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An intelligent state of the art approach in building automation and security system

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ABSTRACT

This paper describes the design and development of a cost-effective home automation and security system with the use of Arduino and GSM technology. The cellular communication is a potential solution for the control of appliances remotely. A home owner will be able to monitor and control the appliances at home remotely by sending a set of commands i.e., Short Messaging System (SMS) messages to the Global System for Mobile Communication (GSM) module. This system also deals with a Passive Infrared motion sensor, a password for the door lock and a camera. Data from all of the sensors is received and processed by Arduino Uno board which is the microcontroller unit. Thus, the system provides automation, safety as well as security for the authorized personnel.

Keywords: *Arduino, Automation, Security, GSM, PIR sensor.*

1. INTRODUCTION

In today's developing world, security of our homes, as well as workplaces, has been a very important factor [1]. The importance of providing a dedicated home security system (HSS) is crucial due to rising number of burglaries, thefts and to provide a calm and peaceful environment. A system accessible only by authorized personnel is of utmost importance.

Home automation system (HAS) is referred to as 'Intelligent home' or 'automated home' which indicates the automation of various electrical appliances we used at home. This can include the controlling of light switches, fans, ACs, temperature sensing, automatic load controlling, sensors and many more [2,3]. The concept of home automation provides a convenient, comfortable and safe environment for the occupants. Also, smart maintenance of security especially at homes is given special importance for the safety of the home dwellers [3-4]. The conventional lock and key system may not provide the best form of security. So, it is a very crucial factor that the home dwellers have dedicated system of security that is accessible only by authorized personnel [11]. The Home Security System (HSS) is designed to detect any warm body passing through it, allow access to the door upon correct entry of a password and the camera will capture the image of the person when the PIR sensor detects any motion passing through it.

In this work, the objective is to provide a low cost and flexible home automation and security system (HSS) with the use of PIR sensor, which will detect any warm body passing through it, a camera to record the premises and a password system which will unlock a door upon the correct entry. The PIR sensor triggers an alarm when a warm body passes the system/home. Also, the home automation system includes the controlling of switches using relays which are controlled using a GSM module. The user can set the status of the appliances by sending an SMS to the module remotely. The command is sent from the user's mobile phone to the SIM installed in the GSM module provided in the system. Upon receiving the command, the system performs the designated operations simultaneously.

2. RELATED WORK

Amruta Patil, Pooja Potnis and Karishma Katkar [1] suggested automation techniques which can be applied to control home appliances remotely. Controllers and sensors are used for automation. Transmitter section contains the android mobile and Receiver section is the actual controlling electronic system for home automation which is designed using the Arduino circuit containing the GSM module for wireless communication.

A system to develop a low-cost means of a home security system using sensors like a motion sensor, PIR sensor is introduced by Viraj Mali [2]. This system deals with the OTP (One Time Password) generation is used as entry password for the user. Data from all these sensors is received and processed by Arduino Uno board which acts as a microcontroller unit. In case of untoward situations, the Arduino will trigger an alarm and alert messages will be sent to user's mobile via GSM.

S. Das et. al [3] and Rozita Teymourzadeh [4] described the design and development of a system for household appliance control using cell phone through global system for mobile communication (GSM) technology. The concept of serial communication and AT-commands has been applied towards the development of the smart GSM-based home automation system. Home owners will be able to receive feedback status of any home appliances under control whether switched on or off remotely from their mobile phones. Similar techniques are described in [5] and [6].

Avadhoot R. Telepatil proposed a system which demonstrates interfacing between MATLAB and Arduino board for control [7]. Arduino board is interfaced with MATLAB using serial household equipment monitoring and communication to control home appliances. Image acquisition device is interfaced to MATLAB that will continuously show the status of household equipment on Graphical User Interface (GUI) designed in MATLAB. Proper commanding is done from MATLAB GUI, household equipment can be turned ON or OFF which are interfaced to Arduino through relay board.

3. PROPOSED WORK

The proposed work is described in the block diagram as shown in Figure 1. It has two mechanisms i.e., the Home Security System (HSS) and the Home Automation System (HAS).

The HSS is made up of a network of a motion detecting passive infrared (PIR) sensor, a password entry, and a camera to record whenever the PIR sensor senses any motion.

The HAS is made up of an Arduino and GSM network with relays. Whenever a set of specific commands is sent from the user's mobile phone to the GSM Module in the system, the Arduino performs the task according to information or command it received. The relays are operated as per instructions from the user.

A. Home security system (HSS)

Here the password from the keypad, the infrared detector activated by the motion of a person (i.e., from PIR sensor) and camera are taken as inputs. The output of the system is the information visualization in the Liquid Crystal Display (LCD), a buzzer alarm and a dc motor. To implement the system, we use a microcontroller AT89C2051, 16x2 LCD, a 4x4 keypad to enter a password, a camera, a servo motor and PIR sensor. Whenever the PIR sensor detects any warm body (human or animal) it will sound a buzzer alarm. The camera starts recording at the same moment the PIR sensor detects any motion. The camera is connected to a laptop or any other recording device. The password is entered through a 4x4 keypad at the entrance. If the correct password is entered, the door will open. Otherwise, the door remains locked.

B. Home automation system (HAS)

In this part, Arduino and GSM module are used for controlling the whole process. A SIM900 GSM module is used for wireless communication in controlling the home appliances. Commands such as "#A.Fan.on*" "#A.Fan.off*" is used for controlling the appliances. Arduino receives the message through GSM. It then sends the signal to relays to switch ON or OFF the home appliances using relay driver. A prefix in command "#A." is used to identify that the main command is coming next to it and * at the end of the command indicates the message has ended. When the message is sent from the GSM module of a mobile phone to the GSM module in Arduino, the Arduino reads the message by extracting the main command from the received message and stores it in a variable. After this, Arduino compares the command with a predefined command. If the command is matched then the Arduino sends a signal through the relay driver for switching ON and OFF the home appliance and simultaneously the result is displayed on the LCD using appropriate commands.

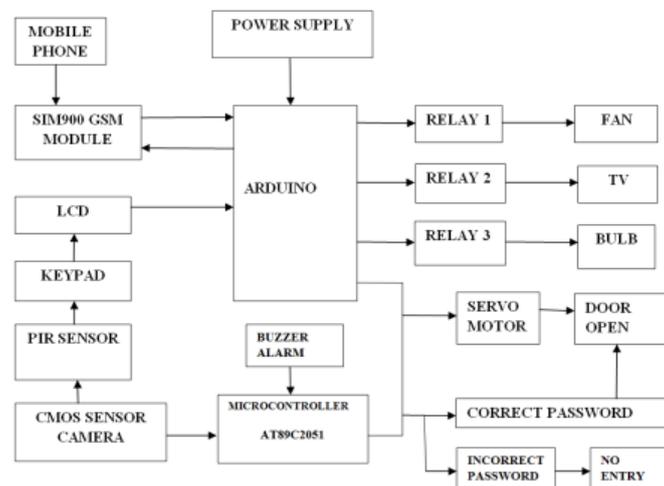


Figure 1. Block diagram of the proposed system

4. SYSTEM SPECIFICATIONS

A. Hardware Requirements

i. Arduino Uno

The Arduino Uno is an open source microcontroller board based on the Atmega328P microcontroller and developed by Arduino.cc. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. We can simply connect to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. It is programmable with Arduino IDE (Integrated Development Environment) via a type B USB cable.

ii. GSM Module

GSM Modem is a class of wireless modem devices that are designed for a communication of a computer with the GSM and GPRS network. It requires a SIM (Subscriber Identity Module) card like mobile phones to activate communication with the network. They also have IMEI (International Mobile Equipment Identity) number similar to mobile phones for their identification. A GSM/GPRS MODEM can perform the following operations:

- Receive, send or delete messages in a SIM.
- Read, add, search phonebook entries of the SIM.
- Make, receive or reject a voice call.

iii. Relay driver

Relay board consists of three SPDT (Single Pole Double Throw) relay and a relay driver ULN2003. ULN2003 is a high voltage and high current Darlington array IC. It contains seven open collectors Darlington pairs with common emitters.

iv. QHM495LM PC Camera

It has a built-in mic with noise reduction, Interpolated to 25 Mega Pixels, 10 Level Zoom on live Motion Picture, Special Visual Effects, True Motion Picture, Night Vision 6 Bright light switch ON through switch and potentiometer, Inbuilt Sensitive Microphone, Background Changeable of Live Motion Picture, Up to 30% Better Exposure To Give better Picture Even in dark, Auto Exposure, Special Face Effects, USB 2.0.

v. PIR Sensor

PIR sensors allow you to sense motion, almost always used to detect whether a human has moved in or out of the sensors range. They are small, inexpensive, low-power, easy to use and don't wear out. For that reason, they are commonly found in appliances and gadgets used in homes or businesses. They are often referred to as PIR, "Passive Infrared", "Pyroelectric", or "IR motion" sensors. PIRs are basically made of a pyroelectric sensor, which can detect levels of infrared radiation. Everything emits some low-level radiation, and the hotter something is, the more radiation is emitted. The sensor in a motion detector is actually split into two halves. The reason for that is that we are looking to detect motion (change), not average IR levels. The two halves are wired up so that they cancel each other out. If one half sees more or less IR radiation than the other, the output will swing high or low.

vi. AT89C2051 Microcontroller

The AT89C2051 is a low-voltage, high-performance CMOS 8-bit microcomputer with 2K bytes of Flash programmable and erasable read only memory (PEROM). The device is manufactured using Atmel's high-density nonvolatile memory technology and is compatible with the industry-standard MCS-51 instruction set. By combining a versatile 8-bit CPU with Flash on a monolithic chip, the Atmel AT89C2051 is a powerful microcomputer which provides a highly-flexible and cost-effective solution to many embedded control applications.

vii. LCD

The 16x2 alphanumeric Liquid Crystal Display (LCD) can display alphabets along with numbers on 2 lines each containing 16 characters.

viii. Mobile phone

The mobile device communicates with the GSM Modem via radio waves. The mode of communication is wireless and the mechanism works on the GSM technology. The cell phone has a SIM card and a GSM subscription. This cell phone number is configured on the system. The user transmits instructions via SMS and the system takes action against those instructions. The mobile phone can be any GSM-enabled phone which will be used to send the SMS command to the GSM Module embedded in the system.

B. Software requirements

i. Arduino Software

The open-source Arduino Software (IDE) makes it easy to write code and upload it to the board. It runs on Windows, Mac OS X, and Linux. A program for Arduino may be written in any programming language with compilers that produce binary machine code for the target processor. Atmel provides a development environment for their microcontrollers, AVR Studio and the newer Atmel Studio.

The Arduino project provides the Arduino integrated development environment (IDE), which is a cross-platform application written in the programming language Java. It originated from the IDE for the languages Processing and Wiring. It includes a code editor with features such as text cutting and pasting, searching and replacing text, automatic indenting, brace matching, and syntax highlighting, and provides simple one-click mechanisms to compile and upload programs to an Arduino board. It also contains a message area, a text console, a toolbar with buttons for common functions and a hierarchy of operation menus.

A program written with the IDE for Arduino is called a sketch. Sketches are saved on the development computer as text files with the file extension .ino. Arduino Software (IDE) saved sketches with the extension .pde. The Arduino IDE supports the languages C and C++ using special rules of code structuring.

ii. Keil μ Vision Software

Keil MDK is the complete software development environment for a wide range of Arm Cortex-M based microcontroller devices. MDK includes the μ Vision IDE and debugger, Arm C/C++ compiler, and essential middleware components. It supports all silicon vendors with over 4000 devices.

5. RESULT ANALYSIS

At the first level, when the PIR motion senses any motion, it triggers the alarm and the camera attached to the circuit starts recording at the same instant. The recording is stored on a computer or laptop for future reference. At the second level, a keyboard is available for entering a dedicated password. If the correct password is entered, the door will open. If the entered password is not correct, the door remains closed. In the automation system, a set of specific commands is sent from the user's mobile phone to the SIM embedded in the GSM module of the system. A different set of instructions is sent for performing a particular task like switching on or off a TV, fan or bulb.



Figure 2. Experimental setup

The Arduino software is used for coding the operation of the home automation system (HAS). Arduino board is incorporated with the SIM900 GSM module to carry out this operation. When the SIM module receives a command, it performs operations as specified in the program.

```
File Edit Sketch Tools Help
gsm_lcd_based_home_appliance_on_off
#include<LiquidCrystal.h>
LiquidCrystal lcd(6,7,8,9,10,11);
#define Fan 3
#define Light 4
#define TV 5
int temp=0,i=0;
int led=13;
char str[15];
void setup()
{
  lcd.begin(16,2);
  Serial.begin(11500);
  pinMode(led, OUTPUT);
  pinMode(Fan, OUTPUT);
  pinMode(Light, OUTPUT);
  pinMode(TV, OUTPUT);

  lcd.setCursor(0,0);
  lcd.print("GSM Control Home");
  lcd.setCursor(0,1);
  lcd.print("Automaton");
  delay(2000);
  lcd.clear();
  lcd.setCursor(0,1);
  lcd.print("System Ready");
  Serial.println("AT+CMMS=2,2,0,0,0");
  delay(500);
  Serial.println("AT+CMGF=1");
  delay(1000);
  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("Fan Light TV");
  lcd.setCursor(0,1);
  lcd.print("OFF OFF OFF");
}
void loop()
```

Figure 3. Software simulation of HAS

```

99  if(!key1) {delay(10); if(!key1) temp = 1; keystate=1; while(!key1);}
100 else if(!key2) {delay(10); if(!key2) temp = 2; keystate=1; while(!key2);}
101 if(!key3) {delay(10); if(!key3) temp = 3; keystate=1; while(!key3);}
102 if(!key4) {delay(10); if(!key4) temp = 4; keystate=1; while(!key4);}
103 if(!key5) {delay(10); if(!key5) temp = 5; keystate=1; while(!key5);}
104 if(!key6) {delay(10); if(!key6) temp = 6; keystate=1; while(!key6);}
105 if(!key7) {delay(10); if(!key7) temp = 7; keystate=1; while(!key7);}
106 if(!key8) {delay(10); if(!key8) temp = 8; keystate=1; while(!key8);}
107 if(!key9) {delay(10); if(!key9) temp = 9; keystate=1; while(!key9);}
108 if(!key0) {delay(10); if(!key0) temp = 0; keystate=1; while(!key0);}
109 if(keystate) {
110     keystate=0;
111     cnt++;
112     if(cnt==10) cnt=0;
113     if(cnt==1) {
114         if(temp==1) lcd_string("  ");
115         if(temp==2) lcd_string(" ** ");
116         if(temp==3) lcd_string(" *** ");
117         if(temp==4) lcd_string(" **** ");
118     }
119     if(temp==0) {
120         lcd_string("Enter Password");
121         if(temp==1) lcd_string(" ");
122         if(temp==2) lcd_string(" ");
123         if(temp==3) lcd_string(" ");
124         if(temp==4) lcd_string(" ");
125     }
126     if(temp==0) {
127         inpass = 1000*temp[0] + 100*temp[1] + 10*temp[2] + temp[3];
128     }
129 }
    
```

Figure 4. Software simulation of HSS

The Keil μ Vision software is used to code the microcontroller for the home security system (HSS). The dedicated password is set and the door is programmed to open when it receives the correct password. Otherwise, it displays “Intruder Detected”.

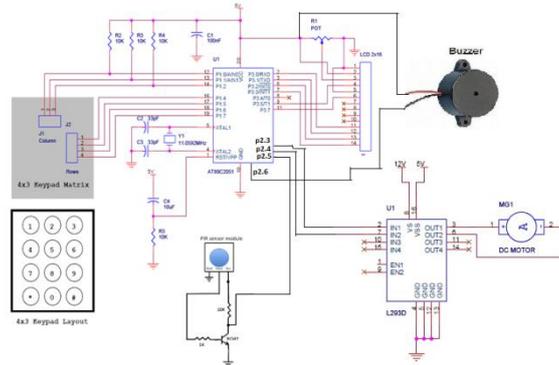


Figure 5. Circuit diagram of HSS

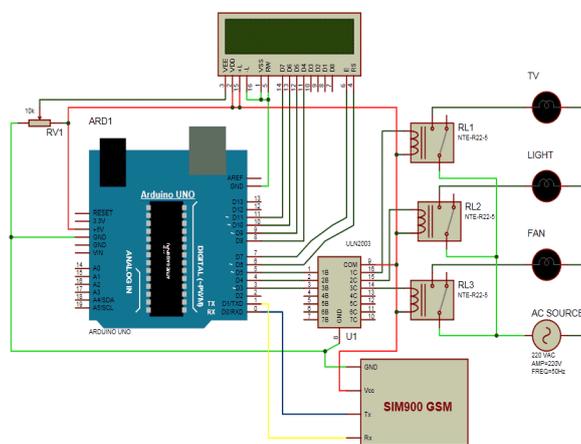


Figure 6. Circuit diagram of HAS

6. CONCLUSION AND FUTURE SCOPE

The system implemented using Arduino Uno, GSM, PIR sensor, password system and a camera provides a safe, efficient and cost-effective system for the maintenance of security at homes or any dwelling place. It also provides ease of controlling various appliances from a remote location. The system detects any warm body that passes through and the camera records the premises. The door opens upon correct entry of a password and vice versa. The user can control the appliances by sending specific commands to the GSM module. In future, the security system can be improved by adding a line of biometric sensors like a fingerprint, an iris scanner, etc. The IP camera can be used for improved surveillance. The automation can also be used for more sensors and appliances at home like gas sensors, smoke sensors, temperature control, etc.

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