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Design and Simulation of Motion Control Module for Non Steering Chassis of Knapsack Robot

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Abstract

By reading a lot of literature, this paper solves the problem of how the knapsack robot walks in the actual environment. Aiming at the complex and changeable robot environment, the insufficient control accuracy of fuzzy control itself and the problem of local oscillation, a hierarchical fuzzy control structure is proposed. The control method is fuzzy PID control without obstacles and improved fuzzy control with obstacles. The rationality and effectiveness of the improved method are illustrated by the comparative analysis of the simulation results before and after the improvement.

Keywords

Backpack-Typerobot; Pathplanning; Fuzzylogic; Pidcontrol.

1. Introduction

Knapsack robot is an intelligent robot which is widely used in indoor, road and field to complete a special task and can move all-weather and in real time. This kind of robot can perceive the environmental information, and can make decision planning, behavior control and other operations according to the specific situation [1-2]. In this paper, a motion control system based on non steering chassis of knapsack robot is designed and implemented by using PID controller and lag feedback control theory.

2. Path planning based on fuzzy control

2.1 Basic principle of fuzzy control

Fuzzy control avoids the requirements of traditional algorithms. Its principle is to input the obstacle information collected by the sensor and the pose information of the robot into the fuzzy controller after fuzzy processing, and map it to the corresponding output language set by querying the fuzzy control rule table. Finally, after defuzzification processing, the knapsack robot receives and outputs the corresponding control quantity, Follow the instructions to complete the task of path planning.

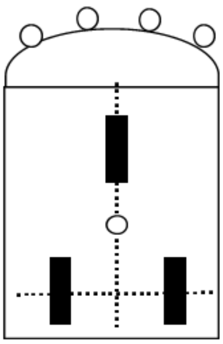

Fig. 1 Schematic diagram of robot model

The structure of knapsack robot adopts wheel structure, and its simplified model is shown in Fig. 1. In the figure, the motion structure of the knapsack robot is composed of one supporting front wheel and two independently driven rear front wheels. Its sensor system consists of one target sensor and four ultrasonic sensors [3]. Divide into groups according to the left, front and right directions, read the distance signals of two sensors each time, and take the smallest data as the input of the group, which is the simplest data fusion method.

2.2 Fuzzy controller design

Taking the distance information ‘d’measured by the ultrasonic sensor and the target positioning information ‘tr’ measured by the position sensor as the input of the controller and the control angle output variable ‘ta’ as the output, a fuzzy control system is established. In this way, the structural frame diagram of the four input one output fuzzy controller is obtained, see Fig. 2.

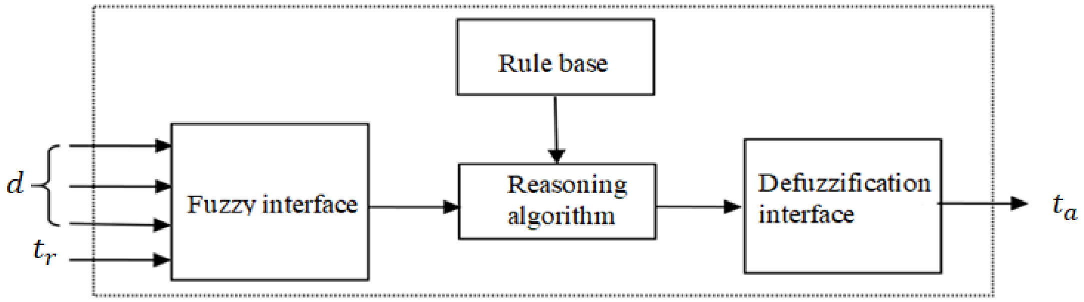

Fig. 2 Structure block diagram of fuzzy controller

2.3 Determination of fuzzy membership function

The input variables of the fuzzy controller are ‘Dr, DL and DC’. Their corresponding fuzzy language variables are d = {near, far} = {"near" and "far"}, and the universe is (0~6cm). The corresponding membership function is shown in Fig. 3. The fuzzy language of the target positioning variable TR is divided into tr = {lb, LS, Z, RS, Rb} = {"large left", "small left", "zero", "small right", "large right"}. The corresponding membership function is shown in Fig. 4, and the domain range is (-180 °, 180 °). The fuzzy language of the output variable TA is divided into TA = {TLB, TLS, TZ, TRS, TRB} = {"left large", "left small", "zero", "right small", "right large"}, and the scope of Discourse (-30 °, 30 °) [4], and the corresponding membership function is shown in Fig 5.

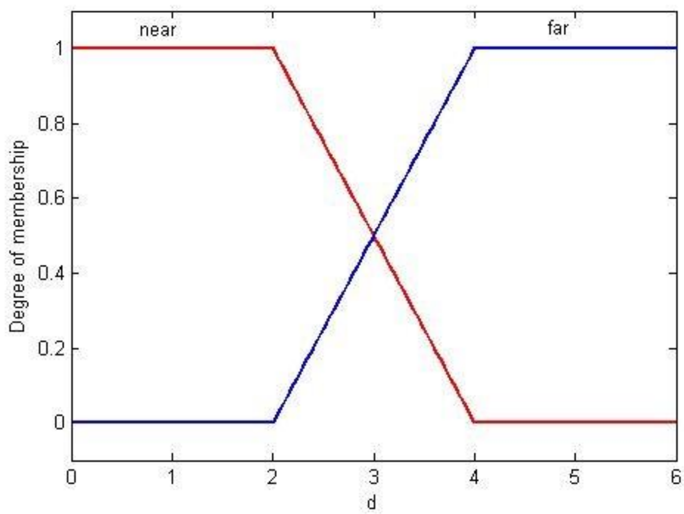

Fig. 3 Fuzzy membership function of distance from obstacles

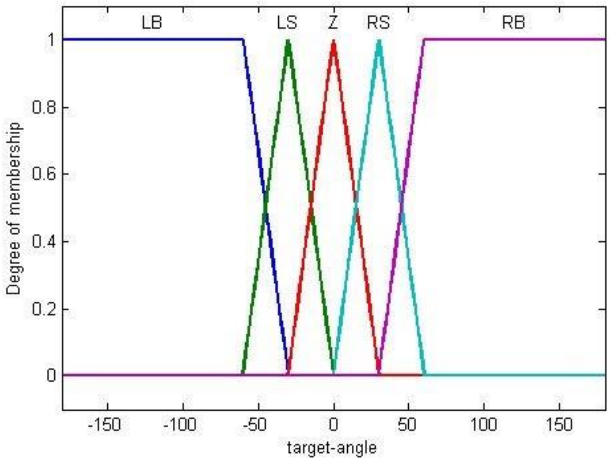

Fig. 4 Fuzzy membership function of target location

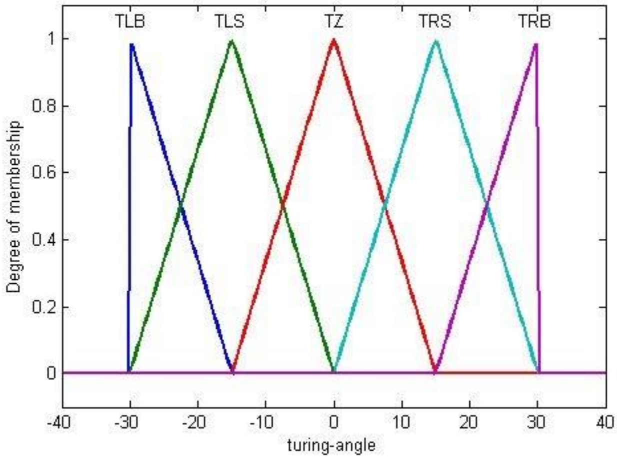

Fig. 5 Fuzzy membership function of rotation angle

2.4 Establishment of fuzzy control rules

According to the distribution of sensors, obstacles are placed in front, left and right of the robot. Fuzzy language is related not only to the distance information of obstacles, but also to the azimuth information of targets. The relationship is that two fuzzy language values correspond to the information distance of the obstacle, and five fuzzy language values correspond to the angle information of the target orientation. The situation of the backpack robot approaching the obstacle is shown in Fig. 6 [5]. Based on the above analysis, we can determine the total number of fuzzy rules. On the basis of combining with human driving control, the basic idea of formulating fuzzy rules is: when the knapsack robot approaches the obstacle, it will use the way of big turn to avoid the obstacle; When the knapsack robot is far away from obstacles, it will take the end point as the goal and reach the target by means of multiple small turns; The fuzzy rule relationship diagram is shown in Fig 7.

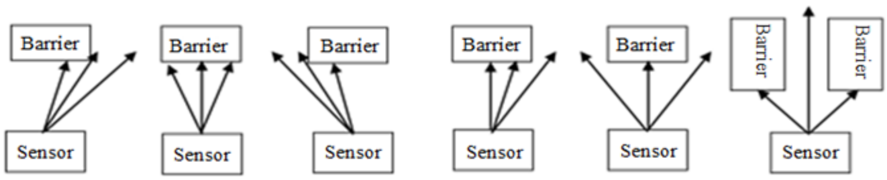

Fig. 6 Analysis of robot approaching obstacles

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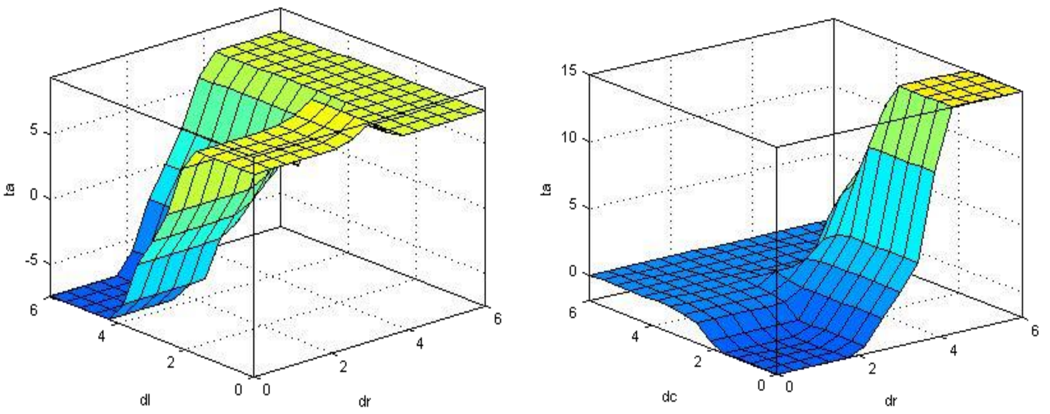
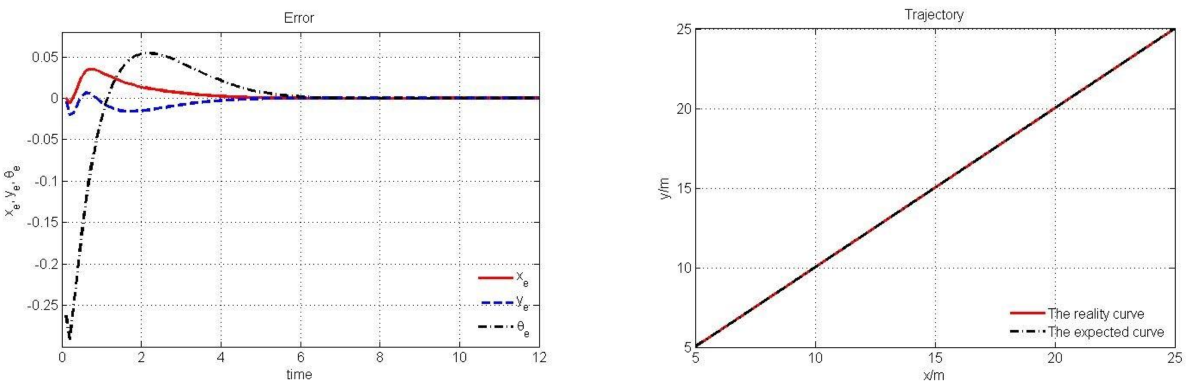


Fig. 7 Fuzzy rule graph

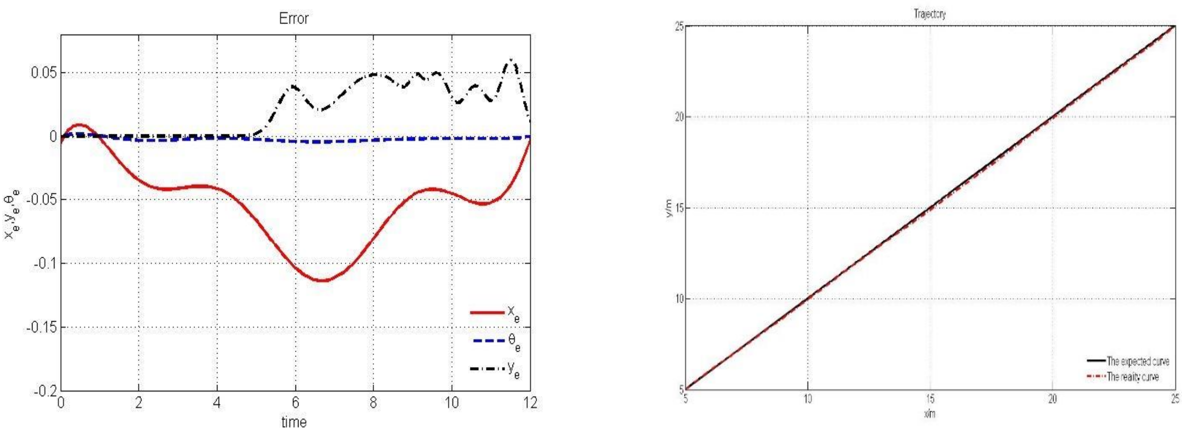
2.5 Fuzzy PID control of knapsack robot

In the case of obstacle free, a desired path from the starting point to the end point is assumed. PID algorithm and fuzzy control method are used for path tracking respectively. The two methods are compared in terms of angle error, position error and formed path. The path planning curve of obstacle free under PID control is shown in fig 8, The path planning curve with obstacles under fuzzy control is shown in fig 9.



a) PID angle and position error curve b) PID path planning curve

Fig. 8 PID control path planning without obstacles



a) Fuzzy control angle and position error curve b) fuzzy control path planning curve

Fig. 9 Fuzzy control path planning with obstacles

Through the comparative analysis of simulation results, it is found that in terms of overshoot and regulation time, in the obstacle free environment, the performance of traditional fuzzy control is not as good as that of traditional PID control, and jitter occurs; However, in terms of path planning, both

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control performances are very good when there are no obstacles. In general, the simple fuzzy control has some problems, such as insufficient control accuracy and large overshoot. The control effect is obviously not as good as the traditional PID control. At present, the most used control method is PID control, but it still can not meet the requirements of nonlinear, large lag and time-varying control of complex systems. In addition, the traditional PID control can not well deal with the contradiction between dynamic and static, set value and disturbance suppression, and the parameters are generally fixed [6]. Aiming at the problem that the parameters do not have variability, it is proposed to apply fuzzy control to the control of PID parameter adjustment. The mixed structure diagram of fuzzy controller and PID controller is shown in Fig 10.

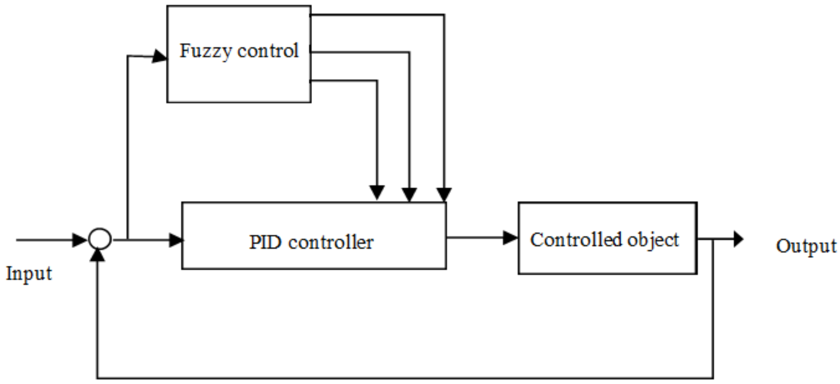

Fig. 10 Structure diagram of fuzzy PID controller

3. Conclusion

As an important branch of robotics, the research significance and value of knapsack robot is self-evident. Through the study of fuzzy control theory, it is applied to the research and Simulation of path planning of knapsack robot. Aiming at the control accuracy of fuzzy control, a hierarchical fuzzy control structure of fuzzy PID control without obstacles and improved fuzzy control with obstacles is proposed. Finally, it is verified by simulation. However, in the case of obstacles, the improved fuzzy control still has the phenomenon of jitter when it is close to obstacles, so more detailed research work is needed in this area.

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