Design and Implementation of a Family Living Supporting System Based on ZigBee

Mohammad Asif
Computer Science & Engineering Department
SAVEETHA SCHOOL OF ENGINEERING, INDIA.

Abstract—For enhancing the self-caring ability of senior citizen, releasing the pressure of the warding people, a family living supporting system, which is very useful for the paralyzed patients or some people with mobility difficulties, is proposed. It is composed of the wireless transmitting unit, the speech recognition module and the network communication part. A speech recognition processing algorithm is designed to get some command messages from the user. The system not only uses these commands to control some household equipment, but also sends some helping signals via wireless network or Internet. If the family members aren’t prompt to respond to these helping messages, these messages will be transmitted by network communication part to the community service center for assistance immediately. It has some advantages of low-cost, low-power, high-performance, easy-operation and so on. As a result, it could be employed as a terminal of health-care of hospital or home.

Key words: ZigBee, Network Coordinator, Full Function Device(FFD), Reduced Function Device(RFD), Speech Recognition.

I. INTRODUCTION
With the gradual aging of the society approaching and an increasing number of aging populations, many families and community service systems will be faced with enormous pressure. In order to alleviate this problem, the paper proposed a family living supporting system based on the ZigBee technology \[1,2\]. The system not only helps the elder with mobility difficulties and some paralyzed patients to control some electronic devices by speaking some command words, but also aids them to send some helping messages when they encounter some risks of health symptoms or some electronic devices are out of controlling. For instance, wanting to switch some household appliances, the user no longer needs the help from his family members instead of saying some simple command words (such as light on, light off, air conditioning on, air conditioning off, open window, close window, etc.). In addition, when the user sends the helping message, the computer will help him to identify the command and set it to the most advanced, then sends it to his family member who carries an alarming child node, as a result, the ring triggers and alarms continuously. When the family member presses the “Cancel” button which embedded in the child nodes, the child nodes will feedback a response signal to the coordinate. If the user did not receive the response signal in a short time (2 minutes), the computer will transmit the helping message through Internet to the community service center for assistance.

II. SYSTEM ARCHITECTURE
The family living supporting system based on ZigBee consists of three main units, as shown in Figure 1, the wireless transmission module, the speech recognition unit and the network transmission part respectively.

Fig. 1 Fundamental component diagram of the proposed system

When the user speaks a command word, the voice signal which is acquired by the wireless microphone input to the computer and is recognized into command words by the speech recognition unit, then the recognized result is transmitted to the network coordinator via RS-232 serial port. After receiving these commands, the coordinator will classify these commands and send different commands to the corresponding child node in order to control the state of different electronic devices. In this way, the system achieves the requirement about control of the household appliances.

The function of wireless transmission module, which composes of one network coordinator and some child nodes, is used to receive command words and transmit them to the child node. The system establishes a wireless network by the coordinator and then distributes network address to the child nodes. Once the speech recognition unit sends a command word to the coordinator via RS-232, the coordinator will identify it and transmit it to the corresponding child node. Then these child nodes which accord to the different tasks control the corresponding electrical appliances. Speech recognition unit, which contains a main thread and speech recognition thread, acquires speech signals by the microphone and recognizes it. Main thread is used to complete system initialization, parameter settings and open the audio recording equipment, etc.. Speech recognition thread is used to identify voice commands from the user and send the results to the network coordinator via RS-232 port. The network transmission part is used to transmit helping messages via Internet transferred to the social service center when the user cannot receive the response signal in a short time.
III. IMPLEMENTATION

A. Wireless Communications Based on ZigBee

ZigBee technology, which is an emerging short-range; low power consumption and low-rate wireless access technology, mainly applies to industrial control, electronics devices, automotive automation, medical equipment and so on [3]. It works in 2.4GHz and the maximum transfer rate up to 250kbit/s, transmission range (between 10m to 100m) depends on the output power and channel environment. Network structure can be star, mesh and cluster tree topology, etc.. ZigBee defines the two types of physical equipment, namely, Full-Function Device (FFD) and Reduced-Function Device (RFD) [4,5]. Generally speaking, FFD can act as a network coordinator, hence, it not only supports any net topology, but also communicates with any wireless equipments; RFD is usually used only for star-network topology and it cannot implement the coordination function, namely, it only communicate with FFD and cannot communicate each other. In addition, the circuit of RFD is simpler than the FFD and its energy consumption is very low, so the implementation of RFD is relatively simpler than FFD and the energy of RFD conservation is more conducive.

1) Hardware Design

There are some sensors and switches in the system terminals and the amount of data wireless transmission is not too much. Hence, the star topology structure is adopted in the proposed system. The network topology of the wireless communication module is showed in Figure 2.

![Network topology of the wireless communication module](image)

From fig.2 we can see that the FFD module acts as ZigBee network coordinator and some RFD modules serve as the child nodes. It’s obviously that every child node does not need to communicate with each other. In order to reduce the power consumption, these child nodes are designed to reduced function device named RFD. The network coordinator, which is used to establish the wireless network, watches all the nodes state within its network and manages the information about each child node as well as the information that is being transmitted/received within the network. The communication between the network coordinator and PC is implemented through RS-232 serial bus. The RFDs, which can be installed on the doors, windows and air conditioners etc., implement to receive the signals, process messages and communicate with the network coordinator.

The chip CC2430 is selected in the system for its small size; full-function; very few peripheral devices and the ease of implementation. The current consumption of the chip is lower than 27mA in receive mode and 25mA in transmit mode. In addition, CC2430 can prolong the battery life because the conversion time from sleep mode to active mode is very short

2) Software Design

We denote that the node which the family member carries it is named the node N. The program flowchart of network coordinator and RFD nodes are respectively showed in Figure 3 and Figure 4.

![Flowchart of FFD](image)

![Flowchart of RFD](image)

In order to establish a new wireless network, the procedure which embeds in the network coordinator initializes CC2430 and the protocol stack, and then opens the interruption. Some parameters are set, for example, the baud rate for serial communication is 57600; data bit equals 8; no parity bit and a stop bit. After these processes, the physical address of network coordinator; the ID of the new network; the channel number and some other detailed information are displayed on the LED when we turn it on. Furthermore, the coordinator will watch the wireless signals which express RFD nodes join the network, if so, the network coordinator will distribute the network address to this nodes. Next, the program will scan whether there are some control commands which sent from the serial port to the network coordinator. If there are no commands, the network coordinator will wait for commands; if there are some commands sent to the network coordinator, it will judge whether the node N is the destinations of the command. If not, the coordinator directly sends the command to the destinations; if so, it will wait for the response from the node N. And if the coordinator didn’t receive the response from the node N immediately, it will send the commands to community service centers through the Internet for new assistance.

On the other hand, the procedure which embeds in the RFD nodes firstly initializes CC2430 and turns the power of sensor on. Then it initializes the protocol stack and
sends a request for the allocation of address to the network coordinator. If the RFD joins the network successful, it will watches the control signals that came from the coordinator and deals with these signals. If the node N receives the command signals, the alarm will sound. When “Cancel” button is pressed, the node N will send a response message to the network coordinate.

B. Non-specific Speech Recognition

1. Speech Signal Acquisition

The system uses a clip-on wireless microphone to acquire the voice signals come from the user and utilizes a windows message function named WAVEINAPI to read the voice data. Recording parameters are corresponding to the corpus, namely, mono, 16KHz sampling rate and 16bits bit rate. Once any cache overflowed, WINDOWS will throw out a message function named OnMM_WIM_DATA to response this message automatically. After dealing with the relevant operation, the system will reload this buffer to the recording equipment by calling the function WaveInAddBuffer to guarantee the continuity of voice collection.

2. Voice Commands Detection

The program flowchart of the voice commands detection is shown in figure 5.

In the process of detection, the system records circularly and produces OnMM_WIM_DATA messages continually.

After the program responses these messages, the sum of voice amplitude is calculated by message processing function. If the sum amplitude is less than the preset threshold, it means that there is no effective voice command input. Else the voice command is collected. Five buffers data (about 3 seconds) are saved in order to ensure that voice commands records completely and then the system stops recording and writes the data in WAVE format to file. Next, the thread of speech recognition is stared by AfxBeginThread function and communicates with the main thread through the PostMessage function to display the system state.

![Flowchart of Voice Command Detection](image)

(3) Using HTK to Implement Speech Recognition

The Hidden Markov Model Toolkit (HTK) is a portable toolkit for building and manipulating hidden Markov models. HTK is primarily used for speech recognition research although it has been used for numerous other applications including research into speech synthesis, character recognition and DNA sequencing. HTK consists of a set of library modules and tools available in C source form. The tools provide sophisticated facilities for speech analysis, HMM training, testing and results analysis. The software supports HMMs using both continuous density mixture Gaussians and discrete distributions and can be used to build complex HMM systems. In the propose system, the speech recognition system uses HTK of 3.4 version to implement.

C. Network Transmission

The function of the network transmission module is: when no one responds the helping message which sent from the user, the helping message will be transmitted to the community service center through Internet to get more assistance. Before the system transmitting the helping message through Internet based on TCP/IP protocol, the parameters of the network transmission should be established, such as the static IP address of the remote server; the user name and the password and so on. When there is no response for help, the main thread automatically activates the two communication sub-thread. A sub-thread responds the request of the connection with the server, including user names; passwords; login information and socket connection error handling, etc.. Another sub-thread transmits the helping message to the server. If some error exists, the data will transmit repeatedly.

IV. CONCLUSION

The proposed family living supporting system not only greatly improves the anti-interference performance when it transmits the data, but also reduces some troubles of cabling, in addition, the management of sensor nodes is also more convenient. Furthermore, the realization of speech recognition greatly decreases the difficulty of the operation, especially for the elder or the paralyzed patients.

REFERENCES


[5] LAN/MAN Standards Committee. Part 15.4: Wireless medium access control (MAC) and physical
layer (PHY) specifications for low-rate wireless personal area networks [EB/OL].

