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Optimized Thunderstorm and Lightning Detection System

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Abstract: ***Thunderstorm and lightning is a sudden electrical expulsion manifested by a blaze of lightening with a muffled sound. It is one of the most stunning mesoscale weather phenomena in the atmosphere which occurs seasonally. Every thunderstorm produce lightening, this kills more people every year than tornadoes, and prediction of thunderstorms is said to be the most complicated task in weather forecasting, due to its limited spatial and temporal extension either dynamically or physically. Many of the researchers proposed various methodologies like STP model, MOM model, CG model, LM model, QKP model, DBD model and so on for the detection, but neither of them could provide an accurate prediction. The proposed system is to meet the satellite images obtained from dataset in order to predict whether the cloud images produces thunderstorms or not. The proposed system improves the prediction rate to a greater extent, on the basis of some statistical analysis. For more Accuracy, we are going to do comparative study of different model using Hybrid Approach.***

Keywords: Clustering, Haar wavelet transform, K-Medoids, Remote Sensing, Image Processing, PAM

1. Introduction

Computers are widely utilized in today's weather forecasting as a powerful tool to leverage an enormous amount of data. Yet, despite the availability of such data, current techniques often fall short of producing reliable detailed storm forecasts. Each year severe thunderstorms cause significant damage and loss of life, some of which could be avoided if better forecastswere available.Following figure shows thunderstorm image.

Figure.1- Thunderstorm Image

Thunderstorm is a vicious, climatic disturbance that is associated with heavy rains, lightening, thunders, thick clouds and gusty surface winds. 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 development of precipitation. Columns of frozen air then sink earthward, striking the ground with strong downdrafts and horizontal winds. Meanwhile, electrical charges mount upon cloud particles and causes lightning. This further heats the air in a violent manner by which shock waves are produced, resulting in thunder .Usually, thunderstorms have the spatial area for a few 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. Throughout the world it is estimated that 16 million thunderstorms occur each year, and at any given moment, there are roughly 2,000thunderstorms in progress. There are about 100,000thunderstorms each year in the U.S. alone. About 10% of these reach severe levels. Under the right conditions, rainfall from thunderstorms causes flash flooding, killing more people each year than hurricanes, tornadoes or lightning 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.

2. Literature Survey

Table I shows the summary of Different Thunderstorm Detectiontechniques proposed by various authors.

Table 1: Summary of Different Thenderstorm Detection Techniques

Sr. No.	Title of the paper	Author	Year	Proposed concept & Detail
1	Detection Of Thunderstorms Using Data Mining and Image Processing	Kishor Kumar Reddy	2013	Adopted clustering and wavelet transform
2	Application of Artificial Neural Network to Predict Squall-Thunderstorms Using RAWIND Data	Himadri Chakrabar	2013	Multilayer Perception (MLP) model to predict seasonal severe thunderstorms.
3	A K-means-like Algorithm for K-medoids Clustering and Its Performance	Hae-Sang Park	2014	Proposed a new algorithm for K-medoids clustering
4	Medical Image Denoising In The Wavelet Domain Using	Kanwaljot Singh Sidhu	2012	MRI,ultrasound, X-ray, CT scan. It is performed

	Haar And DB3 Filtering			using haar and db3 wavelets at both soft and hard threshold levels
5	Image segmentation by Clustering	Manjit Chintalapalli	2000	K-means, K-medoids, Hierarchical Clustering

3. Proposed Method

Research is a continuous phenomenon which involves the identification of a problem in any field and adopting the existing technologies or models or invention of new models and techniques for solving the problem. In this paper, a model is proposed for the detection of thunderstorm. The goal of this proposed system is to analyze the satellite images obtained from Indian Meteorological Department, in order to predict whether the cloud images produces thunderstorms or not and also find out whether thunderstorm touches to the ground or not. Initially, the in order to predict whether the cloud images produces thunderstorms or not. The original satellite image of clouds is taken as the input image for the experimentation. As the input image is a satellite image, it may restrain with different type of noises such as striping noise, speckle noise, blurs and so on which are ought to be removed. It may also contains various textures such as water bodies, forests, grass, asphalt, barren lands, concrete, clouds and so on. These textures are to be separated to acquire the image of interest so that the othertexture does not have an effect on the precise forecasting of thunderstorms. If the satellite image containing such typesof noises and textures are analyzed, the result obtained maydeviate from original value.

The proposed methodology for Optimized Thunderstorm and Lightning Detection System is used following algorithms:-

- Harr Wavelet transform
- K-Medoids Clustering Algorithms.

k-medoids clustering is a partitioning method commonly used in domains that require robustness to outlier data, arbitrary distance metrics, It is similar to *k*-means, and the goal of both methods is to divide a set of measurements or observations into *k* subsets or clusters so that the subsets minimize the sum of distances between a measurement and a center of the measurement's cluster. In the *k*-means algorithm, the center of the subset is the mean of measurements in the subset, often called a centroid. In the *k*-medoids algorithm, the center of the subset is a member of the subset, called a medoid.

The *k*-medoids algorithm returns medoids which are the actual data points in the data set. This allows you to use the algorithm in situations where the mean of the data does not exist within the data set. This is the main difference between *k*-medoids and *k*-means where the centroids returned by *k*-means may not be within the data set. Hence *k*-medoids is useful for clustering categorical data where a mean is impossible to define or interpret.

The most common realisation of k-medoid clustering is the Partitioning Around Medoids (PAM) algorithm and is as follows & figure.2 shows A Typical K-Medoids Algoritham(PAM)

1) Initialize: randomly select k of the n data points as the medoids
2) Assignment step: Associate each data point to the closest medoid.
3) Update step: For each medoid m and each data point o associated to m swap m and o and compute the total cost of the configuration (that is, the average dissimilarity of o to all the data points associated to m). Select the medoid o with the lowest cost of the configuration.

Repeat alternating steps 2 and 3 until there is no change in the assignment.

a) Typical K-Medoids Algorithm (PAM)

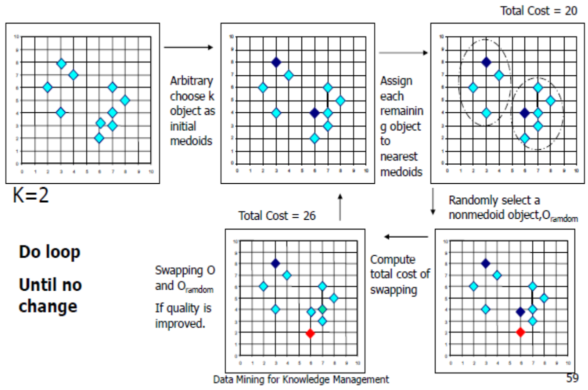

Figure 2: Structure of PAM

4. Concept of Clustering

In Proposed system concept of clustering is use. Clustering is the search for distinct groups in the feature space. It is expected that these groups have different structures and that can be clearly differentiated. The clustering task separates the data into number of partitions, which are volumes in the n-dimensional feature space. These partitions define a hard limit between the different groups and depend on the functions used to model the data distribution.

It is an efficient technique to segment the input image into several clusters based on similarity measure

Below Figure shows Image segmentation by clustering based on color factor

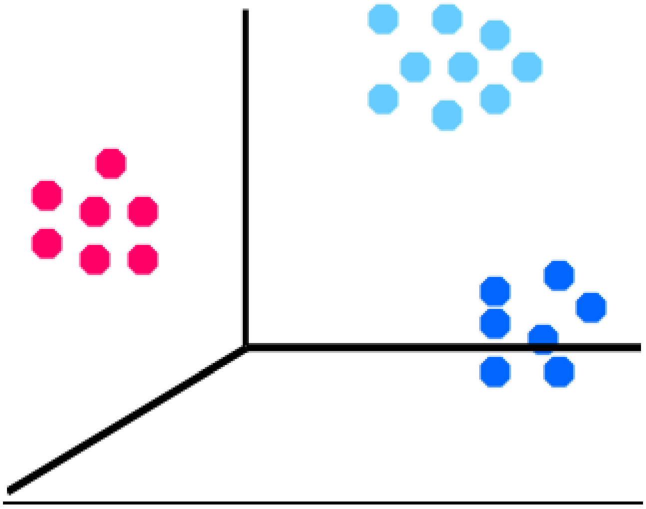

Figure 3: Similar data points grouped together into clusters.

There are many algorithm are use for clustering. In this paper we use we use **K-medoids**

The segmentation process applied for a thunderstorm satellite image is shown in figure 4(a) and the resulted clusters generated are shown in figure 4(b), 4(c), 4(d), 4(e)and 4(f) respectively.

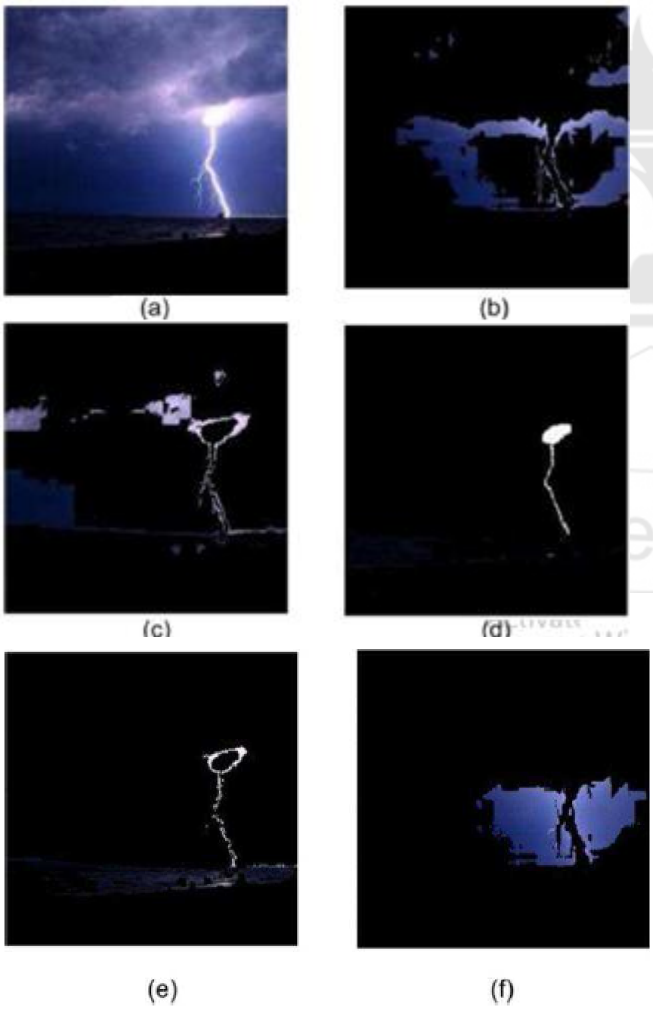

Figure 4: (a) Original image 4(b) Cluster 1 4(c) Cluster 24(c) Cluster 3 4(d) Cluster 4 4(e) Cluster 5 4(f)

The feature extracted clustered image shown in figure 4(d), is analyzed further by applying Wavelet transformations,

Harr Wavelet Transform

Haar wavelet is one of the oldest and simplest type of wavelet. The Haar Transform provides prototype for all other wavelet transforms. Like other wavelet transforms, the Haar Transform decomposes the discrete signal into two sub-signals of half its length. One sub-signal is a running average or trend and other sub-signal is running difference or fluctuation. The advantage of Haar wavelet is that it is fast, memory efficient and conceptually simple.

The wavelet transform has emerged as a cutting edge technology, within the field of signal & image analysis. Wavelets are a mathematical tool for hierarchically decomposing functions. Though routed in approximation theory, signal processing, and physics, wavelets have also recently been applied to many problems in computer graphics including image editing and compression, automatic level-of-detailed controlled for editing and rendering curves and surfaces, surface reconstruction from contours and fast methods for solving simulation problems in 3D modeling, global illumination and animation.The wavelet transform can be implemented by a two channel perfect reconstruction (PR) filter bank . A filter bank is a set of filters, which are connected by sampling operators.

Following Figure.5 shows an example of a two-channel filter bank applied by one dimensional signal. d*(n)* is an input signal and dR(n) is reconstructed signal. In the analysis bank, b0(n) is a analysis low pass filter and b1(n) is a analysis high pass filter.

5. HAAR Wavelet Structure

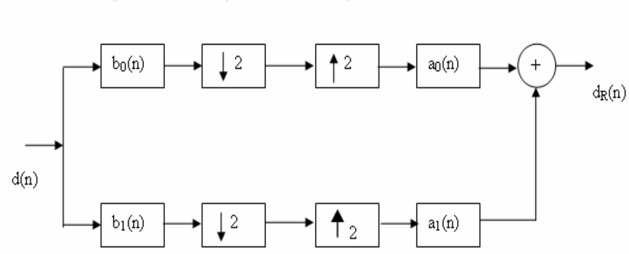

Figure 5: Two channel wavelet structure

In this paper the **Haar Wavelet transform** is adopted for the further analysis. As a satellite image is an RGB image, Haar wavelet transform automatically converts RGB image into gray scale image and further de noise the image and present it in one dimension.

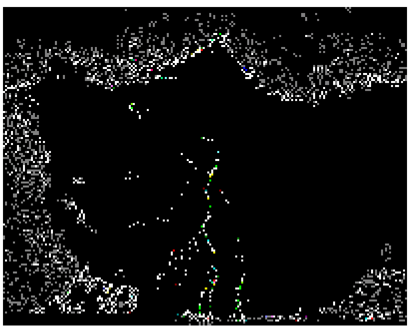

Figure 6: Wavelet image

In Haar wavelet, soft threshold value is considered for computing square root balance-sparsity norm threshold value

The soft threshold expression is shown in equation (1).

$$\bar{c}_S(k) = \begin{cases} sign\, c(k)(c(k) - \tau), & c(k) \geq \tau \\ 0, & c(k) < \tau \end{cases} \quad (1)$$

For the determination of threshold values, equation (2) is used.

$$\tau = \sqrt{\frac{2\sigma^2 \log(n)}{n}} \quad (2)$$

Fixed threshold value is calculated by using equation (4).

$$\tau_k = \int_0^{255} \left(\frac{d\Delta}{d\lambda} \sqrt{\frac{2\sigma^2 \log n}{n}} \right) dn \quad (3)$$

Now wavelength factor value is to be computed by using equation (3)

Wavelength factor

$$\left(\frac{d\Delta}{d\lambda} \right)$$

Now wavelength is computed by following formula

Wavelength

$$(\lambda) = \tau * \frac{d\Delta}{d\lambda}$$

As thunderstorm image comprises a wavelength in between 350nm to 450nm.The main goal of the proposed system is to detect the thunderstorms as accurate as possible .and find out ground position to determine whether lighting touched to the ground or not

In order to compute accuracy for the present research TP, TN, FP, FN values are to be computed. The true positive (TP) specifies the positive tuples that were correctly labeled. The true negative (TN) specifies the negative tuples that were correctly labeled. The false positive (FP) specifies the negative tuples that are incorrectly labeled. The false negative (FN) specifies the positive tuples that are incorrectly labeled. The four basic performance measures i.e. sensitivity, specificity, accuracy and precision are computed for the present research in order to test how well the proposed system is working and the computations are done by using following equation and 7. The proposed algorithm aims for 100% sensitivity100% specificity, 100% accuracy and 100% precision.

$$Sensitivity = \frac{TP}{TP + FN}$$

$$Specificity = \frac{TN}{FP + TN}$$

$$Accuracy = \frac{TP + TN}{TP + FP + FN + TN}$$

$$Precision = \frac{TP}{TP + FP}$$

6. Proposed System Design

The architecture of proposed approach is shown in Figure.4which consists of two Algorithms such as Harr-Wavelet and K-Mediods. In the architecture of proposed approach, find out result of thunderstorm by calculating wavelength and lightning position by scanning image pixel by pixel.

The steps to design a proposed system are as follows,

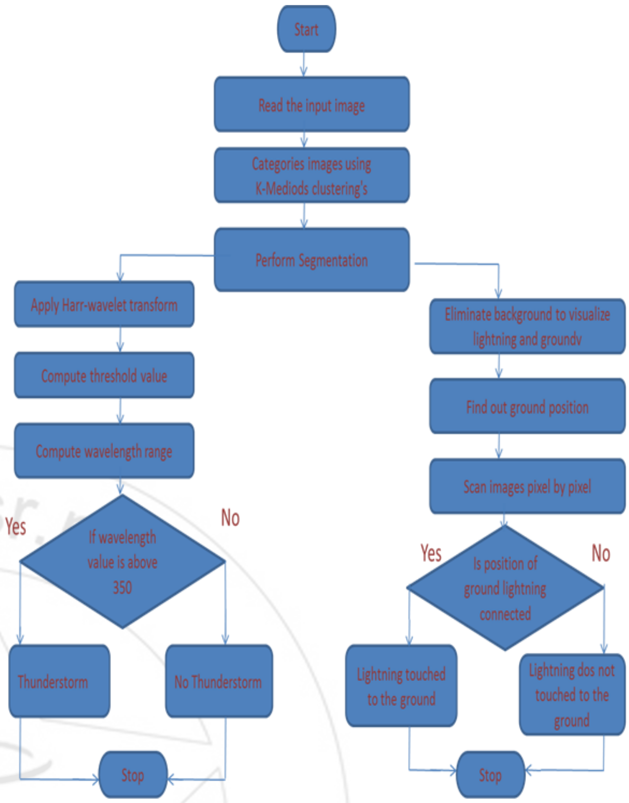

Figure 7: Block diagram of proposed system

<u>The steps to design a proposed system are as follows-</u>

Step 1- Take the satellite images as input in order to find out thunderstorm

Step 2-Perform segmentation on image by K-Mediod algorithm which is used to perform the classification on the input image to focused on the region of interest

Step 3- Next step is to perform segmentation on the classified images with the help of Harr-wavelet transform algorithm. It is used find out the wavelength of the thunderstorms.

Step4- Next step is compare the wavelength range, If wavelength is between 350-450 nm result will be thunderstorm otherwise no thunderstorm

Step 5- after segmentation eliminate background so that lightning and ground is visualize

Step 6– find out ground position & scan image pixel by pixel

Step 7- find out whether lighting touches to the ground or no

Step 8- Stop

7. Conclusion

In the proposed work, experiments have been conducted with k-medoids clustering technique and Haar wavelet transforms for the detection of thunderstorms. Various researchers have already been worked to propose the system using different algorithms but they were not getting the optimized result. The proposed method uses a hybrid approach which gives the optimized result for detecting the thunderstorm and lightning touches to the ground or not. It was demonstrated that the resulting mechanism out performs the previous methods such as STP model, MOM model, CG model, LM model, QKP model, DBD model in the detection of thunderstorms. In order to compute accuracy, the four basic performance measures i.e. sensitivity, specificity, accuracy and precision are computed. The proposed system is used for the welfare of weather forecasting department in order to detect the thunderstorm, and check weather that thunderstorms is hazardous to human life or not.

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