A Survey: An Efficient Approach towards Thunderstorm Detection Using Saliency Map

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Abstract: ***Thunderstorm is a sudden electrical expulsion manifested by a blaze of lightening with a sound. It is one of the most spectacular mesoscale weather phenomena in the atmosphere which occurs seasonally. On the other hand, detection of thunderstorms is said to be the most complicated task in weather forecasting. Every thunderstorm produce lightening, kills more people every year. Heavy rain from thunderstorm leads to flooding and causes extensive loss to property and living organisms. In this regards, Saliency Map method is used to make important decision to accurately construct a system. The present research adopted clustering and wavelet transform techniques in order to improve the prediction rate to a greater extent. The study carried on thunderstorm prediction using the clustering and wavelet techniques resulting with higher accuracy. The proposed model yields the accuracy for identification of thunderstorm***.

Keywords: Clustering, Haar wavelet transform, Image processing, Remote sensing

1. Introduction

Thunderstorm is a vicious, climatic disturbance that is associated with heavy rains, lightening, thunders, thick clouds and gusty surface winds. Thunderstorms take place when a layer of warm and moist air rises to a larger extent, and updrafts to the cooler regions of the atmosphere. The updraft that contains moisture condenses in order to form massive cumulonimbus clouds and eventually leads to the formation of precipitation. Meanwhile, electrical charges mount up on cloud particles and causes lightning. This further heats the air in a fierce manner by which shock waves are produced, resulting in thunder [1]. Usually, thunderstorms have the spatial area for a few kilometers with a life span less than an hour. However, multi-cell thunderstorms have a life span of several hours and may travel over a few hundreds of kilometers [2]. A thunderstorm is said to be severe when it contains hail measuring of about an inch or more, winds gusting to an extent of 50 knots (57.5 mph). Throughout the world it is estimated that 16 million thunderstorms occur each year. Under the right conditions, rainfall from thunderstorms causes flooding, killing more people each year than hurricanes and tornadoes[2]. Cloud to ground lightning frequently occurs as part of the thunderstorm phenomena, which on severity becomes hazardous to the property, wildlife and population across the globe to a major extent. One of the most significant lightning hazards is to the wildfires, as they can even ignite the ground surfaces. Wildfires can devastate vegetation and the biodiversity of an ecosystem. Recently, thunderstorms in Uttar Pradesh has taken more than 110 human lives and dented famous mango belt of U.P during May 15 th 2008 [6]. In Canada, Alberta and southern Ontario are places best known for severe thunderstorms. In Canada the Saskatchewan Government Insurance estimated that 5900 claims cost close to $4 million and total damages were estimated at $10 million due to the thunderstorms. On 18 th May 2013, United States incurred losses of about $125 millions to $250 million dollars due to the disastrous effect of thunderstorms. Significant research work carried out in the last two decades for understanding the life cycle and the prediction of thunderstorm, still a challenging task to the forecasters and the researchers. The behavior of thunderstorms is still subjected to the experience of the forecasters and the analysis of numerical weather prediction models. Thunderstorms were predicted based on the severity of the sounds of the thunder, statistical test and graphing were the other parameters used for the prediction purpose. This motivates the present research to utilize satellite images, which are high in quality and can be an efficient and effective source for the prediction purpose.

2. Literature Survey

Watson-Watt and Herd [13] in 1920 developed a cathode-ray direction finder (CRDF) that utilized a pair of orthogonal loop antennas tuned to a frequency near 10 kHz, where propagation in the earth- ionosphere waveguide is relatively efficient to detect the horizontal magnetic field produced by lightning. The angle to the discharge was obtained by displaying the north-south and east- west antenna outputs simultaneously on an x-y oscilloscope, so that the resulting vector pointed in the direction of the discharge [14]. Two or more CRDFs at known positions were sufficient to determine the location of a discharge from the intersection of simultaneous direction vectors. Various low frequency CRDF systems were used up to and during World War II in many regions of the world.

Lewis et al. [17] in 1960 have described a method for locating lightning that is based on measurements of the time-of-arrival of a radio pulse at several stations that are precisely synchronized. A constant difference in the arrival time at two stations defines a hyperbola, and multiple stations provide multiple whose intersections define a source location. Time- of-arrival (TOA) methods can provide accurate locations at long ranges [18].

E. P. Krider, R. C. Noggle, and M. A. Uman in 1976 an improved magnetic DF system was developed for locating cloud-to-ground lightning within a range of about 500 km [15], [16]. This system operated in the time-domain (i.e., covering the LF and VLF bands from about 1 to 500 kHz) and was designed to respond to field waveforms that were characteristic of the return strokes in CG flashes [16]. When such a field was detected, the magnetic direction was sampled (in both a north-south loop and an east-west loop) just at the time of the initial field peak. The resulting direction vector pointed as closely as possible to the onset of the stroke and to the place where the stroke struck ground.

Hayenga and Warwick [25] in 1981 showed that a radio interferometer could be used to measure the azimuth and elevation angles of lightning sources at VHF frequencies. Rhodes et al. [26] and Shao et al. [27] have developed this technique and have used single-station interferometers to improve our understanding of the development of both IC and CG lightning. These were single station systems that provide a “projection” of lightning onto a plane. Richard et al. [28], and [29] have developed multiple-station networks of interferometers that can locate and map the sources of VHF radiation in two- or three-dimensions with high time resolution.

J.A. Cramer, K.L. Cummins[18] in 1989, they are capable of detecting VLF “spherics” produced by very distant cloud-to-ground lightning. These signals propagate thousands of kilometers by ionospheric reflection. Standard LF/VLF sensors can be simultaneously employed for their conventional use and for this long-range application. For this long-range application, the sensor information is processed in a manner that identifies and employs ionospherically-propagated electromagnetic signals produced by distant lightning, rather than the “normal” ground-wave propagated signals.

Casper and Bent [19] in 1992 have developed a wideband TOA receiver (termed the Lightning Position and Tracking System or LPATS) that is suitable for locating lightning sources at medium and long ranges using the hyperbolic method [20].

K.L. Cummins, R.O. Burnett, W.L. Hiscox and A.E. Pifer [21] in 1993, Global Atmospherics developed a method for combining direction-finding and time-of-arrival to produce yet another lightning location method which we refer to as the IMPACT method. In this approach, direction finding provides azimuth information and absolute arrival time provides range information. These measurements produce three parameters -- latitude, longitude, and discharge time. Thus, IMPACT method has redundant information which allows for an optimized estimate of location even when only two sensors provide both timing and angle information.

L. Maier, C. Lennon, T. Britt, and S. Schaefer in 1995, the NASA Kennedy Space Center has developed a Lightning Detection and Ranging (LDAR) System that is capable of providing three-dimensional locations of more than a thousand RF pulses within each lightning flash [32], [33]. This system is similar to that of Proctor, but the data acquisition is automatic, and the data displays are generated in real-time. In order to facilitate the support of this system, which had been the only one of its kind, NASA entered into a technology transfer agreement with GAI to build a COTS version of the system in 1997.

Kishor Kumar Reddy, Anisha P R, Narasimha Prasad L V presented the work in 2014. The segmentation is based on k-means clustering technique [18] in order to extract the thunderstorm features from the original image. In the second stage, Haar wavelet transform [15-17] is adopted to acquire square root balance sparsity norm threshold value for the feature extracted image.

2.1 Table

Table 1: Comparison of Detection Technique

Sr.No	*Year*	*Author*	*Proposed Work*
1	1920	Watson-Watt and Herd	Developed a cathode-ray direction finder (CRDF).
2	1960	Lewis et al	Locating the lightning for the measurements of the time-of-arrival of a radio pulse at several stations.
3	1976	E. P. Krider, R. C. Noggle, and M. A. Uman	An improved magnetic DF system was developed for locating cloud-to-ground lightning.
4	1981	Hayenga and Warwick	A radio interferometer could be used to measure the azimuth and elevation angles of lightning sources at VHF frequencies.
5	1989	J.A. Cramer, K.L. Cummins	Detecting VLF “spherics” produced by very distant cloud-to- ground lightning.
6	1992	Casper and Bent	Developed a wideband TOA receiver that is suitable for locating lightning sources.
7	1993	K.L. Cummins, R.O. Burnett, W.L. Hiscox and A.E. Pifer	Direction-finding and time-of-arrival to produce yet another lightning location method.
8	1995	L. Maier, C. Lennon, T. Britt, and S. Schaefer	A Lightning Detection and Ranging (LDAR) System that is capable of providing three-dimensional locations of more than a thousand RF pulses within each lightning flash.
9	2014	Kishor Kumar Reddy, Anisha P R, Narasimha Prasad L V	The segmentation is based on k-means clustering technique in order to extract the thunderstorm features from the original image

3. Proposed Metrology

The Proposed System consist of 3 phases.

3.1 Saliency Map

In the first phase, various thunderstorm images will be collected from data source or from the satellite for further evaluation of the image so that the process of further detection and clustering has been started. The highest energy portion of the image which is called as saliency map will be evaluated so that we get only the thunderstorm image and rest portion is removed from the image that we taken from the satellite.

3.2 Segmentation And K-Means clustering

In the Second phase, the image will be segmented and clustered using K-Means algorithm to form various clusters of thunderstorm. Clustering is an efficient technique to segment the input image into several clusters based on similarity measure. In this, the k-means clustering is adopted for segmenting the image. Here, Segmentation is performed to image by based on various color factors because colors possess wavelength values. The image containing relatively similar wavelength values are grouped into different clusters.

3.3 Haar wavelet And Wavelength Detection

In the third phase, wavelet transform will be applied and the wavelength will be calculated so that we can detect the presence of thunderstorm if the range of the wavelength is in between 350nm and 450nm then the thunderstorm is detected or else not detected. In this, the result analysis and optimization has been takes place. In this, the accuracy of thunder storm is evaluated and the system is optimized which is required and we clearly detect the thunderstorm.

The Haar wavelet transform is adopted for the further analysis where decomposition is applied to the image in rows and columns by transforming from data space to wavelet space in frequency domain. As a satellite image, Haar wavelet transform automatically converts image into gray scale image and further de noise the image and present it in one dimension.

4. Conclusion

In this paper, I have surveyed different thunderstorm detection technique. It has been concluded that all the techniques are good for detection of thunderstorm which having their own advantages and disadvantages, but the saliency map technique is used to clearly describe image for the accuracy of the primary image. The proposed method predicts the thunderstorms accurately than the previous method.

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