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Optimizing Dashboard Control in Mobile Robot Control

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Abstract: *Fuzzy control is an intelligent control method that imitates the processing of unclear information and human control decisions. This method is very suitable for controlling complex objects with uncertain mathematical models. However, direct dimming controllers are usually designed based on expert experience and have a "trial and error" characteristic, so when encountering complex objects, designers will spend a lot of time, and the results will not be optimal. In order to overcome the above limitations, this article introduces the application of cluster optimization algorithms to optimize the relevant functional parameters of the dimming controller, as well as the application of motion control for two-wheeled robots, where the speed of the left and right wheel motors is completely independent of each other. This model is built based on Matlab software, with the control target being the position of point P (x, y, ϑ) on the mobile robot, and tracking the position of the moving reference point Pd (xd, yd, ϑ). The simulation results indicate that introducing motion control methods for two-wheeled mobile robots is feasible and effective.*

Keywords: *Particle Swarm Optimization (PSO), Fuzzy-PSO, Mobile Robot Control*

I. Introduction

Fuzzy controller design involves choosing the membership function parameters, pre- and post-processing coefficients, and fuzzy rule bases. Most of these parameters are determined based on experience and are "trial and error", so it will take a lot of time to adjust when encountering complex objects whose results will not be optimal [1]. To overcome this, one of the methods used to optimize the fuzzy controller parameters is to apply the PSO swarm optimization algorithm. This is a random but directional search method that mimics the evolution of organisms in nature or the social behavior of swarms.

Ritesh B. Meshram and colleagues designed a matte controller to control the movement of mobile robots relative to leading robots to the desired position. Its inspiration comes from the behavior of swarms of organisms, such as birds and fish. Here, a team composed of n mobile robots will change their positions accordingly, without colliding with the leading robot when the robot changes its position. Therefore, guide the robot as a reference point for other robots in the group [2].

In Daniela Coman's research, robot control typically includes methods for creating and tracking paths. Guiding robot motion is a challenging task, especially in real-time and high-speed control. In order to achieve good tracking ability, the author proposes a path method based on fuzzy logic [3], [4].

In this study, the author suggests studying the application of clustering algorithms to automatically identify appropriate correlation functions for distance fuzzy controllers and angle fuzzy controllers, in order to determine the speeds of the left and right wheel motors of mobile robots, helping robots effectively move to any desired position in two-dimensional space. The successful control of a two-wheeled mobile robot using a

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Fuzzy PSO controller has scientific significance and high practicality. Control methods can be applied to multiple related objects.

II. Mobile Robot Control System

Physical model of mobile robots [5]

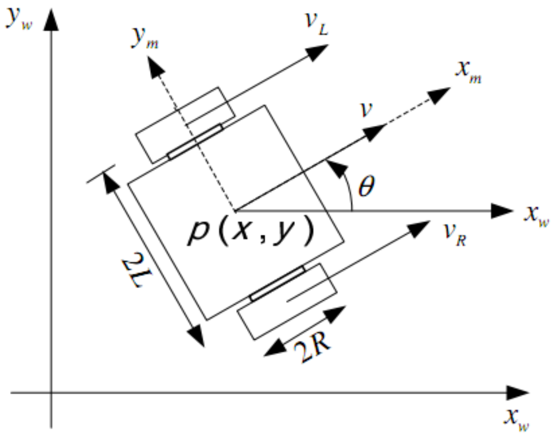

Figure 1:2 Schematic diagram of the movement of a 2-wheeled robot Among them: Xw, Yw: Global coordinate system X µ m, ym: Local coordinate system installed on the robot P: The Soul of Robots R: Wheel radius L: Distance from the center of the robot to the center of the wheel (x, y): Position of P θ: Counterclockwise angle between xm and xw B. A Mathematical Model for Describing Mobile Robots

The dynamic equation of a two-wheeled mobile robot [3]:

$$\begin{bmatrix} \dot{x} \\ \dot{y} \\ \dot{\theta} \end{bmatrix} = \begin{bmatrix} \cos\theta & 0 \\ \sin\theta & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} v \\ \omega \end{bmatrix}$$

In which: is the speed of the robot along the Xw and Yw axis; v is the linear velocity of the robot; is the angular velocity of the robot. >0 when the robot rotates counterclockwise;

C. Control target

Control the position of the point P(x, y, θ) on the mobile robot that follows the position of the moving reference point Pd(xd, yd, θd).

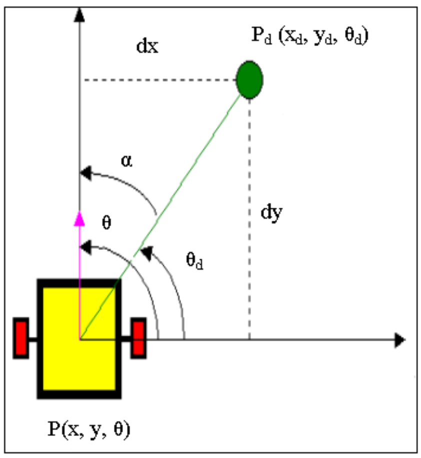

Figure 2. Mobile robot position and reference point

Figure 2 shows the position (x, y, θ) of the mobile robot. Where θ is the angle of the mobile robot relative to the horizontal axis Xw. (xd, yd) and θd are the position and angle of the reference moving point. α is the difference between the reference point angle (θd) and the robot head angle (θ). d is the distance between the robot and the reference point.

D. Design of fuzzy controller Mobile robot

- Input includes 2 variables:

+ distance d between robot and reference point

+ Angle error α between robot head direction and reference point

- Output includes 2 variables:

+ Speed left gear ωL

+ Right gear speed ωR

- Define fuzzy set for input variables and output variables Input variables value domain: + Distance d Є [0 6] (m)

+ Angle error α Є [-3.14 3.14] (rad)

Range of output variables:

+ Left wheel speed ωL Є [-120 120] (rad/s)

+ Right wheel speed ωR Є [-120 120] (rad/s)

- Constructing composition rules

Left wheel speed fuzzy rule ωL: there are 25 rules IF...THEN

Table 1: Left wheel speed fuzzy rule ωL

Left wheel speed ω_L		Distance d				
		VS	S	M	B	VB
Sai số góc α	NB	PB	PB	PB	PB	PB
	NS	ZE	PS	PS	PB	PB
	Z	ZE	PS	PS	PB	PB
	PS	NS	ZE	ZE	PS	PS
	PB	NS	ZE	PS	PS	PS

- Defuzzification and optimization

+ Selecting composition rules according to max-min rules

+ Defuzzification by centroid method

- Matlab simulink simulation diagram

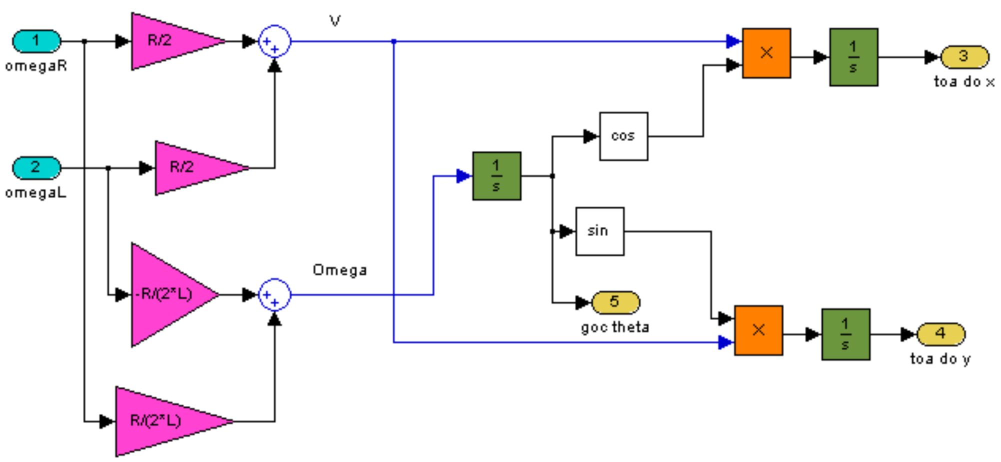

Figure 3. Simulation diagram of Mobile robot

III. Simulation results

- Select parameters of PSO algorithm
• Number of swarm individual N = 20
• Number of swarm generations Iter = 50
• Inertial weight w = 0.9
• Coefficient c1 = c2 = 1
- Simulation results

Simulation results with reference point running in grid pattern
+ Simulation time T = 60s
+ Number of sampled data K = 81
+ Location simulation results robot (x,y) and reference point position (xr, yr) as shown in Figure 4.

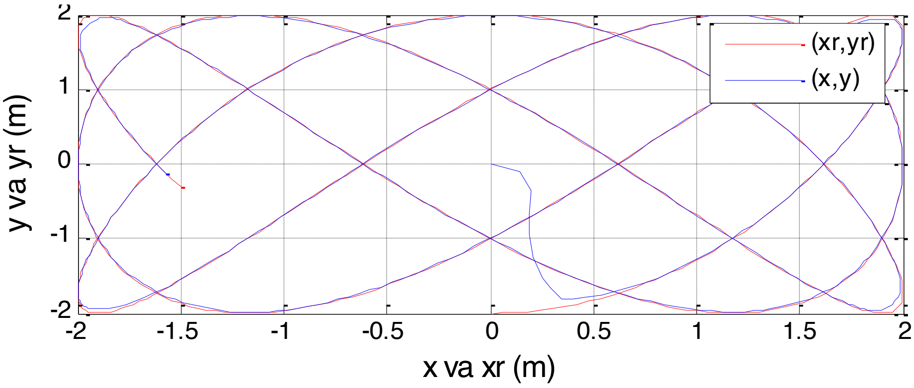

Figure 4. Robot position and reference point position after alignment

+ Angle theta and thetad

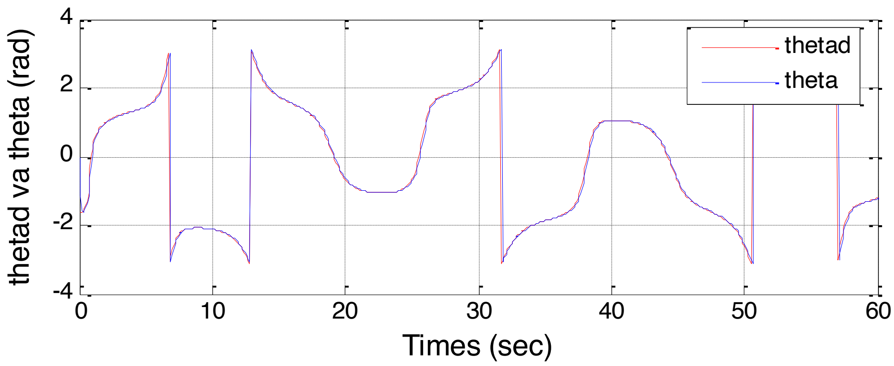

Figure 5. Angle theta and thetad after adjustment

+ Angle error alpha

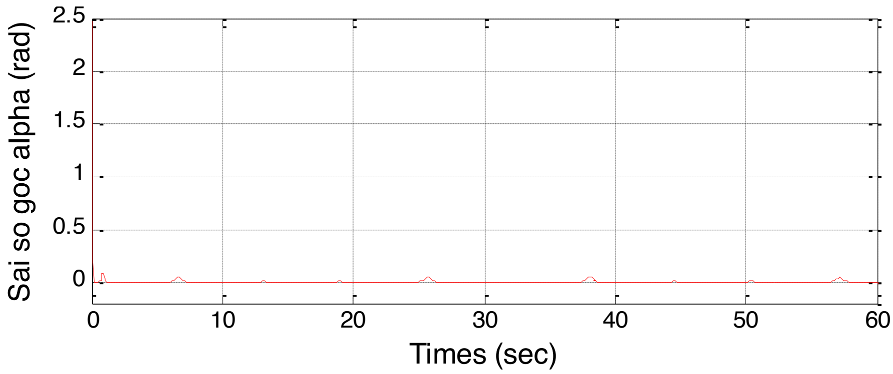

Figure 6. Alpha angle error after correction

+ Distance d

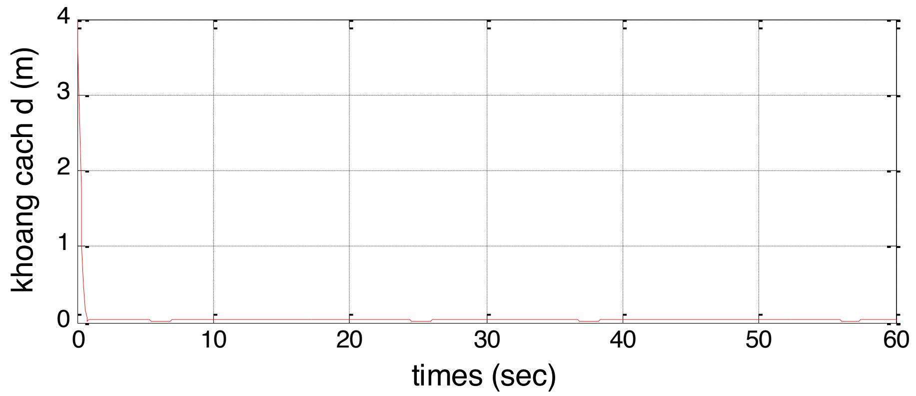

Figure 7. Distance d after setting

+ Simultaneously simulating the system with the case of using an unadjusted fuzzy controller and using a fixed fuzzy controller, the results show that: Distance d of the robot and the moving reference point after using the PSO algorithm to adjust the fuzzy parameters of the controller is significantly reduced compared to the case of using the undefined fuzzy controller when the reference point follows the grid line. The results of comparing the values of the control objective function are shown in Table 3. The robot always follows the moving reference point, for using the Fuzzy-PSO controller, the control results are better than the controller Fuzzy.

Table 3. Objective function values when using Fuzzy and Fuzzy-PSO controllers

Reference points running on grid paths				
Controller	***Fuzzy***		***Fuzzy-PSO***	
	v_r= 0.5	***v_r= 1***	***v_r= 0.5***	***v_r= 1***
Value Fitness	0.1276	0.5052	0.0549	0.0817
Value Fitness_D	0.1200	0.4900	0.0478	0.0720

IV. Conclusion

The author has successfully studied the swarm optimization algorithm in the fuzzy controller parameter setting and control application for the mobile robot object that follows the moving reference point in the grid.
- The left and right wheels of Mobile robot are controlled independently.
- The parameters of the PSO algorithm are selected with the number of individual N = 20 and the number of Iter generations = 50 but the simulation results show that the algorithm converges very quickly with very small objective function values fitness = 0.0549 and fitness_d = 0.0478.
- Simulation results have also demonstrated the effectiveness of the application of PSO algorithm in fuzzy controller parameter adjustment, showing the comparison results in Table 3.

The results of applying the PSO algorithm to the adjustment of fuzzy parameters is an effective optimization method to help designers find the optimal fuzzy parameters than the classical fuzzy method. At the same time, from this simulation result, it is possible to study and apply control to a class of correlated objects.

V. REFERENCES

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