Implementation of IoT-based Automatic Inventory Management System

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Abstract

Recent development of IT industry including smart phones and communication technologies has resulted in rapid growth of Internet of Things (IoT) technology and relevant markets. The access to IoT is becoming easier thanks to the boards and IoT products, such as Arduino and Raspberry Pi. Large-scale business sites use IoT technology to manage inventories, but small-scale business sites do not. In the present study, We ported Linux-based Raspbian to Raspberry Pi, It utilizes web server communication to control the Arduino through the application. We used a color sensor to figure out the kind of inventory. We also built a database using MySQL to store the data. We used raspberry pi to check whether the proposed system works and apply it to small-scale business.

Keywords: Internet of Things, Raspberry Pi, Smart Phone, Color Sensor

1. Introduction

According to the recent statistics of Ericsson, the number of smart phone users is predicted to be 6.1 billions in the world in 2020[1]. The trend of smart phone service subscribers indirectly indicates that the number of users of smart phone-based IoT technology will be also increased in the future. As the number of smart phone users in the world is increasing, the IoT industry will be extended. As a result, the IoT industry, now in a growing stage, will be well established with many users. As the number of users is increased, the price of IoT service will be stabilized and the access to IoT service will be easier. Therefore, the IoT service for small-scale inventory management will be provided at a reasonable price in the future[2]. The drawbacks of IoT system, including the difficult access of general users and the high cost, will be resolved as the IoT market expands.

The Raspberry Pi-based automatic inventory management system proposed in the present study enables a user to manage the inventory without the limitations of time and place by using an application or the internet website because the database and the server of the system were established by employing a relatively cheap Raspberry Pi device to control Arduino and utilize color sensors, ultrasonic sensors, and motors.
2. Related Research

2-1. IoT Technology Introduction
The dictionary definition of IoT is “a spatial network of things where intelligent relationships, such as sensing, networking, and information processing, are formed by mutual cooperation between three distributed environmental elements, which are humans, things, and service, without an explicit human intervention”[3]. The key technologies required to realize IoT include a sensor technology to collect information in behalf of the five senses of humans, a network infrastructure technology to establish the IoT network, and an IoT service interface technology to save, process, and convert information.

3. IoT-based Automatic Inventory Management System

3-1. Raspberry Pi
Raspberry Pi is different from Arduino because Raspberry Pi enables to choose an operating system so that the sensors may be operated by a user’s own program[4]. In addition, Raspberry Pi includes an HDMI port for video output, a LAN port for communication, and an audio port for sound output. A keyboard or a mouse may be connected to Arduino through an USB port, and an SD card is used as a storage device[5].

A separate server is not required in managing and controlling the inventory management system, because the web server of Raspberry Pi is used. All the devices in a user’s home may be controlled through the web browser or application included in the user’s smart device. A Tomcat-based web container may be used for Raspberry Pi to independently play the role of a web node. Therefore, Raspberry Pi may simplify the high-level language-based programming environment and provide an environment that may be simultaneously accessed by multiple users[6].

3-2. System Design
In the present study, an automatic inventory management system was developed by employing Raspberry Pi and Arduino as boards, color sensors to identify product types, wireless communication devices for the interconnection with a web server and an application (Bluetooth, Wifi), and a ultrasound sensor and a infrared sensor to determine the existence of a product. This article proposes an automatic inventory management system to remotely manage inventory and view the inventory status in a smart phone environment. Figure 1 shows the system architecture.

![Figure 1. System Architecture](image-url)
As shown in Figure 1, the system architecture includes an Arduino module that has an elevator function and an inventory judgment function, and a Raspberry Pi module that controls the Arduino module and manages the database and the web server. The application performs XML parsing of Jsoup Library[7] through the web server page of Raspberry Pi to receive the inventory status information in the data type of text and enables to use the inventory movement function not only automatically but also manually through the connection with Bluetooth.

The Judgment module consists of a ultrasound sensor that judge whether the inventory is located at a specific position or not, and a color sensor that identifies the types of inventory and allocate the inventory to an appropriate layer according to the inventory type. The Movement module moves through the elevator function the inventory to the layer allocated by the color sensor. The Confirm module, a module that confirms whether the inventory is sufficient or not, confirms the inventory on the basis of the values measured by an infrared sensor and a ultrasound sensor. The information is put into the database of the Raspberry module. The information included in the database is saved in the web server without modification, and displayed on the web site in text. The application also expresses the text-type information on a text viewer through parsing of the Jsoup Library.

As shown in Figure 2, the application remotely controls Arduino through Bluetooth, and the status and types of the inventory are investigated through the color sensor and the ultrasound sensor during the controlling process. The obtained information is transmitted to Raspberry Pi through Wifi and saved in the web server. The data saved in the web server is transmitted to the application through the Jsoup Library.

3-3. System Implementation
The system of the present study was realized in the MAC OS X El Capitan 10.11.5 operating system. The Android Minimum Required SDK was realized in the API 14 : Android 4.0 (Ice Cream Sandwich), and the Target SDK in the API 18 : Android 4.4.2 (Kit Kat). Figure 3 shows connected Raspberry Pi with Arduino and Color Sensor, Figure 4 shows the algorithm that recognizes the color of inventory by connecting Arduino and the color sensor[8].
The Judgment module recognizes, through the algorithm shown in Figure 4, the RGB values from the color sensor within 255 and then runs the “if” statement according to the RGB value to judge if the color is green, blue, or yellow, etc[9]. For example, when the “if” statement for green color, allocated to the second floor, is run, the sub-motor having the elevator function is operated. A pulley is operated in 10 cycles to move the inventory up to the second floor.

3-4. Performance Evaluation

The system was operated in Exynos 4412 1.4 GHz Quad Core CPU, 2 GB LPDDR2 SDRAM, and Android 4.4.2 (Kit Kat). Figures 5 to 7 show the system realization results.

The frame shown in Figure 5 has two floors: a red inventory is allocated to the first floor, while a green inventory is allocated to the second floor. The up-and-down movement is performed by an elevator using a sub-motor[10]. A color sensor that judges the color of an inventory product is installed in the moving elevator.

![Figure 5. System Implementation Result 1](image)

The Confirm module shown in Figure 6 recognizes the number of products in the inventory as the types of inventory products are identified by the Judgment module and the elevator is under operation. The number of inventory products recognized by the Confirm module is transmitted to the web server of Raspberry Pi.
4. Result

Figures 7 and 8 shows the evaluation results of the performance of the automatic inventory management system developed in the present study. The performance was evaluated in terms of accuracy of color sensing and the implementation of automatic management.

The result shown in Figure 7 indicates that the Movement module was operated normally according to the command given by the Application module. Although a considerable amount of time was taken for moving up due to the insufficient power of the sub-motor, the function of moving the product was normally implemented.

Figure 8 shows the number of products identified as purple, orange, and white was 21, 23, and 22. As the result indicates, products in purple and orange colors, which are the colors not near to the R, G, and B colors...
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may not be detected, depending on the color sensor position, LED light, and the size of inventory products. White products were not well identified due to the LED light of the color sensor and the shadow.

5. Conclusion
In the present study, an automatic inventory management system was realized by using Raspberry Pi, an Arduino board, Wifi, Bluetooth, an infrared sensor, a color sensor, and a ultrasound sensor. An automatic inventory management system to remotely manage inventory and view the inventory status in a smart phone environment was proposed, designed, and realized. Experimental results show that the proposed system correctly recognizes the color sensor and that the Color Judge Algorithm is performed properly. Experimental results show that the proposed system can be used in a small-scale business without using a separate terminal.

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