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Fastidious Fire Smothering

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***Abstract*: Various methods are being used to smother the fire in the industry or offices. But these systems possess lots of shortcomings. For example, purely sensor based detection and the extinguishing system takes much longer time to detect fire and the water sprinklers sprays the whole area rather than specifically using it in fire affected area. It eventually damages the the costly machinery or important documents. So, a system based on image processing based fire detection technique and then a mechanical system to fastidiously smother it. Its biggest benefit is that it will be possible to detect the fire at comparatively early stage and extinguish it selectively so that the other unaffected areas of the room won't be damaged. This system is divided into three stages. First of all, fire is detected using image processing. Secondly, exact co-ordinates of the location of fire are determined. Then, an electro-mechanical system is built to fastidiously smother the fire without damaging other property. With this system, fire is detected at comparatively earlier stage than other present systems and its location is also traced which present systems aren't equipped to do. Proposed system is almost accurate as far as fastidious fire smothering is concerned and its accuracy is 94.44% when its fire detecting ability is taken into account.**

Keywords*— *fire detection, fire smothering, Image Processing, YCbCr colour space, background subtraction.

I. INTRODUCTION

A fire may occur anytime at any place irrespective of its occupancy status. Fire in any occupancy has the capability to cause damage to its occupants and severe damage to property. Approximately, in India, every year, about 25,000 persons lose their lives due to fires and related causes [1]. Out of them, about 66% of those are female. It is estimated that roughly 42 females and 21 males die every day in India because of fire. These deaths could have been avoided with the help of protective measures. No comprehensive and reliable data is available in India on the economic losses suffered due to fire. However, according to one estimate the major losses reported by the Indian Insurance Companies over the years indicate, that about 45% of the claims reported are due to fire losses. Based on another estimate about Rs.1000 crores are lost every year on account of fires. According to India Risk Survey, 'Fire' climbs 3 places to attain the No. 9 position in the Risk Ranking in 2015[2]. Major reasons for fire threats are because of non-compliance to safety norms and non-renewal of safety licenses, existence of poor infrastructure obsolete equipment and lack of preparation, plus non-up-gradation of skills of firemen even increases the threat. In India, against 70,868 fire stations required as per the norms of Standing Fire Advisory Council, only 1,705 Fire Stations exist. So, firstly there is shortage of 97.59 per cent fire stations, secondly 96.28 per cent firemen and 80.04 per cent fire tenders and rescue vehicles. In India, urban fire services lack 72.75 per cent in fire stations, 78.79 per cent in man power and 22.43 percent in firefighting and rescue vehicles [2].

Since fire is unavoidable at times, it is highly recommended to detect it as early as possible. There are many ways of doing this. Traditionally, various sensors are used. But their accuracy depends upon various factors such as position. If it is too far from location of fire, then it will be detected in later stages or may fail to detect. Also, sensors increase the cost of the system [7].

So, an alternate system based on image processing can be used to detect fire at very early stage. With the help of camera, continuous images can be captured and with the help of image processing algorithms those images can be checked for presence of fire. Then with the help of the electromechanical system, fire can be extinguished by reaching to its location by sprinkling water. In this way, fire can be extinguished selectively, preventing the damage to the unaffected areas. That is why the system proposed is cost effective and accurate [7].

II. LITERATURE SURVEY

Many fire detection techniques are available. Traditionally, system based on sensors is used to detect fire. There are various types of sensors are used in these systems such as heat, smoke, flame and particle [3]. There is different response speed associated with each of them. There are other parameters such as false alarm rate, cost and application areas are also associated with it. Other than traditional techniques, researchers also worked on image processing techniques to detect the fire. All these techniques to detect fire are summarized in the TABLE I.

Considering the various parameters as well as the cost constraints it is recommended to avoid the use of sensors in the fire detection procedure and make use of image processing technology as it has various advantages and is getting popular rapidly.

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TABLE I: SUMMARY OF FIRE DETECTION METHODS

Sr. No.	Authors	Techniques used	speed	False alarm rate	Cost	Application
1.	Richard W. Bukowski [3]	Heat sensor	Slow	Low	Low	Confined spaces
		Smoke sensor	Fast	Medium	Medium	Open or confined spaces
		Flame sensor	Very fast	High	High	Flammable material storage
		Particle sensor	Fast	Medium	High	Open spaces
2.	C. Emmy Premal and S.S. [4]	YCbCr model	Very fast	Low	Low	Open spaces
3.	Jeenarat S., S. Praising and P. Riyamongkol [6]	YCbCr + HSV model and motion detection	Very fast	Low	Low	Confined spaces

Image processing based forest fire detection using YCbCr colour model is used by C. Emmy, Premal et.al [4]. Their method adopts rule based colour model because of its less complexity and effectiveness. YCbCr colour space effectively separates luminance from chrominance compared to other spaces like RGB and rgb(normalized RGB). Since YCbCr colour space [5] separates luminance from chrominance, hence it is robust to changing illumination than other colour spaces like RGB and rgb (normalized RGB.In [6], a fire detection system based on light detection and analysis is proposed. This system uses HSV and YCbCr colour models with given conditions to separate orange, yellow, and high brightness light from background and ambient light. Growth of the fire is analysed and calculated based on frame differences.

III. METHODOLOGY

The block diagram shown in Fig. 1 gives the overview of the system. In this, each block represents operation at every stage.

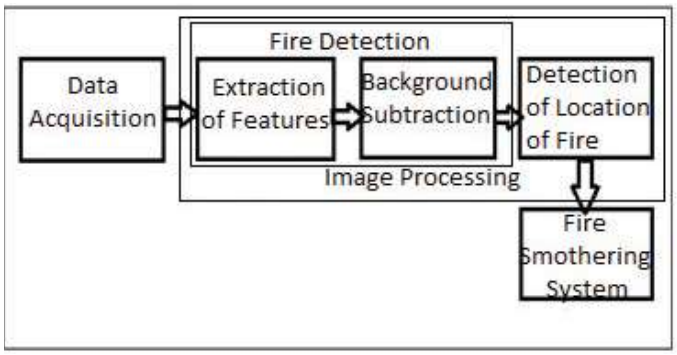


Fig. 1: Block diagram of the system

In the first section, data is captured using CCTV camera. According to the requirements type of the camera is chosen. The camera captures continuous images and then sends it to the next block to perform further image processing. In the next section, fire pixels are detected in the captured images in the first section if any. Here, MATLAB is used. In most cases MATLAB supports image processing tools.

The rule based algorithm is used to detect the fire pixels in the extracted data. Flow chart of the algorithm is shown in Fig. 2.

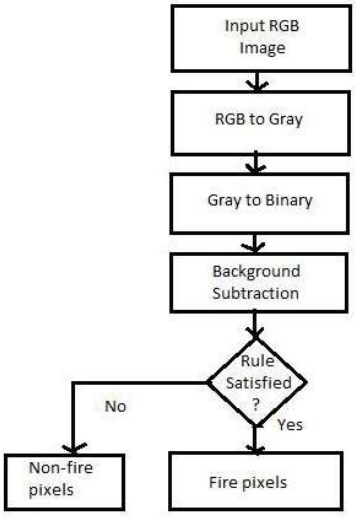


Fig. 2: Rule based algorithm

In this algorithm, a RGB image is taken and converted into gray scale image. Then the obtained gray scale image is converted into binary image. After this, background subtraction is done where the pixels other than suspected fire pixels are eliminated. Then to detect whether the suspected fire pixels are actually fire pixels or not, a rule is formed.

According to the rule, in that binary image, closely connected pixels or blobs are searched. Then property of that blob such as area is obtained. All the blobs are numbered. Then if the area of the blobs is greater than say 500, then the

blobs are considered as fire pixels otherwise they are non-fire pixels.

Once the fire is detected, the location of the fire is identified. This will be helpful to smother the fire fastidiously with the help of the electro-mechanical system. Here, tracing of the location is done by taking into account the number of pixels captured by the camera and the actual physical area that camera is capturing. Then, location of pixel is calculated in cm or meter.

In the final section, the fire is smothered by using water. The area of fire location is selected which is determined in the previous section. A DC and stepper motor based mechanical system which will be controlled by the PIC controller based system. In this way, the fire is smothered in the shortest possible time.

A. Hardware

To make a prototype of the whole system, a laptop or a pc with the desired software is needed. For fire smothering, an electro-mechanical system is needed which will extinguish the fire selectively by reaching the location of the fire. So a DC and a stepper motor are needed for that. To run these stepper motors, a micro controller based circuit is needed.

B. Software

For the major part of the project, image processing tool, MATLAB is needed to detect fire and locate it. Then in the last part of the project, for controller based circuit, a software programming tool is required e.g. MPLAB and a compiler.

With the help of the above hardware and software, system reaches out to the location of the fire and smothers it with the help of water sprinkler. The whole working of the system can be divided into three modules for convenience. The complete flow of system is shown in Fig. 4.

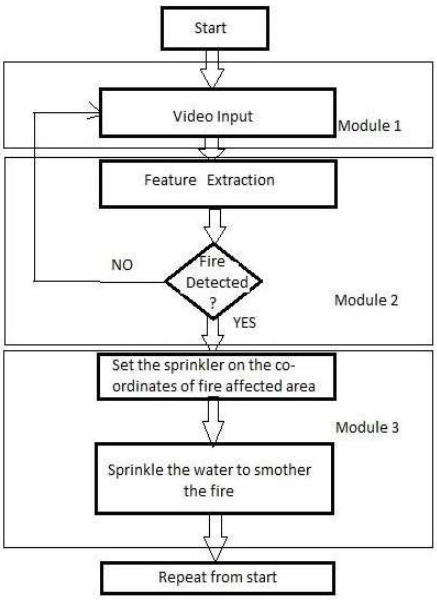


Fig. 4: Flow chart of the system

In module 1, various ways of collecting data are dealt. Since, image processing tools such as MATLAB are used here, it is important to extract better quality and proper frame rate for accurate analysis. More than one camera can be integrated depending upon the requirement of the place. Video cameras can be integrated or interfaced with many other techniques such as USB, Wi-Fi, and Bluetooth etc.

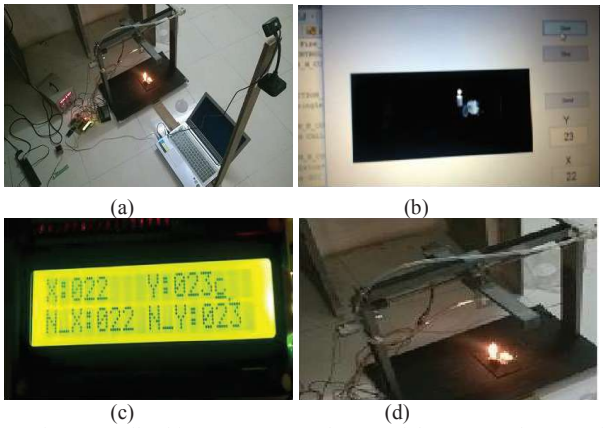
In module 2, analysis of every frame obtained is done frame by frame by image processing tool. These frames are checked for availability of fire pixels, detection of motion and availability of smoke pixels. If fire is obtained then location of it is traced. If all the above things are found then only module 3 comes into action.

In module 3, it contains pure hardware operation to extinguish the fire. Co-ordinates of the location of the fire are obtained from previous module then accordingly with the help of motor drivers water sprinkler is positioned just above the detected location of the fire and fire is extinguished.

IV. RESULTS

To test the working of the proposed system, various cases are considered such as small cabin, long hall and covered parking. In each of these cases, subcases such as low, medium and high brightness are considered. In addition to that, in each subcase, distance of the object is also considered such as near to camera and far away from the camera.

Fig. 5 shows the case of small cabin. In this case, all the above subcases and combinations of conditions are tested. Fig. 5(a) displays the actual setup of the system containing electro-mechanical assembly, a laptop and camera.



(a) (b) (c) (d)

Fig. 5: Small cabin case, (a) Actual setup of the system, (b) GUI of fire detection, (c) LCD screen displaying co-ordinates (d) Sprinkler reaching to fire location

Fig. 5(b) shows GUI displays the detection of the fire and exact location of fire. It displays the co-ordinates of fire calculated by image processing and Fig. 5(c) displays the situation when the co-ordinates of sprinkler become equal to co-ordinates of fire. Fig. 5(d) displays the condition when the sprinkler has reached to desired location. In this way, all the cases are tested with all possible combinations of conditions. Experimental results of the system considering the small cabin case are shown in TABLE II.

TABLE II: EXPERIMENTAL RESULTS

Case	Brightness Level	Location of fire	speed	Actual condition of fire	Fire detected by system	False detection of other object as fire
Small cabin	Low	Near camera	Fast	Yes	Yes	No
		Far from camera	Fast	Yes	Yes	No
	Medium	Near camera	Fast	Yes	Yes	No
		Far from camera	Fast	Yes	Yes	No
	High	Near camera	Fast	Yes	Yes	No
		Far from camera	Medium	Yes	Yes	No

As shown in the TABLE II, a case of small cabin is considered, fire is detected in all the cases without a false detection. The subcases which are considered are low, medium and high brightness level. Plus in each subcase there are two situations such as near camera and far away from camera.

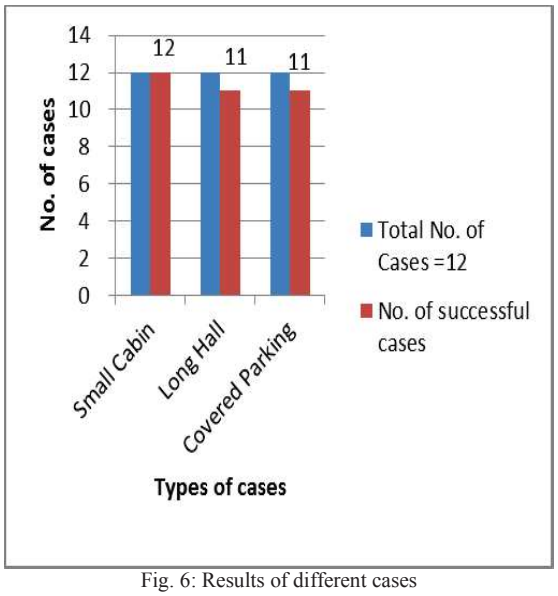


Fig. 6: Results of different cases

Similar to the above case, other cases such as covered parking and long hall are considered. In each of these cases, false detection is found only in the particular combination of high brightness and far away from the camera. Otherwise fire is correctly detected in each combination of environment.

Fig. 6 shows the results of different cases. In small cabin case, in 12 out of 12 cases, desired results were obtained. But in other two cases, in 11 out of 12 cases, desired results were obtained.

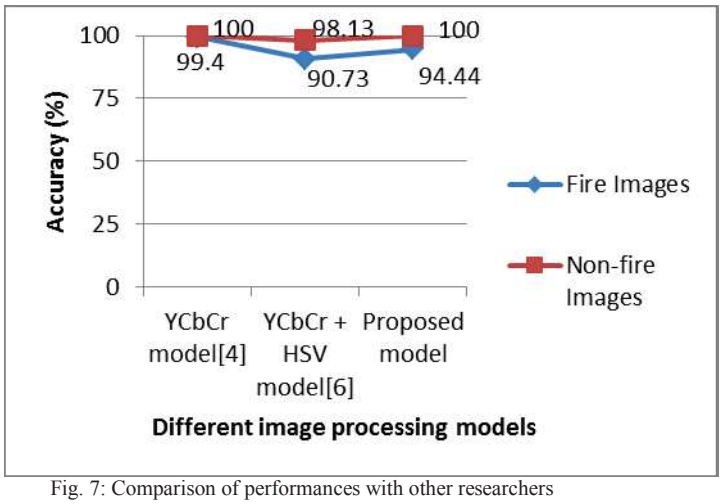


Fig. 7: Comparison of performances with other researchers

Fig. 7 shows the comparison of proposed image processing model with other models in terms of accuracy (%). In fire images, accuracy of YCbCr model and YCbCr + HSV model is 99.4% and 90.73% respectively. The accuracy of proposed model is 94.44%.

In non-fire images, accuracy of YCbCr model and proposed model is 100%. Accuracy of YCbCr +HSV model is 98.13%.

V. CONCLUSION

It can be concluded from the experiments performed on the proposed system, that it is much more effective than the traditional purely sensor based systems in terms detection speed, fire detection and rate of false detection. Its accuracy is 94.44% as false detection is found in very few combinations of conditions. As seen in results, in high brightness areas where the camera is located far away from the location of fire, there is a possibility of false detection of objects. But as far as extinguishing is concerned, it is approximately accurate as whenever fire is detected, it is smothered every time.

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