Multifunctional Intelligent Autonomous Parking Controller for Carlike Mobile Robots

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Introduction

- Designed for Carlike Mobile Robot (CLMR)
- Autonomous Parking and Obstacle Avoidance
- Array of ultrasonic sensors
Ultrasonic Sensors

- Arrangement
Ultrasonic Sensors

- Firing Sequence

Sequence 1
Ultrasonic Sensors

- Firing Sequence

Sequence 2

LF DFL
FR
FL
DFR RF
LM RM
RL DBR RB
LB DBL RR
Top Bottom
Ultrasonic Sensors

• Firing Sequence
Ultrasonic Sensors

- Firing Sequence

Sequence 4

[Diagram of sensor placement with labels for LF, DFL, FR, FL, DFR, RF, LM, RM, RL, DBR, RB, LB, DBL, RR, Top, Bottom]
Ultrasonic Sensors

- Firing Sequence

![Sequence 5 Diagram](image)

- LF DFL
- FR
- FL
- DFR RF
- LM
- RM
- RL DBR RB
- Top
- LB DBL
- Bottom
Determination of Reflector Position

\[ x = A \cos(\alpha) \cos(\phi) - B \sin(\alpha) \sin(\phi) + x_{tr} \]
\[ y = A \cos(\alpha) \sin(\phi) + B \sin(\alpha) \cos(\phi) + y_{tr}. \]

Where,

\[ \phi = \arctan((y_r - y_t)/(x_r - x_t)), \]
\[ A = L/2, \]
\[ B = \left(\left(\frac{L^2 - d_{tr}^2}{2}\right)\right)^{1/2}, \]
\[ d_{tr} = \left(\left((x_r - x_t)^2 + (y_r - y_t)^2\right)^{1/2}\right) \]
\[ x_{tr} = (x_r + x_t)/2 \]
\[ y_{tr} = (y_r - y_t)/2 \]
Determination of Types of Reflectors

1. Multichannel Method

\[ \text{Sensor1} \quad \text{Sensor2} \quad \text{Sensor3} \]

(a)

(b)

(c)

[1]
Determination of Types of Reflectors

2. Displacing Position Method

![Diagram of sensor positioning](a) and (b)
Behavior Modes of CMLR

- Fuzzy Parallel Parking Mode

  - Basic Constraints:
    
    \[
    (1.2W < d_{rf} < 1.5W) \\
    (1.35L < d_f < 1.75L) \\
    (1.6L < d_{dfl} < 2.2L)
    \]

  Where,
  
  \( W \rightarrow \) Width of CMLR
  
  \( L \rightarrow \) Length of CMLR
  
  \( d_{rf} \rightarrow \) Distance detected by RF
  
  \( d_f \rightarrow \) Distance detected by FR
  
  \( d_{dfl} \rightarrow \) Distance detected by DFL

[1]
Fuzzy Parallel Parking Mode

[Diagram showing steps (a) to (f) of the parking mode process]

[1]
Fuzzy Parallel Parking Mode

[1]
Behavior Modes of CMLR

- Fuzzy Garage Parking Mode
  - Basic Constraints
    
    \[
    (1.4L < d_{rf} < 1.8L)
    \]
    
    \[
    (1.8W < d_f < 2.4W)
    \]
    
    \[
    (1.4L < d_{rm} < 1.8L)
    \]

  Where,
  
  \(W\) → Width of CLMR
  
  \(L\) → Length of CLMR
  
  \(d_{rf}\) → Distance detected by RF
  
  \(d_f\) → Distance detected by FR
  
  \(d_{dfl}\) → Distance detected by DFL
Fuzzy Garage Parking Mode
Fuzzy Garage Parking Mode

[Diagram of the fuzzy garage parking mode process]

[1]
Experimental Results

1. FPPM

2. FGPM

[1]
Conclusion

- Multifunctional intelligent autonomous parking controllers of CLMR implemented using NIOS-embedded systems
- Autonomous parking controller capable of effectively parking CLMR in parking space has been developed
- It can recognize parking space and obstacle’s position to ensure safe autonomous parking