A
DISSERTATION
ON

"An Automated Fire Suppression Using an Arduino Nano"

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AWARD OF DEGREE OF

BACHELOR OF VOCATION

IN

Bachleior of Voccation (Hardware Technology and Networking)

SUBMITTED BY

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UNDER THE GUIDANCE OF

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DEPARTMENT OF BACHELOR OF VOCATION
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BHIWAPUR, NAGPUR

CERTIFICATE

This is to certify that the project work entitled "An Automated Fire Suppression Using an Arduino Nano " is a bonafide work done by Ashwini Krishna Kale , Payal Dnyaneshwar Ramteke in the Bachleior of Voccation (Hardware Technology and Networking) section of the Bachelor of Vocation, BhiwapurMahavidyalaya, Bhiwapur, Nagpur, in partial fulfillment of the requirement for the award of Bachelor of Vocation in "Hardware Technology and Networking ".

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ACKNOLEDGEMENT

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I wish to express my gratitude to my parents for sparing me to undertake this research project without any hindrances.

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DECLARATION

This Project wok entitled "An Automated Fire Suppression Using an Arduino Nano " is my own work carried out under the guidance of A.P.Ramteke Assistant Professor in Bachelor of Vocation, BhiwapurMahavidyalaya, Bhiwapur, Nagpur. This work in the same form or in any other form is not submitted by me or by anyone else for the award of any degree.

Ashwini Kale

Payal Ramteke

CERTIFICATE

This is to certify that the Project work entitled "An Automated Fire Suppression Using an Arduino Nano", is the bonafide work done by Ashwini Krishna Kale , Payal Dnyaneshwar Ramteke and is submitted to BhiwapurMahavidyalaya, Bhiwapur, Nagpur, for the partial fulfillment of the requirements for the degree of Bachelor of Vocation in Hardware Technology and Networking.

ABSTRACT

The proposed fire suppression system is a real time monitoring system that detects the presence of flame of certain wavelength in the air due to fire and suppresses the fire via continuous water running through multiple sprinklers. The controlling unit used to develop the fire alarm system is an Arduino Nano. The key feature of this system is the ability to remotely send an alert when a fire is detected. Fire is an undesirable event that could cause a great loss of social wealth, human life and confidential amenities. To prevent these losses, various alarm systems have already been developed such as smoke detectors, temperature sensor based systems etc. These systems comes with a high chance of human error that can mislead the sensing and hence the whole system in general. Our fire suppression system on the other hand is extremely well thought out; it has no chance of human error as it is fully self-sufficient. The sensors we will be using are highly sensitive, thus it will detect fire even before it reaches to a point of concern.The components we used are readily available and reasonable in price. Our automated fire suppression system can be used both for commercial and residential purposes.

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Introduction

In this chapter we first introduce the topic of Fire Suppression System using Arduino Uno and describe the problem statement related to the simulation environment. Then the main research objectives are outlined followed by the research contributions. Finally, the main thesis overview is presented.

Motivation of the work and background

Fire has been a danger to assets and population through ages. In very recent times there have been multiple cases of fire throughout Dhaka city damaging properties worth millions and moreover taking away lives of innocent people. Locations like factories, slums and other open areas are most vulnerable to such disastrous events. Offices and other workplaces are also exposed to such events which may cause loss of important confidential documents and treasuries.

From January to February, incidents of 1,845 fires were recorded by Fire Service and Civil Defense all over Bangladesh.

Table-1[2]:

Year	Countrywide fire	Financial loss	Casualty/Injury
2006	16,858	240 crore 43 lakh	152/247
2007	1,845	35 crore 81 lakh	14/41
Year	Dhaka city fire	Financial loss	Casualty/Injury
2006	3,020	100 crore 63 lakh	15/81

The estimated financial loss from fires last year was Tk240.43 crores according to Fire Service and Civil Defense.

Some related factory and slum incidents in and around Dhaka are mentioned below in **Table 2**[1]:

Factory name	Location	Incident date	Cause and outcome	Injuries	Deaths
Next Collection	AshuliaSavar	3\1\2015	Thirty people have been injured in a stampede when the garment workerswere stepping down from the factory following fire panic. The incidenttook place at Next Collection in Narshinghapur area of Ashulia around 11a.m.on Sunday. An electrical short circuit caused a "sparkle of fire."	30	0
Unnamed shoe factory	Bangshal Dhaka	2/21/2014	Four workers have sustained burn injuries after a shoe factory in the capital's busy Bangshalarea was burned down in a fire on Friday night. The fire broke out at a small shoe factory at the Kayettuli area around 10p.m. Two firefighting units doused the flames after 30 minutes of effort. Another victim of the shoe factory fire succumbed to his injuries last night at the Burn and Plastic Surgery Unit of Dhaka Medical College Hospital.	3	1
Amin dyeing	Fatullah, Narayanganj	1/5/2016	Some workers were smoking in the chemical go down of Amin Dyeing Factory around 1am. The explosion took place due to the leakage in the gas pipeline	5	0
Matrix Sweaters Ltd.	Choydana, National University	2/2/2016	Fire broke out at Matrix Sweater Factory at 7:30 am for the second time in last four days in the district. Joydebpur Fire Service station officer said fire broke out at the eighth floor of the factory. On information, eight unit of Tongi and Joydevpur fire service rushed to the spot and was trying to douse fire. Causes of fire and damages caused could not be known yet.On January 29 fire broke out on the same factory.	5	0

Multifabs etc.	Gazipur, Dhaka	7/4/2017	A boiler explosion at a Bangladeshi garment plant near the city of Dhaka killed 10 people and injured dozens. The blast occurred at a plant operated by local Bangladeshi firm Multifabs while maintenance work was going on, company and fire brigade officials said. The explosion at the boiler, located in a tin-roofed shed, partially damaged a nearby three-storey factory building. This was one of the latest industrial tragedy to hit one of the world's biggest garment producers.	Unknown	10
Korail Slum	Mohakhali, Dhaka	3/16/2017	Many houses at one of the largest slums in Dhaka have been razed to the ground by a fire that broke out at the early hours of 16th march. Authorities are yet to report any casualties over the fire, the third in a year, at the Korail slum in the capital's Mohakhali area. Fire service said that the incident was reported around 3am on Wednesday. It took the firefighters a little over five hours to put out the flamesMohakhali'sKorail slum is one of the largest slums in the capital with thousands of inhabitants, hundreds of tin-shed houses at the slim were gutted. The slum, on a 150-acre land of the state run BangladeshTelecommunication Company Ltd (BTCL), is home to several hundreds of thousands of people of the low-income group. Hundreds of houses of the slum were burnt in two incidents of fire on Dec 4 and Mar 14 last year.	Unknown	Unknown
Banshbarhi slum	Mohammadpur, Dhaka	2/16/2017	A fire has raged through a slum in Dhaka, leaving more than 100 shanties completely burnt. The fire service said no casualties were reported from the incident which took place early on Thursday morning at the 'Banshbarhi Slum' in the capital's Mohammadpur area. Flames erupted at the slum around 3:30am, said Fire Service Control Room official PalashModak. It took 13 fire-fighting units almost two and a half hours to put out the fire. The cause of the fire is yet to be known. Locals said more than 100 shanties were completely gutted in the fire.	Unknown	Unknown

These are just some of the reported events, other than these there have been news of multiple fire events in the last 3 or 4 years which were not reported. The very recent fire ravaged around 500 homes in Korail slum in Mohakhali. Fire disasters are increasing day by day and should not be overlooked time after time. These

unfortunate events gave rise to our project which suppresses fire in a much more efficient way than the existing methods. Slums have narrow lanes and many flammable materials in its premise which causes fire to spread out quickly and makes work harder for Fire brigade to operate on the inside. Factories have many electrical appliances which may be the cause for fire. We motivated ourselves to build a technology that could reduce the fire hazard to a minimum at a minimum cost.

Literature review and problem formulation.

Fire causes huge loss of lives and properties every year in Bangladesh. Analyzing past fire incidents, facts are revealed. Some of the main causes are insufficient fire defense materials, electric short circuit from faulty electrical wiring, presence of inflammable materials, violation of fire safety and lack of adequate awareness etc. Some factories and recent buildings have proper installation and fire safety arrangements such as fire alarm, fire extinguishers, water supply system etc. But the argument is these conventional fire extinguishing systems are not enough to take prompt action during fire and save life. Traditional manual system does not ensure 24/7 monitoring from fire protection. Moreover, existing fire protection system could spread panic inside the whole building since it does not announce the location of fire or intensity. It only raises alarm whenever fire is detected at any place. Frightened people could start to run away haphazardly. As a result buildings full of workers in the factories women, children could be smashed by the outgoing pressure of the frightened crowd and injured severely. On the contrary, sometimes people do not realize the intensity of the fire and not willing to evacuate fire affected building quickly. It could lead a devastating result.

In this paper a Fire suppression system is presented that can reduce these hazards to a great extent. The proposed system is fully automated and does not effectively require any human effort to extinguish the unfortunate event. It is self-sufficient as well. The fire alarm will set off once the fire breaks down which will open the solenoid valves connected to water pipes by the help of a controlling unit (Arduino Uno). Relays are connected in between the Arduino and the solenoid valve in order

to provide the required voltage to the valve. The sprinklers used in this system can cover a relatively large radius and can effectively suppress the fire within seconds.

Fire suppression systems are used to extinguish or prevent the spread of fire in a building or in an open space. An automatic fire suppression system control and extinguish fires without human intervention. When fires are extinguished in the early stages loss of life and property is minimal since 93% of all fire related deaths occur once the fire has progressed beyond the early stages.

Today there are numerous types of Automatic Fire Suppression Systems and standards for each one. Systems are as diverse as the many applications.

The existing fire alarm system in market nowadays, is too complex in term of its design and structure. Since the system is too complex, it needs regular preventive maintenance to be carried out to make sure the system operates well. Meanwhile, when the maintenance is been done to the existing system, it could raise the cost of using the system. Therefore, the proposed project is designed with a low cost and all level users can have one for a safety purpose.

Project objectives

Our projects objective is to design a Fire Alarm & Fire suppression System that would fulfill the following objectives:

i) Indicate the room in which fire erupted.

ii) Sound the alarm if fire occurs.

iii) Run the controlling unit (Arduino Nano) and control the fire by supplying water to the remote area by motor pump.

iv) False Alarm occurrence should be kept to minimum.

v) The system should also provide the flexibility to suppress the fire in multiple rooms.

vi) The sprinklers used in the system should suppress the fire over thecorrect radius and not waste any water unnecessarily.

vii) The system should never be in any ambiguous state. Under normal conditions the system should indicate the state of the room as safe to the normal people.

Furthermore there are other objectives to our research as well which includes:

i) To have a clear concept of an automated fire suppression system.

ii) To have a clear perception of the Arduino and its different characteristics involved in the project.

iii) To have a clear idea of the flame sensors those are used in the project by proper identification of their detection mechanism.

iv) Design and implement our proposed system at a proper place and safe environment.

v) Determine the faults in our system and finding the proper solution.

vi) Monitor the overall system over certain period of time.

In a way to achieved above objectives, this project needs to be implemented as below:

i) This fire alarm system can incorporate the solenoid valve and flame sensors.

ii) The Arduino is used as the heart of this fire alarm system that controls the entire operations involved.

iii) The fire alarm system is capable to locate and identify the place that is in fire while it is controlled by the Arduino.

iv) Capable to display the output in terms of extinguishing the fire completely in a short period of time.

Contributions of the research

i) Once properly executed, this project will save human lives and amenities from disaster.

ii) A self-sufficient fire suppression system is always required in both residential and industrial environment.

iii) An advanced controlling unit (Arduino Uno) is coded and designed in such a manner that can effectively and efficiently control this system under all circumstances.

iv) An ideal power back up has been proposed in case of emergency power supply and its performance has been justified.

v) An automated fire suppression system is created at such a low cost that can prove to be very beneficial for government purposes in the near future.

Thesis organization

The rest of the research is divided into the following chapters:

Chapter 2: Fire suppression mechanism

Chapter 3: Fundamental concept of an embedded system and components used in our embedded system.

Chapter 4: An automated fire suppression mechanism controlled using an Arduino.

Chapter 5: Field tests and analysis.

Chapter 6: Conclusion and future work.

Conclusion

In a nutshell Chapter 1 gives us an idea of the overall project in terms of its objectives, contributions and literature review. This chapter also talks about the tragedies caused by fire in Bangladesh which motivated us to come up with this self-sufficient system. It also states the problems we faced during the project and ways to formulate those problems. The thesis organization gives us hints about how the rest of the paper will be followed through.

Chapter 2

Fire Suppression Mechanism

Basic concept of Fire suppression mechanism.

Suppressing fire by throwing water onto it has been used since ancient times. To provide an automatic spray of water to control a fire, sprinkler systems were developed in the late 19th century. Since then, automatic sprinklers have become the most common fixed fire suppression system for providing fire safety in buildings. Sprinklers control fire development by wetting and cooling the fuel surface.

They are effective for fires involving solid materials (referred to as solid fuels) but are not effective for flammable liquids (called liquid fuels) such as gasoline, diesel and jet fuels. The old adage "oil and water do not mix" must be kept in mind. Fire suppression systems for liquid fuels typically use foam or dry chemicals, which cover the fuel surface, hence limiting thermal feedback to the liquid fuel surface and fuel vaporization.

Existing fire extinguishing mechanisms

The new fire suppression systems use technologies such as: inert and halocarbon gaseous agents, water mist systems and solid gas generator.

Gaseous Systems:
Two types of gaseous agents are available for use in total flooding systems-halocarbon agents and inert gases. A general requirement for such systems is that the enclosure must be capable of holding the gas and be able to withstand the high pressures produced during discharge.

Halocarbon Agents-

Halocarbon agents are chemicals similar to Halon except that their molecular structure has been modified to reduce the number or to eliminate completely, the chlorine and bromine atoms, which are responsible for ozone depletion. These agents extinguish fires primarily by cooling. Acceptance of a halocarbon agent by regulatory authorities hinges on the agent's toxicity. Two toxicological aspects must be considered. One is the toxicity of the agent itself, and the other is the toxicity of combustion by-products of the agent produced under fire conditions. Results from both small-scale and full scale tests have shown that the halocarbon replacement systems extinguish fires well, though not as effectively as Halons. To provide the same level of fire protection as Halons, larger amounts of halocarbon agents are needed. This means larger and heavier cylinders are required, which may create weight and space problems. The test results also show that halocarbon agents produce five to ten times more toxic gases than Halon 1301 during fire suppression. These gases include hydrogen fluoride (HF) and carbonyl difluoride (COF2), with levels produced in test fires significantly exceeding all human exposure limits. The levels of HF and COF2 likely to be produced in actual applications will depend on many factors such as agent type and concentration, fire type and size, and discharge and extinguishment times.

Inert Gas Agents-

Inert gas agents are applied as total flooding agents. They extinguish fire by displacing the oxygen in the enclosed space and eventually reducing its concentration below the level required for combustion. Inert gases, such as nitrogen, argon and helium, are clean and naturally occurring, have zero ozone depletion potential and no global warming potential. They are not subject to thermal decomposition when used in extinguishing fires, and hence form no combustion by-products. One of the disadvantages of using inert gas systems is that a large volume of agent is required to extinguish a fire. As well, inert gases cannot be liquefied and must be stored in cylinders as high pressure gases, which has implications for space and weight. Inert gases also require a discharge system sufficiently robust to withstand the high pressures involved. The rapid displacement of oxygen, high noise levels and rapid cooling are also a concern if the agent is to be discharged into an occupied space. [4]

Water Mist:

The term "water mist" refers to fine water sprays in which 99% of the volume of the spray is in droplets smaller than 1000 microns in diameter. Fire suppression by water mist is mainly by physical mechanisms. No significant chemical effects are involved. Water mist does not behave like a "true" gaseous agent. The compartment tests showed that its effectiveness in fire suppression is substantially affected by the fire size, the degree of obstruction, ceiling height, and the ventilation conditions. Water mist characteristics, such as variety of drop sizes and spray momentum, have a direct influence on effectiveness. To effectively suppress a fire, a water mist system must generate and deliver optimum-sized droplets with an adequate concentration. The selection of the optimum size of droplets for the design of the system is dependent on the potential size of the fire, properties of the combustibles, and the degree of obstruction and ventilation in the compartment. There is no one drop size distribution to fit all fire scenarios.

There are several water mist systems available commercially. Some employ high or intermediate pressures of water through small orifices in a nozzle to produce the mist, while others use twin fluid nozzles (water and air). Water mist systems have demonstrated a number of advantages, such as good fire suppression capability, no environmental impact and no toxicity. As a result, they have been considered for numerous applications. One potential application is shipboard machinery spaces. Water mist systems are able to extinguish a wide variety of fires when natural ventilation, such as open doors and hatches are allowed, whereas gaseous agents were not effective under such conditions. Water mist systems also rapidly reduced the compartment temperature and significantly improved visibility. These advantages allow accessibility to the compartment during fire suppression. [5]

Gas Generators:

Based on automotive airbag technology, gas generators have been developed for fire suppression applications. Gas generators can produce a large quantity of gases (mainly N2, CO2 and water vapor) by combustion of solid propellants. Solid propellants consist of oxidizers and fuel ingredients, and are able to burn without ambient air. Gas generators can be very compact and can provide very fast discharge (in a few milliseconds). Currently, there are two types of gas generators available: conventional and hybrid. Conventional gas generators contain a propellant and an electrical initiator. When a signal is received from a

detector/controller, the electrical initiator ignites a charge to start a combustion process in the propellant. Rapid combustion of the solid propellant generates large amounts of N2, CO2 and water vapor, which rapidly increases the internal pressure. A hermetic seal is ruptured and the gas products are discharged within milliseconds into the protected space. Suppression is by oxygen displacement and gas discharge dynamics (blowing effect).A hybrid gas generator consists of an electrical initiator, a solid propellant chamber and a suppression agent chamber. The heat and pressure generated by the combustion of the propellant are used to heat and expel the liquefied suppressant. Gas generators are limited for use in unoccupied spaces only, because of their high temperature and high momentum discharge.[6]

Advantages of our automated system over existing technologies.

The automated system that we designed has multiple advantages over other technologies:

i) We used solenoid valves which allow water to flow on one dedicated pipe; this enables us to localize one affected region at a time rather than spreading water over the entire area.

ii) The flame sensors we used are effective and responsive to fire over a relatively large distance.

iii) The time delay is negligible between the emergence of fire and detection procedure. As soon as the fire is detected, the buzzer turns ON and makes a loud noise alerting the people around the affected area to evacuate as the sprinklers project water.

iv) No external power supply is required since batteries are used to supply power to the solenoid valves. Two 12V batteries in series, which is 24V is enough to run a single system.

v) The Arduino Uno used in our project only requires a power supply of 5V which is readily accessible. The 24V power supplied from the battery can be converted to 5V through a step down voltage regulator.

vi) A protection circuit is designed using capacitor and diode in such a way that will reduce the flow of back EMF which can be an issue when the system is switched ON and OFF.

Conclusion

Chapter 2 portrays the basics of fire suppression mechanisms along with the existing systems of fire suppression mechanisms such as gaseous systems, water mist systems and compressed-air foam mechanisms.

Most importantly this chapter tells us the advantages of our systems over the existing mechanisms. These advantages include localizing the fire, highly responsive flame sensors, fast response between fire detection and extinguishing process, independence of the system from grid power, an intelligent and efficient controlling unit and the system's own protection unit.

Chapter 3

Fundamental Concept of an Embedded System and Components Used In Our Embedded System

Introduction to an embedded system

The electronic system which integrates the hardware circuitry with the software programming techniques for providing project solutions is called as embedded systems. By using this embedded system technology the complexity of the circuits can be reduced to a great extent which further reduces the cost and size. Embedded system was primarily developed by Charles Stark for reducing the size and weight of the project circuitry.

An embedded system is basically an electronic system that can be programmed or non-programmed to operate, organize, and perform single or multiple tasks based on the application. In the real time embedded systems, all the assembled units work together based on the program or set of rules or code embedded into the microcontroller. But, by using this microcontroller programming techniques only a limited range of problems can be solved.

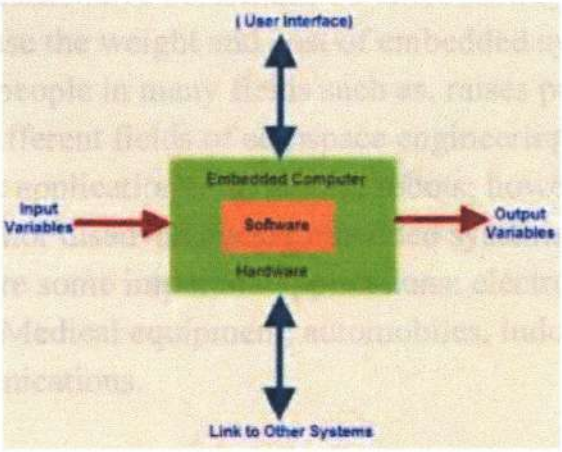

Figure 3.1: Flow diagram of an embedded system.[8]

Modern embedded systems are often based on microcontrollers (i.e. CPU's with integrated memory or peripheral interfaces), but ordinary microprocessors (using external chips for memory and peripheral interface circuits) are also common, especially in more-complex systems. In either case, the processor(s) used may be types ranging from general purpose to those specialized in certain class of computations or even custom designed for the application at hand. A common standard class of dedicated processors is the digital signal processor (DSP).

One of the very first recognizably modern embedded systems was the Apollo Guidance Computer developed by Charles Stark Draper at the MIT Instrumentation Laboratory. [8]

Benefits of an embedded system

Many electrical and computer engineering projects involve some kind of embedded systems which makes it important to study these kind of systems. An embedded system is an electronic system that contains at least one controlling device, for instance, the brain. This brain is called the microcontroller that controls the peripherals as input and output devices. In fact, every embedded system consists of two parts. The first part is called the hardware and the other one is the software. The software part always needs a program that can be used to manipulate the hardware. There are several examples of devices containing embedded systems such as: automobiles, traffic lights, cameras, mp3 audio players, wireless network routers, and many other electronic devices.

Moreover, a lot of upgrades have been made on embedded systems in the last ten years that led to decrease the weight and cost of embedded systems. Embedded systems could benefit people in many fields such as, raises people's standard of living; being used in different fields of aerospace engineering and industry; being widely used in military applications and mobile robots; however, Embedded Systems have some minor disadvantages. Embedded systems are used in a variety of applications. Here are some important applications: electronic products, household appliances, Medical equipment, automobiles, industrial applications, aerospace, and communications.

Embedded systems helped in developing automotive safety systems, for instance, electronic fuel injection systems, Global Positioning System (GPS), and anti-lock braking systems (ABS).

Figure 3.2b: An example of an embedded system-Intel 4004. [7]

Alternatively, embedded systems are being used in mobile robots and some military applications. In fact, there has been an enormous increase of interest in mobile robots as they are perfect tools for engineering education. In the past, mobile robots were controlled by large, expensive, and heavy computer systems that could not be carried and had to be linked via cables.

Furthermore, it is hard to maintain embedded systems because the software part of embedded systems is typically monolithic and these systems are hard to upgrade and customize. Also, it is hard to carry files from one machine to another because there are different programming languages that can used to manipulate the hardware of the embedded system, so carrying files from one machine to another is hard and may not work with the other hardware. In conclusion, it can be seen that there are many beneficial uses of embedded systems in our daily life which are raising people's standard of living in many fields, being used effectively in different fields of industry and aerospace applications, being used in mobile robots and in some military applications. [7]

Arduino Nano

Arduino is an open source computer hardware and software company, project, and user community that designs and manufactures single-board microcontrollers and microcontroller kits for building digital devices and interactive objects that can sense and control objects in the physical world.

Arduino board designs use a variety of microprocessors and controllers. The boards are equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The boards feature serial communications interfaces, including Universal Serial Bus (USB) on some models, which are also used for loading programs from personal computers. The microcontrollers are typically programmed using a dialect of features from the programming languages C and C++. A program written with the IDE for Arduino is called a *sketch*. Sketches are saved on the development computer as text files with the file extension *.ino*. Arduino Software (IDE) pre-1.0 saved sketches with the extension *.pde*.

```
ine Sensor 2
ine Buzzer 3
ine LED 4

 setup() {
erial.begin(9600);
inMode(Sensor, INPUT);
inMode(LED, OUTPUT);
inMode(Buzzer, OUTPUT);


 loop() {
 value = digitalRead(Sensor);
erial.println(value);

 (value == 0) {
 digitalWrite(LED, HIGH);
 digitalWrite(Buzzer, HIGH);
 else {
 digitalWrite(LED, LOW);
 digitalWrite(Buzzer, LOW);
```

Figure 3.3a: A typical example of a code in the Arduino software. [9]

The version that we will be using in our research is Arduino Nano. The **Arduino Nano** is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (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. It contains everything needed to support the microcontroller. We need to simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started.

A summary of the configuration of the device:

Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
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 (ATmega328)
EEPROM	1 KB (ATmega328)
Clock Speed	16 MHz

The Arduino Nano can be powered via the USB connection or with an external power supply. The power source is selected automatically.

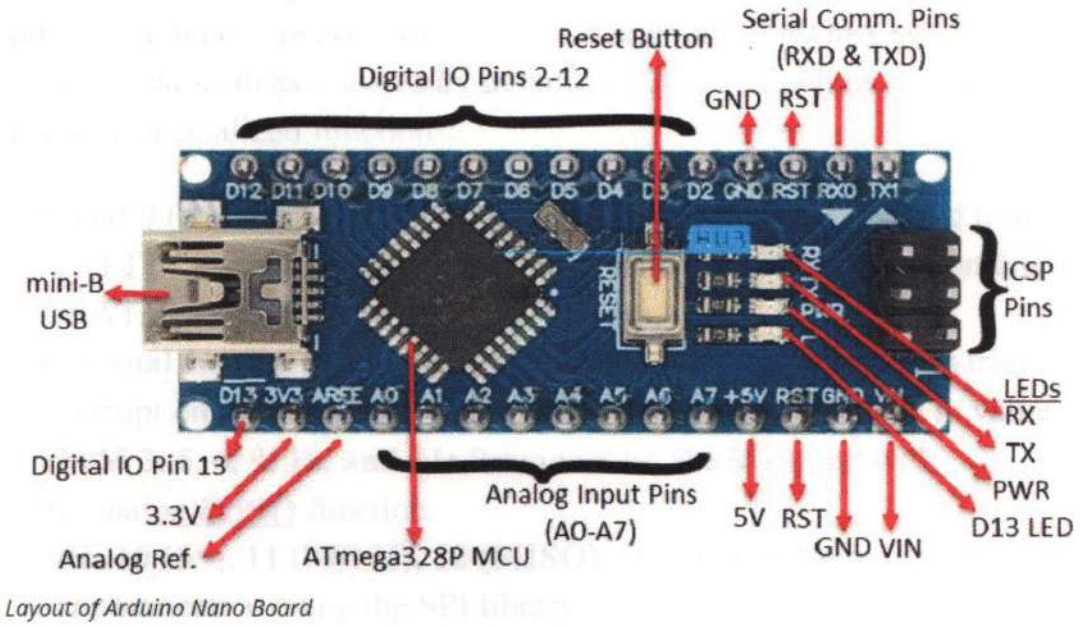

Figure 3.3b: A typical ArduinoNano. [9]

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

The power pins are as follows:

- **Vin:** The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source).
- **5V:** The regulated power supply used to power the microcontroller and other components on the board.
- **3.3V:** A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
- **GND:** Ground pins.

Each of the 14 digital pins on the Uno can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead()functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kiloohms. In addition, some pins have specialized functions:

- **Serial 0 (RX) and 1 (TX):** These are used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.
- **External Interrupts 2 and 3:** These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value.
- **PWM 3, 5, 6, 9, 10, and 11:** Provide 8-bit PWM output with the analogWrite() function.
- **SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK):** These pins support SPI communication using the SPI library.
- **LED 13:** There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

The Nano has 6 analog inputs, labeled A0 through A5, each of which provide 10 bits of resolution (i.e. 1024 different values).

There are a couple of other pins on the board:

- **AREF:** Reference voltage for the analog inputs. Used with analogReference().
- **Reset:** Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

The Arduino nano can be programmed with the Arduino software. The maximum length and width of the nano PCB are 45 mm and 18 mm respectively,with the USB connector and power jack of mini-B USB connection. [9]

Flame sensor

The flame sensor module that we used is sensitive to the flame and radiation. It can also detect ordinary light source at the range of a wavelength from 760nm to 1100 nm. The detection distance is up to 100 cm (1 m). This Flame sensor has a digital signal as an output. The output is 0 (0V) when radiation in its range is detected, else the output is 1 (3.3 or 5V, depends on its Vcc). [10]

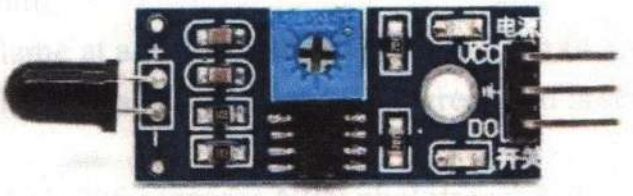

Figure 3.5a: The flame sensor module used in our project.

The descriptions of the pins are as follows:

- Vcc: (3.3-5V).
- GND- Ground.
- DO - board digital output interface (0 and 1).

Some of the common characteristics of this flame sensor module include [11]:

- It can detect a flame or a light source of a wavelength in the range of 760nm-1100 nm.
- It can detect flame at a distance ranging from 20cm (4.8V) ~ 100cm (1V).
- It can detect flame at an angle about 60 degrees and is sensitive to the flame spectrum.
- It is based on YG1006 sensor, a NPN phototransistor.
- Comparator chip LM393 allows the module readings to become more stable and easy to capture.
- The range of wavelength detection can be adjusted in accordance to our needs.
- The module operates at voltage ranging from 3.3V-5V.
- Digital Output : DO- digital switch outputs (0 and 1)
- The module contains a power indicator and digital switch output indicator.[10]

Conclusion

Basic concept of an embedded system, its benefits and its importance in our project has been justified at the start of this chapter. The controlling unit used in our system, an Arduino, has been described part by part along with its control algorithm (code). Supporting devices such as the flame sensors, Ardino nano basic functionality and their contribution in our projecthave been explained.
Miscellaneous devices such as the buzzer and LED which make up the alarm system, the capacitor and the diode which make up the protection circuit and thebatteries for our power management has been talked about.
In the end it is shown with the aid of before and after pictures how the glass bulb containing the heat responsive liquid has been removed from the sprinkler heads before installing in the pipe lines.

Chapter 4

An Automated Fire Suppression Mechanism Controlled Using an Arduino

Overview of the whole system

Introduction

Fire Alarm Systems are very common in commercial building and factories, these devices usual contain a cluster of sensors that constantly monitors for any flame, gas or fire in the building and triggers an alarm if it detects any of these. One of the simplest way to detect fire is by using an IR Flame sensor, these sensors have an IR photodiode which is sensitive to IR light. Now, in the event of a fire, the fire will not only produce heat but will also emit IR rays, yes every burning flame will emit some level of IR light, this light is not visible to human eyes but our flame sensor can detect it and alert a microcontroller like Arduino that a fire has been detected.

In this thesis we interface Flame Sensor with Arduino and learn all the steps to build Fire Alarm System by using Arduino and flame sensor. Flame sensor module has a photodiode to detect the light and an op-amp to control the sensitivity. It is used to detect fire and provide a HIGH signal upon the detection. Arduino reads the signal and provides alert by turning on the buzzer and LED. The flame sensor used here is an IR based flame sensor.

Connection of our experiment

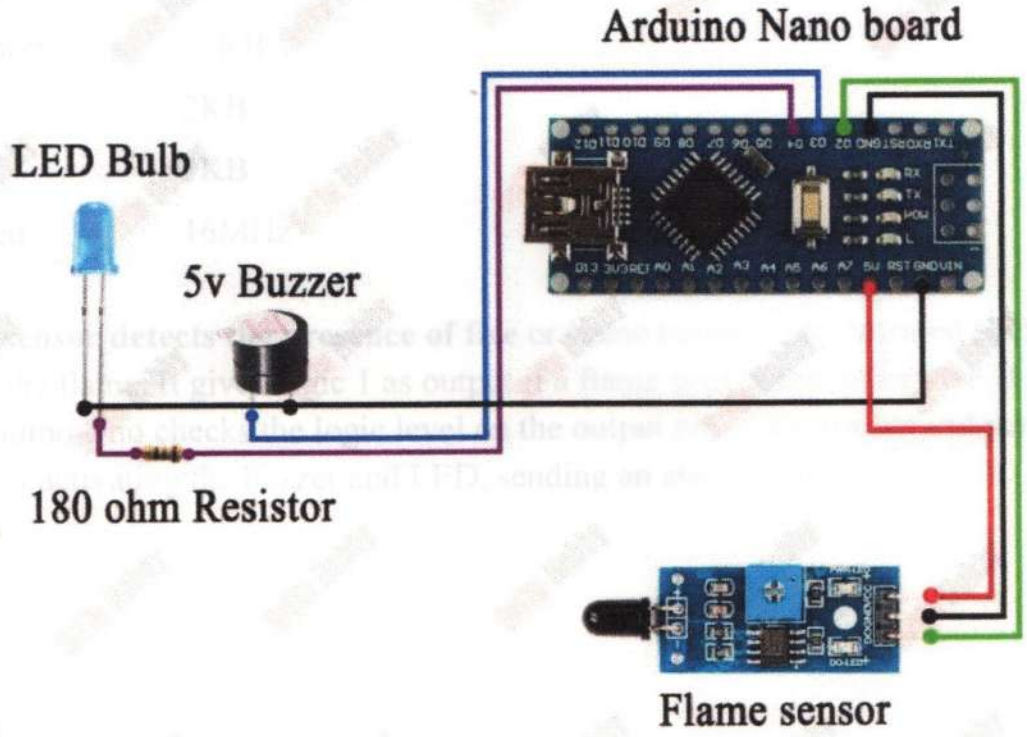

Figure 4.1.2: Connection of our experiment.

Working of Flame Sensor with Arduino

Arduino Uno is a open-source microcontroller board based on the ATmega328p microcontroller. It has 14 digital pins (out of which 6 pins can be used as PWM outputs), 6 analog inputs, on-board voltage regulators etc. Arduino Uno has 32KB of flash memory, 2KB of SRAM and 1KB of EEPROM. It operates at a clock frequency of 16MHz. Arduino Uno supports Serial, I2C, SPI communication for communicating with other devices. The table below shows the technical specification of Arduino Uno.

Microcontroller	ATmega328p
Operating voltage	5V
Input Voltage	7-12V (recommended)
Digital I/O pins	14
Analog pins	6
Flash memory	32KB
SRAM	2KB
EEPROM	1KB
Clock speed	16MHz

The **flame sensor detects the presence of fire** or flame based on the Infrared (IR) wavelength emitted by the flame. It gives logic 1 as output if a flame is detected, otherwise, it gives logic 0 as output. Arduino Uno checks the logic level on the output pin of the sensor and performs further tasks such as activating the buzzer and LED, sending an alert message.

CHAPTER 4

Control Algorithm

Arduino Code

```
#define Sensor 2
#define Buzzer 3
#define LED 4

void setup() {
 Serial.begin(9600);
 pinMode(Sensor, INPUT);
 pinMode(LED, OUTPUT);
 pinMode(Buzzer, OUTPUT);
}

void loop() {
 bool value = digitalRead(Sensor);
 Serial.println(value);

 if (value == 0) {
   digitalWrite(LED, HIGH);
   digitalWrite(Buzzer, HIGH);
 } else {
   digitalWrite(LED, LOW);
   digitalWrite(Buzzer, LOW);
 }
}
```

Figure 4.6.1a: Arduino code of an automated fire suppression mechanism controlled using an Arduino.

Explanation of the code

Code Explanation

Firstly, the sensor, buzzer and LED pins are defined.

```
#define Sensor 2
#define Buzzer 3
#define LED 4
```

In the setup function, the sensor PIN is set to the input PIN. Also, LED pins and buzzer pins are set as output pins.

```
void setup() {
 Serial.begin(9600);
 pinMode(Sensor, INPUT);
 pinMode(LED, OUTPUT);
 pinMode(Buzzer, OUTPUT);
}
```

In the loop function,

```
void loop() {
// Obtains values from the sensor
 bool value = digitalRead(Sensor);
 Serial.println(value);
// Those values are checked using the IF condition. If the value is 0, the LED and Buzzer activated.
 if (value == 0) {
  digitalWrite(LED, HIGH);
  digitalWrite(Buzzer, HIGH);
//Otherwise, the LED and Buzzer turns off
 } else {
  digitalWrite(LED, LOW);
  digitalWrite(Buzzer, LOW);
}
```

Conclusion

Main electrical connections, conditions, calculations and working principles were elaborately described in this chapter. The chapter started with the detailed conception of the electrical connections used in our system through step by step description. It was explained how the protection circuit that we used suppresses back EMF. Flame sensors along with measurements, calculations and diagrams were also shown with the aid of diagrams, tables and calculations. Finally the chapter was concluded with the control algorithm we used to run our system. The code has been sequentially explained along with a flow chart. All in all, this chapter covers the most importantand fundamental mechanism of our system.

Chapter 5

Field Test and Analysis

Wavelength of fire

Effect of sensor triggering wavelength

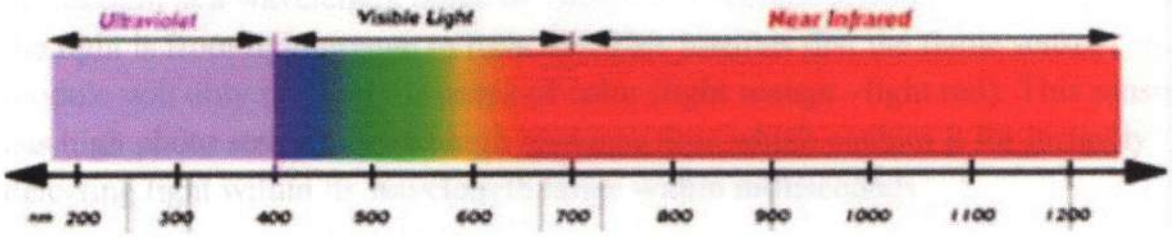

Figure 5.1.1a: The spectral range of an electromagnetic spectrum. [26]

Electromagnetic spectrum is the entire range, scope (spectrum) of frequencies of electromagnetic radiation, their wavelengths and photon energies. The spectrum extends from frequencies that are low and wavelengths that are in nanometer. It starts from ultraviolet radiation and end at infrared radiation with visible light in the middle. Infrared radiation can be further divided into far infrared, mid infrared and near infrared. Figure 5.1.1a shows the near infrared radiation at the spectral range which ranges from around 700nm to 1200nm.

The flame sensor module that we used with the Arduino Uno in our project contains aYG1006 sensor which is a high speed and high sensitive NPN silicon phototransistor in a standard 5mm package. Its black epoxy makes the device sensitive to infrared radiation. This sensor can detect infrared radiation at a wavelength ranging from 760nm to 1100nm.

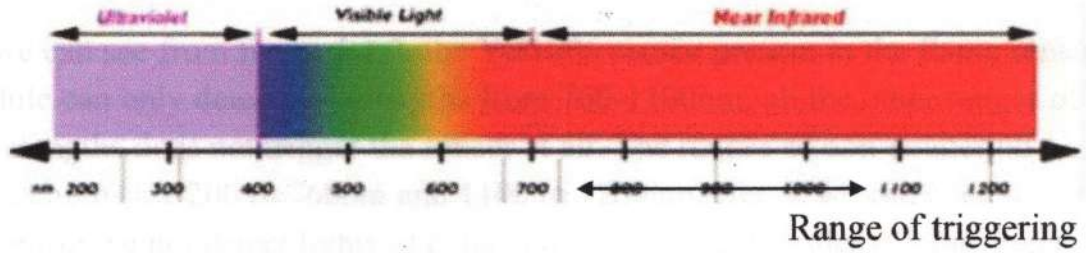

Figure 5.1.1b: The spectral range in the infrared radiation at which the flame sensor triggers. [26]

As we can see in figure 5.1.1b the YG1006 sensor in the flame sensor module can detect light at a wavelength range of 760nm to 1100nm. The range of the color of the light is from light orange to light red. This justifies that the flame sensor module will only respond to flames of color (light orange –light red). This sensor has high photo sensitivity and high response time which enables it for instantly detecting light within its wavelength range within milliseconds.

Effect of non-sensor triggering wavelengths

In topic 5.1.1 we have seen the wavelength range in the electromagnetic spectrum within which the flame sensor module we used in our project can detect radiation. In this chapter we will come across the range of wavelength in which the flame sensor does not trigger.

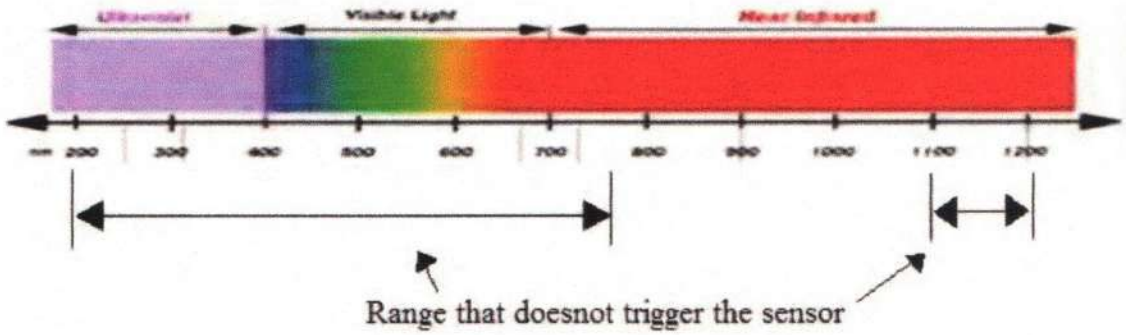

Figure 5.1.2: The ranges in which the flame sensor does not trigger or cannot detect any infrared. [26]

As we can see from figure 5.1.2, the YG1006 sensor present in the flame sensor module can only detect wavelengths from 760-1100nm, all the other ranges of wavelengths does not trigger the sensor at all. The ranges of non-triggering wavelengths are 200 to 760nm and 1100 to 1200nm. Hence we can conclude that the sensor cannot detect lights of colors purple, different shades of blue, green, and few shades of yellow and orange. All in all, the flame sensor cannot response to any of the ultraviolet and visible light spectrum.

Chapter 6

Conclusion and Future Work

Summary

Our project named as "An automated fire suppression mechanism controlled using an Arduino" mainly focuses on the idea of developing a system of extinguishing fire, which can be effective and efficient while being cheap and reasonable at the same time. Our system is effective in the sense that it can detect fire at a wide range of distance and efficient in the sense that it can extinguish fire within a short period of time. The components that we used for our project are readily found at the market and are quite reasonable in price. Unlike other projects on automated fire suppression mechanisms, our project focuses greatly on decreasing the delay which occurs between the ignition of fire and the extinguishing process. Through proper coding in the Arduino

If we look at our system at a glance, we can summarize the whole project into these simple steps:

- First the flame sensor detects the fire at its certain wavelength range of 760nm-1100nm.
- The flame sensors send the signal to the Arduino Uno through the comparator circuit.
- The Arduino Uno has been set up with required codes previously which come in terms.
- The LED lights up and the buzzer goes ON simultaneously.

- The fire will be extinguished in minimum time!

Conclusion and future work

The project that we developed was intended for many future applications in our country. The main target customers are the Factories especially Garments factories, Banks and Slum areas. These areas will be hugely benefitted if they implement our system into their premises.

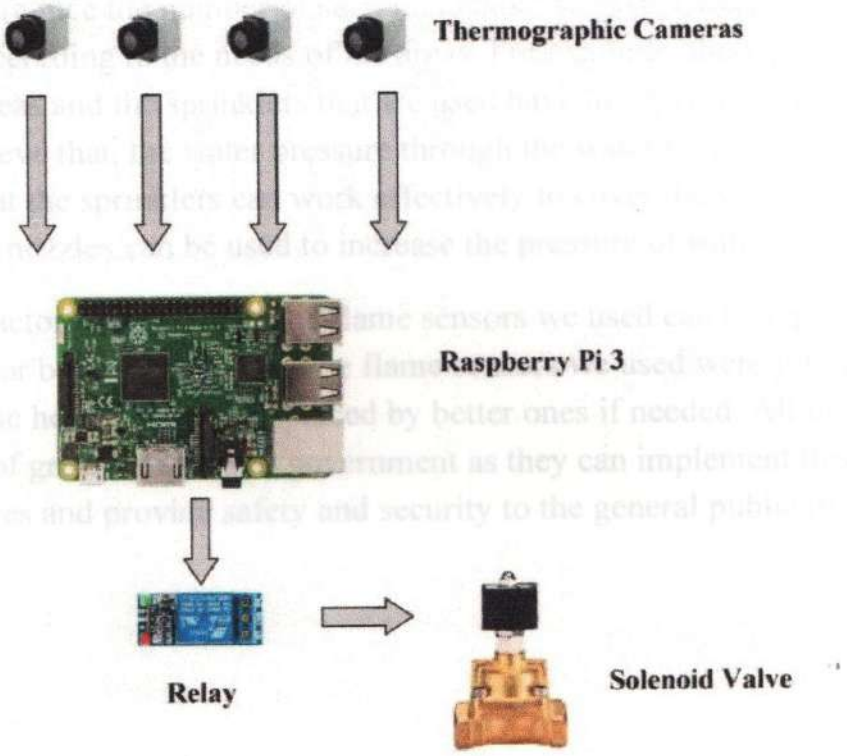

Figure 6.2: System replaced with Thermo-graphic cameras and Raspberry Pi 3.

The major improvement that can be made on this system is the end detector. Instead of using just flame detectors we can use Thermo-graphic cameras. The controlling unit can be replaced with a Raspberry Pi 3 which is more than 40 times

faster than an Arduino. The cameras can detect fire and its intensity. If the fire detected is large enough only then the solenoid valve will be turned ON. This will prevent any unwanted infrared from triggering the system such as cigarette amber. Raspberry Pi will be a better option in case of complex tasks such as image processing.

The slum areas are also vulnerable to such fire incidents at all times. The recent fire that occurred at the Korail slum located at Mohakhali, Dhaka ravaged and destroyed round 500 homes which left hundreds of people homeless. We believe our system can reduce the number of such incidents to a great extent if implemented according to the needs of the areas. For example, the slum areas are usually open areas and the sprinklers that we used have to cover a large distance. In order to achieve that, the water pressure through the water pipes can be increased so that the sprinklers can work effectively to cover the whole ignited area. Also, thin nozzles can be used to increase the pressure of water.

In case of the factories and banks, the flame sensors we used can be replaced by heat detectors for better sensitivity. The flame sensors we used were for our protocol purpose hence it can be replaced by better ones if needed. All in all, our system can be of great value to the government as they can implement this in their designated places and provide safety and security to the general public of our country.

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