International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 06 | June 2021 www.irjet.net p-ISSN: 2395-0072

Ignis: Fire Detection and Mitigation System

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Abstract - *It is observed that during a fire in a building 83% of deaths are the result of smoke inhalation rather than burns due to the inability to find a safe route with minimal exposure. So our system is a camera-based fire monitoring system that can monitor the specified area in real time. The users will initially register on the system through a QR code linked to the web platform of the system. When a fire or smoke is detected using YoloV5 algorithm, it will send the corresponding visuals to a security personnel or a person designated using webRTC on the platform. The system makes a final confirmation based on the submitted data by this person, who will make sure the fire can be cut off at its early stages but during a worst case scenario the security personnel can send an alert through the system to evacuate the building which will be received to all users present via the web platform. When people try to evacuate through the same path, it will create a congestion in the path and thus make it difficult to move through it. Therefore a IoT based method is introduced to reduce the congestion. The path with less crowd density, moderate crowd density and high crowd density will be shown using green light, orange light and red light respectively. Depending on the crowd density the people will be dynamically routed to the exit.*

Key Words: Fire detection, Web platform, Yolov5, WebRTC, Dynamic Routing, IoT.

1.INTRODUCTION

Our Project aims at detecting fire in a building at early stages to contain and extinguish it by using real time camera feed. In case the fire is intense our system will provide an efficient and hassle free mitigation route which will be dynamically routed by the system by taking the population density into account. When people try to evacuate through the same path, it will create a congestion in the path and thus make it difficult to move through it. Therefore a IoT based method is introduced to reduce the congestion.

1.1 Background

With the rapid growth in population, buildings are also growing vertically due to the shortage of occupancies. However, with these buildings growing vertically, there arise problems regarding the safe evacuation of people during an emergency like a fire. Similarly, with the growth of insulating materials which catch fire easily and their excessive use in building, a threat to the life of buildings and humans is also increasing. Many people lost their lives, and more are admitted to hospitals due to the fire in India. On an average 520+ injuries and 40+ deaths occur per year according to the National Fire Protection Association.

A fire Accident occurs very rarely, but once it occurs it's consequences will be devastating. As a result, there is substantial attention given by researchers worldwide for the development of intelligent building systems. Many of these casualties can be avoided if we detect a fire early and guide people to a safe location. To build a suitable fire detection and safe evacuation system it is necessary to focus on parameters such as appropriate sensors, software and hardware tools, and combination techniques and at the end effective user interface.

This project gives systematic implementation of intelligent fire detection and evacuation systems as a combination of fire detection (image and video processing), evacuation assistance and crowd monitoring and prediction.

1.2 Scope

History has proven that early detection of a fire and the signaling of an appropriate alarm remain significant factors in preventing large losses due to fire. Properly installed and maintained fire detection and alarm systems can help to increase the survivability of occupants and emergency responders while decreasing property losses. Early detection also plays a significant role in protecting the safety of emergency response personnel. Property loss can be reduced and downtime for the operation minimized through early detection because control efforts are started while the fire is still small.

In general, fire alarm systems are installed :

1. To provide for the safety of occupants in buildings, and to make provision for their evacuation or refuge during a fire or other emergency.

2. To provide the fire department with early notification of a fire in a building and to direct them to the area of risk.

3. To reduce loss of property; the property may have considerable intrinsic value and the insurers either require a fire detection system or may encourage its use.

4. To reduce building damage; the building may be unoccupied for periods where equipment is still powered and the owner wishes to ensure that if anything goes wrong the fire department is called to the scene in a timely manner. Sometimes fire detection and alarm systems are used to compensate for structural fire protection shortcomings or to give special cover for items of high value.

5. To reduce the amount of business lost.

6. Minimize risk to the public who attend unfamiliar properties. It is often a mandatory requirement by the Building Codes.

7. During fire accidents, it is also important to guide people within the building to exit safely.

2. EXISTING SOLUTIONS

There are many techniques by which fire and smoke can be detected and is majorly classified into two categories: sensor based [1] [4] and video processing based [2] [3] [5].Video processing includes computer vision [2], image processing [3] and detection using Fusing Visual and Non-visual Flame Features [1]. Iot based detection includes Camera and sensor detection [5], and Sensor(multi-sensor) only detection [5].

3. PROPOSED METHODOLOGY

When a fire occurs in a building, it is detected using image and video processing by camera based fire monitoring system. An alarm is sent across the building. When people try to escape through the same exit path, it will create a congestion in the exit path which will led to huge disaster. A method is introduced to reduce the congestion in the exit path.

The crowd density along each exit path is calculated and the path with less crowd density will be dynamically routed using green light signal and the path with more crowd density will be dynamically routed using red light signal. The path with moderate crowd density will be shown using orange light signal.

A QR code will be provided at the entrance of the building. The customer who enters into a building should scan the QR code and enter the details for user registration so that if a fire occurs in the building, the customer will be alerted to move across the green light signal through a message sent to their phone.

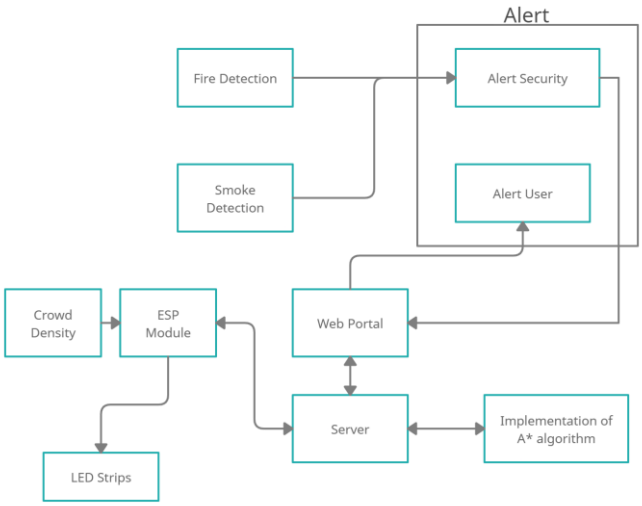

Fig -1: Block Diagram of Ignis: Fire Detection and Mitigation System

4. SOFTWARE IMPLEMENTATION

4.1 YoloV5

YOLO, an acronym for **'You only look once'** , is an object detection algorithm that divides images into a grid system. Each cell in the grid is responsible for detecting objects within itself. YOLO is one of the most famous object detection algorithms due to its speed and accuracy. YOLO is an algorithm that uses neural networks to provide real-time object detection. Object detection consists of various approaches such as fast R-CNN, Retina-Net, and Single-Shot MultiBox Detector (SSD). Although these approaches have solved the challenges of data limitation and modeling in object detection, they are not able to detect objects in a single algorithm run.

Equation for bounding box

$$y = (pc, bx, by, bh, bw, c) \quad (1)$$

where pcis 0/1 indication if any class is detected, bw is the Width bounding box, bh is the Height bounding box, c is the Class (for example, person, car, traffic light, etc.). by is the center of the bounding box.

4.2 A* Algorithm

A* Search algorithm is one of the best and popular techniques used in path-finding and graph traversals. A* is a graph traversal and path search algorithm, which is often used in many fields of computer science due to its completeness, optimality, and optimal efficiency. A* is an informed search algorithm, or a best-first search, meaning that it is formulated in terms of weighted graphs: starting from a specific starting node of a graph, it aims to find a

path to the given goal node having the smallest cost (least distance travelled, shortest time, etc.). It does this by maintaining a tree of paths originating at the start node and extending those paths one edge at a time until its termination criterion is satisfied.

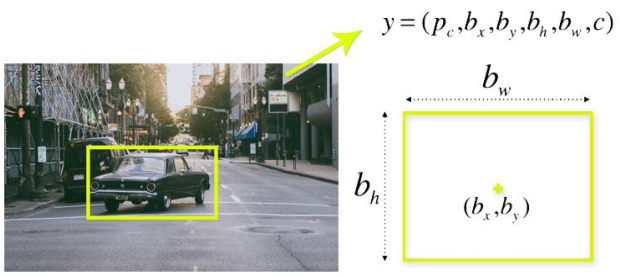

Fig -1: bounding Box of YoloV5

Equation for finding cost function

$$f(n) = g(n) + h(n) \quad (2)$$

where n is the next node on the path, g(n) is the cost of the path from the start node to n, and h(n) is a heuristic function that estimates the cost of the cheapest path from n to the goal.

4.3 OpenCV

An OpenCV (Open Source Computer Vision) is a library of python functions developed to solve computer vision problems. The OpenCV-Python uses Numpy, which is a highly optimized library for numerical operations. All the OpenCV array structures are transformed to and from the Numpy arrays. So whatever operations performed in umpy, can be combined with OpenCV. OpenCV supports many algorithms associated with computer vision and machine learning etc.. and it is growing day-by-day. As of now, OpenCV is being supported by a huge variety of programming languages such as Java, Python,C++ etc and is out there on different platforms such as iOS, Linux, Windows, OS X, Android etc. Hence, OpenCV- Python is an appropriate tool for fast prototyping of computer vision problems.

4.4 Twilio

Twilio is an American cloud communications platform as a service company based in San Francisco, California. Twilio allows software developers to programmatically make and receive phone calls, send and receive text messages, and perform other communication functions using its web service APIs. Twilio uses Amazon Web Services to host telephony infrastructure and provide connectivity between HTTP and the public switched telephone network (PSTN) through its APIs.

5. HARDWARE IMPLEMENTATION

5.1 Arduino Uno

Arduino Uno is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.cc.The board is 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 board has 14 digital I/O pins, 6 analog I/O pins, and is programmable with the Arduino IDE (Integrated Development Environment), via a type B USB cable.It can be powered by the USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts.

5.2 NodeMCU

The NodeMCU (Node MicroController Unit) is an open-source software and hardware development environment built around an inexpensive System-on-a-Chip (SoC) called the ESP8266. The ESP8266, designed and manufactured by Espressif Systems, contains the crucial elements of a computer: CPU, RAM, networking (WiFi), and even a modern operating system and SDK.

5.3 RGB LED

LED, a semiconductor device that converts electricity into light. RGB LED means red, blue and green LEDs. RGB LED products combine these three colours to produce over 16 million hues of light. Note that not all colours are possible.

5.4 Buzzer 5V

Buzzer is an audio signaling device which has been used as an alarm for detection of fire hazard. It will buzz at a predefined frequency (2300 ±300 Hz) on its own even when you just apply steady DC power.

6. CONCLUSIONS

This project proposed a fire detection algorithm by using existing hardware which is free from sensors as the ordinary fire detection systems contain. The objective of this project was to create a system which would be able to detect fire as early as possible from a live video feed and dynamically show the safest exit path using a light based system.

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