Wireless Fire Detection and Evacuation System

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Abstract— Fire is a disaster which causes huge loss to human life and infrastructure. A technique is needed that would not only detect fire and the hazardous gases released due to fire, but also determine the cause of the fire outbreak. This would be achieved via a fusion of two technologies - Image processing of data obtained from the cameras, and Wireless Sensor Network. Moreover, detection must be accompanied by evacuation for curbing the loss. The evacuation technology consists of a shortest and safest path depicting algorithm which would accordingly trigger emergency lighting system that will help people evacuate the premises.

Key words: Evacuation System, Wireless Fire Detection

I. INTRODUCTION

Fire detection systems are nowadays installed in almost every corporate and residential structure. It has been observed that a fire breakout doesn't occur so often, yet, when it occurs, even once or twice, it consumes life as well as property. In such a scenario, the installation of fire detection and evacuation systems would help in curbing the disaster to a considerable level.

Present day fire detection systems use one of the following technologies – conventional sensors based approach, image processing techniques (smoke and flame detection), infrared imaging, ultraviolet detection, optical fiber application, wireless sensor network, controller area networking, adaptive sensory fusion method or probabilistic neural network.

These technologies although, do not offer detection of parameters associated with fire detection, such as – cause of the fire, fire flame, smoke and the gases released due to fire. Hence, a fusion of the two technologies - Image Processing and Wireless Sensor Network can be implemented to detect all the above mentioned parameters.

Apart from this, detection of fire would only let us know about the occurrence of fire. In order to curb fire and evacuate the people from the affected region, fire detection systems must also incorporate immediate evacuation program. This is because, in India, there's a lack of proper planning and crowd management is not efficient.

II. LITERATURE REVIEW

Lei Zhang and Gaofeng Wang suggested in "Design and Implementation of Automatic Fire Alarm System based on Wireless Sensor Networks [1]" that wireless sensor networks are more reliable as compared to wired network of sensors. The initial cost of installation is greatly reduced and these devices are lesser prone to damage. Moreover, they suggest a communication link between the nodes and the base station via repeaters followed by local servers covering a limited area. The information from this server is transmitted to the base station through wired networks.

According to Alberto De San Bernabe Clemente, José Ramiro Martínez-de Dios and Aníbal Ollero Baturone in "A WSN-Based Tool for Urban and Industrial Fire-Fighting [2]", mobile WSN nodes are employed along with static ones. This ensures greater speed of communication. Also, the mobile nodes are carried by firefighters which ensure continuity of transmission of information even when static nodes are damaged due to fire.

Byungrak Son, Yong-sork Her, and Jung-Gyu Kim suggest in "A Design and Implementation of Forest-Fires Surveillance System based on Wireless Sensor Networks for South Korea Mountains [3]" that a number of Micro Electro Mechanical Systems MEMS can be deployed over a geographical area through which the data is sent of the affected region, to the base station where it is stored in middleware.

Sanjit Kumar Dash, Subasish Mohapatra and Prasant Kumar Pattnaik suggest in "A Survey on Applications of Wireless Sensor Network Using Cloud Computing [4]" that the data acquired from the nodes can be stored on the cloud. This data can then be accessed from any location. Also, the large storage capability of cloud allows huge amounts of data to be stored.

In "Computer vision based method for real-time fire and flame detection [5]", authors suggest that image processing can be used as the acquisition of video frames can be done without pre-installation cost. They carried out fire detection by determining moving pixels of the frame and checking the color information of those pixels with the fire color values. This is followed by wavelet analysis and spatial domain is then carried out to determine high frequency activity.

Supriya Bhargava and Anand Vardhan Bhalla suggest in "Performance Improvement of Vision Based Fire Detection System [6]" that fire can be analyzed in a frame by edge detection, color detection followed by motion detection, gray scale detection and area detection. The outputs are then applied to AND/OR operators to check for fire. Depending on the area sensitivity, operator can be programmed.

According to Turgay Çelik, Hüseyin Özkaramanlı, and Hasan Demirel in "Fire and Smoke Detection without Sensors: Image Processing Based Approach [7]", color detection is solely used to determine flame and smoke characteristics of fire pixels. RGB and YCbCr models are used as the color models.

S. P. Kale has suggested in "Novel Technique for Fire detection [9]" that fire can be determined by using color detection, edge detection and motion detection.

Kumarguru Poobalan and Siau-Chuin Liew suggested in "Fire Detection Algorithm Using Image Processing Techniques [10]" that segmentation techniques can be used to detect fire. RGB color model is converted to HSV model. Simultaneously, edge detection is applied to RGB image and the two results are combined. Then segmentation technique is used.

III. PROPOSED TECHNIQUE

The block diagram of the proposed technique is shown in Fig. 1 Fire would be detected simultaneously using two units – wireless sensor networks and the image processing unit.

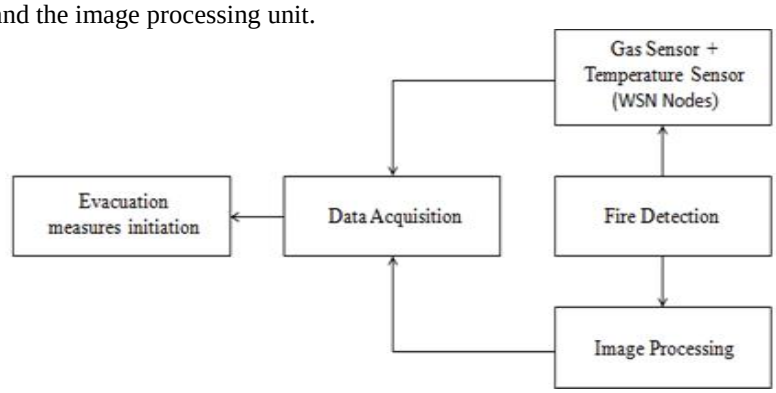

Fig. 1: Block diagram of the Detection and Evacuation Technique

It has been analyzed that wireless sensor network (WSN) normally consists of smoke sensors. But, when the sensors are deployed at various locations, they might get damaged due to fire after certain interval. Thus, WSN nodes consisting of temperature sensor are proposed to be used to measure the variations in room temperature. In addition to this, a gas sensor would be used to detect hazardous gases released due to fire. This is because; many people lose their lives when exposed to high concentration of these gases, apart from the fire conditions. The temperature of the fire flame and the gases liberated would thus be detected by the nodes. Followed by this, the data would be sent to the base station where the storage would be done on the cloud to achieve accessibility from any region.

Image processing was solely used as a technique to detect fire. It led to detection of larger areas and supported real time constraints, when compared to WSN technology. However, this technique provides detection of flame and smoke just when fire outbreak occurs and most of the time works well than WSN technology to detect fire. But to detect the gases released due to fire or gases (such as hydrocarbons) which might cause fire, WSN consisting of gas sensors may successfully lead to prevention of fire outbreak.

Moreover, another parameter of fire can be determined only when a fusion of the two technologies is used – cause of the fire. It is necessary to determine the cause of the fire because different types of fires are generated depending on the causes. These mainly differ in terms of the color of the flame and smoke. Thus image processing would help us in determining the type of fire based on color detection.

Thus, a technology that incorporates detection at every possible stage and determination of the cause of fire outbreak is proposed to be implemented, by using a fusion of the two technologies – Image processing and WSN. Apart from this, it is evident that detection though provides information about fire, but there's also a need of evacuation that must have technology as a fragment.

IV. DETECTION TECHNIQUE

A. Wireless Sensor Networks (WSN)

A wireless sensor network consist of units equipped with sensors, microcontroller, radio transceivers that cooperate to form fully connected network of a sensor node unit. The wireless nodes are basically autonomous devices, which are often battery powered that ensures uninterrupted and reliable sensing, processing and communication. Sensor helps in sensing environment parameters as desired and converts the sensed data into an electrical signal. The sensed data is sent via radio transmitter to an intermediate node (acting as a sink to server) or directly to the server.

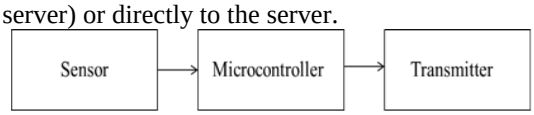

Fig. 2: Block diagram of the node

Fig. 2 shows the block diagram of a node. In a node, data is sensed from the sensors and video processing devices. Here sensors and video processing devices are synchronized with the microcontroller. Data is formed as packets and then sent to the server using transceiver. Here transceiver acts as transmitter.

Fig. 3: Block diagram of the Base Station

Fig. 3 shows the block diagram of the server. On the server side, the transceiver works as receiver to receive sensor data packets. Using TCP/IP and http protocol internet access is given to the microcontroller. Data is then stored on the cloud so that the person monitoring can have access to the data through wireless network by taking remote of the data.

B. Image Processing Unit

Image processing technique is used along with WSN as it ensures greater reliability. Installation cost of such systems is low as CCTV cameras are nowadays installed in most of the areas. The image processing techniques are robust, thus ensuring low sensitivity to false alarms. Moreover, these systems cover a broader area of surveillance.

Fire can be detected based on various characteristics such as - color, motion, shape and intensity of both fire flame as well as smoke. There are two important attributes which would be analyzed – flame and smoke because during the daytime smoke is always associated with fire and becomes quickly visible. At night, the visibility of smoke decreases but the detection capability of fire flames becomes high.

Fig. 4 shows the overall process of the image processing unit. Firstly, video frames or images of the area under surveillance would be obtained through cameras at the server region. These frames will undergo pre-processing, that is color models will be generated following which color detection and edge detection will be carried out. If fire flame or/and smoke is detected, the frames are further sent for processing for a thorough analysis. Another set of image processing techniques are applied on each frame – motion detection, grey scale pixel detection and area detection.

Through these techniques, precise information is obtained about the area affected due to fire and intensity of fire. Following the application of these techniques, each frame is sent to an operator that checks for the 3 results of the techniques. The operator sensitivity can be programmed depending on the characteristics of the area being analyzed, as in [8]. Once there is a through confirmation of fire detection of the frame analyzed, the next frames are analyzed one by one in a similar manner. In case there are 80% or more frames detected for fire, evacuation measures would be initiated.

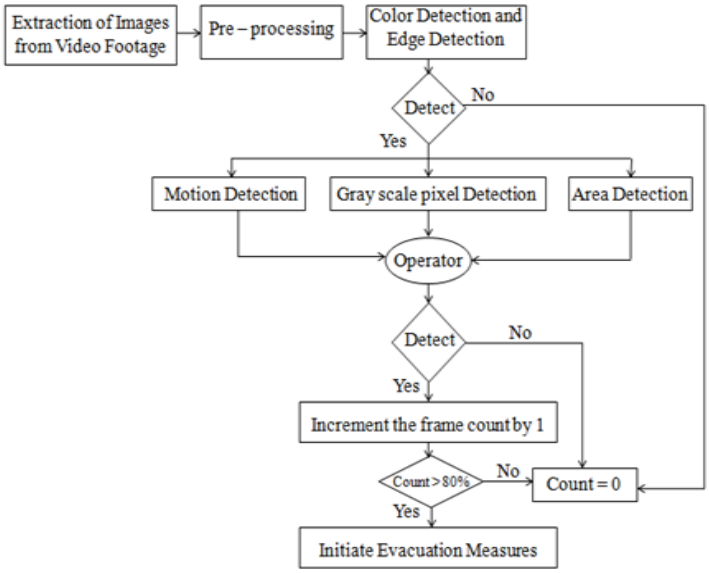

Fig. 4: Process flow of image processing unit

V. EVACUATION TECHNIQUE

A building layout is complex and evacuation during a fire emergency is a critical element. Using conventional devices such as sirens often does not have the desired and accurate effect. They implicitly assume that it is a false alarm – an assumption that can be fatal. Moreover, traditional exit signs always indicate a specific direction and may sometimes lead people to the site of fire outbreak.

Thus, evacuation technology must be more robust medium. An algorithm that provides an efficient solution supporting real time stringent conditions can be implemented along with traditional alarms and visual indication units. This would provide a shortest and safest path for evacuation.

VI. CONCLUSION

The integration of WSN and image processing would provide a precise approach for detection of cause of the fire and other important parameters of fire. It ensures sensing and monitoring of fire accurately. Information is available at real time and all time accessible configurations via any location through Internet or wireless network. In future, in the detection system, threshold values can be calibrated depending upon the characteristics of the environment. Also, in evacuation system, a feature can be included to send notification regarding the fire outbreak to the fire department of the region. Moreover, panels indicating

information about the temperature and gases liberated can be installed at the entrance of the building to provide information to fire fighters as soon as they reach the location. This reduces their time to survey the area

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