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TCS3200 BASED COST EFFECTIVE FIRE DETECTION MODULE FOR AUTONOMOUS SECURITY SYSTEM

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Abstract: -

Traditional Fire Detectors respond mostly to Smoke and Heat. The smoke sensors function by detecting the presence of smoke particles either in a photoelectric chamber or in an ionization chamber. These sensors being placed on the ceiling Fire is seldom detected in the incipient stage.

Loss due to fire damage not only accounts for equipment and property destruction, but also loss of data, interruption of service, cleanup and recovery cost. On an average about $250,000 per incident.

The key to control these damages are not only to detect fire as early as possible but also identify exactly the origin of incident. All over the world the latest technologies are being tested upon and implemented to detect the fire at early stage. However these require expensive proprietary solutions and may not be easily deployable in existing infrastructure.

Technologies do exist today to detect fire at an early stage but are expensive in nature and requires pre-engineered planed deployment.

This paper demonstrates means to detect the fire instantly and extinguished at initial stage. An autonomous robot equipped with advanced fire detection technology detect fire at initial stage, extinguished by small conceived extinguisher, sound hooter and also send message to pre assigned number through GSM modem. A novel approach using color sensor TCS3200 and simple LDR (Light Dependent Register) makes the system highly cost effective. It is effectively a fire surveillance system that continuously read sensor values and received data are processed by various complex algorithms to ensure fire detection with highly reduced false alarm and immediate action. It also covers a large area and thus the system costs are minimized. It is highly useful for domestics as well as industrial environment. The total system cost is less than $200.

It is important to note that electrical supplies must be cut down in case of a fire incident and thus also takes the fire detection system offline. This system being self-sufficient and battery powered can still function.

***Index terms*:** *fire extinguisher, autonomous fire extinguisher, fire detector, color sensor, Pic micro controller*

1. Introduction

Fire is the rapid oxidation of a material in the exothermic chemical process of combustion, releasing heat, light, and various reaction products. The flame is the visible portion of the fire. If hot enough, the gases may become ionized to produce plasma. Depending on the substances alight, and any impurities outside, the color of the flame and the fire's intensity will be different [1].

As we know that fire has both a positive and a negative side. By controlled use make life easier. Uncontrolled use creates destruction.
Fire has been used by humans for cooking, generating heat, light, signaling, and propulsion purposes. The negative effects of fire include water contamination, soil erosion, atmospheric pollution and hazard to life and property [1].

Fire involving a conflagration which occurs in an industrial setting causes disaster and often, but not always, occurs together with explosions. These type of industrial fire are most likely to occur in facilities where there is a lot of flammable substance present. Such material can include petroleum, petroleum products such as petrochemicals, or

natural gas. Facilities with such combustible material include oil refineries, tank farms (oil depots), natural gas processing plants, and chemical plants, particularly petrochemical plants [2].

There are a lot of products within a home which are highly flammable. According to the National Fire Protection Association 40 percent of all house fires are caused by cooking related incidents. For instance, an oven or stove left unattended. Fires due to electrical problems are another very common cause of house fires. One of the leading culprits is the over-use of extension cords. Except the above cause Candle, Fireplace, Dryer creates fire. [3]

A fire extinguisher is an active fire protection device used to extinguish or control small fires, often in emergency situations. There are two main types of fire extinguishers: stored pressure and cartridge-operated. In stored pressure units, the expellant is stored in the same chamber as the firefighting agent itself. Depending on the agent used, different propellants are used. With dry chemical extinguishers, nitrogen is typically used; water and foam extinguishers typically use air. Stored pressure fire extinguishers are the most common type. [4]

Prevention is better than cure. It will be much better to extinguish the fire at initial stage. So a fire surveillance system to monitor the occurrence of fire is needed. There are many technologies focused on Fire detection system.

1.1 Related Work

In the field of fire incident management solution latest technologies are always being researched upon and introduced.

Anand Mohan Misra from Integral University has built a robot, which will sense the flame by the help of fire sensor. It will be having a wireless camera on its head that will show the exact location of the fire to a computer via wireless transmission. Since the whole functioning will be handled manually from the distance, this will reduce human life risk and will increase efficiency. The system however bears some drawbacks [5]. In this system there is lack of independency. Manual intervention is necessary otherwise system is not effective since no action will be taken. Also use of a camera and the necessary hardware software for image processing is not cost effective.

V. Vimala Bharathi and M. V. D. Prasad from K.L.University has design a fire detection system using four flame sensors in the Fire Sensing and Extinguishing Robot, and program for fire detection and extinguishing procedure using sensor based method. The firefighting robot is equipped with four thermistors / flame sensors that continuously monitor the temperature. If the temperature increases beyond the predetermined threshold value, buzzer sounds to intimate the occurrence of fire accident A warning message will be sent to the respective personnel in the industry and to nearby fire station with the GSM module provided to it. Fire Sensing and Extinguishing Robot continuously monitors the temperature at four sensors and if fire accident is true, the robot moves to the

S0	S1	OUTPUT FREQUENCY SCALING (f_o)
L	L	Power down
L	H	2%
H	L	20%
H	H	100%

direction to which the temperature is recorded to be the relatively maximum among the four sensors and extinguishes the fire with water pump provided to it. After extinguishing the fire Robot comes back to its initial position [6]. The fire detection is based on UV sensor, which is prone to error. Many flames (depending on the material that cause fire) create UV too little at initial stage. By the time the UV radiation from fire is detected, it may be too late as the fire grows out of control.

2. Proposed Methodology

After various system studies and their drawback we propose here a novel approach to detect and extinguish the fire. The system reads the surrounded optical signal in continuous mode. If any signal change i.e. if previous R, G, B color value does not match with current data, system halt and start LDR scanning, focusing to the target angle. The system zooms to the particular area and read R, G, B value. Analyzing the received data, the system automatically triggers the extinguisher and informs concerned authorities, achieving fully autonomous operation.

2.1 Block Diagram

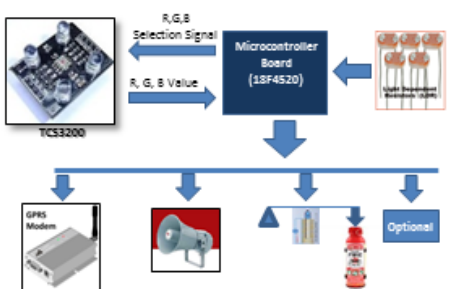
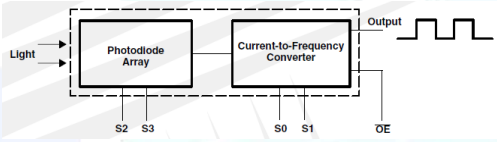


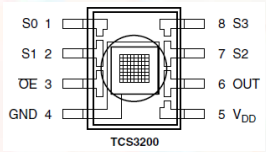
Fig.2
Functional Block Diagram

2.2 Description: Color Sensor (TCS3200)

The TCS3200 is programmable color sensor which converts from light-to-frequency. It is configurable silicon photodiodes and built-in current-to-frequency converter on a single monolithic CMOS integrated circuit. The output is a square wave (50% duty cycle) with frequency directly proportional to light intensity (irradiance).



The full-scale output frequency can be scaled by one of three preset values via two control input pins. Digital inputs and digital output allow direct interface to a microcontroller or other logic circuitry. Output enable (OE) places the output in the high-impedance state for multiple-unit sharing of a microcontroller input line.



In the TCS3200, the light-to-frequency converter reads an 8 x 8 array of photodiodes. Sixteen photodiodes have blue filters, 16 photodiodes have green filters, 16 photodiodes have red filters, and 16 photodiodes are clear with no filters.

The four types (colors) of photodiodes are inter digitized to minimize the effect of non-uniformity of incident irradiance. All photodiodes of the same color are connected in parallel. Pins S2 and S3 are used to select which group of photodiodes (red, green, blue, clear) are active. Photodiodes are 110 µm x 110 µm in size and are on 134-µm centers. [10]

S2	S3	PHOTODIODE TYPE
L	L	Red
L	H	Blue
H	L	Clear (no filter)
H	H	Green

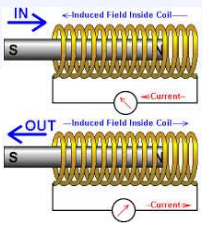
2.3 Controller (PIC18F4520)

A microcontroller (sometimes abbreviated µC, uC or MCU) is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals. Program memory in the form of NOR flash or OTP ROM is also often included on chip, as well as a typically small amount of RAM. Microcontrollers are designed for embedded applications, in contrast to the microprocessors used in personal computers or other general purpose applications.

Microcontrollers are used in automatically controlled products and devices, such as automobile engine control systems, implantable medical devices, remote controls, office machines, appliances, power tools, toys and other embedded systems. By reducing the size and cost compared to a design that uses a separate microprocessor, memory, and input/output devices, microcontrollers make it economical to digitally control even more devices and processes. Mixed signal microcontrollers are common, integrating analog components needed to control non-digital electronic systems.

Some microcontrollers may use four-bit words and operate at clock rate frequencies as low as 4 kHz, for low power consumption (single-digit milli watts or microwatts). They will generally have the ability to retain functionality while waiting for an event such as a button press or other interrupt; power consumption while sleeping (CPU clock and most peripherals off) may be just nano watts, making many of them well suited for long lasting battery applications. Other microcontrollers may serve performance-critical roles, where they may need to act more like a digital signal processor (DSP), with higher clock speeds and power consumption.

2.4 Trigger (Solenoid and lever)



A solenoid is a coil wound into a tightly packed helix. The term was invented by French physicist André-Marie Ampère to designate a helical coil. In physics, the term refers specifically to a long, thin loop of wire, often wrapped around a metallic core, which produces a uniform magnetic field in a volume of space when an electric current is passed through it. A solenoid is a type of electromagnet when the purpose

is to generate a controlled magnetic field which is an integrated device containing an electromechanical solenoid which actuates either a pneumatic or hydraulic valve, or a solenoid switch, which is a specific type of relay that internally uses an electromechanical solenoid to operate an electrical switch; for example, an automobile starter solenoid, or a linear solenoid, which is an electromechanical solenoid. [7]

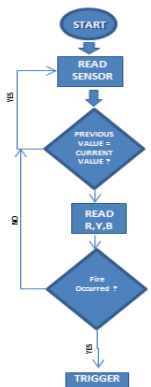
2.5 Fire Extinguisher

Today there are numerous types of Automatic Fire Suppression Systems. Systems are as diverse as the many applications. In general, however, Automatic Fire Suppression Systems fall into two categories: engineered and pre-engineered systems.

Engineered Fire Suppression Systems are design specific. Engineered systems are usually for larger installations where the system is designed for the particular application. Examples include marine and land vehicle applications, computer clean rooms, public and private buildings, industrial paint lines, dip tanks and electrical switch rooms. Engineered systems use a number of gaseous or solid agents. Many are specifically formulated. Some, such as 3M Novec 1230 Fire Protection Fluid, are stored as a liquid and discharged as a gas.

Pre-Engineered Fire Suppression Systems use pre-designed elements to eliminate the need for engineering work beyond the original product design. Typical industrial solutions use a simple wet or dry chemical agent, such as potassium carbonate or monoammonium phosphate (MAP), to protect spaces such as paint rooms and booths, storage areas and commercial kitchens. In Europe, a small number of residential designs have also emerged. These units often employ water mist with or without a surfactant additive, and target retrofit applications where the risk of fire or fire injury is high but where a conventional fire sprinkler system would be unacceptably expensive. [8]

3. Flowchart



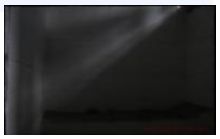
4. Functional Description

The complete system is fitted near about 10 to 20 feet above the ground surface so that the system is able to scan the whole area. Line of sight visibility is preferable. There is no hard and fast rule but the system must be able to scan the target area of the whole surrounded surface. The system is best used best in probability of fire area.

The system is run from electric supply as well as built-in battery backed up power. Since fire damages the electrical supply infrastructure and poses risks of further damage, electrical supplies are cut immediately when fire is detected. The battery can run almost 4-5 hours.

At first we complete installation. Next we have to power the system. On the front of the system there is a power switch. A led will glow and buzzer will sound if the power is ok. Then system will check all attached system automatically. Not only check the system at first time, on the pre specified interval the system will check the whole system repeatedly. In normal mode, the system will read surrounded sensor. If any abnormalities on sensor data, the system read more times to confirm. It eliminates the misfire of alarm, annunciation and trigger the gas chamber. After determination of fire occurred, the system hooter sound loudly, send message through GPRS modem. And lastly trigger the fire extinguisher. This process continues until manual reset pressed. Details faults are logged into remote server, because fire may damage the system itself.

5. Experimental Results

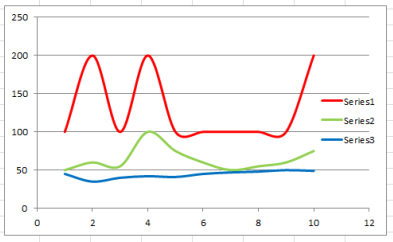


We have tested our sensor (TCS3200) on different light intensity and collect the Red, Green and Blue value. The value is fed to excel sheet and draw the sample versus R, G, and B value.

Dark Room

Sample	R value (HZ)	G value (HZ)	B value (HZ)
1	100	50	45
2	200	60	35
3	100	55	40
4	200	100	42
5	100	75	41
6	100	60	45
7	100	50	47
8	100	55	48
9	100	60	50
10	200	75	49

R, G, B value in Dark Room



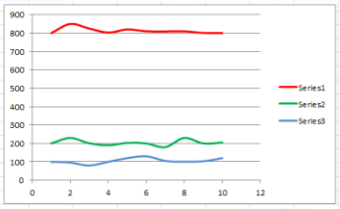
The above curve depicts the fluctuate data of tri-sensor data. The R value from 100 Hz to 200 Hz. This channel requires offset data to compare with base value. The Green sensor occasionally getting more differentiates value from its general tendency value range between 50 Hz to 75 Hz. It requires fine tuning. It is probable error of electrical hazards.

The Blue sensor data depicts almost steady curve. Actually in dark room or industrial inventory places are invariant light illuminate surrounded area. So it is expected the value of the sensor steady. More steady value means higher sensitivity.

We have also conducted our experiment on fire, which indicates the real situation. We arrange our module in an inventory place where all door was closed in day or night. There was no light in normal situation. We start our scanner i.e. our model project. We were collecting data to the laptop's SQL server. Now we burn the jute into the room on remote place which one hundred feet distance from scanner. We used movable high focal length convex lenses in front of sensor to capture R, G, and B color value on fire.

Sample	R value (HZ)	G value (HZ)	B value (HZ)
1	800	200	100
2	850	230	96
3	825	201	80
4	803	190	100
5	820	203	120
6	810	200	130
7	809	180	105
8	810	230	100
9	801	200	103
10	800	205	120

R, G, B Value focused on fire



The above R, G, B value depicts the on Graph format. The graph shows that red color value is more sensitive on fire. The threshold value can be detected too easy in case of Red data. The tendency of RGB color value fluctuation is low when focused to the object by zooming specific suspected fire area.

7. Future Scope

This project has been motivated by the desire to detect fires and intervention. In the present condition it can extinguish fire only in the way and not in all the rooms. It can be extended to a real fire extinguisher by replacing the fan by a carbon-di-oxide carrier and by making it to extinguish fires of all the room using microprogramming. This provides us the opportunity to pass on to robots tasks that traditionally humans had to do but was inherently life threatening.

Fire-fighting is an obvious candidate for such automation. Given the number of lives lost regularly in firefighting, the system we envision is crying for adoption. Of course, this project has only scratched the surface. As in the design simplifications and the implementation constraints in suggest, our project is very much a proof-of-concept. In particular, a practical autonomous fire-fighting system must include a collection of robots, communicating and cooperating in the mission; furthermore, such a system requires facilities for going through obstacles in the presence of fire, and ability to receive instructions on-the fly during an operation. All such concerns were outside the scope of this project. However, there has been research on many of these pieces in different contexts, e.g., coordination among mobile agents, techniques for detecting and avoiding obstacles, on-the-fly communication between humans and mobile agents, etc. It will be both interesting and challenging to put all this together into a practical, autonomous fire-fighting service.

8. Applications

1. The main purpose is to alerts and rescues the people by extinguishing fire in a house or industry.
2. It can be used in record maintaining rooms where fire can cause loss of valuable data.
3. Can be used in Server rooms for immediate action in case of fire.
6. The potential application of the multifunctional firefighting system has been defined as a group that includes the chemical and oil industry, nuclear plants, military storage facilities, as well as mine fields and dangerous substance transport.

9. Conclusions

This paper has presented a unique vision of the concepts which are used in this particular field of fire. It aims to promote technology innovation to achieve a reliable and efficient outcome in the field of fire extinguishing field. Experimental work has been carried out carefully. The result shows that higher efficiency is indeed achieved using the embedded system. With a common digitalized platform,

these latest instruments will enable increased flexibility in control, operation, and expansion; allow for embedded intelligence, essentially foster the resilience of the instruments; and eventually benefit the customers with improved services, reliability and increased convenience. This paper presents such a way to fight with fire. Since this initial work cannot address everything within the proposed framework and vision, more research and development efforts are needed to fully implement the proposed framework through a joint effort.

Acknowledgements

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Dr. Dhritinandan Kole was born in Hooghly district of West Bengal, India on 11th December, 1977. He had carried out B.Tech degree in Instrumentation Engg. from University of Calcutta, Kolkata, India in the year of 2000. After that he had completed his M. Tech degree from the same university in 2002. He is awarded with Ph.D degree in the year of 2012 in the field of Applied Physics (Instrumentation Engineering) from University of Calcutta. He has more than five years of teaching experience in the post of Senior Lecturer in MCKV Institute of Engineering, Howrah, West Bengal, India. He had also engaged with research and development work for more than 7 years in Industrial sector like Simplex Infrastructure Limited, R&D section of IIMC, Kolkata, Pervcom Consulting Pvt Ltd etc. Presently he is working as R&D Executive in Eltron Wireless, Kolkata and also as consultant of Deep Micro System, Hooghly. His research interests include wireless sensor network, control and instrumentation, embedded system etc.

Sudip Chakraborty was born at Chhinamore in Hooghly district, West Bengal, India on 7th January 1977. He received the master degree in Computer science from Sikkim Manipal University in 2013. He is pursuing his Ph.D. in Artificial Intelligent in Robotics, Department of Computer science, Swami Vivekananda University, Sagar, (M.P.), India. His research interests include modeling and virtual simulation, autonomous Test Bench, autonomous security system etc. He is currently working as a Senior Engineer in the R&D Department at P.C. Electronics & system, Kolkata, since 2012, Mr. Chakraborty published / presented a research paper in the International Journals of high repute.

Sougata Das was born in Kolkata, West Bengal, India on the 6th of December 1974. He owns and runs Andig Technologies, an embedded system design house. He is also the technical director of Second Solar Private Limited. Backed by over two decades of experience his interests and expertise include power electronics, industrial automation systems and communication equipment.

References

[1] http://en.wikipedia.org/wiki/Fire
[2] http://en.wikipedia.org/wiki/Industrial_fire
[3]http://commissionerleonard.typepad.com/commissioner_randy_leonar/2011/03/10-most-common-causes-of-house-fires-.html
[4] http://en.wikipedia.org/wiki/Fire_extinguisher
[5] http://ijesat.org/Volumes/2012_Vol_02_Iss_04/IJESAT_2012_02_04_10.pdf

[6] http://www.ijsr.net/archive/v2i4/IJSRON2013738.pdf

[7] http://en.wikipedia.org/wiki/Solenoid
[8] http://en.wikipedia.org/wiki/Automatic_fire_suppression

;
[10]http://www.dfrobot.com/image/data/SEN0101/TCS3200%20TCS3210.pdf