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A Simulated Smart-Phone Based Home Security System

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***Abstract*—With the recent advancement in technology, security is a major concern to ensure safety of lives and properties. There is need to invest in home security as the possibilities of burglary are increasing day by day. Safety from theft, gas leakage and fire are the most important requirements of home security system. So many people have been installing surveillance systems to monitor their premises at all times due to high crime rate and emergence of terrorism. This study is aimed at addressing some of the challenges associated with the existing security systems such as set up cost, power wastage, and incomplete coverage of the home. In this work, we incorporate fire and motion sensors to actively monitor the surroundings so that video surveillance is done only when fire or motion is detected and as a result, only useful footage is stored. The Global System for Mobile Communications (GSM) Shield interfaced with the Arduino Microcontroller and provides enhanced security such that whenever a signal from sensor occurs, a text message is sent to the desired number to take necessary actions. A simulator has been built in this work to demonstrate the operations of the system and from the performances of the simulator we are able to affirm that the system is efficient and less prone to errors.**

Keywords—Home security; Smart-phone; Surveillance Systems; Fire; Motion Sensor.

I. INTRODUCTION

Security has always been a challenging issue in the society today and this is one of the reasons why researchers continue to design and implement new ideas in this area of study to safeguard lives and properties. Incidents like fire outbreak, burglaries, and murders are more prevalent in our society today. Therefore, there is the need for proper monitoring and controlling of the environment. Home security is indispensable and it is a way to overcome home intrusion problem especially when occupants are not at home.

A. Home Security System

Home security system is a major issue in our society. Crime rate is increasing and everybody wants to take proper measures to prevent intrusion. According to [4] the basic design of any security system begins with analyzing the needs of the inhabitants, surveying existing technology and hardware, reviewing system costs, considering monitoring choices, and finally planning the installations. In addition to perimeter and interior protection offered by a security system, surveillance monitoring includes features that enable occupants to observe environmental conditions inside and outside the home when at home or away from home. [4]

Home or business premises security is indisputably important in our current world. Burglary methods have changed drastically in recent years; old simple locks which have been in the market traditionally are no longer useful. In order to keep a home secured, there is need for proper burglar proof system which cannot be easily tampered with. [3]

According to [7] Intelligent home security system in simple terms can be described as homes that are fully automated in terms of carrying out a predetermined task, providing feedbacks to occupants and responding accordingly to situations. Intelligent home security systems such as controlled networks, and communication systems, emergency responses, anti-theft monitoring systems, fire detection systems and gas leak detection systems requires automated and controlled system both near and at a distance of control. Intelligent home security systems play important roles in providing extra layer of security through user authentication to prevent break-ins at entry points and also to track illegal intrusions or activities within the vicinity of the home. [7]

An intelligent home or a smart home has been described in [10] as a home or building that is equipped with special structured wiring (wired or wireless) to enable occupants to remotely control or program an array of automated home electronic

devices by entering a single command. For example, a homeowner on vacation can use a touchtone phone to arm a home security system, control temperature gauges, switch appliances on or off, control lighting, program a home theatre or entertainment system, and perform many other tasks.

The concept of intelligent home is like a server-client model. There should be a server in the "center" of home. This server communicates with other devices which have been made networked-enable. The difference between these devices from traditional devices is that they have ability to receive digital signals from servers and transfer these digital signals as control signals. For example; a television can receive program from the Internet with the help of a digital chip, a washer can start to work by receiving commands from a server, and a recorder can record program at a setting time. All these can happen automatically without house holders being at home [10].

According to [11] automated security systems assume an imperative and crucial part of giving an additional layer of security through client confirmation to counteract break-ins and track unlawful interruptions or spontaneous activities inside and around the home.

There has been much research done in the configuration of different sorts of automated security systems. Sensor-based systems that depends on light or contact-based systems, for example, unique finger impression and palm print sweep or keypad initiation that require considerable measure of contact with a scanning device.

As technology is advancing, fire-safety is also a prime concern in the society. Fire hazards can be fatal and denigrating for industrial and household security and also threatening to human life. The best way to reduce losses as a result of fire hazards is to respond to the emergency situation as quickly as possible.

So, there comes the necessity of fire detection systems. These systems render the works of quick detection, alarm notification, and sometimes initiation of fire extinguishing. The systems which are equipped with smoke, temperature, pyro-electric sensors can detect unfavorable accidental situations, as it happens, and with the help of a processing unit can alert instantly for undertaking cautious measures as affirmed by [2]

B. Related Works

Many researchers have proposed different methods on home security system with each providing ways on how to save lives and properties.

A system on microcontroller-based home security and load controlling using (GSM) technology was developed in [8]. There work demonstrated how a person can control appliances from a remote location by mobile phone using GSM technology and monitor actions that occur inside the house while occupants are away from home.

A reliable home surveillance system based on embedded system and multiple sensors to enhance the system efficiency and reliability was designed in [6]. A method of installing sensing loop to restrict unauthorized entry into a building was proposed in their work.

A Microcontroller Based Home Security System with GSM Technology using the Atmel Mega (Atmega16) microcontroller unit that uses pressure sensors and Pyro electric sensors to monitor activities around the home was developed in [5].

According to [9] keeping in view the rapid growth of wireless communications, among the various contributions, the part of providing automatic text message notification to a desired number preferably (police department) regarding any undesirable movements and the live streaming of camera of user's desired secured zone is more trustable and provides an extra layer of security feature to the system which ensure the safety and security to lives and assets.

Depending on the system specifics users can access and view security cameras, track activity into and out of the restricted environment, turn the system on or off, and perform other tasks and control actions, all through any web-enabled device. Systems can also be set up to inform the owner via e-mail or short message service (SMS) if an alarm is tripped as affirmed by [1].

Studies have shown that home fire deaths are common in homes with no gas, smoke or temperature sensor. Hence, no warning can be given to residence of the house or prompt notification to the fire department when there is an outbreak. [10]

II. MOTIVATION

In today's world as a result of the various challenges with security. There is the need for an error free and cheap security access control systems for homes. Hence automation is the only solution since this will decrease cost, man power, and reduce power wastage.

In present systems, if an occupant is taken as hostage away from the home and he or she is being led to his apartment by abductors, the system would not be able to detect the intruders since the homeowner will provide the right access details to the security system. Therefore, we provide an extra layer of security to avoid such limitation by creating a **mock access code** for the system which when entered, the security system would act in a stealth mode by not blaring the alarm but would alert the security via SMS which would be sent instantaneously incase the intruders decides to damage or disconnect the system.

In this work, a prototype home security system has been designed using arduino microcontroller, which is a microcontroller based burglar alarm system and we evaluate the performance of the simulated system.

III. METHODOLOGY

The method of study that we adopted in this work includes the review of relevant literatures on the subject matter. We focused on developing a home

security system with motion sensors, recording camera, temperature and flame sensors which are controlled by a arduino microcontroller that has a transmitter coupled with portable receiver to alert occupants and authorities through SMS and a video live feed of event which can be viewed remotely on a web enabled device in situations of burglary or fire. We divided the work into hardware and software parts respectively.

The hardware part is concerned with the electronic interconnection of hardware components interfacing with the arduino microcontroller. The ultrasonic sensor, PIR sensor, recording camera and matrix keypad are the input components while the buzzer, Light Emitting Diodes (LED) indicators, and Liquid Crystal Display (LCD), GSM shield, Servo, relays are the output components that are controlled by the arduino microcontroller.

The Software part is based on programming the arduino microcontroller to control the hardware components connected to it.

Some of the components that were used in the simulation of this work are briefly described below:

A. *Arduino Microcontroller*

Arduino is an open-source prototyping platform based on easy to use hardware and software. Arduino boards are able to read inputs: light on a sensor, a finger on a button, and turn it into an output activating a motor, turning on an LED, publishing an article online.

B. Arduino Software

The open-source Arduino Software is an Integrated Development Environment (IDE). It is used to control the Arduino board by sending a set of instructions to the microcontroller on the Arduino board. It runs on Windows, Mac OS X, and Linux.

C. Passive Infrared Sensors

PIR sensors employ a group of radiation sensors coupled through amplifiers to a logic circuit. The radiation sensors detect changes in ambient infrared radiation. The detection system has an electrical circuit operatively coupled to the heat sensor for producing a detection signal in response to the heat sensor detecting a change of temperature caused by the body heat of a person entering the detection pattern.

D. Ultrasonic Sensor:

In an ultrasonic motion detector, there are two transducers; one emits an ultrasonic wave and the other picks up reflections from the different objects in the area. The reflected waves arrive at the receiver in constant phase if none of the objects in the area are moving. If there is a movement, the received signal is shifted in phase. A phase comparator detects the shifted phase and sends a triggering pulse to the alarm.

E. *Flame Sensor*

Flame sensors are sensitive to flame and radiation or a light source of a wavelength in the range of 760nm-1100 nm with a detection distance of 20cm.

F. Internet Protocol Camera:

An Internet Protocol camera or IP camera is a type of digital video camera employed for surveillance and can send and receive recorded visual data via a computer network and the internet.

IV. SYSTEM DESIGN

We present a proposed model that will provide security by using an arduino microcontroller to manage the security components. We employed the use of a passive infrared (PIR) sensor to actively monitor the environment and a recording camera to capture live images of moving objects, the video surveillance is done only when motion is detected so that only useful footage is stored and energy is conserved. A mock password is used to gain entry into the home and in a situation where the occupant is under duress it will trigger the system to send a distress message through SMS to notify the security operatives about being held hostage.

Also, temperature and flame sensors are used to monitor sudden rise in temperature. If there is fire outbreak, related authorities are immediately notified. If there is any disastrous event around the home, video footage is sent to a web server for processing and it is viewed on a web based interface.

At the heart of this system is the Arduino Mega 2560 microcontroller which is capable of functioning as a micro web server and as an interface for all the hardware modules connected to it. All communications and controls in this system pass through the microcontroller. The architecture of the system is shown in figure one below. It consists of three main modules which are: **input**, **microcontroller** and **output** modules respectively.

The microcontroller module remains at a waiting state for receiving of signals from the input section which includes: ultrasonic sensor, PIR sensor, flame sensor, 4x4 matrix keypad, and a mobile device. The output of all the sensors is connected to the arduino microcontroller which gives alerts to occupants.

The motion sensors are placed at strategic locations to protect the system. If anyone tries to unlock the system without authority, then those sensors will be activated and the microcontroller will receive a suitable pulse.

According to the pulse from the input device, the microcontroller takes decision and activates the output section which includes: the LCD display, GSM Shield, Servo Motor, LED and Buzzer.

However, the activation of the output device depends on the activity of the input section which

indicates whether the user access the home in an authorized way or not. For authoritative access, the user enters the deactivation code which will place the sensors on standby mode. Hence, no motion will be detected. At the same time, a message will be displayed at the LCD to show the status of the system.

Conversely, without authoritative access, the microcontroller sends signals to the LED, Buzzer and GSM Shield simultaneously. Consequently, a buzzer blare the alarm when motion is detected and the GSM shield will send an SMS to the occupant's mobile and related authorities.

The system is armed with a distress deactivation code which is useful when the occupant is under duress to deactivate the security system. When the occupant enters the distress deactivation code, the system goes into standby which gives the impression that the security system is deactivated. Thus, the system sends a distress message to security agents alerting them of a hostage situation without any sound from the alarm.

The flame sensor is strategically placed where fire accident is most likely to happen. When the flame sensor senses a sharp increase in temperature, its sends a pulse to the microcontroller alerting the system of fire. The system activates the buzzer to notify occupants and neighbors and also sends a message to the fire department alerting them of an emergency.

The Ethernet Shield allows occupants to view the status of the home from a remote location. When the microcontroller reads the signals given off by the PIR sensor, and the camera starts to record live feeds of the event, the camera can be controlled to view a particular section of the house by controlling the servo which the camera is mounted on to focus on the area of interest as specified by the occupant.

A relay switch is used to send control signals from the microcontroller to the electronic device used to achieve the switching on and off actions of the camera to record only when motion is detected.

LED is placed around the home to indicate an unforeseen event or detect mal-operation within the system. Our proposed system consists of mechanical, electrical, and electronic components, which are integrated to complete the system design. The components include the following:

A. Ultrasonic Sensor:

Ultrasonic Sensors are based on measuring the properties of sound waves with frequency above the human audible range. They offer very short to long-range detection and ranging. They are non-intrusive in that they do not require physical contact with their target, and can detect certain clear or shiny targets otherwise obscured to some vision-based sensors.

B. Passive Infrared Sensor:

Passive Infrared Sensor (PIR Sensor) allows user to sense motion. It is always used to detect if anyone has moved in or out of range. The PIR Sensor detects motion by measuring changes in the infrared (heat) levels emitted by surrounding objects

C. Arduino Microcontroller (Arduino Mega 2560):

The control unit is built using the Arduino Mega 2560 open-source microcontroller. The Arduino Mega 2560 is a microcontroller board based on the ATmega32. It has 54 digital input or output pins, 16 analog inputs, ceramic resonator, USB connector, power connector, ICSP, and reset button. The microcontroller can be powered by connecting it to a computer via a USB cable or with a AC-to-DC adapter or battery to get started.

D. GSM Shield:

The GSM Shield unit is built using SIMCOM SIM900 that specialized for Arduino Mega 2560 controller. This unit can send SMS to user mobile phone and also can receive SMS from user.

E. Recording Camera:

Recording camera is a video camera that is used to capture activities around an area or building by transmitting recorded images to the microcontroller which is then uploaded to the web server to be viewed by a user from a remote location.

F. Relay:

A relay receiver board provides independently programmable control for each of the on-board relays. Relay outputs are used to automatically turn sensors and system devices On or Off.

G. Ethernet Shield:

The Arduino Ethernet Shield allows users to easily connect the Arduino to the Internet. This shield enables Arduino to send and receive data from anywhere

H. Flame Sensor:

A flame detector is a sensor designed to detect and respond to the presence of a flame or fire. Flame sensor can be used to detect fire source or other light sources.

I. Liquid Crystal Display:

In this work, we incorporates a 16x2 LCD display which serves as an interface which the user uses to arm and disarm the system through the matrix keypad. This module also turns on the buzzer if five (5) wrong passwords are entered consecutively.

J. Servo Motor:

Servo motors uses feedback to determine the position of the shaft, by using their built-in circuitry to control their movement. As a result, servo motors are used to control position of objects, rotate objects, move sensors etc; with high precision.

K. Piezo Buzzer:

Piezo buzzer is an electronic device commonly used to produce sound. Piezo buzzers are used for making beeps, tones and alerts

L. Light Emitting Diode:

Light emitting diodes (LEDs) are electronic semi-conductor device that emits light when an electric current passes through it. We use LEDs in our research to show the status of the system if it is in the arm or disarm state.

M. Keypad:

A keypad is a set of buttons arranged in a block manner which usually bear digits, and symbols. A 4x4 Matrix Keypad is used in our proposed system to arm and disarm the system via the LCD display interface.

N. Mobile Device:

A mobile device is a small portable computing device such as smartphones or tablet computer. The mobile device is used in this work by the occupant as an internet-enabled device to enable him or her view activities in the home from anywhere.

O. Power Supply:
The Arduino Microcontroller requires a minimum of five volts (5v) and a maximum of twelve volts (12v) to power the components connected to the microcontroller. A USB cable or a nine volts (9v) battery is used to power the system.

V. SYSTEM SIMULATION

A home simulator is built using plywood and foam board to simulate the operations of the home security system. All the components described in the architecture in figure one are connected to the arduino microcontroller which acts as the brain of the system by controlling the operations of the components connected to it.

The sensors are placed at strategic points in the simulator to cover a large area and to reduce the effect of factors that causes inaccurate reading which generates false alarm. The system is powered by a 9 volt battery which offers adequate and independent power supply as the GSM shield and Ethernet shield draws more power from the arduino board than the other components connected to the microcontroller.

Fig. 2: Overview of the Home Simulator System

A. User Interaction Module

The User interaction module consists of the matrix keypad, LCD Screen, and LED lights. The user enters the activation code to arm the system; the code is displayed on the LCD screen. The code is masked by using special characters to protect the integrity of the code. The LED light shows the status of the home. The red LED shows that the system is activated, green LED shows deactivated mode, and red-green-blue (RGB) LED flashes siren like light when the system is triggered.

Fig. 3: User Interaction Module

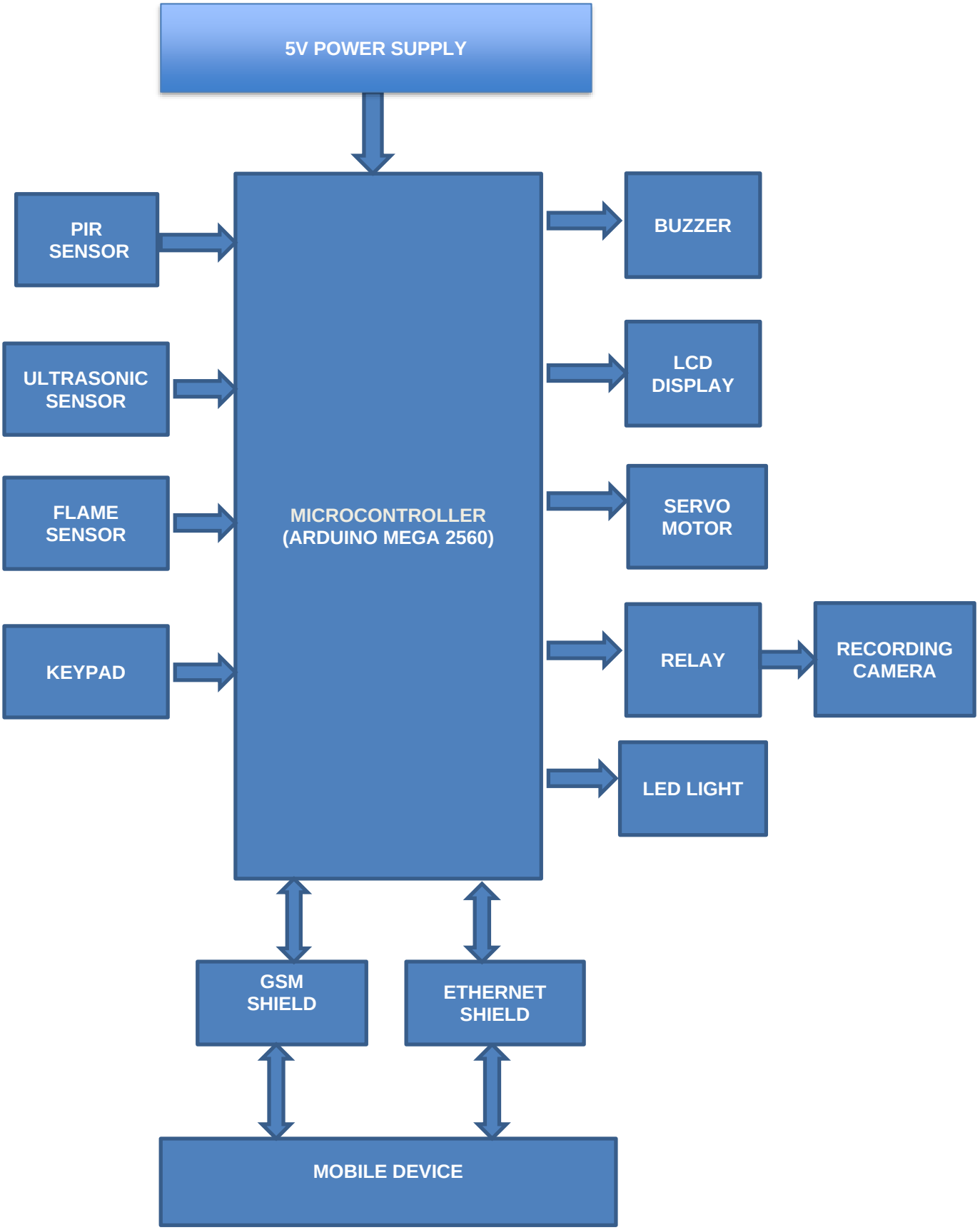

Fig.1: Architecture of the proposed system

B. Flame Sensor Module

The flame sensor is placed in the kitchen area where fire accident is most likely to happen. The flame sensor is encased in a matchbox to shield it from light which could generate false readings as the sensor is sensitive to light. The flame sensor does not depend on the state of the security system whether it is armed or disarmed. It triggers the alarm and sends a message when fire is detected in both states.

Fig. 4: Flame Sensor Module

C. Motion Sensor Module

The Ultrasonic Sensor is positioned in such a way that it faces the front door to detect intrusion through the front door. The PIR Sensor shown in Figure 6 above is placed around the home to detect motion; it covers a broader area than the ultrasonic sensor

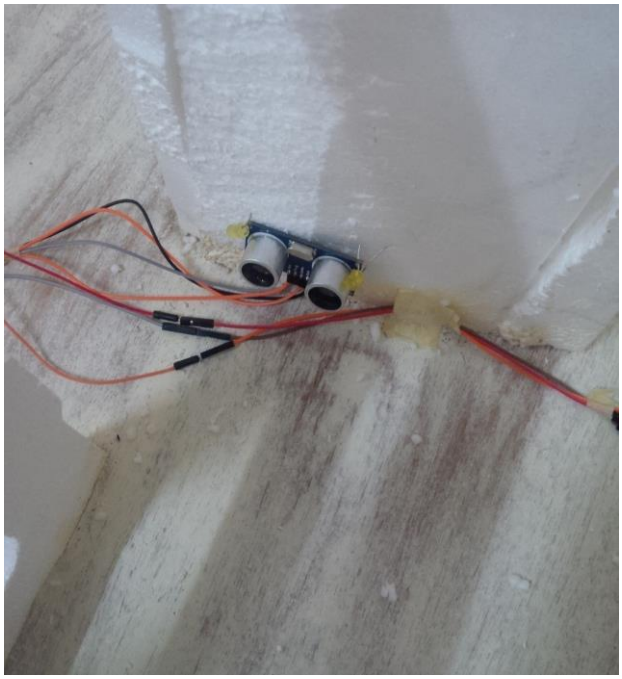

Fig.5: Ultrasonic Sensor

Fig. 5: PIR Sensor

D. Recording Camera Module

The recording camera is mounted on a servo which is placed at a vantage point to cover a large area. The camera is turned on when motion or fire is detected and it rotates to the point where motion or fire is detected. The camera stores the recorded event on a cloud storage which can be retrieved at a later time for investigation purpose. The servo can also be controlled over the internet to view activities around the home.

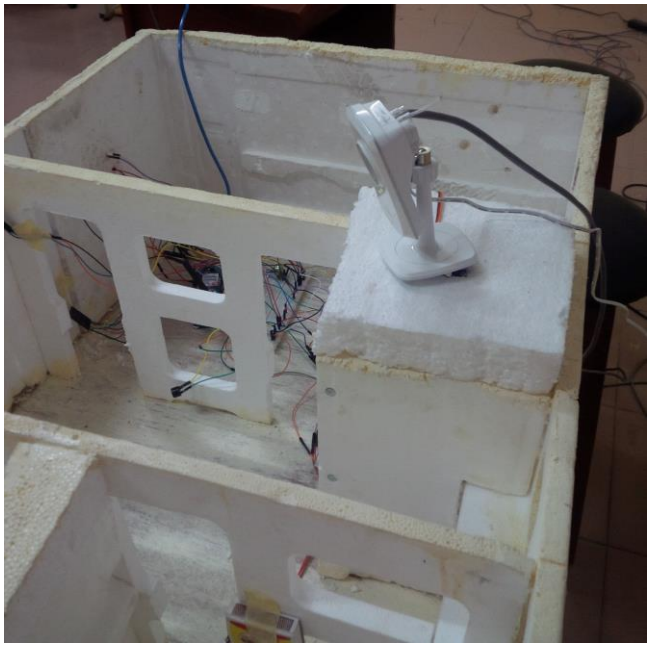

Fig. 6: Recording Camera Module

E. System Control Unit

The system control unit consists of the arduino microcontroller which is the heart of the system; other components are connected to it through jumper wires.

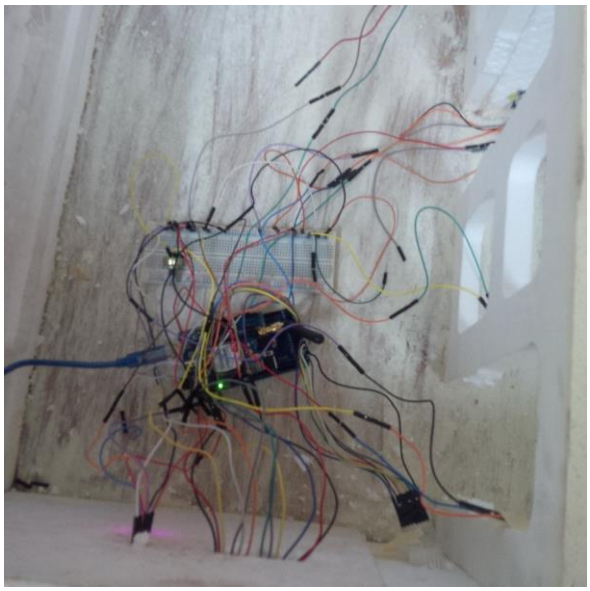

Fig.7: System Control Unit

VI. SYSTEM TESTING

After the completion of the hardware coupling and uploading of the program codes on the microcontroller, several tests were conducted to evaluate our simulated system. The purpose of testing and evaluating the performance of the system is to detect any inconsistencies between the various components of the system and to check the effectiveness of each module. The following criteria for successful system testing were met:

i. The system meets the requirements that guided its design and development.
ii. The system's operations were efficient and effective.
iii. The system was simulated with a high degree of reliability.

VII. CONCLUSION

An intelligent home security system whose goal is to send alerts on intrusion and movement around restricted places and event of fire accident in the home to the occupant has been simulated and tested. The system can be extended by implementing a complete home automation system which will create a platform for users to interface with their household appliances. Incorporation of more security subsystems can be added to the central monitoring unit. The system can include fingerprint authentication systems, production control systems, voice recognition systems, and biometric scanner for efficient user authentication. Also, wide range of sensors such as pressure sensors, gas sensor, reed switches, and temperature sensor may be included to improve security of the system if implemented.

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