Using Artificial Intelligence to Improve Fire Detection Systems in the Workplace and Sending Information to the Nearest Fire Brigade Based on the Intensity

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Abstract

Safer workplaces result in fewer accidents, which reduces occupational health expenses, reduces employee downtime, improves employee retention and satisfaction, and shortens retraining periods. Every person in the work sector desires to work in a safe and secure environment. Unfortunately, fire is one of the main problems in our workplace safety; even most industries don't have a better fire detection system. This research is based on a fire detection system and modeling to send the data in the shortest time to the nearest fire brigade. Poor vision is a typical obstacle for fire personnel while a rescue effort is underway in an area covered in flames and smoke. It becomes harder to detect obstacles such as doors, staircases, and other impediments in their line of rescue, delaying the execution of the rescue operation. When a person's life is in jeopardy, such considerations are more troubling. Even sometimes, the fire brigade doesn't get information about incidents; they get the information lately. The suggested model focuses on a system capable of Real-Time Fire Detection. Using an artificial intelligence-based fire detection system, the immediate single will be sent to the workplace authority and start the alarm. Data will be sent to the nearest fire brigade when the fire intensity area is very high. This process is also applicable to residential areas, schools, hospitals, etc.

Keywords
Machine Learning, Safety Management Systems, Artificial intelligence, Fire detection and Workplace safety.

1. Introduction
Fire safety is crucial; it is essential for a workplace to avoid and safeguard against fire-caused devastation. Fire safety decreases the likelihood of property damage and harm caused by flames. Executing and Developing fire safety practices in the workplace is not only mandated by law but also vital to the protection of everyone who may be present in the building during a fire emergency. Whether it's a business or a home, a group of people, or a single individual, if a severe fire catastrophe occurs, the results will be devastating. Life is more precious than everything else on Earth. Hence it is the essential item on the planet. Classes on fire safety educate us about the technologies that help in fire prevention, the numerous procedures involved in addressing such fire catastrophe situations, and how to escape a building safely in the case of a fire. But, most of the time, we do not give fire awareness or fire-related concerns a greater priority because we do not feel they are obligatory or essential. Many authors have been worked on this fire detection system. Borges and Izquierdo (2010) used Computer vision-based fire detection algorithms those are usually applied in closed-circuit television surveillance scenarios. The proposed method can be applied not only to surveillance but also to video classification for retrieval of fire catastrophes in databases of newscast content, the authors say. Celik(2010) proposed a method, in which the suspected region of fire (SRoF) is detected with its spatial features against non-fire objects by the Faster Region-based Convolutional Neural Network. Deep learning-based method emulates a human process of fire detection called DTA, in that SRoFs are detected in one scene and the temporal behaviors are continuously monitored and accumulated to finally decide whether it is a fire or not. The proposed method has been experimentally proven to provide excellent fire detection accuracy. Mueller (2013) focused on the feature extraction block, where two optical flow fields (OMT and NSD) are computed in parallel from which the 4D feature vector is built.

Now, this study uses a fire detection system and modeling to provide data to the closest fire department as quickly as possible. As we said, firefighters often struggle with impaired visibility during a rescue operation in a region engulfed in flames and smoke. Even sometimes, the fire department needs to get information about occurrences; they receive the information seldom. Using an AI-based fire detection system, the instant alert will be delivered to the workplace authorities, and the alarm will sound. Data will be forwarded to the closest fire department when the fire intensity is really high.

1.1 Objectives
The main objective of this research is –
1. Develop an improved fire detection system
2.Sending Information to the Nearest Fire Brigade Based on the fire Intensity

2. Literature Review
Numerous studies have been conducted on fire detection systems. Ti Nguyen et al. (2013) introduced a system to detect fire by extracting color and motion from video sequences. This paper's findings enabled a system capable of performing region-growing segmentation to determine color pixels in the picture and, subsequently, fire regions. The region growth approach and YCbCr color space model, which compares all adjacent unallocated pixels to the region, are used. Borges and Izquierdo (2010) adapted the Bayes classifier to identify fires based on other parameters, such as the color of the fire area's area, surface, and perimeter. Mueller (2013) suggested an optical flow-based neural network fire detection approach for the fire zone. The technique combines two visual flow models to differentiate between fire and dynamically moving objects. Moreover, Foggia (2015) suggested a multi-expert system that integrates the findings of analyses of a fire's color, shape, and mobility characteristics. Despite being inadequate, the additional Punam et al. (2012) proposed a method that uses the RGB color model and background removal technique. Jaree et al. (2012) provided a method that employs the HSV and YCbCr color models in conjunction with circumstances to distinguish the fire's brightness from the backdrop and ambient light. Wenhao and Hong's (2012) study retrieved flame objects using repeated adaptive threshold approaches. At the same time, Tian Qiu et al. (2012) developed a method capable of detecting edges for the same aim, which is to catch fire, Tian Qiu et al. This method identified the region between thermochemical and non-thermal reactions to see a fire. This experiment demonstrates that the fire's edge may be observed clearly and continuously. In contrast to Petro et al. (2012), who offered a real-time algorithm based on the background subtraction approach, we propose a background subtraction algorithm that operates in real-time. Utilizing an algorithm based on detection and tracking, the purpose was to decrease the false alarm rate of fires that usually occurs with standard electrical approaches. Lei and Liu (2013) detected flame using median filters, frame differences, and a Bayes classifier. Celik (2010) separates the method into color modeling and backdrop registration.

3. Methods
Here, first, we will build an Arduino project capable of fire detection in a short time; here, we need mainly Arduino UNO, a flame sensor, and a temperature sensor with other components. Then, we will also implement CCTV-based video processing to detect fire; for this, we are using python, Open CV, etc. At the same time, microcircuits will inform the authority by a fire alarm, call, and SMS. The temperature sensor will continuously measure the temperatures; an image from CCTV will be collected for measuring fire intensity, so when fire intensity measured from the image is out of safe range, it will directly call the nearest fire brigade; these purposes can be done in two ways, such as manually stored or using geolocation, here manually stored data that means a specific mobile number was used. This simple framework is shown in the figure 1 below.

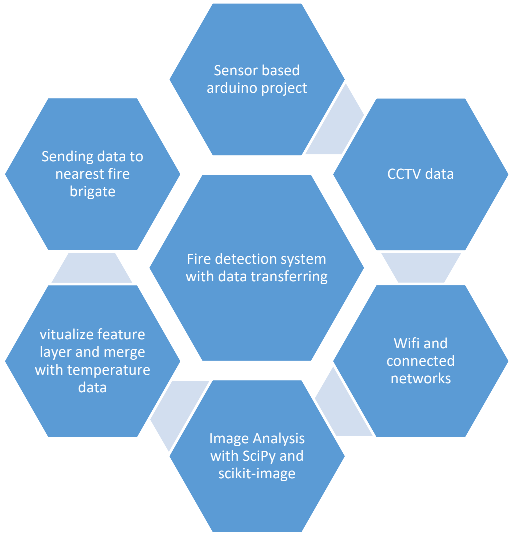

Figure 1. Required methods for the research.

Image processing can be done in various ways; here, we are using RGB to HSV color conversion, as it will be easy to work with converted images; so, for this, we need to divide the R, G, and B values by 255, we need to divide them for changing the range value.

R' = R ÷ 255
G' = G ÷ 255
B' = B ÷ 255

Now we need to determine the highest value of R, G, and B; then determine the difference between the highest and lowest value. Hue calculation is a piecewise function, and the value depends on *Cmax.* Saturation value is the ratio of the difference value to the *Cmax* value when *Cmax* is not zero.

Cmax(highest value of *R*',*G*', *B*') = max (*R*', *G*', *B*')
Cmin (lowest value of *R*', *G*', *B*') = min (*R*', *G*', *B*')
Δ = difference between highest and lowest value = *Cmax* - *Cmin*

Hue calculation:

$$\text{Hue} = \begin{cases} 0° & \Delta = 0 \\ 60°\left(\frac{G' - B'}{\Delta} mod6\right) & ,Cmax = R'\ (red\ is\ maximum) \\ 60°\left(\frac{B' - R'}{\Delta} + 2\right) & ,Cmax = G'\ (green\ is\ maximum) \\ 60°\left(\frac{B' - G'}{\Delta} + 4\right) & ,Cmax = B'\ (blue\ is\ maximum) \end{cases}$$

Saturation calculation:

$$Saturation = \begin{cases} 0 & ,Cmax = 0 \\ \left(\frac{\Delta}{Cmax}\right) & ,Cmax \neq 0 \end{cases}$$

Value calculation: this will be equal to *Cmax*-value.

$V = Cmax$

After that, we need to apply a threshold mask; then, we will measure the area. When the area is under the highest affected range, it won't send any alert to the nearest fire brigade, but when the affected area and temperature are both very high, it will send it to the fire brigade. Here we are using a small GSMSim800L modem data transmission system. The SIM800L GSM/GPRS module is compatible with a wide range of Internet of Things applications. All the features of a regular mobile phone, including texting, calling, and GPRS internet access, are available via one single module.

4. Data Collection

As stated in Figure 2, the data Collection process will be started from the CCTV data. We have discussed it already. Then in Figure 4, circuit diagram has been shown. We have added an image ,Figure 5 from the video showing fire detection process. An processed image from this has shown in result part later, in Figure 8.So data collection is mainly based on video data and data collected from the Arduino based project.

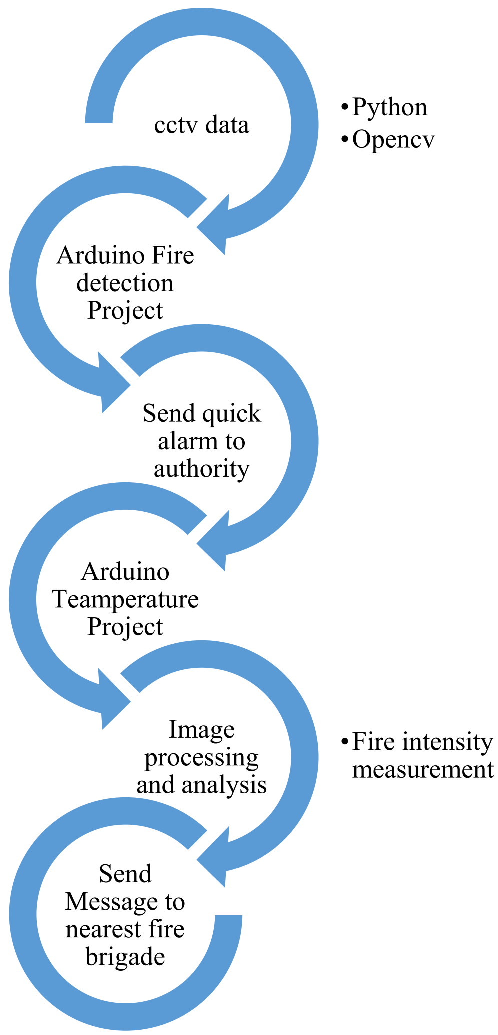

Figure 2. Data Collection process

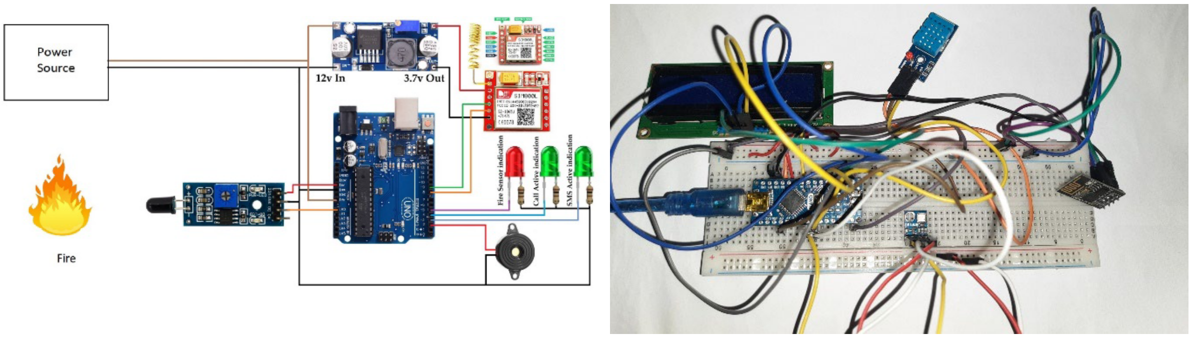

Figure 3. Circuit Diagram

5 minutes 10 minutes

Figure 4. Fire detection

5. Results and Discussion

5.1 Numerical Results

Here affected area vs time data will look like Table 1,

Table 1. Affected area vs time data.

time in minutes	affected areas	Decision
1	0.5	Low
5	500	Low
10	1500	Low
15	1800	Low
20	1900	High
25	2000	High
30	2100	High
35	1700	Low
40	1100	Low
45	0.5	Low

The affected area was at the last 45th minute; we used a fire extinguisher. As a result, the value of the affected area has dropped down suddenly. Now, temperature vs. time data will look like the table below, Table 2.When a fire is confined to a compartment, the temperature within that compartment may quickly increase to the point where all combustible things within that compartment will catch fire.Suppose the fire persists owing to the introduction of fuel (flammable gases or liquids, or a substantial fuel load in the space). In that case, temperatures will continue to climb to a point where building components, including steel structural elements, will begin to break (if not safeguarded).

Table 2. Temperature vs time data

time in minutes	temperature
1	23
5	80
10	126
15	131
20	167
25	244
30	200

5.2 Graphical Results

Here affected areas vs time graph will look Figure 5, here the affected area value was largest at nearly 30 minutes. Image processing is done the Temperature graph can be easily found be from Thing Speak like Figure 6, this can be set up by using temperature sensor; for example, fire alarms may employ thermistor temperature sensing to detect fires by monitoring for a rapid rise in temperature just like in Figure 7.Here the temperature rise was quite rapid for 25 minutes and then start to decrease.

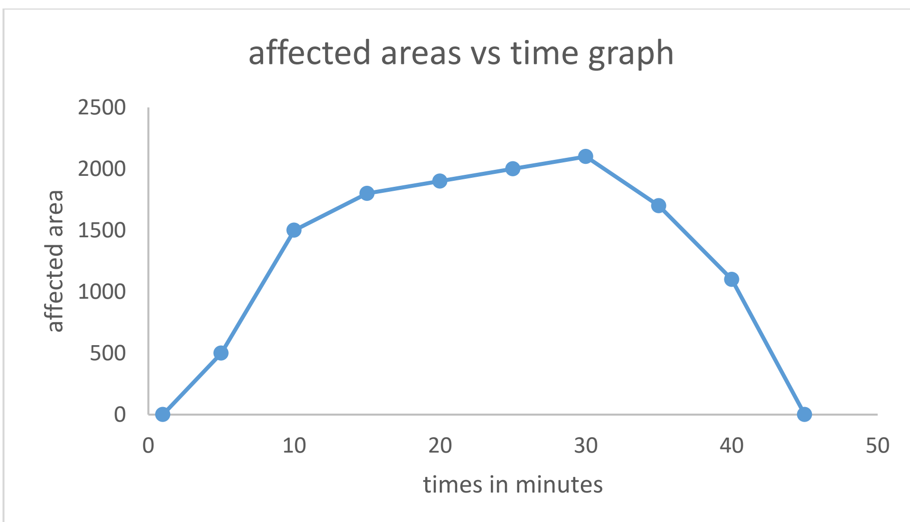

Figure 5. Affected areas vs. time graph.

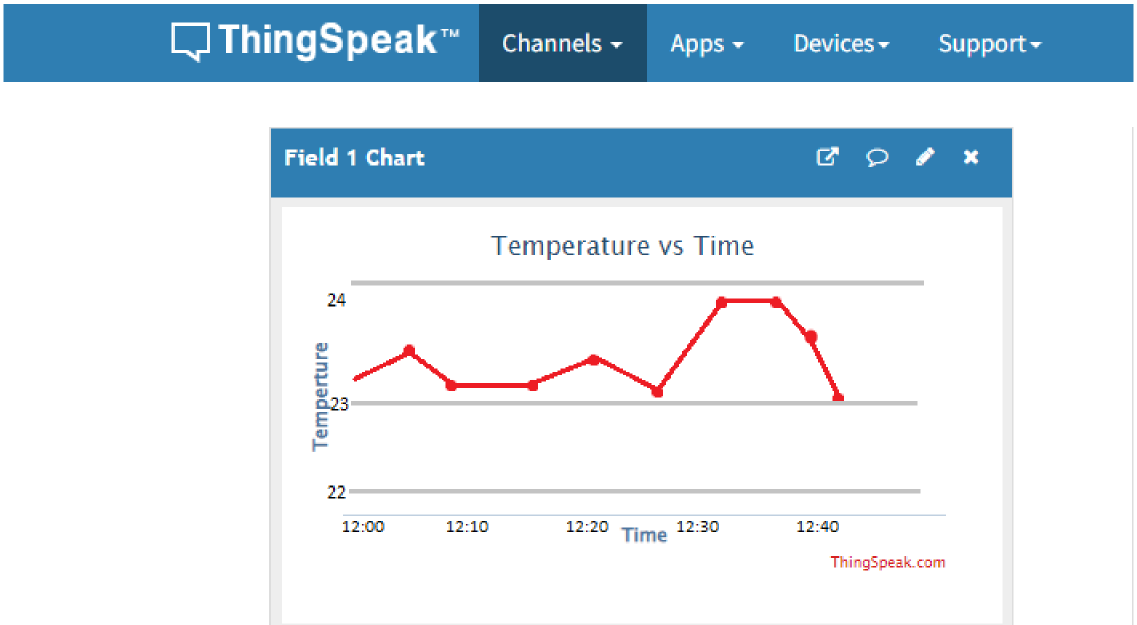

Figure 6. Temperature data from Thing Speak Server

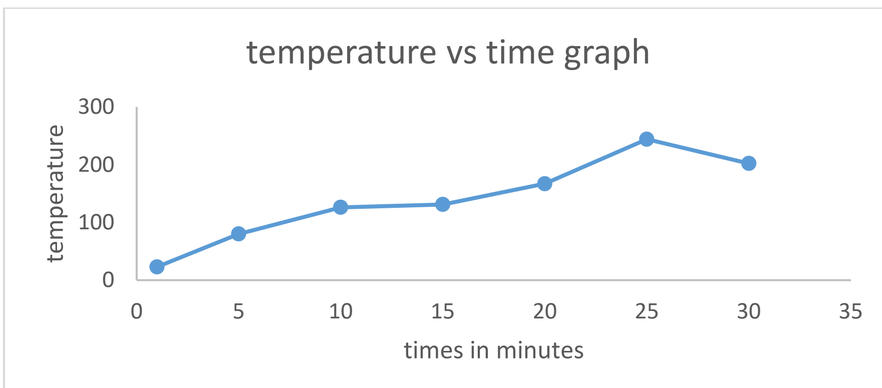

Figure 7. Temperature vs. time graph

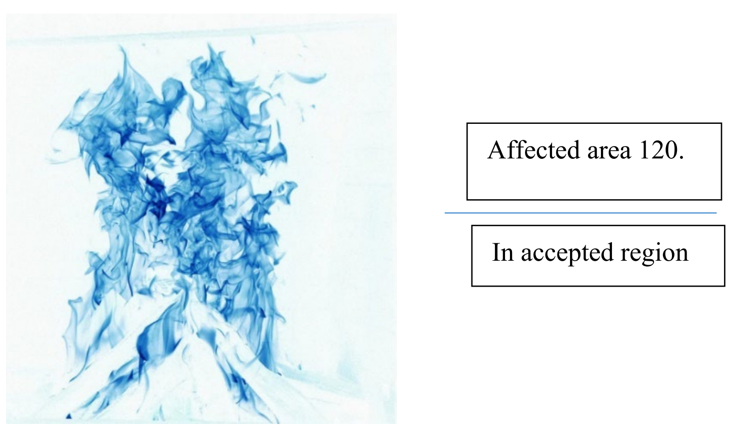

Figure 8. Area calculation from processed image data

As in Figure 8, first picture was taken from processed image from previous video or image data, here image or video processing has been done with SciPy and scikit-image. Then area is calculated from this image, as here only the bright part has taken for consideration. And here the collected area is 120, which is in a low range so, it is accepted to be safe.

5.3 Proposed Improvements

This model can be improved by taking the following steps such as

1. Including real-time multiple camera CCTV camera setup arrangements for better results
2. Including motion detection sensor
3. Including integrated fire distinguisher circuit
4. Including thermal camera
5. Including Gas Sensor for smoking level measurement

An improved design will be like Figure 9, where additional fire controller system is integrated in the existence model.

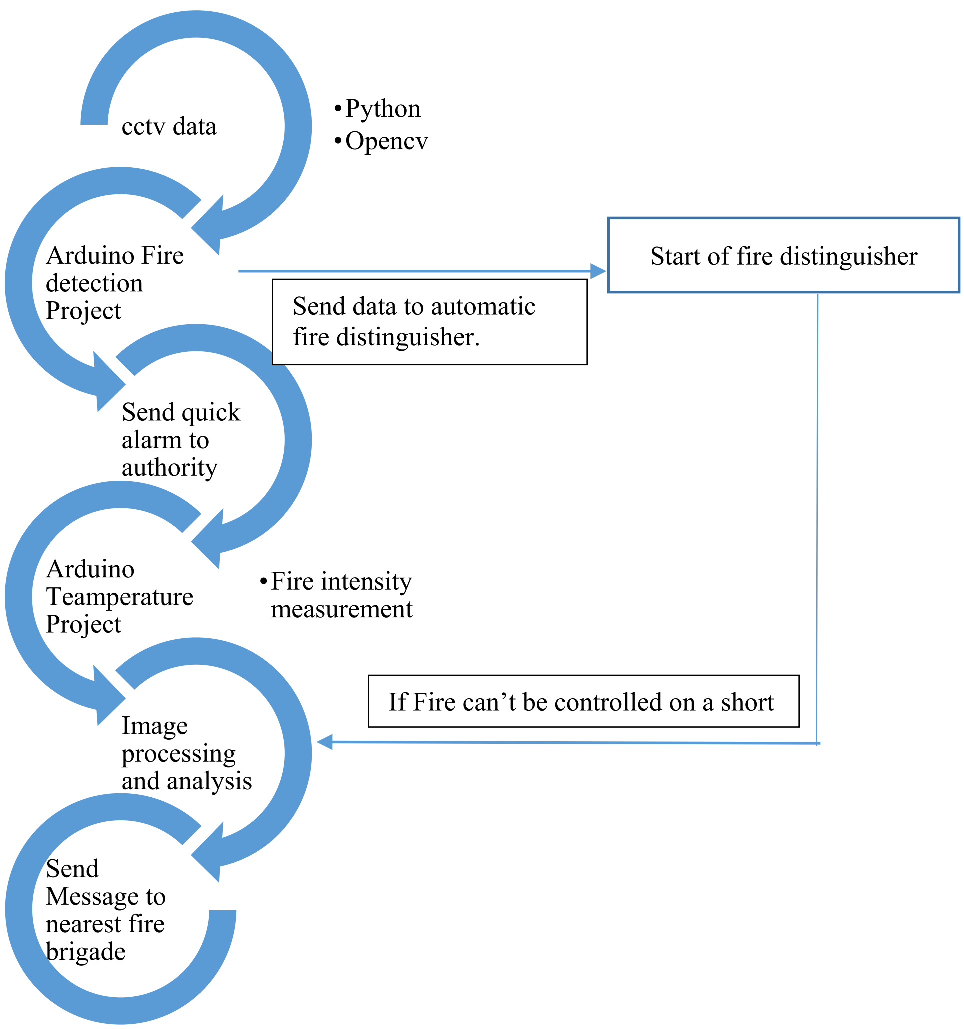

Figure 9. Future improvement for this model

6. Conclusion

There have already been several effective visual-based fire detection systems established. Here this research combines sensor use such as sensors for temperature and fire, visual analysis, then sending the data to the authority. Experiments have shown that the suggested technique provides effective fire detection with data transmission.

Therefore, we want to continue our study in this field and further enhance our outcomes; as we have said earlier, this research can be improved by using several factors and implementing more methods and sensors.

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Biography

Toukir Ahamed is a final year BSc student in the Department of Industrial and Production Engineering (IPE) at Bangladesh University of Engineering and Technology (BUET). He is currently doing undergraduate research on machine learning and data science. He is interested in topics like Machine Learning, Healthcare, Data Science, Optimization, Artificial intelligence, etc.