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Pioneer robot motion control based on ZigBee wireless electronic communication technology

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Abstract. In order to explore the multi-intelligent network collaborative control that involves the multi-intelligent control, network communication, computer technology application and so on, American pioneer robot is used as the intelligent body. Through ZigBee, the wireless communication network is set up. On the platform of host computer built by LabVIEW, the consistency of multi-intelligent biped robot network is studied. The research content is shown as follows: the application of discrete consistency control algorithm in multi-intelligent biped robot network collaborative control is achieved. The shortcomings of using theoretical value for collaborative control in the previous collaborative control are overcome. In addition, the application of sensors on the steering gear of robot is realized. The entire experiment process makes use of the actual value of motion angle of robot steering gear for the consistency experiments. Compared with the experiments using the theoretical value, it has high practical significance. Based on the requirements of multi-intelligent interaction mechanism, starting from human-computer interaction, LabVIEW is adopted to set up biped robot cooperative control host computer. What is more, the monitoring of robot collaborative control process is achieved, which well implements the requirements of interaction. The results showed that the robot consistency control evolution step is displayed accurately, which achieves the expected effect. At last, it is concluded that the biped robot display platform well meets the needs of multi-intelligent intelligence, achieving good effect on the control of multi-intelligent robot.

Key words. ZigBee, wireless communication, pioneer robot, cooperative control.

1. Introduction

In recent years, with the development of wireless communication technology, swarm robot technology and embedded system, the organic combination of the three, that is, wireless communication between swarm robots, has become the focus of today's research. With the rapid development of social production technology, the field of robot application is also being expanded. But in terms of the development of current level of robot technology, single robot is very limited in information ac-

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quisition, processing, control ability and so on. For complex tasks and changing work environment, it faced difficult problems of communication and coordination, complex wiring and so on. A swarm system composed of many robots, through coordination and cooperation to accomplish the tasks that a single robot cannot or will not be able to accomplish, will be a trend in the development of robots. At present, multi-robot communication usually adopts wired communication. Although the technology is mature and reliable, it has not been widely applied because the cable has limited the range and flexibility of the robot.

ZigBee network technology is a wireless communication protocol based on IEEE 802.15.4. It has the characteristics of low cost, low power consumption and low transmission speed. It also supports many network topology structure, such as star, tree, mesh and so on [1]. Multi-robot collaboration only needs to transfer limited information intermittently and to save energy as much as possible. In order to solve the problem of multi-robot cooperation, the use of ZigBee module is proposed to build the hardware platform for group robot mutual communication, and the ZigBee node is introduced into the hardware system. A mesh network is constructed through the ZigBee module, which can achieve reliable point-to-point communication. At the same time, the network can reach the purpose of simple wiring and convenient collaboration, which extended the work space of group robots and improved the work efficiency.

2. State of the art

ZigBee technology is a new wireless network technology with short distance, low complexity, low power consumption, low data rate, and low cost [2]. It is between the wireless tag technology and Bluetooth technology, mainly used for short distance wireless connection, to complete the function of network and communication between nodes. Compared with other short distance communications, it has great advantages. This article makes use of ZigBee technology to complete the information transmission and networking of the intelligent robot system.

ZigBee is an IEEE802.15.4 standard based, and newly emerging wireless network technology with short range and low rate. It is a technical proposal ranged between Bluetooth technology and wireless tag technology [3], mainly used for short distance wireless connection and wireless data transmission. It has its own radio standard, which coordinates and communicates through thousands of tiny sensors. These sensors require only a small amount of energy to transfer data from one sensor to another by radio waves in relays, so it is highly efficient in communication [4]. Finally, these data can be entered into computers for analysis or to be collected by another wireless technology.

ZigBee can be viewed as a wireless data network platform consisting of up to 65000 wireless digital modules, similar to CDMA networks or GSM networks for mobile communications [5]. Among them, each ZigBee network data transmission module is similar to a base station of a mobile network, which can communicate with each other over the entire network within the entire network range [6]. Moreover, the entire ZigBee network can also be connected with other existing networks. The

transmission distance between each network node can be extended from the standard 75m to hundreds of meters or even thousands of meters.

For simple point to point, and point to multi point communication, packaging structure is relatively simple, mainly composed of synchronous preamble, data, and CRC check-sum several parts. ZigBee is to use the concept of data frame. Each wireless frame includes a large number of wireless packaging, which contains a lot of time, address, command, synchronization and so on information. The real data only occupies a small part, which is the key that ZigBee can realize the network organization management and implementation of reliable transmission [7]. At the same time, ZigBee uses MAC technology and DSSS (Direct Sequence Spread Spectrum) technology to achieve high reliability and large-scale network transmission.

From another point of view, the emergence of MANETs is inevitable. The wired communication mode limits the application scope greatly and reduces the flexibility greatly. What's more, wired communications have poor resistance to damage and it cannot work in some special cases, like earthquakes. As a result, it requires a network that can withstand strong damage, and communication continuity is guaranteed under any circumstances. The army, in particular, has a strong demand for it. The study origin of ad hoc network is similar to that of TCP/IP protocols. In 1970s, Defense Advanced Research Projects Agency DARPA funded the new network architecture model using packet radio network for data communication in the battlefield environment in PRNET [8]. Later, in 1983 and 1994, it funded the SURAN (Survivable Adaptive Network) and the GloMo (Global Mobile Information Systems) project research. Ad hoc, which is called ad hoc network, absorbs the above networking ideas and ensures the rapid networking and super invulnerability of the army in the battlefield environment [9]. Similar to TCP/IP, ad hoc not only has wide application in the military field, but also lays a foundation for civil communication services, which has become the research focus of the industry. At present, there are as many as 70 kinds of routing protocols of ad hoc, which fully illustrates this point. For the network application of the previously described special environment (such as natural disasters, scientific investigation, exploration, battlefield environment and so on), these kinds of networks are powerless to do so. To communicate and implement the dynamic process of cooperative communication in special environment requires the network that has dynamic and rapid deployment, and does not rely on or rarely depends on the existing wired network, which is the mobile Internet [10].

Short duration. The delay sensitive applications are optimized, and the communication delay and the delay activated from the sleep state are very short [11]. ZigBee's response rate is faster, which generally just takes 15 ms transferring from sleep to work. The connection for node into the network only takes 30 ms, which further saves the electricity. By comparison, Bluetooth requires 3∼10 s, and WiFi requires 3 s.

3. Method

3.1. ZigBee wireless communication module

Similar to the multi-agent collaborative consistency, the information exchange between nodes is accomplished through communication. In the researches on motion pioneer robot control, the information exchange between nodes plays a very important role. The ZigBee wireless communication system is adopted in the experiment. As a newly developed wireless communication technology, ZigBee, in the network communication with short distance and low rate requirements, becomes more and more popular, and it is widely used in practical engineering. ZigBee has good network capacity, and a large number of nodes can be extended to realize wireless communication between multiple nodes. Secondly, with license free frequency, low cost, high efficiency, convenient and fast communication system, it can be used repeatedly. The ZigBee wireless communication system adopted in this experiment is the ZigBee wireless communication system development kit produced by Chengdu Wireless Dragon Communication Technology Co.Ltd. It is an economic, efficient, convenient and fast development kit. The system supports the USB high-speed download, and supports IAR integrated development environment, with online download, debug and simulation function, and it provides ZigBee protocol source code. In this experiment, we use ZigBee wireless communication system development kit, which is developed by Wireless Dragon Company and used for communication and location. The system uses the IAR development environment, which can download, compile and debug the communication code, and provide ZigBee protocol code by Wireless Dragon Company, which supports downloading the source program through USB.

The ZigBee stack structure consists of a set of modules called layers. Each layer performs a specific set of services for the above layer: the data entity provides the data transfer service, and the management entity provides all the other services. Each service entity provides an interface for the upper layer through a service access point (SAP), and each SAP supports a variety of service primitives to implement the required functionality. The ZigBee stack is built on the basis of the IEEE802.15.4 standard, and the protocol stack structure is described in Fig. 1. It is based on the standard open system interconnection (OSI) seven layers model, but defines only the layers that involve ZigBee. The IEEE802.15.4-2003 standard defines two lower layers: the physical layer (PHY) and the media access control (MAC) sublayer. The ZigBee alliance builds the network layer (NWK) and the application layer architecture on this basis [12].

3.2. Wireless data transmission of robot

The core part of this paper is to apply the ZigBee wireless communication system in intelligent robot system. First of all, the hardware design scheme of communication platform is designed, which designs and implements the connection circuit. Through the data communication of motor angle value, pioneer robot motion control system is achieved. In addition to positioning, one of the essential role of ZigBee

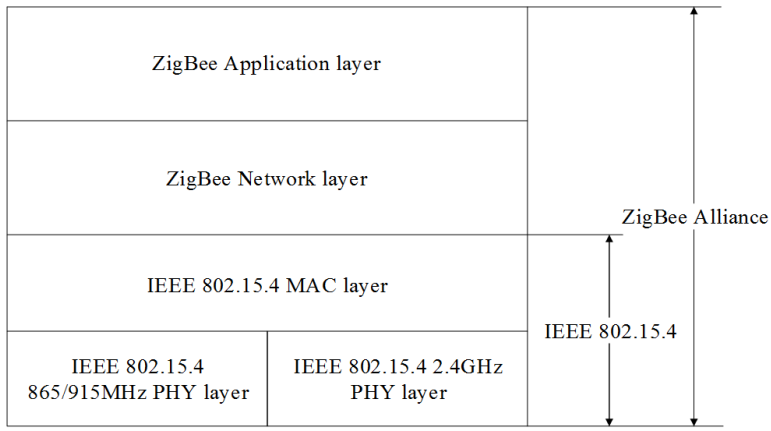

Fig. 1. ZigBee structural system diagram

system is the networking and communications. Firstly, the coordinator establishes the network, and then the coordinator, the router and the terminal node communicate with each other to realize the sending and receiving of the data information. Three basic and typical network topology structures, namely star networks, cascade networks and mesh networks, are introduced previously. In order to better study the network characteristics of ZigBee wireless communication system, we design several different forms of networks according to the network topology in the three forms, to verify if all the nodes run within the network can realize the communication connectivity, reliability and so on.

In order to achieve communication between the robots, a series of networking and communication experiments are done with ZigBee. Two biped robots are used as multi-intelligent individuals, labeled as A robot and B robot. This experiment adopts A and B two robots' right arm for collaborative control experiment. Each robot, as the communication node, is added to ZigBee wireless communication network. Two robots communicate with each other to obtain the state of right arm of another robot, and communicate its own angle value to each other. Then, the next step action is calculated through the consistency control protocol, and ultimately the right consistency control is achieved. And then, through the host computer interface monitoring and processing, information of each robot arm is reacted to the host computer. Because the information receiving of robot is real-time, the monitoring process is real-time and dynamic. The design diagram of the wireless communication network in this paper is shown in Fig. 2.

4. Results and discussion

This experiment is a two-order network topology model experiment. The information receiving in the process of experiments is based on sequential cooperative control. In the process of experiment, A robot arm information is displayed through

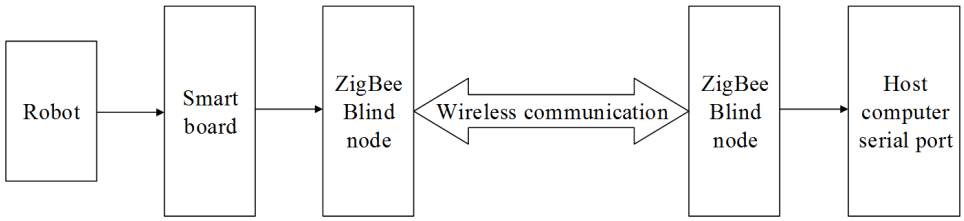

Fig. 2. Wireless communication network block diagram

the control components. The horizontal axis for displaying control is selected as the number of steps of the coordination and control, and the vertical axis is the robot steering angle information. The angle information is adjusted according to the actual size. The display control is shown in Fig. 3.

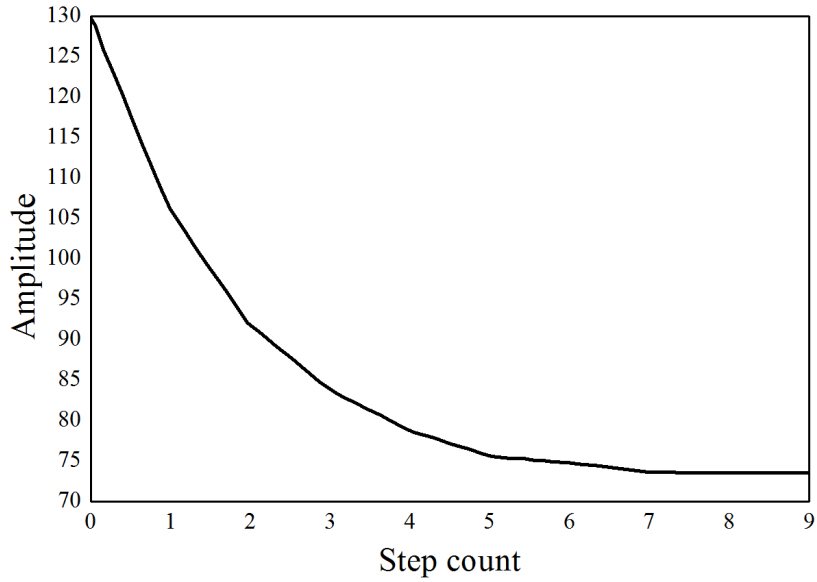

Fig. 3. Robot A right arm angle value

In the experiment, the information of the B robot is displayed by the corresponding display control components, and the angle value of the steering wheel of the B right arm is displayed, as shown in Fig. 4.

In the experiment, through the design of the program, the angle difference between the two servos in the process of consistency cooperation can be displayed, which can reflect the evolution process of cooperative control to some extent, as shown in Fig. 5.

The following analysis is made for the three curve graphs:

In the two robots monitoring experiment, steering angle can reach agreement, but

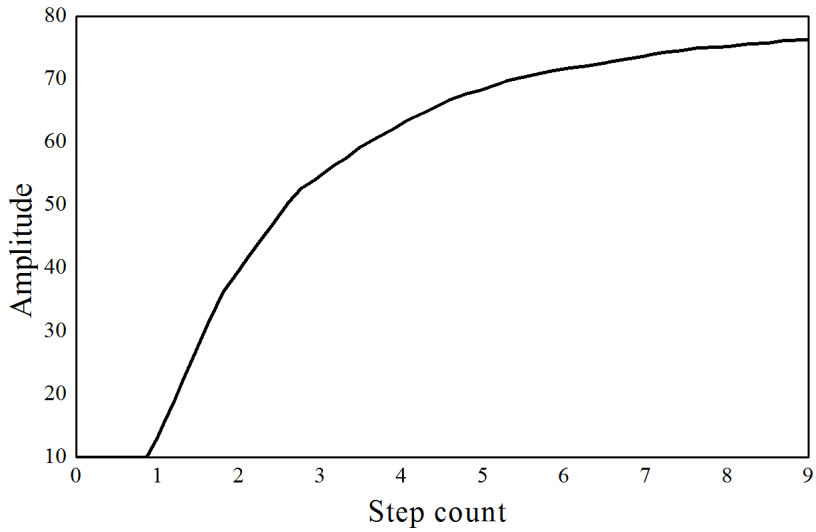

Fig. 4. Robot B right arm angle value

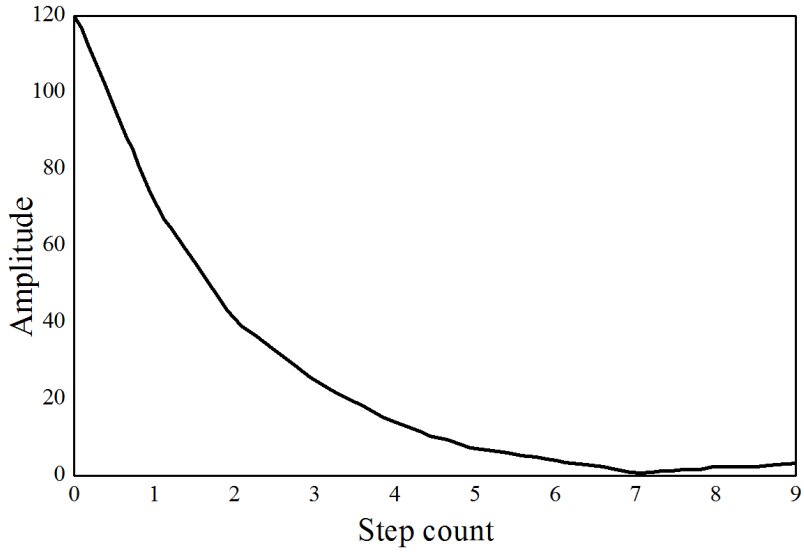

Fig. 5. Robot angle difference value

there is still a gap with the experimental theoretical value, and in the calculation of the theoretical value, two different steering gears can finally make intermediate values. It can be seen from the experimental results that the angle of motion of the steering gear in the initial experiment is relatively large, and then the change value becomes smaller, and finally the consistency is achieved. From the arm monitoring diagram of robots A and B, because the horizontal coordinate is the number of steps

needed by the collaborative evolution, and the time for performing a step basically is certain, so it is able to see the time that the experiment needs. Through the data in the upper computer, we can conclude that the experiment can indeed monitor the actual value of the robot rudder, and it has very good practical significance.

Through the experimental data, several instructions are made for the experiment. Based on the actual value of the angle, the cooperative control experiment is made. The robot steering angle value only makes feedback of integer data, so it is calculated by integer data. But in the calculation of the theoretical value, when the sensor is failed in reading, it will still take the theoretical value. In the selection of control conditions, the previous experiment is based on the theoretical value to be out of the program when the difference of two angles is less than 0.2 degrees. But in the process of experiment, due to the application of actual value, through the instructions, the robot's motion angle and actual movement angle has 2 degrees or so error. In the iterative process, with the accumulation of errors, the cooperative control evolution process is not as before, having relatively fixed consistency angle value, thus the conditions for ending the cycle will change.

5. Conclusion

This paper mainly studies the multi-agent system based on ZigBee wireless communication module, which has far-reaching theoretical and practical significance. It focuses on the ZigBee technology which has a huge advantage in the short distance communication technology. The protocol stack structure and network characteristics are studied. First of all, a wireless communication between nodes under several different network ways is designed and achieved. This is the important foundation of its application in multi-intelligent robot system. In this paper, the software and hardware platform of the wireless communication system is designed and implemented. Under the Z-Stack protocol stack software platform, a communication platform for communication is constructed, which successfully completes the functional requirements of cooperative control in the multi-robot motion process on communication functions. The experimental results basically verify the consistency of the system, and for the application of ZigBee, a new idea is broaden. The work done in this paper can be divided into the following three aspects:

Firstly, the multi-intelligent system development and research content object are studied. The multi-robot system is led out, the communication requirements of the system are analyzed, and the communication scheme of the robot system based on ZigBee wireless network is designed. For the popular ZigBee technology, the full range and multi-angle study is carried out. And it is compared with several other popular short distance communication technologies. In addition, its characteristics advantages are analyzed, and the network technology is especially discussed. Four kinds of networking modes are designed and achieved, and the communication between nodes is completed. An in-depth study is conducted for the ZigBee protocol stack, and the hierarchical structure and data format are explored in detail. For the communication needs, it is developed in the application layer platform. What is more, the hardware platform of wireless communication system is set up, the de-

sign, implementation, debugging and analysis are performed, and the consistency of multi-agent action robot system is verified.

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