Research and Applications: Embedded System
Volume 2 Issue 3
DOI: [To be assigned]

A Review on Forest Fire Detection

Jijitha R.*, Shabin P.
M-Tech Signal Processing, Department of ECE, College of Engineering, Thalassery, Kerala, India
****Corresponding Author***
E-mail ID**: **jijithar456@gmail.com

ABSTRACT

Forest are considered as one of the most important and indispensable resources. The common hazards in forest are forest fire. It causes great harm to the forest and result a very serious economic loss. In order to prevent the natural resources and human safety and property. Early detection in forest fire can be significant impact on the control of forest fire. Many forest fire detection techniques have been proposed by different researchers. There are so many techniques to detect the occurrence of forest fire. A fire detection method for the application of UAV-based forest fire surveillance using IR camera. This approach improves the accuracy and reliability of forest fire detection. This paper presents a literature study on forest fire detection.

Keywords: *Forest fire detection, UAV based forest fire surveillance*

INTRODUCTION

Forests are the protectors of earth's ecological balance. Forest fires can potentially result in a great number of environmental disasters, causing vast economic and ecological losses as well as endangering human lives. In order to preserve natural resources and protect human safety and properties, forest fire monitoring and detection have become a significant solution, which attract an increasing interest around the world. Especially, the growth number of large scale worldwide forest fires has made automatic fire detection as an important technique for the early fire alarm. Unfortunately, the forest fire is usually observed when it has already spread over a large area of forest, making fire control and stoppage is very difficult and impossible. The result is devastating loss and irreparable damage to the environment and atmosphere (30% of carbon dioxide (CO_2) in the atmosphere comes from forest fires), in addition to irreparable weaken the ecology. Among other dreadful consequences of forest fires are long-term calamitous effects such as impacts on local weather patterns and global warming. The difficulty with forest fires is that the forests are generally remote, unmanaged zones filled with trees, dry and dehydrating wood, leaves, and so into view that act as a fuel source. These elements form a highly inflammable material and represent the perfect context for initial-fire ignition and act as fuel for later stages of the fire. The fire ignition may be caused through human actions like smoking or barbeque parties or by natural reasons such as high temperature in a hot summer day or a broken glass working as a collective lens focusing the sun light on a small spot for a length of time thus leading to fire-ignition. Once ignition starts, inflammable material may easily fuel to feed the fires central spot then which becomes bigger and it spread easily. The initial stage of ignition is normally mentioned as "surface fire" stage. This may then lead to feeding on adjoining tree sand the fire flame becomes higher and higher, thus becoming "crown fire." Mostly, at this stage, the fire become sun

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controllable and damage to the landscape may become excessive and could last for a very long time depending on prevailing weather conditions and the terrain. The very huge area of forest is destroyed by fire every year. Monitoring of the potential risk is sand an early detection of fire can significantly shorten the reaction time and also reduce the potential damage as well as the cost of firefighting. Known rule supply here: 1minute—1cup of water, 2 minutes—100litre of water, 10minutes—1, 000litres of water. The objective is to detect the fire as fast as possible and its exact localization and early informing to the fire units is crucial. This is the deficiency that the present Invention attempts to remedy, by early stage, so as to enhance or ensure the chance to put it out before it has grown beyond control or causes any significant damage. There are a number of detection and monitoring systems used by authorities. These include observers in the form of monitoring towers, satellite monitoring and increasingly encourage detection and monitoring systems based on optical camera sensors, and dissimilar types of detection sensors or their combination.

RESEARCH PAPERS RELATED TO FOREST-FIRE DETECTION

Jorge Moragues, Ignacio Bosch, Luis Vergara [1] - This paper describes a scheme for automatic forest surveillance. An absolute system for forest fire detection is firstly presented although we focus on infrared image processing. Each infrared image corelated to a pixel matrix and each pixel is related with a resolution cell which is located by means of its azimuth and range coordinates. First estimation the difficulty of automatic alarms detection, possibly to decide the presence of fire, in one resolution cell, once the energy level of the pixel in test reaches a particular threshold. If the statistic distribution of the noise is well known, the threshold can be used to satisfy a desired probability of false alarm (PFA), getting a probability of detection (PD) that depends on the signal to noise ratio (SNR). The captured images are processed by pixel to pixel. The invented scheme based on infrared image processing performs early detection of any fire threat. With the goal of finding the presence or absence of fire, in the algorithms implements the fusion of diverse detectors which exploit different anticipated features of a real fire, like tenacity and increase. Theoretical results and practical stimulations are conforming to control of the system related with probability of false alarm. Probability of detection (PD) is dependent on signal to noise ratio (SNR) is also calculated. We can take benefit of this extra statistics about infrared background noise to increase the SNR using a noise predictor. The estimated level may be subtracted from the pixel under test, thus improving SNR. Note that if we improve the SNR we get a better PD for a given PFA. The scheme based on infrared image processing performs early detection of any fire threat. With the purpose of determining the presence or absence of fire, the suggested algorithms execute the fusion of diverse detectors which exploit different predictable features of a real fire, like determination and increase. Theoretical results and practical simulations are presented to conform the control of the system related to probability of false alarm (PFA). Possibility of detection (PD) dependence on signal to noise ratio (SNR) is also estimated.

J. Xiao, Jie Li, Junguo Zhang [2] Certain fire automatic monitoring alarm and control functions are required in modern forest fire prevention facilities because of the characteristics of sudden, stochastic in forest fire, which make it difficult to fulfil the real-time monitoring. In recent years, the remote monitoring system based on network video camera provides reliable technical support for the real-time monitoring. It is comprised of monitoring management command center, wireless transmission, vidicon, lens, and console control and power supply system. The fire identification with the digital image processing can greatly improve the technological content and the automation level of the fire detection system. In the light of the difficult of monitoring forest fire, the design plan and practical application of establishing the fire monitoring system founded on digital image facts are invented. The system is based on the continuous image captured by CCD camera. The configuration features, dynamic features and color information of that interesting region of fire with an application of the digital image processing algorithm, and then to recognize the fire cause according to the attained features. The experimental output show that the system can accurately identify and confirm the fire C. Yuan [3] - In this paper, an unmanned aerial vehicle (UAV) based forest fire detection and tracking method is proposed. Firstly, A UAV-based forest fire detection and tracking system is presented first. Most of the early researches detect fire by videos, and then researchers gradually use cameras to do fire detection in the real situation. Vision-based fire detection usually makes use of three dominant features of fire: color, motion, and geometry. Variety of vision-based methods primarily depends on image processing algorithms. In order to achieve the goals of automatic forest fire detection and tracking, this paper conducts a preliminary research on developing a set of image processing algorithms that is capable of effectively detecting and tracking forest fire. The basic idea of the proposed method is to adopt the channel “a” in Lab colour model to extract fire-pixels by making use of chromatic features of fire.

Wen-Bing Hang, Jim-wen peg [4] - Fire flame detection is an important issue because it closely related to every people's safety and property. The frequently used flame detection methods are based on particle sampling, temperature sampling, and air transparency testing, to the traditional ultraviolet and infrared flame detectors. However, most of these detectors suffer from some serious problems. They require a close proximity to the flame. In this paper, a new visual real-time flame detection method is proposed based on, machine vision techniques and the theory of chromatics to meet the above requirements. The intuitive HSI colour model is chosen to describe flame features extracted from a set of flame images. The colour separation method is applied to roughly segment regions with fire-like colours based on the extracted flame features. Then, the image difference method and the invented colour masking technique based on chromatics are used to remove spurious fire-like regions, such as objects with similar fire colours or areas reflected from fire flames. They have developed the rules for brighter and darker environments. After segmenting the fire region based on HSI rules the lower intensity and lower saturation pixels are removed to avoid fire aliases (fire like region). They also formed a metric based on binary counter difference images to measure the burning degree of fire flames such as no fire, small, medium, and big fires. Their result includes false positives and false negatives. But there is no way to reduce the false positives and false negatives by changing their threshold value. The experimental results show that the proposed method can achieve approximately 97% detection rate on average with thirty frames per second. In addition, the method can recognize fire flames within one second from the test videos, which seems very promising.

Turgay, Hasan Demirel [5]-In this paper, a rule-based generic colour model for flame pixel classification is proposed. The proposed method is use the yCbCr colour space to construct a generic chrominance method for flame pixel classification. In addition to translating the rules developed in the RGB and normalized Rgb to YCbCr colour space, new rules are developed in YCbCr colour space which further alleviate the harmful effects of changing illumination and improves detection performance. The flame pixel classification rates of the proposed system with new rules and new generic chrominance model is compared with the previously introduced flame pixel classification model. This method segments the flame region except the flame center. But this proposed model gives 99.0% correct flame pixel classification rate with a method classifies fix pixels only based on colour information. 31.5% false alarm rate. This is a significant improvement over other method used in the literature.

J. Zhao, Z. Zhang, S. Han, Z. Yuan [6] - Different with the other kinds of fire surveillances, forest fire monitoring has its own properties. The cameras are placed on the top of mountains, and they are not stable because of wind. Focal length of the cameras is changeable, and the size of objects in recorded images is not constant. Most of the researched papers based on detection of fire detection. All of them have caused a great deal of problem for vision based fire detection, therefore it is necessary to specially study the case of forest fire recognition. In this proposed forest fire detection algorithm considers static and dynamic features subsequently. Support vector machine (SVM) trained with static features of the extracted from Gaussian mixture model was used. Fire was detected with good success but still had a problem with false positives when red objects are on the analysed image.

T.Qiu ,Y.Yan, G.Lu [7] - several method for edge-detection have been used to assess their success in flame edge identification. Despite the adjustment of many parameters in the use of this methods. Edges take out from non-trivial images are frequently inhibited by fragmentation, denotation that the edge curves are not connected, edge segments are false edges that do not resemble to notable phenomena in the image are shown. It is desirable to develop an edge detection method for flame and fire image processing.

D.Y. Chino, L.P. Avalhais, A.J. Traina [8] Emergency situations can cause economic losses, environmental disasters or serious damage to human life Existing solutions are based on ultraviolet and infrared sensors, and usually explore the chemical properties of fire and smoke in particle sampling. In this proposed method to detect fire in images captured by camera, without information, using visual features extracted from the captured images. To overcome the problems a fore mentioned, we propose a new method to detect fire in still images that is based on the combination of two approaches: pixel-colour classification and texture classification. The use of fire traces present particular textures that permit to differentiate between actual fire and fired regions. Even the information present in the images, it is possible to get a high accuracy level in the detection. The main contribution of this paper is BoW Fire (Best of both Worlds Fire detection), a novel method to detect fire in still images. By merging colour and texture information, our method showed to be effective in detecting true-positive regions of fire in real-scenario images, while discarding a considerable quantity of false-positives. Our method uses fewer parameters than former works, what leads to a more intuitive process of fine tuning the automated detection.

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K.Angayarkkani, N. Radhakrishnan [9]- Forest fires are a chief environmental concern, causing economic and ecological damage while endangering human lives across the world. In this paper presents an system to detect the presence of forest fires in the forest using Artificial Neural Network(ANN). The digital images of the forest fire are converted from RGB to XYZ color space and then segmented by using anisotropic diffusion to identify the fire zones. Radial Basis Function Neural Network is used in the design of the intelligent system, the color space values of the segmented fire regions.

T.celik, H.demirel, H.ozkaramanli [10] - An algorithm is proposed which combines color information of fire with temporal changes in video sequences. Number of rules using normalized value in order to avoid the effect of changing illumination. In this method statistical analysis is carried out in rg, rb and gb planes.in each plane lines are used to specify a triangular region representing the region of interest for this pixel. A pixel is declared as fire pixel if it falls in to the triangular region of rg, rb and gb planes. The normalized RGB color space overcome the effects of variation in illumination to extent further improvement can be achieves by YCbCr color space with separate illumination from chrominance.

EXISTING WORK

Sensors

Nowadays almost all the fire detection system uses sensors. The accuracy, reliability and positional distributions of the sensor determine the betterment of the system. For high accuracy fire detection systems, large numbers of sensors are require in the case of open-air applications. Sensors also need a recurrent battery charge which is not possible in a large open space. Sensors are detected fire if it is close to fire. This will lead to damaging of sensor. These days, two different types of sensor networks are offered for fire detection, camera surveillance and wireless sensor network. The development of sensors, digital camera, image processing, and industrial computers resulted in the development of the modern technology system for optical, automated early recognition and warning of forest fires. Different types of detection sensors can be used in terrestrial systems.

1. video-camera, responsive to visible spectrum of smoke noticeable during the day and a fire recognizable at night,
2. Infrared (IR), thermal imaging cameras based on the detection of heat flow of the fire,
3. IR spectrometers to identify the spectral characteristics of smoke,
4. Light detection and ranging systems—LIDAR (detection of light and range) that compute laser rays reflected from the smoke particles. The variant optical

Systems working according to different algorithms planed by the builds, all have the same general concept in smoke and fire glow detection. Simply, the camera produces image severs while. The image consists of a number of pixels, where the processing unit tracks the motion in images and check show many pixels contain smoke or fire glow and then the processing unit sends the results for another algorithm to decide whether or not to produce an alarm for the operator.

Computer Vision Based Systems

These replace conventional fire detection systems, due to the rapid development of digital camera technology and video processing. Computer vision based systems use three stages.

1. Flame pixel classification.
2. Segmentation of moving object.
3. Analysis of the candidate region.

The performance of the fire detection system depends on the performance of the fire pixel classifier which generates major areas on which rest of the system operates. Thus a precise fire pixel classifier is needed with high true detection rate and less false detection rate. A video flame detection algorithm, which initially applies background subtraction and color analysis to identify candidate flame region on the video frame and subsequently distinguishes between fire and non-fire object based on a set of fire extracted features including color probability. Spatial variation, temporal variation, spatial temporal variation and contour variability of candidate blob regions, however there exist some algorithms which directly deal with fire pixel classification. The fire pixel classification can be considered in both in gray scale and color video sequence.

CCD Cameras

Low cast CCD cameras are used to detect fires in the long range passenger aircraft. This method employs statistical features mean, standard deviation and second order moments along with the non-image features such as humidity and temperature. The system can also be used in smoke detector to reduce the false alarm. The system also provides visual inspection capability to confirm the presence or the absence of fire for the aircraft crew. Thermal camera or pan tilt zoom cameras can be added to the system. EYEfi does not offer automatic detection of smoke but plans to introduce it sometime in the near future. Simply, EYEfi can provide images for fire agencies whenever the operator notices smoke and can use EYEfi software to use the GIS map and locate the smoke position on the ground. A weather station and lightening detector are included in the system for more accuracy.

UAV-Based System

Owing to the development of modern technologies, more advanced forest fire detection approaches integrating remote sensing techniques with various platforms (such as satellites, ground-based equipment's, and aircrafts) are designed to overcome drawbacks of traditional methods. Particularly, due to their rapid maneuverability and improved personnel safety, there is an increasing demand to make unmanned aerial vehicles (UAVs) has been devoted to the application of UAVs for forest fire monitoring and detection. A typical UAV-based forest fire surveillance system is illustrated in below figure. Which is composed of a team of UAVs, different kinds of onboard sensors, and a central ground station? The goals are to take advantages of UAVs to detect and track fires, predict their propagation, and supply real time fire information to human firefighters and even to execute fire extinguishment with UAVs. The system can fulfil the missions of fire monitoring (search a potential fire), detection (find potential fire and produce fire alarm to firefighting staff), diagnosis (compute parameters of the fire position, extent and evolution), and prognosis (predict the fire propagation).

Fig.1: *Schematic Illustration of the UAV Based Forest Fire Surveillance System.*

Forest fire monitoring is to find the possible occurrence of fire before it has appeared, while fire detection is to confirm whether there is a real fire in progress. Fire diagnosis is for the purpose of finding detailed data of fire. Fire prognosis aims to track and predict the fire propagation based on real time information of weather, vegetation composition of forest and fire parameter as powerful tools for operational fire-fighting. Recent decades, growing efforts In order to complete the above-mentioned tasks with minimum interference of human operators, the specific activities are the development of 1) UAV frames (fixed wing and rotary-wing types) carrying the necessary payload (remote sensing sensors for day-time, night-time, and all weather conditions) for fire detection and surveillance; 2) Remote sensing technologies for fires monitoring and detection; 3) Sensors fusion and image processing methods for quick fire detection, decision-making, and localization; 4) Guidance, navigation, control (GNC) algorithms for single UAV and multiple UAVs for monitoring, detection, tracking and prediction of fire development, and fire extinguishing operations; 5) Helpful localization, deployment, and control tactics of UAVs for ideal coverage of fire areas for accurate and rapid fire tracking, prediction, and support/guidance of firefighting; 6) Autonomous and reliable path planning and re-planning strategies before and after fire being detected based on the fire development situations; 7) Ground station which includes satellite and wireless communications, ground computation, visualization for fire detection, image processing, tracking and forecast with automatic fire alarm and for safe and efficient operation of UAVs systems during the entire mission.

It can be seen that the computer vision based fire detection technique is one of the most important elements in the UAV-based forest fire detection system. This is due to its numerous merits such as monitoring wide range object, offering intuitive and real-time images and recording information conveniently. More specifically, charge-coupled device (CCD) cameras and infrared (IR) cameras are usually mounted on UAVs. Massive efforts have been dedicated to the development of more effective image processing scheme for fire detection. The color and motion features in visual images captured by CCD cameras are mostly utilized for fire detection. However, the usage of CCD cameras is normally considered as not robust and reliable enough in some outdoor applications. Given highly sophisticated, non-structured environments of forest, the chance of smoke blocking the fire, or the situation for analogues of fire including reddish leaves swaying in the wind and reflections of lights, false fire alarm rate often tends to be considerably high. Due to the fact that IR images can be obtained in either weak or no light situations, and smoke can be seen as transparent in IR images, IR cameras are widely applied to capture monochrome images in both daytime and nighttime, even though IR camera is more expensive than CCD camera. By employing this effective solution it is expected to significantly reduce false fire alarm rate and enhance adaptive capabilities of the forest fire detection system in various environments.

CONCLUSION

Forest fires can potentially result in a great number of environmental disasters, causing vast economic and ecological losses as well as endangering human lives. In order to preserve natural resources and protect human safety and properties, UAV based forest fire monitoring and detection have become a significant solution, which attract an increasing interest around the world. This approach takes advantages of both brightness and motion features of fire in IR images to improve the accuracy and reliability of forest fire detection. The invented system achieves 99.4% fire detection rate and 12% false detection rate. The invented method was compared with other methods in the literature and demonstrates superior performance in terms of higher fire detection rate and less false alarm rate.

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Priyadarshini M Hanamaraddi* et al.
(IJITR) INTERNATIONAL JOURNAL OF INNOVATIVE TECHNOLOGY AND RESEARCH
Volume No.4, Issue No.1, December - January 2016, 2695 – 2700.

A Literature Study on Image Processing for Forest Fire Detection

PRIYADARSHINI M HANAMARADDI
M.Tech-Student
Computer Science and Engineering,
R V College of Engineering,
Bangalore, Karnataka, India.

Abstract: **Forests can purify water, stabilize soil, cycle nutrients, moderate climate, and store carbon. They can create habitat for wildlife and nurture environments rich in biological diversity. They can also contribute billions of dollars to the country's economic wealth. However, hundreds of millions of hectares of forests are unfortunately devastated by forest fire each year. Forest fire has been constantly threatening to ecological systems, infrastructure, and public safety. 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. This paper presents a literature study on Image processing for forest fire detection.**

Key words: **Forest Fire Detection, Image Processing, Colour Model, Colour Space**

I. INTRODUCTION

Image processing is processing of images using mathematical operations by using any form of signal processing for which the input is an image, such as a photograph or video frame the output of image processing may be either an image or a set of characteristics or parameters related to the image. Most image-processing techniques involve treating the image as a two-dimensional signal and applying standard signal-processing techniques to it. A **colour model** is an abstract mathematical model describing the way colours can be represented as tuples of numbers (e.g. triples in RGB or quadruples in CMYK).

1. **CMYK Colour Model:** Colours can be created in printing with colour spaces based on the CMYK colour model, using the subtractive primary colours of pigment (cyan (C), magenta (M), yellow (Y), and black (K)). To create a 3-D representation of a given colour space, we can assign the amount of magenta colour to the representation's X axis, the amount of cyan to its Y axis, and the amount of yellow to its Z axis. The resulting 3-D space provides a unique position for every possible colour that can be created by combining those three pigments.

2. **RGB Colour Model:** Colours can be created on computer monitors with colour spaces based on the **RGB** colour model, using the additive primary colours (**red, green,** and **blue**). A 3-D representation would assign each of the three colours to the X, Y, and Z axes. The colours generated on given monitor will be limited by the reproduction medium.

3. **YCbCr Colour Model: YCbCr** is a family of colour spaces.Luminance information is stored as a single component **Y**. Chrominance information is stored as two colour-difference components Cb and Cr resp. **Cb** represents the difference between the blue component and a reference value. **Cr** represents the difference between the red component and a reference value.

II. RESEARCH WORK ON FOREST FIRE DETECTION

The line of sight and the early stage of the fire process problem could be solved with the second type of sensors. A new technology called wireless sensor network (WSN) is nowadays receiving more attention and has started to be applied in forest fire detection. The wireless nodes integrate on the same printed circuit board, the sensors, the data processing, and the wireless transceiver and they all consume power from the same source batteries. Unlike cell phones, WSN do not have the capability of periodic recharging. The sensors are devices capable of sensing their environment and computing data. The sensors sense physical parameters such as the temperature, pressure and humidity, as well as chemical parameters such as carbon monoxide, carbon dioxide, and nitrogen dioxide. The sensors operate in a self-healing and self-organising wireless networking environment. One type of wireless technology is ZigBee which is a new industrial standard based on IEEE 802.15.4. This technology emphasises low cost battery powered application and small solar panels and is suited for low data rates and small range communications. Wireless sensor networks have seen rapid developments in a large number of applications. This kind of technology has the potential to be applied almost everywhere; this is why the research interest in sensor networks is becoming bigger and bigger every year.

The researchers defined more than 27 mathematical models to describe the fire behaviour where they stated that those models developed according to different countries experience of forest fire and each model is different according to the input parameters and the environments nature (fuel indexing). The researchers of forest fires manage to use some of these models in simulations or even create their own methods to create maps that can be used to analyse the fire behaviour at any time in the future so that they can help the fire fighters to determine the best method to extinguish the fire, such as BehavePlus, FlamMap, FARSITE, Geodatabase, and ArcSDE. On the contrary, researchers are trying to initiate a reliable technology that can detect the fire, localise the fire, and help in decision making in terms of requiring an immediate reaction in case of crisis possibility or a high fire risk situation. As a result, the fire can be extinguished in early stages within a short time to minimise the damage save lives, environment, fire fighter equipment, time and effort.

FIRESENSE (Fire Detection and Management through a Multi-sensor Network for the Protection of Cultural Heritage Areas from the Risk of Fire and Extreme Weather Conditions, FP7-ENV-2009-1-244088-FIRESENSE) is a Specific Targeted Research Project of the European Union’s 7th Framework Programme Environment (including climate change).

The FIRESENSE FP7 project aims to implement an automatic early warning system to remotely monitor areas of archaeological and cultural interest from the risk of fire and extreme weather conditions.

FIRESENSE is a very complicated system; it consists of multi-sensors, optical, IR, and PTZ cameras in addition to temperature sensors, and weather stations. In this system, each sensor collects the data and applies some processing techniques and different models and data fusion algorithms in order to provide a clear understanding for the event to the local authority. Demonstrator deployments will be operated in selected sites in Greece, Turkey, Tunisia, and Italy.

This project builds on very complicated scientific models, algorithms, concepts, and comparisons, such as the following.(i)Scene model: the fire and smoke, heat flux or emitted thermal (Planck’s radiation formula), the fire flickering, the reflectance, absorption emission lines, and analysis of the atoms (e.g., potassium) and the molecules (water and carbon dioxide) are characteristics to be investigated.(ii)The background emits the thermal heat, the reflectance of sunlight, the clouds (clouds shadow) the buildings and the sky polarisation.(iii)The atmosphere has a number of gases (N_2, O_2, CO, CO_2, H_2O, etc.); each one has its own absorption and reflection behaviour. Water vapour concentration could vary as a result. Carbon dioxide is more uniformly distributed but its value is larger over industrial cities and vegetation fields than over oceans and deserts.

III. RESEARCH PAPERS RELATED TO FOREST-FIRE DETECTION

Infrared image processing and its application to forest fire surveillance.

This paper describes a scheme for automatic forest surveillance. A complete system for forest fire detection is firstly presented although we focus on infrared image processing. The proposed scheme based on infrared image processing performs early detection of any fire threat. With the aim of determining the presence or absence of fire, the proposed algorithms performs the fusion of different detectors which exploit different expected characteristics of a real fire, like persistence and increase. Theoretical results and practical simulations are presented to corroborate the control of the system related with probability of false alarm (PFA). Probability of detection (PD) dependence on signal to noise ration (SNR) is also evaluated.

The Identification of Forest Fire Based On Digital Image Processing.

In the light of the problem of monitoring forest fire, the design strategy and practical implementation of establishing the fire monitoring system based on digital image information are proposed. The system is based of the continuous image sampling provided by CCD camera. We can obtain the configuration characteristics, dynamic characteristics and color information of interesting region with an application of the digital image processing algorithm, and then to identify the fire source according to the acquired characteristics. The experimental results show that the system can accurately identify and confirm the fire. Besides, the amount of data processed can be reduced because of the use of sampling algorithm thus shortening the execution time.

UAV-based Forest Fire Detection and Tracking Using Image Processing Techniques.

In this paper, an unmanned aerial vehicle (UAV) based forest fire detection and tracking method is proposed. Firstly, a brief illustration of UAV-based forest fire detection and tracking system is presented. Then, a set of forest fire detection and tracking algorithms are developed including median filtering, color space conversion, Otsu threshold segmentation, morphological operations, and blob counter. The basic idea of the proposed method is to adopt the channel "a" in Lab color model to extract fire-pixels by making use of chromatic features of fire. Numerous experimental validations are carried out, and the experimental results show that the proposed methodology can effectively extract the fire pixels and track the fire zone.

IV. EXISTING WORK

1. ***SENSORS:*** Nowadays almost all the fire detection system uses sensors. The accuracy, reliability and positional distributions of the sensor determine the betterment of the system. For high precision fire detection systems, large numbers of sensors are needed in the case of outdoor applications. Sensors also need a frequent battery charge which is impossible in a large open space. Sensors detect fire if and only if it is close to fire. This will lead to damaging of sensor.

2. ***COMPUTER VISION BASED SYSTEMS:*** These replace conventional fire detection systems, due to the rapid development of digital camera technology and video processing. Computer vision based systems use three stages.

   1. Flame pixel classification.

   2. Segmentation of moving object.

   3. Analysis of the candidate region.

   The performance of the fire detection system depends on the performance of the fire pixel classifier which generates major areas on which rest of the system operates. Thus a precise fire pixel classifier is needed with high true detection rate and less false detection rate. However there exist some algorithms which directly deals with fire pixel classification. The fire pixel classification can be considered in both in gray scale and colour video sequences.

3. ***CCD CAMERAS:*** Low cast CCD cameras are used to detect fires in the long range passenger aircraft. This method employs statistical features mean, standard deviation and second order moments along with the non-image features such as humidity and temperature. The system can also be used in smoke detector to reduce the false alarm. The system also provides visual inspection capability to confirm the presence or the absence of fire for the aircraft crew.

Related development

i. T.Chen et al. [2], developed a set of rules to separate the fire pixels using R, G and B information.

ii. B.U. Totryin et al. [3] used a mixture of Gaussians in RGB colour space which is developed from a training set of fire pixels, instead of using a rule based colour model in [2].

iii. B.U. Totryin et al.[4] employed a hidden markov models to detect the motion characteristics of the fire flame that is fire flickering along with the fire pixel classification.

iv. G. Marbacr et al.[7] used YUV colour space for the representation of video data, where the candidate fire pixels are obtained by the derivative of the luminance component Y and the candidate fire pixels are confirmed by using the information from the chrominance components U and V. But in this method the number of test conducted was not mentioned.

v. Wen- Homg et al. [8], used HSI colour model to separate the fire pixels. They have developed the rules for brighter and darker environments. After segmenting the fire region based on HSI rules the lower intensity and lower saturation pixels are removed to avoid fire aliases (fire like region). They also formed a metric based on binary counter difference images to measure the burning degree of fire flames such as no fire, small, medium, and big fires. Their result includes false positives and false negatives. But there is no way to reduce the false positives and false negatives by changing their threshold value.

vi. T. Celik et al. [5] formed number of rules using normalized (rgb) values in order to avoid the effects of changing illumination. In this method statistical analysis is carried out in rg, rb and gb planes. In each plane three lines are used to specify a triangular region representing the region of interest for fire pixels. A pixel is declared as fire pixel if it falls in to the triangular region of rg, rb and gb planes. Even though the normalized RGB colour space overcomes the effects of variation in illumination to some extent further improvement can be achieved by using YCbCr colour space which separates luminance from chrominance.

vii. Turgay Celik et al. [9] proposed a generic colour model to segment the flame pixel from the background using YCbCr colour model. This method segments the flame region except the flame centre. But this method classifies fire pixels only based on colour information.

viii. Vipin V[10] proposed a model to segment the fire from the image which uses RGB and YCbCr colour space. This method does not work well under all environmental conditions and is not reliable.

Open source tools for image processing

1. ***OPENCV***

OpenCV(Open source computer Vision) is a library of programming functions mainly aimed at real-time computer vision, originally developed by Intel research center in Nizhny Novgorod(Russia), later supported by Willow Garage and now maintained by Itseez. The library is cross-platform and free for use under the open-source BSD license. The first alpha version of OpenCV was released to public at the **IEEE Conference on Computer Vision and Pattern Recoginition** in 2000. OpenCV is written in C++ and its primary interface is in C++ , but is still retains a less comprehensive though extensive older C interface. There are bindings in Phython, Java and MATLAB/OCTAVE. The API for these interfaces can be found in the online documentation. Wrappers in other languages such as C#, Perl, Ch, and Ruby have been developed to encourage adoption by a wider audience. OpenCV runs on a variety of platforms.

2. ***VTK***

The Visualization Toolkit (VTK) is an open-source, freely available software system for 3D computer graphics, image processing and visualization. VTK consists of a C++ class library and several interpreted interface layers including Tcl/Tk, Java, and Python. **BSD license**

3. ***ITK***

ITK is an open-source, cross-platform system that provides developers with an extensive suite of software tools for image analysis. Developed through extreme programming methodologies, ITK employs leading-edge algorithms for registering and segmenting multidimensional data. **Apache 2.0 license**

4. ***FSL***

FSL is a comprehensive library of analysis tools for FMRI, MRI and DTI brain imaging data. FSL is written mainly by members of the Analysis Group, FMRIB, Oxford, UK. FSL runs on Apple and PCs (Linux and Windows), and is very easy to install. Most of the tools can be run both from the command line and as GUIs ("point-and-click" graphical user interfaces). **license**

5. ***SPM***

Statistical Parametric Mapping refers to the construction and assessment of spatially extended statistical processes used to test hypotheses about functional imaging data. These ideas have been instantiated in software that is called SPM. The SPM software package has been designed for the analysis of brain imaging data sequences. The sequences can be a series of images from different cohorts, or time-series from the same subject. The current release is designed for the analysis of fMRI, PET, SPECT, EEG and MEG. **GPL license**

6. ***GIMIAS***

GIMIAS is a workflow-oriented environment for solving advanced biomedical image computing and individualized simulation problems, which is extensible through the development of problem-specific plug-ins. In addition, GIMIAS provides an open source framework for efficient development of research and clinical software prototypes integrating contributions from the Physiome community while allowing business-friendly technology transfer and commercial product development. GIMIAS has functionalities for manual and automatic segmentation, visualization, mesh editing and electro mechanical and CFD simulation among others. **BSD license**

7. ***3DSlicer***

Slicer, or 3D Slicer, is a free, open source software package for visualization and image analysis. 3D Slicer is natively designed to be available on multiple platforms, including Windows, Linux and Mac Os X. **BSD license**

8. ***MIA***

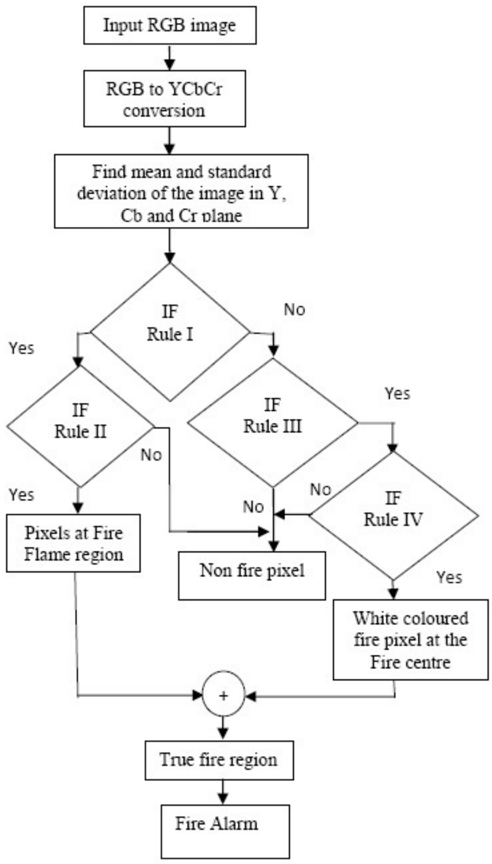
MIA is a general purpose image processing toolbox written in C++ that puts its focus on 2D and 3D gray scale medical image analysis. It is designed around a plug-in infrastructure that makes adding new functionality easy, uses a test-driven development to ensure reliability of the implementation, and provides command line tools as a means for algorithmic prototyping based on interactive execution of image processing tasks and their combination in shell scripts. **GPLv3+ license**

V. IMAGE PROCESSING FOR FOREST-FIRE DETECTION USING YCbCr COLOUR MODEL

The YCbCr Detection Method uses YCbCr colour space. Because YCbCr colour space separates luminance information from chrominance information than other colour spaces. For fire pixel classification, four rules (Rule I, Rule II, Rule III, and Rule IV) are formed. The colour of the fire at the high temperature centre region is white. However the colour of the fire in the region except the centre region is of the colour that varies from red to Yellow. Among the four rules used in the proposed method, 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). Finally the image obtained by satisfying Rule I & II and the image obtained by satisfying Rule III & IV are added to get the true fire image.

Understanding the system using flow chart

This section deals with the proposed fire pixel classification method. The flow chart for the proposed method is given below. It uses YCbCr colour space. For fire pixel classification, four rules (Rule I, Rule II, Rule III, and Rule IV) 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). Finally the image obtained by satisfying Rule I & II and the image obtained by satisfying Rule III & IV are added to get the true fire image.



Flow Chart of Fire Detection System

Firstly a RGB image is considered as input and it is converted in YCbCr image and once that image is obtained the mean and standard deviation of the image in Y, Cb and Cr plane is calculated then to that image rule I is applied. If rule I can be successfully applied then apply rule II on the image obtained after applying rule I. Then conclude that that image is fire pixel image. If not then apply rule III on the YCbCr image and then rule IV on the image obtained after applying RuleI II. If the rules III and IV are successfully applied then conclude the image as fire centre image. If none of the rules can be applied then conclude that the image is a non-fire image. Once image satisfying Rule I and II is obtained add it with the image that has been obtained by satisfying Rule III and IV and obtain the true fire region image and trigger the fire alarm

Formal Analysis

The method is, YCbCr colour model for flame pixel classification using statistical feature of the fire image i.e, mean and standard deviation because in YCbCr colour space, the relation between pixel is more compared to other colour models. The centre of the flame is white in colour like cloud. We developed a new rule to segment the fire centre from the background in YCbCr colour space. The proposed method was tested for nearly 800 images collected from the internet with different illuminations. Compared to the previously introduced flame pixel classification methods, the proposed method detects fire with high true detection rate and low false detection rate. The proposed method gives 99.2% true detection rate. The proposed method provides significant improvement over other methods used in the literature.

VI. PERFORMANCE ANALYSIS

Performance of the proposed fire detection system is compared with the different models.

The model defined by Chen et al. [2] uses RGB colour space and rules are formed in RGB colour space. Celik et al. [5] uses rgb values to identify the fire region. Turgay Celik et al. [9] uses YCbCr colour space to segment the fire flame pixel from the RGB image. But all the above discussed methods do not separate the high temperature fire pixels in the fire centre region. Analysis is carried out using more than thousands of images. This fire set consists of flame like objects such as sun, red coloured car, red rose etc. Table 3 shows fire flame detection rates of other methods and the proposed method. Celik et al. proposed a method which uses rgb values that shows better detection rates than the method proposed by Chen et al.using RGB values. Turgay et al. [9] proposed a method using YCbCr colour space that produces improved detection rate. Vipin V [10] proposed a model to segment the fire from the image which uses RGB and YCbCr colour space. This method is not reliable under all situations. The proposed method effectively segments fire flame and the high temperature fire centre (white coloured region) with high detection rate and low false detection rates.

VII. CONCLUSIONS

The proposed system uses YCbCr colour spaces. Because YCbCr colour space separates luminance from chrominance, hence it is robust to changing illumination than other colour spaces like RGB and rgb (normalized RGB). The proposed 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. It uses four rules to classify the fire pixels. Two rules are used for segmenting the fire flame region and two rules are used for segmenting the high temperature fire centre region.

The proposed method is tested on three set of images. First set contain fire. Second set contain fire like regions. The third set contain fire centre like regions. Computational complexity of the proposed system is very less, hence it can be used for real time forest fire detection. The proposed system achieves 99.4% fire detection rate and 12% false alarm rate. The proposed method was compared with other methods in the literature and demonstrates superior performance in terms of higher fire detection rate and less false alarm rate.

VIII. ACKNOWLEDGEMENTS

The author thanks Dr.S.Sridhar, Professor and Dean, Cognitive & Central Computing, R.V.College of Engineering, Bangalore, India for communicating this article to this Journal for publication. The author also thanks Dr.G.Shobha, Professor and Head, Department of CSE, R.V.College of Engineering, Bangalore, India for the support given.

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A SURVEY ON FOREST FIRE DETECTION

Article · January 2015

DOI: 10.16962/EAPJCSIS/issn.2394-0441/20150930.V1I2.03

L. Latha
Kumaraguru College of Technology

ELK ASIA PACIFIC JOURNAL OF COMPUTER SCIENCE AND INFORMATION SYSTEMS

ISSN: 2454-3047 (Print) ISSN: 2394-0441 (Online) Volume 1 Issue 2 (2015)

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A SURVEY ON FOREST FIRE DETECTION

P. Tamil Mathi
PG Student
Department of Computer Science and Engineering, Kumaraguru College of Technology, Coimbatore, India

Dr. L. Latha
ASP
Department of Computer Science and Engineering, Kumaraguru College of Technology, Coimbatore, India

ABSTRACT

Fire detection at an early stage is important for the safety of the people. Lack of information due to manual detection is the main cause of failure of fire detection. Fire can be detected by using smoke at an early stage as it is the fire indicator. Generally automatic forest fire detection using image processing techniques represents one of the significant aspects of forest fire avoidance earlier. Detection using image and video is effective than using sensors. In image processing the inputs for the fire detection may be an image or a video but the input as a video is quite complex process but provides good result. The techniques such as Wavelet decomposition, spatial and temporal analysis, Gaussian Mixture Model, Multi-Feature fusion detect fire in an accurate manner.

Keywords: Wavelet and Color model, Static and Dynamic characteristic analysis, Wavelet Transform, Spatio-temporal flame Modeling, Texture Analysis, Neural Network, Covariance Descriptors, Probabilistic approach

1. Introduction

Wildfires are a significant hazard to ecological systems around the world and pose a serious threat to human safety. People visually look for signs of fire or smoke appearance to detect fire in older days. To detect fire at early stage we use smoke which is the good indicator of fire which is visible before flames. Characteristics of smoke need to be considered such as transparency, its response to environmental condition, its shape. In open environment smoke detection pose a serious challenge in such areas sensors may be used but this has limitations such as time and wide area coverage. To overcome this video fire detection systems are used.

Different image processing techniques can be used to detect fire and smoke. In image processing image or video is taken as input and the output may either an image or parameters or characteristics of an image. Various tasks like analysis classification, extracting the features, recognizing different patterns can be performed using image processing. The features and textures of smoke can extract using various image processing techniques. By using these techniques the dangerous situations caused due to fire can be avoided and safety of the people can be preserved.

ISSN: 2454-3047 (Print) ISSN: 2394-0441 (Online) Volume 1 Issue 2 (2015)

2. Literature Survey

Surapong Surit, Watchara Chatwiriya [8] proposed a method to detect fire by smoke detection in video. This approach is based on digital image processing approach with static and dynamic characteristic analysis. The proposed method is composed of following steps, the first is to detect the area of change in the current input frame in comparison with the background image, the second step is to locate regions of interest (ROIs) by connected component algorithm, the area of ROI is calculated by convex hull algorithm and segments the area of change from image, the third step is to calculate static and dynamic characteristics, using this result we decide whether the object detected is the smoke or not. The result shows that this method accurately detects fire smoke.

P. Piccinini, S. Calderara, and R. Cucchiara [2] proposed a method based on the wavelet model and a color model of the smoke. The proposed method exploits two features: the variation of energy in wavelet model and a color model of the smoke. Smoke is detected based on the decrease of energy ratio in wavelet domain between background and current. The deviation of the current pixel color is measured by the color model. Bayesian classifier is used to combine these two features to detect smoke.

R.Gonzalez proposed a method to detect fire based on Wavelet Transform. Stationary Wavelet Transform is used to detect Region of Interest. This method involves three steps preprocessing, SWT, histogram analysis. In preprocessing unwanted distortions are removed and image is resized and transformation of resized image is performed. High frequencies of an image are eliminated using SWT and the reconstruction of image is done by inverse SWT. Image indexation is performed to group the intensity colors that are closed to each other. Histogram analysis is used to determine the various levels of indexation. After analysis a comparison is made with non-smoke frame and non-smoke images are eliminated. These three are combined and fire is detected.

Osman Gunay and Habiboglu [4] proposed a system based on Covariance Descriptors, Color Models, and SVM Classifier. This system uses video data. Spatio-temporal Covariance Matrix (2011) [13] is used in this system which divides the video data into temporal blocks and computes covariance features. The fire is detected using this feature. SVM Classifier is used to filer fire and fire-like regions. This system supports only for clear data not for blur data.

Dimitropoulos (2015) [1] proposed an algorithm where a computer vision approach for fire-flame detection is used to detect fire at an early stage. Initially, background subtraction and color analysis is used to define candidate fire regions in a frame and this approach is a non-parametric model. Following this, the fire behavior is modeled by employing various Spatio-temporal features such as color probability, flickering, spatial and spatiotemporal energy. After flame modeling the dynamic texture analysis is applied in each candidate

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region using Linear Dynamical Systems, Histogram and Mediods. LDS is used to increase the robustness of the algorithm by analyzing temporal evolution of pixel intensities. Pre-processing is done after this to filter non-candidate regions. Spatio-temporal analysis is done to increase the reliability of the algorithm. The consistency of each candidate fire region is estimated to determine the existence of fire in neighboring blocks from the current and previous video frames. Finally, a two-class SVM classifier is used to classify the fire and no fire regions.

(*Refer Figure 1*)

Hamed Adab [6] proposed another system which is based on Indexing. GIS techniques and remote sensing [10] provides further assistance. The indexing may be structural fire index, Fire risk index, Hybrid fire index. Depending on the geographical condition of the area the indexing differs. Validations of indices are based on hot spot data. Structural fire indices show static information and it does not change over short time span and used to predict the risk in advance. Fire risk index changes as the vegetation or climate changes. Hybrid index is a combination of Structure and Fire index. The disadvantage of this indexing is that way of combining.

Akshata & Bhosale [7] proposed another method where Local Binary Pattern acts as a base for fire detection and Wavelet Decomposition is used to detect fire. Pixel level analysis is required in this method. This method uses YCbCr color model to detect fire. Detection is based on three phase. The first phase involves segmentation of image using LBP. LBP is a texture operator whose value is computed using image's center and neighboring pixel values. Further accuracy is improved using Wavelet Transform and complicated data is classified using this approach. 2D Discrete Wavelet Transform is used for decomposition in this system. 2 images should be used as input and the sub bands of every image are compared with the other, if sub bands are equal the images are same else different.

(*Refer Figure 2*)

Celik (2007) [3] proposed a generic model for fire and smoke detection without the use of sensors [15]. Fuzzy based approach is used in this system. Color models such as YCbCr, HSV are used for fire and smoke detection. The fire is detected using YCbCr color model samples because it distinguishes luminance and chrominance. Y, Cb, Cr color channels are separated from RGB input image. A pixel is more likely a fire pixel if intensity of Y channel is greater than channel Cb and Cr.

For example consider the following image set,

(*Refer Figure 3*)

In the above image set, the pixel is fire pixel as the intensity of Y channel is greater than Cb and Cr channel. HSV color model is used for Smoke detection as is does not show chrominance characteristics as fire. As smoke is the early indicator of fire it

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should be detected at lower temperature, here its color varies from white-bluish to white, the saturation is low which satisfies the HSV color model property. As like smoke, sky also has grayish color property and it may be identified as smoke. This problem is rectified by Motion Property, where sky will be removed.

Cheng (2011) [5] proposed a fire detection system based on Neural Network; here neural network is used in detection information for temperature, CO concentration, and smoke density to determine probability of three representative fire conditions. RBF neuron structure is used, the information regarding temperature, CO concentration, and smoke density are collected and data fusion is used to generate fire signal decision. The detectors have continuous analog outputs, when detection limit is exceeded the hardware circuit sends a local fire indication to fusion center, this force the system detectors to generate final decision. Single-sensor detector is used to generate the final decision.

(*Refer Figure 4 & 5*)

Zhanqing (2001) [9] proposed another method using NN and Multi-threshold algorithm. In this method the NN not only classify the smoke, sky, background but also generates a continuous random output representing mixture of these. NN consumes time in case of large areas so multi-threshold algorithm also used as well. These two approaches may be combined or used separately depending on the size of the area. Multilayer Perceptron Neural Network is used here. The number of neurons in the output layer is equal to the number of desired parameters of the output vector, which are "smoke," "sky," and "background". The degree of separation between pixels is identified by Euclidean Distance. Multi threshold algorithm is based on channel wise approach, reflectance of each channel value is used for threshold assumption and is applied to each and every pixels of the image, smoke pixels are marked and false pixels are removed. Threshold value is set as 0.9 <= channel 1 reflectance / channel 2 reflectance<= 1.5. Pixels which reach this threshold are smoke pixels else are false pixels and are removed.

(*Refer Figure 6*)

Paulo Vinicius Koerich Borges [11] proposed a fire detection method based on probabilistic method and classification. Computer vision based approach is used in this approach. Though this approach is used surveillance it is also used to automatic video classification for retrieval of fire catastrophes in databases of newscast content. There are large variations in fire and background characteristics depending on the video instance. The proposed method observes the frame-to-frame changes of low-level features describing potential fire regions. These features include color, area size, surface coarseness, boundary roughness, and skewness within estimated fire regions. Bayes classifier [12] is used for fire recognition. In addition, *apriori* [12] knowledge of fire events captured in videos is used to significantly improve the results. The fire region is usually located in

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the center of each frame. This fact is used to model the probability of occurrence of fire.

(*Refer Figure 7*)

3. Conclusion

Different fire detection techniques have been proposed for safety and protection of the people and environment. It is very crucial to develop an appropriate detection system to avoid dangerous situation caused due to fire. Though fire detection using image produce satisfying result we now go for fire detection to produce accurate result. Wavelet based smoke detection is used for smoke detection in video sequences of outdoor environment. Covariance method is for flame detection. This method use temporally extended covariance matrices representing all the information together. The method works only well when the fire is clearly visible. If the fire is small and if it is far away from the camera or covered by dense smoke the method fails. Wavelet and Color model combined together and detect smoke earlier. Neural Network produces accurate result as it uses temperature, smoke density and CO concentration. Fuzzy based approach uses YCbCr and HSV model and detects fire at an early stage. By these approaches we cannot completely protect the forest from fire but we reduce the level of damage. Perception Neural Network along with Multi Threshold algorithm classified image pixels of cloud, land, smoke, and background and produced accurate result of smoke.

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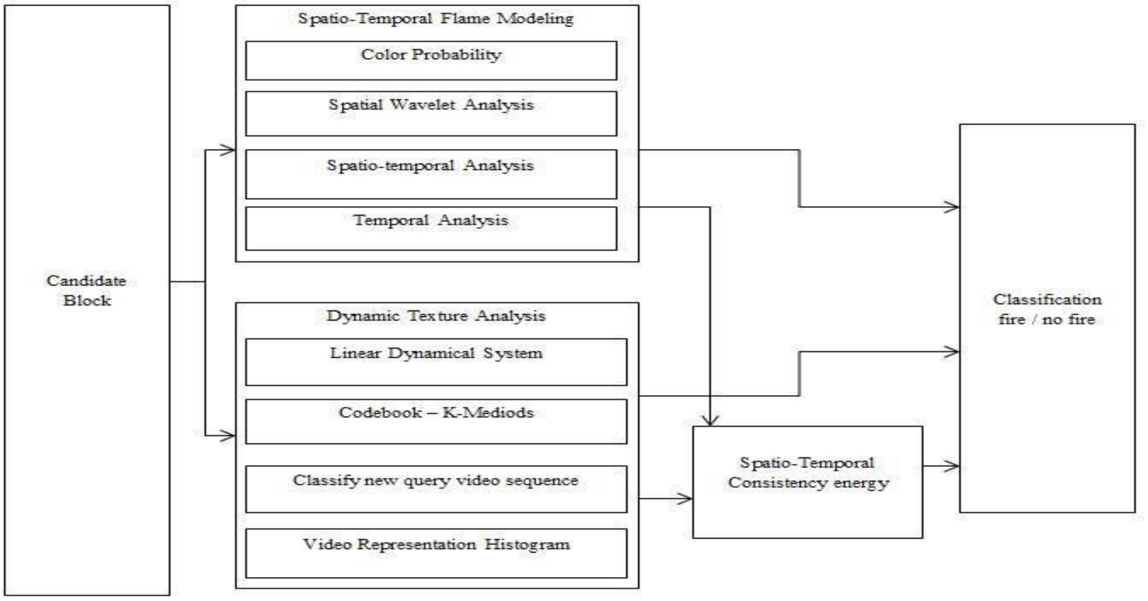

Fig. 1. Detection of candidate fire region

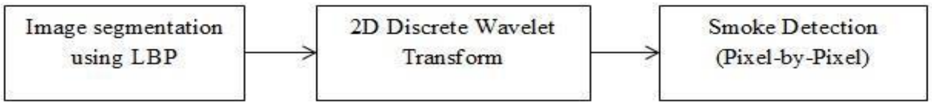

Fig. 2. Smoke detection using LBP and Wavelet transform

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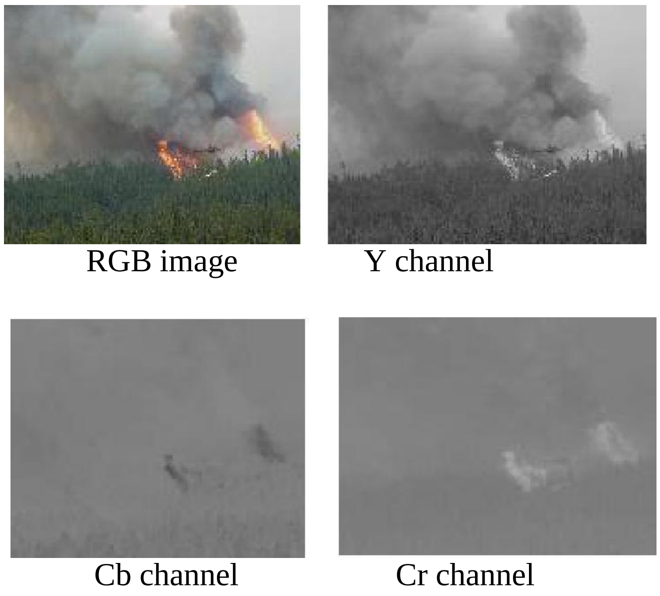

Fig. 3. YCbCr color model

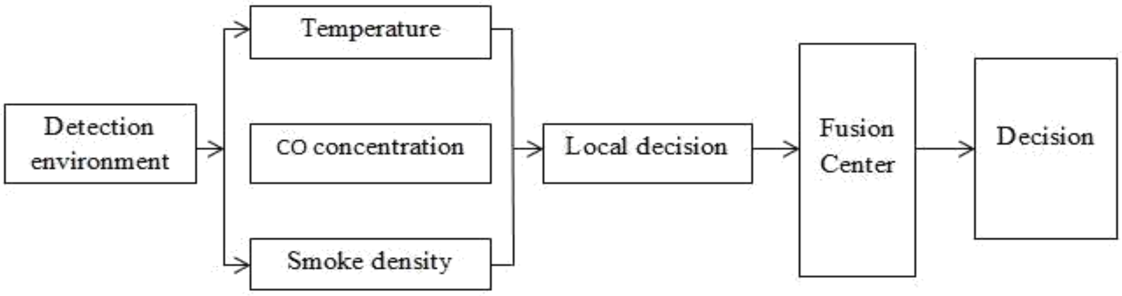

Fig. 4. Multi-sensor information fusion detection system

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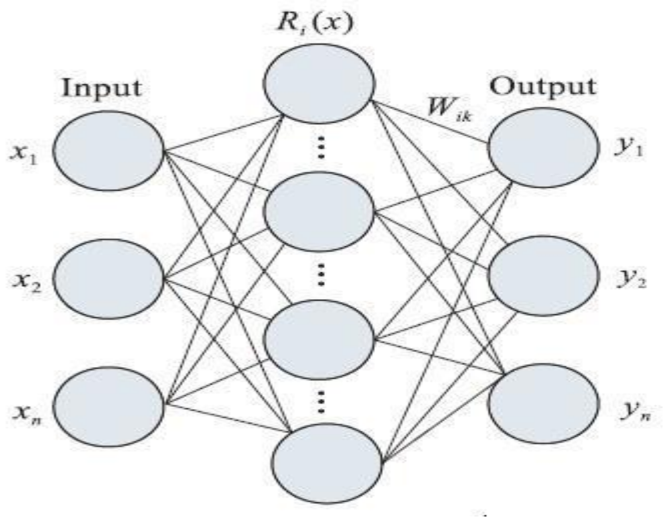

Fig. 5. RBF network structure [9]

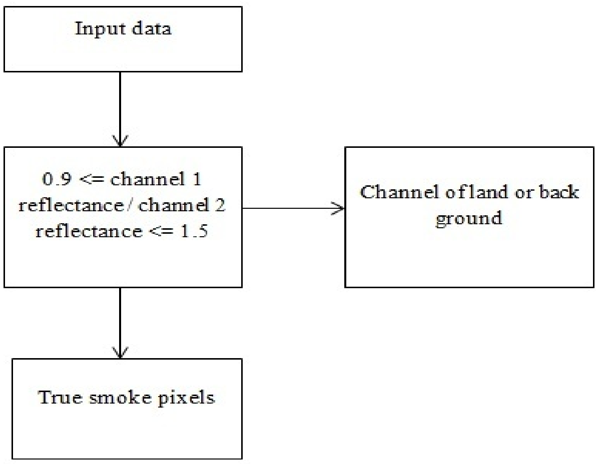

Fig. 6. Multi threshold algorithm

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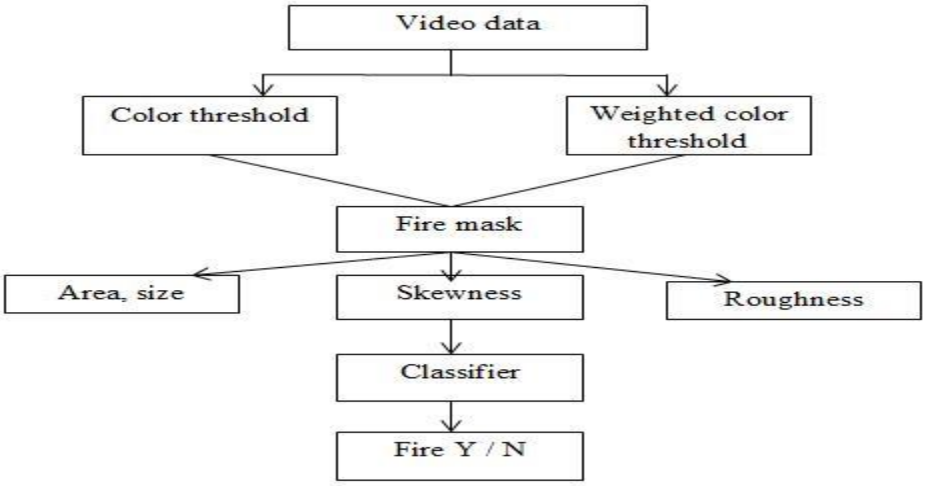

Fig. 7. Fire Detection Process