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Design and Implementation of a Real-Time Smart Home Automation System Based on Arduino Microcontroller Kit and LabVIEW Platform

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Abstract

In this paper a design and implementation concept for a real-time smart home automation system based on Arduino microcontroller board and LabVIEW platform has been presented. The proposed automation system consists of two main hardware components: personal computer (PC) as a home main server including the LabVIEW platform management and the Arduino microcontroller board. Some appliances and sensors are connected to the microcontroller board. The home appliances can be monitored, controlled, and accessed automatically in response to any signals came from related sensors or by the system user. The architecture of the proposed system and processes flow charts have been developed. To evaluate the reliability and the effectiveness of the proposed system, a hardware realization for three operational home appliances: temperature management, light energy saving, and security camera based on an ultrasonic distance detection sensor has been developed. The proposed system is shown to be a simple, cost effective and flexible that making it a suitable and a good candidate for the smart home future.

Keywords: Smart home automation, Arduino Uno kit, LabVIEW platform, Hardware realization, Home appliances, Sensors

INTRODUCTION

Recently, man's work and life are increasingly tight with the rapid growth in communications and information technology. The informationized society has changed human being's way of life as well as challenged the traditional residence. Followed by the rapid economic expansion, living standard keeps raising up day by day that people have a higher requirement for dwelling functions. The intellectualized society brings diversified information where safe, economic, comfortable and convenient life has become the ideal for every modern family [1].

Due to the rapid development in electronics technologies and their integration with traditional building industry, the concept of smart or intelligent home automation system has been adopted by researchers and lifestyle practitioners. The first smart house idea was presented in the early 1980's as a project of the National Research Center of the National Association of Home Builders (NAHB) with the cooperation of a collection of major industrial partners. The basic idea of home automation is to employ sensors and control systems to monitor a dwelling, and accordingly adjust the various mechanisms that provide heat, ventilation, lighting, and other services [2]. Modern homes need to use many appliances for comfortable human life and the demand for energy will increase. For that, smart home can achieve an efficient and intelligent energy management and consumption through scheduling, controlling, diagnostic, and monitoring the different appliances. Economically, it will increase the lifelong of the appliances and reducing the maintenance expenses [3-6].

Considerable efforts have been made to the development of remote control systems for home automation. The earlier work of such systems are mainly based on the use of phones, such as a phone-based system for home automation using remote controlling some of them based on a personal computer approach [7-10]. These kinds of systems which make use of the phone as the remote control input device have some way to be connected through any user interface. The proliferation of telecommunications technology has made most of recent home automation scenarios focus on using wireless communication to communicate the home appliances. One of the modern designed systems work with the new wireless technologies like a Bluetooth, GSM, RF, Zig-Bee ,…etc for remote control household devices [11-17]. Pavana H. in [18], the PLC was used to build the monitoring and controlling system by sending the data based on wireless device. R. A. Ramlee in [19] has introduced the idea of using Bluetooth wireless technology as a cable replacement that exploited the wireless interconnectivity which can be implemented using android system to control the home devices. In [20], an evaluation study based on the ability of users to install their own smart home in a box (SHiB) is proposed. The results show the effectiveness and limitations of the proposed SHiB design. In [21], the load balancing and the related IT architecture for monitoring and controlling of distributed smart grad energy systems are based on the smart metering and smart home technologies. The design and prototyping of a smart home lighting system with effective and efficient daylight harvesting capability is presented in [22]. The

system comprises an Arduino controlled luminaire with RGB channels, a Raspberry Pi main controller and a mobile application on the user's smartphone. Users are able to control individual or multiple luminaires conveniently and securely using their mobile devices at home through the local Wi-Fi network.

Based on all the preceding materials, a design concept for a real-time home automation system using Arduino microcontroller with LabVIEW platform are proposed in this work. The proposed Arduino controller introduced in this work provides a simple implementation at the system as compared to the other types of controllers in the literature. The proposed automation system consists of two main hardware components: PC as a home main server including the LabVIEW platform management and the Arduino microcontroller board. Three types of appliances and sensors are connected to the microcontroller board. The home appliances can be controlled and accessed automatically or by the system user. To support our claim, a hardware implementation for the proposed system is developed to verify its reliability and limitations.

The remainder of this paper is organized as follows: section 2 describes the design aspects of the proposed smart home automation system. The system hardware implementation is presented in section 3. Finally, the conclusions of this paper are reported in section 4.

PROPOSED SYSTEM DESIGN

The core of the proposed smart home automation system consists of two main hardware components: the PC home server and the Arduino microcontroller board which is flexible, inexpensive, offers a variety of digital and analog inputs, serial interface and digital and PWM outputs. It is easy to use and can be connected to computer via USB and communicates using standard serial protocol. Also, it comes with free authoring software as an open-source project. The architecture of the system developed is shown in figure 1. A PC home server hosts the LabVIEW platform management and Arduino control algorithm that enables the user to access the home appliances through it. A number of appliances and sensors are connected to ports of the microcontroller board. The home Appliances can be controlled automatically or accessed through the system user.

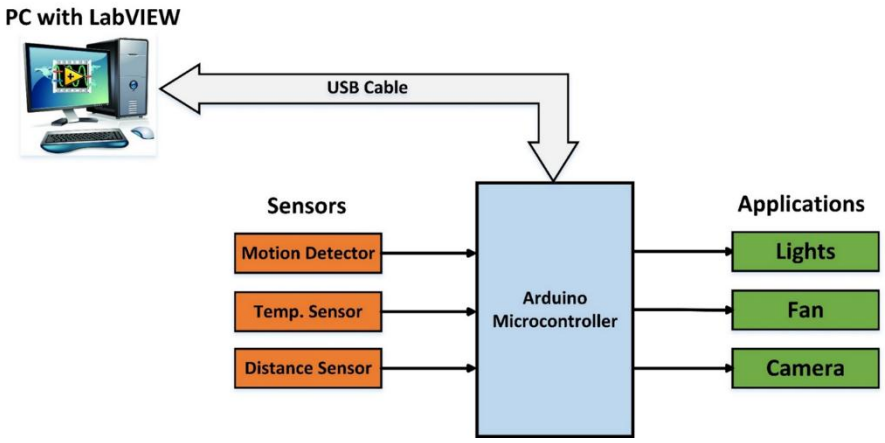
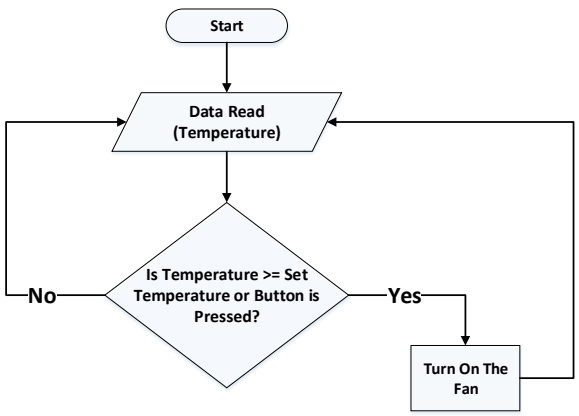
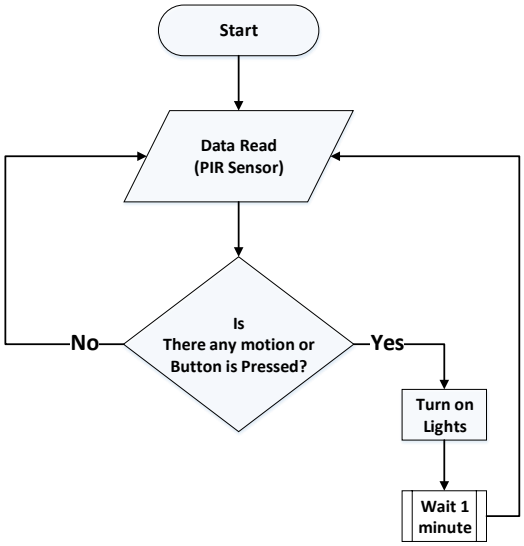


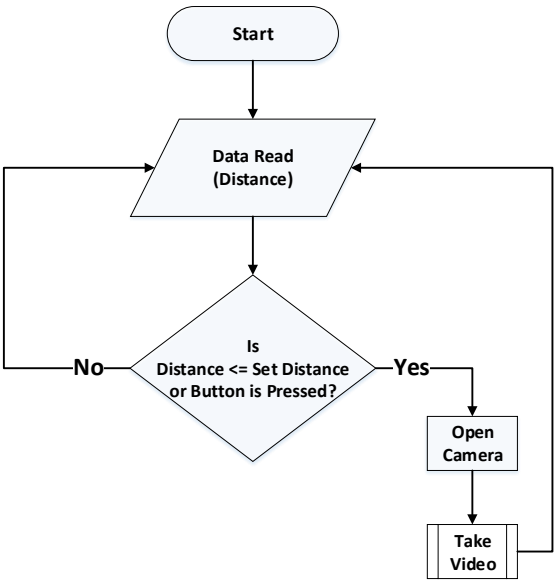
Figure 1: Proposed smart home automation system architecture.



(a)



(b)



(c)

Figure 2: Proposed smart home automation system processes.

a. Temperature management **b.** Light control **c.** Security camera ultrasonic based

In this study, three appliances for temperature management, light control, and security camera system have been introduced. The proposed flow charts of these processes are shown in figure 2. In case of temperature control system, temperature sensor is used to measure the ambient temperature. The temperature is adjusted to be less than a reference level (in this study 30^{o}C is considered as a reference temperature). If the temperature exceeds 30^{o}C, microcontroller will turn on the fan automatically to reduce the temperature or the system user can manage the system manually as shown in figure 2 (a). In automatic light control system, sensor is used to detect the condition for the object motion. In object motion state the light will turn on automatically as shown in figure 2(b). The light will keep on for one minute and the system will check the object status again, if there no object the system will turn off the light. This system also can be accessed through the system user manually. This application is important for saving the energy. Security camera ultrasonic based is developed as a third appliance. The sensor detects the object distance range, if it is in the design setting range (in this case, 15 cm is considered as a distance range) the camera will turn on and record a video online for this object automatically. Also, this application can be managed by the system user manually as in figure 2 (c).

HARDWARE IMPLEMENTATION

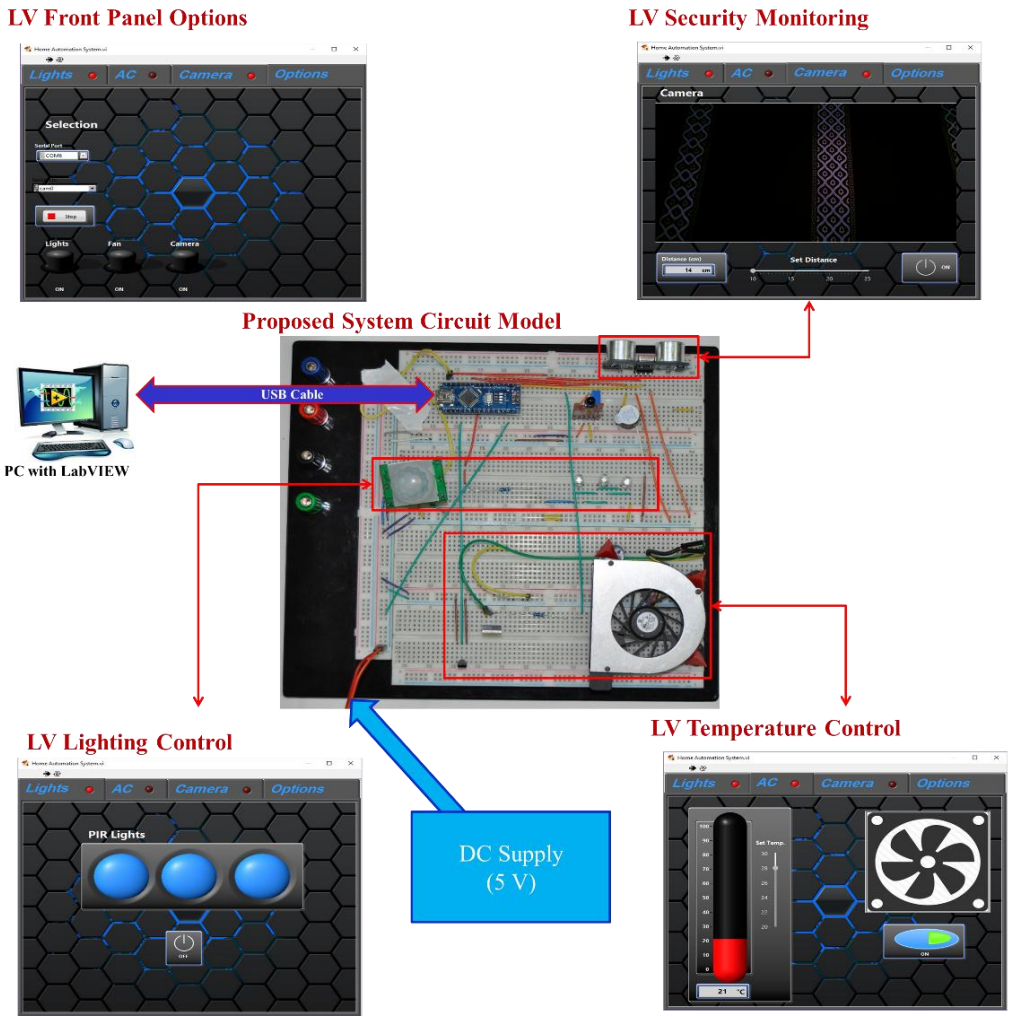


Figure 3: Proposed smart home automation system hardware realization.

To verify the correct operation and limitation of the designed system, a hardware implementation is developed to model the proposed system. The system consists of a PC home main server including the LabVIEW platform management panels and Arduino control algorithm that enables the control processes for three home appliances. A number of appliances and sensors are connected to ports of the microcontroller board. The home Appliances can be controlled automatically or accessed through the system user. The computer is connected to the Arduino controller via USB. The system circuit model includes three types of sensors and appliances: TMP36 temperature sensor with fan for temperature management appliance, passive infrared sensor (PIR) based motion detector which used to sense the object movement, and an ultrasonic sensor that can measure the distance to an object by using sound waves and turn on a security camera for recording the object action. To monitor, control and access these appliances, LabVIEW (LV) panels have been developed as shown in figure 3.

CONCLUSIONS

In this paper, a design concept for a real-time home automation system using Arduino microcontroller with LabVIEW platform are proposed. The proposed automation system consists of two main hardware components: PC as a home main server including the LabVIEW platform management and the Arduino microcontroller board. Three types of appliances and sensors are connected to the microcontroller board. The home appliances can be monitored, controlled, and accessed automatically in response to any signals came from related sensors or manually by the system user. A hardware implementation of the system was carried out to verify the reliability of the system. The implemented system was a simple, low cost and flexible that can be expanded and scaled up. A future improvement can be added to the proposed system using wireless sensors and internet of things technologies. The proposed system can be developed and fabricated as a commercial hardware package.

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