Smart Automation System for Controlling Various Appliances using a Mobile Device

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***Abstract*—This paper outlines the methodology of designing and developing a smart control system for controlling light, air conditioning and ceiling fans in a room. This system considers the requirements of the users appropriately and makes a comfort zone for the users. An android application with a user friendly Graphical Interface, which is easy to communicate with the smart control system, has been developed. The application is connected with the control system through Wi-Fi across a cloud network and it can respond quickly. RGB LED panel light system that controls the color, color temperature and luminance was designed by considering the requirements of the instances and lighting conditions. Although there are RGB LED panel lights available, there are no systems defined for the activity based color modes. An IR Remote module controller system was built for controlling inverter type air conditioners by giving commands from a smart phone application. This system considers the mean value of the preferences of many users to control the air conditioning system. The running mode of the air conditioner is chosen from the data given through the application by many users in a same place. Although the inverter type air conditioners continuously regulate the temperatures, the fan does not do it. Because of this problem, a ceiling fan controlling system with two modes, automatic and manual, was designed. Automatic mode utilizes the users skin moisture related hybrid system to set the room temperature. Manual mode works according to the suggestions given by the crowd just as the air conditioning system. This air conditioning and ceiling fan control system that works according to the suggestions of crowd is better than the individual preference system using a conventional remote controller.**

Keywords— smart homes, smart city, smart farming, IoT, cloud networking, wireless communication, air conditioning control system, ceiling fan control system, RGB LED panel light, arduino microcontroller, pulse width modulation, mobile application, color psychology

I. INTRODUCTION

Smart automation systems allow users to control electric appliances of various kinds smartly and automatically from anywhere in the world. When using an automation system with wired communication, cabling is required which will have to be installed during the construction of the building or after [1]. The implementation cost for these two occasions are very high. Therefore people are moving towards wireless automation systems, which are powered by the wireless technologies such as ZigBee, Wi-Fi, Worldwide Interoperability for Microwave Access (WiMAX), Near Field Communication (NFC), and cloud networks. The advantages of using the wireless technologies are system scalability and easy extension, smart building interior design, integration of mobile devices.

Smart automation system is not a new terminology in the field of science and technology even though it is still far away from people's vision. It has highly advanced automatic systems for controlling light, temperature, security, appliances and other functions by using smart devices. Internet of Things (IoTs) is linked together with smart automation systems. IoT is a computing concept that the physical objects communicate between things and people, and between things themselves, and across the internet. Methods like Radio-Frequency Identification (RFID), sensor technology, and wireless technology or Quick Response (QR) codes are used in communicating with each other. In the last couple of years, IoT has become significantly important and it has added a new dimension to the communication technologies in the world [2]. IoT technology helps in creating wide development space for smart homes with intelligence, human comfort zone and improvement of quality of life. In addition to controlling of devices IoT can also continuously monitor the home environment and the amount of energy consumption. As this system can be designed to control automatically in an optimum way, the power consumption reduces and it will contribute to the cost reduction and energy saving which are more important in today's world.

When automating a home by using Wireless Automation System with IoT, it is called a smart home. Nowadays the world tends to move towards the concept of smart city without satisfying with smart homes. The concept of the smart city is to build eco and socio friendly city, which provides high standards of living for citizens and broadens their participation in the development of a smart and resilient city. Smart City Projects focus on the vital role of infrastructure facilities in the city. The smart systems such as Smart health facilities, smart road systems, smart cinema and lecture theaters, smart classrooms, and smart farms are designed under smart city concept. The smart city concept has achieved worldwide success in both developed and developing nations. The solutions for the challenges in the fields of economic, social and environment are given from combining innovation in digital technology, engineering and social sciences for the success of this concept [3].

When doing this study, the attention was given not only to the smart home but also for the smart city concept. This study

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contains seven major systems. They are room temperature, lighting condition, skin moisture sensing, RGB LED Lighting, air conditioning control, ceiling fan control, and mobile application with the main controlling system. Room temperature, lighting condition, and skin moisture sensing systems consists of a Radio Frequency (RF) transmitter & receiver, skin moisture sensor, room temperature detection sensor, light sensor and micro-controller. The purpose of the sensing system is to supply the data needed to the main controller system.

The RGB LED Lighting system was designed by programming the ATMEGA 328P-PU microcontroller with the RF receiver. It consists of a RGB LED panel light, which is powered by switch mode power supply (SMPS), and it controls the microcontroller by using Pulse Width Modulation (PWM) technique across TIP 122 transistors.

Air conditioning control and ceiling fan control systems are designed by programming the ATtiny85 microcontroller with RF receiver. Air conditioning control system controls an inverter type air conditioner (AC) using an IR remote transmitter. Ceiling fan control system controls a ceiling fan by using PWM technique across a Triac, according to the signals of the main controller. Room temperature, lighting condition & skin moisture sensing system, RGB LED Lighting system, air conditioning control system and ceiling fan control system are connected with the main controller across RF communication.

Main controller consists of a programmed ATMEGA 328P-PU (Arduino UNO) microcontroller with a RF transmitter and receiver. It is connected with the LoLin Node MCU V3 (ESP 8266 MDD) Wi-Fi module. The data given from the mobile application according to the user's requirements are supplied to the main controller through a Wi-Fi module across the cloud network. The mobile application is designed by using android studio for the latest smart phones using the Operating System post Android Version 5.1 (Lollipop). The mobile application is paired with smart automation system through a QR code.

II. PROCEDURE

A. *Room Temperature, Lighting Condition and Skin Moisture Sensing System*

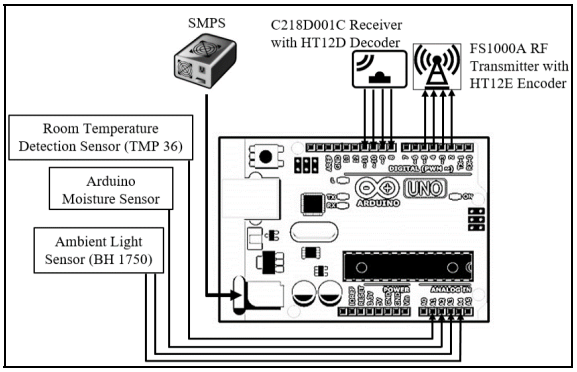

Fig. 1. Room temperature, lighting condition and skin moisture sensing system.

Fig. 1 shows the block diagram of the room temperature, lighting condition and skin moisture sensing system, which transmits the data of the environmental conditions to the main control system. The sensing system controlled by a programmed ATMEGA 328P-PU (Arduino UNO) microcontroller. It also consists of 230V AC to 12V DC SMPS, RF transmitter (FS 1000A), RF receiver (C218D001C), HT 12E Encoder, HT 12D Decoder, Arduino moisture sensor, room temperature detection sensor (TMP 36) and ambient light sensor (BH 1750).

Arduino moisture sensor detects the skin moisture of a contacted skin and TMP 36 temperature detection sensor measures the atmospheric temperature. Ambient light sensor measures the light luminance. ATMEGA 328P-PU microcontroller analyzes the data given from the above sensors. Then the data needed for the main controller are transmitted according to the commands given from the main controller. RF communication is used in communicating data between main controller and room temperature, lighting condition and skin moisture sensing system.

B. *RGB LED Lighting System*

LED lights are abundantly used in the industry. There is less power consumption and easy usage hence these are low voltage devices. LED lights have 90% less power consumption when compared with Halogen and incandescent lights. LED lights operate in an optimum way on precise voltages such as 12V or 24V DC.

In this study, a 12V DC RGB LED panel light was designed to obtain different color modes. This lighting system controls color, color temperature and luminance by considering the instances and the lighting conditions. RGB panel lights are commercially available but there are no panel lights that are designed for multi-function activity based color modes. This designed RGB LED panel light can be used in different requirements in different fields without doing any changes to the structural design to the RGB LED panel. It is commercially valuable, important and user friendly since the same light can be used in different purposes.

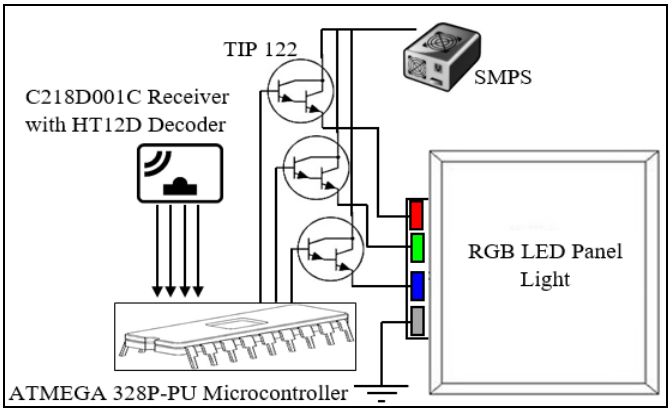

Fig. 2. RGB LED lighting system.

Fig. 2 shows the block diagram of the RGB LED lighting system. The lighting system controlled by a programmed ATMEGA 328P-PU microcontroller. It also consists of 230V AC to 12V, 5V DC SMPS, RF receiver (C218D001C), and three TIP 122 transistors. According to the commands given

from the main controller, the ATMEGA 328P-PU microcontroller controls the color, color temperature and luminance of the RGB LED panel light by using PWM technique.

This lighting system is designed for nine modes for different activities in different fields. The modes are named as Relax, Read, Bath, Wisdom, Romance, Kids, Chick, Plant and Fish breeding. These modes are programmed according to the RGB values given in Table I.

TABLE I. MODE, THEIR RGB VALUES AND RELEVANT PLACES

Trial No.	Mode	(RRR,GGG,BBB) Value	Places that can be use this mode
i.	Relax Mode	(211,224,255)	Living rooms, Individual rooms, Casual areas, Meditation rooms
ii.	Read Mode	(255,234,217)	Fig. 3. Reading areas, Libraries, Study rooms, Individual rooms, Office, Lecture theaters
iii.	Bath Mode	(197,215,255)	Bathrooms
iv.	Wisdom Mode	(238,166,231)	Meditation rooms, Yoga institutes, Religious places, Anxienty therapy centers, Medical treatment centers
v.	Romance Mode	(255,128,131)	Bed rooms, Hotel rooms, Restaurants
vi.	Kids Mode	(243,167,241)	Kids rooms, Indoor playing areas
vii.	Chicks Mode	(255,212,029)	Chicks farms
viii.	Plant Mode	(255,246,237)	Indoor Plantations
ix.	Fish Breeding Mode	(221,230,255)	Fish tanks

The theories of color psychology, color therapy, chromotherapy and biology were used in selection of the RGB values of the colors and luminance for different modes. When selecting RGB values for the modes Chicks, Plant and fish breeding, the colors suitable for the chicks, indoor plants and fish breeding were selected [4-14]. The RGB values used in the study can be changed according to the requirements of the user, age of the chicks, type of plants and fish. These selected values can be obtained more qualitatively by doing further studies and researches on the above-mentioned theories. When selecting colors for the farming modes like chicks, plants and fish breeding, the RGB values can be obtained by doing statistical surveys and analysis by considering the factors like age and chromosomes of chicks, plant and fish types. Even though nine modes are designed in this study, many other modes can be programmed according to the user requirements for many activities in different fields. In this way, a single bulb can represent many modes so that the light, which is scientifically defined for many activities, can be obtained in a same place and it is important. Therefore, this is commercially valuable for the fields like residential developments, tourism, hotel industry and farming.

C. Light Dimming System

Today most of the household and offices use switching on-off controls in their lighting systems but they do not use the light dimming systems due to high initial cost. 30% to 90% of energy can be saved by using the dimming system in daylight [15].

Light sensor BH 1750 is used to measure the light intensity. The dimming is controlled according to the data given from the room temperature, lighting condition and skin moisture sensing system. The data given from the light sensor are processed from the main controller system and commands are sent to the RGB LED light system across RF communications [16]. According to the commands of the main controller, the ATMEGA 328P-PU microcontroller provides the necessary PWM signal to the power unit via the TIP 122 transistor. It controls the duty cycle of the power unit and controls the illumination of the bulbs.

D. Air Conditioning Control System

The inverter type air conditioners are the latest technological and most popular air conditioners in today's world in the heating, ventilation and air conditioning (HVAC) field. They are environmental friendly and energy saving systems, which provides the human comfort zone for the users.

In this study, a 38K BTU/h 230V LG inverter air conditioner is used. In here, an IR module is designed to control AC as shown in Fig. 3, according to the commands of the main control system. The air conditioning control system consists of programmed ATtiny 85 microcontroller and YS-IRTM IR sensor. Initially, the remote controller of the AC is decoded by using YS-IRTM IR module and Arduino microcontroller. Designed air conditioning control system is programmed according to the above recorded decoded data.

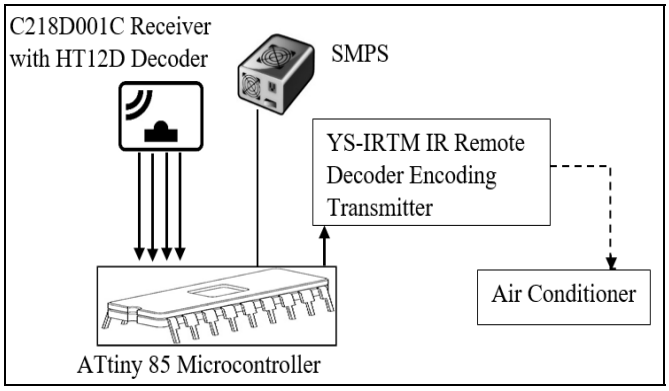

Fig. 4. Air conditioning control system.

According to the data given by the user through the mobile application, the main controller decides the operation condition of the AC and the commands are sent to the air conditioning control system through RF communication. User can decide three conditions of the AC and those are ON/OFF condition of AC, temperature value and ON/OFF condition of the swing mode. This air conditioning system can be used in a place with a heavy crowd according to their preferences and the running mode of AC is chosen from the data given through the application by many users in a same place. ON/OFF condition of AC and swing mode are decided according to the preferences of the majority of the users. Temperature value is automatically set to the nearest integer value of the mean value of the suggestions given by the users. There are no control systems that operate according to the suggestions of a heavy crowd. Therefore, this is better than an individual preference system using a remote. Hence this air conditioning control

system is mostly suitable for a places like lecture theaters and conference halls.

E. Ceiling Fan Control System

Ceiling fan is a low cost selection for the comfort of users mostly in developing countries. When using a ceiling fan, there are two main problems. One of them is that they have no continuously regulating system like in inverter type ACs. In addition, the other problem is the drying of the skin quickly. These problems effect the power consumption and human comfort. Mainly, skin diseases can occur due to the drying of the skin.

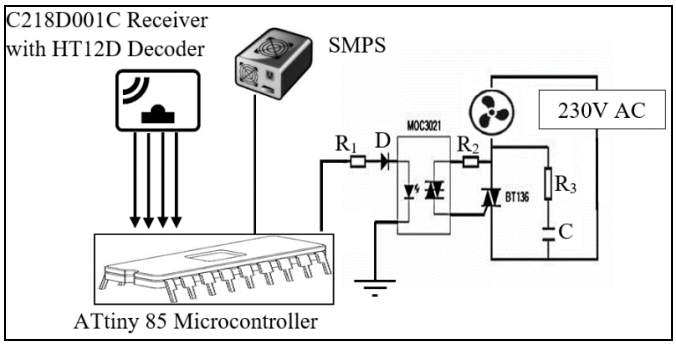

Fig. 5. Ceiling fan controlling system.

By considering above reasons, a ceiling fan controlling system was designed as shown in Fig. 4. It also has a programmed ATtiny 85 microcontroller, which works according to the commands of the main controller. User can select two running conditions of the ceiling fan using the mobile application. There are automatic and manual modes. In automatic mode, the running condition of the ceiling fan is decided by the main controller according to the temperature and skin moisture level data given from room temperature, lighting condition and skin moisture sensing systems. When programming the system, the standard initial temperature and moisture level were considered as 26 ºC and 40 % respectively. These values can be adjusted according to the conditions of the skin of the user and medical advices. In manual mode, user can decide the speed of the fan among five speed values (1, 2, 3, 4, and 5). In here, the ON/OFF condition of the ceiling fan and the auto mode are selected according to the preference of the majority of the users and the speed is automatically set to the nearest integer value of the mean value of the suggestions given by the users as in the air conditioning control system.

F. Mobile Application with Main Controlling System

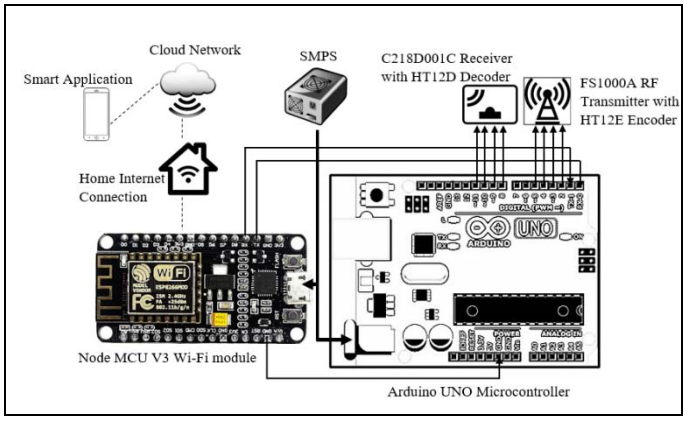

Fig. 6. Mobile application with main controlling system.

Block diagram of the Mobile application with main controlling system is shown in Fig. 5. This is the direct interface that communicates with the user and the main controlling system is the processing unit, which gives the commands to control the ceiling fans, AC and lights according to the user requirements and ambient environmental conditions. This consists of a programmed ATMEGA 328P-PU (Arduino UNO) microcontroller with RF transmitter and receiver. It is connected with LoLin Node MCU V3 (ESP 8266 MDD) Wi-Fi module. The data given by the user through the mobile application are supplied to the Node MCU Wi-Fi module through the cloud network. These data are supplied to the ATMEGA 328P-PU microcontroller. The receiving of the data from room temperature, lighting condition and skin moisture sensing system and sending the commands to room temperature, lighting condition and skin moisture sensing system, RGB LED Lighting system, air conditioning control system and Ceiling fan control system is done by the Arduino UNO microcontroller through RF communication using RF receiver (C218D001C) and transmitter (FS1000A) modules.

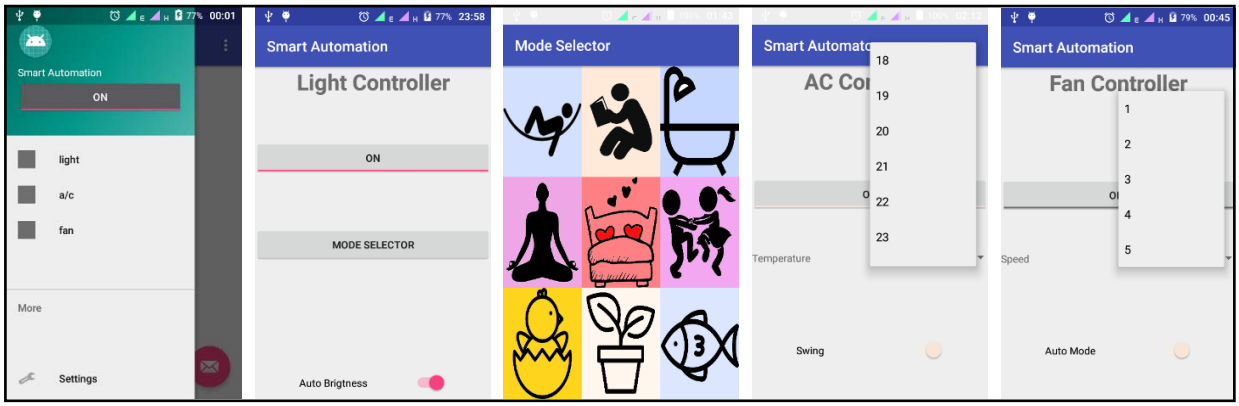

Fig. 7. Mobile application User Interfaces.

As shown in Fig. 6, Mobile application is designed by using android studio for the latest smart phones using the operating system post Android Version 5.1 (Lollipop). There are mainly five interfaces in the mobile application. They are main menu, light controller, mode selector, AC controller and fan controller. Light, AC, fan can be turned ON/OFF from the main menu by a single touch. Main menu is linked to light controller, AC controller and fan controller. In light controller, the lights and auto brightness mode can be turned ON/OFF. Mode selector user interface is linked to light controller. In mode selector interface, there are nine modes that can be selected which were defined earlier. In the AC controller interface, AC and swing mode can be turned ON/OFF and the temperature value can be selected. In fan controller interface, ceiling fan and auto mode can be turned ON/OFF, and the speed of the ceiling fan can be selected. Application can pair with the smart automation system via internet using a uniquely designed QR code.

III. Conclusion

Following are the main features of the designed unit that make it unique compared to the existing smart automation systems.

Wireless technology such as Wi-Fi, RF Communication and cloud networking are used in communication between devices and user interfaces in order to avoid the disadvantages of wired communication in turn reducing costs. Automation systems can be monitored from anywhere in the world because of the use of the cloud network. Additionally, this technology can be developed with low cost and more efficient way by using the technologies like WiGig, Zigbee, and LoRa.

Another achievement of this study is the design and development of an activity based color mode LED lighting and dimming system. This is important not only to home but also for many fields like farming which use artificial lights. This reduces the power consumption and provides a comfort zone because of color psychology. Many modes can be designed to increase the efficiency of the farming and industrial fields. Therefore, this is commercially valuable for the fields like residential developments, tourism, hotel industry and farming. When creating the LED lighting system, the quality of the output can be increased by using the modern technology and by proving the accuracy of the given colors experimentally. In the light dimming system, this can be developed further to gain more efficiency by using few light sensors which are placed in locations like doors and windows.

Ceiling fan and air conditioning control system is designed to be used in places with heavy crowds according to their preferences so that the system satisfies everyone. This would be a successful system as it operates according to the suggestions of all users in the same place. As celling fan control system automates according to the skin moisture of the user, which is important for skin health. In this study, a separate sensor was used in detecting the level of the skin moisture. However, it is suggested that designing an automation system that can collect the data from the smart ring, smart watch or fitness band, which is included with a skin moisture detection sensor would be the best way forward. It can supply the accurate data directly to the automation system according to the skin condition of the client. It is suggested that if experiments can be carried out to create a bed sheet or blanket in a way such that it can obtain data about the skin moisture, a solution can be given for those who do not like to use a smart watch, smart band or other physical instruments.

In this study, the automation system and mobile application is paired with a QR code. When using this automation system in places like lecture theaters, the QR code can be implemented in the backside of the seats so that the user can access it quickly. This can be modified by using technologies like NFC and RFID.

This concept can be modified furthermore with necessary alterations.

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