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An Approach For Identifying The Forest Fire Using Land Surface Imagery By Locating The Abnormal Temperature Distribution

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Abstract: *Forest fires have a detrimental impact on economy and environment. The rapid distribution of the fire could cause many causalities and a lot of effort is required to control. To overcome this problem it is highly important to detect forest fire before it spread its wing on the surroundings. Till to date, many of the approaches like smoke velocity distribution, usage of sensors, sounding systems and usage of thermal images have been applied in forest surveillance and found to be ineffective. In this paper, we present an improved system for identification of forest fire by using land surface temperature satellite imagery. From these images an analysis is carried out to identify the mean wavelengths of abnormal temperature distribution when compared to the surroundings on a small region and the mean wavelength for forest fires exceeds 10.14 from the experimentation. If the mean wavelength is beyond 10.14, it is treated as no forest fire. This approach uses k-mean clustering and haar wavelet, resulting an average accuracy rate of 89.5 %.*

Keywords: *Forest fire, Haar wavele, Image processing, k-means clustering, Surface temperature satellite imagery, Temperature scale.*

I INTRODUCTION

A forest is a complex ecosystem which is predominantly composed of trees, shrubs, wild life and is usually a closed canopy. Forests are warehouses of a large variety of life forms such as plants, mammals, birds, insects, reptiles and so on. Forests have major position in the life tree providing shelter for many species of genealogy. Forests are considered as the source of vast gene pool and protect the diversity of nature by balancing the harmful gases and absorbing aerosols which reduces the pollution.

Forests occupy around 31% of land on Earth (4 billion hectares) which is relatively less compared with industrial area (5.9 billion hectares). According to the U.N. Food and Agriculture Organization survey, deforestation at an average rate of 16 million hectares with highest being in 1990. At the same time, forest area is expanded globally at certain regions, either through planting or natural processes, bringing the global net loss of forest to 8.3 million hectares per year. In the first decade of this century, the rate of deforestation was slightly lower compare to other decades, but still, a disturbingly high 13 million hectares were destroyed annually. As forest expansion remained stable, the global net forest loss between 2000 and 2010 was 5.2 million hectares per year.

Forest fires are one of the major natural and manmade hazards which show adverse effects not only on wild life, surrounding environment but also on humans. Fires can have a positive as well as negative effect on forests, and its impact on forest health varies greatly in different ecosystems, environment, society and economy. Fires are sometimes essential for forest regeneration but also detrimental if it is repeated in the same area.

When a forest is destroyed the rate of oxygen production decreases and so the carbon dioxide absorption rate. Carbon dioxide is dangerous for health and it increases the atmospheric pollution, global warming and greenhouse effect. Soil and forest leafage absorbs up to 50% of rain. After a fire water cannot be retained anymore and floods occur as a consequence. Soil is no more protected by the rain intensity and erodes.

The normal temperatures of the forest is around 4°C to 10°C and low temperatures from -10°C to -6°C but they can also have extremely high temperatures around 20°C to 27°C. In forests, the fuel is provided by trees and bushes. Oxygen is not hard to find, seeing as it is all around us in the air and without heat, the fire could not continue. When fire occurs, wood reaches 300ºC and gives off a gas which reacts with oxygen to make a flame. The flame will heat the remaining wood, making the fire grow stronger. This will happen even on cold days. The temperature at which something ignites is called its flash point.

The various causes of forest fires can be classified into two broad categories: environmental (which are unable to control) and human related (which are controllable). Most forest fires are due to human involvements when compared with natural causes. Environmental causes are related to climatic conditions such as temperature, wind speed and direction, level of moisture in soil and atmosphere. Other natural causes are the friction of bamboos swaying due to high wind velocity and rolling stones that result in sparks setting off fires in highly inflammable leaf litter on the forest floor. Human related causes result from human activity as well as methods of forest management. Fires lit intentionally by people living around forests for recreation of plants and trees. Fires started accidentally by careless visitors to forests who discard cigarette butts [3].

Ground fires, burn on the ground or below the ground. These fires usually destroy many small organisms and fungi that live in organic layer. Surface fires, which burn along the surface and tend to move quicker, burning small trees on ground. A crown fire are most dangerous and spread fastly and occurs in the tops of the trees where fire can jump from one tree to another and in extremely windy conditions jumps over rivers and even lakes.

The present economic down in the world, with profit margins around the world in all industries including forestry under pressure, has resulted in examining all input costs including fire protection. This situation has stimulated examining alternative forest fire detection systems. Different approaches are used by many researchers to detect forest fire. Some approaches are based on visual cameras aims to detect the smoke plume produced by the fire. They can detect fires without direct vision, e.g., behind a hill. Different approaches to smoke detection with visual images have been developed based on contrast or texture or motion analysis through wavelet analysis among others. Visual-based methods require daylight to operate and the accuracy in locating the fire is lower than in the case of infrared detection.

Jerome Vicente and Philippe Guillemant [1] have presented an automatic system for early smoke source detection using landscape images by ground base video system. More recently, a semi automatic fire detection system using infrared satellite images from advanced very high resolution radio meter is proposed [2-5]. These systems have been successfully tested in large, uniform and unpopulated regions. However, in populated areas these methods have relevant limitations. Satellite spatial and temporal resolutions involve significant detection delays that can be unsuitable in crowded areas. In addition, human activity can cause frequent false alarms that hamper the application of the systems in operational conditions.

We propose a new novel approach for automatic fire detection by making use of land surface temperature images obtained from NASA earth observation satellite by observing the abnormal temperature distribution. The entire process is analyzed in two stages: first the images are segmented into clusters using k means algorithm and the region of interest is separated. In second stage haar wavelet is applied to compute mean wavelength. If the mean wavelength exceeds a value of 10.14, it is identified as a forest fire.

The rest of the paper is organized as follows. Section II describes relevant work, and Section III describes experimental methodology. Section IV focuses on experimental results obtained from research, Section V concludes the paper and finally, Section VI discusses the future enhancements that can be applied to the present work.

II RELEVANT WORK

Research and experimental development comprises creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications. The research activity is comprised of series activities they are: identifying and formulating the problems, extensive literature review, developing the hypothesis, objectives or research questions, preparing the research design, determining the sample, collection of data, analysis and interpretation of data.

Forest fire detections are being the research domain for several years. Several researchers contributed their related work to detect forest fire. Jerome Vicente and Philippe Guillemant [1] used smoke images of forest to detect forest fire using temporal algorithm. L. Giglio, J. Kendall and C.O. Justice [2] proposed a detection algorithm which uses AVHRR. T.M. Lillesand and R.W. Kiefer [3] had given a remote sensing and image interpretation technique. T. Hame and Y. Rauste [4] uses multitemporal data to monitor the fire. M.D Flannigan and T.H Vonder Haar [5] monitors forest fire using NOAA satellite AVHRR to identify the fire. Yasar Guneri Sahin and Turker Ince [6] a radio-acoustic sounding system with fine space and time resolution capabilities for continuous monitoring and early detection of forest fires is proposed. Koji Nakau and Masami Fukuda [7] based on MODIS satellite imagery, and comparison of NOAA satellite imagery with fire fighters' information. J.L. Casanova, A. Calle, A. Romo and J. Sanz [8] proposed a method for forest fire detection and monitoring by means of an integrated modis-msg system. K. Angayarkkani and Dr. N. Radhakrishnan [9] presented an intelligent system to detect the presence of forest fires in the forest spatial data using artificial neural networks. Radomir S. Stankovi and Bogdan J. Falkowski [10] presents the haar wavelet transform and efficient symbolic calculation of haar spectrum. J. R. Martinez - De Dios and A. Ollero [11] given some sensors and communication systems with potential applicability in forest fire fighting and it describes some fire detection and monitoring systems on satellite platforms, on aerial platforms and on ground stations. Damir Krstinic, Darko Stipanicev and Toni Jakovcevic [12] proposed histogram based forest fire detection using smoke. Wright

D.B., T. Yotsumata and N. El-Sheimy[13] identifies and locate forest fire hotspots using thermal images. Turgay Çelik, Huseyin Ozkaramanli and Hasan Demirel [14] given a method to detect fire and smoke based on image processing. Junguo Zhang, Wenbin LI, Ning Han and Jiangming Kan [15] given a wireless sensor network paradigm based on a ZigBee technique to detect forest fire. Nuria Utande Gonzalez de la Higuera and Juan Carlos Garcia Seco [16] developed a software which detects the fire using different methodologies. Zhong Zhang, Jianhui Zhao, Dengyi Zhang, Chengzhang Qu, Youwang Ke and Bo Cai [17] proposed a method which uses the FFT and wavelets to detect forest fire. Z. Li, S. Nadon and J. Cihlar [18] designed a fire detection algorithm to monitor the fires using AVHRR (Advanced very high resolution radiometer) images. Suman Tatiraju and Avi Mehta [19] have given an approach to segment the image using K-means clustering. Khaled Alsabti, Sanjay Ranka and Vineet Singh [20] also have given an efficient K-means clustering algorithm to cluster an image. Siddheswar Ray and Rose H. Turi [21] proposed an approach to determine number of clusters in image segmentation etc.

Till to date, the research on detection of forest fires was done only by using smoke images, thermal images and sounding system [1]. For the first time, the present research has opted temperature satellite images for detection of forest fire by using k-means clustering algorithm followed by haar wavelet.

III EXPERIMENTATION METHODOLGY

The objective of this real time processing of satellite image is to observe the abnormal raise in temperature distribution for the identification of forest fires. The systematic procedure applied in the analysis is shown in Fig.1. The input for this application is a land surface temperature image with noise or without noise.

The satellite images obtained may contain noise due to various image defects like electromagnetic noise, striping noise, speckle noise and are ought to be removed to obtain accurate results. When the satellite image containing noise is analyzed, the value obtained may deviate from original value.

The original image contains various colors analysed based on temperature scale where each spectral range represents a definite temperature. These spectral ranges must be separated to differentiate between high and low temperatures. Here, temperature scale is used to identify the range of temperatures by using color factor, shown in Fig. 2.

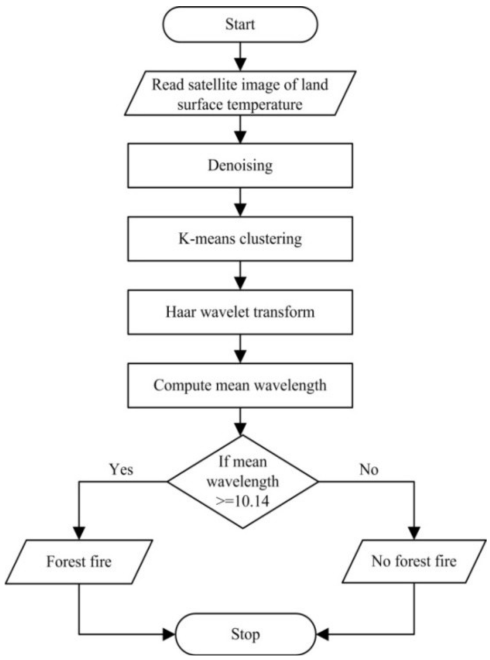

Figure 1. Real time detection of forest fire

There are various techniques for the classification of distinctive objects. In this research, clustering technique is applied to segment the spectrum into various identical regions called clusters. K-means clustering [19-21] algorithm is used with a value of 6 to segment the image into six regions based on wavelength as similarity measure to locate the high temperature region of interest.

The high temperature region will be separated from the surroundings and the abnormal temperature distribution is observed and if it raises continuously, providing a good estimate for the forest fire identification.

The segmentation process is applied for the original image shown in Fig 3, to form segments and the segmented images are shown in Fig 4. The entire process is implemented using MATLAB R2011a with image

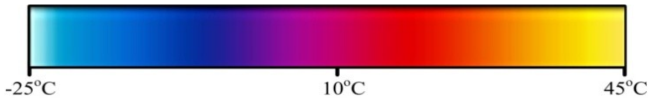

Figure 2. Temperature Scale

processing tool box, which provide image segmentation algorithms, tools and a comprehensive environment for data analysis, visualization and algorithm development.

The feature extracted cluster image shown in Fig. 4(F), is selected to analyze it further by applying haar wavelet. The haar wavelet [10] is chosen here as it is an efficient technique, where decomposition is applied to the image in rows and columns by transforming from data space to wavelet space in frequency domain. Further, as we are considering satellite image which is a RGB image, haar wavelet transforms can automatically invert a RGB image into gray scale image and further denoise the image, and present it in two dimensions.

In order to detect the forest fire certain interesting features from the extracted image are identified. The mean wavelength value is to be computed for feature extracted image. This image mean wavelength value plays an important role in the identification of fire in the forest. As the surrounding land surface temperature increases, the mean wavelength is observed to be varying. This abnormal temperature deviation has played an important role. From experimentation on 312 images, it is observed that the mean wavelength values for the identification of forest fire are exceeding 10.13. Table I shows, the calculated mean wavelengths for the images on a situation of fire in the forest. Hence, it can be established that whenever the forest fire occurs the computed mean wavelength of the clustered image of interest value is greater than or equals to 10.14.

IV EXPERIMENTATION RESULTS

Forest fire detection is one of the challenging tasks that researchers of present day are experiencing. The identification of forest fire from satellite images are even more challenging as the images are always covered by different temperature distribution over a region.

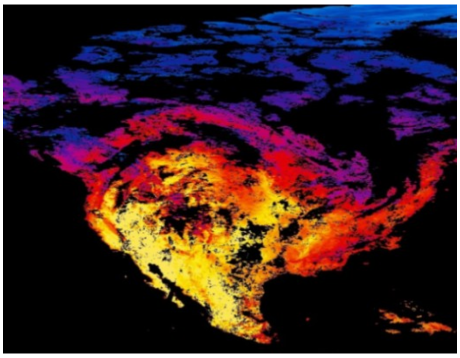

Figure 3. Original image taken as input

TABLE I. HISTORICALLY ESTABLISHED λ FOR FOREST FIRES

Image number	Mean wavelength (λ)	Historically established result
Image 1	12.43	Forest Fire
Image 2	11.47	Forest Fire
Image 3	10.86	Forest Fire
Image 4	11.83	Forest Fire
Image 5	12.24	Forest Fire
Image 6	12.6	Forest Fire
Image 7	10.92	Forest Fire
Image 8	14.43	Forest Fire
Image 9	13.23	Forest Fire
Image 10	11.28	Forest Fire

Till date, many other approaches like smoke velocity distribution, usage of sensors and sounding systems are applied in the identification of forest fire. But, these techniques are unable to perform up to their true extent.

The images obtained from NASA satellite of earth observations are used to analyze for the identification of high land surface temperature distribution. In the experimentation, around 312 images are analyzed to compute the success rate of detection. The preliminary results shown in Table II comprises of 57 images, represents forest fire or not a forest fire. Consider image 11, its computed mean wavelength is 13.92, this value exceeds the established value of 10.14. The predicted experimental result is forest fire which is same as historical result. Hence, the prediction is true. Similarly, consider image 29, its computed mean wavelength is 4.54. The predicted experimental result is no forest fire and also historical result is no forest fire. Hence, the prediction is true. Consider another image 15, its computed mean wavelength value is 9.05 which does not lies in the established range. The predicted experimental result is no forest fire but the historical result is forest fire. Hence, the prediction is false.

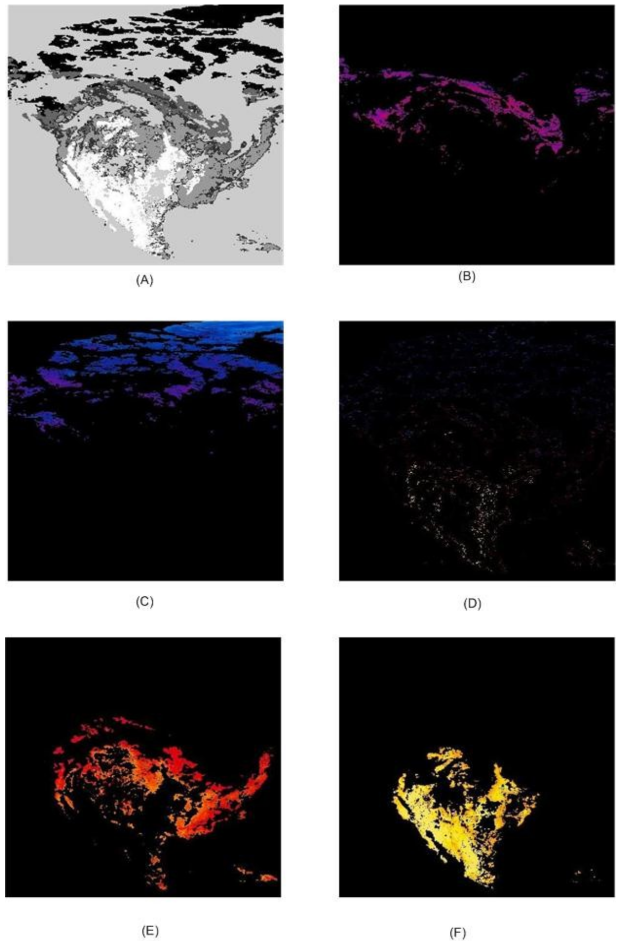

Figure 4. Temperature image segmented into six clusters
(A) Cluster 1 (B) Cluster 2 (C) Cluster 3 (D) Cluster 4
(E) Cluster 5 (F) Cluster 6

V CONCLUSION

This paper presents a formal mechanism for choosing mean wavelengths of land surface temperature in the visible and infrared spectrum to discriminate between forest fire and no forest fire for the images obtained from the NASA earth observation satellite. It was demonstrated that the resulting mechanism out performs the methods developed using smoke velocity distribution [1], sensor methods [8] and sounding systems [6]. Henceforth, identification of forest fire by making use of clustering and wavelet transform would be an efficient one. The overhead of getting experienced to the echo and attenuation issues by making use of thermal, radar images can be overcome by the satellite images for the prediction purpose. The limitation of this approach is that satellite permits a detection service at a continental scale, and only at the time when it passes over the same region.

FUTURE ENHACEMENTS

The present research demonstrates only the identification of forest fires. In addition to this, the area affected with fire is determined in future. A model can also be developed for identification of forest fire using association rules and classification techniques.

TABLE II.OBSERVATION TABLE

Image Number	Mean Wavelength (λ)	Experimental view	Historical view	Identification
Image 11	13.92	Forest Fire	Forest Fire	True
Image 12	12.7	Forest Fire	Forest Fire	True
Image 13	12.96	Forest Fire	Forest Fire	True
Image 14	11.34	Forest Fire	Forest Fire	True
Image 15	9.05	No Forest Fire	Forest Fire	False
Image 16	10.21	Forest Fire	Forest Fire	True
Image 17	12.34	Forest Fire	Forest Fire	True
Image 18	10.2	Forest Fire	Forest Fire	True
Image 19	10.68	Forest Fire	Forest Fire	True
Image 20	11.16	Forest Fire	Forest Fire	True
Image 21	10.68	Forest Fire	Forest Fire	True
Image 22	11.76	Forest Fire	Forest Fire	True
Image 23	14.18	Forest Fire	Forest Fire	True
Image 24	10.93	Forest Fire	Forest Fire	True
Image 25	11.41	Forest Fire	Forest Fire	True
Image 26	14.9	Forest Fire	Forest Fire	True
Image 27	10.15	Forest Fire	Forest Fire	True
Image 28	8.974	No Forest Fire	Forest Fire	False
Image 29	4.54	No Forest Fire	No Forest Fire	True
Image 30	12.6	Forest Fire	Forest Fire	True
Image 31	8.96	No Forest Fire	Forest Fire	False
Image 32	11.59	Forest Fire	Forest Fire	True
Image 33	11.77	Forest Fire	Forest Fire	True
Image 34	13.95	Forest Fire	Forest Fire	True
Image 35	10.66	Forest Fire	Forest Fire	True
Image 36	7.48	No Forest Fire	Forest Fire	False
Image 37	9.58	No Forest Fire	Forest Fire	False
Image 38	12.79	Forest Fire	Forest Fire	True
Image 39	7.91	No Forest Fire	Forest Fire	False
Image 40	9.13	No Forest Fire	Forest Fire	False
Image 41	9.36	No Forest Fire	Forest Fire	False
Image 42	15.66	Forest Fire	Forest Fire	True
Image 43	14.4	Forest Fire	Forest Fire	True
Image 44	7.292	No Forest Fire	Forest Fire	False
Image 45	14.78	Forest Fire	Forest Fire	True
Image 46	14.75	Forest Fire	Forest Fire	True
Image 47	12.07	Forest Fire	Forest Fire	True
Image 48	13.42	Forest Fire	Forest Fire	True
Image 49	8.651	No Forest Fire	Forest Fire	False
Image 50	13.44	Forest Fire	Forest Fire	True
Image 51	12.26	Forest Fire	Forest Fire	True
Image 52	13.18	Forest Fire	Forest Fire	True
Image 53	8.994	No Forest Fire	Forest Fire	False
Image 54	14.62	Forest Fire	Forest Fire	True
Image 55	4.63	No Forest Fire	No Forest Fire	True
Image 56	5.02	No Forest Fire	No Forest Fire	True
Image 57	6.48	No Forest Fire	No Forest Fire	True
Image 58	5.02	No Forest Fire	No Forest Fire	True
Image 59	7.30	No Forest Fire	No Forest Fire	True
Image 60	5.51	No Forest Fire	No Forest Fire	True
Image 61	4.51	No Forest Fire	No Forest Fire	True
Image 62	6.79	No Forest Fire	No Forest Fire	True
Image 63	4.58	No Forest Fire	No Forest Fire	True
Image 64	5.78	No Forest Fire	No Forest Fire	True
Image 65	4.64	No Forest Fire	No Forest Fire	True
Image 66	4.891	No Forest Fire	No Forest Fire	True
Image 67	5.738	No Forest Fire	No Forest Fire	True

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