SURVEY OF VARIOUS FOREST FIRE DETECTION ALGORITHM IN IMAGE PROCESSING AND REMOTE SENSING APPLICATIONS.

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ABSTRACT

Forests are part of the essential and indispensable resources for human survival and social development that protect the balance of the earth bionomics. However, because of some uncontrolled anthropogenic activities and abnormal natural conditions, forest fires occur regularly. These fires are among the most serious disasters to forest resources and the human environment. This paper deals with a review of various fire detection techniques. The existing techniques mentioned in the present review have certain advantages and limitation. Based on this study by analyzing various parameters, we can determine which technique provides an optimum result.

Keywords: *Wireless Sensor Network, Image processing, Remote sensing, forest fire*

Introduction

Fire is one of the leading hazards affecting everyday life around the world. Intelligent image processing techniques for the detection and analysis of fire are relatively new. To avoid large scale fire and smoke damage, timely and accurate fire detection is crucial. The sooner the fire is detected, the better the chances are for survival [1]. Furthermore, it is also crucial to have a clear understanding of the fire development and the location. Initial fire location, size of the fire, the direction of smoke propagation, growth rate of the fire are important parameters which play a significant role in safety analysis and firefighting/mitigation, and are essential in assessing the risk of escalation[2].

Strong combustion not only burns forest and plants on the ground, but also changes forestry structure, forest biology, climate and soil performance. So the forest function of preventing water and soil from being washed away and that of regulating weather both decrease. Meanwhile, the earth's surface becomes bare, and soil temperature increases. Then soil

organisms are destroyed and the former forest area becomes wasteland. Traditional fire detecting technology has some drawbacks which are hardly a solution. On the one hand, Detector must be installed near the fire; otherwise it will not be able to effectively detect the fire. Massive efforts have been devoted to the detection of forest fires before they develop into uncontrollable[3].

Traditional forest fire monitoring and detection methods employing watchtowers and human observers to monitor the surroundings usually require extensive labour forces, are subject to the spatio-temporal limitations, and potentially threaten personnel safety. Along with the new development of technologies, in the past decades, monitoring of forests and detection of forest fires primarily rely on ground fire monitoring systems, manned aircraft, and satellites. However, different technological and practical problems exist in each of these systems[4]. Ground monitoring system is normally fixed in a specific place and may suffer from limited surveillance ranges. Manned aircraft is usually large and expensive; meanwhile, the hazardous environments, harsh weather, and operator fatigue can potentially threaten the life of the pilot. Satellite systems are typically expensive for launching and less flexible for deployment and technology updates; moreover, their spatio-temporal resolutions sometimes may be difficult to meet the requirement of detailed data capture and operational forest fire detection.

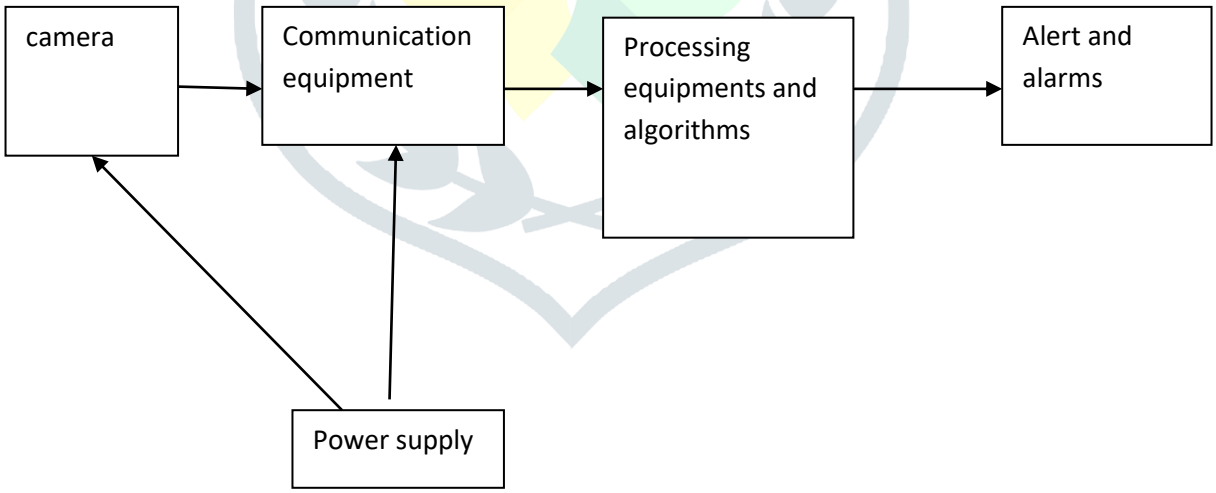

Figure 1-block diagram of image capturing during forest fire detection

The paper analyzes the forest and wild land fires issues with particular reference to South East Asia and emphasizes on development of national and regional fire management plans considering the complexity and diversity of fire. The paper also attempts to assess the current

status of application of satellite remote sensing for fire detection, monitoring and assessment. According to a classification of forest fires by type and causes, three types of forest fires are prevalent [5]

a) Ground fires: Ground fires occur in the humus and peaty layers beneath the litter of under composed portion of forest floor with intense heat but practically no flame. Such fires are relatively rare and have been recorded occasionally at high altitudes in Himalayan fir and spruce forests

b) Surface fires: Surface fires occurring on or near the ground in the litter, ground cover, scrub and regeneration, are the most common type in all fire-prone forests of the country[6]

c) Crown fires: Crown fires, occurring in the crowns of trees, consuming foliage and usually killing the trees, are met most frequently in low level coniferous forests in the Siwaliks and Himalayas (NCA Report, 1976)

Traditional fire protection methods use mechanical devices or humans to monitor the surroundings. The most frequently used fire smoke detection techniques are usually based on particle sampling, temperature sampling, and air transparency testing. An alarm is not raised unless the particles reach the sensors and activate them. Some of the methods are mentioned below:-

A. Fire Watch Tower:

In watch towers human are made to observe the location throughout. If any fire occurs he reports it. However, accurate human observation may be limited by operator fatigue, time of day, time of year, and geographic location.

B. Wireless Sensor Networks:

In a wireless sensor-based fire detection system, coverage of large areas in forest is impractical due to the requirement of regular distribution of sensors in close proximity and also battery charge is a big challenge[7].

C. Satellite and Aerial Monitoring:

Satellites based system can monitor a large area, but the resolution of satellite imagery is low[8]. A fire is detected when it has grown quite a lot, so real time detection cannot be provided. Moreover, these systems are very expensive[9]. Weather condition (e.g. clouds) will seriously decrease the accuracy of satellite-based forest

fire detection as the limitations led by the long scanning period and low resolution of satellites[10].

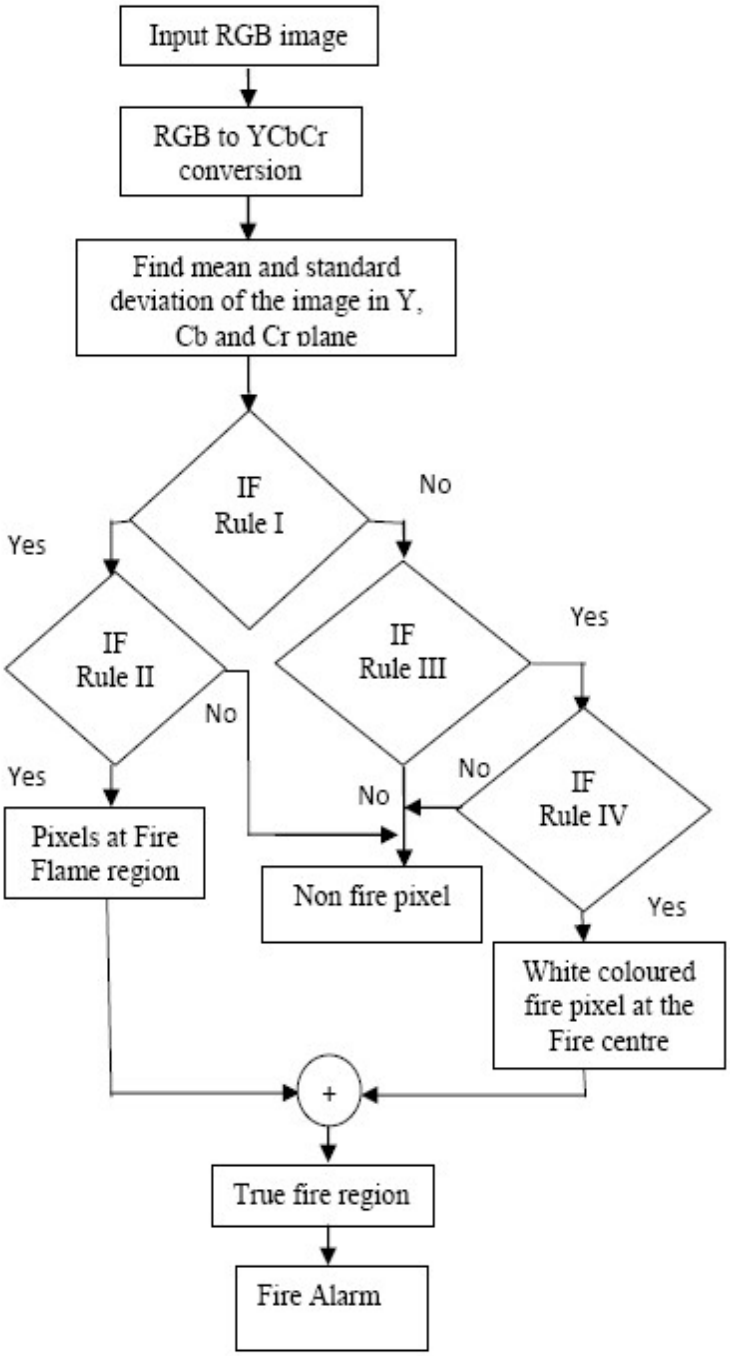

Figure 2. Forest Fire Detection using YCbCr Model

YCbCr Detection Method uses YCbCr color space separates luminance information from chrominance information than other color spaces. The above figure 2 shows the YCbCr model using Forest Fire Detection.

Fire pixel classification

- The color of the fire at the high temperature centre region is white.
- The color of the fire in the region except the centre region is of the color that varies from red to Yellow.

Four Rules are formed

- Rule I and Rule II are used for the segmentation of fire flame region.
- Rule III and Rule IV are used for the segmentation of centre fire pixels (high temperature region)

The motivation for an image processing based approach is due to rapid growth of the electronics; digital camera technology has grown such that cheap CCD and CMOS digital cameras are available in market with decently good resolution. Most of these cameras can be directly connected to the computer and store the captured images to the computer. Computer-vision-based systems which utilize digital camera technology and image/video processing techniques play a very promising role to effectively replace conventional forest fire detection systems.

LITERATURE REVIEW

Chi Yuan (2016) proposed a novel forest fire detection method using both color and motion features for processing images captured from the camera mounted on a UAV which is moving during the whole mission period. First, a color-based fire detection algorithm with light computational demand is designed to extract fire-colored pixels as fire candidate regions by making use of chromatic feature of fire and obtaining fire candidate regions for further analysis. The good performance is anticipated to significantly improve the accuracy of forest fire detection and reduce false alarm rates without increasing much computation efforts [11]

Liqiang Wang (2010) established a new method based using the hidden Markov model (HMM) based on spatio-temporal feature and the variance of luminance map motivated by visual attention, and combining both for fire detection.

The wrong detection can be reduced greatly. Experiment results showed that the proposed method has a good performance and it is robust to be used in complex environment[12].

Xian-Feng Han (2016) motion detection using Gaussian Mixture Model-based background subtraction is applied to extract moving objects from a video stream. Then, multi-color-based detection combining the RGB, HIS and YUV color space is employed to obtain possible fire regions. The experimental results obtained by applying this method on different fire videos show that the proposed method can achieve better effectiveness, adaptability and robustness[13].

Rui Chen(2013) adopted the L*a*b*, YCbCr color space and k-means clustering algorithm to isolate the forest fire detection. This algorithm is characterized by high stabilization and versatility, improves fire detection in real time and accurate, and has been used in the forest fires detecting[14].

T. Celik (2006) proposed a real-time fire-detector which combines foreground information with statistical color information to detect fire. The foreground information which is obtained using adaptive background information is verified by the statistical color information to determine whether the detected foreground object is a candidate for fire or not. The frame processing rate of the detector is about 30 fps with image size of 176x144 which enables the proposed detector to be applied for real-time applications[15].

B. Ugˇur To¨reyin (2006) proposed a novel method to detect fire and/or flames in real-time by processing the video data generated by an ordinary camera monitoring a scene. Color variations in flame regions are detected by computing the spatial wavelet transform of moving fire-colored regions. Another clue used in the fire detection algorithm is the irregularity of the boundary of the fire-colored region[16].

Pavel Chmelar (2004) proposed Gaussian Mixture Models of fire need to be developed in order to decide if an object in a scene is a fire or no. The models are trained using color images in RGB color model.

Two aforementioned color models in a fire detection system to demonstrate the superiority of the HSV color model. It makes hence the recommendation of using the latter model in vision based fire detection systems[17].

Bosch (2013) proposed the evolution of multi-sensor wireless network systems in the early automatic detection of forest fires. To determine the presence of a forest wildfire, the system

employs decision fusion in thermal imaging, which can exploit various expected characteristics of a real fire, including short-term persistence and long-term increases over time[18].

Liu Longshen (2011) designed embedded forest fire monitoring system based on machine vision. According to the bulky, high cost and interfered seriously of present forest fire monitoring system, Liu et al. designed the embedded forest fire monitoring and positioning system based on machine vision. Users can adjust the system parameters by positioning system or held terminal to work more efficiently, acquire needed image[19].

N. Vasyukov (2014) designed to implemented the forest fire early recognize system based on the image analysis algorithm. He described a principle of development of some forest image analysis algorithms proposed for implementation in forest fire early detection systems. Reduction of false alarm probability without damage to right detection probability is provided by automated finding a sky locality (it definitely cannot contain fires) and including sky locality into a dead zone. Application of the described geometric transformation together with image intensity aligning procedure improves segmentation quality [20].

Toreyin (2007) detect flames in LWIR by searching for bright-looking moving objects with rapid time-varying contours. A wavelet domain analysis of the 1D-curve representation of the\ contours is used to detect the high frequency nature of the boundary of a fire region. In addition, the temporal behavior of the region. is analyzed using a Hidden Markov Model (HMM). The combination of both spatial and temporal clues seems more appropriate than the luminosity approach and, according to the authors, their approach greatly reduces false alarms caused by ordinary bright moving objects [21].

Tian Qiu, Yong Yan and Gang Lu (2009), a flame edge-detection method has been developed. The identification of fire edges is the process of determining a boundary between the area where there is thermochemical reaction and those without. First the algorithm detects the coarse and superfluous edges in a fire image and then detects the edges of the fire and removes the irrelevant artifacts. This flame edge-detection algorithm can contribute to the in-depth understanding and advanced monitoring of combustion flames. Also, the algorithm provides a useful addition to fire image processing and analysis in fire safety engineering[22].

C. Yu, Z. Mei, and X. Zhang(2013), A real-time video fire flame and smoke detection algorithm method has been developed. Optical flow and foreground image accumulation techniques are used to detect smoke and flame in real-time. There are two cases for wrong fire detection, first is object with fire like reddish color and second might be that the background with illusion of burning fire, solar reflections, and artificial light. So to overcome this drawback, this paper used the key to distinguish between smoke and smoke colored and flame and flame-colored objects is their physical movement[23].

Liyang Yu, (2016) proposed forest fire node based detection system consists of a vast amount of inexpensive and small sensor nodes. Compared with the satellite imagery based approach, our design can detect forest fire more promptly and forecast the forest fire danger rate accurately[24].

Martin Mueller(2013) proposed two novel optical flow estimators, optimal mass transport (OMT) and Non-Smooth Data (NSD). The dynamics of fire have motivated the use of motion estimators to differentiate fire from other non-fire object. The obtained moving region provides useful space on which to define motion features. These features reliably detect fire and reject non-fire motion, on a large dataset of videos. There is a chance for false detections in the presence of significant noise, partial occlusions, and rapid angle chang[e25].

Ahmad A. A. Alkhatib (2014) will summarize all the technologies that have been used for forest fire detection with exhaustive surveys of their techniques/methods used in this application. A lot of methods and systems are available in the market and for research. The paper reviews all the methods and discusses examples of research experiment results and some market product methods for better understanding.

Result: Each technique has its own advantages and disadvantages. Full discussions provided after each type. A full table is provided at the end to summarize a comparison between the four methods[26].

Priyadarshini M Hanamaraddi (2016), In the image processing based forest fire detection using YCbCr colour model, method adopts rule based colour model due to its less complexity and effectiveness. YCbCr colour space effectively separates luminance from chrominance compared to other colour spaces like RGB. The method not only separates fire flame pixels but also separates high temperature fire centre pixels by taking in to account of statistical parameters

of fire image in YCbCr colour space like mean and standard deviation. The author[27] presents a literature study on Image processing for forest fire detection.

COMPARISON TABLE WITH VARIOUS PARAMETERS:

author	Proposed method	accuracy	adaptability	Computational cost	complexity
Chi Yuan et al	color-based fire detection algorithm	high	less	moderate	less
Liqiang Wang et al	the hidden Markov model (HMM) based on spatio-temporal feature	moderate	high	less	more
Xian-Feng Han	Gaussian Mixture Model-based background subtraction	high	Very high	moderate	high
Rui Chen	L*a*b*, YCbCr color space and k-means clustering algorithm	Very high	moderate	Very low	low
T. Celik	a real-time fire-detector using adaptive background information	Low	high	moderate	Very high
B. Ugˇur	spatial wavelet	moderate	Very high	low	Very low

To¨reyin	transform of moving fire-colored regions				
Pavel Chmelar	Gaussian Mixture Models	high	low	Very low	moderate
Bosch	fusion in thermal imaging	Very high	high	moderate	low
Liu Longshen	positioning system based on machine vision	Very low	low	moderate	Very high
N. Vasyukov	image analysis algorithm	moderate	high	Very low	moderate
Toreyin	a Hidden Markov Model (HMM)	low	Very low	high	low
Tian Qiu	edge-detection method	moderate	Very high	moderate	moderate
C. Yu, Z. Mei	real-time video fire flame and smoke detection	Very high	moderate	Very low	low
Liyang Yu	forest fire node based detection system	high	Very high	moderate	low
Martin Mueller	Two optimal operators: optimal mass transport (OMT) and Non-Smooth Data (NSD)	Very low	low	Very high	moderate

Conclusion

Through this review paper we have studied different techniques which were involved in detecting forest fire. A system to detect fire and alarm the people before it breaks out is a need to our environment. With the help of these techniques, we need to develop some less expensive technique in order to detect forest fire accurately. When the forest environment happen mutation, the system can find in time, take alarm, and take measures to reduce losses. Reduction of false alarm probability without damage to right detection probability is provided by automated finding a sky region (it definitely cannot contain fires) and including sky region into a dead zone.

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