

SCHOOL *of* BUSINESS AND TECHNOLOGY

Department of Engineering and Aviation Sciences

**The Design of a**

**Smart Fire Detection System**

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The Design of a Smart Fire Detection System

By

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Signature

Date

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**Table of Contents**

[**List of Contents 2**](#_30j0zll)

[**List of Figures 4**](#_1fob9te)

[**List of Tables 5**](#_3znysh7)

[**Abstract 6**](#_2et92p0)

[**1.0**](#_tyjcwt) **Introduction 7**

[**1.1**](#_3dy6vkm) **Backgound/Motivation 7**

[**1.2**](#_1t3h5sf) **Objective 7**

[**1.3**](#_4d34og8) **Design Requirements 7**

[**1.4**](#_2s8eyo1) **Design Constraints 7**

[**1.5**](#_17dp8vu) **Design Methods 7**

[**2.0**](#_26in1rg) **Project Description 9**

[**2.1**](#_lnxbz9) **System Description 9**

[**2.2**](#_35nkun2) **System Diagram 9**

[**2.3**](#_44sinio) **System Functions 9**

[**3.0**](#_2jxsxqh) **Implementation Plan 11**

[**3.1**](#_z337ya) **Tasks 11**

[**3.2**](#_3j2qqm3) **Team Organization 12**

[3.2.1.](#_1y810tw) Responsibility of Team Member 1. 12

[3.2.2.](#_4i7ojhp) Responsibility of Team Member 2. 12

[**3.3**](#_2xcytpi) **Timeline/Milestones/Delivery Plan 12**

[**4.0**](#_3whwml4) **Implementation 13**

[**4.1**](#_2bn6wsx) **Implementation of Task 1. 13**

[4.1.1.](#_qsh70q) Implementation of Subtask 1.1 13

[**4.2**](#_3as4poj) **Implementation of Task 1. 13**

[**5.**](#_1pxezwc) **Conclusion (Discussion and Future Plans) 14**

[**Acknowledgment 15**](#_49x2ik5)

[**Appendix 16**](#_2p2csry)

[**A.**](#_147n2zr) **Component Specs 16**

[1.](#_3o7alnk) Specs of Arduino Due 16

[2.](#_23ckvvd) Specs of Raspberry Pi 16

[**B.**](#_ihv636) **Source Code. 16**

[1.](#_32hioqz) Source Code of Graphic User Interface 16

[2.](#_1hmsyys) Source Code of Robotic Arm 16

[**REFERENCES 17**](#_41mghml)

**List of Figures**

Figure [1.](#_1ci93xb) System Diagram 11

**List of Tables**

**Abstract**

By the end of the project, summarize the project into short text and put here.

1. **Introduction**

This project will be the design, development, and implementation of a smart fire detection system. This system will utilize modern sensor and network technologies to help notify firefighters and building occupants of an impending or life threatening situation.

## Background/Motivation

We are designing a smart fire detection system, understanding there are other ideas out there, we hope to improve and add things to differentiate our project. With our design we hope to take out all the problems previous systems had as well as make it user friendly so everyone has a good understanding of it, from the first responders to the civilians. Our design will include a fire/ carbon detection system, a panel lined up with Led’s which will flash upon the detection of either fire or carbon monoxide. with our design we plan to have an sms, a phone message that’ll inform you when the panel starts to flash notifying you of a fire. Additional to the fire and carbon detection, our design will have a temperature sensor, ionization sensor and of course an alarm. All of this put together with a Raspberry Pi, we will have a display and a pi phone all connected with a (WSN) wireless sensor network.

In our research of earlier/ other designs relating to our idea, we found ideas such as a mini fire detection system on newton projects, it detected fire using a thermistor, with a simple led that flashes for to alert you and a piezzo buzzer for the alarm. This idea was a base because it left a lot to be desired, we looked at this and thought of how to make the system for this simple detection system to a more elaborate detection system that can actually be used in place of the system already in place. We found another system in the nest smart detector, which used a photoelectric sensor and a split-spectrum sensor to detect the threats of a fire. This gave us our first idea to use a photoelectric sensor in our system as first, which we later decided would be inefficient to our system due to cost, we aim to keep our project/ design within affordable cost meaning we do not want to overdo it on cost of the equipment used in building our system. The Nest smart detector technology is equipped with its own app, used to inform people who own it, we liked this idea and decided to build on it by making it so not only you the user get a notification, the first responders as well get notified, in say so we decided to make this form of notification an SMS message. The function of the SMS will be done using a Pi-phone, we will have a Raspberry Pi connected to a (wsn). The nest system had a function in the app that allows you to shut it off incase of a false alarm, realizing that to be an issue we may encounter, we decided to look into that for our system, leaving no doubts that our system can keep up with, the modern technology as well and surpass it by being more affordable and efficient.

We found another similar system in the alexa enabled smoke detector and CO monitor also uses a photoelectric sensor, compatible with both systems such as Apple and Android, but the price range is more excessive than what we plan to charge, this being one of the more expensive systems out there, we compare this to the earlier systems we for the “nest smart detector” to find a range of where we plan to have our product price placed.

We were inspired to to this project based on background experiences, 2 of the 3 members of our group being firefighters and having experience in the field we thought to ourselves, what would we want to see, what do we think could make responding quicker, safier and more efficient. We also employed the ideas of other first responders to get their thoughts on it, we aim to limit casualties of civilians as well a fellow firemen. We’ve seen casualties caused by flashovers, and other problems caused by high temperatures, by having the system relay the temperature to you we hope to greatly decrease casualties caused by flashovers, there are signs of a flashover in which firefighters are thought to be aware of but due to human error that can be missed, we hope to have an effect on that. Our system will inform you on what side of the building, and floor so we can pinpoint where needs to be focused on and have a plan before arriving onto the scene.

When researching our idea we realized people often do not react to fire alarms, based on the idea that they think it is either a test of false alarm, which pushes them to sit a while and watch what everyone else does, the problem in that situation is not the fire alarm but the civilians. We plan to eliminate this system by having a SMS message sent out, it will state, “there is a fire this is not a test”, we also realize the problem that can occur with people running to escape the building as soon as possible, we plan to impact this problem by having a website that show people possible escape routes, depending on where you are in the building, the overall goal of our system is the safety of both the civilians and our first responders.

Another thing that pushed us in the direction of this product was we saw the value in fire detection and co monitors, between January 1, 2019 and March 4, 2019 a total of 427 civilian home fire fatalities were reported by the U.S. media, not to mention the ones not mentioned. We know we cannot completely eradicate the issue btu with our system we hope to have an impact on that number and lessening it for the years to come. over the years systems have improved to lessen the number of casualties but it is still a problem, the numbers are still to high, to be complacent with the system we have in place now, igniting the idea for the design of a smart fire detection system, to have and impact as small as in our community to as large and the nation.

## Objective:

The project objective is to design a smart fire detection system that can be implemented for commercial and in home use. This system will be able to determine the fires location, notify 911 operators of the fire location, and alert building occupants of the potential threats location.

## Design Requirements:

1. The system will have an autonomous 911 call that will notify dispatch of the fire and its location within the building.
2. Should be able to detect the temperature of the fire and determine if it is at flash point.
3. Monitor carbon monoxide levels and alert occupants if level is above acceptable threshold.
4. Send out a sms message to registered occupants of the structure of the fire and its location.
5. In home detector base must have a diameter of five inches.
6. Must provide output signals for PPE systems.
7. In home fire detector should mount to existing detectors base plate.
8. The time from the detector’s issuing a fire alarm signal to the controller’s receiving should be controlled within the 10 seconds (GB4717-2005 Fire Alarm Control Units).
9. If any module in the system fails, fire alarm controller should detect the fault in 100 seconds (GB4717-2005 Fire Alarm Control Units).

## Design Constraints

1. Detector should be less than 200 dollars.
2. System must have voice alarm notification for building occupants.
3. Wireless nodes must be no more than 60 feet apart.

## Design Method (Approach)

The first step for this design method is to select the appropriate sensors for smoke, carbon monoxide, and temperature detection. The second step is to program each of these sensors for their perspective measurement thresholds and if these thresholds are passed issues a warning signal. The third step is to interface these sensors with a microcontroller that will drive each of these sensors processes and transmit their data to the CPU. The fourth step in this project is to program the RF transmitter, RF receiver, and logic level converter for the interface between the microcontroller and raspberry pi. The fifth step is to download PIVLO onto the raspberry pi and program the pi to make autonomous phone calls to emergency services. The sixth step is to implement reference ID’s for each node and assign them to their proper autonomous emergency call. The seventh step is to create a website that will allow the building administrator to see a virtual map of the building and location of where a potential problem will be located. The eighth step will be to again use PIVLO to send sms warning messages to all registered building occupants of potential problem. The tenth step is to create a printed circuit board that will house contain the sensors, alarm module, and microcontroller. The eleventh step is to design and print a 3D housing that will contain the PCB. The twelfth step is to connect raspberry pi with display and test the administrative web page. Finally the thirteenth step is to interface the entire project and test the system as a whole.

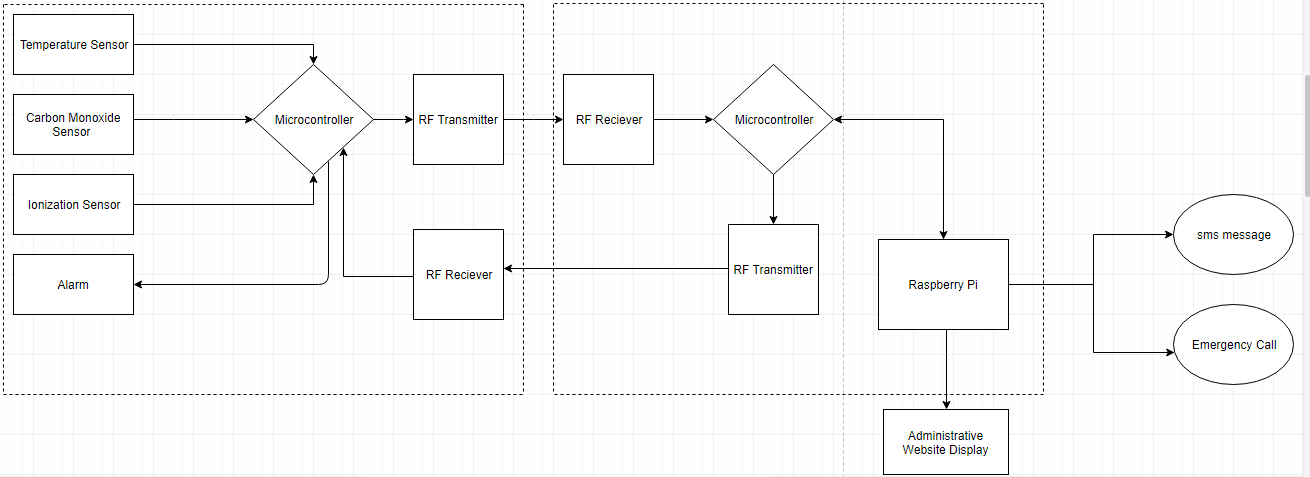
## Standards

1. The initiation function provides the input signal to the system. (NFPA 101, 9.6.1.7).
2. The notification function is the means by which the system advises that human action is required in response to a particular condition. (NFPA 101, 9.6.1.7).
3. The control function provides outputs to control building equipment to enhance protection of life. (NFPA 101, 9.6.1.7).
4. Occupant notification shall be by means of voice announcements. (NFPA 101, 9.6.1.7).
5. Fire alarm circuits shall be installed in a neat workmanlike manner. (NFPA 70 Art. 760.24).
6. Cables and conductors installed exposed on the surface of ceilings and sidewalls shall be supported by the building structure in such a manner that the cable will not be damaged by normal building use. (NFPA 70 Art. 760.24).
7. All fire alarm drawings shall use symbols described in NFPA 170, Standard for Fire Safety and Emergency Symbols.
8. With every new system, a documentation cabinet shall be installed at the system control unit or at another approved location at the protected premises.
9. Smoke detector must be replaced every ten years in accordance to Maryland Smoke Alarm Law.
10. The smoke alarm requirements for existing older homes are based upon when the house was built.
11. The Law heavily emphasises the use of sealed smoke alarms with long life batteries and silence/hush buttons.
12. Any new home in Maryland constructed after January 1, 1989 required at least one hardwired electric smoke alarm on every level of the home, including the basement.
13. The units must be interconnected in order that activation of any one of the required smoke alarms resulted in the sounding all of the required smoke alarms.
14. **Project Description**

## System Description

The fire detector is going to consist of three core sensors, a temperature sensor, carbon monoxide sensor, and an ionization sensor. The sensor data will be transmitted over a wireless sensor network made up of a series of RF transmitters and receivers. The sensors. RF transmitter, and RF receivers will be controlled by a microcontroller (arduino). The detector will transmit sensor data to a RF receiver that will be connected to a logic level converter. This logic level converter will step the microcontrollers voltage up from 3.3 volts to 5 volts. This will allow communication between the microcontroller and microprocessor (raspberry pi). The raspberry pi will process the data contiguously and if a problem is detected will use a program called PIVLO to transmit an autonomous emergency call that is specific to the ID of the sensor that identified a problem. The raspberry pi will transmit a warning message to any numbers programmed in the occupant network alerting building occupants of the potential problem and its location. The microprocessor will also send a warning signal back through the system and activate an alarm in the detector.

## System Diagram



1. System Diagram: (a) main system, (b) subsystem1, and (c) subsystem2.

## System Functions

Here you need to clearly define every function and every state of the system. Make you’re your state graph is complete. For example:

"

1. When either of the sensors threshold is tripped it will issue a message signal that will be transmitted to the microcontroller.
2. The microcontroller will process this message signal and transmit it via the RF transmitter.
3. This will be received by the RF receiver that will pass this information through a second microcontroller and a logic level converter.
4. This data will then be transmitted to the raspberry pi that will identify the warning signal which will then pass a message signal back to the the detector and activate the voice alarm notification.
5. The raspberry pi will generate an autonomous phone call to emergency services notifying them of the problem and the location via the detectors ID.
6. The raspberry pi will send out a sms message to all registered occupant phone numbers of the problem and its location within the building.
7. The potential threat will be updated to the administrative web page and its location within the building will be highlighted.
8. This will then be displayed on the external display that is connected to the raspberry pi.
9. **Implementation Plan**

## Tasks

* Task 1. Sensor Design
  + Subtask 1. Design program for Temperature Sensor

The temperature sensor should have an alarm threshold between 126 - 205 degrees fahrenheit.

* + Subtask 2. Design program for Ionization Sensor

The threshold should not be programmed for more than 100 ppm

* + Subtask 3. Design program for Carbon Monoxide Sensor

The algorithm should have a minimum threshold of no more than 1500 ppm and no less than 1000 ppm.

* + Subtask 4. Interface microcontroller with all three sensors.
  + Subtask 5. Test interface with microcontroller and alarm.
  + Subtask 6. Design PCB for transmitter.
  + Subtask 7. Design PCB for receiver.
  + Subtask 8. Test PCB design for receiver.
  + Subtask 9. Test PCB design for transmitter.
* Task 2. Wireless Sensor Network Design
  + Subtask 1. Design microcontroller and RF transmitter interface
  + Subtask 2. Program microcontroller and RF transmitter.
  + Subtask 3. Design microcontroller and RF receiver interface
  + Subtask 4. Program microcontroller and RF receiver interface.
  + Subtask 5. Interface microcontroller and raspberry pi.
  + Subtask 6. Design program for proper data processing and storage.
  + Subtask 7. Test Wireless Sensor Network data transmission and reception.
* Task 3. Website Design
  + Subtask 1. Design background and layout of website.
  + Subtask 2. Design login for administrator and user access.
  + Subtask 3.Program a grid that will establish compartments for each room in building.
  + Subtask 4. Design a program that will interface the raspberry pi and website.
  + Subtask 5. Design a program that will pair node ID with corresponding room on the grid plan.
  + Subtask 6. Program grid to highlight room where potential threat arises.
  + Subtask 7. Test website warning and raspberry pi interface.
  + Subtask 8. Connect raspberry pi to external display and display webpage.
* Task 4. Design Automated Emergency Phone Call
  + Subtask 1. Setup pivlo account and install software on raspberry pi.
  + Subtask 2. Design virtual auntanamous alert message for each node ID.
  + Subtask 3. Design program that will correlate voice message with specific node ID.
  + Subtask 4. Program raspberry pi for sms data transmission.
* Task 5. Design SMS Warning Message Database
  + Subtask 1. Program sms message corresponding to correct node ID
  + Subtask 2. Design database for building occupant phone number storage.
  + Subtask 3. Design program to send link to the webpage.
  + Subtask 4. Test sms warning message for building occupants
* Task 6. Complete System Assembly and Testing
  + Subtask 1. Assemble entire system.
  + Subtask 2. Test full platform with nodes placed in their desired positions.
  + Subtask 3. Test all warning message software and assure they work properly.

## Team Organization

### Responsibility of Team Member 1 (David Goslee).

Task 1, Subtask 1.2, 1.3, 1.3, 1.6, 1.9

Task 4, Subtask 4.1, 4.2, 4.3, 4.4

Task 6, Subtask 6.1, 6.2, 6.3

### Responsibility of Team Member 2 (Israel Akinsoyinu).

Task 1, Subtask 1.4, 1.5,1.7, 1.8

Task 2, Subtask 2.1, 2.2, 2.3, 2.4

Task 5, Subtask 5.1, 5.2

Task 6, Subtask 6.1, 6.2, 6.3

### 3.2.3. Responsibility of Team Member 3 (Dedrick McCoy).

### 

Task 3, Subtask 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7

Task 5, Subtask 5.3, 5.4

Task 6, Subtask 6.1, 6.2, 6.3

## Timeline/Milestones/Delivery Plan

1. **Project Timeline and Delivery Plan**

|  |  |  |  |
| --- | --- | --- | --- |
| **Time** | **Task** | **Comments** | **Responsible Personnel** |
| Week 1 | Start Subtask 1.1-1.3 | Program sensors two weeks needed. | David |
| Week 2 | Start Subtask 1.4-1.5 | Program RF transmitter receiver. | Israel |
| Week 3 | Start Subtask 3.1, 3.2 | Website Design login and website layout three weeks needed.. | Dedrick |
| Week 4 | Start Subtask 2.1, 2.2, 2.3, 2.4 | Design and program RF transmitter and receiver interface, two weeks needed.. | Israel |
| Week 5 | Start Subtask 2.5, 2.6, 2.7 | Interface pi with RF transmitter receiver and test data processing two weeks needed. | Da vid |
| Week 6 | Start Subtask 3.3, 3.4, 3.5 | Design grid layout for building, pi interface, and program ID’s for nodes three weeks needed. | Dedrick |
| Week 7 | Start Subtask 1.7-1.8 | Transmitter PCB design and testing four weeks needed. | Israel |
| Week 8 | Start Subtask 1.6-1.7 | Receiver PCB design and testing four weeks needed. | David |
| Week 10 | Start Subtask 3.6 | Program website with grid layout and warning light three weeks needed. | Dedrick |
| Week 11 | Start Subtask 4.2-4.3 | Design warning message and algorithm for specific room ID. Three weeks needed. | David |
| Week 11 | Start Subtask 5.1, 5.2 | Design sms message and Data base four weeks needed. | Israel |
| Week 13 | Start Subtask 3.6, 3.7, 3.8 | Program warning light to highlight specific portion of floor plan and interface website with pi two weeks needed. | Dedrick |
| Week 14 | Start Subtask 4.1-4.2 | Set up Pivlo and design virtual message for 911 operator two weeks needed. | David |
| Week 16 | Sart Subtask 4.3, 4.4 | Design program that will correlate 911 call with specific node three weeks needed. | David |
| Week 20 | Start Subtasks 6.1, 6.1, 6.3 | Test complete system two weeks needed. | David, Israel, Dedrick |

1. **Implementation**

For each task/subtask, create a section and add tech details of how it is implemented.

## Implementation of Task 1.

…

### Implementation of Subtask 1.1

…

## Implementation of Task 1.

…

1. **Conclusion (Discussion and Future Plans)**

By the end of the project, conclude the project and your learning experience.

**Acknowledgment**

If you get help or support from someone else (besides the team member and the advisor) and want to show your appreciation, put here (**do not include the advisor**).

**Appendix**

You can put reference info here, including: i) specs of components used in the system, ii) source code (must be here but not in the body text), iii) CAD figures, etc.

1. **Component Specs**
2. ***Specs of Arduino Due***

...

1. ***Specs of Raspberry Pi***

…

1. **Source Code.**
2. ***Source Code of Graphic User Interface***

…

1. ***Source Code of Robotic Arm***

…

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