



INTERNATIONAL JOURNAL OF PURE AND APPLIED RESEARCH IN ENGINEERING AND TECHNOLOGY

A PATH FOR HORIZING YOUR INNOVATIVE WORK

INTELLIGENT HOME CONTROL SYSTEM BASED ON ZIGBEE WIRELESS SENSOR NETWORK

SWATI U.GULHANE, SNEHLATA MUNDHE,

M.E. Second Year (Electronics & Telecommunication), Ramrao Adik Institute of Technology, Nerul, Navi Mumbai, India

Accepted Date:

27/02/2013

Publish Date:

01/04/2013

Keywords

Zigbee,
Intelligent Space,
Wireless Sensor Network,
Home Service robot.

Corresponding Author

Mrs. Swati U.Gulhane

Abstract

In this paper, based on the characteristics of ZigBee protocol, ZigBee technology is used to construct a wireless sensor network. Several intelligent services based on ZigBee wireless sensor and actor network are shown to certify the reliability of this communication network. The intelligent space consists of the following main components: smart devices with intelligent artificial mark; home server that connects the smart device and maintains the information through wireless sensor network; and the service robot that perform tasks in collaboration with the environment.

In the study of intelligent space oriented to home service robot, an important technology is how to construct a communication network which has the characters of high reliability and easy building. ZigBee wireless sensor and actor network builds an information bridge for the components in the intelligent space, the spatially distributed devices are connected together seamlessly. With this network, robot can share the mass information in the intelligent space and improve its performance with "light-packs", devices in intelligent space, such as lamp, curtain, TV can be controlled autonomously.

Introduction

In recent decade, as the aging problem becomes increasingly serious in many countries and in order to improve the life quality of elderly persons and persons with physical disabilities, many attention has been put into the field of intelligent space oriented to home service robot. Intelligent space becomes a platform of ubiquitous computing. There are some research fields under ubiquitous computing, such as: intelligent space, context-aware computing, and nomadic computing.

Intelligent space technology is a new research field. It is an important research field of ubiquitous computing. The concept of "Intelligent space" is proposed by Hashimoto Lab in University of Tokyo in 1996. In recent 15 years, more and more studies have been focused on it. The research to intelligent space has expanded its meaning from human-machine interaction to intelligent space system which interact with physical space.

An intelligent space is an area such as a room, a corridor or a street that is equipped with sensors (CCD cameras, microphones

etc.), actuators (display, speaker etc.), information database, communication devices and computational ability. The intelligent space can continuously monitor what is happening in it, can communicate with its inhabitants, can make related inference and decisions and act on these decisions. It can be used to enhance the quality of people's the everyday life in it.

In the intelligent space oriented to home service robot, since ZigBee technology has the characters of lower speed, lower power and less complexity, it is adopted to build wireless sensor and actor network to transfer the environmental sensor data, the intelligent space commands and their feedback, so that the intelligent space and service robots can be closely connected.

The Architecture of the Intelligent Space Oriented to Home Service Robot

The architecture of an intelligent space is shown as Figure 1.

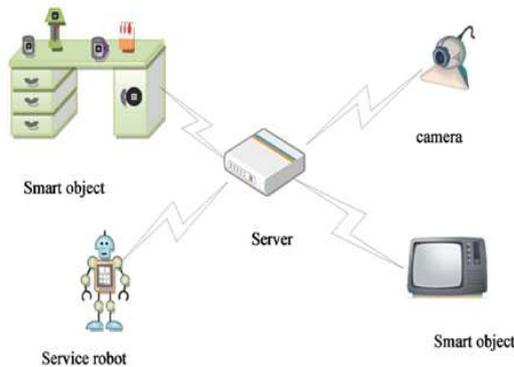


Fig.1: Architecture of an intelligent space

Our intelligent home environment system mainly consists of three components: smart objects; home server and service robot. Smart objects are the basic elements of the intelligent space. They are objects with artificial land mark or objects with either sensor capabilities or actuator capabilities or both. They can communicate with the home server through wireless networks. Home server manages smart objects, collects data in the intelligent space, makes decisions based on the collected data and controls the smart objects. Service robot provides reliable service by symbiotic interactions with the environment through the wireless communication networks. Suppose robot needs to turn on the TV in the intelligent home for some reason, in the traditional robot platform, the robot should

calculate the position of the TV switch through vision processing and object recognition system while moving to the TV, then move its arm to touch the switch. In our intelligent home environment, what the robot need to know is the network address of the TV. Some complex tasks can be finished easily and satisfied.

Zombie Overview

Zombie is a new wireless communication technology based on wire-less standard 802.15.4. Compared with other protocol standards, Zombie stack offers a practical application solution coupled with low rate, low cost, low energy consumption characteristics for wireless sensor network. The data amount of the sensor and control commands in intelligent space oriented to home service robot are small, so the wireless sensor networks requires a little transmission rate. Based on these characteristics, Zombie protocol is selected to construct the wireless sensor and actor network in intelligent space oriented to home service robot.

Zombie is a novel radio frequency (RF) communications standard based on IEEE

802.15.4. It defines the application layer and network layer, utilizing the IEEE 802.15.4 standard as the communication protocols of medium access control (MAC) layer and physical (PHY) layer. The structure of ZigBee protocol stack is illustrated in Fig.2.

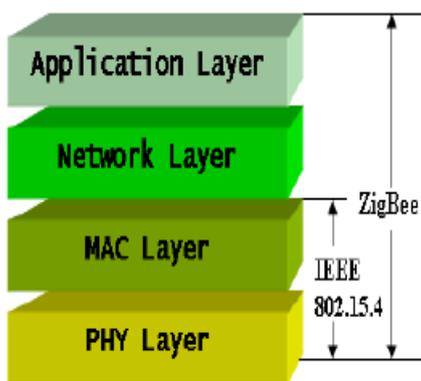


Fig.2: Structure of ZigBee protocol stack

The ZigBee wireless networks consist of three roles: one coordinator, several end devices and routers. The coordinator is a special FFD (full function device) responsible for creating and maintaining the whole ZigBee PAN (personal area network). During the network initialization phase, the coordinator scans the available radio channels to find the most suitable channel. Normally, this will be the channel with the least activity. The coordinator can

be pre-programmed with the PAN ID (Personal Area Network Identifier) or dynamically scans for existing network PAN IDs in the same frequency and generate a conflict-free PAN ID. After the coordinator's initialization phase, the coordinator waits for the requests from ZigBee devices to join the network. The end device can be an FFD or RFD (reduce function device). An FFD can act as anyone of the three roles, while an RFD can only act as the end device. During the initialization, the end devices scan for available channels to identify the network distinguished by their PAN ID and requests are sent to the coordinator of the network they wish to join. Router is an optional device for ZigBee which may be needed in some special network configuration. In the internal networks, the ZigBee protocol is adopted in to built wireless sensor and actor networks in intelligent space. It can be used not only to transfer the environmental sensor data to the sever, such as temperature, humidity, but also to transfer the control command decided by the sever to the intelligent device. The wireless sensor and actor networks based on ZigBee protocol is listed in Figure 3.

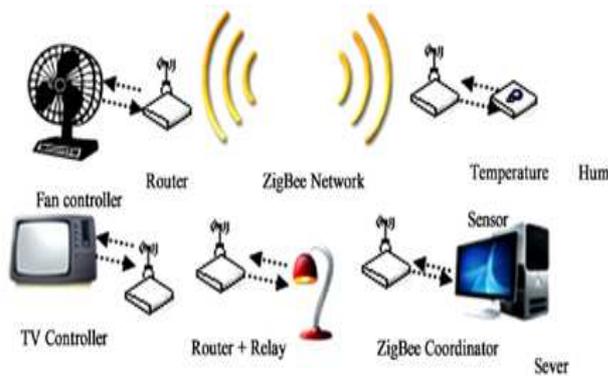


Fig.3: Wireless sensor and actor networks based on ZigBee protocol.

4. Intelligent Home Service system Based on ZigBee Wireless Sensor and Actor Network

4.1. The Control to the Intelligent Device

With the help of ZigBee technology, the normal device will become an intelligent device by adding ZigBee node with simple alteration. In the intelligent space system oriented to home service robot, in order to complete the collection of the sensor data and the control to the intelligent device, such as curtain, lamp, a SQL Server database of Microsoft is adopted. Four data tables such as Sensor data table, action data table, INEQ_state data table & task data table are built to save the relative data.

Sensor data table is used to save all kinds of sensor data, these data are transferred to the computer by ZigBee network coordinator. Action data table is used to save the human behaviors which are detected by the related detecting program. INEQ_state data table is used to save the current status of the curtain or lamp, the default status is "0" which means the intelligent device is off. The actuating result of the task is saved in task data table.

4.2 Ceiling Project Control Based on ZigBee Wireless Sensor Networks

The ceiling projector is used for robot navigation in the intelligent space oriented to home service robot. The principle of robot navigation based on ceiling project is shown in Figure 4

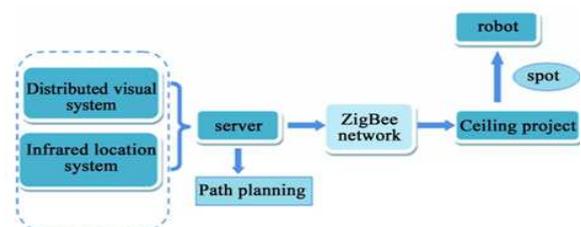


Fig.4: Principle of robot navigation based on ceiling project.

The system of robot navigation based on ceiling project is made up of server, distributed visual system, ceiling project, wireless communication system and robot. The server is the central processing unit, it decides the path planning according to the information which is provided by other units in intelligent space and transfers the path planning into the control command to the ceiling project. The path data are sent to the controller of the ceiling projector through ZigBee wireless sensor networks, and casts a spot along the path. Then, the mobile robot follows the moving spot using its on board sensors.

The server uses serial port to communicate with ZigBee coordinator, the data packet which sent by the server to ZigBee coordinator contains three parts:

Part I: ZigBee node's physical address, hexadecimal, occupies 8 bytes.

Part II: Laser control information, "1" means laser is on, "0" means laser is off, it occupies 1 byte.

Part III: Projector control information, information format occupies 7 bytes.

Communication interface of ZigBee node is RS-232, interface of projector controller is RS-485, therefore, it is necessary to add RS-232-RS-485 converter module between ZigBee node and projector controller. After receiving the data packet broadcasted from ZigBee coordinator, ZigBee nodes begin to parse the packet. If the ZigBee physical address in the packet matches with the physical address of this node, the further data analysis will be handled. Firstly, extract the information of laser controller and decide the control of laser through the information is "0" or "1". Secondly, extract information of projector controller, send the data of 7 bytes to the projector controller through the serial port. Figures 5 and 6 are the robot navigation based on ceiling project and infrared sensors respectively. The yellow line is the path planned by the sever, the green line is the robot's trace. We can find the accuracy in Figure 5 is better than in Figure 6.

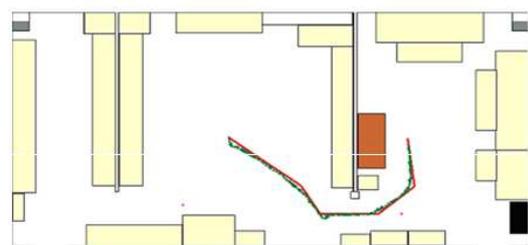


Fig.5.: Robot navigation based on ceiling project.

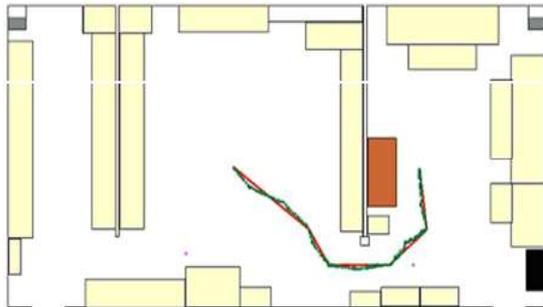


Fig.6.: Robot navigation based on infrared sensors.

4.3. Object Search Based on the Fusion of RFID and ZigBee

One of the main tasks of service robot is to provide different kinds of services to persons in complex indoor environment, such as delivering water or medicine. So the robot must have the ability to search the target and recognize the target autonomously. In intelligent space, robot can finished the task successfully with the help of distributed intelligent device in the space and onboard sensor of the robot. RFID (Radio Frequency Identification) and ZigBee technology are very important for the actuating of the task. The principle of object search for the robot

based on the fusion of RFID and ZigBee is shown as Fig.7.

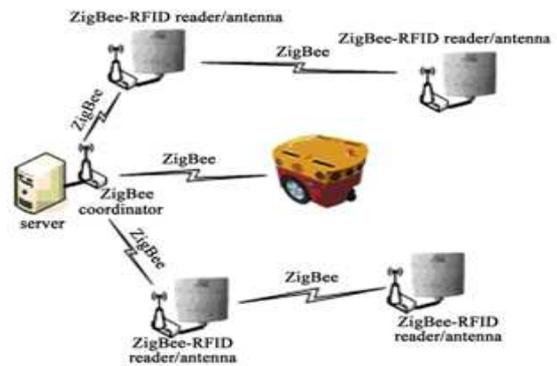


Fig.7: Object search based on ZigBee-RFID.

The robot will send control command to the server in the intelligent space when it needs to search and locate an object. Server will look for the ZigBee nodes which connect with the RFID reader and send the command to these nodes, then the ZigBee terminal node will control to turn on the RFID reader and RFID antenna. When RFID antenna finds the tag which is attached on the object, RFID reader will send the RFID tag information to the ZigBee terminal node through serial port. ZigBee terminal node will add its physical address to the RFID tag information, and transfer this information to the sever by ZigBee wireless sensor network and server will transfer this information to the robot. Robot can complete the object search

according to the information. The program flowchart is show in Figure 8.

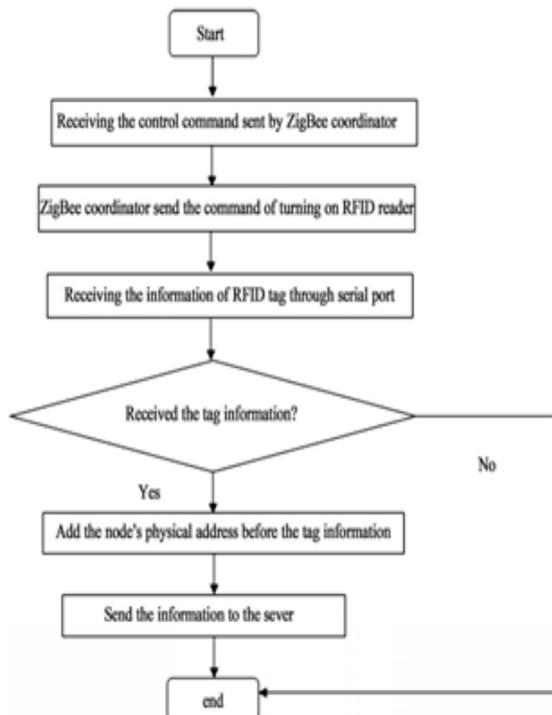


Fig.8: The Flowchart of program.

5. Conclusion and Future Work

In this paper, the wireless sensor and actor network based on the ZigBee technology is introduced in the intelligent space home service robot. The intelligent service based on this sensor and actor network is shown. These services certified the reliability of the network. But the study of ZigBee wireless sensor and actor network in the intelligent

space oriented is limited home service robot, there could be many issues to be studied detail in future.

6. Acknowledgements

I gratefully acknowledge Prof. Sujata Kadam, RAIT, Nerul, Navi Mumbai for providing her guidance in the preparation of this research paper.

References

1. G. H. Tian, X. L. Li, S. P. Zhao, et al., "Research and Development of Intelligent Space Technology for Home Service Robot," Journal of Shandong University: Engineering Science, Vol. 37, No. 5, 2007, pp. 53-59.
2. J.-H. Lee and H. Hashimoto, "Intelligent Space," Proceedings of the IEEE International Conference on Intelligent Robots and Systems, Takamatsu, 30 October-5 No-vember 2000, pp. 1358-1363.
3. S.-H. Baeg, J.-H. Park, J. Koh, et al., "Building a Smart Home Environment for Service Robots Based on RFID and Sensor Networks," International