DESIGN AND IMPLEMENTATION OF AN IOT BASED FIREFIGHTING AND AFFECTED AREA MONITORING ROBOT

Vinay Kulkarni[1], Md. Ashraf[2], Dr. Farha Anjum[3]
[1] PG Scholar, Dept. of VLSI & Embedded System, SIET, Hyderabad.
Vinaykulkarni997@gmail.com
[2]Associate Professor, Dept. of ECE, SIET, Hyderabad.
[3]Professor & HOD, Dept. of ECE, SIET, Hyderabad.

ABSTRACT

In this paper, an IOT based fire-fighting and affected area monitoring robot is proposed. This fire-fighting robot can be used as a supplementary to the firefighters in critical situations. To function this robot, a flame sensor, a gas sensor, an PIR sensor, and a temperature humidity sensor has been used. The flame sensor is used to detect the fireplace at the same time as the gas sensor informs about the presence of flammable gases, the Passive Infrared Sensor confirms the presence of a human, and the temperature humidity sensor sends statistics about the temperature and humidity of the locality. This paper discusses the detail and top working condition of a fire-fighting robot and recapitulates an IOT based communication system to monitor the fire affected area using Wi-Fi and also discusses the elaborate functions of each module and the implementation of the system. All the data are sent to the cloud server for further investigation. The proposed firefighting robot has been used for many experiments and proper evaluation has been done based on its performance. It has an excellent performance to extinguish the fire in an emergency situation.

INTRODUCTION

The devastation of a fire incident is like a nightmare. Every year many people around the world lose their lives because of it. A statistics report provided by 'International Association of Fire and Rescue Services' made on official reports of fire incidents of 34 countries shows that 16.9 thousand people lost their lives in 2016 [1], and that is very unfortunate. This report is an only official report, but the number of causalities may be much higher in reality. It also shows that the average occurrence of fire incidents is 2.9 per 1000 inhabitants, which is relatively high. In Bangladesh, the average number of fires per year is 17,743 [2]. So, tackling the fire incidents timely and adequately is an important task. While tackling a fire incident, two essential aspects are speed and safety. When a fire incident occurs, it becomes difficult for the firefighters to evaluate the situation without being subjected to harm. It is sometimes impossible for firefighter personnel to get access to the fire affected area. So, the speed and safety of the firefighters become questionable. However, a fire-fighting robot can help to overcome this problem. Fire-fighting robots have the property of being fire-fighting equipment, and that can be an alternative to firefighters to fight a fire and perform rescue operations effectively. This robot can also be used as surveillance of the area after a fire incident. Such a kind of automation will detect fire and use an appropriate extinguishing system accordingly. The fire-fighting robots can become alternatives to firefighters as robots are not affected by smoke or flame and do not require oxygen. So by using them, the number of fire injuries can be minimized. If IoT is incorporated with these robots, then the affected site's environmental situation can be easily interpreted, and coordinated control of multiple robots can be achieved. So, the rescue operation can be speedier and safer by using fire-fighting robots. In other works, Different types of fire-fighting robots are available. Each has a different type of sensing, operating, and extinguishing mechanism. J. Suresh detected fire using a flame sensor but has no IoT system [3]. H. U. Zaman used manual control Arduino Uno microcontroller with bluetooth controlled feature to control fire-fighting robot [4], while A. R. P detected it by using heat, gas presence, or a multisensory system and control manually remotely [5] [6]. The majority uses water but J. Suresh used air or a gaseous substance to extinguish the fire [3]. Some operate automatically and some have provision for manual control [4]. H. U. Zaman used IoTs to control the robot manually via live streamming [6]. P. Bhosale with other researcher designed a system where the sensors data are collected from industrial site sensors and upload the information on the internet that can take the crucial decisions and make alert based on IoT but has no autonomous control system [7]. Another IoT based fire alarm and monitoring system have designed by S. Tiwari that is integrated with several sensors and send it to monitoring station using GSM which has no control system [8]. H.P. Singh et al developed an Autonomous Industrial Fire Fighting Mobile Robot. The robot performs based on five infrared sensors that control the movement of the robot, and for flame detection. The microcontroller controls a D.C. motor to carry water from container to extinguishing fire [9]. But this system is not a IoT based system. A wireless firefighting robot has been developed by Swati Deshmukh et al. It can recognize fire and blow it OFF. It is a smart multisensory based security framework but is not IoT based.

EXISTING SYSTEM

When a fire incident occurs, it becomes difficult for the firefighters to evaluate the situation without being subjected to harm. It is sometimes impossible

for firefighter personnel to get access to the fire affected area. So, the speed and safety of the firefighters become questionable. However, a fire-fighting robot can help to overcome this problem. Fire-fighting robots have the property of being fire-fighting equipment, and that can be an alternative to firefighters to fight a fire and perform rescue operations effectively. This robot can also be used as surveillance of the area after a fire incident. Such a kind of automation will detect fire and use an appropriate extinguishing system accordingly.

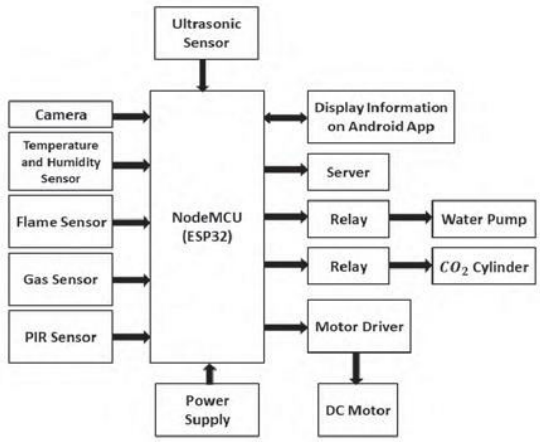
PROPOSED SYSTEM

The whole system includes a sensor, a Microcontroller unit, and motors. The sensors data is sent continuously to the NodeMCU. NodeMCU Collects the data from sensors and camera and then process the data depending upon the program. If the data are analog value, then the data are converted to a digital value using ADC conversion and sent to the server and the android app. The PIR sensor, Gas sensor, and the humidity and temperature sensor values are directly sent to the server and app through NodeMCU. Only the flame sensor value is used to decide to switch on the water cylinder automatically.
Four sensors have been used to develop this robot. They are the PIR sensor, Flame sensor, Humidity and Temperature sensor, and Gas sensor. All the sensors are used to monitor the fire accident area properly. Every possible incident has been considered to avoid colossal damage. All the sensors work parallely at the same time.

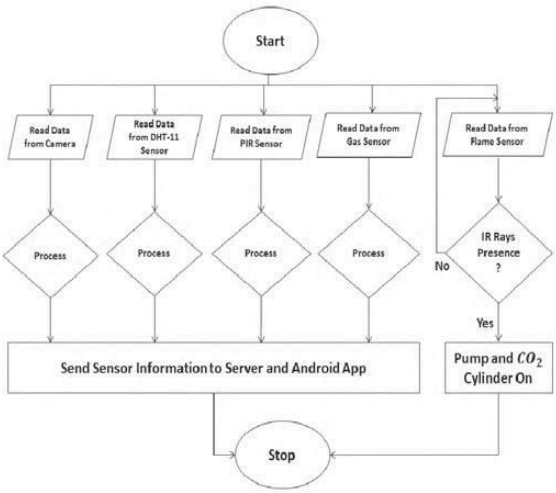
PROJECT DESCRIPTION

In the indoor of an industrial organization, the robot is placed at the place where fire accidents can happen. A microcontroller and sensors are used to operate this robot. If there exist any fire signal, the sensors will send the information to the central co-ordinator unit. The co-ordinator unit is the brain of the robot. It makes decisions based upon the sensor signals. The whole system includes a camera, sensors, a Microcontroller unit, and motors. The sensors' data is sent continuously to the NodeMCU. NodeMCU Collects the data from sensors and camera and then process the data depending upon the program. If the data are analog value, then the data are converted to a digital value using ADC conversion and sent to the server and the android app. The PIR sensor, Gas sensor, and the humidity and temperature sensor values are directly sent to the server and app through NodeMCU. only the flame sensor value is used to decide to switch on the CO2 and water cylinder automatically. For manual mode, the joystick added in the app is used to control the robot. Moreover, an ultrasonic sensor and flame sensors have been used to move the robot automatically. While the robot is in autonomous mode, the central processing unit collects data from the ultrasonic sensor to avoid obstacles to find the way and the flame sensors find the exact position of the fire. The module must be connected with a Wi-Fi router or mobile hotspot to transfer the feedback data from the robot to the server and Android App. The following Figure 1 shows the block diagram of the proposed system.

BLOCK DIAGRAM



Four sensors have been used to develop this robot. They are the PIR sensor, Flame sensor, Humidity and Temperature sensor, and Gas sensor. An IP camera has been used to live stream around the affected area through an android app. All the sensors are used to monitor the fire accident area properly. Every possible incident has been considered to avoid colossal damage. All the sensors work parallely at the same time. The sensors collect data according to their working principle. The gas sensor, PIR sensor, and temperature sensor collect data, and this data are processed in micro-controller and then sent the decision to the android application. On the other side, the flame sensor continuously collects the data parallelly and send to the micro-controller. If the sensor finds any flame around it, it will activate the motor to spray the CO2 and water pump to the firing place that will extinguish the fire. The following Figure 2 shows the flow chart of the proposed system.



Microcontroller	ATmega328P
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
PWM Digital I/O Pins	6
Analog Input Pins	6
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328P) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328P)
EEPROM	1 KB (ATmega328P)
Clock Speed	16 MHz
LED_BUILTIN	13
Length	68.6 mm
Width	53.4 mm
Weight	25 g

ARDUINO UNO

Arduino/Genuino uno is a microcontroller board based on the ATMEGA328P (datasheet). 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. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a ac-to-dc adapter or battery to get started. You can tinker with your uno without worrying too much about doing something wrong, worst-case scenario you can replace the chip for a few dollars and start over again.

"Uno" means one in Italian and was chosen to mark the release of Arduino software (IDE) 1.0. The uno board and version 1.0 of Arduino software (ide) were the reference versions of Arduino, now evolved to newer releases. The uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform; for an extensive list of current, past or outdated boards see the Arduino index of boards.

TECHNICAL SPECIFICATIONS

TEMPERATURE AND HUMIDITY MONITORING

The DHT11 temperature and humidity sensor is used for the robot to get the temperature and humidity data from the desired localization. It is a simple digital sensor device that updates its value every 2 seconds; thus, it provides excellent options to monitor the environmental condition.

- Compatible Card codes: Manchester64- bit, modules64
- Current Rating: 35mA (Max)
- Operating Voltage:4.6V - 5.4VDC

GAS DETECTION

Gas sensor module MQ2 is used in this robot which detects the presence of combustible gases such as smoke, Methane (CH4), LPG, I-Butane (HC(CH3)3), Alcohol. Hydrogen (H2) and Propane (C3H10). The sensor is highly sensitive and provides a speedy response. It provides additional safety on the occurrence of fire to detect the places where combustible gases may congregate due to leakage from a gas pipe or any other sources. The gas sensor sends a signal to the developed app based on its detection of gases. I f combustible gases are found, the app displays “GAS: HIGH” notation and “GAS: LoW” notation when no combustible gases are detected.

PIR SENSOR

A passive infrared (PIR) sensor is used in this robot, which is simply a PIR-based motion detector. It is used to detect the presence of a human in the affected area, such as a highly fired locality where firefighters cannot reach. Based on its detection, it sends a signal to the built app, and the corresponding text is displayed in the app. When there is no human detected, the app shows “PIR: HIGH,” and when humans detected, the app shows “PIR: LoW.”

FIRE SENSOR

A large amount of infrared radiation is emitted along with a sparse amount of UV rays and visible rays during a fire. The human eye captures the radiation as visible yellow-red flames. However, some fire occurrences, such as hot charcoal, may not emit visible light, but it does emit infrared. Thus, a flame sensor is used in this robot that detects infrared rays and sends a signal upon the fire detection to assure the occurrence of fire.

SOFTWARE SPECIFICATIONS

Android Application

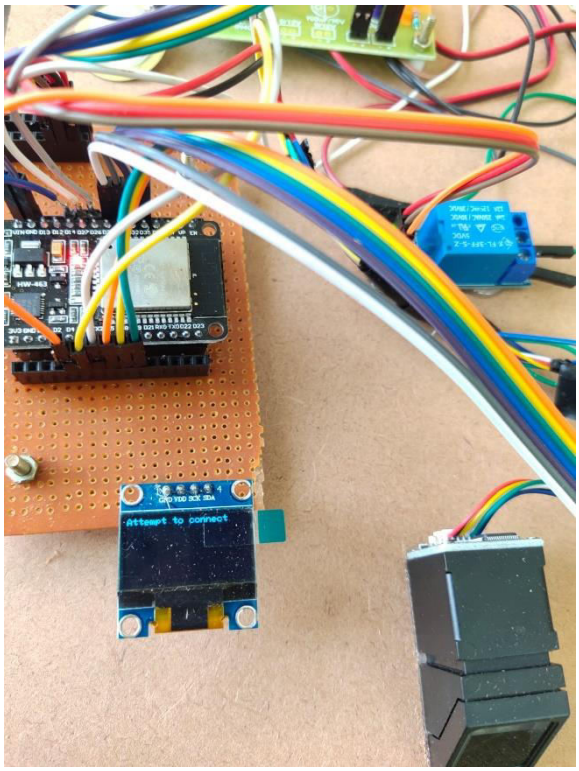
The robot transfer all of the information to the android app named Blynk App. Blynk app is the easiest way to build a mobile app that supports hardware platforms such as Arduino, Raspberry Pi, and a similar micro-controller, which can be used to create required project. This app can control the robot via Wi-Fi and shows the temperature and humidity value on the mobile screen. It additionally indicates the presence of human beings and gas leakage. A switching option has been developed between auto and manual mode. A Joystick has set up for the manual control system. The camera view can also be seen through this application. Figure shows the Android Application functions and operation.

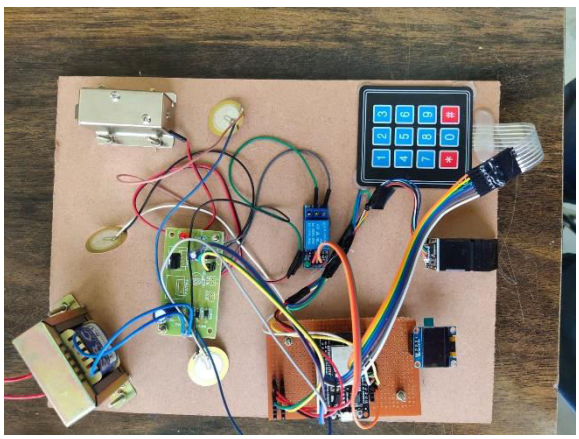
Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino and Genuino hardware to upload programs and communicate with them.

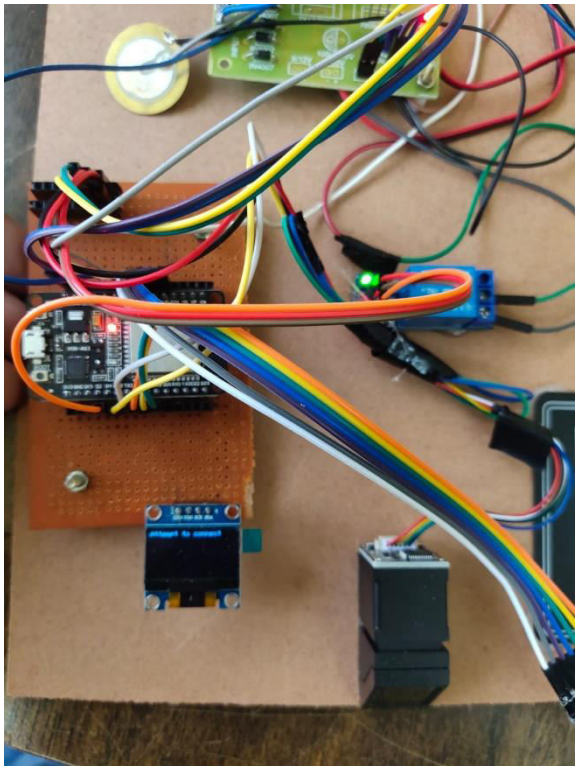
Programs written using Arduino Software (IDE) are called sketches. These sketches are written in the text editor and are saved with the file extension .ino. The editor has features for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino Software (IDE), including complete error messages and other information. The bottom righthand corner of the window displays the configured board and serial port. The toolbar buttons allow you to verify and upload programs, create, open, and save sketches, and open the serial monitor.

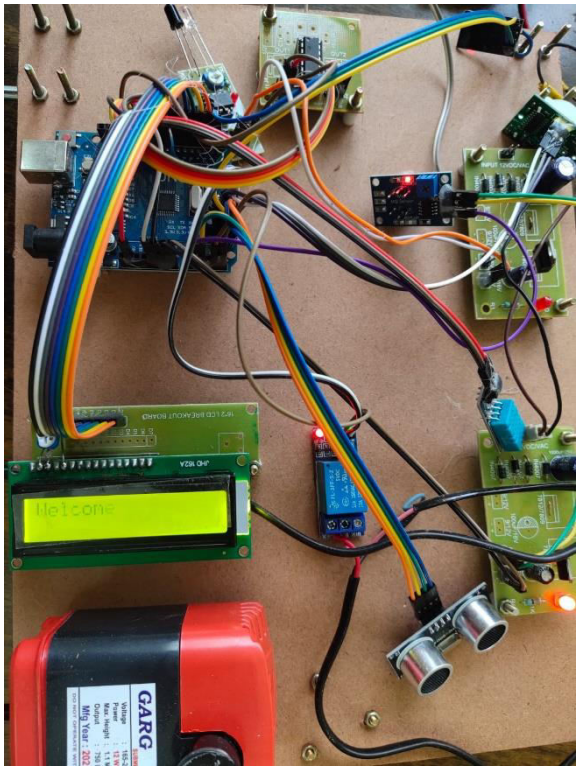
NB: Versions of the Arduino Software (IDE) prior to 1.0 saved sketches with the extension .pde. It is possible to open these files with version 1.0, you will be prompted to save the sketch with the .ino extension on save.

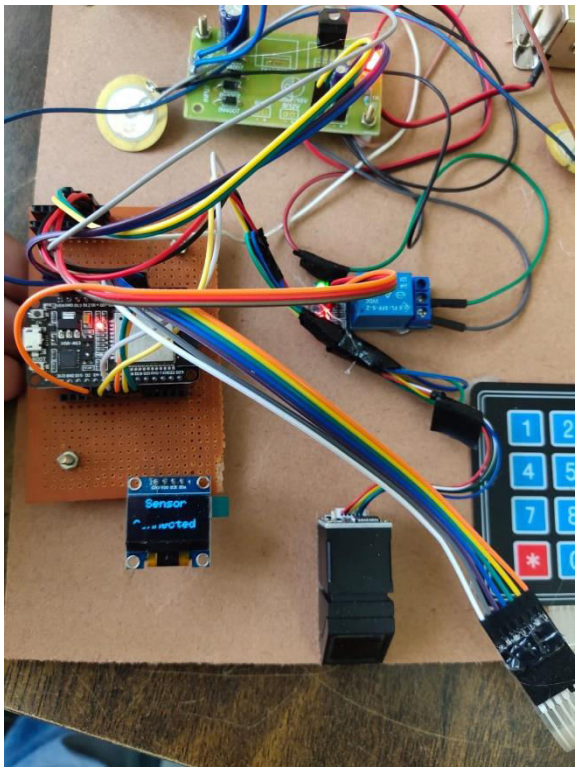
IMPLEMENTATIONS








Welcome
GARG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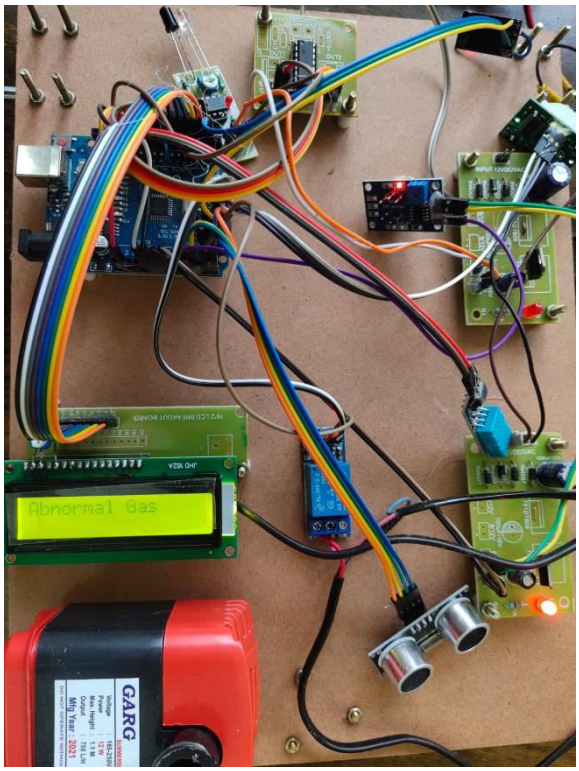
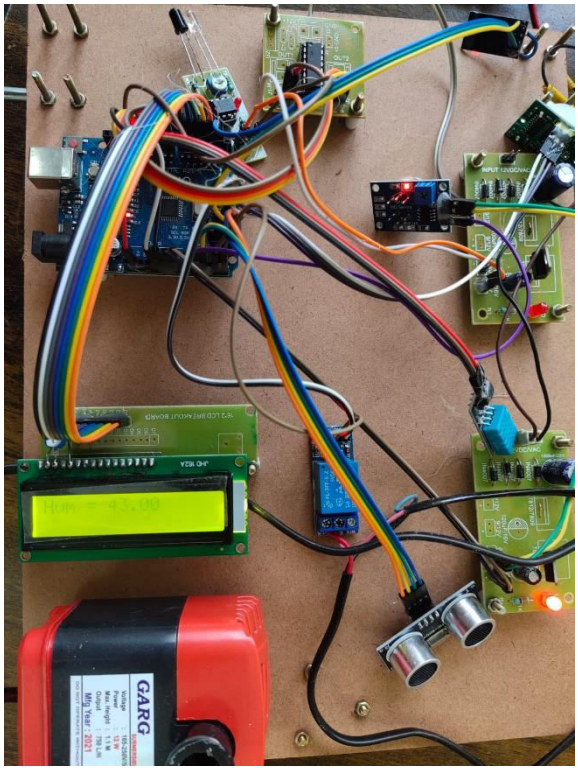
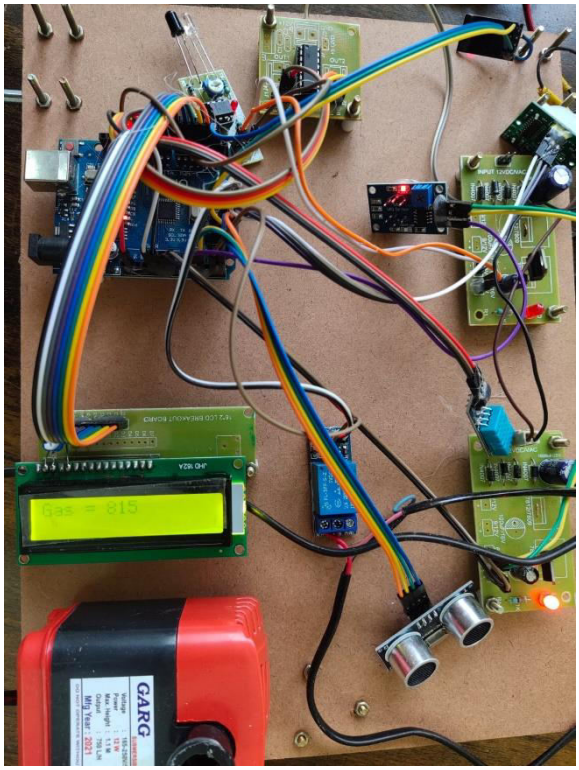

Abnormal Gas
GARG


Hum = 43.00
GARG


Gas = 815
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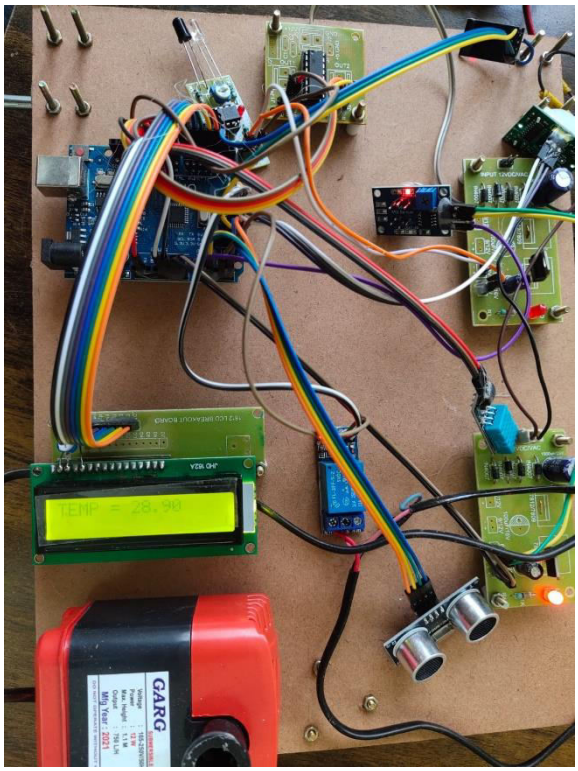
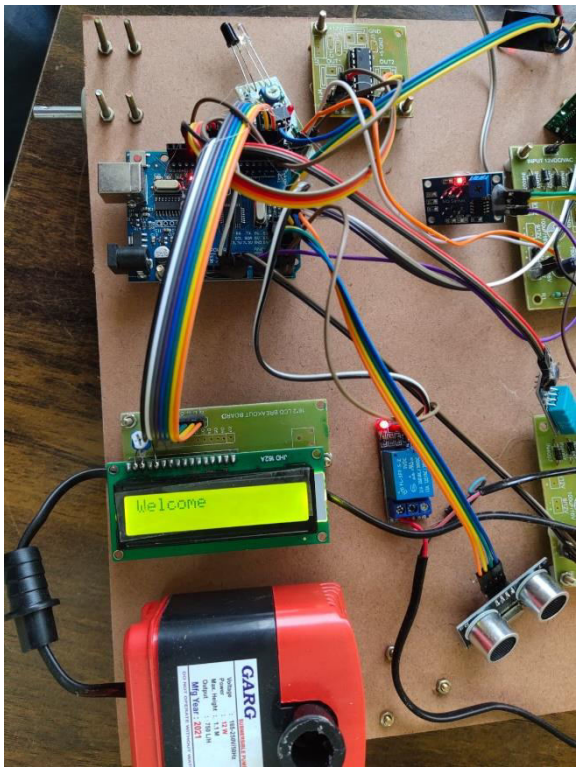
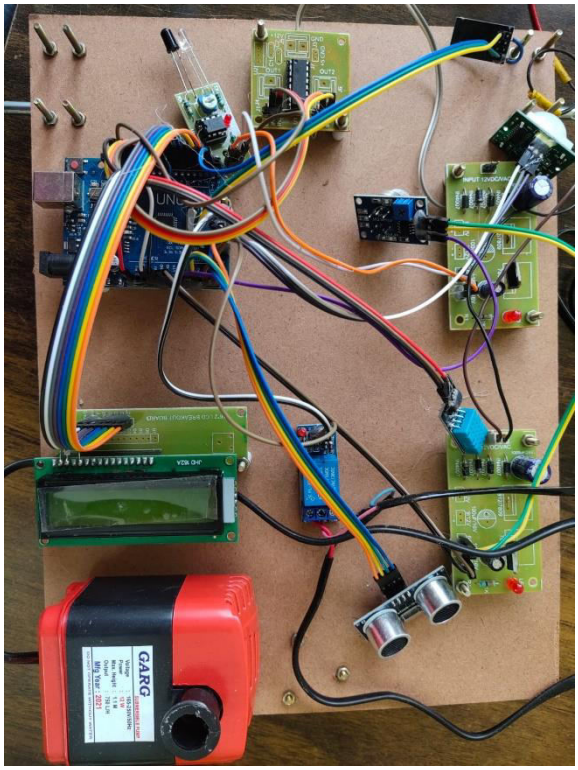

TEMP = 28.90
GARG


Welcome
GARG



CONCLUSION

In this paper, a firefighting and affected area monitoring robot is proposed based on the Internet of Things environment, which can take instant steps during fire accidents. This robot can be used to reduce the risk of human firefighters and in the area which is out of reach for human beings. The industries with a higher risk of fire accidents can use this robot to avoid huge damages. In future, Machine Learning and AI systems can be implemented to improve the performance of the robot.

FUTURE SCOPE

Based on the Future Technology, We connect camera to monitor the fire affected area by Image Processing Technique.

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AUTHOR PROFILE'S

VINAY KULKARNI, is a proficient PG Scholar, Master of Technology, Dept of ECE, VLSI & Embedded System, Siddhartha Institute of Engineering & Technology (SIET), JNTUH Ibrahimpatnam, Hyderabad, T.S. Along with initial degrees of Bachelor of Technology in Electronics & Communication Engineering (ECE), Siddhartha Institute of Engineering & Technology (SIET), JNTUH Ibrahimpatnam, Hyderabad, T.S.

He has successfully completed Certified Automation Engineer (CAE) Course from the PROLIFIC SYSTEMS under National Skill Development Corporation (NSDC) Hyderabad.

He is Currently bounded and working as a junior engineer in Dynaspede Integrated System Private Limited, Hosur, TamilNadu

MD. ASHRAF working as an Associate Professor for Siddhartha Institute Of Engineering and Technology Hyderabad. His Research

preferential area in VLSI System Design. He has completed his Master's degree with specialization in VLSI System Design from JNTU Hyderabad. He has completed his bachelor's degree in Electronics & Communication Engineering from JNTU Hyderabad. He has completed his Diploma in Electronics & Communication Engineering from SBTET Hyderabad.

He has very much interest to do research on VLSI Technology and Design, communication systems and Digital Electronics and Wireless Communication.

Dr. Farha Anjum is working as Professor and Head of the Department of Electronics and Communication Department in Siddhartha Institute of Engineering & Technology, Ibrahimpatnam. She has around 12 years of experience in both teaching & industry. She did B.Tech in ECE, M.Tech in VLSISD & M.Tech in IT. She also did MBA in Project Management. She received her Ph.D in VLSI in Jan 2017. She published 30 international papers and guided many M.Tech & B.Tech students. She is a member of LMISTE & IETE. She received Award for Best Teaching Methodology – 2017 for significant Contribution in the field of Teaching by RAMPROS Education.