Collision Avoidance

AE353

Spring 2023

Bretl

Collision Avoidance By Gradient Descent

Define a function $h(p)$ that is

1. small near the goal
2. large near obstacles

and choose the desired position by gradient descent:

$$p_{des} = \hat{p} - k_{des} \nabla h(\hat{p})$$

$$h(p) = h_{att}(p) + h_{rep}(p)$$

$$\Downarrow$$

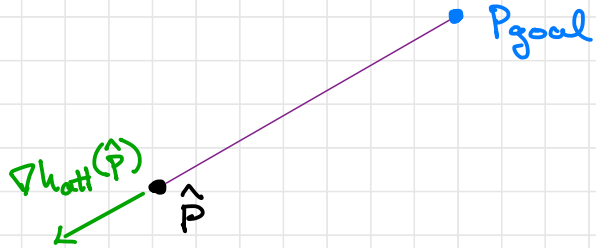
$$\nabla h(p) = \nabla h_{att}(p) + \nabla h_{rep}(p)$$

ATTRACTIVE PART ("small near the goal")

$$h_{att}(p) = \frac{1}{2} k_{att} \| p - p_{goal} \|$$

$$\Downarrow$$

$$\nabla h_{att}(p) = k_{att} \left(\frac{p - p_{goal}}{\| p - p_{goal} \|} \right)$$



Repulsive Part ("large near obstacles")

$$h_{rep}(p) = k_{rep} \sum_i \left(\frac{1}{d_i(p)} \right)$$

$d_i(p)$: distance to closest point on obstacle i

$$\Downarrow$$

$$\boxed{\nabla h_{rep}(p) = -k_{rep} \sum_i \left(\frac{1}{d_i(p)^2} \right) \nabla d_i(p)}$$

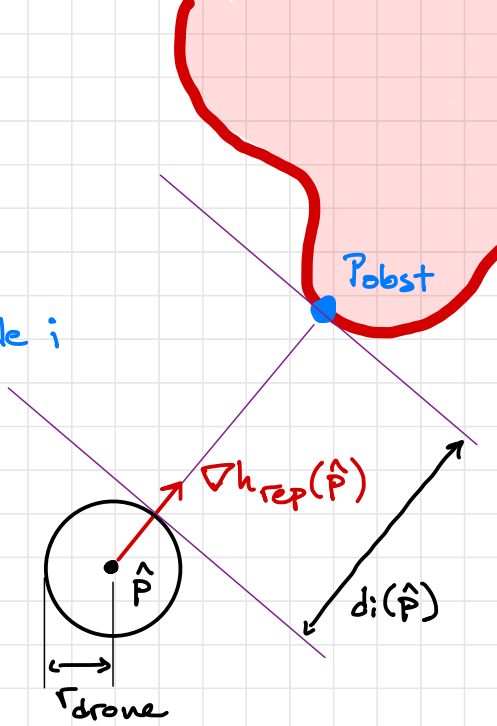
$$d_i(p) = \| p - p_{obst\,i} \| - r_{drone}$$

r_{drone}: radius of sphere around drone

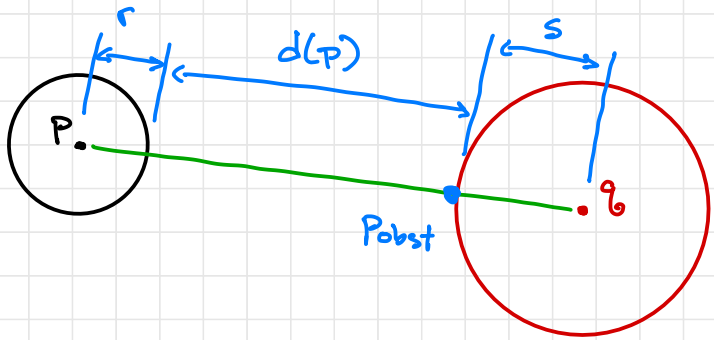
$p_{obst\,i}$: closest point on obstacle i

$$\Downarrow$$

$$\boxed{\nabla d_i(p) = \left(\frac{p - p_{obst\,i}}{\| p - p_{obst\,i} \|} \right)}$$

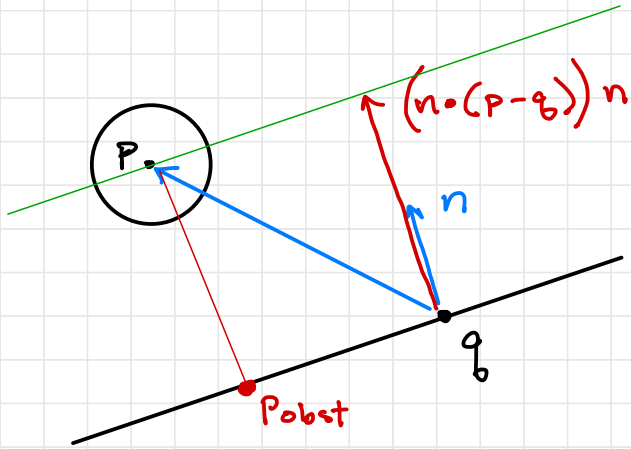


SPHERICAL OBSTACLE



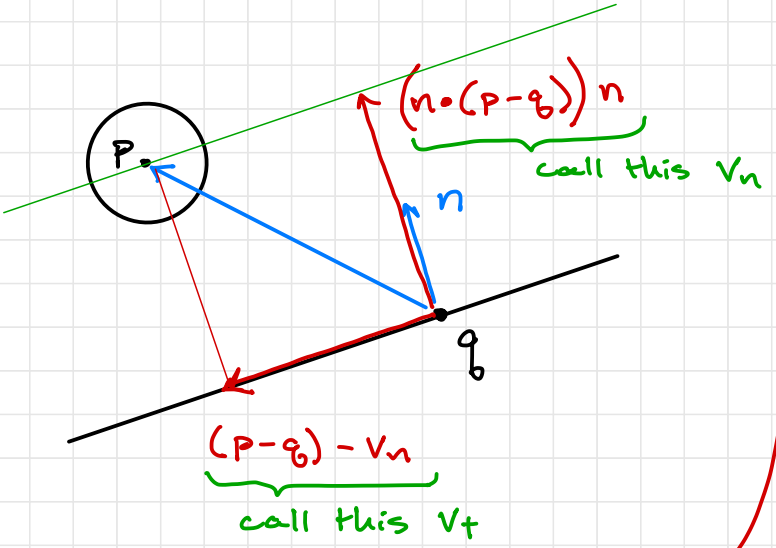
$$P_{obst} = q + s\left(\frac{p-q}{\|p-q\|}\right)$$

PLANAR OBSTACLE



$$p_{obst} = p - (n \cdot (p - q))\, n$$

PLANAR OBSTACLE WITH CIRCULAR HOLE



IF $\|v_t\| > s$ THEN

$p_{obst} = q_b + v_t$ ← same as $p - v_n$

ELSE

$p_{obst} = q_b + s\left(\frac{v_t}{\|v_t\|}\right)$