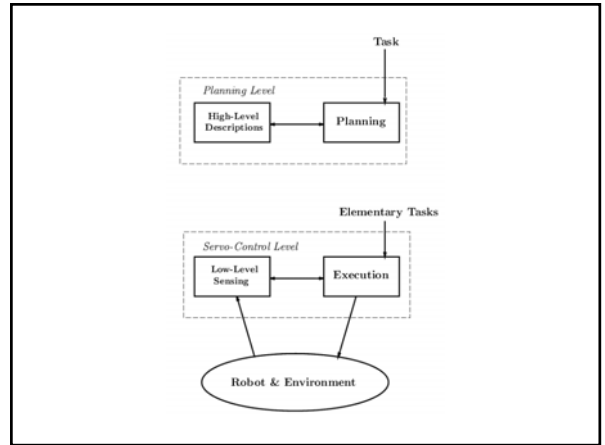
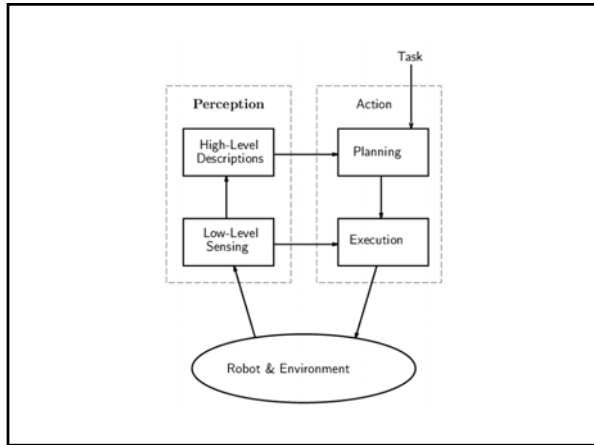
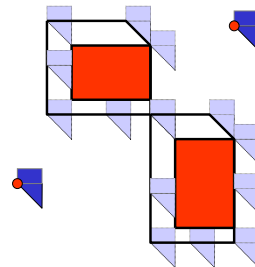


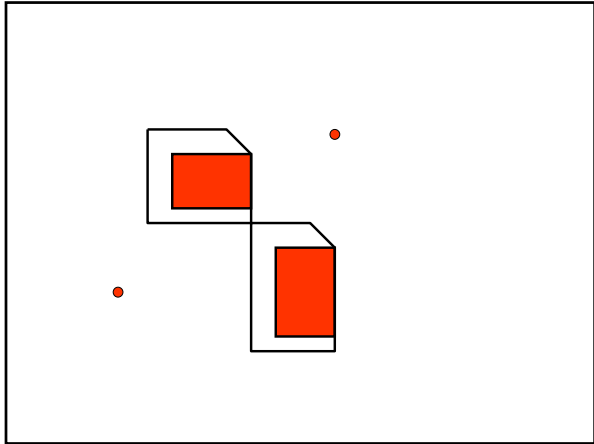
Collision Avoidance

Video



Configuration Space



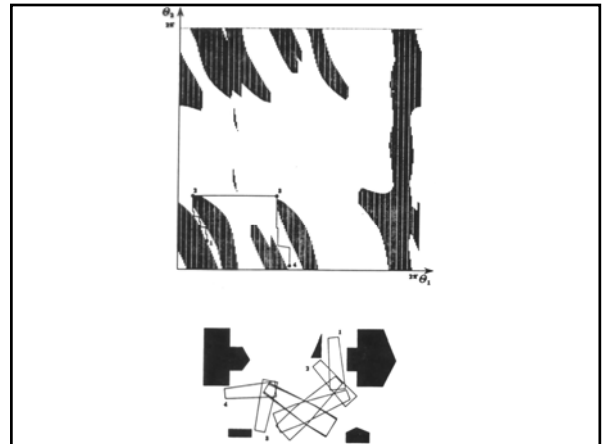
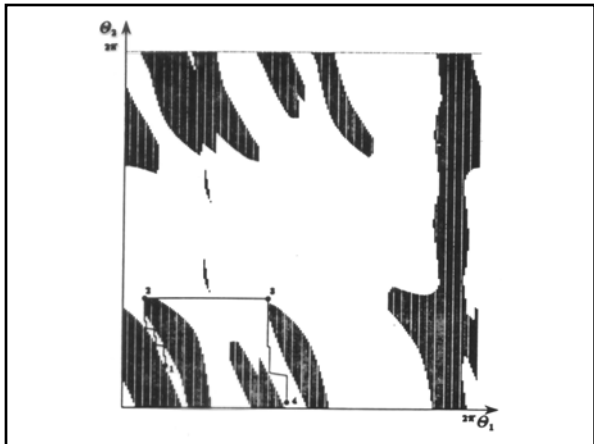
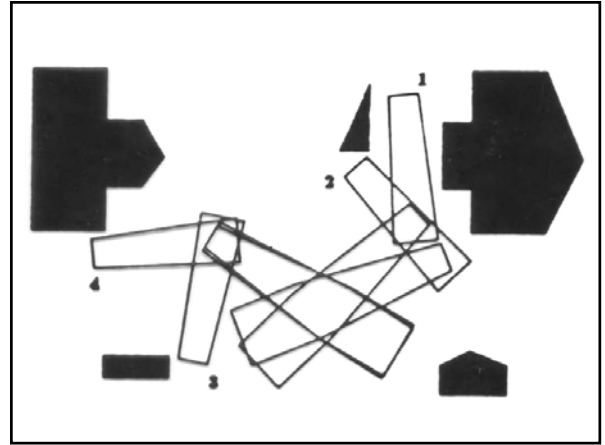
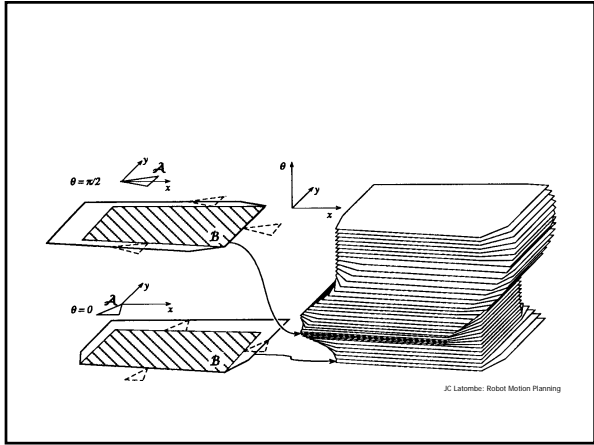


Convex Polygonal Mobile Robot (3 DOF)

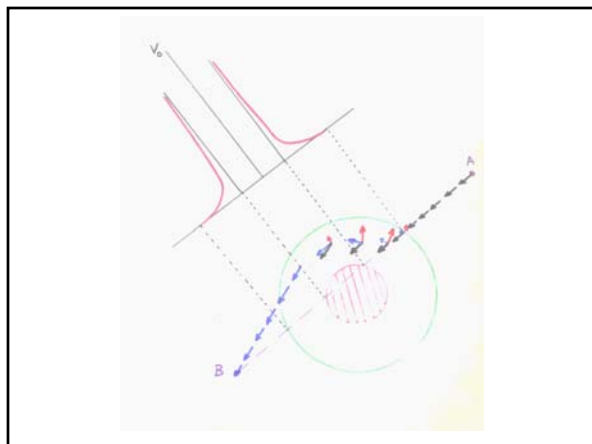
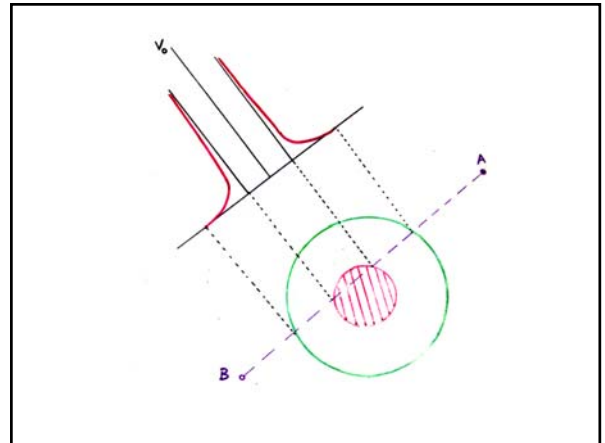
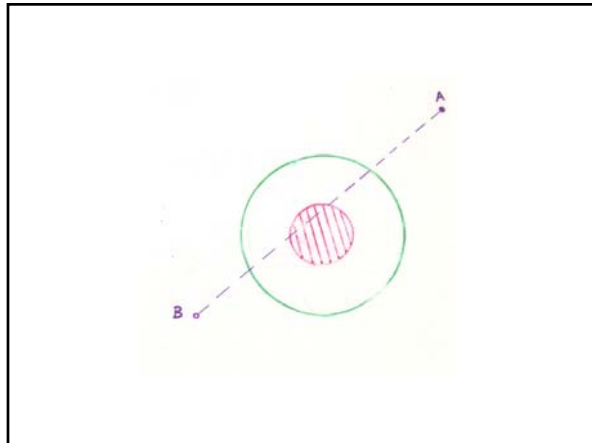
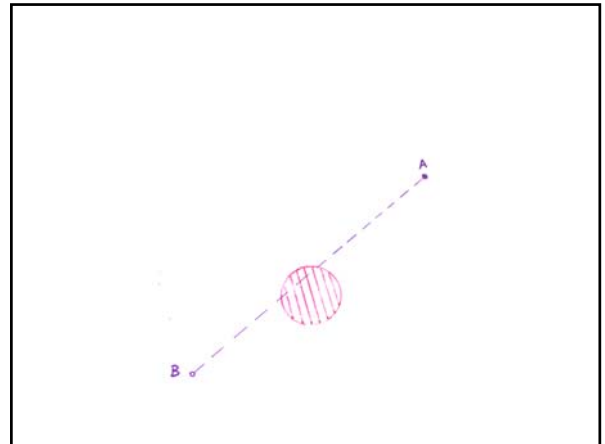
The top diagram shows a robot at orientation $\theta = \theta_1$. A coordinate system with axes O_1 and F_A is shown. The robot's footprint is a hatched rectangle labeled 'B'. To the right, a black polygon labeled 'CB' represents the obstacle's shape in the environment.

The bottom diagram shows the robot at orientation $\theta = \theta_2$. The footprint 'B' is rotated. The corresponding obstacle shape 'CB' is also rotated and translated.

J.C. Latombe: Robot Motion Planning



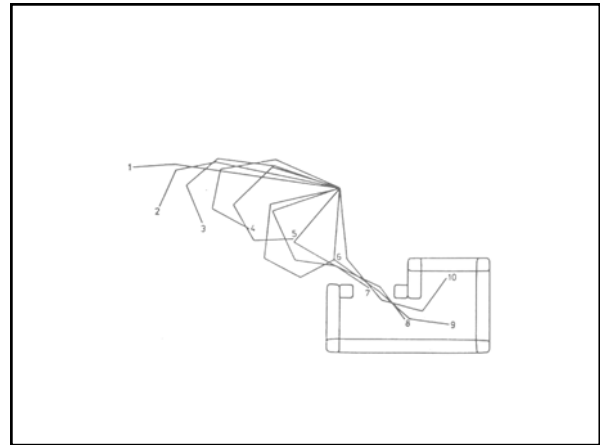
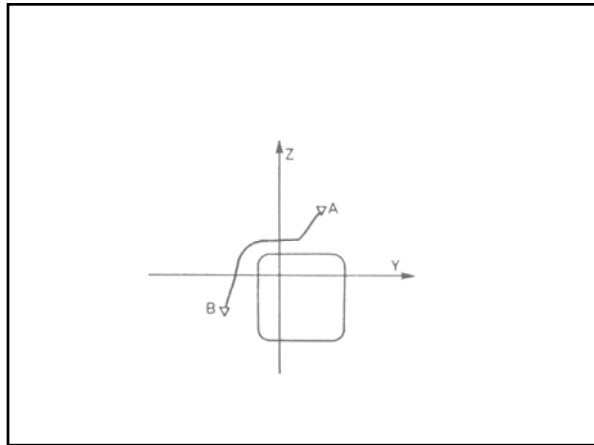
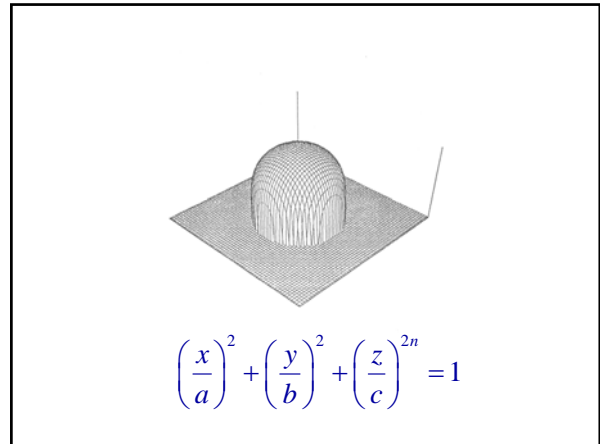
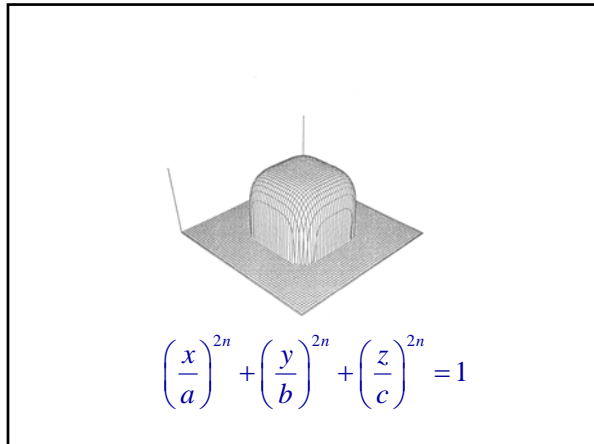
Artificial Potential Field



Repulsive Potential Field

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

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

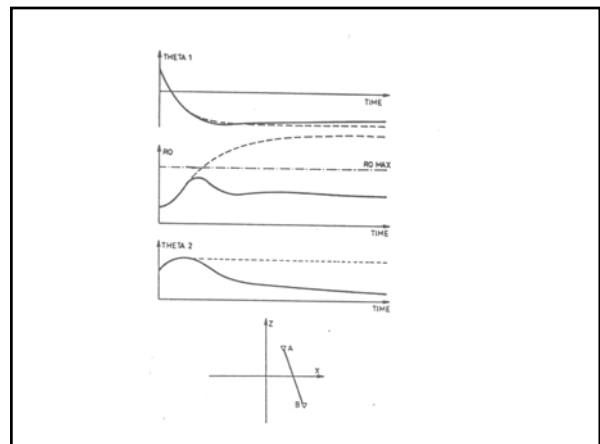


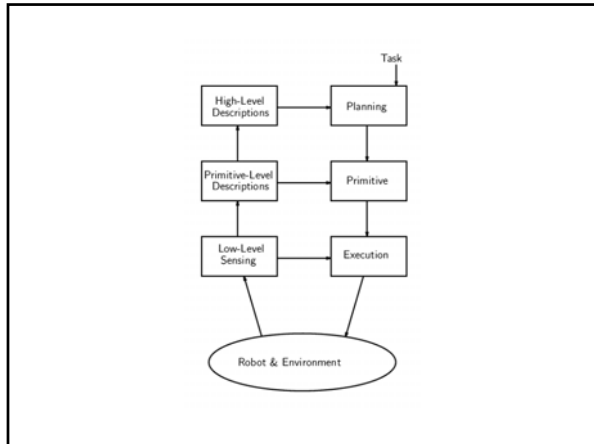
Joint Limits Avoidance

$$\gamma_{q_i} = \begin{cases} \eta \left(\frac{1}{\rho_i} - \frac{1}{\rho_{i(0)}} \right) \frac{1}{\rho_i^2} & \text{if } \rho_i \leq \rho_{i(0)}; \\ 0 & \text{if } \rho_i > \rho_{i(0)}; \end{cases}$$

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

$$\rho_i = q_i - q_i;$$

$$\bar{\rho}_i = \bar{q}_i - q_i.$$




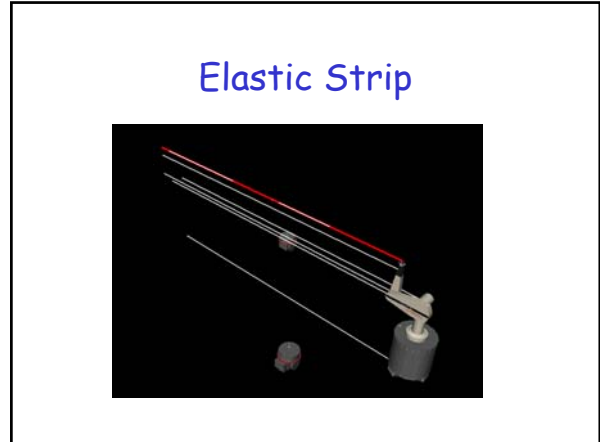
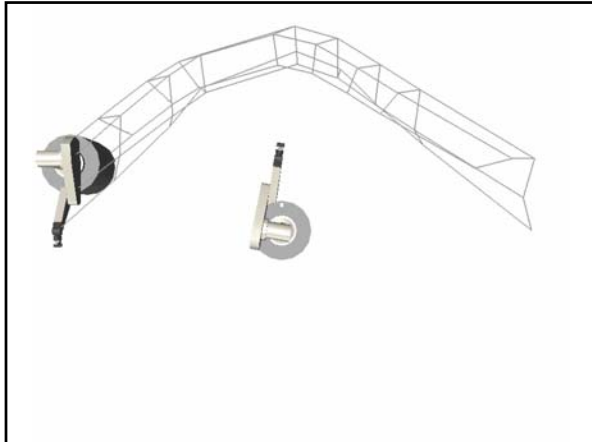
Elastic Planning

Real-time collision-free path modification

- **Reactive & Global**
Collision-Free Paths
- **Elastic Bands**
Bubbles - Configuration Space
- **Elastic Strip**
Elastic Tunnel - Workspace
- **Task Consistency**
Integrated Constraints with control

Free-Space Representation

Free-Space Tunnel

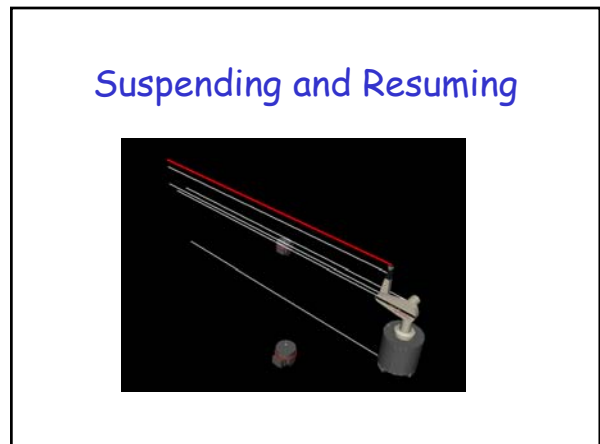
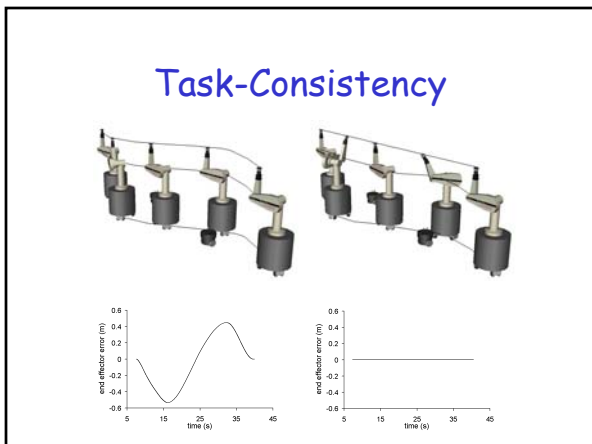
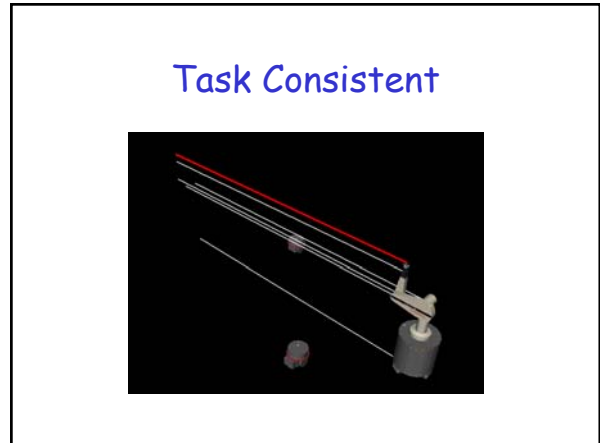


Task Consistent Obstacle Avoidance

$$\Gamma = \Gamma(\Gamma_{Task}, \Gamma_{Posture}, \Gamma_{Obstacles})$$

$$\Gamma_{Consistent} = J^T \mathbf{F}_{Task} + N^T (\Gamma_{Posture} + \Gamma_{Obstacles})$$

$$\Gamma = \alpha \Gamma_{Consistent} + \bar{\alpha} \Gamma_{Obstacles}$$

$$\alpha = \frac{\|N^T \Gamma_{Obstacles}\|}{\|\Gamma_{Obstacles}\|}$$


Task Suspension

