Potential Field Path Planning

Reference:

Principles of Robot Motion
H. Choset et.al.
Mit Press

Also: Siegwart text, section 6.3.2
Potential Field Path Planning

• Simple idea: Have robot “attracted” to the goal and “repelled” from the obstacles
• Think of robot as a positively charged particle moving towards negatively charged goal – attractive force
• Obstacles have same charge as robot – repelling force
• States far away from goal have large potential energy, goal state has zero potential energy
• Path of robot is from state of high energy to low (zero) energy at the goal
• Think of the planning space as an elevated surface, and the robot is a marble rolling “downhill” towards the goal
Potential Field Path Planning

Repulsive force

Attractive force

start

goal
Potential Field Path Planning

• A potential function is a function that may be viewed as energy
• the gradient of the energy is force
• Potential function guides the robot as if it were a particle moving in a gradient field.
• Analogy: robot is positively charged particle, moving towards negative charge goal
• Obstacles have “repulsive” positive charge
• Potential functions can be viewed as a landscape
• Robot moves from high-value to low-value Using a “downhill” path (i.e negative of the gradient).
• This is known as gradient descent –follow a functional surface until you reach its minimum
Attractive Potential Function is distance from goal. High energy away from goal, Zero at goal. Path is negative gradient, largest change in energy.
Figure 4.5  The repulsive gradient operates only in a domain near the obstacle.
Online Distance Computation

Figure 4.7  Local minima of rays determine the distance to nearby obstacles.
Total Potential Function

\[ U(q) = U_{\text{att}}(q) + U_{\text{rep}}(q) \]

\[ F(q) = -\nabla U(q) \]
Potential Field

- Obstacles create high energy barriers
- Gradient descent follows energy minimization path to goal
Potential Field Limitations

Local minimum:
attractive force (goal) = repulsive force (obstacles)
Potential Field Methods

Local minimum: attractive force = repulsive force
Solution: Take a random walk – perturb out of minima
Need to remember where you have been!
Potential Fields Summary

- More than just a path planner: Provides simple control function to move robot: gradient descent
- Allows robot to move from wherever it finds itself
- Can get trapped in local minima
- Can be used as online, local method:
  - As robot encounters new obstacles, compute the Potential Function online
  - Laser/sonar scans give online distance to obstacles