EXPERIMENTAL INVESTIGATION OF THE EXISTING FIRE SURVEILLANCE RESEARCH AND DEVELOPMENT OF A ROBUST FIRE DETECTION SYSTEM

[1]Ashik Raheem G M

[1]Student, Department of Mechanical Engineering, PSG College of Technology, Coimbatore, India.

ABSTRACT

Fire surveillance has always been a significant research topic in safety engineering. With the rapidly emerging technology, many developments in the fire detection system have been made. There are two prominent types of fire detection systems generally used: (a) Multi – sensor-based fire detection system (b) Motion analysis and video-based technique. These two methods have many subdivisions, differing in the proposed mechanisms. The first part reviews different detection systems proposed to date and assesses the associated mechanisms. Overall it is shown that, despite the literature published in the fire detection systems, there are major data gaps in the development of an optimal system. This points to a need for a strategically planned algorithm for the fire detection system. The second part focuses on developing a multi-criteria algorithm for fire detection. Unlike the prior works done, the proposed system makes use of the optimality of various fire detection systems proposed, and a highly accurate, fail-proof algorithm is developed.

Index Terms: Multi-sensor, motion analysis, multi-criteria, fail-proof.

1. INTRODUCTION

Fire disaster has always been a huge threat to lives, and also causes extensive damage to property. So there arises a need for fire alarms, providing real-time monitoring, surveillance and auto – alarm system. Considering the timeline of the 1800s the fire detection system was invented, there has been a dearth of fail-proof development of the system. Conventionally, when a single sensor system was used, it was likely to be affected by the ambience, leading to false alarms and also malfunctioning. The use of multi-sensor algorithms have been proposed in many theories and few applications were developed using the same over the past two decades. But, most of these applications fail to meet the two objectives of the system: (a) No false alarm should take place (b) No overlooking of fire detection by the system to alarm.

2. OBJECTIVE

The prime objective is to develop a system bringing together the optimality of various systems proposed. This system considers the various necessities proposed in different theories and is developed optimally, taking the consideration of (a) time required for detection and alarm (b) area to be covered in detection (c) avoiding false alarms (d) differentiating the emergency of fire using GSM (e) record the source of fire with precise time and location (f) feasible cost to develop the system.

3. EXISTING SYSTEM

The existing system for fire surveillance research in a generalized overview is as follows:

3.1 Wireless Sensor Networks

Wireless sensor networks make use of ‘repeaters’ to relay information from detector to surveillance centre. The algorithm consists of a huge number of detectors and repeaters (10000) to cover a large area [1]. The system is generally similar to a hierarchical tree structure. The detectors are deployed in many locations. A detector consists of a flame sensor and / or a temperature sensor, being sensitive to fire and flame spectrum. The output may be an analogue resistance, attached to a load resistor. The change in resistance is used as the input for the microcontroller. These detectors monitor their local area and report it to the repeater. These repeaters have two functions: (a) monitor its local area, acting as a detector (b) provide network access for the detector. A local centre aggregates information from many repeaters and reports the monitoring information to the surveillance centre. So when a fire is detected, the information obtained at surveillance centre follows the path: (a) the detector acting as a node (b) the repeater acts as a network address (c) the local centre for the relay. Based on the time reported by a certain detector, it is possible to identify the origin of the fire. But the number of sensors required to increase with an increase in area. And also there have been many reports of false alarms, due to the ineffectiveness of the system

3.2 Motion Analysis Technique

Motion analysis and video-based technique were introduced to overcome the stated inefficiencies of a sensor-based algorithm. The proposed sensors cannot alert the detection until the particle or heat reaches the sensors. Also, there is a plausibility of these sensors getting affected by the stimuli. Hence there arises a need for visual analysis based fire detection system. Flame recognition in video-based technique has been in existence from early 2000 and there have been many developments since. The initial idea of fire detection using vision-based technique consisted of (a) fire pixel detection (b) verification using machine learning algorithms. The main characteristics of the flame are that its shape and size constantly varies depending upon airflow, fire material, and oxygen thickness. Ko et al [2] proposed fire pixel detection following three steps: (a) five coloured pixel detection using unimodal Gaussian to generate and to process RGB probability models, (b) moving pixel detection using frame difference and non-fire pixel removal by analysing the frame difference and temporal luminance using a luminance variation map, (c) fire pixel verification using Support Vector Machine (SVM) and notification. Jagathisan et al [3] made use of a Gaussian blur format in which it converts RGB to HSV (Hue Saturation Value) and then to Gray Scale Format. When the loop value based on Gray Scale Format increases beyond the specified limit, a fire alarm is actuated. A PIR sensor is used to record only when a fire is detected for efficient data storage. Truong et al [4] identified the shortcoming of the then existing research in video-based smoke detection. Their research proved to eliminate the limitations of (a) colour filter based technique applied to smoke colour attributes, (b) smoke alarm based on few smoke features [5]. Their proposed method consists of a combination of static and dynamic features of colour smoke with the KNN algorithm. The KNN algorithm sorts out the best possible candidate region of fire, based on the various inputs obtained. But the system could not meet the first objective of raising false alarms. Ting et al [6] proposed a data fusion based detection through Dempster Shafer theory. The proposed system enhanced reliability and avoided false alarms. According to this system, the sensor data of light, smoke and temperature are the input to Arduino, which is then transferred to Raspberry Pi. It processes the data based on the Dempster Shafer theory to deduce whether the fire has occurred.

4. PROPOSED METHOD

4.1 Data Measurement

The proposed system makes use of all the aforementioned systems, forming a compact, fail-proof design. The experimental setup consists of two phases – the data measurement phase and the response phase.

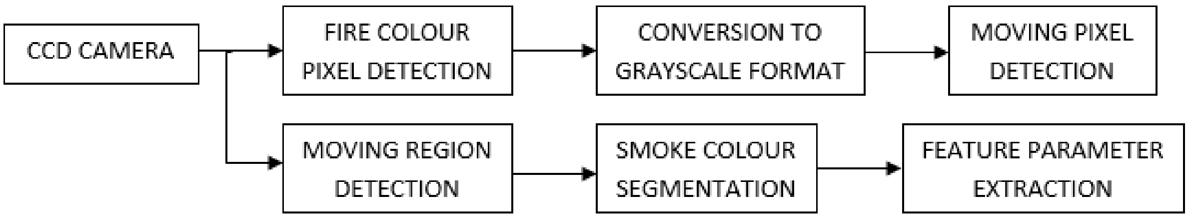

Fig.1 Data measurement system

The data measurement phase is the initial phase to sense the input parameters, convert these parameters into a meaningful format for further processing in the next phase. The design of experiments for the first phase consists of two methods. The first method is based on the work of Jagathisan et al [3], wherein the pixels are converted to grayscale format, by which it aids the system to focus only the fire. In addition to this, it was also found to provide the advantage of reducing the time complexity to O (n). The signals of the focussed pixels are then fed into the moving pixel detection system. The second method is based on the work of Truong et al [4], wherein the moving region is detected and the smoke parameters are taken into consideration. As proposed in their work, the parameters of smoke colour concerning temperature, and the usage of RGB equations to result in a smoke image are considered to extract the feature parameters of fire. The data extracted as a result are tested in the next phase for their accuracy.

4.2 System Architecture

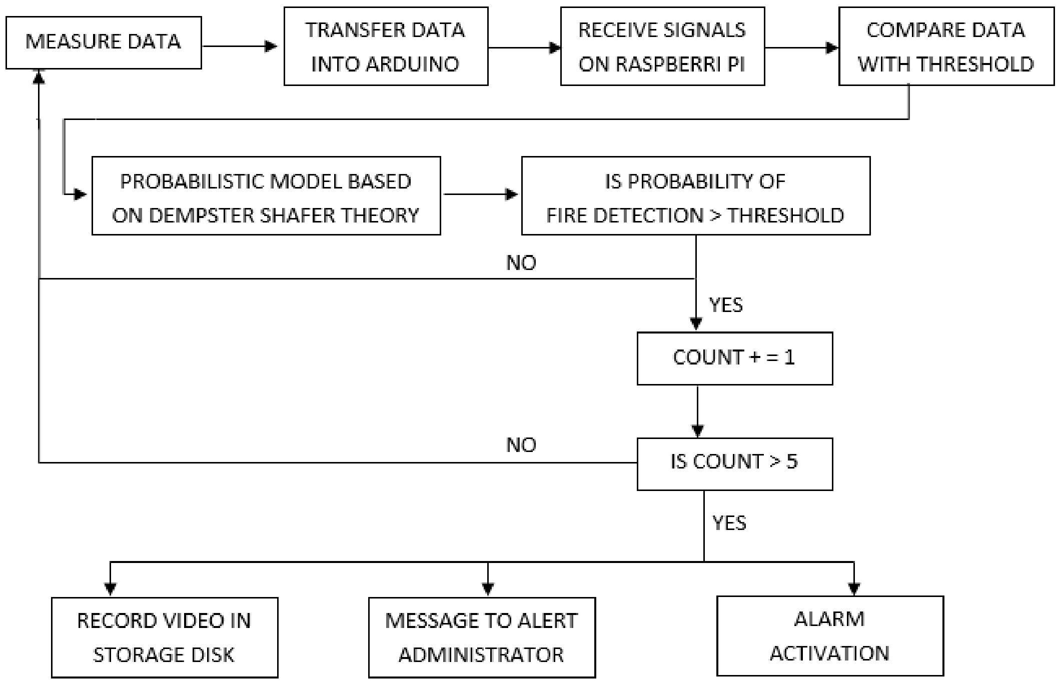

Fig.2 System architecture

The procured data is then processed through Arduino. The threshold values are fixed for the two methods in the first phase. For the smoke sensor, the threshold value is set as ‘100’ provided in the range of 0 to 255. For the light sensor, the threshold value is ‘100’ during night time and ‘165’ during daytime for fire detection. From the research work of Ting et al [6], we deduce the probabilities for the smoke sensor and light sensor as mentioned in the derived equations. When the combined probability exceeds the specified threshold limit, the counter increases the count by one. When the count increases beyond 5, the alarm is activated. Then the camera is actuated to record the videos by Raspberry Pi, before which it will be in the idle state without capturing [7]. The alert is also sent to the administrative authority through the GSM.

5. RESULTS AND CONCLUSION

A wide array of determinants are made use of for efficient detection. As these determinants are mutually exclusive of each other forming a frame of discernment, the reliability of the system is quite high. The implementation of this model satisfies the aforementioned objectives. An accuracy of 98% during daytime and 95% during night times is observed, contributing to overall accuracy achieved as 96%. This is one of the highest accuracy achieved in fire detection systems to date without raising false alarms. The current system developed leads to the future work of more efficient computation and a more compact, feasible system.

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