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IOT Based Fire Prevention System

Haque Mohammed Azim Anwarul., Prof. N. D. Mehta

UG Student, Department of EC, LJ Institute of Eng. & Technology, Ahmedabad, Gujarat, India

Assistant Professor, Power Electronics Department, VGEC, Chandkheda, Ahmedabad, Gujarat, India

ABSTRACT: The main objective of this research work is the safeguard for fire-fighter working at high-temperature. Even non-technical person can easily operate this system after training which demand minor maintenance. This IOT based Fire Prevention Machine is acting like fire-fighter which can work at high radiation conditions. Based from existing method of extinguishing the fire; it has been concluded that 360-degree night vision camera which observe the surrounding of the situation, would be more efficient. Instead of using existing way of extinguish the fire, using this device would help in saving in water, protecting human life and economic losses. Safety has become very important constraint for top quality of life. Due to fire hazard it effects human health and create economic losses. To solve these problems, our focus stays on affordable cost of fire prevention machine using PS2 wireless controller. This system can observe whole situation and control the fire standing at safe distance.

KEYWORDS: 360-degree night vision camera, RF transmitter / receiver, motor driver circuit, water-tank, Nozzle, Gripper.

I. INTRODUCTION

Safety of human is very much essential in all industrial as well as residential areas. An injury is usually accompanied by a loss of self-confidence. Designing a system with no harm to human being is our goal for this project. Statistics shows that in India over 10, 00,000 people are moderately or severely burnt every year. This report introduces a fire prevention machine without human presence to prevent human death and to control on fire. Our prime focus will remain on affordable cost of fire prevention machine for fire-fighters & carry out injured peoples. Fire-fighters can get benefit out of it at different level like they don't required direct contact with fire, with the use of this machine they are able to carry out injured people from horrible situation and they can observe as well as operate at the critical situation during fire with the use of remote control. Also, fire-fighter able to drag out precious things from the place of fire. Fire-fighters can operate this system up to the distance of 50 meter. System coated with fire-proof materials like LI-900 (Silica Tiles) / Chromium Carbide, strengthen the capability to enter in fire-flame and douse the flame with the vicinity of inflammable source up to temperature limit of 1204°C / 1895°C.

This system incorporates movement control of machine without human presence. We present an RF based technique which control robotic vehicle. The system divides into four main components: 360-degree night vision camera, RF transmitter / receiver, Nozzle and Gripper. This technology is extensively used in many fields like motion control. Heart of system is Arduino. 360-degree camera is mounted on top of the robotic vehicle which observe surrounding situation. RF remote control the movement of robotic vehicle. Gripper drags the precious things in hazard. Nozzle moves up-down and extinguish the fire. The main objective of our project is to bring happiness to the stakeholders who will not have to depend on others any more. The project is fully automated and is easy to use having less maintenance. As the fire prevention machine motion is controllable, it will be like a part of body of fire-fighter who can extinguish fire at a safe distance from hazards places and they can also be able to observe and operate at the critical situation [1].

II. BACKGROUND OF THE INVENTION

Generally, fire-fighters of fire brigade reach at the destination place and try to extinguish the fire with the use of water packed pipe. Sometimes there may be situation arises in which they have to get incidental contact with fire to save the people and this may lead to harm to their skin and there may be possibility of death at the site of fire. Sometimes it become very much difficult for fire-fighters to drag out the precious things and this may lead to loss of those things. At a critical situation it is difficult for fire-fighters to observe the location site. Due to working at some distance from fire place they cannot extinguish whole fire and it is difficult for them to work at corner sites. At a very high temperature, the traditional fire-proof clothes unable to protect the fire-fighters. The traditional fire-fighters Fig.1 work up to certain boundaries.

In recent times, there has been various control systems developed which is specialized for fire prevention. The developed systems are highly competitive in replacing the old traditional systems. There are many assistive systems based on temperature sensor. These applications of such assistive systems are quite popular in society which can be used for limited distance as well as limited temperature range as shown in Fig.1. There are certain drawbacks in these

systems as it cannot be used at extremely high temperature. Even it is not possible with conventional system to observe the location site [2].

A. Objectives:

The development of this project idea is for the betterment of the fire prevention machine throughout the society. It could be said that this study will contain the solution for such problems present in the traditional fire prevention machine. The objectives of this study will be the solution for the elaborated problems or complications found on the traditional fire prevention machine.

- To develop a fire prevention machine that will reduce the harmful effect to fire-fighters and save him / her from the burning.
- To prevent the spread of fire both internally and externally safe exit of all equipment and people at the place of incident of fire.

B. Significances of the Study:

Its aims to develop an innovation on traditional fire prevention system. The wireless control of machine will be used as the primary direction controller of the machine. The monitor screen assists this project in order to help the fire-fighter to control the movement of robot, piping control, gripper control. The findings of this study will benefit the following.

The fire-fighters working at extremely high temperature location:

It is difficult for fire-fighters to work inside high temperature location, this may leads to burning sensation, harm to their body and sometimes death may occur. This new system resist this entire situation.

The people inside fire location:

This is a project intended to help the disable people and coward people during critical situation and protect them from burning sensation and harm to body.

C. Limitations:

- This Prototype of Fire Prevention Machine could not be used as means of transportation for long distance.
- It is not advisable to use Fire-Fighter at a very high temperature or at a nuclear blasts or chemical blast.
- If camera fails to operate then the user can not identify the surrounding situation.

III. LITERATURE REVIEW

Assistive devices are devices that help fire-fighter to extinguish the fire. Due to the difficulties that fire-fighters experience on their everyday lives especially when working at high temperature are: fire-fighters, rescue equipment, apparatus and people.

A. Antiquity of Fire Fighting Devices:

People have been using fire extinguishers for many hundreds of years but they generally use it in commercial premises. A fire extinguisher is an active fire protection device used to control small fires, often in emergency situations. It is not intended for use on and out of control fire, such as one which has reached ceilings, endangers the users or otherwise requires fire brigade. Typically, fire extinguishers consist of a hand-held cylindrical pressure vessel containing agent which can be discharge to extinguish fire. Fire-extinguisher is manufactured with non -cylindrical pressure vessel also exist but are less common [2], [7], [8], [9].



Fig. 1. Mechanical dosing system used for fire fighting

There are two main types of fire-extinguishers stored-pressured and cartridge-operated. In stored pressure units, the expellant is stored in the same chamber as the fire fighting agent itself. Depending on agent used, different propellants are used. Nitrogen is normally used with dry chemical extinguishers and air is used in water & foam type extinguisher.

Stored pressured fire extinguisher is the most common type. Cartridge - operated extinguishers contain expellant gas in separate cartridge that is punctured prior to discharge, exposing the propellants to the extinguisher’s agent. This type is not as common, used primarily in areas such as industrial facilities, where they have advantage of simple and prompt recharge, allowing an operator to discharge the extinguisher to discharge it and return to the fire in reasonable amount of time.

Fire extinguisher is further divided into handheld and cart-mounted (also called wheel extinguisher). Handheld extinguishers weigh up to 0.5 to 14 kilograms and are hence easily portable by hand. Cart mounted unit typical weigh more than 23 kilograms. These wheeled models are mostly found at construction sites, airport runway, heliports as well as docks and marinas [2].

B. *Synthesis of the Study:*

Examples of some of the past and present on-going studies / projects are:

- Comparatively study for chaotic behavior in firefighting robot and simulation landmark approach for wall following algorithms on firefighting robot using v-rap presented by directory of open access journal.
- Method and means of sodium firefighting presented by international nuclear information system. Method and means for coaling sodium firefighting are analyzed.
- Firefighting capability assessment program Darlington NGS presented by the international nuclear information system. This report includes completion work relating to the assessment of the capability of Darlington NGS. Fire fighting in nuclear plants presented by Fantom, L. F; Weldon, G. E. In 1978. Since the brown incident, the spectra of fires at nuclear plants has been the focus of attention by NRC.
- Fighting forest fire in Brazil, report presented by science. Gov of United States in 2013. Fire has been used in Brazil in many years, but the increase use of this tool, combine with natural event and presence of large forest and agriculture areas, has led to significant jump in the number of forest fire and most of them caused by accident.

IV. CONCEPTUAL FRAMEWORK

As shown in Fig. 2, the conceptual framework’s illustration shows that there are three different phases such as the input, process and output. Theinputphase,asshownonthefigure,containsthe different requirements needed to start the project prototype. These requirements are basically divided into two which is the hardware or materials requirements and the knowledge requirements. The hardware or materials requirements are the physical components that are needed in order to build the project prototype namely Arduino, camera, gripper, nozzle and DC motor. The knowledge requirements ontheotherhandpertain to the knowledgethatonemusthave inordertostartbuildingtheprototype. This knowledge could be used as a guide to accomplish the project in a faster, easier, and safer way.



Fig 2. Conceptual framework

The process phase relates to the activities done during the development of the prototype project. This phase is sub-divided in four different sub-phases namely the planning, design, development and testing and finalization phase. The planning phase involves the determining of the researchers’ intention of creating such project. The design phase includes the gathering of project materials, determining of the costs involved, development of the circuitry diagram, and the development of the structure or physical appearance of the project. During the development and testing phase,

the prototype project’s assembly commences, the components are being interfaced and the logical structure or source codes are being developed.

V. COMPONENT DESCRIPTION

1. *Arduino Nano:*

Arduino Nano [5] is a surface mount breadboard embedded version with integrated USB, smallest, complete, and breadboard friendly. It has everything that Diecimila / Duemilanove (electrically) with more analog input pins and on-board +5V AREF jumper. Physically, it is missing power jack. The Nano is automatically sense and switch to the higher potential source of power, there is no need for the power select jumper Fig.3.

Nano’s got the breadboard-ability of the Arduino and the Mini+USB with smaller footprint than either, so users have more breadboard space. It’s got a pin layout that works well with the Mini or the Basic Stamp (TX, RX, ATN, and GND on one top, power and ground on the other). This new version 3.0 comes with ATMEGA328 which offer more programming and data memory space. It is two layers, that make it easier to hack and more affordable.

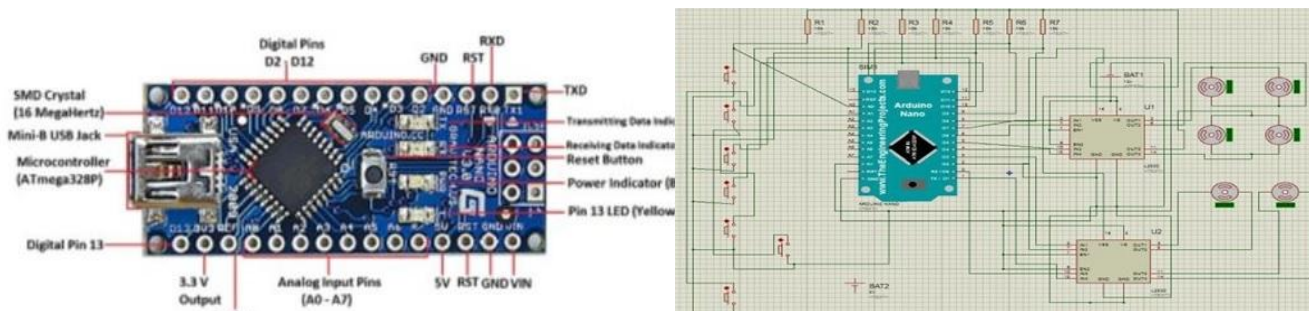


Fig. 3. Arduino Nano

Input/output:

There are totally 14 digital Pins and 8 Analog pins on Nano board. The digital pins can be used to interface sensors by using them as input pins or drive loads by using them as output pins. A simple function like pinMode () and digitalWrite () can be used to control their operation. The operating voltage is 0V and 5V for digital pins. Analog pins can measure analog voltage from 0V to 5V using any of the 8 analog pins using a simple function like analog.

These pins apart from serving their purpose can also be used for special purposes which are discussed below:

Specification:

Microcontroller	Atmel ATmega328
Operating Voltage (logic level)	5 V
Input Voltage (recommended)	7-12 V
Input Voltage (limits)	6-20 V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	8
DC Current per I/O Pin	40 mA
Flash Memory	32 KB (of which 2KB used by bootloader)
SRAM	2 KB
EEPROM	1 KB
Clock Speed	16 MHz
Dimensions	0.70" x 1.70"

Pin Configuration:

Serial Pins 0 (Rx) and 1 (Tx):	Rx and Tx pins are used to receive and transmit TTL serial data. They are connected with the corresponding ATmega328P USB to TTL serial chip.
External Interrupt Pins 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 Pins 3, 5, 6, 9 and 11:	These pins provide an 8-bit PWM output by using analog Write () function.
SPI Pins 10 (SS), 11 (MOSI), 12 (MISO) and 13 (SCK):	These pins are used for SPI communication
In-built LED Pin 13:	This pin is connected with a built-in LED, when pin 13 is HIGH – LED is on and when 13 pin is LOW, it’s off.
I2C A4 (SDA) and A5 (SCA):	Used for IIC communication using Wire library.
AREF:	Used to provide reference voltage for analog inputs with analog Reference () function.
Reset Pin:	Making this pin LOW, resets the microcontroller

Features:

- Automatic reset during program download
- Power OK blue LED
- Green (TX), red (RX) and orange (L) LED
- Auto sensing/switching power input
- Small mini-B USB for programming and serial monitor
- ICSP header for direct program download

2. *RF Transmitter / Receiver:*

The PS2 wireless controller is a standard controller for the PlayStation 2 and is identical to the original controller for the PlayStation console Fig. 4. It features twelve analog (pressure-sensitive) buttons (X, O, II, Δ, L1, R1, L2, R2, Up, Down, Left and Right), five digital button (L3, R3 Start, Select and the analog mode button) and two analog sticks. The controller also features two vibration motors, the left one being larger and more powerful than the one on the right. It is powered by two AAA batteries. It communicates with the console using 2.4 GHz RF protocol. In Sony ps2 remote have a one transmitter and one receiver.



Fig. 4. PS-2 Transmitter Receiver

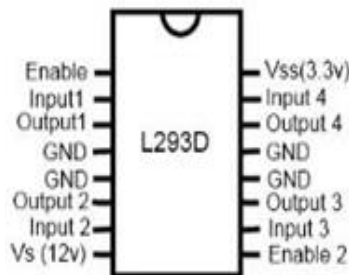


Fig. 5. L293d Pin Diagram



Fig. 6. DC Motor

PS2 Receiver Pin Out:

1. DATA: This is the data line from Controller to PS2. This is an open collector output and requires a pull-up resistor (1 to 10k, maybe more). (A pull-up resistor is needed because the controller can only connect this line to ground; it can't actually put voltage on the line).
2. COMMAND: This is the data line from PS2 to Controller.
3. VIBRATION MOTOR POWER
4. GND: Ground
5. VCC: VCC can vary from 5V down to 3V.
6. ATT: ATT is used to get the attention of the controller. This line must be pulled low before each group of bytes is sent / received, and then set high again afterwards. This pin considers as "Chip Select" or "Slave Select" line that is used to address different controllers on the same bus.
7. CLK: 500kHz, normally high on. The communication appears to be SPI bus.
8. Not Connected
9. ACK: Acknowledge signal from Controller to PS2. This normally high line drops low about 12us after each byte for half a clock cycle, but not after the last bit in a set. It requires a pull-up resistor (1 to 10k, maybe more).

PS2 Signals:

PS2 wireless controller communicates with Arduino using a protocol that is basically SPI. The play station sends a byte at the same time as it receives one (full duplex) via serial communication. There is a clock (SCK) to synchronize bits of data across two channels: DATA and CMD. Additionally, there's a "Attention" (ATT) channel which tells the slave whether or not it is "active" and should listen to data bits coming across the CMD channel, or send data bits across the DATA channel (Reasonably, only one slave device should be active at a time). The PlayStation 2 actually uses this plus an additional line that is not specifically part of the SPI protocol – an "Acknowledge" (ACK) line.

The clock is held high until a byte is to be sent. It then drops low (active low) to start 8 cycles during which data simultaneously sent and received. The logic level on the data lines is changed by the transmitting device on the falling edge of clock. This is then read by the receiving device on the rising edge allowing time for the signal to settle. After each Command is received from the controller, that controller needs to pull ACK low for at least one clock cycle. If a selected controller does not ACK the PS2 will assume that there is no controller present. LSB (least significant bits) are

transmitting first.

Connection Details:

The PS2 receiver CLK line and ATT lines are held normally high. The ATT operates like the Slave Select line under SPI. You pull it low to tell the controller you are talking to it and then send it back high once communications cycle is complete. CMD is the data line to the controller and DATA is the data coming from the controller. Here in our application we are not using the acknowledge pin.

3. Motor Driver (L293d):

L293D [6] is a typical Motor driver or Motor Driver IC Fig. 5 which allows DC motor to drive on either direction. L293D is 16-pin IC which can control a set of two DC motors simultaneously in any direction. It means that you can control two DC motor with a single L293D IC Dual H-bridge *Motor Driver integrated circuit*. The L293d can drive small and quiet big motors as well.

H-bridge is a circuit which allows the voltage to be flown in either direction. As we know voltage need to change its direction for being able to rotate the motor in clockwise or anticlockwise direction, hence H-bridge IC are ideal for driving a DC motor. In a single L293D chip there are two h-Bridge circuit inside the IC which can rotate two dc motor independently. Due to its size it is very much used in robotic application for controlling DC motors. Fig.5 is the pin diagram of a L293D motor controller. There are two Enable pins on L293d. Pin 1 and pin 9, for being able to drive the motor, the pin 1 and 9 need to be high. For driving the motor with left H-bridge we need to enable pin 1 to high. And for right H-Bridge we need to make the pin 9 to high. If anyone of the either pin1 or pin9 goes low then the motor in the corresponding section will suspend working.

Working of L293D:

There are 4 input pins for L293d, pin 2, 7 on the left and pin 15, 10 on the right as shown on the pin diagram Fig.5. Left input pins will regulate the rotation of motor connected across left side and right input for motor on the right-hand side. The motors are rotated on the basis of the inputs provided across the input pins as LOGIC 0 or LOGIC 1. In simple we need to provide Logic 0 or 1 across the input pins for rotating the motor.

L293D Logic Table:

Let's consider a Motor connected on left side output pins (pin 3, 6). For rotating the motor in clockwise direction, the input pins have to be provided with Logic 1 and Logic 0.

- **Pin 2 = Logic 1 and Pin 7 = Logic 0** Clockwise Direction
- **Pin 2 = Logic 0 and Pin 7 = Logic 1** Anticlockwise Direction
- **Pin 2 = Logic 0 and Pin 7 = Logic 0** Idle [No rotation] [Hi-Impedance state]
- **Pin 2 = Logic 1 and Pin 7 = Logic 1** Idle [No rotation]

In a very similar way the motor can also operate across input pin 15, 10 for motor on the right hand side.

Voltage Specification:

VCC is the voltage that it needs for its own internal operation 5v; L293D will not use this voltage for driving the motor. For driving the motors, it has a separate provision to provide motor supply VSS (V supply). L293d will use this to drive the motor. It means if we want to operate a motor at 9V then we need to provide a Supply of 9V across VSS Motor supply.

The maximum voltage for VSS motor supply is 36V. It can supply a max current of 600mA per channel. Since it can drive motors Up to 36V hence we can drive pretty big motors with this L293d. VCC pin 16 is the voltage for its own internal Operation. The maximum voltage ranges from 5V and up to 36V.

4. DC Motor:

A DC motor is a motor within a class of electrical machines whereby direct current electrical power is converted into mechanical power. Most often, this type of motor relies on forces that magnetic fields produce. Regardless of the type, DC motors have some kind of internal mechanism, which is electronic or electromechanical Fig.6. In both cases, the direction of current flow in part of the motor is changed periodically.

The speed of a DC motor is controlled using a variable supply voltage or by changing the strength of the current within its field windings. While smaller DC motors are commonly used in the making of appliances, tools, toys and automobile mechanism, such as electric car seats, larger DC motors are used in hoists, elevators, and electric vehicles. A 12V DC motor is small and inexpensive, yet powerful enough to be used for many applications. Because choosing the right DC motor for a specific application can be challenging, it is important to work with the right company. A prime example is MET Motors, which has been creating high-quality permanent magnet DC motor for

more than 45 years.

5. *DC Water Pump:*

Water pumps move water that does not contain suspended solids or particulates Fig.7. These pumps are not so much a type of pump as they are a classification based on the media being transferred. Nearly every pump type that is defined by either a complementary application (fountain water pumps, submersible water pumps) or by motive type (such as centrifugal, cantilever, or hand water pumps) can be used in water service applications.



Fig.7. Water Pump

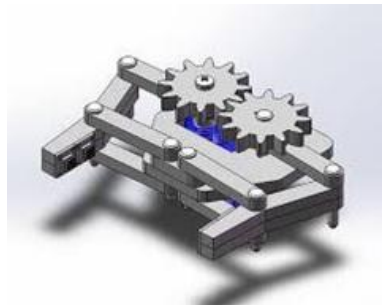


Fig. 8. Internal Structure of Gripper



Fig.9. Gripper

6. *Gripper:*

The gripper is based on a four-bar mechanism which moves the coupler link (grip arm) through an elliptical path grip an object at a perpendicular direction to the object face, as shown in our Solid Works mock-up Fig. 8. This four-bar gripper mechanism has significant advantages above other gripper mechanisms. The gripper is extremely space efficient, as its gripper arms collapse beside the mechanism body. Still, the mechanism has sufficient reach to extend and grab large objects nearly the size of its body.

Additional advantages of the four-bar mechanism being an ideal choice is because the two gripper arms are defined to follow the same path together. As they both form identical four-bar mechanisms and are linked with gears, the mechanical relationship of the two arms produces a symmetric output. This could be extremely useful as it limits the maintenance required to keep the mechanism working overtime.

One limitation of this mechanism is that each gripper must be designed for a single type of object only, as the final grip arm location is defined to be normal to the object it is gripping. While this seems like a downside to the mechanism, we note that the majority of design choices are made to increase long-term reliability Fig.9.

VI. DETAILED DESCRIPTION

Present work is related to a fire prevention machine without human presence for fire-fighters using PS2 wireless controller. During incidence of fire it is not possible for traditional fire-fighters to work at extremely high temperature and high radiation condition. During extinguishing the fire there maybe chances of skin and respiration diseases.



Fig. 10 Receiver Circuits



Fig.11 Working Prototype

This device is built on metal chassis and below the metal chassis there is location of wheels mechanically engaged with DC motor. DC motor controls the movement of wheels. Above the metal chassis there is location of water tank incorporated with water pump and nozzle at the outlet, control circuit box and camera on the top for 360° vision. Water tank is cuboids type structure use for storage of water and nozzle is mounted with coupled motor for movement in all four directions viz. left, right, up and down for the purpose of dousing the fire. Control circuit box consists of Arduino,

voltage regulator, transmitter circuit, receiver circuit and motor drivers. Arduino is the heart of the system used for controlling for whole system. A specific movement of system could initiate five different states of movements; namely forward, reverse, left-turn, right-turn and stop. Voltage regulator is used for controlling the amount of voltage. Transmitter circuit/ Receiver circuit are used for transmitting and receiving signals. Motor driver is used for controlling the DC motor. Camera is mounted on top to the box and it is used for observation of surrounding condition. Front side of device consist of gripper is used for drag out precious things. While system is remotely controlled through the PS2 wireless controller. It is identical to the original controller for the PlayStation console as in Fig. 4. It features twelve analog (pressure-sensitive) buttons (X, O, II, Δ, L1, R1, L2, R2, Up, Down, Left and Right), five digital button (L3, R3 Start, Select and the analog mode button) and two analog sticks. The controller also features two vibration motors, the left one being larger and more powerful than the one on the right. It is powered by two AAA batteries. It communicates with the console using 2.4 GHz RF protocol. Sony ps2 remote have one transmitter and one receiver.

With the use of different material for masking the robotic system, we may use it at different temperature. System coated with fire-proof materials like LI-900 (Silica Tiles) / Chromium Carbide, strengthen the capability to enter in fire-flame and douse the flame with the vicinity of inflammable source up to temperature limit of 1204°C / 1895°C. Few fire resistant material is listed here.

Material	Temperature (In Degree Celsius)
LI-900 (Silica Tiles)	1204
Chromium Carbide	1895
Aluminium Oxide	Above 2050
Tungsten Carbide	2785-2840
Tantalum Carbide	3850-3880
Hafnium Carbide	3900
Titanium Carbide	3160
Tantalum Hafnium Carbide	3942

Fire prevention system is landed to the fire accident point and its movement is controlled by wireless PS2 controller under the camera vision which may be screened on mobile or laptop. Trained fire fighter can handle / operate this system in very comfortable manner.

VII. CONCLUSION AND FUTURE FORK

The study is about a fire prevention machine without human presence with PS2 wireless controller which is intended to help fire fighter who are incapable of extinguish the fire at fire location. Here, we use 360-degree camera that helps in observation of surrounding situation at fire accident spot. Gripper and nozzle helps in drag out the precious things and spray the water at fire site. This system uses low speed but high torque DC motor which helps in movement of fire prevention machine. Practical testing on prototype are executed which includes the accuracy and responsiveness testing of this machine. The main objective of our project is the safeguard for fire-fighter who cannot work at high-temperature. Fire Prevention System is acting like fire-fighter which can work at high radiation conditions. It is concluded that 360-degree camera which observe the surrounding of the situation, would be more efficient in terms of saving water, human protection and reduce economic losses. It is concluded that fire prevention machine has better efficiency, minimal maintenance and reliable.

Future prospect of this design can be enhanced by means of altering its form by changing the wheels and body of the system. Future prospect may also include the unique features like obstacle avoidance tools and emergency navigation tools to this project.

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BIOGRAPHY



Haque Mohammed Azim Anwaul is pursuing his graduation in Electronics & Communication Engineering from LJIT, Ahmedabad, Gujarat, India. He participated in National Children Science Congress competition and reached National Level on the topic of Power Saving Techniques in December-2013. He is member of BlackHawks- LJIT, Ahmedabad and participated in the national level event of BAJA held at Pithampur, Madhya Pradesh – Feb'19. He is member (7190521754) of SAE-INDIA - Society of Automotive Engineers. He has involved in various activities held and college and inter college level. His area of interest is Artificial Intelligence, Arduino Robot & Devices and Internet of Things (IOT).



Nirav D. Mehta received the B.E (Power Electronics) from L.E. College, Morbi in 2000, Saurashtra University, Rajkot and M. Tech in Electrical (Power Apparatus and Systems) from Nirma University of Science and Technology, Ahmedabad in 2008 with Gold Medal for Best Student in Electrical Engineering for the year 2008. He has industry experience for 4-years. He is in academic industry since June, 2004 and presently he is working With Department of Technical Education (GES CL. II), Government of Gujarat as an Assistant Professor in Power Electronics Department of Vishwakarma Government Engineering College, Chandkheda. He is Life Member (LM 48157) of Indian Society for Technical Education and IETE since 2006. He has Published 10 National and 15 International paper in field of his interest. His fields of interest are Power Electronics, Power Electronics application to Power Systems, Power Quality Improvement and Energy Conservation & Management, Power Electronics Converter for Electrical Vehicle.



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