The Design and Implementation of Intelligent Home Control System Based on CC2530

Siyu Zhan*, Chao Xuan, Jianming Liao, Jieyan Liu & Yalan Ye
School of Computer Science and Engineering, University of Electronic Science and Technology of China, Chengdu, Sichuan, China

ABSTRACT: The growing interest in the SmartHome based on wireless networks necessitates the development of an effective scheme which can control household equipment and detect home environment intelligently. On the other hand, current market products only concentrate on small parts of the SmartHome and lots of them are lack of remote control function. Furthermore, there are few mature products to realize in-door wireless localization. Therefore, existing systems cannot meet users’ needs completely. To fill this void, in this paper, a comprehensive smart home scheme is proposed, called the Intelligent Home Control System, which realizes intelligent lighting via PWM, indoor localization, detection of formaldehyde, CO$_2$ and smoke on the basis of CC2530. The main idea here is to transmit data collected by sensors to our system server through the ZigBee network and adjust the lights according to the data parsing results. We can also use mobile devices to communicate with server via GSM network to control household devices and observe home environment.

Keywords: intelligent home; CC2530; PWM

1 INTRODUCTION

With the rapid development of wireless networks and sensor devices, the SmartHome has been the hot topic in our life. This paper has presented a scheme of the Intelligent Home Control System which has implemented intelligent lighting, indoor localization, smoke detecting, formaldehyde detecting and CO$_2$ detecting. Figure 1 shows the structure of the system. The sensors are responsible for collecting data, and they communicate with server through ZigBee network. The server can analyze the data and inform the mobile devices automatically if the analysis result shows there is any emergency. Mobile devices can communicate with server through GSM network [1], so that user can also query household information by mobile devices even they are not at home.

The Intelligent Home Control System has characteristics as follows:

- Automatically control the lamp brightness according to the natural light intensity.
- Automatically turn on or off lights according to the location of the mobile device.
- Detect own fault.

*Corresponding author: zhansy@uestc.edu.cn

Figure 1. The structure of system.
To ensure that users grasp their living environment and get more benefits, our system acquires various environmental information, and provides more convenient operations to manipulate.

The paper is structured as follows. Section 2 presents the choice of sensors and the reasons for choosing them. Section 3 gives the detailed introduction of system design and Section 4 describes the implementation. Section 5 details the test and provides our analysis. Section 6 concludes the paper.

2 DEVICE SELECTION

2.1 CC2530 system-on-chip

CC2530 which is launched by TI is a second generation support IEEE 802.15.4/ZigBee protocol system on a chip in the 2.4GHz brand. Its internal integrated high-performance Radio Frequency transceiver, industry-standard enhanced 8051 MCU core, 256KB Flash ROM and 8KB RAM.

The main characteristics are as follows: 8-bit and 16-bit timers, watching timer, 8 inputs configurable 12-bit ADC, 21 GPIO, AES128 coprocessor, hardware support CSMA/CA, digitized received signal strength indicator, link quality indication and powerful DMA function, battery monitoring and temperature sensing. It supports five operating modes, which can better meet the needs of low-power systems. The current consumption is 24mA and 29mA in receive and transmit modes. Because its hardware design is relative simple, such as small package, and low power, it has been widely used in wireless sensor networks.

CC2530 can be used as ZigBee coordinator, router and end device. After combination with the TI/Chipcon’s ZigBee protocol stack, CC2530 is considered to be the most competitive ZigBee solution in the market. So we choose CC2530 as our communication device for sensor node and server.

2.2 SIM900A

SIM900A which is produced by HUAWEI supports standard AT instructions and enhanced AT instructions. It is two band GSM/GPRS wireless module, providing rich voice and data services and other functions, which is the ideal solution for high speed data transmission. So we choose SIM9332A as our communication device for server and mobile phone. In our system, the server central unit also uses the 8051 MCU which is integrated in ZigBee module, and the ZigBee module communicate with GSM module through the RS232 serial port.

2.3 MG811

MG811 has good sensitivity and selectivity to detect CO₂, which is less affected by change of temperature and humidity, stable and so on. So we choose MG811 to collect CO₂ data.

2.4 MQ-2

MQ-2 is a sensor for detecting smoke. High sensitivity, wide range of application, long use time, and low cost are characteristics of MQ-2. It is suitable for gas leak detection.

2.5 MQ138

We choose MQ138 for detecting formaldehyde, which has distinguishing features of wide range of application, sensitivity, fast response, and stability. MQ138 is mainly used to detect the harmful gas in the environment and check alcohols, aldehydes, aromatic compounds and other organic solvents.

3 SYSTEM ARCHITECTURE

The system consists of three parts, and the architecture of system is depicted in Figure 2.

The first part is sensor nodes that are responsible for collecting data. In this part, we deploy many sensors, which can collect environment information of natural light intensity, density of smoke, CO₂ and formaldehyde, and the sensors we have introduced in previous section. Generally, the signals we have collected are analog signals, and then we convert analog signals into digital signals through AD module of CC2530. Finally, we will send these processed data to server via ZigBee network. Furthermore, it also receives command from server, and CC2530 MCU could give

![Figure 2. Architecture of system.](image-url)
response to server on the basis of different commands.

The ZigBee-GSM server is the second part that is the key of system to realize remote control. This part is composed by three modules: GSM Module, ZigBee RF Module, and CC2530 MCU. The server can send message to mobile device or receives message from mobile device through GSM module [2]. The MCU can analyze the command from mobile device. Then server will send this command to the first part and wait to get responses for transmitting to mobile device.

The third part is mobile device, and in our test, we use Android Phone. We develop software to send control and query command to server.

Indoor localization is an important part of the system. Obviously, it can help us find stuff in a faster and more convenient way. The architecture of indoor localization is shown in Figure 3. We set a blind node, a coordinator and three reference nodes in our experiment [3]. All nodes are CC2530. The coordinator collect position data that gets from all reference nodes, and then compute average value as the result and send to server. Blind node exchanges information with reference nodes to locate. We will introduce the location algorithm in next section.

![Figure 3. Architecture of indoor localization.](image)

4 IMPLEMENTATION

In this section I will give detail about the implementation of intelligent lighting, indoor localization and CO₂ detecting. We omit the description of detection of formaldehyde and smoke as they have similar mechanism with CO₂.

4.1 Pulse width modulation

PWM (Pulse Width Modulation) is the principle of intelligent lighting. We try to control pulse width and duty ratio, which is the proportion of high voltage in one cycle, to regulate voltage [4]. Figure 4 illustrates the meaning of duty ratio. If D stands for duty ratio, then D = T / (T + t). As we can see from Figure 4, D is bigger, the output voltage is larger.

![Figure 4. Duty ratio.](image)

4.2 Principle of Positioning

We locate the blind node based on the RSSI (Received Signal Strength Indication), which can determine the distance between reference node and blind node through analyzing signal strength. The theoretical value of RSSI is,

\[
RSSI = -(10N \times \log(d) + A)
\]

The value of d is the distance between reference node and blind node. A is received signal strength per meters and N is signal dissemination constant whose value is in the range of 2.2 to 4.

We firstly obtain RSSI according to the known distance, and then we can ask for the unknown distance on the basis of previous work.

4.3 Interface of system

Intelligent lighting can realize controlling the lamp brightness according to the light intensity through the PWM automatically. Figure 5 presents the hardware connection of intelligent lighting. We use photoresistor of CC2530 to acquire signals, and then convert digital signals through its own AD module. At last, CC2530 MCU generate PWM signals to adjust lamp brightness according to the digital signals.

![Figure 5. Hardware connection of intelligent lighting.](image)

Figure 6 shows how to transmit analog signals MG811 collected into digital signals by LM393 which is a voltage comparator. LM393 will output zero or one from OUTA port.

We send digital signals to CC2530 MCU to analyze whether safe at home as soon as we get the results from OUTA port of LM393. The connection has been depicted in Figure 7.

![Figure 7.](image)
4.4 Information Transmission

The sequence of information transmission between server and sensor node has given in Figure 8. MCU of sensor node firstly transform analog signals into digital signals, and then judge whether it is safe. Sending alarm message if there are any dangers. Otherwise, deliver processing result to server if CC2530 gets a command from server. If there are dangers at home, server will send message to mobile client actively as soon as receiving alarm messages from sensors.

Figure 8. Flow chart of information transmission between Sensor node and server.

Figure 9 depicts the process of transmitting information between server and mobile client [5]. Generally, server waits mobile client command, and it waits result after forwarding command to sensor node. But

5 TEST AND ANALYSIS

We will illustrate that our system has been realized
through experiments of intelligent lighting. Table 1 shows the light intensity in different time.

<table>
<thead>
<tr>
<th>Table 1. Test data.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015/9/13 Cloudy Lab of UESTC</td>
</tr>
<tr>
<td>Time</td>
</tr>
<tr>
<td>Data</td>
</tr>
<tr>
<td>363</td>
</tr>
<tr>
<td>341</td>
</tr>
<tr>
<td>372</td>
</tr>
<tr>
<td>381</td>
</tr>
<tr>
<td>365</td>
</tr>
<tr>
<td>379</td>
</tr>
<tr>
<td>400</td>
</tr>
<tr>
<td>408</td>
</tr>
<tr>
<td>373</td>
</tr>
<tr>
<td>382</td>
</tr>
<tr>
<td>Level</td>
</tr>
</tbody>
</table>

The system transform analog signals of natural light intensity into digit signals, and the range is from 0 to 2000, which is divided into four ranges as Table 2 shows.

<table>
<thead>
<tr>
<th>Table 2. Light Level.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
</tr>
<tr>
<td>000-100</td>
</tr>
<tr>
<td>101-400</td>
</tr>
<tr>
<td>401-700</td>
</tr>
<tr>
<td>701-2000</td>
</tr>
</tbody>
</table>

6 CONCLUSION

This paper discusses the design and implementation of The Intelligent Home Control System based on CC2530. We implement the proposed system and develop related hardware and software. Throughout this paper we have seen the significant importance of the SmartHome to improve life. In the near future, we are planning to further develop the design. Then, it will be validated by performing more extensive and real life experiments.

ACKNOWLEDGEMENT

This work is supported by the National Natural Science Foundation of China (No. 61202444, No. 61202084,No.61501096) and Chengdu Research Institute of UESTC (No. RWS-CYHKF-02-20150005).

REFERENCES


