Potential Field Method

Potential Field (Working Principle)

– The goal location generates an **attractive potential** – pulling the robot towards the goal

– The obstacles generate a **repulsive potential** – pushing the robot far away from the obstacles

– The **negative gradient of the total potential** is treated as an artificial force applied to the robot

-- Let the sum of the forces control the robot

Artificial **Potential**

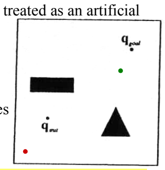
$$U(q) = \underbrace{U_{goal}(q)}_{\text{attractive potential}} + \underbrace{\sum U_{obstacles}(q)}_{\text{repulsive potential}}$$

Artificial **Force Field**

$$F(q) = -\nabla U(q)$$

Negative gradient

$\mathcal{C}$-obstacles



Example: free-flying robot modeled as a point

$$F(q) = -\nabla U(q) = -\begin{bmatrix} \partial U / \partial x \\ \partial U / \partial y \end{bmatrix}$$

Potential Field Method

- Compute an attractive force toward the goal

- Attractive Potential

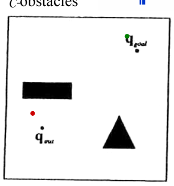
$$U_{goal}(q) = \frac{1}{2}\xi \| q - q_{goal} \|^2$$

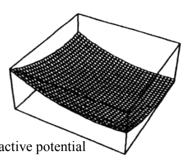
Parabolic
Positive or null
Minimum at q_{goal}

$$F_{att}(q) = -\xi (q - q_{goal})$$

Tends to zero when the robot gets closer to the goal configuration

$\mathcal{C}$-obstacles





Attractive potential

Potential Field Method

- Compute a repulsive force away from obstacles

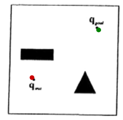
Repulsive Potential

- Create a potential barrier around the C-obstacle region that cannot be traversed by the robot's configuration

- It is usually desirable that the repulsive potential does not affect the motion of the robot when it is sufficiently far away from C-obstacles

Potential Field Method

- Compute a repulsive force away from obstacles
- Repulsive Potential



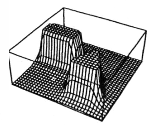
$$U_{rep}(q) = \begin{cases} \frac{1}{2}\eta\left(\frac{1}{\rho(q)} - \frac{1}{\rho_0}\right)^2 & \text{if } \rho(q) \le \rho_0 \\ 0 & \text{if } \rho(q) > \rho_0 \end{cases}$$

η → positive scaling factor

$\rho(q) = \min_{q' \in CB} \| q - q' \|$ → Distance from the actual configuration q to the C-obstacle region CB

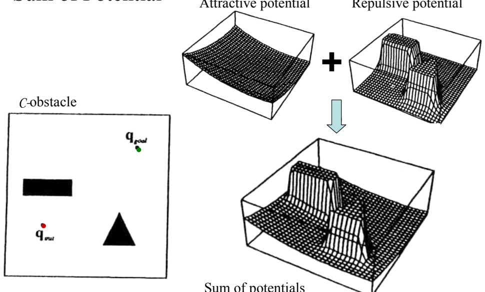
ρ_0 → Positive constant (**distance of influence**) of the C-obstacles

$$F_{rep}(q) = \begin{cases} \eta\left(\frac{1}{\rho(q)} - \frac{1}{\rho_0}\right)\frac{1}{\rho^2(q)}\nabla\rho(q) & \text{if } \rho(q) \le \rho_0 \\ 0 & \text{if } \rho(q) > \rho_0 \end{cases}$$



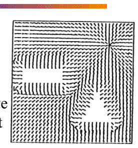
Potential Field Method

- Sum of Potential



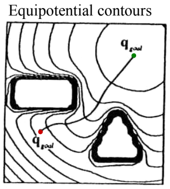
Potential Field Method

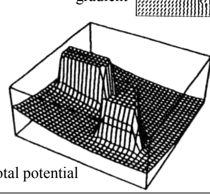
- After get total potential, generate force field (negative gradient)
- Let the sum of the forces control the robot



Negative gradient

Equipotential contours





Total potential

To a large extent, this is computable from sensor readings