Fire-Figthing Robot With Improved A* Algorithm

Mr. Rajendra M[1], Arjun M[2]
[1]Assistant Professor, Dept of Computer Science & Engineering
[2]Dept of Computer Science & Engineering
[1, 2] Atria Institute of Technology, Bangalore

Abstract- *The aim of this paper is to design a robot which acts as an fire fighter. It detects fire in the disaster prone area. With the help of the IOT we can also control our fire robot manually. We can switch between any the two modes i.e., automatic or manual in either way we want. We are using a camera to know what is happening in the area and NodeMCU to know the status of the robot. Here, the fire detection robot overcomestheproblemofhittingtheobstaclebysensingtheobstacl eandmovingintothedirection where it is obstacle free and also detects the shortest path between the paths to reduce time which improves efficiency of the robot.*

Keywords- Camera, Flame sensor, NodeMCU, Fire Robot, IOT, GPS, SMS.A* algorithmn

I. INTRODUCTION

Fire Fighters are being exposed to various hazardous situations. In most of the situations they may not know the exact scenario of their working place.

As the situation is hazardous monitoring the data near from the operating location is putting life at risk.Without nearing the place, Scavengers and Fire Fighters can know about the hazardous situation by using the proposed system. They can arrange protective equipment, corrective measures accordingly. With the advancement of technology, the people are motivated to use automation system. The automation system makes the task easy and reliable. Different people use the automation system for different purposes according to their comfort. Some of them use it for making their life more comfort like developing automatic door closer, automatic fan speed controller, home automatic system etc, and some of them make the use of automation for making the task easier such as automatic railway crossing gate controller or in metro, the automatic smart card detection system. But the operation of all these systems or devices is not possible without the use of internet of things (IOT).

The designs which are developed is based on GSM and GPRS innovation and Public subservience items for communication. It is a Gas or Fire battle Robot which can be used for either prevent our homes or industries, offices etc from fire or from harmful gases. The new and novel thought behind this research is that our robot will move in the area of suffocated fire or harmful gases in our homes or in buildings of other work area, where a normal person may feel lack of oxygen or need to wear a mask, or when nobody is at home and offices. This robot will find the presence of fire using flame sensor and gas sensor and when the flame or fire is observed by the robot, it will send the message in a form of signal to a server of IOT and battle with detected fire using fire extinguishers or sprinklers. These Gadgets can be used at various places where feasibility of human is very difficult. Wireless network has proclaimed its incoming on vast stage and thus the whole world goes dynamic. It is needed to regulate all the things without disturbing the ecosystem. This construction and design of fire or gas battle robot is remotely controlled by using GSM module embedded in NodeMCU. The employment of "Embedded System in Communication" gave rise to several attention- grabbing applications which assured comfort and safety to our life. The main object of this paper is to construct a SMS based Fire/Gas battle Robot tools that may replace conventional flame battle procedure. The tool detects the flame thereby sending message to landlord of the area, this device is made more efficient by SIM card installed in users phone for sending messages so that user got alert during fire.

II. LITERATURESURVEY

A. Monitoring and Controlling of Fire Fighting Robot

It is designed by using a temperature sensor. Fire fighting is the act of extinguishing fires i.e., it sprinkles water onto the fire. Through this we can conclude that a robot can be used in the place of humans reducing the risk of life of Fire fighters. We can use them in our Factories, Homes, Labs, Offices etc. They provide us very greater efficiency to detect the flame. Hence, this robot can play a crucial role.

B. Fire fighting robot with vision camera and the gas sensors.

WSN (Wireless Sensor Network) based Life Save System was designed.

C. IOT Based Fire Detection Robot.

This paper focus on improving the security of houses and industries against harmful Gas Leakage and fire flame. This device is very robust and help the user to notify about if there is any gas leakage or fire. It alerts the user when a person is not at home or offices directly from the Iot server. The designed robot can be easily controlled by sending the commands to the micro controller from anywhere from the world. These commands can be observed by using Attention commands and acceptable action is taken. The main aim of this paper is to design a semiautonomous electronic IoT based firefighting robot which can replace the traditional human firefighters and prevent them from the danger of firefighter. The robot sends message to controller and will take emergency precautions to eliminate the danger for firefighters. The device is made more efficient by sending the message via SIM card to user so that the user could be automatically alert when he/she is out of home or office.

D . Improved A* algorithm

Thee planning effect of the conventional four-way search A∗ algorithm is shown in Figure 1(a). There are a lot of right angle points in the route, and the length of the route is not the shortest. On this basis, eight-way search A∗ algorithms are proposed; the planning effect is shown in Figure 1(b). It can be seen that the eight-way search A∗ algorithm overcomes the problem of right-angle inflection point in the path and plans the shortest path length under the algorithm. However, the algorithm has the problems of closing to the obstacles and crossing the diagonal vertex of the obstacles (Figure 1(a)); this path cannot be used as the traveling path of the robot obviously. Therefore, the conventional eight way search A∗ algorithm is not suitable for robot path planning and it needs to improve the basic safety distance and the constraint**.**

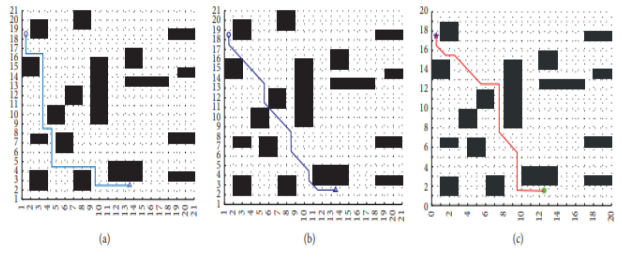

FIGURE 1: The comparisons of A∗ algorithm comparison. (a) Conventional four-way A∗ algorithm. (b) Conventional eight-way A∗ algorithm. (c) Improved eight-way A∗ algorithm.

Fig1:(a) Fig1:(b) Fig1:(c)

in Figure 1(c), when the path is planned according to a lower right slash, then we judge whether there is any obstacle on the right and bottom sides of the parent-node. If there is, the path is not feasible and the subnode needs to be selected again. When the path is planned according to upper left slash, then we judge whether there is any obstacle on the left and upper sides of the parent-node. If there is, the path is not feasible, the subnode needs to be selected again. -e planning path according to this method is shown in Figure 1(c).

III. EXISTINGMETHODOLOGY

It can be modified to a real extinguisher fire by replacing the water by a carbon-dioxide carrier and by making it to extinguishing fire of all the rooms using human controlling by IOT or a marked track for the drone to surveillance. This provides us the opportunity to pass on robots tasks that traditionally humans had to do but were inherently life threat. Fire-fighting is an obvious candidate for such automation. However, there has been research on many of these pieces in the different contexts, e.g., coordination among mobi le 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 together into a practical, autonomous firefighting service. The fire fighting robot uses convectional A* algorithm, first proposed in 1968 by Hart.It, is a heuristic search algorithm combined with the advantages of the above algorithms. It uses heuristic information to guide the search direction, so as to reduce the search scope and improve the search efficiency. It is a typical heuristic path planning algorithm , which has been successfully applied and verified in mobile robot path planning . However, due to the computational characteristic of A∗ m which reduces distance time to reach the fire area.

IV. LIMITATIONSOFEXISTINGSYSTEM

It can be modified to a real extinguisher fire by replacing the water by a carbon-dioxide carrier and by making it to extinguishing fire of all the rooms using human controlling by IOT or a marked track for the drone to surveillance. This provides us the opportunity to pass on robots tasks that traditionally humans had to do but were inherently life threat. Fire-fighting is an obvious candidate for such automation. However, there has been research on many of these pieces in the different contexts, e.g., coordination among mobi le 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 together into a practical, autonomous firefighting service. The fire fighting robot uses convectional A* algorithm, first proposed in 1968 by Hart.It, is a heuristic search algorithm combined with the advantages of the above algorithms. It uses heuristic information to guide the search direction, so as to reduce the search scope and improve the search efficiency. It is a typical heuristic path planning algorithm , which has been successfully applied and verified

in mobile robot path planning . However, due to the computational characteristic of A∗ m which reduces distance time to reach the fire area.

Traversing nodes are used for the smoothing process. This algorithm is used for the smoothing process. two methods need to trace back all path nodes one by one from the origin or termination to determine whether they intersect obstacles. If they do not intersect, the intermediate node will be discarded, and if they intersect, the previous node will be retained. The two methods can optimize the original path, but traversing all the path nodes significantly reduces the execution speed, and the strai- ght path nodes in the original path can avoid traversing judgment completely Therefore, this paper proposes the criterion of the prior inflection point, and Floyd algorithm is used to connect the backtracking method of the inflection point.

V. PROPOSEDMETHODOLOGY

The framework to be comprised of ultrasonic sensor, gas sensor and temperature sensors. A temperature sensor to be installed on the prototype so as to formulate the ultrasonic sensor readings accordingly, since readings of the ultrasonic sensor depends on the temperature. Boundary constraints must be taken into consideration in the source code. For a newly installed prototype, sample readings of the area to be taken to calculate the obstacles for its movement in that particular area. This prototype keeps patrolling around , sensing any kind of gas leakage or raise in temperature. A threshold is set on which, if the sensors detect the raise in the value, a signal is to be sent. While, there is a gas leakage the sensor sends a message to its corresponding user. Else,if there is a fire outbreak, the prototype is given command of sprikling the water or using a fire extinguisher in the particular region. If the temperature does not decrease within the time of its first detection, it is made to send another message to the user else a no-distress signal is sent stating the situation is under control.
More, constraints can be added , for example the gas sensing is to be done only in the kitchen, where there is more chances of a leakage , and also eliminating the fire extinguisher to function in particular region of the kitchen as there is a usage of stove whose temperature is usually very high. The hardware setup must use Wi-Fi Manager modules to connect to internet through L4 redirection and upload data to cloud storage such as Firebase. Mobile or web application derives data from the cloud and notifies the corporation accordingly. This here is a model in order to sense/detect the hazard, with the installation of sprinkler or a fire extinguisher one would also be able to hit the extinguisher through the prototype or sprinkle water by which the area on fire would be drastically reduce the temperature and the further cause of spreading of fire.

In order, to keep the user updated of the region where there is a fire , a camera is installed which sends the user, images of where there is fire. With pre programmed set of protocols where the camera should be held only near a limited distance between the flame and the prototype, so as to not cause as damage to the robot nor its components.

Criterion of the Planning Route Inflection Point for A* algorithm Before path smoothing is completed, the eight-way A∗ path planning has to be improved. Inflection criteria are added after planning; path inflection array is generated. For example, let point D in Figure 2 be the current node n, according to the A∗ algorithm formula:
f(n) =g(n) + h(n), (1). where g(n) indicates the length of the actual path from the origin to the current node and h(n) is the is the distance of estimate cost function from the state node n. to the termination For example, if L(C, D) ≠ L(D, E), then the planning path node D is the inflection point; if L(D, E) = L(E, F), then the planning path node E is a normal node. In the judgment, all the non inflection nodes in the planning path are expressed as (x, y, 0); the inflection nodes are expressed as (x,y, 1); the origin of the robot path is defined as a common node; the termination is defined as an inflection. All the nodes are saved in the file-list array. In the last path backtracking, simply priorly connecting the inflection point can get the path smooth optimization.

In the smooth process, firstly, we need to get the file listof the inflection points of the planning path and directly connect the second inflection point in the backtracking path when backtracking from the termination. If it does not intersect the obstacle, then the third inflection point should be connected. If the connection encounters the obstacle, all nodes between the third inflection point and the second inflection point are traced back in turn until the node that does not intersect the obstacle is found, and the intermediate node is discarded.

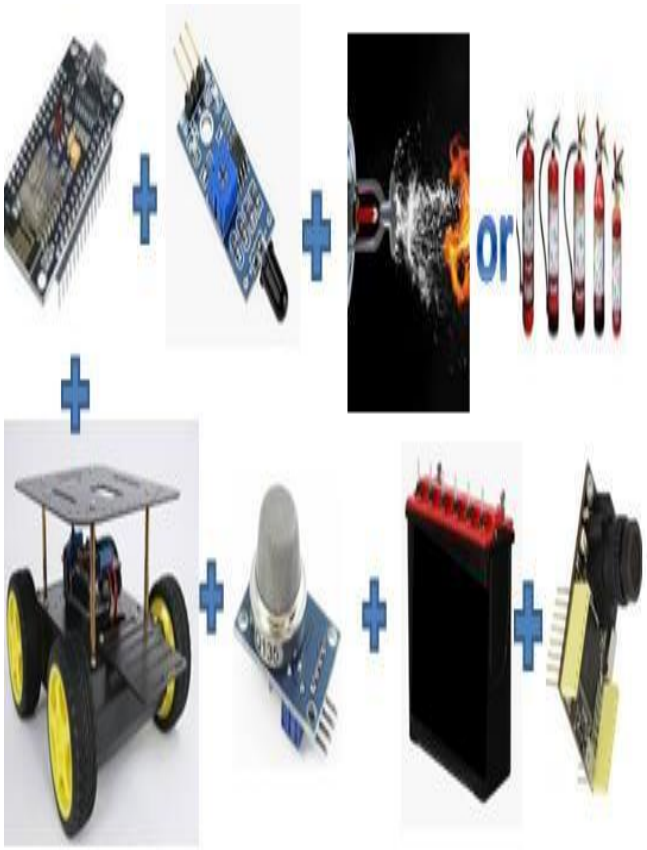

Fig 2: Proposed Methodology Design

VI. ILLUSTRATIVE EXAMPLE

Table 1: The comparisons of performance efficiency for A∗ algorithm.

Origin termination	Algorithm	The length of the path	Turn times
(18, 1) (2, 13)	Four-way A∗	28.00	0.0678
	Eight-way A∗	22.14	0.0196
	Improved eight-way A∗	24.49	0.036

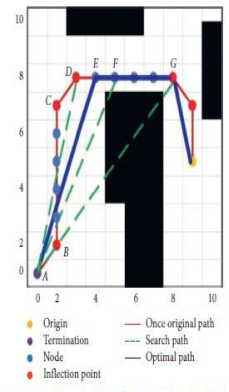

Figure 2: The principle of improved A∗ algorithm.

Fig 3: The principle of A* algorithm

In Figure 3, if points *A* and *B* are adjacent inflection points, they can be connected directly. -e distance is written as *L*(*A*, *B*). Judge *A*⟶*C* and *A*⟶*D* in turn; if they do not intersect obstacles when they are connecting, the original path can be changed to *A*⟶*D*. But, when *A*⟶*G*, they intersect obstacles, so the path length *L*(*A*, *G*) = +∞:*L*(*A*, *C*) <*L*(*A*, *B*) + *L*(*B*, *C*).(3)-en the array of points *A* and *C* are retained, and the array of point *B* is deleted: *L*(*A*,*D*) <*L*(*A*, *C*) + *L*(*C*,*D*).(4) -en, the array of points *A* and *D* are retained, and the array of point *C* is deleted Because *L*(*A*, *G*) = +∞,*L*(*A*, *G*) =*L*(*A*,*D*) + *L*(*D*, *G*). (5) At this time, assume the coordinate of point *G* is *G*(*i*, *j*,1), then the original path node between *D* and *G* will be traced back from point *G*, *G*1(*i* − 1, *j*, 0), *G*2(*i* − 2, *j*, 0),*G*3(*i* − 3, *j*, 0), and *G*4(*i* − 4, *j*, 0), where *G*3 =*F* and *G*4 =*E*. When connected with point *A*, *L*(*A*, *G*1) = +∞, *L*(*A*,*G*2) = +∞, and *L*(*A*, *F*) = +∞ are abandoned: *L*(*A*, *E*) + *L*(*E*,*G*) <*L*(*A*,*D*) + *L*(*D*,*G*). (6)-en, the array of points *A* and *E* are retained, and the array of point *D* is deleted. -e original path *A*⟶*B*⟶*C*⟶*D*⟶G is optimized as *A*⟶*E*⟶*G*, so far, this section of path optimization is completed, and the next path optimization is carried out accordingly.

VI. IMPLEMENTATION OF A* ALGORITHMN

The specific implementation steps of the path smoothing algorithm are as follows:

(i) Step 1: take out the processed nodes of the above improved eight-way A∗ algorithm and carry out the secondary backtracking analysis from the termination.
(ii) Step 2: start the termination to connect all the inflection points one by one, *B*⟶*C*⟶*D*, and then the nodes of non inflection points, such as the points between *B*⟶*C*, are ignored during the connection process.
(iii) Step 3: when points *A* and *D* are directly connected ,continue to search backward inflection point G. At this time, there will be a conflict between search path *A*⟶*G* and obstacles. -en, search the nodes of noninflection point between *G*⟶*D*.
(iv) Step 4: if there is still a conflict with the obstacle when searching to node *F*, then continue to Step 3until node *E*, that is, no conflict with the obstacle is found.
(v) Step 5: at this time, take the direct connection path *A*⟶*E* as the fixed path and repeat step 2⟶3⟶4 from node *E* until reaching the origin

VII. ALGORITHMN FLOWCHART

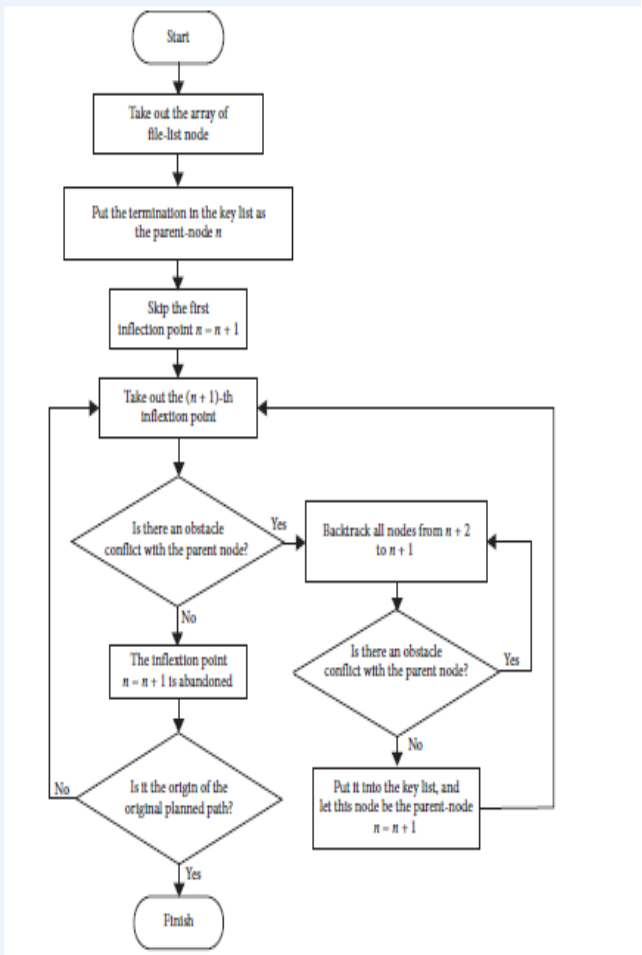

Fig 3: Proposed Methodology Design

VIII. SYSTEMARCHITECTURE

Fig 4: System Architecture Design

This system is combination of both hardware components and software components. Google cloud service namely Firebase is used along with the setup for storage and retrieval of data.

a) Software used – Arduino IDE

The Arduino Integrated Development Environment (IDE) is the cross-platform application (for Windows, macOS, Linux) that is written in that of functions from C and C++. It is used to write and upload programs to Arduino compatible boards, but also, with the help of third party cores, other vendor development boards. We make use of Wi-Fi Manager module and firebase module for our system.

Firebase module enables nodemcu to communicate with google cloud firebase and utilize its services. It ensures secured communication of data over the internet since Asymmetric encryption method is followed. The data to be sent is encrypted at client side before transmission using its encryption mechanism making using of unique client id or key. Data transmission is fast and well secured. The data stored at cloud is encrypted again using google's own security mechanism.

Wi-Fi Manager ensures reliable network connectivity to wireless network. When the setup is installed for the first time, the board activates access point mode, connecting to which leads us to a captive portal via L4 redirection on a mobile or pc connected to same Access Point (AP). The captive portal should be password protected for enhanced security. In the captive portal, one or more WiFi credential scan be added to which user might want to connect in future. Once done, the board changes its state to default mode attempting to connect to WiFi. If a WiFi is down, it will automatically attempt to connect to other WiFi station using credentials fed via captive portal. The credentials entered is not hard coded onto the board via software code, instead it gets stored in RAM and firmware which isn't accessible to users. This ensures reliable and secured connectivity to the internet.

b) Cloud services used: Firebase

Firebase is the Backend-as-a-Service (BaaS) app development platform that provides the host in the backend services such as real time database, cloud storage, authentication, crash reporting, machine learning, remote configuration, and hosting for your static files. Database is stored under the format of JSON and synchronizes with clients in real time. The cross-platform client is the fundamental platform of this database in which all the clients share the same resource from Firebase server and it will automatically update when any data is stored of changed. Firebase uses NoSQL type for its database that removes the constraints when interacting with tables, fields. This helps user freely to

create and decorate database easier. It provides numerous features such as user authentication.

The sensor readings captured from the sensors (ultrasonic sensor, gas sensor, temperature sensor etc) by nodemcu are sent to firebase. The mobile or desktop web applications can fetch the data from the cloud after user authentication check and it can be shown to the end users for monitoring. The user can send appropriate control signal as when required which gets stored in firebase directly. The control commands are read by IoT board and changes can be reflected by sending required control signals to the sensors or devices attached to it.

c) Hardware used

1) Board: NodeMCU

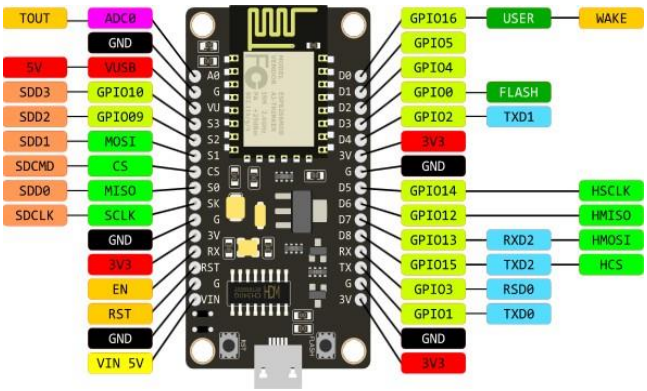

Fig5:NodeMCU

NodeMCU is a low cost open-source development kit that helps to build IoT product. It includes firmware that runs

on the ESP8266 WiFi SoC from the Espressif System, and hardware that is based on the ESP-12 module. The term "NodeMCU" strictly refers to the firmware rather than the associated development kits. The firmware uses the Lua scripting language. The firmware is based on the eLua project, and built on the Espressif Non-OS SDK for the ESP8266. It uses many of the open source projects, such as luacjson and SPIFFS. Digital and Analog are attached to digital and analog pins respectively. The board could be programmed using software Arduino IDE in C/C++ to control pins. Data can be read from or written to the pins.

2) Ultrasonic sensor

The Sensor head emits an ultrasonic waves and it also receives the wave reflections back from the target, ultrasonic sensors measure the distance to the target by measuring the time between the emission and the reception

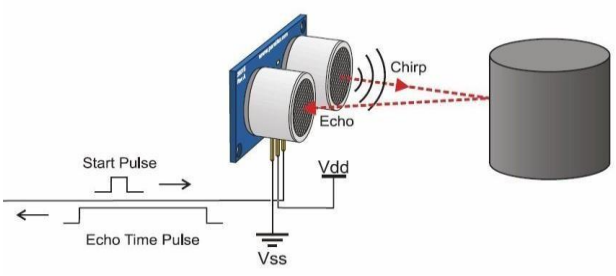

Fig6: Ultrasonic sensor

A special sonic transducer is used for the ultrasonic proximity sensors. The sonic waves emitted by it are reflected by an obstacle and received back into transducer. After it has emitted the sound waves, the sensor will change to receive mode. Time elapsed between emitting and receiving is directly proportional to the distance of the obstacle from the sensor.

3) Flame Sensor

A flame detector is a sensor designed to detect and respond to the presence of the flame or fire, allowing flame detection. Responses to that detected flame depends on the installation, but can be included with sounding an alarm, deactivating a fuel line (such as a propane or a natural gas line), and activating a fire suppression system. When used in the applications such as industrial furnaces, their role is to provide confirmation that the furnace is working properly; in these cases they take no direct action beyond notifying the operator or control system. A flame detector often responds more faster and more accurately than a smoke or heat detector due to the mechanisms it uses to detect the flame.

Fig7:Flame Sensor

IX. CONCLUSION

Fire fighting is the act of extinguishing fires i.e., it sprinkles water or carbon dioxide on to the fire. Through this we can conclude that a robot can be used in the place of humans reducing the risk of life of Fire fighters. We can use them in our Homes, Labs, Offices etc. They provide us greater efficiency to detect the gases and fire. Hence, this robot can play a crucial role. IoT based fire fighting robot designed to detect fire or harmful gas in a certain area and send a signal to

the operator. To implement this function, we need to integrate different sensors and systems together. This robot is accessed from a remote location using an IoT server. To enable the communication between the all the component and the IoT server programming is required. Hence the proposed system is more efficient and cost effective, serving a great help to humans by reaching places where it is difficult for humans to reach.

X. FUTURE ENHANCEMENT

The network reliability can be improvised by providing provision to connect to internet via ethernet as well. More sensors can be implemented and integrated to get further beneficial information out of the system and its environment like GPS for anti-theft. Local storage of data can be maintained for buffering the data from the sensors temporarily in case of network failure. Also by including face recognition system, intruder images can be captured.

Instead of Making the robot on Wheels, which is just moving in a floor , we could be able to give it a platform such that it is able to commute from a floor to another. Also we can Use different shortest distance algorithm instead of improved A*algorithm to find the shortest distance to check the efficiency and time cost of the robot.

REFERENCES

[1] High-Accuaracy Robot Indoor Localization Scheme Based On Robot Operating System using visible light positioning Volume 12, Number 2, April 2020. Weipeng Guan,Shihuan - Chen, Shangsheng Wen, Zequn Tan, Hongzhan Song, W -enyuan Hou.

[2] Wildfire Counter by Unmanned Aerial System Exploiting Its Time-Varying Mass, Diego A. Saikin , Tomas Baca , M -artin Gurtner , and Martin Saska, IEEE Robotics And Auto-mation letter, vol. 5, No. 2, April 2020.

[3] Safe Robot Navigation Via Multi-Modal Anomaly Detection Lorenz Wellhausen, René Ranftl, and Marco Hutter, IEEE Robotics And Automation letter, vol. 5, No. 2, April 2020.

[4] Analysis of firecounter skill with a teleoperated robot Yoshihiro Tamura1, Hisanori Amano, and Jun Ota, Tamura-et al. Robomech J (2020) 7:26 https://doi.org/10.1186/s40648-020-00177-y.

[5] Warehouse-Oriented Optimal Path Planning for Autonomous Mobile Fire-Counter Robots Yong-tao Liu, Rui-zhi Sun, Tian-yi Zhang, Xiang-nan Zhang, Li Li,and Guoqing Shi1 Hindawi Security and Communication Networks Volume 2020, Article ID 6371814, 13 pages https://doi.org/10.1155/2020/6371814.