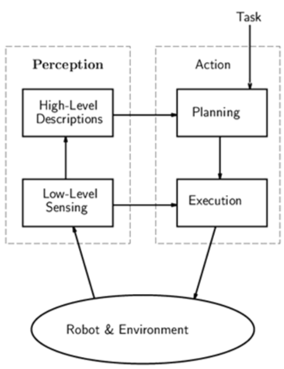
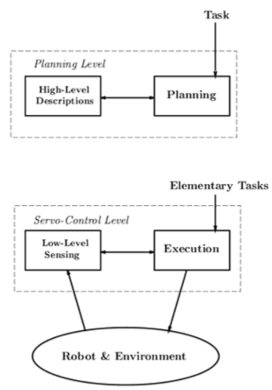
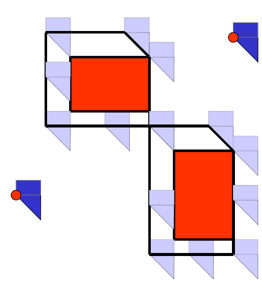
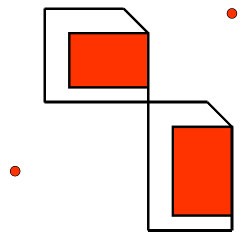
Collision Avoidance



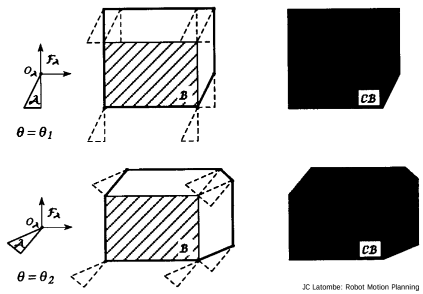


Configuration Space

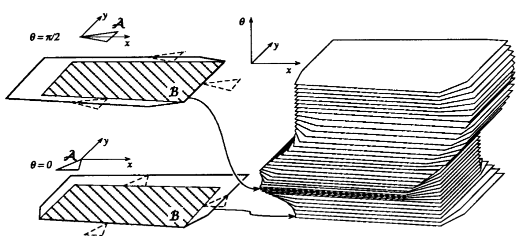




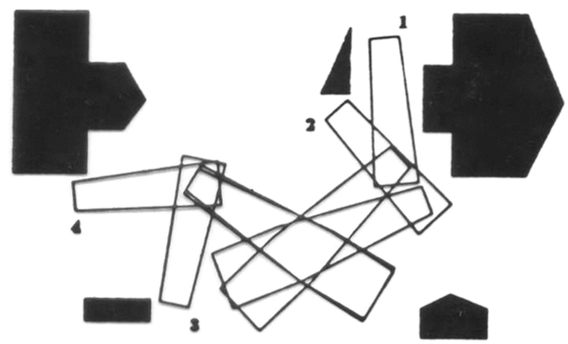
Convex Polygonal Mobile Robot (3 DOF)

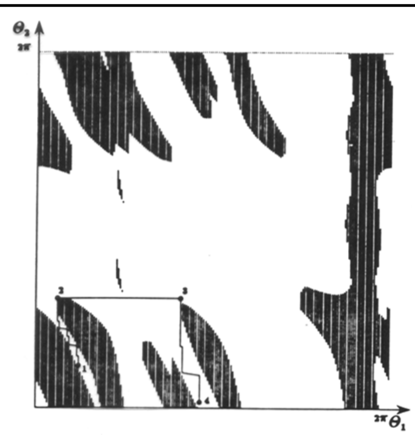


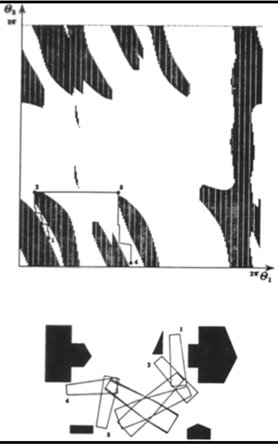
JC Latombe: Robot Motion Planning



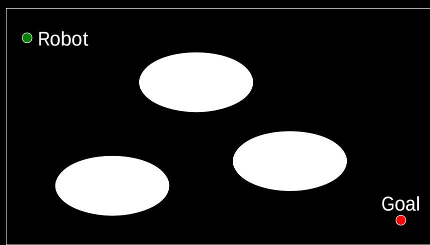
JC Latombe: Robot Motion Planning







Motion Planning for a Point Robot



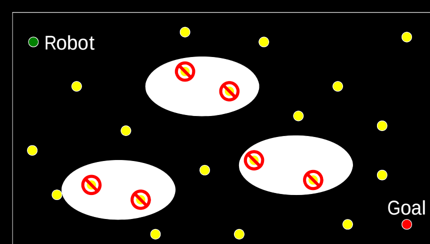
Motion Planning for *n* DOF

- Exact methods only of theoretical value
- More practical: discretize c-space to compute c-obstacles
- Problem: computational complexity grows exponentially in n

Randomized Roadmap

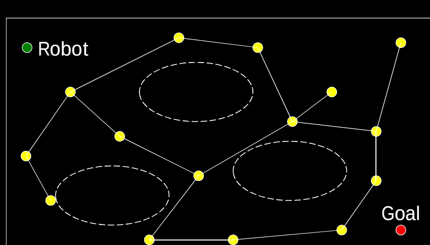
- Observation: most costly operation is computation of c-space obstacles
- Idea: don't compute them!
- (That doesn't quite work, of course. So we'll compute them <u>implicitly</u>, rather than explicitly.)

Randomized Roadmap



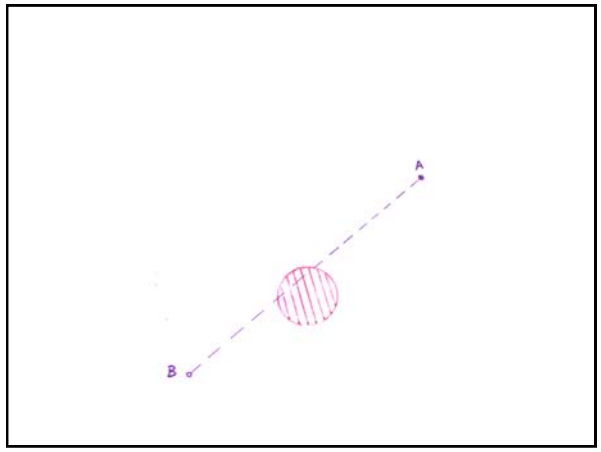
Remember: Now we are in *n*-dimensional space!

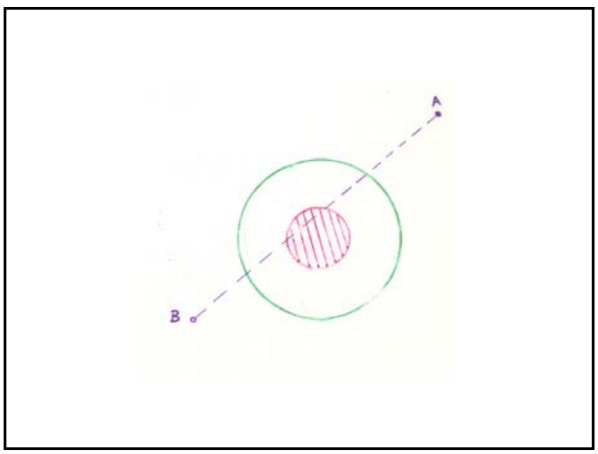
Randomized Roadmap

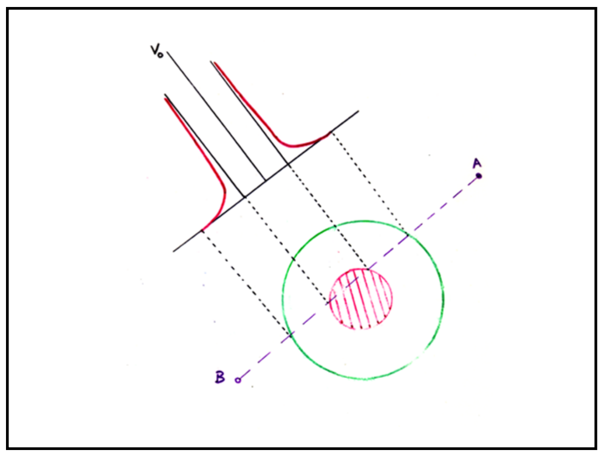


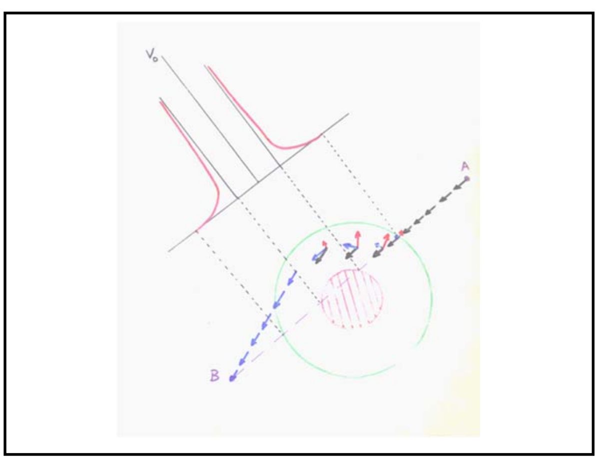
We implicitly computed an approximation of c-obstacles by randomly sampling the configuration space. A simple planner connects randomly chosen, collision-free configurations.

Artificial Potential Field





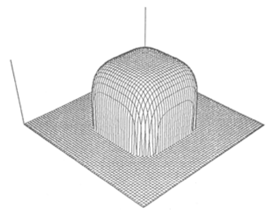




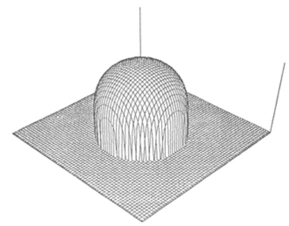
Repulsive Potential Field

$$U_{\mathcal{O}}(\mathbf{x}) = \begin{cases} \frac{1}{2}\eta(\frac{1}{f(\mathbf{x})} - \frac{1}{f(\mathbf{x}_0)})^2 & \text{if } f(\mathbf{x}) \leq f(\mathbf{x}_0); \\ 0 & \text{if } f(\mathbf{x}) > f(\mathbf{x}_0). \end{cases}$$

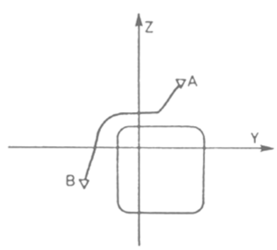
$$U_{\mathcal{O}}(\mathbf{x}) = \begin{cases} \frac{1}{2}\eta(\frac{1}{\rho} - \frac{1}{\rho_0})^2 & \text{if } \rho \leq \rho_0 \text{ ;} \\ 0 & \text{if} \rho > \rho_0. \end{cases}$$

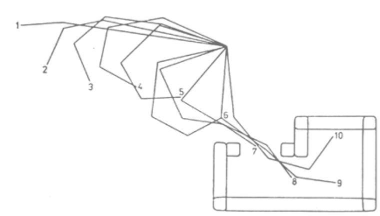


$$\left(\frac{x}{a}\right)^{2n}+\left(\frac{y}{b}\right)^{2n}+\left(\frac{z}{c}\right)^{2n}=1$$



$$\left(\frac{x}{a}\right)^{2}+\left(\frac{y}{b}\right)^{2}+\left(\frac{z}{c}\right)^{2n}=1$$



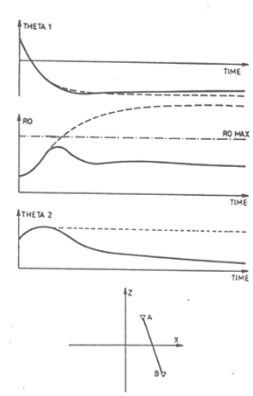


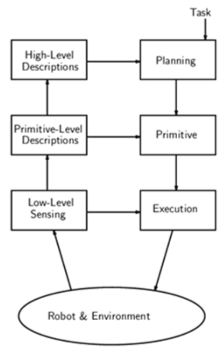
Joint Limits Avoidance

$$\gamma_{\underline{q}_i}=\begin{cases}\eta\left(\frac{1}{\underline{\rho}_i}-\frac{1}{\underline{\rho}_{i(0)}}\right)\frac{1}{\underline{\rho}_i^2} & \text{if } \underline{\rho}_i\le\underline{\rho}_{i(0)};\\ 0 & \text{if } \underline{\rho}_i>\underline{\rho}_{i(0)};\end{cases}$$

$$\gamma_{\overline{q}_i}=\begin{cases}-\eta\left(\frac{1}{\overline{\rho}_i}-\frac{1}{\overline{\rho}_{i(0)}}\right)\frac{1}{\overline{\rho}_i^2} & \text{if } \overline{\rho}_i\le\overline{\rho}_{i(0)};\\ 0 & \text{if } \overline{\rho}_i>\overline{\rho}_{i(0)};\end{cases}$$

$$\begin{aligned}\underline{\rho}_i &= q_i-\underline{q}_i;\\ \overline{\rho}_i &= \overline{q}_i-q_i.\end{aligned}$$

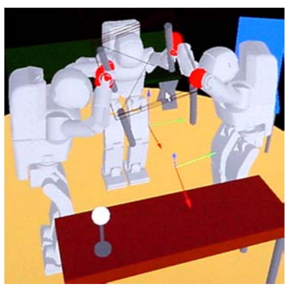




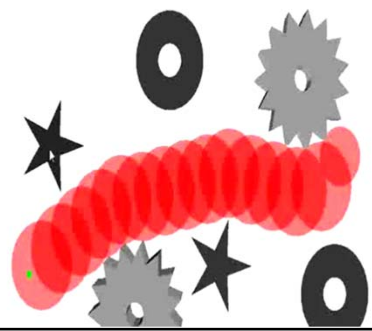
Elastic Planning

Real-time collision-free path modification

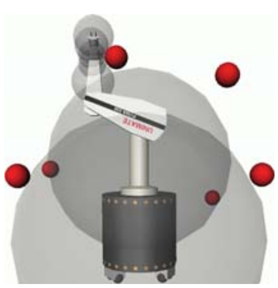
Connecting
Reactive Local Avoidance
with
Global Motion Planning



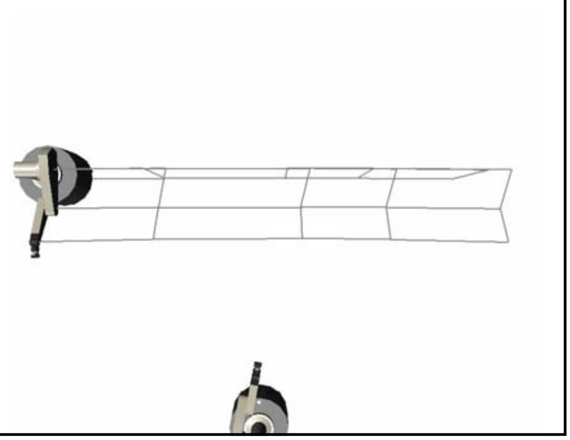
Elastic Band

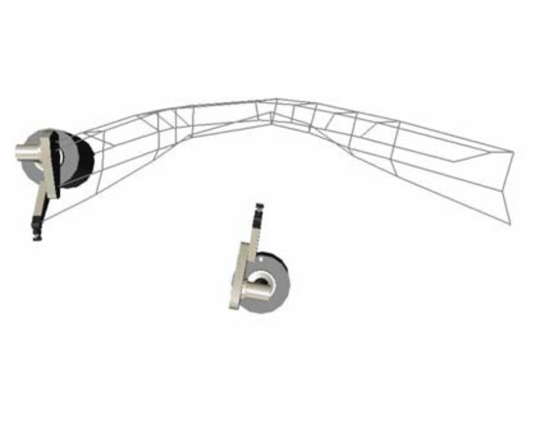


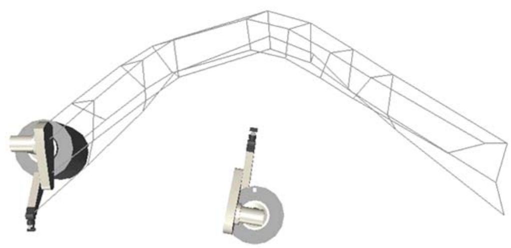
Free-Space Representation



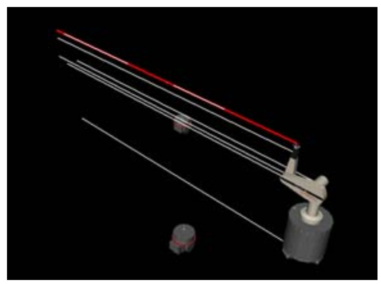
Free-Space Tunnel



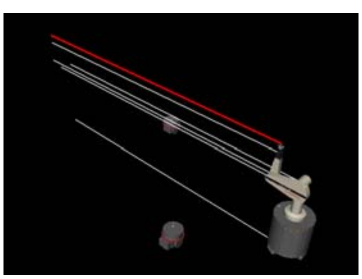




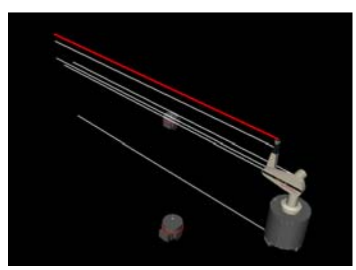
Elastic Strip



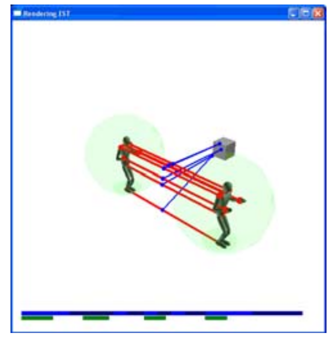
Task Consistent



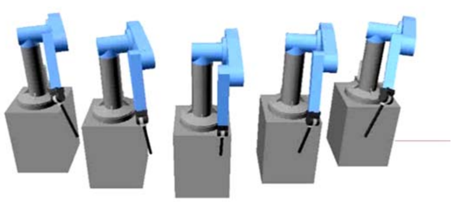
Suspending and Resuming



Computationally Efficient

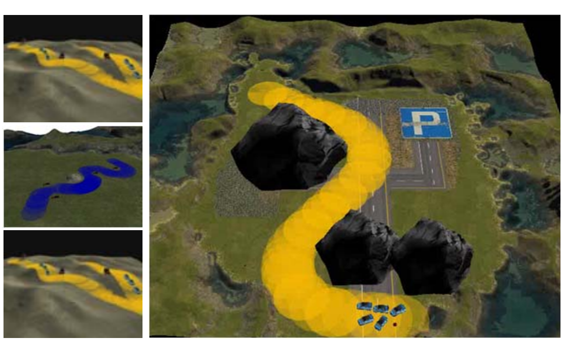


Elastic Strip
for a Mobile-Manipulator Robot



Elastic Planning

Global Path Modification



Real-Time Motion Modification