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A Reinforcement Learning Model for Autonomous Agent Navigation in Shared Spaces

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Overview

- Emergence of self-driving agents
- Shared spaces
- Navigation systems and models
- Conclusion

Emergence of AVs

- Advancements in IoT leads to smart city development.
- Waymo taxis and Tesla cars
- Autonomous trollies and mobile lockers
- The challenge of managing the mixed transportation

Ref: https://images.app.goo.gl/p5xroKffjoW

Shift in Urban Street Design

- Streets can be more of a place, rather than a link
- The "streets for shared spaces" program in New South Wales in 2020
- Transform streets into shared space to make them more inclusive and vibrant urban areas

Old Christchurch Road (UK), Before and After implementation of the shared space design (ref: Evaluation and implementation of Shared Spaces report in NSW 2022).

Shared Environment's Features

- Mixed users
- No traditional traffic demarcations
- Homogenous surface
- Low speed limits
- Informal right of way
- Landscaping and street furniture
- High densely populated
- Stochastic dynamic movements

Autostradas in ports.
Ref: industrysearch.com.au

Location: Detroit, Michigan.
ref: livinglabdetroit.com/portfolio/bagley-shared-street-design/

Self-driving Cars Navigation Methods

- Physics-based models
- Learning-based models

Comparison between the Models

PHYSICS-BASED

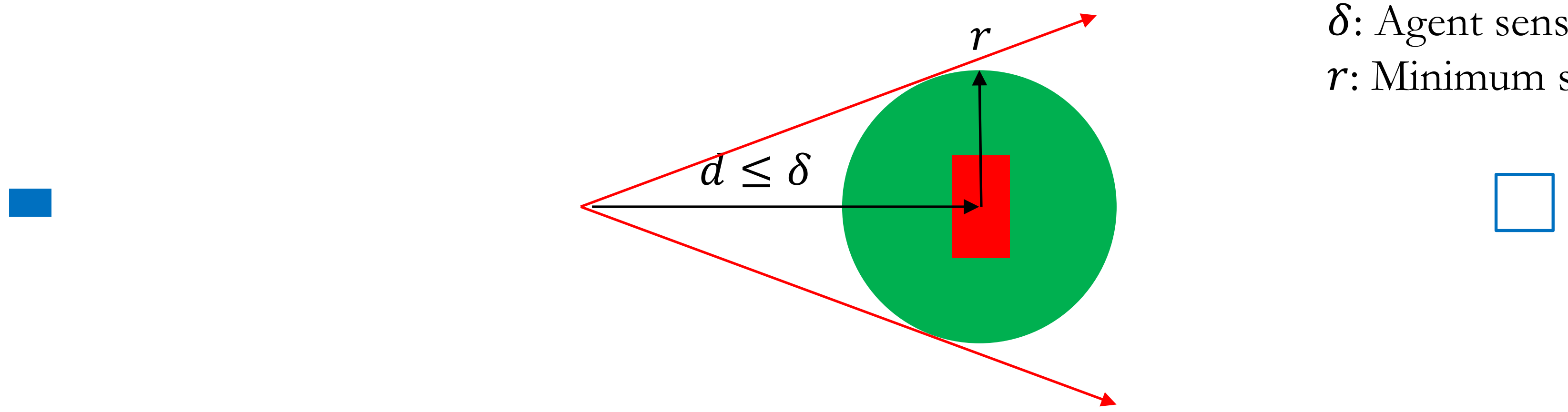
- Based on equations
- Requires manual adjustments
- Require less data to develop
- Computationally efficient
- Cannot capture intricated human behaviours
- Deterministic
- Reliable outputs
- Can ensure safety

LEARNING-BASED

- Learn through interactions
- Adaptable to stochastic conditions
- Can handle uncertainty
- Require a significant amount of data.
- Captures complex behaviors
- Computationally expensive
- Can imitate human behaviour
- Outputs could be unreliable or unrealistic

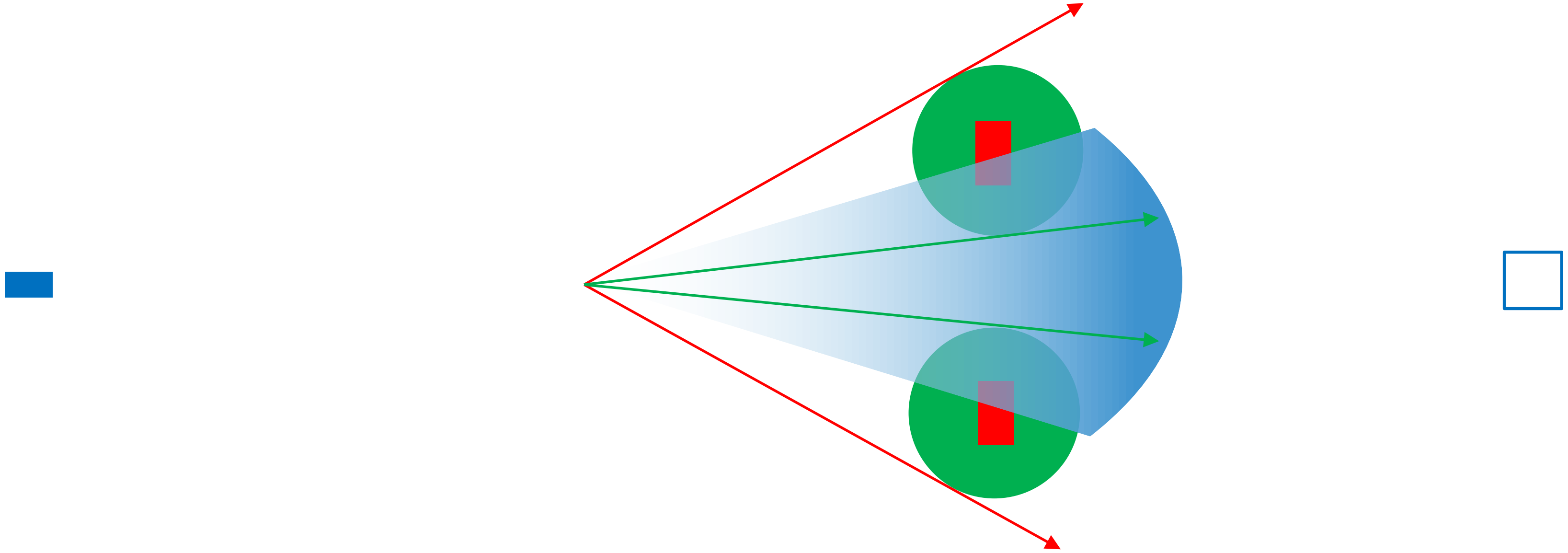
Agent Features

How to Avoid an Obstacle?

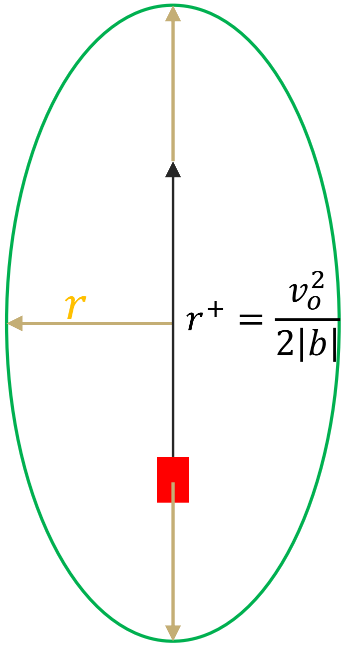


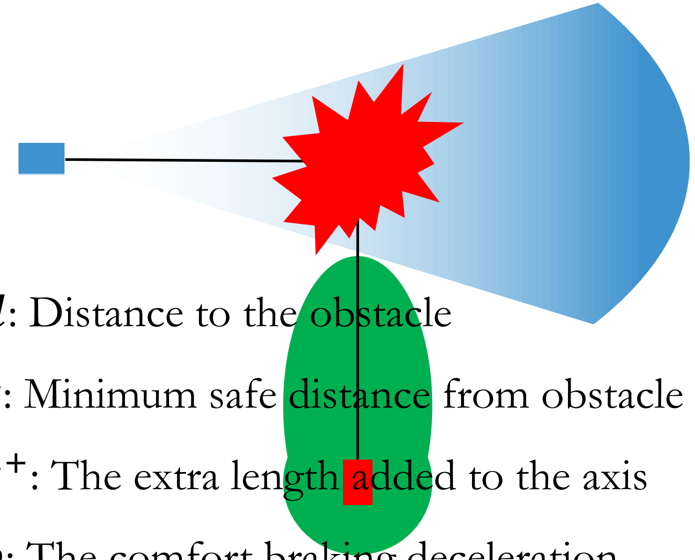
d: Distance to the obstacle.
δ: Agent sensor range.
r: Minimum safe distance from obstacle.

Energy minimization



Avoid the Moving Obstacles





d: Distance to the obstacle

r: Minimum safe distance from obstacle

r^+: The extra length added to the axis

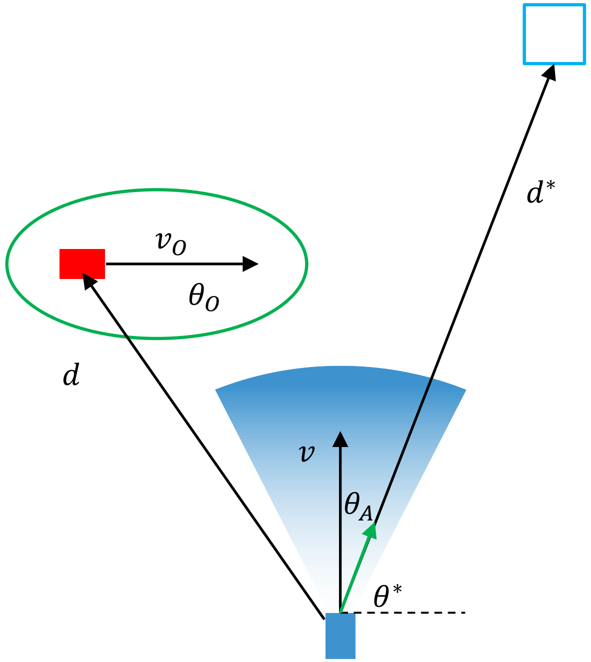
b: The comfort braking deceleration

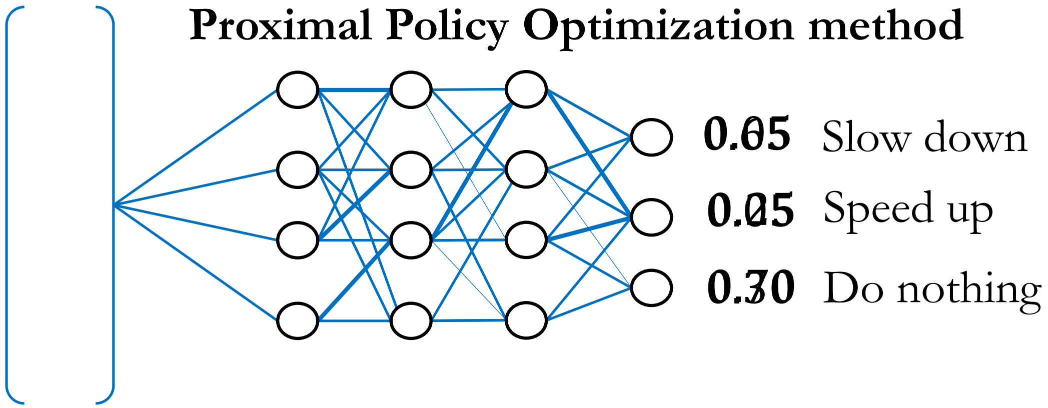
v_A: The agent velocity

v_o: The obstacle velocity

Agent braking deceleration: $\left(-\frac{v_A^2}{2d}\right)$

Learning Process

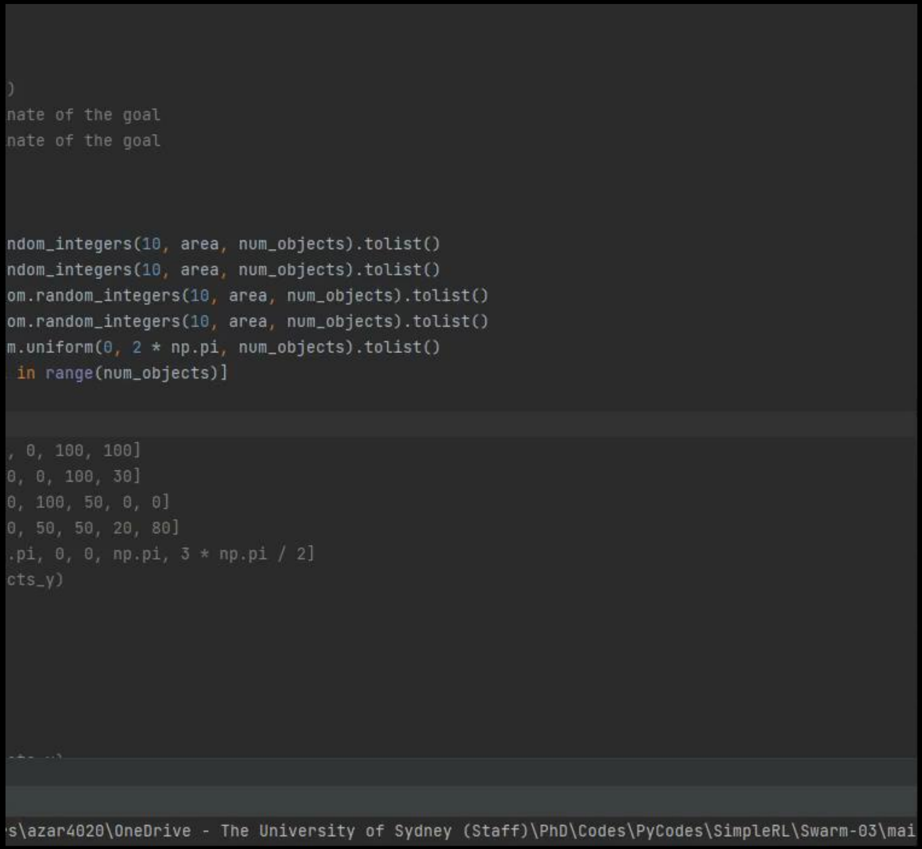




Reward= −(Euclidean distance to the goal state)+ln (distance to the nearest obstacle)

An efficient learning process needs step-by-step training

Simulation result: Agent's navigation



Simulation result: Trajectory of agents

```
x_new, y_new - length, "v= %s" % (np.round(v, 1)), color='r')
jects_goal_x[ind], objects_goal_y[ind], 's', markersize=20, color=colors[ind])

ax(x_edge[1], x_edge[0] + 10))
ax(y_edge[1], y_edge[0] + 10))
ime: {frame} seconds')  # Display the frame number as the title

nd position index

os_index + 1) % len(x_history[0])
# Cycle through actions

(x_history)):
ngle((objects_goal_x[ind] - length, objects_goal_y[ind] - length), 2 * length,
     2 * length, linewidth=1, edgecolor=colors[ind], facecolor='None')
t)

n(decomposed_x[i]) for i in range(len(x_history))])
 # Adjust as needed

on with the specified interval
fig, update, frames=num_frames, repeat=False, interval=animation_speed)
m)")
m)")

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Future Directions

Combined approaches

Energy minimization

Correct the mistakes

Socially acceptable behavior

Motion prediction

Real test

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Thank You!

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