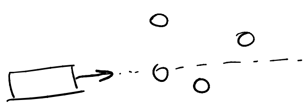
Collision Avoidance documentation

Friday, January 25, 2019 6:10 PM

Idea:

Use gradient descent to determine the ideal steering angle



Robot's environment → model each landmark as a Gaussian function

$$J = \underset{\theta}{\operatorname{argmin}} \left[\int_x P(\theta, x)\, dx + \frac{1}{2} \| \theta - \delta \|^2 \right]$$

basically, we want to pick the trajectory associated with the steering angle θ that has the fewest obstacles (we're integrating the probability of there being an obstacle at arc length x on trajectory θ

We also want to steer as little as possible which is why we add the regularizer $\frac{1}{2} \| \theta - \delta \|^2$, δ is our current steering angle.

The robot should also attempt to steer towards its goal as well, so after this step we run the standard controller.

$$\theta_{t+1} \leftarrow \theta_t + \gamma \nabla J$$

$$\nabla J = \frac{dJ}{d\theta} = \frac{d}{d\theta} \left(\int_x P(\theta, x)\, dx + \frac{1}{2} \| \theta \|^2 \right)$$

$$= \frac{d}{d\theta} \left(\int_x P(\theta, x)\, dx \right) + \| \theta \|$$

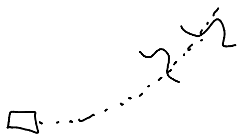
$$= \int_x \frac{d}{d\theta} \left(P(\theta, x) \right) dx + \| \theta \|$$

$\frac{d}{d\theta} \left(P(\theta, x) \right)$ is the derivative of a Gaussian whose mean

... all the obstacles along

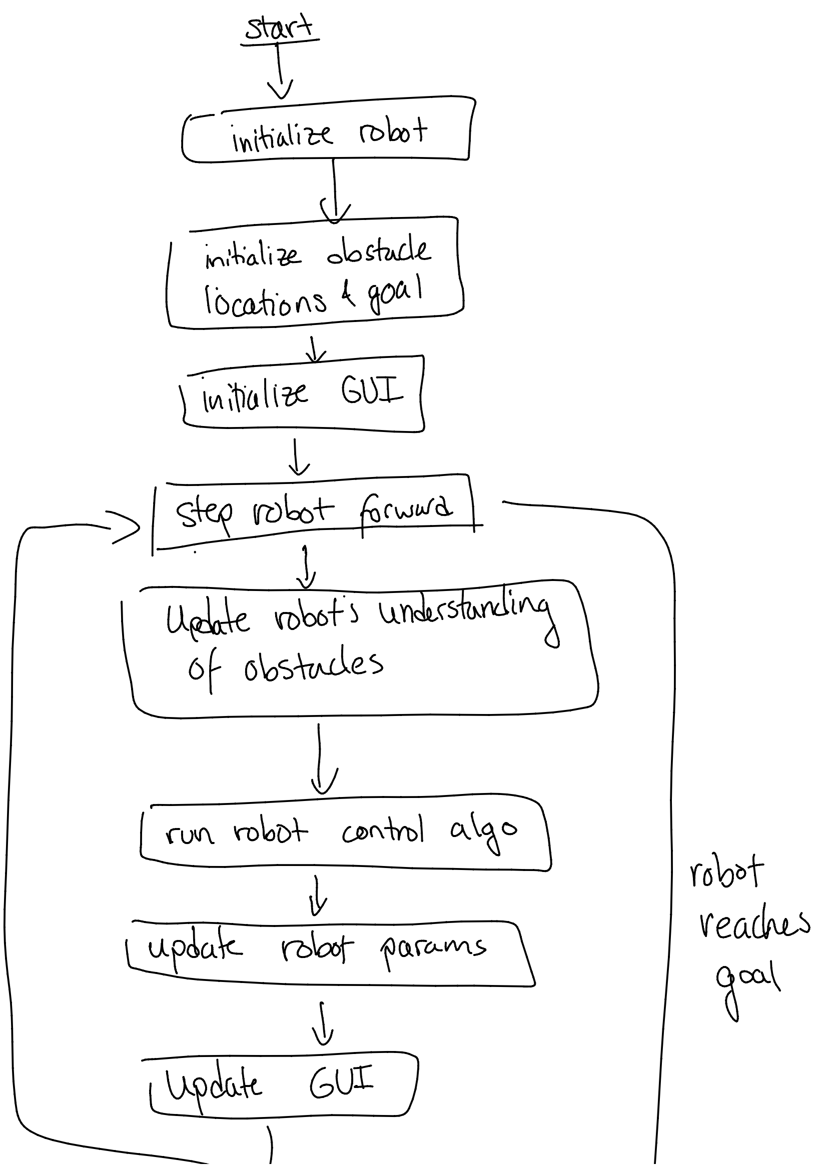
$\frac{d}{d\theta}(P(\theta, x))$ is the derivative of a Gaussian whose mean is an obstacle, so basically take all the obstacles along that trajectory and add their derivatives up

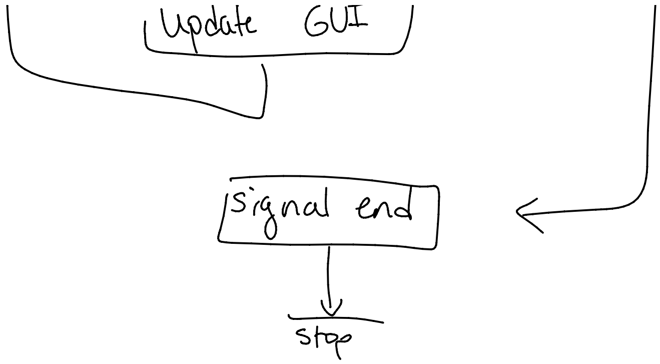
we also need to consider the following:



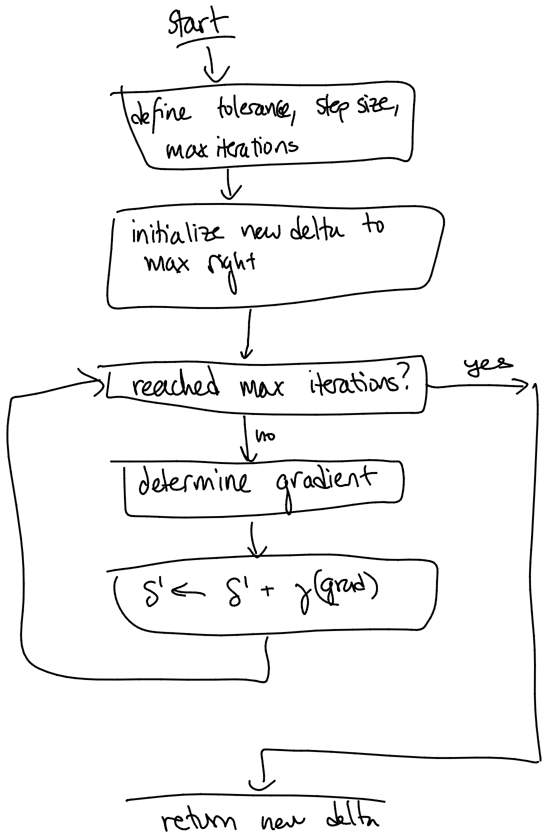
in this situation it's ok because the 2 obstacles will cancel each other out. Therefore, we also need to add on a scaling term for the distance between the buggy and the obstacle, prioritizing closer obstacles.

MATLAB Sim:





Collision Avoidance Algo



determining the gradient:

1) let r = radius of circle created with steering angle δ

2) use circle formula $x^2 + y^2 = r^2$ on each relative landmark to figure out if it's on the path.

3) if it's within the tolerance, consider it in the way

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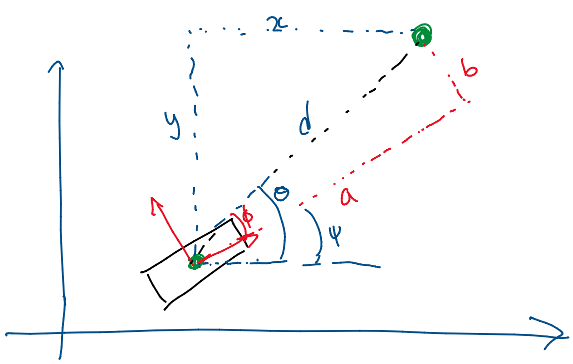
4) Use the difference as the input to the derivative of the normal fn.

5) Calculate derivative & scale according to distance away (priority to closer objects)

6) add the difference between δ' and δ for the regularizer

Getting relative coordinates:



We know blue, want red

$$\phi = \theta - \psi$$

$$a = d\cos(\phi)$$

$$b = d\sin(\phi)$$