Forest Fire Detection Using Texture Analysis

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***Abstract*—Forest fires are a chief environmental concern, causing economical and ecological damage. The application of remote sensing is at present a significant method for forest fires monitoring, particularly in vast and remote areas. Different methods have been presented by the researchers for finding forest types and fire detection. In this study, we propose polygon segmentation for adaptive regional forest fire detection. First in order to detect the type of forest, identify forest and non forest area using polygon segmentation algorithm. Next XYZ color space conversion is performed in polygons to find fire pixel. To do so, a collection of distributed autonomous agents will operate at the forest polygon pixels of the image and identifies the fire regions. The proposed technique is in real time, given the exigencies of forest fires.**

***Keywords*—Autonomous Agents, Forest Fire, Polygon Segmentation, Remote Sensing Image, XYZ Color Space**.

I. INTRODUCTION

India, with a forest cover of 20.55% of geographical area, contains a variety of climate zones, from the tropical south, north-western hot deserts to Himalayan cold deserts. Forest structure can be defined by size, age, and species distributions of living and dead vegetation, often with a focus on the tree component (Spies and Franklin, 1991; Poage and Tappeiner, 2005). Structure includes vertical (e.g. number of tree layers, understory vegetation) and horizontal features (e.g. spatial pattern of trees, gaps) as well as species richness (Maltamo et al., 2005). The conventional organizational level for forest structure was the stand, which in unmanaged systems represent the synthesis of ecological and environmental factors. For management purposes, stand boundaries have traditionally been delineated on aerial photographs by means of human pattern recognition, and then interpreted photogrammetrically with the support of local field knowledge and observation (Franklin, 2001). However, the identification and spatial delineation of clusters of similar trees in the forest stand inventory improves the precision of stand-level growth and yield predictions and stand-level inventories (Magnussen et al., 2006). Forest fire is a major cause of degradation of India's forests. While statistical data on fire loss are weak, it is estimated that the proportion of forest areas prone to forest fires annually ranges from 33% in some states to over 90% in others.

A. Forest Fire

For a long time, fires have been a source of trouble. Fires have notable influence over the ecological and economic utilities of the forest, being a prime constituent in a great number of forest ecosystems. Occasionally, forest fires have forced the evacuation of susceptible communities in addition to heavy damages amounting to millions of dollars. Past has witnessed multiple instances of forest and wild land fires.

TABLE I

THE WORLD'S GREATEST FIRE DISASTER

Country	Date	Total No. of People Affected
Indonesia	OCT 1994	30,00,000
Macedonia Fry	JUL 2007	10,00,000
United States	OCT 2007	6,40,064
Argentina	JAN 1987	1,52,752
Portugal	JAN 2003	1,50,000
Paraguay	SEP 2007	1,25,000
Russia	JULY 1998	1,00,683
Nepal	MAR 1992	50,000

Fires play a remarkable role in determining landscape structure, pattern and eventually the species composition of ecosystems. The integral part of the ecological role of the forest fires is formed by the controlling factors like the plant community development, soil nutrient availability and biological diversity. Fires are considered as a significant environmental issue because they cause prominent economical and ecological damage despite endangering the human lives Due to the forest fires, several hundred million hectares (ha) of forest and other vegetation are destroyed every year.

As per the forest Survey of India 19.27% or 63.3 million ha of the Indian land has been classified as forest area, of which 38 million ha alone are hoarded with resources in great quantity (crown density above 40%). Thus the country's forests face a huge threat. Degradation caused by forest fires jeopardizes the Indian forests. Fires caused huge damage in the year 2007 affecting huge territories in addition to the prominent number of human casualties. Forest fires remains to be a potential threat to ecological systems, infrastructure and human lives.

Section II presents a brief review of some recent researches existing in the literature related to forest fire detection. A concise description of the concepts utilized in the segment system is given in Section III. The conclusions are summed up in Section IV.

II. REVIEW OF RELATED RESEARCHES

The proposed research has been motivated by several earlier researches in the literature related to forest fire detection using color texture segmentation techniques. A concise description of some of the recent researches is given in this section. A scheme of multi-sensorial integrated systems for early detection of forest fires has been presented by Ollero et al. The system presented by the authors uses infrared images, visual images, and data from sensors, maps and models. To facilitate the minimization of perception errors and the improvement in reliability of the detection process, it is necessary for the integration of sensors, territory knowledge and expertise, according to their study. An improved fire detection algorithm which provides increased sensitivity to smaller, cooler fires as well as a significantly lower false alarm rate has been presented by Louis Giglio et al.

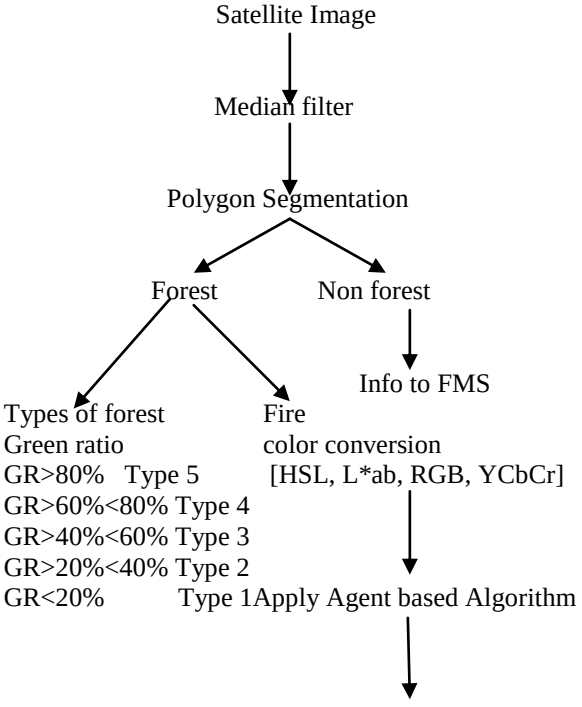
The Theoretical simulation and high resolution Advanced Space borne Thermal Emission and Reflection Radiometer (ASTER) scenes are employed to establish the performance of their algorithm. Seng Chuan Tay et al. have presented an approach to reduce the false alarms in the hotspots of forest fire regions which uses geographical coordinates of hot spots in forest fire regions for detection of likely fire points.

A graph based forest fire detection algorithm based on spatial outlier detection methods has been presented by Young Gi Byun et al. By using the spatial statistics the authors have achieved spatial variation in their algorithm. This (IJCSIS) algorithm illustrates higher user and producer accuracies, when compared with the MODIS fire product provided by the NASA MODIS science team. The ordinary scatter plot algorithm was proved to be inefficient by the authors because it is insensitive to small fires, while Moran's scatter plot was also weak because of the numerical criterion's absence for spatial variation which requires a more and less high commission error. Yasar Guneri Sahin has proposed a mobile biological sensor system for prior detection of forest fires which utilizes animals as mobile biological sensors. The work illustrates that the combination of these fields may lead to instantaneous development of animal tracking as well as forest fire detection.

A number of serious forest fires were detected by the system in the earliest, which reduced their effect and therefore contributes to the reduction of the speed of global warming. The obtained values for the both a fully automated method of forest fire detection from TIR satellite images on the basis of random field theory has been presented by Florent Lafarge et al. The results of the system rely only on the confidence coefficient detection rate and false alarm rate were convincing. The estimation of fire propagation direction presents interesting information associated to the evolution of the fires. In Movaghati et al., the capability of agents to be applied in processing of remote sensing imagery has been studied. Armando et al have studied on the automatic recognition of smoke signatures in lidar signals attained from very small-scale experimental forest fires using neural-network algorithms. An agent based approach for forest fire detection has been presented in this paper.

III. DESCRIPTION OF PROPOSED SYSTEM

The concepts utilized in the presented intelligent system for effective forest fire detection such as polygon segmentation and agent based segmentation are detailed in this section.



Compare real pixel value with Database

↓

Analyze fire region

Fig. 1 Overall process

A. Polygon Segmentation Algorithm

The aim of this step was to use an object- oriented segmentation approach to delineate forest stand boundaries (polygons) and classify them based on intensity value. This algorithm identifies geographical features [14] using the scale and homogeneity parameters.

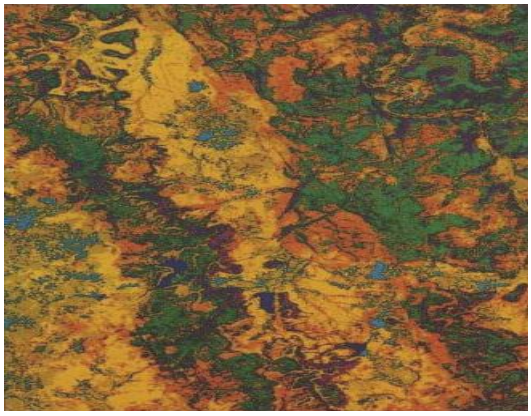


Fig 2.Forest Satellite Image

A total of N polygons are segmented, M containing forest, and N-M consisting of non-forest components such as pasture, shrubs, rocks and bare soil. The M forest polygons were grouped into P structure types by a k-means cluster analysis. Separate cluster analyses are performed on two different combinations of variables derived from the fundamental data within each polygon: (1) mean and standard deviation (S.D.) of height, and (2) median and S.D. of height. In previous work (Garcia-Abril et al., 2006; Pascual, 2006), we have studied several indices and variables derived from the lidar-DCHM: relative gap surface, landscape ecology metrics voxels and texture, but these were rejected as they did not contribute to cluster discrimination. The coefficient of variation (CV) (i.e. standard deviation divided by the mean) was not considered as an entry variable as it depends on the rest.

According to Hair et al. (1995) there is no objective procedure for establishing the number of clusters. These authors suggest obtaining various cluster solutions and deciding based on a priori criteria, experience or theoretical foundations.

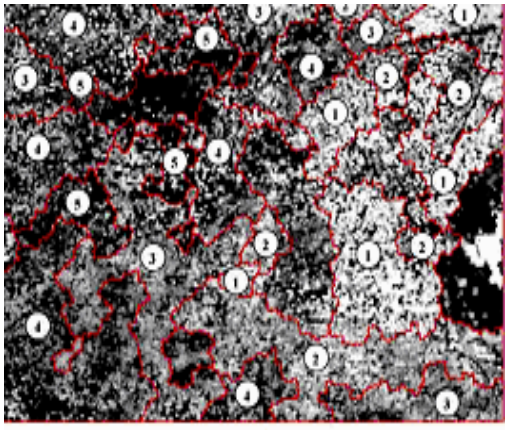


Fig. 2(a) The object-based segmented polygons b) Results of the cluster analysis (k-means). Numbers inside the polygons indicate the forest structure type. Polygons without numbers correspond to non-forest stands

In this study, the decision to base the analysis on five structure types [10] was an iterative process aided by the expert opinion of forest management personnel in the area. The overall process is explained below. Analysis of variance is used to test the statistical significance of the forest structure types derived from the cluster analysis. Euclidean distances between cluster centroids are also used as an indicator of the proximity of cluster groupings.

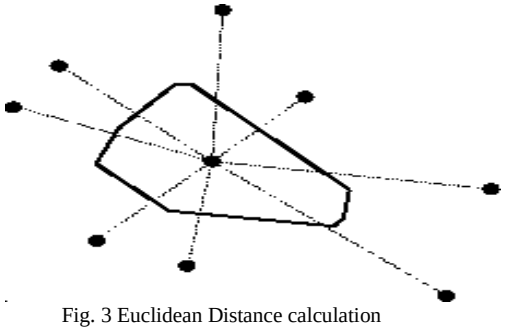


Fig. 3 Euclidean Distance calculation

Given an m-by-n data matrix X, which is treated as m (1-by-n) row vectors x1, x2, ..., xm, the various distances between the vector xs and xt are defined as follows:

$$d^2_{st} = (x_s - x_t)\,(x_s - x_t)' \qquad \text{……equation (1)}$$

B. Color Space Conversion

A color space is defined as a means by which the specification, creation and visualization of colors is performed. A computer screen produces colors based on the varied combinations of red, green and blue phosphor emission required to form a color. Typically color is represented by three coordinates or parameters. The location of the color in the color space is exemplified by these parameters such as HSL. Color space conversion

is defined as the transformation and description of a color from one source to another. Normally, color space conversion is performed while converting an image that is represented in one color space to another color space, with the objective of making the translated image appear as similar as possible to the original.

The commonly used color spaces are RGB, CIE *XYZ*, CIE YUV, CIE L*a*b*, YCbCr and HSV. The three dimensional color space CIE XYZ is the basis for all color management systems. In the proposed intelligent system, the images in RGB color space are converted to *XYZ* color space. *CIE Xyz Color Space:* CIE *XYZ* color space is one of the first mathematically defined color spaces created by the International Commission on Illumination in 1931. Any color can be generated as a mixture of three other colors or "Tristimuli" and commonly RGB for CRT based systems or XYZ (fundamental measurements). The XYZ color space is defined such that all visible colors can be represented using only positive values, and, the Y value is luminance. As a result, the colors of the XYZ primaries themselves are invisible.

The chromaticity diagram is extremely non-linear, in that a vector of unit magnitude denoting the difference between two chromaticities is not uniformly visible. A 3x3 matrix transform is used to transform the RGB values in a particular set of primaries to and from CIE XYZ. CIE XYZ is a special set of tristimulus values.

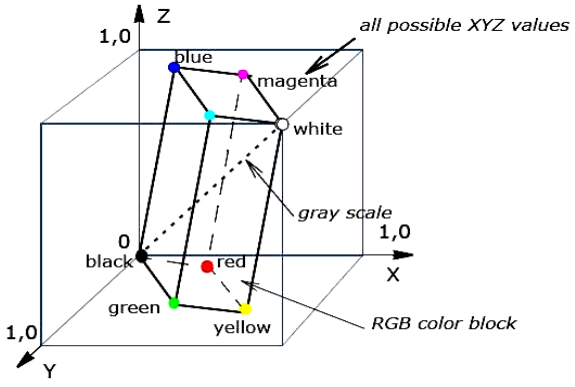


Fig. 4 CIE XYZ Color Space

The equations to convert *RGB* into *XYZ* color space are as follows:

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} 0.019334 & 0.119193 & 0.950227 \\ 0.212671 & 0.715160 & 0.72169 \\ 0.412453 & 0.357580 & 0.180423 \end{bmatrix} * \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

.....equation (2)

The presence of forest fire in an image is detected using the following steps. Initially the image is converted from RGB to *XYZ* color space. Then, the color space converted image is segmented. The *XYZ* color space [5] values of pixels in the segmented regions are fed as input to the trained set for detecting the presence of fires. The designed intelligent system will aid the people in surveillance to detect forest fires and to take appropriate actions.

Fig. 5 Image in RGB Color Space

Fig. 5.1 XYZ Color Space Converted Image

IV. CONCLUSIONS

Forest fires cause noteworthy environmental demolition while menacing human lives. In the last two decades, a significant effort was made to develop automatic detection tools that could aid the Fire Management Systems, Forest Management System (FMS). The motivation behind this research is to obtain beneficial information from satellite images. The Polygon segmentation gives type of forest to FMS to improve vegetation. The color space conversion has been employed to polygons. The converted color space

results can be used to identify the fire regions. The agent based segmentation will give high accuracy result. The proposed system will give better solution to people to detect and take appropriate actions for forest fires.

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