

# Research and Design of the Modular Robot Fuzzy Control Based on ZigBee

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## Abstract

*Design a modular robot teaching device, combine with wireless communication technology, and robot control technology. Introduce ZigBee nodes into the robot's every module, transmit the current motion parameters through the wireless communication, adjust the robot motion state and realize the fuzzy control of the robot motion. This device has good openness, does not involve the establishment of the robot kinematics and dynamics model, and avoid a large number of algorithms in the same time. Its operation is simple, convenient, and more suitable for the teaching.*

**Keywords:** ZigBee; Modular robot; Fuzzy control

## 1. Introduction

As the typical representative and main technical means of information technology and advanced manufacturing technology, robotics develops rapidly in a short few decades. From the automatic production line to the exploration of Marine resources, and even the space operation, *etc*, the robot is ubiquitous. As a typical mechatronics system, the robot is increasingly being paid great attention in the general colleges and universities, and become the common object of teaching and experiment of them. But the current robot teaching mainly introduces the existing product, which has some restrictions as the carrier of teaching. Besides, its encapsulation is stronger, not conducive to the teaching of second development and the students' further study. At the same time, the introduction and establishment of the robot kinematics and dynamics model, bring inconvenience to the students in the actual robot operation and design, thus affecting the teaching quality and teaching effect to further improve and deeply.

As the development of wireless communication technology, robotics and embedded system, the wireless communication between multi-robots become today's research focus, and initiate a new climax to study wireless communication technology. This paper designed a kind of modular robot teaching device with open structure. The device transmits instant information between the modules by using ZigBee wireless network technology. This realizes the fuzzy control of the robot system motion state, and creates a teaching platform helpful for students to study, understand and grasp the robot structure knowledge and implement practices.

## 2. Research Background

Many colleges and universities are introducing the robot courses, but these courses focus on either the industrial robot, the large equipment of the production line, or the robot intelligent design. Besides, most robotic devices are existing products, the one combined with teaching that has good operation and open structure is not common. Even

the vehicles or the small humanoid robot that can be assembled also has many disadvantages as teaching props, because their design purpose is mainly on competition or interest cultivation,

For our school, a vocational college, mainly pays teaching focus on cultivating students' operation ability, and pays more attention to students' practical and innovative ability on the basis of meeting the requirements of theoretical knowledge. Therefore this paper designed a new robot teaching device, it is concise, clear from the appearance to the internal structure, has better openness, and facilitate the students directly observe the action and effect of the robot control. Each module of the robot can interact the state information between themselves in real-time through wireless technology, so as to realize the walking state control of the whole robot device. The device weakens all sorts of model creation and the calculation of the algorithm, very suitable for the experimental teaching of colleges and universities' automatic control subjects.

### 3. Wireless Communication Network Based on the ZigBee

The ZigBee technology introduction

ZigBee is a kind of wireless network protocol of low speed, low power consumption and short distance transmission based on IEEE802.15.4 standard. It is mainly used for wireless connection in close range, can be embedded in a variety of equipment, suitable for automatic control and remote control. The main characteristic of ZigBee network is low power consumption, low complexity, low cost, low rate, reliable, safe, and support a large number of nodes and a variety of network topology.

There are three types of ZigBee network nodes: coordinator, router, end device. The coordinator is responsible for the launch and maintenance of the normal work in the network; the router has the function of forwarding data message; the end device is simple, no forwarding function, and can only send and receive data. Each coordinator can be connected to as many as 255 nodes, and the resulting ZigBee network right has no limit to the number of the transmission. An actual Zigbee network only supports two kinds of wireless devices: full function device (FFD) and reduced function device (RFD) . FFD can provide all the IEEE802.15.4 protocol service, not only can send and receive data, also has the routing function. RFD can only act as an end-node, responsible for collecting data, and then sends it to coordinator or router for processing. The three types of nodes make ZigBee supports three types of network topologies: star structure, tree structure and mesh structure, as shown in figure 1.

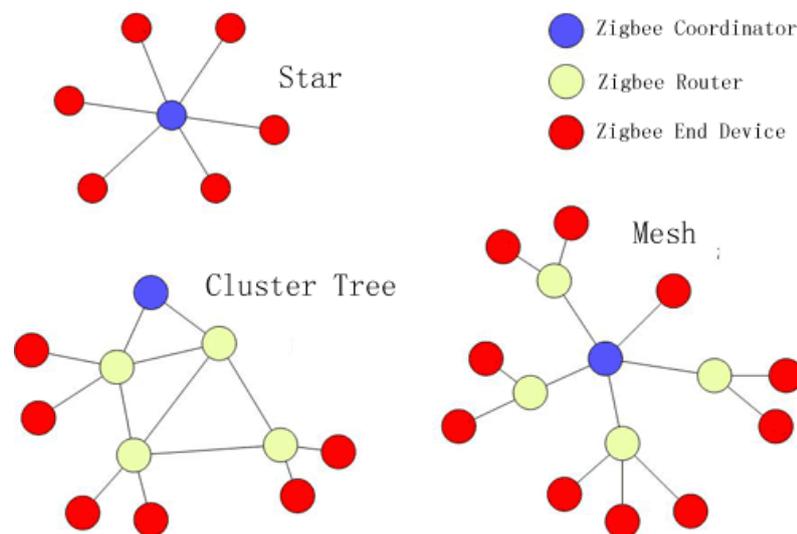


Figure 1. The Network Topology of the ZigBee

For the communication between robots, because of its small data flow and the power consumption, it is very suitable to use ZigBee technology.

#### A. The Commonly Used Wireless Modules Introduction

At present, in addition to the Zigbee technology, short distance wireless communication technology also includes Bluetooth, Wi-Fi technology and so on, their comparison of the main performance parameters is shown in table 1.

**Table 1. Comparison of Short-range Wireless Communication Parameters**

Category	ZigBee	Bluetooth	Wi-Fi
Single point coverage distance	50~300m	10m	50m
Power consumption	low	middle	high
Time for networking	30ms	10s	3s
Transmission rate (bit/s)	250Kbps	1Mbps	1 to 11Mbps
The number of nodes	65535	8	50
Terminal equipment cost	low	low	high
Complexity	Simple	complex	very complex
Network expansibility	auto	no	no
Security	128bitAES	64bit, 128bit	SSID
Integration and reliability	high	high	middle
Cost	low	middle	high

From table 1 shows, ZigBee technology in the field of low network transmission rate has a great advantage.

### 4. The System Design

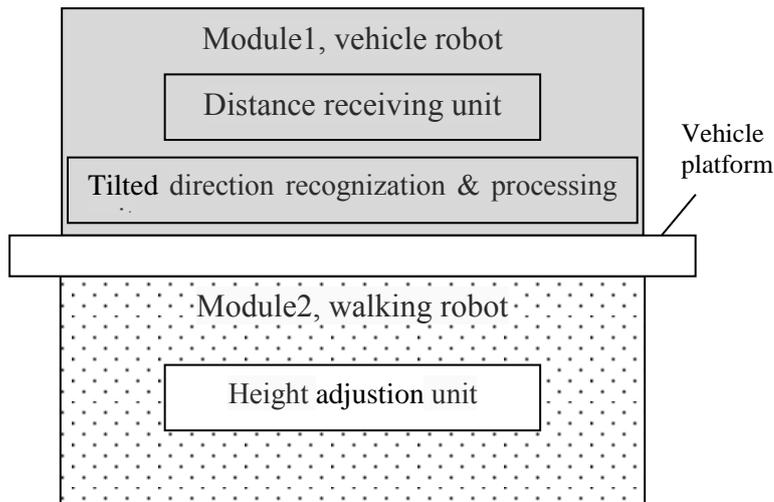
#### A. The System Design Principle

The design of the robot teaching device in this paper adopts modular overlapping type, including the vehicle robot, the vehicle platform, and the walking robot, as shown in figure 2.

Module1, the vehicle robot, locates on the top of the vehicle platform, adopting small vehicle design; its microprocessor mainly includes the distance receiving unit and the tilted direction recognition unit. Module 2, the walking robot, locates in the lower part of the entire device, under the vehicle platform, adopting humanoid walking robot design; its microprocessor includes the height adjustment unit. Module 1 superimposes on module 2 by vehicle platform, which has a ring baffle all around. Module 1 and module 2 both have built-in ZigBee nodes, and communicate each module through ZigBee wireless network transmission technology. Device avoids the trouble of wire connection between each model and the resulting restrictions on the device movement.

When robot moving, module 1, the vehicle robot receives the distance information between it and the baffle around by the distance receiving unit, combines with the tilted direction recognition & processing unit, determines the tilt of the robotic device, and then transmits the parameters to module 2, the walking robot. Module 2, the walking robot adjusts the height of the feet and the walking posture according to the information received, to make the platform trends to level. The entire robot tends to equilibrium state,

and realizes the adjustment and control of the whole robot motion state. The robot's two microprocessor can run the program independently, and also can control the walking robot and adjust the height of the vehicle platform to keep the whole robot balance movement induced by the vehicle robot when it walking.



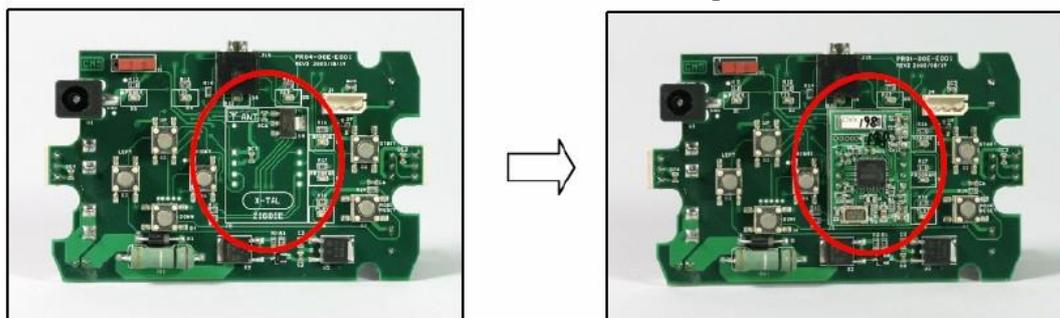
**Figure 2. The Modular Robot Teaching Device Structure Chart**

The openness of the modular overlapping type robot's structure is better, and is convenient for students to visually observe the robot's control of the action and effect. The two modular robots can establish communication connection through the communication interface between them, and realize the information communication, The whole robot control the walking robot through the information identification.

### **B. The Robot Hardware Module Design**

In the robot teaching device system, the robot hardware is generally contains the core controller module, the data acquisition module, drive module, actuators, and ZigBee wireless communication module.

ZIG-100 is a small module that has a built-in MCU and ZigBee IC, allowing UART communication using 2.4GHz frequency. ZigBee Module has a 16 bit address and each ZigBee Module has its own unique address. It can have any address between 1 and 65535, module can implement the communication between each other by it; however, address 65535 (0xFFFF) is reserved for broadcasting mode. Utilized as a PAN (Personal Area Network) Module, it replaces wired serial communication with more modern wireless characteristics. ZIG-100 is installed on the robot controller module. The robot controller module embedded with ZIG-100 modules as shown in figure 3.



(a) The Core Controller (ZIG-100uninstalled) (b) The Core Controller (ZIG-100installed)

**Figure 3. The Core Controller Module**

### C. The Partial Program

Before programming, the first of all is to determine the ZigBee ID of each robot module. The main code of the robot teaching device's motion control program is shown in figure 4.

1	START									
2	[Labe ]									[Comment]
	LOAD		[100]D...	{-	1023					
3	[Labe ]									[Comment]
	LOAD		101:52	{-	1023					
4	[Labe ]									[Comment]
	Double click!									
5	[Labe ] loop									[Comment]
	IF	(	101:26		<	50	)	THEN	JUMP	后退
6	[Labe ] loop1									[Comment]
	IF	(		[100]D...	<	150	)	THEN	JUMP	前进
7	[Labe ]									[Comment]
	IF	(		[100]D...	>=	150	)	AND		
8	[Labe ]									[Comment]
	CONT IF	(	101:26		>=	50	)	THEN	CALL	停止

Figure 4. Part of the Program Code

When the entire robot walking, the vehicle robot located on the vehicle platform detects its relative position to the baffle set on the vehicle platform by the distance sensor installed at its front and rear, gets the vehicle robot's offset relationship from the current position to the platform center, adjusts whether the vehicle robot is in the center of the platform, and sends the position parameters and information to the walking robot under the platform through ZigBee. The walking robot adjusts the angle of each leg's steering gear according to the parameter passed, changes its altitude and attitude to makes the platform trend to level, achieves the walking balance of the entire robot, and realize the fuzzy control to the of the robot state finally.

Using this method to control the robot, the user don't need to establish the robot's kinematics model and dynamics model, and also don't have to consider the various algorithms, just need to compare the state parameters. This device chooses the fuzzy control technology of robots as a breakthrough point, set the stable state parameters of the robot system, and only consider the contrast of the state parameters between the uncertain change and the stabilization in unknown environment. It closes to the equilibrium by adopting adaptive controller, and solves the problem of the stability control of nonlinear systems. at the same time, the further online learning of the fuzzy controller can significantly improve the dynamic performance of module robot, and can accurately realize the robots planned space attitude and action.

## 5. Conclusion

The modular overlapping type robot overcome the lack of poor openness, difficult modeling, and two robots together can't communicate with each other, mutual recognition, coordinated movement. It adopts modular structure, not only has good openness, and avoids common modeling method. It use the sensor to realize the communication between the two robot, can both make the two module robot

automatically run the program independently, and find the suitable trajectory and motion way interact on each other to keep the whole robot balance movement.

The robotic device, from appearance to the internal structure is very concise and clear. It is very suitable for colleges and universities of the experimental teaching of automation control subjects. Whatever the vehicle platform leaning, the robot can through the self-identifying, coordinate and control the walking robot to keep the platform steady level.

This paper creates a modular robot structure, and breaks the situation of poor openness of the teaching robotic device in the existing technology condition. Through the modular education experiment model, implement the verification of the robot system structure, design principle and key technology, and provide the performance testing of the robot system environment and diagnostic tools. Weaken the calculation and create to the robot kinematics and dynamics model for the student, and break through the technical problem of robot application demonstration. Establish a set of robot application demonstration system, creates a teaching platform helpful for students to study, understand and grasp the robot structure knowledge and implement practices, and finally further improve the teaching quality and effect.

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