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ORIGINAL CONTRIBUTION

Design and Implementation of an Efficient Arduino-Based Smart Home Automation System

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ABSTRACT

In this paper we try to present the circuit design and development enactment of smart home automation system which can be used by one Arduino Uno R3 with some special sensors. To showcase the efficacy of the system, it integrates with a variety of devices such as temperature sensor, distance sensor and ambient light sensor, gas sensor. By implementing this sensors data, system can automate the household functionalities like controlling the light, room temperature and security. Arduino Uno R3 takes action based on some parameters like ambient light and temperature, toxic gas, water level. This projects aims to provide an inexpensive, easily recreatable solutions modern households promoting handiness, safety and energy sustainability through IoT-based solutions.

KEYWORDS: Arduino Uno R3, PIR sensor, TMP36, Tinkercad

1. INTRODUCTION

A smart home automation system is a holistic approach that enhances comfortable living, energy sustainability and security by automating home efficiency solutions. Using interconnected sensors and devices like temperature, gas, light, distance and water level sensors, system allows for real time monitoring and control over household essentials. This system typically managed through a main controller like an Arduino. Smart Home Automation not only improves living comfortable but also consumes less energy, which makes it a permanent and suitable choice. As, technology advances, smart home system can also connect with internet of things(IoT),which allows remote access, controlling with smart phones and voice assistant or Artificial Intelligence(AI). This modern approach of Smart Home Automation system aligns with smart cities growing trends and creating an environment which are more productive, safe, adaptive and flexible. Our motivation behind this work is to create a system which enhances practicality, safeguarding and viability. Our work aims to meet those growing demands, providing user with a modern solution that improves the quality of life and support a secure living environment.

Remaining paper is organized as follows. Related works are described in section-II. Circuit diagram with proper explanations are described in section-III. Software implementation and coding part is described in section-IV. Results and Discussion are described in section-V. Applications are described in section-VI and the paper concludes at section-VII.

2. RELATED WORK

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Basically our survey explores the impact of Smart Home Automation System on every day's life. How it focuses on user satisfaction, energy-saving, cost-reduction and security. Nowadays most of the people use smart technologies, especially those people who live in most of the smart cities. Most of them have any smart automation system installed in their house, like almost 68% peoples response indicates that they have at least one smart appliance like smart lighting, security camera, password protected door implemented in their house. This smart appliances also makes our lives easy and convenient. Almost 75% of user indicates that this voice control features and sensor features makes their daily routine easier and efficient. Also 60% of user response is like they got lower energy bills after implementing smart automated system. It makes their planning for long term savings and environmental benefits easier. 80% of user agreed that this automated system enhances their security system more especially when it integrates with mobile phone for sending them an alert. This particular thing helps those people who travel a lot or lives in urban area.

Already a significant amount of research going on smart automation system and it is rapidly growing technology. There are several studies which explores how smart home automation system can improves energy efficiency, home security and health monitoring, voice controlled automation, water conservation and machine learning and predictive automation. Kim j. et al. (2023) developed an energy-efficient home automation system using IoT-based smart thermostats and lighting systems that adapt to occupancy patterns [1]. Alikhazil et al. (2022) developed a different style of password protected door [2]. Sharma et al. developed a smart home automation system with wearable device and motion sensor to monitor the health of elderly people in the house [3]. Johnson and Le (2021) created the most popular voice controlled automation system that is Alexa, Google assistance to control smart home appliances [4]. Patel et al. (2020) developed a machine learning model within a smart home environment which predicts user preferences by the historical data and shows result from that [5].

3. CIRCUIT DIAGRAM

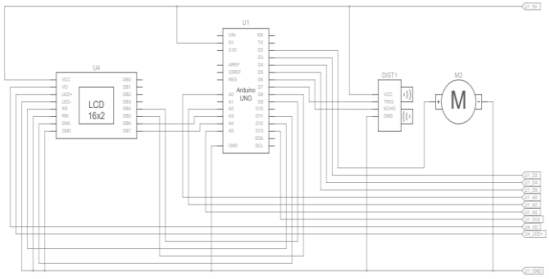

Fig 1: Block diagram of Home automation system

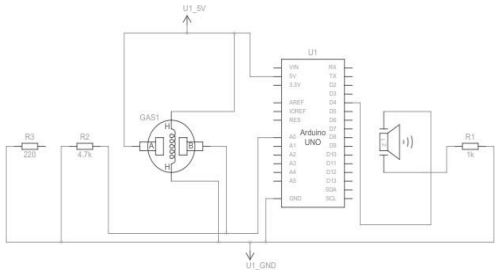

Fig 2: Block diagram of gas sensor

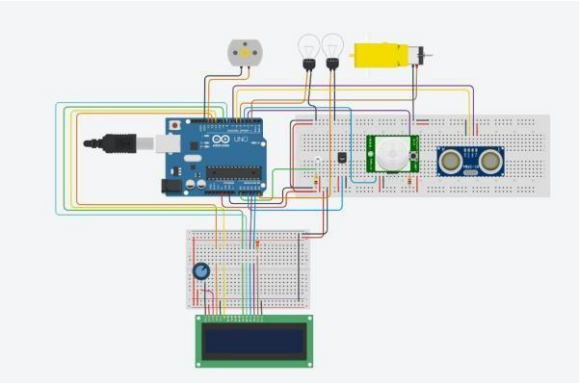

Fig 3: Circuit design of Home automation system

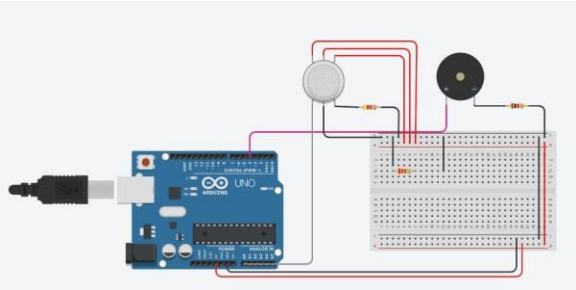

Fig 4: Circuit design of Gas sensor system

The Circuit diagram of smart home automation system is shown in Fig.3. All components are connected one Arduino UNO R3 and two breadboard. This system can run with DC because the whole system use DC motor power supply. Arduino Uno R3 is used to obtain values of physical condition through sensors connected with it. The temperature sensor TMP36 measures temperature. This sensor contains semiconductor material which changes consistently with the changing temperature. There is an ambient light sensor (Phototransistor) which senses changes in light density. It has an NPN transistor where the base is replaced by optical source. Next, there is an Passive Infrared sensor (PIR sensor) that detects changes in infrared light levels over a wide area. It detect heat energy by comparing the signals from a pair of pyro electric elements. There is also an Ultrasonic Distance sensor (4-pin), which uses sound waves to determine how far away an object is. This device emits sounds with a very high pitch and waits for the first echo to come from a nearby object. That's how it determines how far the object is. There is one gas sensor shown in the Fig.4 which detects particles of a particular substance in the air. It detects the presence of a gas by measuring the properties in it.

4. SOFTWARE IMPLEMENTATION USING ARDUINO PROGRAMMING

The programming software we used in our system is Arduino C programming software. We use this programming language because it has so many built-in and external libraries such as servo for controlling motors or liquid crystal for LCD displays, which simplify complex tasks. We use Tinkercad software which is an online tool where we can design circuits, also we can write, compile and upload code to the arduino board. DC motor used to convert electric current to rotational motion. Hobby gearmotor contains DC motor and gearbox. When the motor is powered by DC current, rotor started rotate. One potentiometer is there for changing resistance. There is a Piezo buzzer that makes noise at different frequency measured by distance sensor and work as an alarm bell while there is any toxic gas or fire alarm.

```
#include <LiquidCrystal.h>
int tempVal = A2;
int fan = 13;

int AmbSen = 0;
int outdoor = 5;

long distance;
int duration;

int Burglar = 0;

int trig=7;
int echo=6;

LiquidCrystal lcd(12, 11, 9, 8, A3, A4);
```

Fig.5: Code snippet of Library declaration, variavle declaration, and LCD setup.

Here first of all, add the liquid crystal library, which allow the control of an LCD display. Then declare some variables as temp Val as the analog input for temperature sensor. Assign pin 13 to control a fan, connect ambient light sensor to analog pin 0. Long distance and duration variable used to store the distance and duration for an ultrasonic sensor.

```
//int count = 0;

void setup()
{
  Serial.begin(9600);
  pinMode(fan, OUTPUT);
  pinMode(outdoor, OUTPUT);
  pinMode(tempVal, INPUT);
  pinMode(A0, INPUT);
  pinMode(4, INPUT);
  pinMode(A5, OUTPUT);
   pinMode(2, OUTPUT);
 pinMode(7, OUTPUT);
 pinMode(6, INPUT);
  attachInterrupt(digitalPinToInterrupt(3),stop,CHANGE);
}
```

Fig.6: Code snippet of Arduino pin configuration

It initializes a serial communication at a rate of 9600, allowing data to be monitor or debugging.

Next set the fan pin as output pin to control the fan. Set the temperature sensor pin as an input to read the data. Then attach an interrupt to pin 3, when any change from high to low or low to high detected, then stop function is called in this pin.

```
void loop()
{
//  quakeState = digitalRead(quakePin);
//  autoswitcher();
    // Temperature Controoled Fan
  float temp = analogRead(A2);    //Read the analog pin
  temp = (temp * 0.48828125) - 49;   // convert output (mv) to r
  lcd.clear();
  lcd.print("Temperature: ");
  Serial.print("Temperature: ");
  Serial.print(temp);
  lcd.print(temp);
  Serial.println(" C");  //print the temperature status
  lcd.println(" C");
  delay(100);
```

Fig.7: Code snippet of monitoring temperature data

As shown in the Fig.7, Arduino is continuously monitoring temperature data and displaying it in both monitor and LCD screen. Float temp reads the value from the temperature sensor connected to pin A2. Next line converts the raw analog value into a readable temperature in celcius. There is a delay of 100 milliseconds before repeating the loop.

```
if(temp > 28)
{
  digitalWrite(fan, HIGH);
  delay(100);
}
 else if((temp > 23) && (temp < 28))
{
  digitalWrite(fan, HIGH);
  delay(100);
}
else
{
  digitalWrite(fan, LOW);
    Serial.print("Temperature: ");
   delay(100);
}
```

Fig.8: Code snippet for conditional statement

As Fig.8 shows, if the temperature exceeds 28°C, the fan is turned ON by setting the pin to HIGH. The code then wait for 100 milliseconds before checking the temperature again. If the temperature is below 23 °C, the fan is turned off by setting the pin to LOW.

```
// Automated Outdoor Light
AmbSen = analogRead(A0);
  Serial.println(AmbSen);
  if(AmbSen < 400)
  {

    digitalWrite(outdoor, HIGH);
    delay(100);
  }
  else
  {
    digitalWrite(outdoor, LOW);
    delay(100);
  }
```

Fig.9: Code snippet for controlling automated ambient light

If the ambient light level is below 400, outdoor light is turned ON, by setting the outdoor pin to HIGH. If the ambient light level is above 400, outdoor light is turned OFF, by setting the outdoor pin to LOW. There is a 100 millisecond

delay, so that system does not check the light condition continuously.

```
// Burglar Detection
Burglar = digitalRead(4);
if(Burglar == HIGH)
{
  digitalWrite(A5, HIGH);
  delay(10000);
}
else
{
  digitalWrite(A5, LOW);
  delay(100);
}
```

Fig.10: Code snippet for burglar detection

Burglar detection feature of the home automation system reads the input from PIR sensor and triggers a response when motion is detected. When burglar is high, then it turns on an alert connected to pin A5. When no motion is detected, then it turns off the alert connected to pin A5. The alarm stays active for 10 seconds.

```
 // Water Level Monitoring
digitalWrite(7,HIGH);
digitalWrite(7,LOW);
duration=pulseIn(echo,HIGH);
distance=duration*(0.034/2);
  if(distance>100)
{
digitalWrite(2,HIGH);
delay(100);
}
  else
  {
    digitalWrite(2,LOW);
    Serial.println(distance);
    delay(100);
  }
}


void stop()
{
  digitalWrite(A5,LOW);
  Serial.println(distance);
  delay(100);
 }
```

Fig.11: Code snippet for water level monitoring

If the distance is greater than 100 cm which indicates low water level, an indicator connected to pin2 is turned ON. If the distance is less than 100 cm, which indicates sufficient water level, then indicator is turned off.

```
int buzzer = 4;
int sensor = A0;
int sensorThresh = 400;

void setup()
{
pinMode(buzzer,OUTPUT);
pinMode(sensor,INPUT);
Serial.begin(9600);
}

void loop()
{
  int analogValue = analogRead(sensor);
  Serial.println(analogValue);
  if(analogValue>sensorThresh)
  {
    digitalWrite(buzzer,HIGH);
    delay(1000);
  }
  else
  {
    digitalWrite(buzzer,LOW);
    delay(1000);
  }

}
```

Fig.12: Code snippet for gas sensor

When the sensor reading exceeds 400, the buzzer is turned ON by setting the buzzer pin to high, if the reading is below under 400, the buzzer is turned off by setting the buzzer pin to low. The delay keeps the buzzer on for 1 seconds.

5. RESULTS AND DISCUSSION

After connecting all the components and uploading all the programs, the whole system will start running. All modules and Arduino are kept together with a lot of wires. This is the main area of smart home automation system.

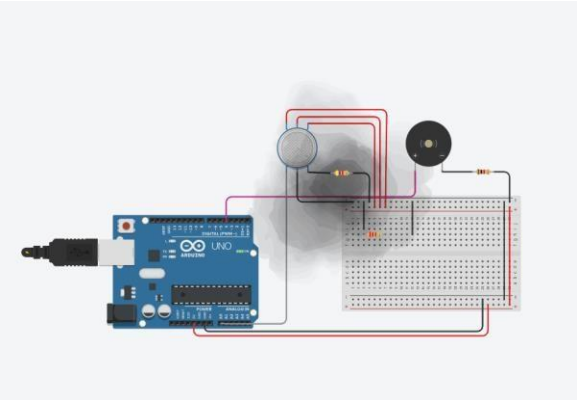

Fig.13: Working of Gas sensor

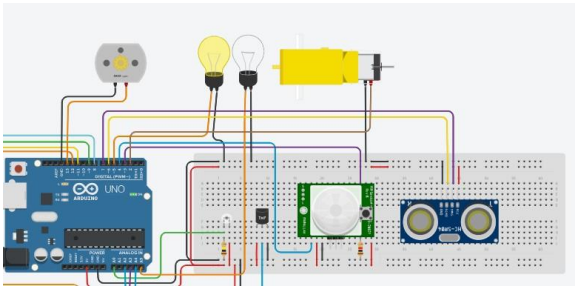

Fig.14: Working of ambient light

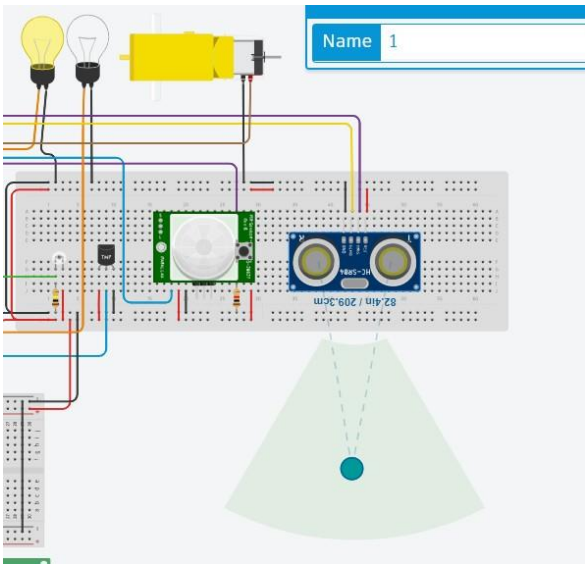

Fig.15: Working of Ultrasonic Distance sensor

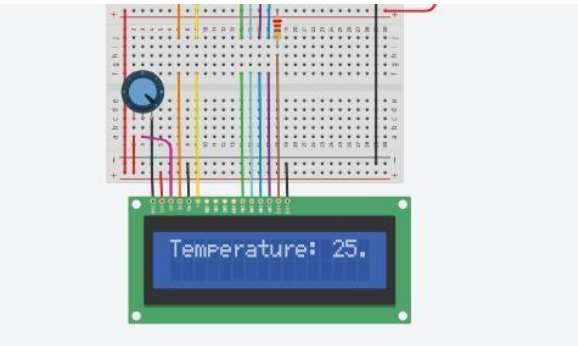

Fig.16: Temperature showing on LCD 16*2 display

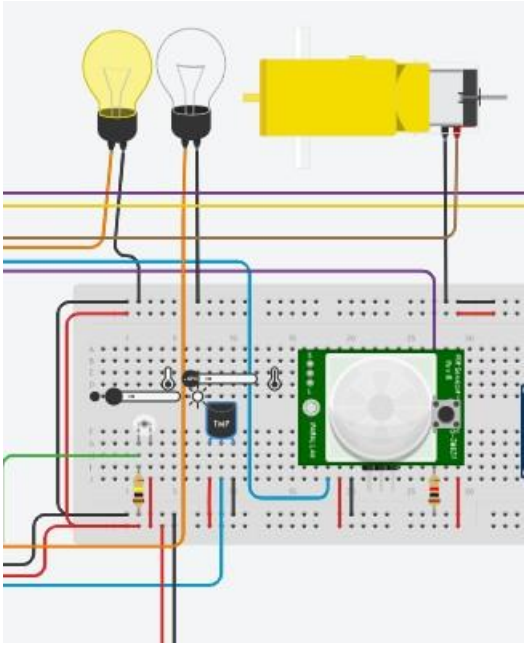

Fig.17: Working of temperature sensor and ambient light sensor

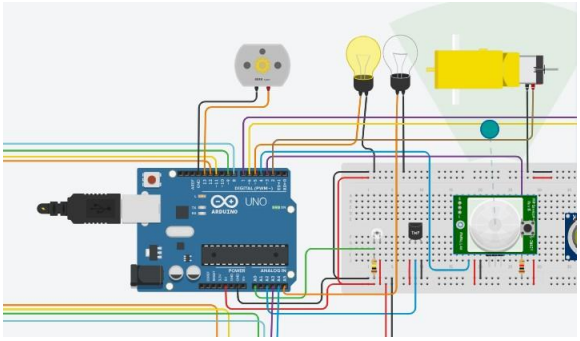

Fig.18: Working of PIR sensor

Smart home automation system allows user to control everything by sensors or voice commands or by smartphones which makes theirdaily routine pretty easier. Automated system can customize itself by adjusting so that it can save as much energy as it can for low cost-bill. it reduces unnecessary power consumption. It offers the best security surveillance by sensors, camera, motion detector or alarm which will help to the user to monitor their property comfortably. Features like automatic lock and alarm provides good solution for potential threats. Smart home can includes health and safety monitoring by gas sensor which will detect any toxic gas and will try to control the air quality. This is mainly useful for elderly or disabled person.

6. APPLICATION

[1] Automated lighting system allows user to control lighting by motion sensor or it can schedule based on movement or time. Also this can be programmed when there is vacant room then turn off the light which enhance the energy saving. [2]Smart thermostats can control heating and cooling based on occupancy and weather condition or based on user preference. [3] Also smart home includes smart cameras, password protected door, motion sensors and alarm which notify the user if there is any suspicious activity going on and the user can monitor every situation properly. [4] Gas sensor can detect any toxic gas which might be harmful for any person and it will notify the user by an alarm. [5] Smart entertainment setups allow users to control audio and video with voice commands and also offers personalize streaming experience. In this paper we discuss about the overall development of smart home automation system. How this system approach a cost effective, energy saving method to increase home security. By connecting all the sensors –temperature sensors, ambient light sensors, gas sensor, PIR sensor – this system can automatically control everything. Each sensor plays an very important role and make the this smart system adaptable to the real world. As the technical world is evolving every day, this systems design supports the integration of

additional sensors or any other improvement. Smart technology is a boon for us.

We can avoid bad consequence and try to do better improvement in the future. This paper shows that practical and theoretical aspects of designing circuit.

7. CONCLUSION

In this paper, smart home automation system has been demonstrated using Tinkercad software. All the home appliances can be controlled and monitored from this system. Further research can make it wireless and make it more cost effective and affordable. It will be more flexible and it will create a new path for more smart appliances which will make our daily lives smarter, accessible and intelligent. This work demonstrates the feasibility of creating a cost-effective, accessible home automation system that meets the demands of daily life while promoting energy conservation and improved security. Overall, this work underscores the potential of IoT-based automation to transform residential spaces, making them more responsive, secure, and sustainable. Future work may explore integrating wireless capabilities and AI for predictive responses, further enhancing the system's functionality and user experience.

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