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Artificially Intelligent Home Automation System Based on Arduino as the Master Controller

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ABSTRACT
The popularity of home automation has been increasing vastly in recent years due to much higher affordability and simplicity. Being able to control aspects of our houses, and for having the feature to respond automatically to events, it is becoming more and more popular and necessary due to security and cost purposes. We propose to implement an integrated home automation and security system. Our project proposes a low cost solution using off the shelf components to reduce cost and open source software to get around licensing requirements of software. An Arduino controls sensors and actuators that monitor a defined location and take action based on specified parameters like ambient light, temperature etc. The Arduino can also send alerts if it detects an abnormality. The voice recognition schema allows the user to use voice commands to control his house.

Index Term: *Home Automation, Arduino, Voice Recognition, Graphical User Interface, Microsoft Visual Basic.*

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I. INTRODUCTION

Home automation systems are quickly emerging and becoming popular nowadays in the world and its end users are specifically the disabled and elderly but due to their complexity and cost it is not always accepted. Population ageing is taking place in nearly all the countries of the world. Ageing results from decreasing mortality, and most importantly, declining fertility. This process leads to a relative reduction in the proportion of children and to an increase in the share of people in the main working ages and of older persons in the population. The global share of older people (aged 60 years or over) increased from 9.2 per cent in 1990 to 11.7 per cent in 2013 and will continue to grow as a proportion of the world population, reaching 21.1 per cent by 2050. [1]

With rapid economic growth, living standard are also rising day by day. The modern society wants safe, economic, comfortable and convenient life which is ideal for every family. "Home automation is a very promising area. Its main benefits range from increased comfort and greater safety and security, to a more rational use of energy and other resources, allowing for significant savings. It also offers powerful means for helping and supporting the special needs of people with disabilities and, in particular, the elderly. This application domain is very important and will steadily increase in the future [2]." Home automation is known as the automation of the home, housework or household activity.

It commonly defines a residence that integrates technology and services through home networking to improve the quality of living. Home automation is not a new term for science society and has been around for a significant time.

Home automation include mainly centralized control of lighting, temperature, appliances, and other systems, to provide improved comfort, convenience, efficiency and security. For disabled and elderly person home automation can be the substitute of institutional care. Shepherd [3] has introduced the idea of using Bluetooth wireless technology as a cable replacement using the wireless interconnectivity which can be implemented using radio home automation system method. Sriskanthan et al. [4] explained an automated system based on Bluetooth wireless technology which allows the user to monitor and control different appliances that are connected over a Bluetooth network based on a mobile host controller. Maqsood, J. [5] implemented techniques and provided a viable solution to realize home automation system which constitutes Bluetooth control via Android app development for in-house control and GSM (Global System for Mobile Communication) technology for mobile control using Arduino. Cubukcu, A. et al [6] has implemented speech recognition-based remote control of home devices. Adriansyah, A. et al [7] designed a system able to monitor and control lights, room temperature, alarms and other household appliances.

As for this project, the proposed solution is to develop an economical smart home system without increasing the complexity and using off the shelf components to reduce the cost and open source software to get around licensing requirements of software. The sensors will be controlled with the help of Arduino, and the voice command part has been developed on Visual Basic, both of which are FOSS (Free Open Source Software) and the security system GUI is designed with the help of MATLAB 2013. Arduino is an
open-source prototyping platform that provides easy-to-use hardware and programming environments. It is relatively inexpensive compared to other microcontroller-based platforms like Beagle Bone. Thus creating an economic and energy efficient system development.
In the next part we have described the hardware setup of our system. We had described the methodology in the Section III, while Section IV describes the experimental evaluation and the conclusion is presented in Section V.

II. HARDWARE PLATFORM

The hardware part mainly consists of a digital computer, an Arduino Uno board, Light Detecting Resistors, Temperature sensor (LM35), LPG and Smoke sensor (MQ2), Temperature and Humidity sensor (DHT11), Webcam, DC Motor, which are being discussed along with their specific functions.

A. Arduino Uno

An Arduino board [8] consists of an Atmel 8-, 16- or 32-bit AVR microcontroller with complementary components which helps in programming and other circuit incorporation. This board has a 5 volt linear regulator and a 16 MHz crystal oscillator.

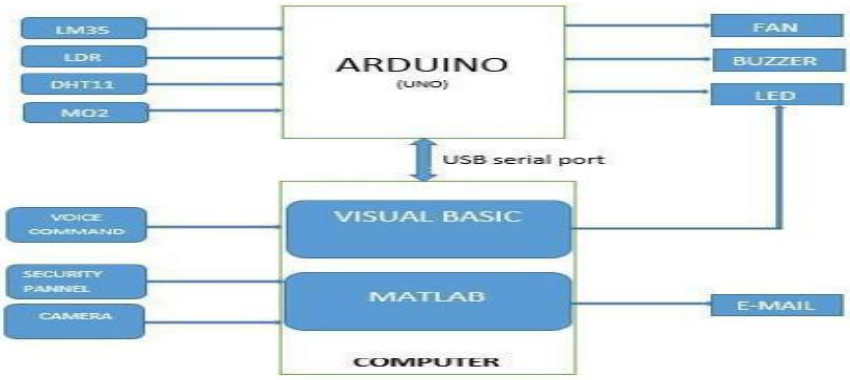

Fig 1.1. A block diagram representing the circuit developed

B. Light Detecting Resistors (LDR)

It is a special type of resistor that has a (variable) resistance that changes with the light intensity that falls upon it. This allows them to be used in light sensing circuits.

C. Temperature Sensor (LM35)

It is a precision integrated-circuit temperature sensing device with an output voltage linearly proportional to centigrade temperature. LM35 [9] device has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from
output to obtain convenient centigrade scaling.

D. LPG and Smoke Sensor (MQ2)

In Industry, It can detect H2,LPG, CH4, CO, alcohol, Smoke, Propane. Based on its fast response time, measurements can be taken as soon as possible. Also the sensitivity of the Sensor Module (MQ2)10 Module si useful for gas leakage detection in home and can be adjusted by the potentiometer. When the target combustible gas exist, the sensor's conductivity is higher along with the gas concentration rising.

E. Temperature and Humidity sensor (DHT11)

DHT11 [11] uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin (no analog input pins needed). It's fairly simple to use, but requires careful timing to grab data. The only real downside of this sensor is one can only get new data from it once every 2 seconds.

III. METHODOLOGY

In this paper our main aim is to propose model for home automation system. Proposed system architecture is shown in Figure 1.1.

The home automation system consists of two main hardware components: the computer which runs the Matlab, Visual Basic, and the Arduino Uno microcontroller board which is flexible, inexpensive, offers a variety of digital and analog inputs, serial interface and digital and PWM outputs. A PC home server hosts the Matlab-GUI platform management and Arduino Uno controls the home appliances and also enables the user to access them through voice commands. The computer communicates with the Arduino Uno microcontroller board through USB data transfer cable. A number of appliances and sensors are connected to ports of the microcontroller board. The home Appliances can be monitored and accessed remotely.

A. Monitoring sensor reading

Arduino enables users to monitor various kinds of sensors such as thermometer and motion detectors in real-time. The analog and digital pins on the Arduino board can serve as general purpose input and output pins (GPIO). The ATmega328 microcontroller embedded on the Arduino board contains the analog-to-digital converter (ADC), which converts the analog input signal to a number between 0 and 1023.

The integer number is proportional to the amount of the voltage being applied to the analog input. Any sensor operating on 5 volts can be directly connected to the Arduino board. As a prototype for monitoring sensor readings with Arduino, we have implemented a simple setup to connect the analog sensor to the Arduino board.

B. Controlling actuators

The Arduino gateway can trigger actions (e.g., pushing notifications and turning on or off switches) while monitoring sensors in real-time. While reading the sensor data in real-time, the Arduino takes required actions like controlling the speed of fan, switching the LED, and turning ON/OFF the alarm accordingly.

In this proposal, two operating modes are designed. The first one is a manually– automated mode in which the appliance (lights) is monitored and accessed by voice command. The selected appliances can be switched ON/OFF according to the suitable decision.

The other mode is a self-automated mode. In this case the microcontroller accesses the appliance automatically without returning back to the user decision. The user can monitor the action only.

The security panel is designed with Matlab-GUI platform. The designed Matlab-GUI platform can control the whole system and turns ON/OFF the system accordingly and also sends required information to the user.

C. Smart Home Temperature Sensing System

At this section we will control the home temperature automatically by using a special temperature sensor LM35. It has an output voltage that is proportional to the Celsius temperature. It has low self-heating capability, suitable for remote applications, low cost due to wafer level trimming, operates from 4 to 30v, low impedance output in this case. In this project we used this to sense the room temperature, the Arduino classifies the measured temperature as hot, normal or cold and then controls the speed of the fan accordingly by varying the duty cycle of the motor using the PWM technique. So if room temperature goes very high or low it can be automatically adjust the fan as per the temperature.

D. Smart Home Lighting Control Systems

In this section user will be able to control the light by LDR sensor automatically. In automatic light control system, Light Dependent Resistor (LDR) sensor is used to detect bright/medium/dim/dark conditions.

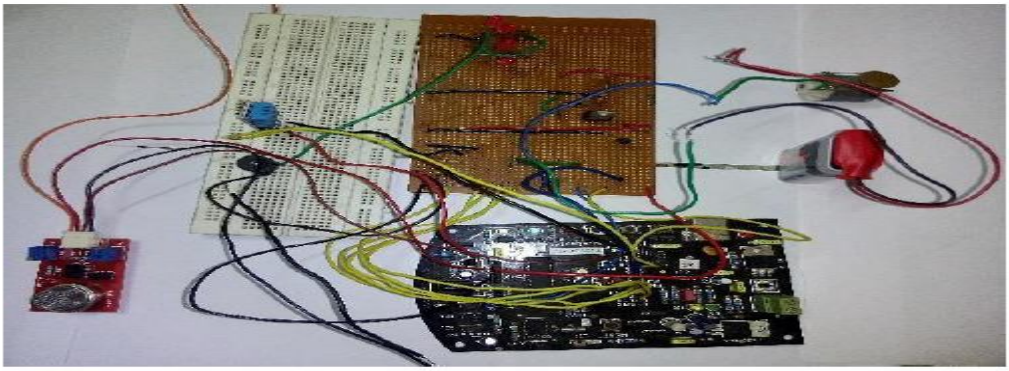

Fig. 2.1: Complete Circuit.

The number of LED lit is controlled by the Arduino and depends on the lighting condition of the room and is inversely proportional with the brightness of the room. This application is important for saving the energy.

E. Humidity Sensing System

The humidity of the room is measured by using a DHT11 sensor. The DHT11 is a basic, ultra-low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin. The data is received by Arduino and the temperature and humidity is viewed on the computer screen.

F. LPG/Smoke Detecting System

The smoke sensor we used is the MQ-2. This is a cheap sensor that is not only sensitive to smoke, but also to flammable gas. The MQ-2 smoke sensor reports smoke by the voltage level as output. The more smoke is there, the greater the voltage output. The MQ-2 also has a built-in potentiometer to adjust the sensitivity to smoke. By adjusting the potentiometer, one can change how sensitive it is to smoke, so there is a form of calibrating it to adjust how much voltage it will give in relation to the smoke it is exposed to. We wired the MQ-2 to the Arduino so that the Arduino can read the amount of voltage output by the sensor and sound a buzzer and flashes a message "House on fire" on the computer screen if the sensor outputs a voltage above a certain threshold. This way, we will know that the sensor is detecting smoke and will sound a buzzer alerting the user.

G. Smart Home Security Systems

The security system is designed using the MATLAB GUI platform. A security system consists of a portable panel consisting of pushbuttons, a LCD screen and a camera. On start up the system requires a 4 digit password which was previously set up by the user. If the entered password matches the previously set up password then Matlab sends an affirmative message to the Arduino via USB cable so the door opens and the entire smart home system turns ON. If the password does not match, then the camera captures an image of the intruder and saves the image in the system and also e-mails the image to the user and the door remains locked.

Fig 2.2: Real Time Security System,Developed Using GUI.

H. Voice Control

At the end of our work we have introduced a special features for our smart home system which will be highly beneficial for elderly or differently abled person. The user will be able to turn on and control the brightness of lights (led) by giving voice commands. A program is written in visual basic to accomplish this action. Using this program, the system recognizes the voice command and sends a predefined message according to the command, to the Arduino. The Arduino turns ON/OFF the lights or control the brightness according to the message received.

IV. EXPERIMENTAL EVALUATIONS

In order to implement and demonstrate the system developed theoretically, we created a prototype that represents different home appliances. Thus the whole system that is being developed is given below, (Fig. no:2.1). From this figure given here we can see different parts of the circuit board that is developed, which is connected with the Arduino`s digital and analog pins as required. The image of the security panel designed by Matlab GUI is given above which consists of several pushbuttons and a camera screen.

V. DISCUSSIONS AND CONCLUSIONS

A novel architecture for an economic smart home system is proposed and implemented in this paper. It gives basic idea of how to control various home appliances and provide a security using Arduino Uno and Matlab GUI. The cost of smart homes technology is for some people an argument against the choice of such installations. This project uses low cost off the shelf components, and is based on Visual Basic and Arduino platform which both are FOSS (Free Open Source Software). So the overall implementation cost is very cheap and is affordable by a common person. This low cost system is designed to improve the standard living in home. The voice control function provides help and assistance especially to disabled and elderly. The security system designed in Matlab GUI also ensures the security of the home and provides a safeguard from possible intruders.
For future work, some recommendation can be made like adding motion sensors for automatic turning ON/OFF of lights, fans depending upon the position of user, wireless connectivity can be added to system, and schedulers can be added for controlling home appliances. The whole system can be fabricated as economic commercial hardware package. The concept of this home automation can also be used for grid automation in smart grids in power systems.

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