IVO: Inverse Velocity Obstacles for real time navigation

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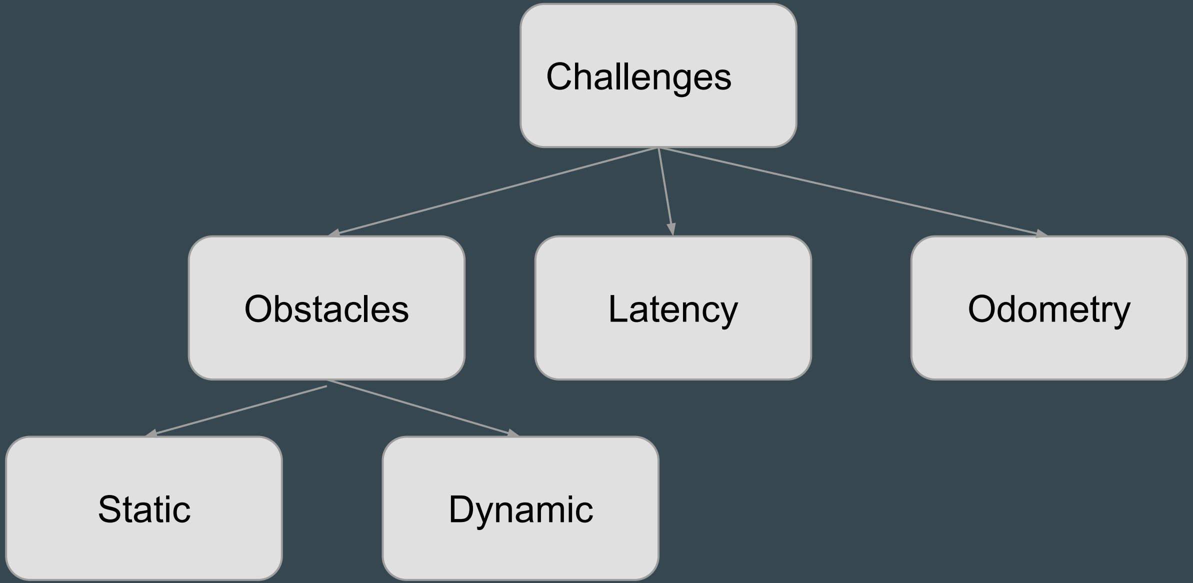
Reference Paper:

Jyotish, P.N., Goel, Y., Kumar, A.S.B. and Krishna, K.M., 2019. IVO: Inverse Velocity Obstacles for Real Time Navigation. In *Proceedings of the Advances in Robotics 2019* (pp. 1-6).

Motivation

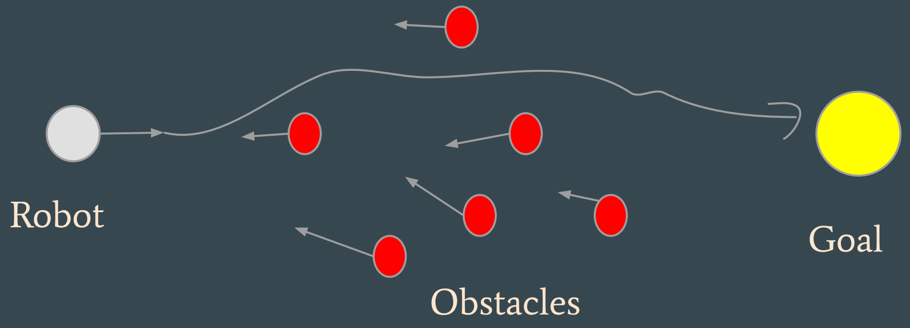
- Navigation is a highly studied problem in robotics that deals with planning trajectories for the robots in their operating environment.
- But, doing so can have challenges:



AIM

The aim of the paper is to:

- Propose an algorithm that demonstrates a collision avoidance scheme in real time scenarios while seeking the target.
- Compare it with the parent algorithm i.e. Velocity Obstacles.
- Scale this algorithm to a multi-obstacle scenario.



Approach

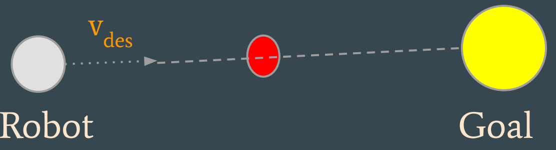
- Use ego-centric framework for collision avoidance.
    - The frame of reference is placed on the robot itself.

- The optimization problem is independent of the robot’s absolute velocity and position in the world.

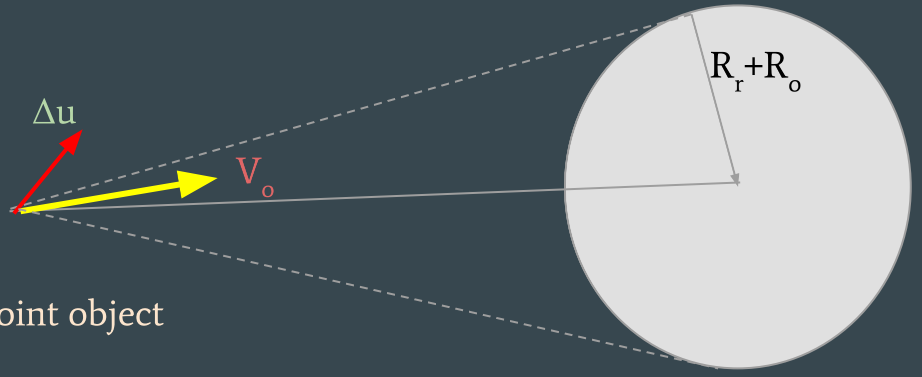
- The optimization uses a collision cone constraint for avoiding the obstacles that are in the sensor range of the robot.

Objective Function

$$minJ_{u_x,u_y} = \| v_{desired} - (v_r + u) \|^2 + \lambda \| u \|^2$$



Robot

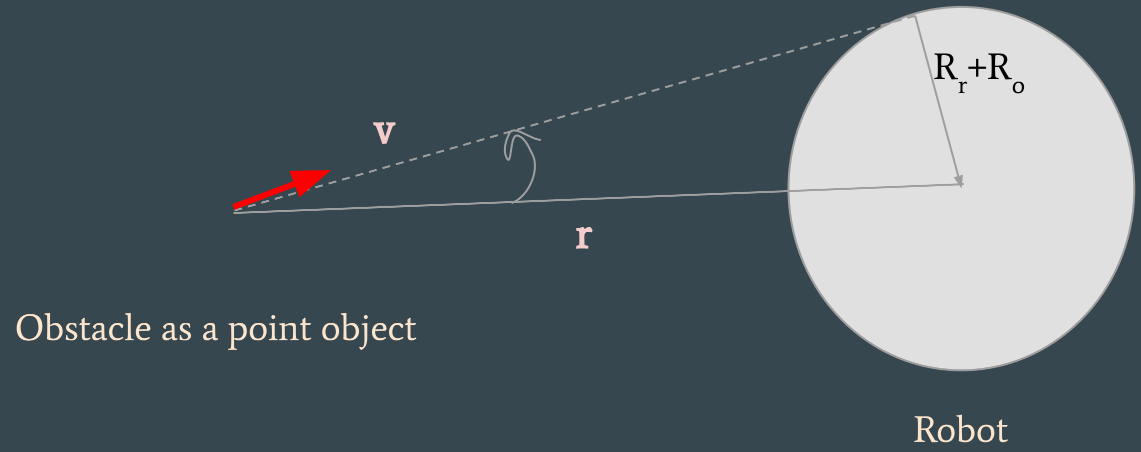


Obstacle as a point object

Robot

Collision constraint

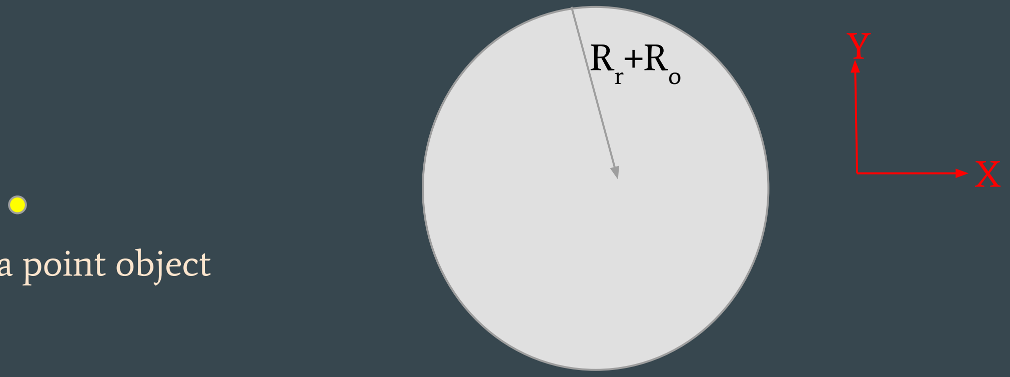
$$\frac{(r^T v)^2}{\|v\|^2} - \| r \|^2 + (R_r + R_o)^2 \leq 0$$



r: relative position of the obstacle w.r.t robot.
v: relative velocity of the obstacle w.r.t robot.

Ego-centric framework

- Assuming that the robot is stationary.
- Make the obstacle a point object and grow the radius of the robot to $R_r + R_o$.
- Watch the obstacle from the frame of the robot (ego-frame).
- Then the compute the collision cone.

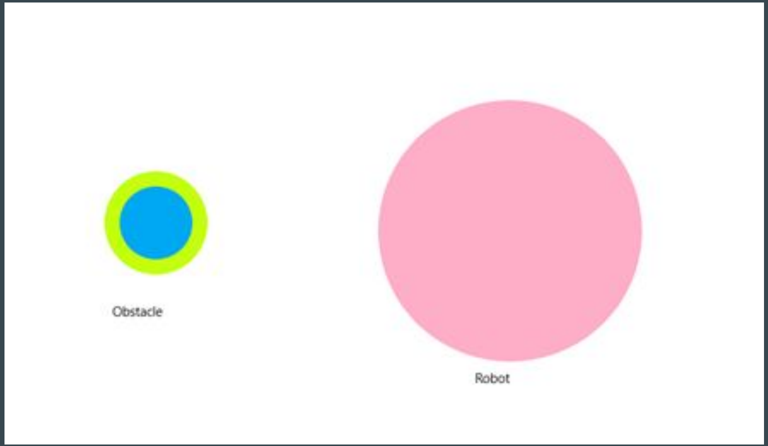


Obstacle as a point object

Robot

Advantages of using the ego-centric framework

- The uncertainty in the position of the robot gets eliminated.
- The blue region is the position of the obstacle and the green region is the perception error of the position of the obstacle.
- Since the frame of reference is the robot itself, there is no error associated with the perception of the position of the robot.



Simulation time!

Thank You!