Study on the Genetic and Fuzzy PID Control Algorithm of Soccer Robot

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Abstract — soccer robot is an important approach to the study on artificial intelligence control system at present stage. Taking FIRA robot as an example, this paper studies on the fuzzy PID control algorithm, it improves and optimizes the genetic algorithm, and makes analog and simulation towards the optimized results, and compares the optimized simulation results, the initial fuzzy simulation with the simulation results of original algorithm. It can be found through comparison that the optimized fuzzy PID control algorithm has stronger response timeliness, higher regulating temperature and shorter feedback time compared with traditional algorithm. It demonstrates that the genetic fuzzy PID control algorithm studied in this paper has a lot of improvement for the steadiness control of the robot, and the studying methods in this paper have some guiding significance to the study of artificial intelligence control system.

Keywords - soccer robot, genetic algorithm, fuzzy control, PID algorithm

I. INTRODUCTION

Artificial intelligence has a very wide field, and the studies on the artificial intelligence cover robots, intelligence control, information communication, the identification of sensors and other fields[1]. If the research is carried out only with artificial simulation, the research results are very difficult to adapt to changes of the complex environment. Due to the changes of complex factors such as site, rules and light rays, higher requirements are made to the robot control system for the robot soccer match; the unpredictable and complex changes have a strong guiding significance to the study on the control system of artificial intelligence.

Taking FIRA robot as an example, this paper is based on traditional PID control algorithm, and eliminate the interference of some factors such as information communication and the identification of sensor, it only optimizes PID control algorithm and makes optimized complementary towards the fuzzy control structure to study the actual control effect[2-4].

II. ROBOT SOCCER MOVEMENT PRINCIPLE

A. Basic Introduction to FIRA Soccer Robot

Soccer robot has "eyes", "brain" and "feet" similar to real soccer players, but all these are realized through electronic equipment. In the FIRA games of current stage, the "eyes", namely the image capture device, usually takes high-speed cameras with over 40 frames per second to capture the movement of the football on the ground. The captured images are decided on the route by soccer robot's "brain", namely the movement decision system after being processed by image processing software, and then instructions are given to the robot's "feet", wheeled power device driven by the motor to perform the order. In this process, first-class soccer robots control the achievement of this process within 15 milliseconds, about 6 milliseconds for the image processing for the present stage, 3 to 5 milliseconds for the route planning due to the complexity of situations and the conditions of equipment, then 5 milliseconds for the control algorithm about the effective execution (this time includes the data communication time).

Through the equipment of advanced cameras and high-speed processing chip, the robot’s reflex arc’s reaction time can be shortened to a certain degree, but it must be through the optimization of algorithm in the executive part of robot to shorten the time needed for execution. Diagram of FIRA game scene is shown in figure 1.

Figure 1. Diagram of FIRA Game Scene

The FIRA has complex hardware system and software system, the study in this paper focuses on the performance part of soccer robot, and the hardware of performance part includes drive motor, micro controller, communication module and power module. The specific structure diagram is shown in figure 2. This paper mainly studies the software algorithm of microcontroller.
III. PRINCIPLES OF FUZZY PID CONTROLLER

Due to the relatively strong robustness, high reliability, simpler algorithm and more convenient simulation platform of PID control, most of the industrial control systems use PID control system.

A. Basic Principles of PID Controller

PID controller consists of proportion unit P, integral unit I and differential unit D. In the process of control, the goal of control is achieved through the setting and adjustment of three parameters kp, ki and kd. PID controller is mainly used in the systems with the basic linear property and dynamic characteristics not changing with time. Specific principle diagram of PID control system is shown in figure 3. Among it, the control law can be expressed as:

\[ u(t) = k_p e(t) + k_i \int_0^t e(t) dt + k_d \frac{de(t)}{dt} \]  

(1)

In formula (1): u(t) and e(t) are the control value and input value of PID controller at t time; Ti and Td are the integral time constant and differential time constant; kp is the proportional gain. Formula (1) can be converted into:

\[ u(t) = k_p e(t) + k_i \int_0^t e(t) dt + k_d \frac{de(t)}{dt} \]  

(2)

In formula (2): kp is proportional coefficient; ki is integral coefficient; and kd is differential coefficient.

Among it: \( k_p = \frac{T_i}{T_p} \); \( k_d = \frac{T_d}{T_d} \).

B. The Application of PID Control in Soccer Robots

The main actions in the process of movement of soccer robots include running movement and turning angles, running movement is from one point to another, turning angles is rotating from one direction; these two actions are the foundation for the robots to complete other complex movements. The control principle diagram of using PID in soccer robot is shown in figure 4.

Provided that point \( (x_1, y_1, \Theta_1) \) is the starting position for the robot, point \( (x_2, y_2, \Theta_2) \) is the position of targeted balls, x, y is the horizontal and ordinate values in the coordinate system established with a certain point in the plan as the original point, \( \Theta \) is the clockwise angle of the robot heads for y axis, the position relation of the robot with the ball is shown in figure 5.

The distance between the robot and the ball is as follows:

\[ d = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2} \]

Angle difference is: \( \Theta = \Theta_1 - \Theta_2 \)

Robot needs to adjust the movement locus in the process of moving towards the ball according to the values of d and \( \Theta \) so as to achieve the goal of better tracking the ball.
C. Fuzzy control theory

In general, control problems need to be abstracted to be a mathematical model, and then answered. But in many cases, objects needing to be controlled are very complicated and difficult to establish a model, or simple mathematical models need basic supplement due to the irregular changes of data and information. In terms of this situation, a controlled choice is obtained through the making of information and rules, and the summary of experience. Although this choice will not solve the problem, it can be closer to the reality. Through the constant adjustment of the information obtained, the controlled results are made infinite close to the targeted state.

Fuzzy control is a kind of selection method based on experience and rules, first of all, there is a need to blur the current state, namely the actual state is abstracted to be a corresponding state which can match the established rules, and then the corresponding results are obtained in comparison with the rules information, and then the corresponding action instruction is selected according to the contrasting results. After the completion of the action, then according to the feedback information, the abstraction is made once again with contrasting with the established rules to get the judgment in next round, until the predicted aim is infinite closed or achieved. Simple fuzzy control rule table is shown in table 1, while the actual rule table is more complicated than table 1.

<table>
<thead>
<tr>
<th></th>
<th>&gt;R</th>
<th>~R</th>
</tr>
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<tbody>
<tr>
<td>d</td>
<td>Anti-clockwise Turn &amp; Walk</td>
<td>Anti-clockwise Turn</td>
</tr>
<tr>
<td>~d</td>
<td>Walk</td>
<td>Shot</td>
</tr>
<tr>
<td>&lt;d</td>
<td>Clockwise Turn &amp; Walk</td>
<td>Clockwise Turn</td>
</tr>
</tbody>
</table>

(Note: R is the radius of the underside projection of soccer robots)

D. Multidimensional Fuzzy Controller

In the process of practical application, more detailed judgment should be made on the number of data input variables. The more variables for the input system and the more latitudes of fuzzy control, soccer robots can choose distance variable and angle variable to control the whole motion process, so the fuzzy control adopted in the development process of this project is two-dimensional fuzzy controller. The principle diagram of the two-dimensional fuzzy controller is shown in figure 6.

IV. FUZZY PID CONTROL WITH THE GENETIC ALGORITHM

Through many years of study on traditional PID control, people obtained a more thorough understanding of the rules of PID control. Integral gain is smaller, the elimination effect of static error is poorer, but the integral gain is too big, it will cause too large error correction. The effect of fuzzy control can be improved by the establishment and extraction of enough intermediate variables and the establishment of comprehensive contrasting rules.

A. Fuzzy PID Control by Parameter Self-regulating

In the fuzzy control system of soccer robots, the method of parameter self-regulating of fuzzy controller is to establish table query with the use of fuzzy control rules and using fuzzy set method and theory, the formulation of rules form is adjusted based on experience, there is a need to blur the feedback information, and then compared with those rules.

Figure 7 is the structure drawing of fuzzy PID control by parameter self-regulating.
B. Introduction to the Genetic Algorithm

Based on natural selection and genetics, the genetic algorithm is adaptive iterative search algorithm, and it sets up intervals based on the feedback information in the motion process of soccer robots to judge the fitness of previous behavior and select better fitness to preserve and further select optimized algorithm. The specific calculation process of genetic algorithm is as shown in figure 8.

According to the operation process of genetic algorithm, fuzzy PID structure is modified, with the genetic algorithm added in. The structure drawing of fuzzy PID controller based on the genetic algorithm is shown in figure 9.

C. Simulation contrast of the genetic algorithm

After using the genetic algorithm, the optimized algorithm is obtained through the field practice of a lot of actual match situations and the exercise of algorithm, which is beneficial to the establishment of simulation model via the genetic algorithm to optimize fuzzy PID control, and the simulation of its actual regulation effect. The simulation model diagram of genetic algorithm to optimize PID control is shown in figure 10.

At the same time, the previous algorithms are simulated using the same simulation model, and initial parameters kp, ki, kd of fuzzy PID control are optimized and conducted with simulation comparison, the specific results are as shown in figure 11.

In figure 11, three curves respectively represent different algorithms. a. optimized genetic algorithm model. b. non-optimized genetic simulation algorithm model. c. traditional fuzzy algorithm of PID control model.

Through the comparison of waveform, it can be directly seen that genetic algorithm has obvious advantages over traditional fuzzy algorithm in the PID control process of soccer robots, and the optimized genetic algorithm can better debug PID, and it has advantages of small overshoot, short adjustment time and low steady state error.

V. CONCLUSION

Through the study of genetic fuzzy PID control algorithm of soccer robots, it can be clearly found that the genetic algorithm has obvious effect on the solution to complex and changeable PID control, and this conclusion has certain significance to the study of identification and control in the
field of artificial intelligence. It is believed that the continuous training and optimization of the genetic algorithm will be a common research direction in the field of control of different artificial intelligences.

REFERENCES


