Research on Intelligent Control Based on Multi-Agent Technology and Its Application in Robot Field

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Abstract. Firstly, the definition and characteristics of multi-agent technology are described. By analyzing the application research literature of multi-agent technology at home and abroad, the basic research of multi-agent system is analyzed and the technological development in the direction of multi-agent consistency and control is combed. Then the technical methods of intelligent control are analyzed, and the application of intelligent control in robot field is analyzed and explored. It is pointed out that the advantages of intelligent control are open, hierarchical and distributed structure, strong comprehensive information processing ability, and good at handling uncertain, highly nonlinear and complex control tasks of the model. Its shortcomings are that the theoretical basis is still in the development stage, the control accuracy is not high, and the real-time performance is poor. Finally, the development direction of intelligent control is expounded in combination with the above contents, hoping to create conditions for the overall improvement of Chinese intelligent control technology.

1. Introduction

The application research of multi-agent technology originated in the 1980s and was widely recognized in the mid-1990s. Since its development, it has become a hot topic in the field of distributed artificial intelligence. Its intelligence is mainly embodied in perception, planning, reasoning, learning and decision-making. With the development of robot technology, people’s requirements for robots are no longer limited to a single robot. And more energy will be transferred to the system composed of multiple robots. As an important milestone in the history of automatic control technology, the birth of intelligent control technology has overturned the concept of control technology.

In the intelligent control technology, the advanced technologies of computer technology, intelligent technology and artificial neural network technology are combined. Intelligent robot systems are usually composed of several specialized subsystems that have division of labor, cooperation, coordination and competition. Designing the whole system with traditional centralized control or hierarchical control methods will encounter some difficulties that are difficult to overcome [2]. The goal of multi-agent system is to enable several systems with simple intelligence but convenient management and control to realize complex intelligence through mutual cooperation, so as to reduce the complexity of system
modeling and improve the robustness, reliability and flexibility of the system. In order to further promote the better application of robots in various fields, this study discusses the application of intelligent control in the field of robots based on the control theory of multi-agent technology, hoping to provide reference for further research on robot technology.

2. Multi-agent System
An agent is a computer system in a specific environment. The system can autonomously accomplish the set goals in its environment according to its own perception of the environment, existing knowledge or through autonomous learning, and communication and cooperation with other agents. It is generally believed that individual agents can form a powerful multi-agent system through mutual cooperation and mutual service. It can be composed of multiple agents with lower intelligence and capability or a single agent, or it can be based on a few more complex agent members. Multi-agent system refers to a distributed intelligent system composed of several simple agents that can cooperate with each other and use relevant technologies to accomplish some global or local goals. Among them, multi-agent technology plays a crucial role in the construction of multi-agent system. Deliberative agent, also known as cognitive agent, is a symbolic model of display, including the logical reasoning ability of environment and intelligent behavior. It maintains the tradition of classical artificial intelligence and is a knowledge-based system. Environmental models are generally implemented in advance to form a knowledge base of major components. Deliberative agent can be regarded as an active software entity with internal state, with modules such as knowledge representation, problem solving, environment representation, specific communication protocol, etc. The structural block diagram of the deliberative agent is shown in Figure 1.

3. Development and Characteristics of Intelligent Control Theory
Feng Chenyu puts forward the idea that intelligent control is a "dualism" of the intersection of artificial intelligence and automatic control, and lists three kinds of intelligent control systems [4]: (1) the control system with human as controller; (2) the control system with man-machine combination as controller; (3) Unattended Intelligent Control System. Intelligent control is a combination of artificial intelligence, operations research and automatic control, which is a "three-element theory" and the structure of hierarchical intelligent control system. Knowledge is the basis of reasoning and execution of agents. It includes domain knowledge, communication knowledge, control knowledge, etc. Communication is the key for agents to achieve local planning and global goals. It can be data exchange between software modules, hardware network interfaces and high-level communication protocols. After decades of development, academic organizations and conferences in China have achieved certain results. Among them, intelligent control methods and technological processes based on computer intelligence have also successively proved their value. Its optimization and the establishment of immune system have provided

![Fig. 1. Structural block diagram of deliberative agent](image-url)
new materials for Chinese industrial modernization. Document [5] puts forward the four-element structure theory of intelligent control on the basis of Saridis’s "triple theory", that is, intelligent control is the intersection of four disciplines of automatic control, artificial intelligence, operational research and information theory, and proposes that information theory is an important and indispensable subset in the intersection structure of intelligent control. The idea of "quaternion" further perfects the structural theory of intelligent control. In the future, more attention will be paid to the application and development of intelligent control technology in the process of Chinese modernization, and it is hoped to contribute to the improvement of the overall level of Chinese modernization.

In the research of control theory, we often choose some empirical mathematical models as the research framework, and then express and mine them according to the actual system requirements. The development of traditional control theory to intelligent control theory has realized a comprehensive change in epistemology and methodology. The intelligent control system has an open, hierarchical and distributed structure and has strong comprehensive information processing capability. Intelligent control is not to pursue the high degree of autonomy of the system as the ultimate goal, but to pursue the overall optimization of the system. The basis of intelligent control theory is related theories in operations research. The characteristics of intelligent control system are mainly distributed, hierarchical and open [6]. At the same time, the intelligent control system also has strong comprehensive information processing capability. The service objects of intelligent control are mainly non-linear and uncertain research objects, which are the contents that the traditional control theory, which mainly studies linear structure, cannot operate. In the practical application process, intelligent control usually integrates multiple methods and then uses them. The common and typical methods are mainly fuzzy intelligent control and expert intelligent control. The design of intelligent control system focuses on the description of mathematical models, the identification of symbols and environments, and the design of knowledge base and inference engine. It is different from the traditional method of describing the system through mathematical models such as kinematic equations, dynamic equations and transfer functions.

4. Technical Method of Intelligent Control Based on Multi-agent Technology

The technical methods of intelligent control include neural network control, fuzzy control, expert control, hierarchical intelligent control, anthropomorphic intelligent control, integrated intelligent control, etc. In practical application, several intelligent control methods are usually combined together or combined organically with traditional control. Multi-agent system is composed of a series of agents with different functions, but it is not a simple integration of multiple agents. It mainly studies the coordination of intelligent behaviors among agents in the system [7]. Among them, distributed control systems implemented by mobile robots in unknown environments are gradually occupying the mainstream of mobile robot control. With the rapid development of artificial intelligence and robot technology, there is a new upsurge in the research of intelligent control. Various intelligent decision-making, expert control, learning control, fuzzy control, neural control, active vision control, intelligent planning and fault diagnosis systems have been applied to various industrial process control systems, intelligent robot systems and intelligent production (manufacturing) systems. In daily practical operation, the common method for intelligent control application is to combine several intelligent control modes. Typical intelligent control methods include the following.

4.1. Fuzzy control

The fuzzy control system is mainly composed of four parts: input quantity fuzzification module, knowledge base, fuzzy inference engine and output quantity fuzzification module, as shown in fig. 1. The external visual information is converted into task information and environment information through the vision system. At the same time, the agent determines the head motion parameters through the detection of features, so that the internal and external parameters of the three-dimensional stereo vision system can be reasonably adjusted to capture high-quality image information. The fuzzy control process is as follows: firstly, the input quantity fuzzification module converts the precise quantity of the input measurement parameters into fuzzy quantity; Then the fuzzy inference engine deduces the fuzzy control
quantity with the support of the knowledge base. Finally, the output clarification module converts the fuzzy control quantity into the control quantity that the actuator can receive. Since robot vision is different from human vision, it can sense the environment through various sensing methods and understand the surrounding environment through system modeling. Once the modeling accuracy is accurate enough and the range is large enough, the movable range of the mobile robot will be effectively expanded.

Fig. 2. The structure of fuzzy control system

4.2. Expert control
Expert control is a control method that combines expert system technology and traditional control technology and makes the controlled system optimize to the greatest extent based on the knowledge and rules of expert system. A typical structure of the expert control system is shown in fig. 2. All local solutions in the system are integrated to form the final optimal solution that meets the system requirements. This agent obtains the solution of the left/right hand motion planning agent, and adjusts it by driving saturation constraint and double-arm kinematics dynamics constraint to obtain the global optimal solution of joint angle, joint speed and joint acceleration of 7 joints of double arms. This method is based on the theoretical basis of expert intelligent control and optimizes the control method. From the point of view of path planning and obstacle analysis, good environmental positioning can also help robots to better avoid obstacles, thus realizing the planning and deployment of mobile paths, and further improving the engineering adaptability and exploration ability of mobile robots.

Fig. 3. Curved structure of expert control system

4.3. Hierarchical intelligent control
Hierarchical intelligent control is a control method based on the idea of "triple theory". The system consists of three levels: organization level, coordination level and execution level. This agent mainly completes how to select appropriate image and model features to correctly describe the target and how to effectively track the features to achieve the goal of tracking the target. Its development has greatly promoted the enrichment of its theory, and its application in the robot industry has greatly improved its humanization. How to select an optimal route for robots in complex environment has become a hot topic in current scholars' research, namely the so-called path planning problem. At the organizational level, for task planning, a set of primitive events is defined to represent the decomposed basic actions, action objects, action results, etc. that the control system can complete. Primitive events and their combinations can represent both external task inputs and subtasks and their combinations. Each robot and strategy can write useful information related to itself into a global central database similar to a blackboard for other robots or strategies to read, so that each robot and strategy can read the information they think useful to make their own decisions. Therefore, it is most appropriate to use neural networks in this process. At
the same time, fuzzy algorithms and genetic algorithms can be introduced to enrich the types of neural networks, thus realizing local planning more perfectly.

5. Application of Intelligent Control Method in Robot Technology

5.1. Trajectory control of robots

Document [8] studies a wheel-legged robot. The robot has four legs, and the leg mechanism consists of a connecting rod and a driven roller connected at its end. The robot's walking is realized by driving the driven roller backward by two connecting rods of the rear two legs to make a "back pedal" action similar to skating action. This kind of robot is also called "skating robot". The agent determines the driving capability of the motor according to the mechanical characteristics of the joint motor and feedback signals (such as current and rotation speed) of the motor in actual work, and then uses certain adaptive rules to adjust the joint motion speed of the robot in real time. The output of the agent is a series of joint motion speed adjustment coefficients. The microprocessor control system can realize information exchange with the host computer, thereby obtaining joint instructions and carrying out information feedback.

The mass of each bar of the 5-DOF robot, the distance from the center of gravity of each bar to the corresponding joint rotation axis, and the length of each bar are shown in Table 1. The length and mass of the connecting rod 5 are small, and the motion amplitude of the wrist joint is small. The influence of the small angle motion of the wrist joint on each heavy moment value can be ignored. When calculating the heavy moments of the first three joints, the connecting rod 3, the connecting rod 4 and the connecting rod 5 can be regarded as one rod.

| Member number | Quality(g) | Distance between center of gravity and axis of rotation (mm) | Bar length (mm) |
|---------------|------------|-------------------------------------------------------------|-----------------|
| 1             | 2461       | 110                                                         | 96              |
| 2             | 964        | 125                                                         | 124             |
| 3             | 674        | 78                                                          | 59              |

At the same time, this system can also control the joint movement. In this system, the fuzzy control method can not only eliminate the error of the control system, but also improve the stability of the system. From the point of view of dynamics, the relevant technical characteristics of robots are non-linear and change at any time. What we pursue in the control technology of robots are various tasks, which is precisely the relevant advantage of intelligent control. In order to stimulate the intelligent robot through the target instruction, so that the robot can complete more complicated work and labor according to the human expectation, it is necessary to properly adjust and reconstruct the motion, which also involves the relevant principles of process intelligent control.

5.2. Motion planning of robots

Process intelligent monitoring is one of the most widely used types in industrial production at present. Its characteristic is to realize process monitoring of steel rolling, oil refining and material processing through continuous industrial production lines. Distributed control system realizes sensing and navigation control in complex environment through cooperation among heterogeneous agents. The structure of the system includes a deliberation layer, a control layer and a coordination layer, and a plurality of heterogeneous Ai Zhen bodies complete corresponding functions. The centralized management agent plans the path from the starting point to the target position for each robot according to certain rules, assuming that there are no dynamic obstacles on the path, and each robot keeps its own path unchanged in the actual movement process. Through the establishment of a set of traffic rules and the use of priority strategy in the conflict area, the movement speed of robots on each path is coordinated.
and planned in a distributed manner to avoid collisions. According to known target pose information or tasks assigned by users, and combined with environmental information (obstacles in working space, information of each joint of another mechanical arm, etc.), the agent plans the position, speed and acceleration of each joint of the robot according to a dynamic motion planning algorithm [9]. Through the effective application of process intelligent monitoring system, not only can production accidents be avoided, but also problems such as production quality decline and efficiency decline can be found and solved in time in the production process. Therefore, process intelligent monitoring is also the most widely used type of monitoring in the current production environment.

5.3. High speed and high precision motion control of parallel robot

In general, PID control is often used for point-to-point control of linear systems. Since the linear motor is of direct drive type, nonlinear factors such as thrust fluctuation, load variation, friction and the like have great influence on the dynamic performance of high-speed and high-precision parallel robot systems, which makes it difficult for a single PID controller to have good dynamic performance in high-speed and high-precision motion control [10]. Head movement control is carried out according to the head adjustment parameters determined by the three-dimensional visual perception agent. The agent needs multiple interactions with the perception agent to adjust the visual system to a reasonable internal and external parameter. At the same time, planning work can be added to the whole category of intelligent control to better carry out automatic adjustment work. In the application of some semi-automatic systems, one or two technicians may be required to supervise the equipment on site, mainly because the equipment itself does not have automatic adjustment capability. In the process of moving, it mainly relies on two back-up rollers. The application of fuzzy neural network intelligent control technology can be well realized, and in the actual application process, the robot system error can be reduced. In addition, intelligent control technology can also control the robot’s action plan in the application process. On the basis of unchanged single-path action route, distributed action characteristics are adopted to design, so that robots can avoid collision in areas where collision may occur. Through this design idea, collision of multiple robots is also avoided [3]. The application of this method fully shows that intelligent control can solve the problem of avoidance and coordination when multiple robots move.

6. Summary

Multi-agent technology has always been one of the most important research directions in the field of distributed artificial intelligence. After the rapid development of multi-agent technology in the past 20 years, how to construct a more flexible and adaptive multi-agent model in combination with the actual application background and how to reduce the cooperation and communication costs of multi-level complex systems have become urgent tasks at this stage. Using multi-agent technology and controlling in a way of "breaking the whole into parts" can greatly reduce the complexity of intelligent dual-arm robot system control. At the same time, the control system not only has the characteristics of general distributed systems, but also has strong robustness and reliability. In our country, intelligent control technology is in the development stage, and its technology is not mature. As one of the main aspects of its application, the robot industry, if combined with the application of various intelligent control technologies in its design, can promote the robot industry to obtain new development and provide greater convenience for mankind.

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