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Research paper



Design and implementation of integrated security and safety system based on internet of things

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Abstract

In the recent years, with the development of technology, it has been noticed that thefts are increasing for various public and private establishments, homes, offices, companies, etc., as well as increased fires due to sabotage, for example, or because of the gas leak inside the house. The homes when their owners are abroad for vacation or business trip the danger increased so, it is necessary to find means and systems for the security and safety, in this paper the implemented system based on two parts, the first part is responsible on the security and the second part responsible on the safety. The implemented system based on the Arduino NANO microcontroller, gas sensor, flame sensor, PIR sensor, laser and LDR, the gas sensor used in order to detect the gas leak, the flame sensor used to detect the fire, the PIR sensor and the LDR used to detect the motion. In this work the security made up from two level of security where, the first level based on PIR sensor to detect the motion and second level based on the laser and LDR when the thief tries to cutting the laser beam or passing from the front of PIR sensor the alarming system will be turning on and send SMS message to alert the home owner in the same time the another message will be appears on the specific GUI programmed by HTML language this done by the NodeMCU module where this module allows the home owner from accessing to his system wirelessly in other words supports the IoT technology , additionally through this GUI user can turning ON/OFF the outdoor lighting system and monitor his home in case gas leak, fire and in the case of a thief attempting to enter the house.

Keywords: *Arduino NANO; Gas sensor; Flame sensor; LDR; PIR; NodeMCU; IoT.*

1. Introduction

Recently, technology is rapidly evolving and developing. With the development of current technology, some of the system must constantly evolve to avoid being obsolete. Several years ago, the home monitoring system cannot be managed without human operation, but with current technology discovery, especially on the Internet of Things (IoT), it gave a new face to the home monitoring and security system. The concept and its application can be explored by understanding the basic concept of home security using the Internet of Things. Once this happens, it is possible to develop using the technology concept. Different home security systems have been developed where Bluetooth, RFID, Android and short message (SMS) communication links are used. All of this has different approaches to the home security system but serves the same purpose as monitoring the safety and the security of homes [1].

The smart homes that use the Internet of Things to focus on safety, security and comfort to feel safe at home for homeowners. New technology and devices made life more comfortable and comfortable for people. Smart devices can share data It's smart and good for our community because the internet is going to be completely inclusive. In addition, the Internet of Things has had a major impact on everyday life through improved safety, time savings and health monitoring. IoT is likely to be the third wave of the information industry after computer and internet with the rapid development of information technology and the internet. National Science and Technology Development Program Guideline in China (2006-2020) Included IoT explicitly in key research areas. However, due to the complete openness of its architecture, IoT's information security has faced unprecedented challenges, and a variety of new and potential information security issues are constantly emerging. It is therefore the focus of attention to build a security and reliable system in the context of IoT [2].

Traditional information security solutions, such virus checking and destroy, security scanning, patch upgrades, intrusion detection and other safety techniques, which are mostly proposed for only a part or a phase of IoT application, the rapid increase in security threats and attacks is difficult to cope with, not to mention the fundamental solution of IoT security issues. Therefore, a general confidential security system architecture IoT - based information security issues appearing in the application of IoT are first proposed to address. Then IoT's trusted security system core modules, including the trusted module, confident collection module, trustworthy terminal module and a confident re - sell module, aim to eliminate the different security risks posed by IoT the IoT's trusted security system [3].

2. System parts

Many sensors and microcontrollers have been used in this work, the parts used in the construction of this system will be explained and clarified in this part.

2.1. Arduino NANO

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An Arduino is a single board microcontroller, programmed via a built - in software system. The hardware is simple and open and contains an Atmel AVR processor. And on - support for the I / O board controller. The program contains a standard programming language and the bootloader is on the board. An Arduino is a small computer, in other words that can be programmed to process inputs and outputs between the device and external components that you connect to. [4].
can only control the Arduino board to enable the real world to interact and to respond to electricity. These sensors can transform certain aspects of the physical world into electricity, so that the board can feel the electricity or actuators from the board, which can transform electricity into something that changes the world. Sensor examples include switches, accelerometers, and distance sensors for ultrasound. Actuators are items such as lights and LEDs, speakers, engines and displays [16]. Modulation of pulse width is a process used in many applications. Using an Arduino is one of the easiest ways to do this. This application note is going to look What is Pulse Width Modulation and how to modulate Pulse Width using two different methods [5].
This can be done in several ways by the Arduino. The Arduino Nano is an ATmega328 (Arduino Nano 3.0) or ATmega168 (Arduino Nano 2.x) small, complete and breadboard - friendly board. The Arduino Duemilanove has more or less the same functionality, but in a different package. It only lacks a DC power jack and works with a Mini - B USB cable instead of a standard one. The Arduino Nano can be powered by a Mini - B USB connection, 6 to20V unregulated external power supply (pin 30), or 5V regulated external power supply from pin 27. The power source is automatically selected to the highest voltage source, the Arduino NANO usually based on Atmega328 microcontroller such that in Arduino UNO but the difference in Arduino NANO the ATmega328 comes as SMD [6]. The figure.1 illustrate the Arduino NANO microcontroller.

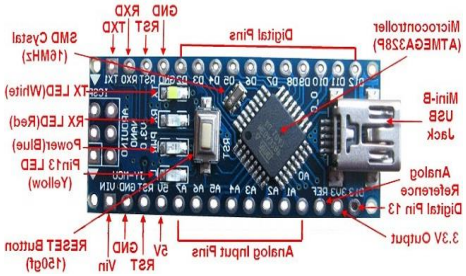


Fig. 1: Arduino NANO Microcontroller.

2.2. NodeMCU

The NodeMCU developed by Espressif Systems with integrated ESP8266is Wi - Fi SoC. The ESP8266 was designed to solve the problem of Wi - Fi networking by bridging the Wi - Fi module between the microcontroller embedded. There is also the ability of NodeMCU microcontroller to run loaded applications. The NodeMCU can use a USB micro cable; It is possible to connect and run the NodeMCU development kit like Arduino. The NodeMCU embedded system is shown in Figure.2, this module features with high processing speed than Arduino and some other controllers, but The main problem with this module is a limited number of analog input pins with a single input pin in this controller. [7]. the table.1 illustrate the specifications of NodeMCU module.

Table 1: The Specifications of NodeMCU

Module	NodeMCU
Wi-Fi Module	ESP-12E module similar to ESP-12 module but with 6 extra GPIOs.
USB	micro USB port for power, programming and debugging.
Headers	2x 2.54mm 15-pin header with access to GPIOs, SPI, UART, ADC, and power pins.
Misc.	Reset and Flash buttons.
Power	5V via micro USB port.
Dimensions	49 x 24.5 x 13mm.

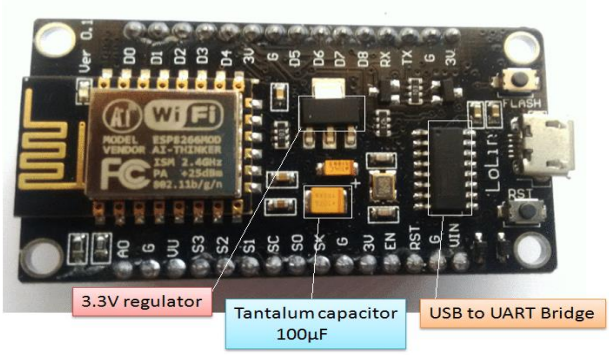


Fig. 2: NodeMCU Microcontroller.

2.3. Arduino UNO microcontroller

A board based on the ATmega328 microcontroller is the Arduino UNO microcontroller. The Arduino Uno can be supplied with an external power supply via a USB connection. The power source is automatically selected, it includes 14 digital pins used in digital output or digital input (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. Arduino has the ability to reprogram since it is a prototyping platform for open source electronics [8]. The figure.3 illustrate the Arduino UNO microcontroller and table.2 illustrate the Arduino UNO specifications.

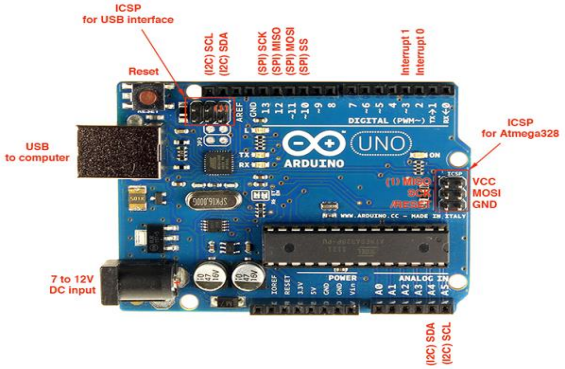


Fig. 3: The Arduino UNO Microcontroller.

Table 2: Arduino UNO Specifications

Microcontroller	ATmega328
Rated.Operating.Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Number of Digital I/O Pins	14 (of which 6 provide PWM output)
Number of Analog Input Pins	6 pin
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328) of which 0.5 KB used by bootloader
SRAM	2 KB
EEPROM	1 KB
Clock Speed	16 MHz

2.4. Flame sensor

This type of sensor used to detect flames in closed areas and respond to them. Because of its flaming mechanisms the flaming sensor can generally detect faster and more precisely than a smoke or heat detector. The flaming sensor identifies fire or other light sources within the wavelength range of (760nm - 1100 nm). The module consists of an IR sensor, potentiometer, circuit of operational amplifier and an indicator of LED. Moreover, it is based on the sensor YG1006, which is a high velocity and high sensitive

NPN silicon phototransistor. The module will turn on its red led when a flame is detected. This module is flame - sensitive but can detect ordinary light as well. The sensor detection angle is 60 degrees. This sensor's sensitivity can be adjusted via the potentiometer; it has a stable performance. This sensor consists of four pins as illustrated in Figure.4 and Figure.5 shows the output of the flame sensor over distance [9].



Fig. 4: Flame Sensor Module.

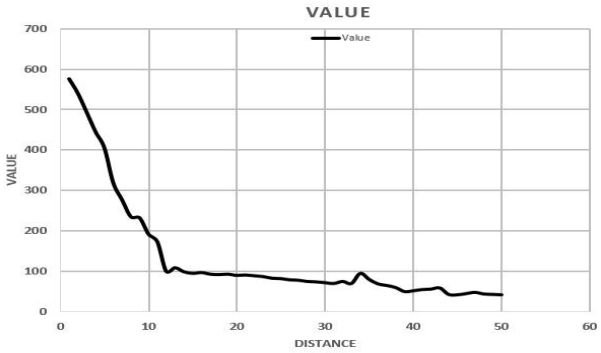


Fig. 5: Flame Sensor Output vs. Distance.

2.5. MQ-04 gas sensor

MQ-4 gas sensor's sensitive material is SnO_2, which in clean air has lower conductivity. When the target fuel gas exists, the conductivity of the sensor is higher and the concentration of gas increases. MQ-4The gas sensor is highly susceptible to methane, LPG, propane and butane as well. The sensor could be used to detect various fuel gases, It's low - cost and especially suitable for different applications, especially methane. This sensor is used for numerous uses such as a domestic gas leak detector, an industrial gas sensor and a mobile gas sensor [10]. The figure.6 illustrate the MQ-04 gas sensor.



Fig. 6: The MQ-04 Gas Sensor.

2.6. Passive infrared sensor

The PIR sensor is a passive electronic sensor used to detect motion by detecting infrared fluctuations emitted by the human body or by the moving target precipitation. The sensor produces digital two level output 0V which means normal mode or 5V which means motion detected this voltage reads by the Arduino, the lens is equipped with a sensor to increase sensitivity and detection area [11]. The Figure.7 illustrate the Passive Infrared sensor.



Fig. 7: Passive Infrared Sensor.

2.7. Light dependent resistance

This sensor is a variable resistor controlled by light, a light controlled variable resistor (or light dependent resistor, LDR or photoconductive cell). The resistance of a photoresistor decreases with the increase of incident light on the sensor surface; in other words, photo - conductance. In luminous detector circuits and light - activated and dark - activated switching circuits a photo - resistor can be applied. A high - performance semiconductor consists of a photoresistor. In the dark, a photo - resistor can be as resistant as some meg - ohm (MΩ), A photo - resistor may have as low a resistance as a few hundred ohms while in the light. If the incident light on a photo - the photon absorbed by the semiconductor exceeds a certain frequency, the bonded electrons will generate enough energy to jump into the conductivity band. Electricity is generated by the resulting free electricity (and its hole partners), thus reducing resistance. The photo - resistor's strength and sensitivity can be significantly different Between different equipment. Moreover, unique resistors in wavelength bands can react significantly differently to photons [12]. The figure.8 illustrate the LDR sensor and the relationships between the resistance value and the light.

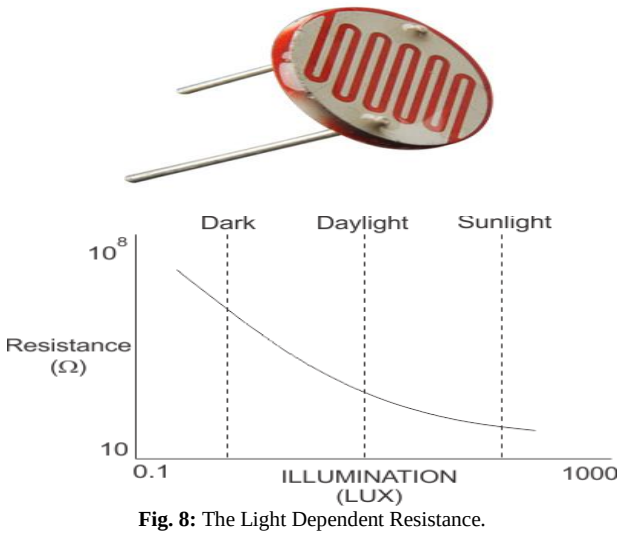


Fig. 8: The Light Dependent Resistance.

2.8. SIM 900 GSM GPRS module

The SIM900 is a complete GSM / GPRS Quad - Band Solution in a customer integrated SMT Module. A standard industrial interface, SIM900 supplies voice, sms, data and fax performance in the form of a small form factor to GSM / GPRS 850/900/1800/1900MHz. You can use the GPRS / GSM Shield to receive data using the GSM cellular telephone network Outside a remote place. The shield allows users to do this by using any of three methods, such as Short Message, Audio and GPRS, as well as the shield. 12 GPIOs, 2 PWMs and an ADC of the SIM900 module (They are all 2V8 logic) present onboard. [13] [14]. The figure.9 illustrate the GSM/GPRS SIM900 module.

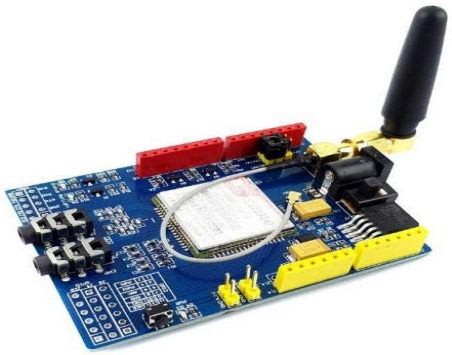


Fig. 9: The SIM 900 GSM Module.

3. System design and implementation

In this work, an integrated safety and security system has been designed based on Arduino Microcontroller and various of available sensors. The implemented system divides into two main parts the first part responsible on the security, the security part is based on two levels of security. The first level is the use of the motion sensor (PIR sensor), which senses the movement through the change of the infrared radiation emitted from the human body. The second level of security is the use of laser beam line and optical resistance (LDR sensor), which in turn will be the reader(receiver) of the laser beam, when the thief tries to pass from the front of PIR sensor or cutting the laser beam the Arduino NANO will be turning ON the alarm buzzer, send message through the GSM module to the mobile phone of home owner to alert him there is thief attempt and in the same time through the programmed GUI the NodeMCU will send a message also to alert the home owner .In this work the GSM module is connected to an independent controller and the motion signal is received from the Arduino NANO, the reason of this connection because the GSM module suffers from the input current, if the input current lower than the rated current the GSM module would not be work and this has been proven in practice. The figure.10 illustrate the block diagram of the security part.

The second part of the implemented system is responsible on the safety such the detection of the leakage of cooking gas by the MQ-04 gas sensor and detection the fire by the flame sensor. In the case of fire detection, when the flame sensor detects the fire the owner of the house will be alerted by sending a short message through the GSM unit and water dispenser will be operated. In case of gas leak the gas sensor detects the gas leak and the home owner also alerting by a message, at the same time, the status of the house can monitored remotely via Internet of Things technology (IOT), which is supported by the NodeMCU controller where all the alarm messages will appear on the special GUI programmed inside Arduino environment, the NodeMCU grant to the user a local IP allows him to monitor his house wirelessly and the user can convert this local IP into public IP by some algorithms or by using the some websites that's powered by network companies, the public IP allows the user from monitor his home from anywhere of the world. Additionally, the home owner can be turning ON/OFF the outdoor light through the GUI to provide the comfortable to home owner. The figure.11 illustrate the block diagram of the safety part and the figure.12 illustrate the implemented system.

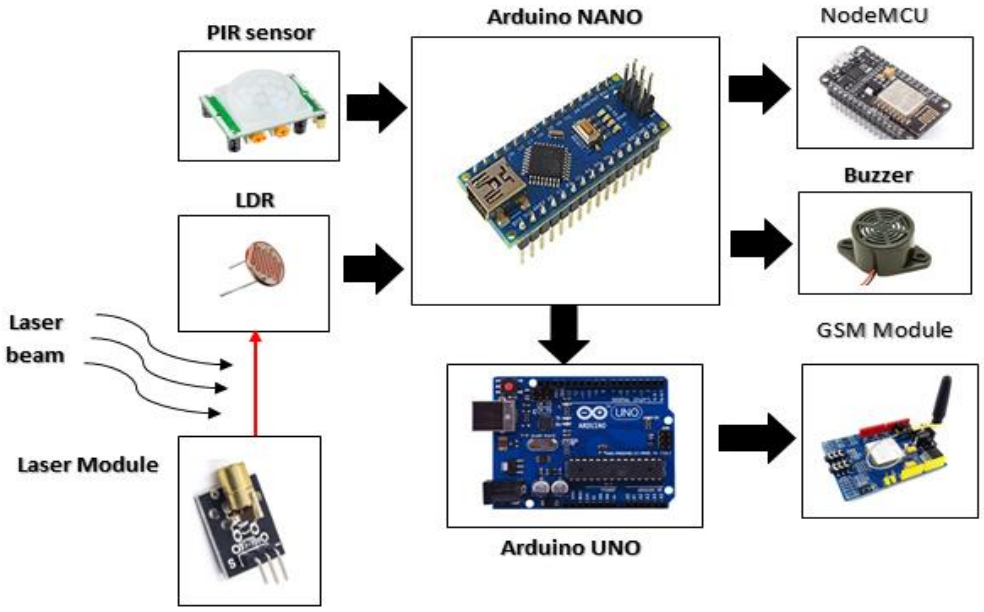


Fig. 10: Block Diagram of Security Part.

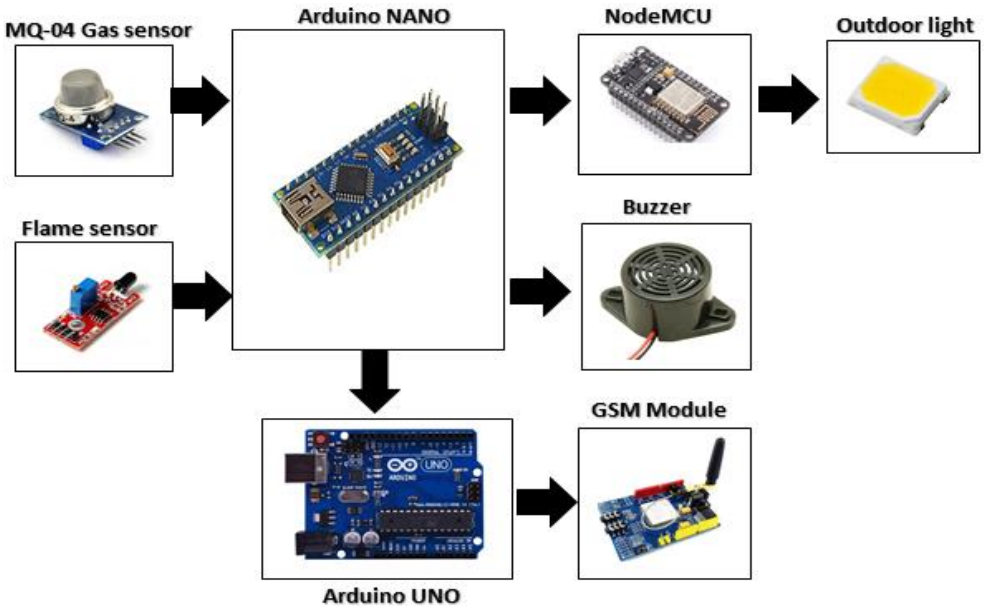


Fig. 11: The Block Diagram of Safety System.

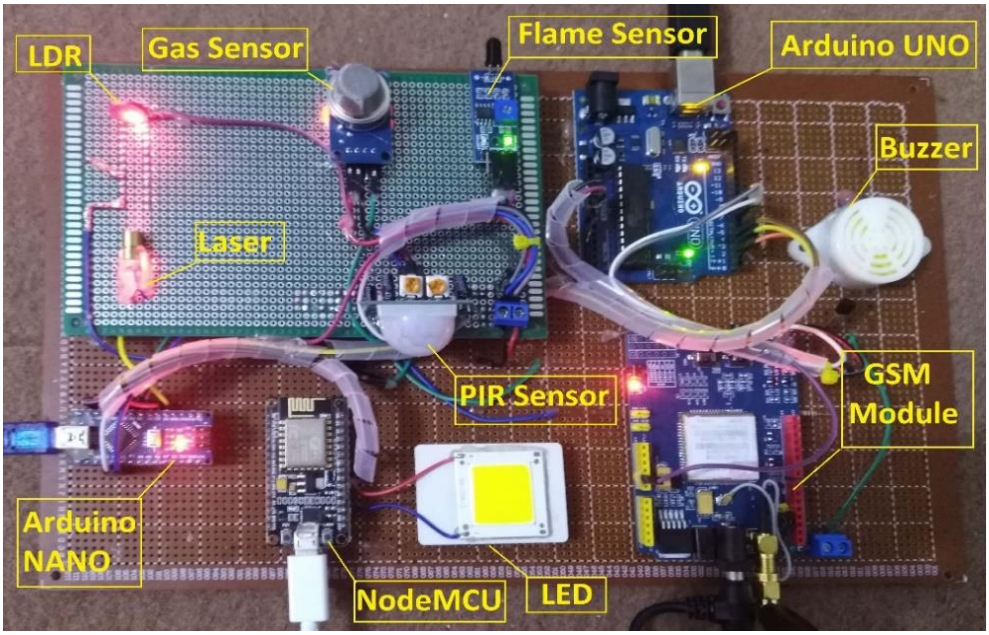


Fig. 12: The Implemented Safety and Security System.

4. Results

In this section all the results obtained after the practical operation of the built-in system will be discussed. The figure.13 illustrate the alerting messages that arrived to the mobile phone of the home owner in case of theft, gas leak and fire detection. The figure .14 illustrate the messages appears on the GUI in all cases that mentioned. The figure.14 and figure.15 illustrates the results obtained in case of fire detection, motion detection, gas leak detection and in safe mode, the button in the GUI used in order to turn ON/OFF the outdoor light. All these messages appear on the GUI after operate the system practically.



Fig. 13: The Practical Test of the System.

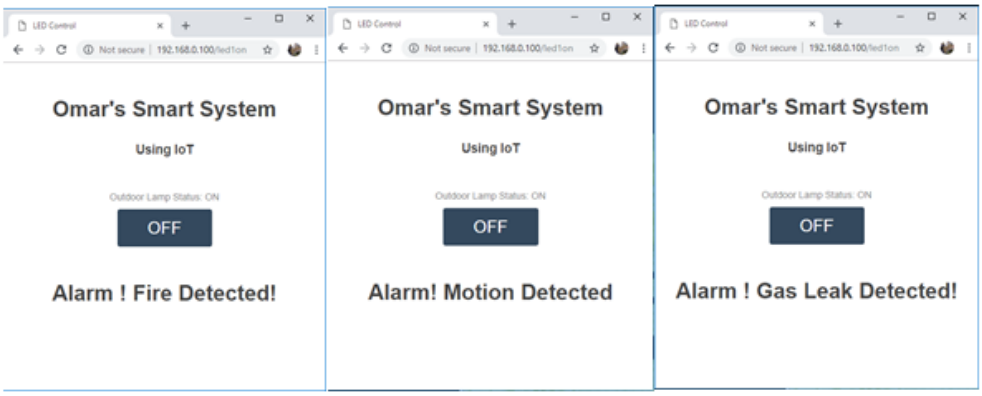


Fig. 14: The Result on GUI in Case of Fire, Gas Leak and Motion.

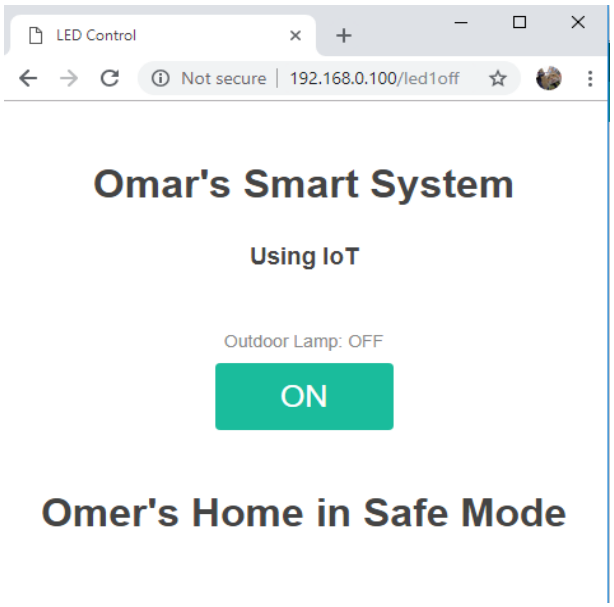


Fig. 15: The Result on GUI in Safe Mode.

5. Conclusion

This paper explores the concept of smart security and safety system. In this paper the implemented system based many microcontrollers in order to increase the reliability and make the system independent on single failure point. The security based on two levels to make the system more secure. This system can be described as very useful to everyone in providing safety and security, the uses of IoT technology in this work to facilitate the system accessing by the user, where the home owner can monitor his home wirelessly through the special programmed GUI and in additionally the GSM chosen alert home owner in the various cases in motion detection, gas leak detection and in fire detection This is a second way to alert the owner of the house and so while a malfunction in one of the controllers can the owner of the house to monitor his house through the another controller.

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