RBE550 Valet Assignment

Introduction:

Algorithm used: Hybrid A* (A-star)

Hybrid A* is a variation of A* that uses kinematic constraints on the motion of the robot to find neighbouring configurations. Much like A*, Hybrid A* achieves efficient exploration by applying a heuristic. In the code here, this heuristic is the Euclidian distance (square root of the sum of squares of differences between coordinates)

Pseudocode for Hybrid A:*

1. Initialize the start and goal positions.
2. Generate a graph of motion primitives.
3. Initialize the closed and open lists.
4. Insert the start position into the open list with f-cost = heuristic(start).
5. while the open list is not empty do
    a. Pop the node with the lowest f-cost from the open list.
    b. Generate the successors of the current node.
    c. For each successor node, do the following:
        i. Compute the cost to move from the current node to the successor node.
        ii. If the successor is the goal position, compute the continuous path using numerical integration and optimization techniques.
        iii. If the successor is not in the closed list or has a lower cost than its previous cost, add it to the open list with f-cost = g-cost + heuristic(successor).
    d. Add the current node to the closed list.
6. If no path is found, return failure.
7. Compute the continuous path using the final node from the closed list.
8. Apply the path to the vehicle by generating a sequence of control inputs (e.g., steering angles, velocities) that follow the trajectory.

Algorithm Design and Development:

In the algorithm, nodes represent the configuration of the car.

The constraints are imposed based on the type of robot being simulated.

- For the Diff drive robot:

$$\dot{x} = \frac{r}{2}(u_l + u_r)\cos\theta$$
$$\dot{y} = \frac{r}{2}(u_l + u_r)\sin\theta$$
$$\dot{\theta} = \frac{r}{L}(u_r - u_l).$$

- For the car-like robot:

$$\dot{x} = u_s \cos\theta$$
$$\dot{y} = u_s \sin\theta$$
$$\dot{\theta} = \frac{u_s}{L}\tan u_\phi.$$

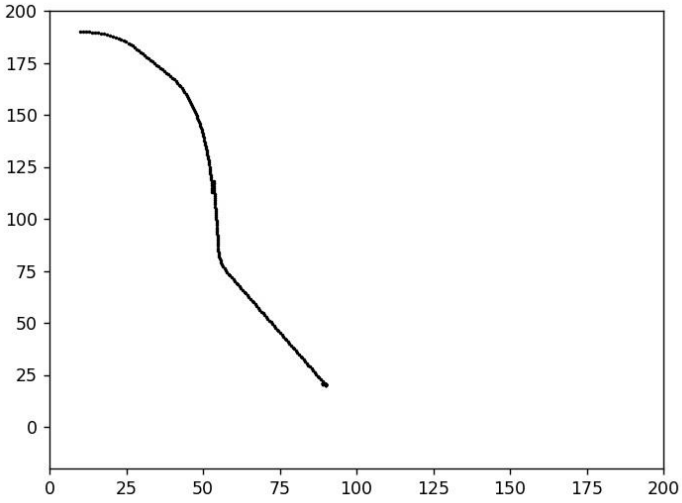
- For the car+trailer:

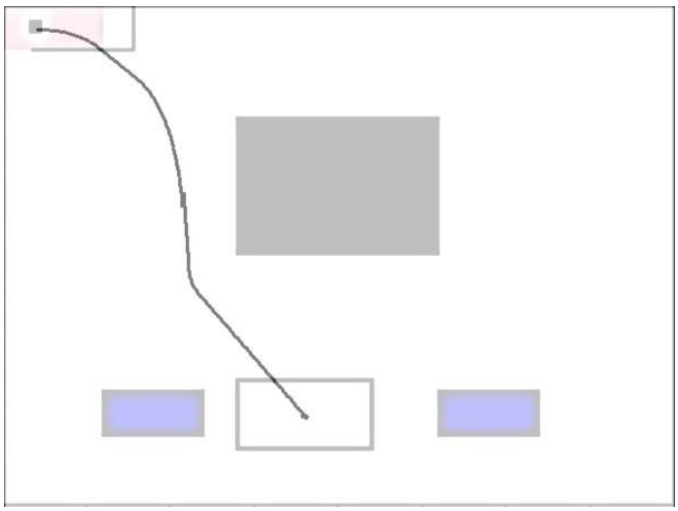
$$\dot{x} = s\cos\theta_0$$
$$\dot{y} = s\sin\theta_0$$
$$\dot{\theta}_0 = \frac{s}{L}\tan\phi$$
$$\dot{\theta}_1 = \frac{s}{d_1}\sin(\theta_0 - \theta_1)$$

Results:

Car Like Robot:

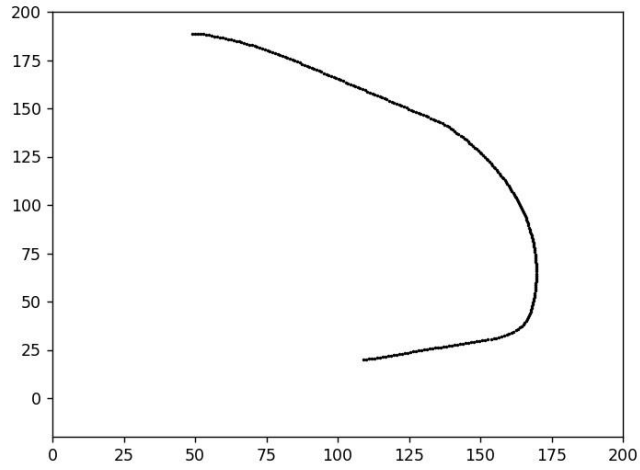
Path:

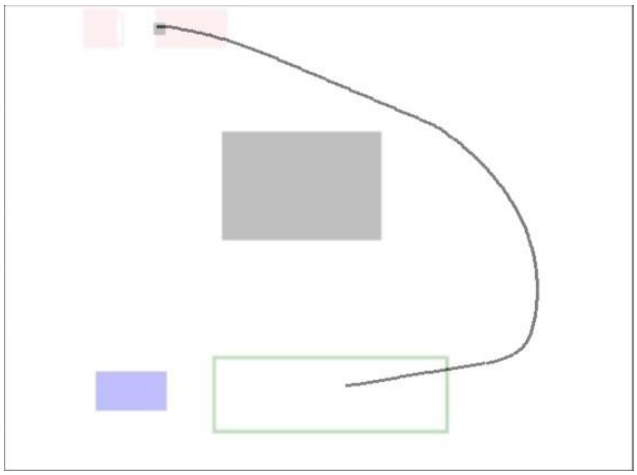




Car+Trailer:

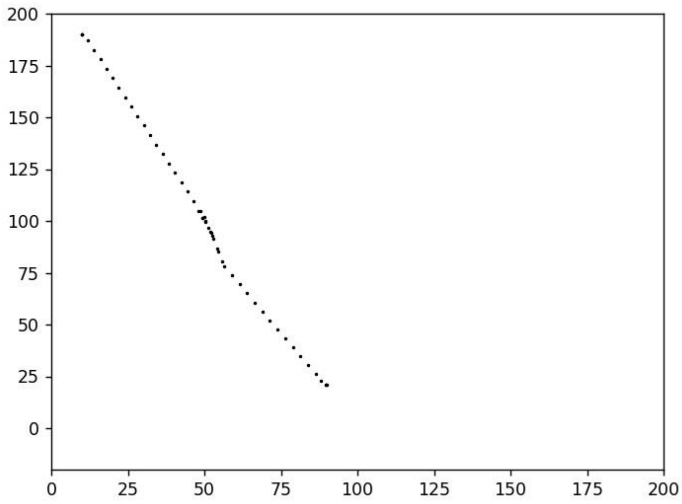
Path:





Diff drive:

Path: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