CR501 Advancing Autonomous Mobile Robots with the Dynamic Window Approach

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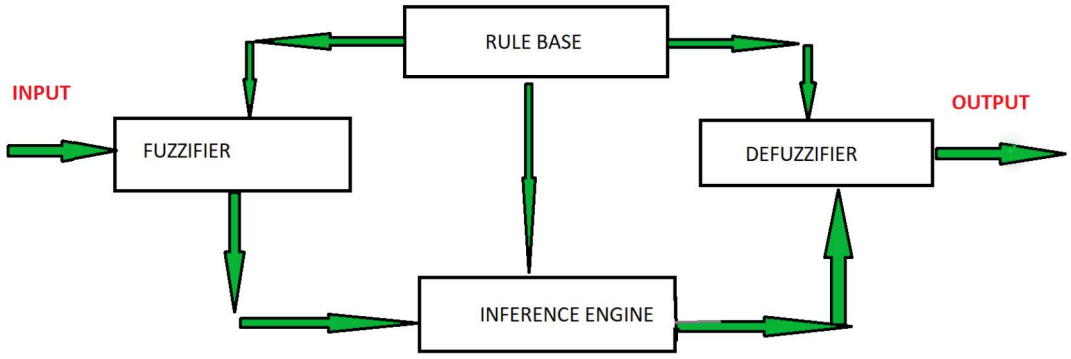
Contents

Introduction I

Fuzzy Logic

- Components: fuzzifier, rules, an inference engine, and a defuzzifier



FUZZY LOGIC ARCHITECTURE

Source: Fuzzy Logic (Surya, 2023)

Introduction I: Fuzzy Logic

In-detail

Weighted average decision method

- FS (Fire Strength)
- OW (Output Wight): each degree has a weight

$$Output = \frac{\sum_i FS_i * OW_i}{\sum_i FS_i}$$

Final output = 7.85 > 5 => Should break

Introdcution II

Dynamic Window Approach

$$G(v, \omega) = \sigma(\alpha \cdot heading + \beta \cdot dist + \gamma \cdot velocity)$$

- objective function
  - Target heading: The Angle between the robot's current attitude direction and the target direction
  - Clearance: 'dist' is the distance of the nearest obstacle intersecting the arc of the robot's motion trajectory
  - Velocity

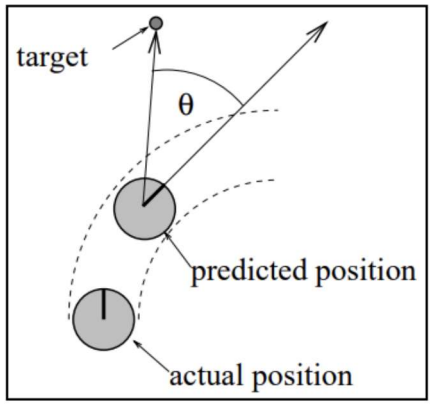


Figure 6. Angle θ to the target

Source: Dynamic window approach (Fox et al.)

Introdcution II: DWA

Source: DWA algorithm simulate (AtsushiSakai, 2020)

System Structure

1. Aims to decrease the cost that will be used to guide the robot

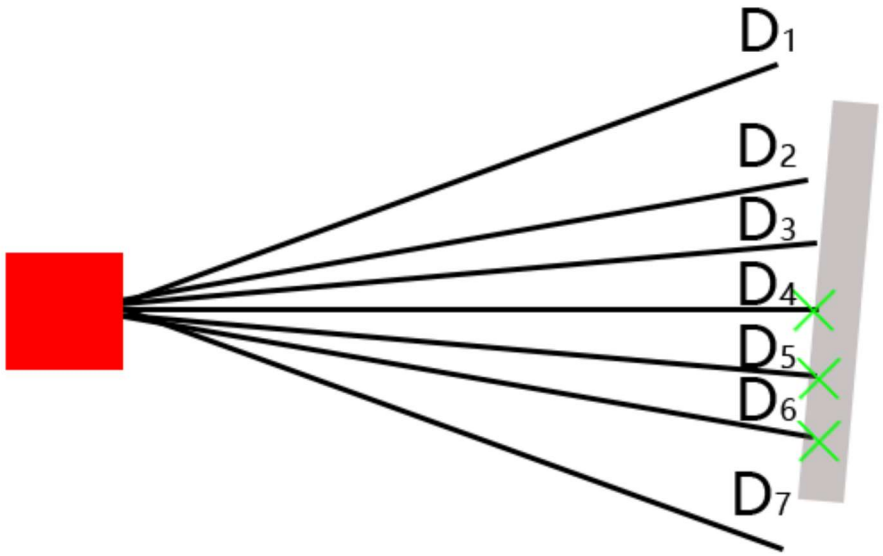
- Built on unity develpoment platform
- Simplified movement
- Equiped with one camer and Lidar

2. Maintain a relatively reliable accuracy

- Known target location
- Obstacles with fixed height

System Structure: Robot

- Each line D_n represents a LiDAR detection result in current state
- The green cross-hire means detected front obstacle



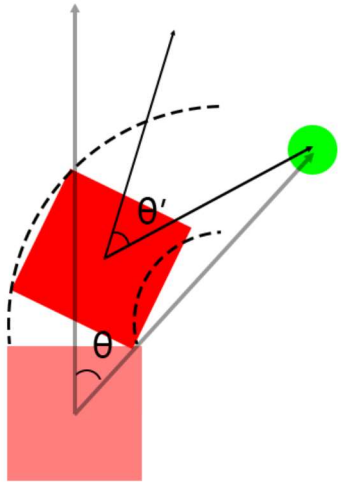
System Structure: Algorithm

1. Generate turning angles and speed array by current angle between the moving direction and the target point and robot velocity

2. Evaluate the array combines with current situation

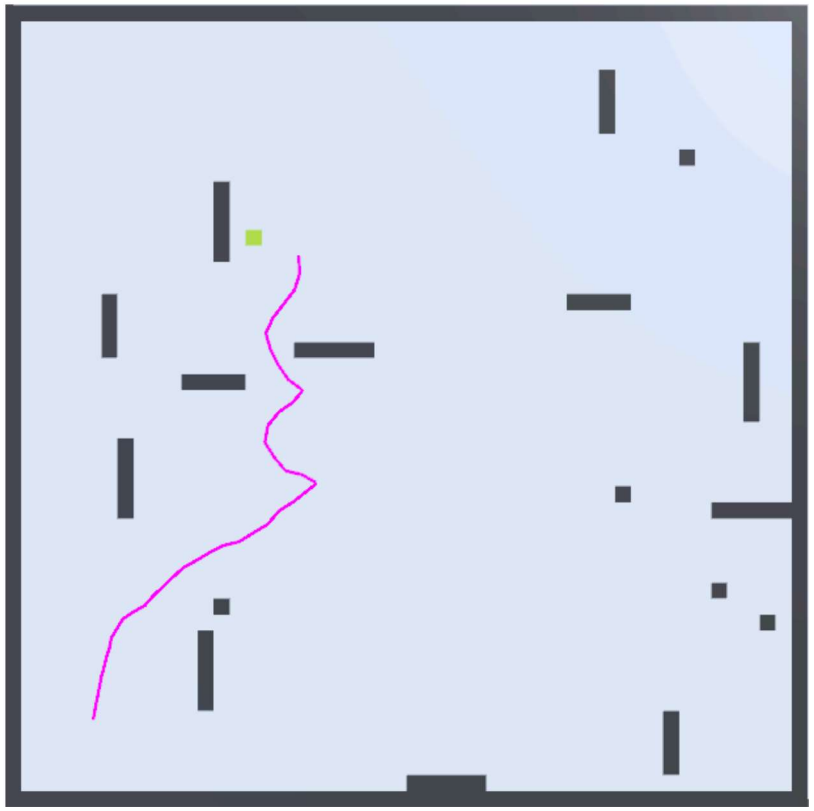
$$E = \alpha \cdot movement + \beta \cdot heading + \gamma \cdot obstacle$$

1. Pick best angle and speed and convert them to turning and acceleration (deceleration) commands



Results

- Smooth turn
- Obstacle avoidance



Limitation

- Tested exclusively in flat environments.
- The camera's power is often underestimated.
- The system's frame rate affects the outcome.
- Increasing the map's complexity can cause instability.

References

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- *Sakai, A. (2024). PythonRobotics: PathPlanning. https://github.com/AtsushiSakai/PythonRobotics/tree/master/PathPlanning. GitHub repository.*
- *Surya Priy, A. r. Fuzzy Logic. URL: https://www.geeksforgeeks.org/fuzzy-logic-introduction/.*

Thanks!

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