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Hybrid Approach for Weather Prediction using Satellite Images

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Abstract*: One of the most powerful and important tools used by the meteorologist for weather forecasting is satellite images. Satellite images have always reassured forecasters the behavior of atmosphere as they provide facts that are clear, conscience and accurate representation of how events are unfolding. From satellite images some features will be extracted using image processing technique. The numerical method takes different parameters as input and forecasts weather using a computer to process the data. Equations used in this method will determine the precision of the forecast. In this paper, we are proposing a hybrid method for prediction by combing weather satellite image analysis with the numerical method which increases the accuracy.

***Index Terms*: Weather forecasting, Satellite images, Numerical method, Image processing**

I. INTRODUCTION

Image processing is a powerful technical tool which is used for various purposes. In a satellite image, pixels are the unit used to represent an area of the particular space, which may not necessarily be of uniform type. Crucial part in analysis of the image is to identify the pixels of similar type. Plenty of image processing techniques are present to perform this task. Satellite images are used by meteorologists to figure out the cloud shapes, heights and types. Variation in these cloud attributes, along with cloud movement, gives important details to the weather forecasters, to establish what is happening, and what might occur in the future. Image retrieval and feature extraction can be done using fuzzy SOM strategy for satellite image retrieval and information mining projected by Yo-Ping Huang, Tsun-Wei and Li-Jen Kao [1]. This strategy has two parts. It uses a computation algorithm for offline satellite image feature extraction, image data representation and image retrieval. Another strategy proposed by Craig M. Wittenbrink et. al is Feature extraction of clouds from GOES satellite data for integrated model measurement visualization [2]. Another strategy is the use of ICA/Fast ICA Algorithm proposed by Du Huadong and Wang Yongqi is Studies on Cloud Detection of Atmospheric Remote Sensing Image using ICA Algorithm [3]. A paper by Chiang Wei et al suggests a multi-spectral spatial convolution approach for real-time rainfall forecasting using geostationary satellite images [4]. Studies were done in this area in 1998 in a paper titled "Localized Precipitation Forecasts from a Numerical Weather Prediction Model using Artificial Neural Networks" by Robert J. Kuligowski and Ana P. Barros [5].

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II. TYPES OF SATELLITE IMAGES

A. Panchromatic Image

These are usually black and white images. An example for this is Corona Satellite, launched by United States National Reconnaissance Office in 1960. Since the photos were taken as stereo pairs, it is possible to turn them into digital elevation models (DEMs).

B. Multispectral Image

These are commonly referred as RGB images, where R stands for Red, G stands for Green, B stands for Blue. RGB images records visible light. One example of Multispectral Imagery is 'GeoEye-1'.

C. Hyperspectral Image

These images are capable of recording hundreds of very narrow bands. The ultimate goal is to cover the continuous spectrum of light instead of recording it in discrete bands. These types of images are mostly used in more specific applications.

III. TYPES OF CLOUD

All cloud types are not same as they are not created equal. Some are puffy and sweet, whereas some are grey and uniform and some are erratic and capricious. The clouds are named based on their shapes and how high up they hover in the troposphere. Cloud types are divided into three categories. They are High-level clouds, Mid-level clouds, and Low-level clouds.

A. High -level Cloud

This category of clouds comprises of Cirrocumulus, Cirrus, and Cirrostratus. Clouds coming under this category hover above 5-13 km from the ground. Cirrus is the most common type of cloud and can be seen at any time of the year. They appear as a very thin and wispy layer. Moreover, these types of clouds are made of ice crystals. Their degree of separation is used to determine the transparency of cirrus clouds. Cirrocumulus clouds are most attractive of all.

They form at a distance of 5km above the ground level with white fluff patterns that is spread over the sky for miles. Cirrocumulus clouds do not have shading and these clouds come out after Cirrus clouds during warm frontal system. These clouds never generate rainfall.

Cirrostratus clouds have a sheet like appearance and look more like a curly blanket covering the sky. Sun light and moon light can easily peer through these clouds as they are very translucent. Their color varies from light grey to white. These clouds are found to move in a westerly direction mostly. Their presence usually means rainfall is imminent in the next 24 hours.

B. Mid-level Cloud

This category of clouds comprises of Altocumulus, Altostratus, and Nimbostratus. Clouds coming under this category hover above 2-7 km from the ground. Altocumulus clouds are also called social clouds as they appear in groups.

They are found in a greyish white color. These clouds are formed in the lower altitude. Because of this reason they are largely made of water droplets and may retain ice crystals as they are formed higher up. These clouds are very common in most parts of the globe. Altostratus can be found spread over miles and these generate light rain or snow. These are not capable of generating heavy rain. They are also called 'boring clouds' because of their uniform greyish color and are featureless. Nimbostratus clouds are the main bearer of heavy rain. This layer of cloud is formed in thick layer. They can be formed from other types of cloud like descending altostratus.

C. Low-level Cloud

This category of clouds comprises of Stratus, Cumulus, Cumulonimbus, and Stratocumulus. Clouds coming under this category hover above 0-2 km from the ground. Stratus clouds are made of very thin layer of clouds and covers large areas of the sky. Stratus clouds are formed from large air masses that rise to the atmosphere and later condense. Stratus clouds are very commonly found all around the globe and especially in coastal and mountainous regions.

Cumulus clouds are the most recognized cloud type out of all type of clouds. They have a fluffy appearance with white color.

Cumulus clouds are considered sign of fair weather. Cumulonimbus clouds are fluffy are white like cumulus. But cloud formation is more in cumulonimbus. These are also called tower clouds as they are vertical developing type of clouds. These clouds come with a thunderstorm along with heavy rain. Stratocumulus appears like a thick white blanket. Stratocumulus appears as dark grey hues. They almost resembles to cumulus cloud.

IV. WEATHER FORECASTING METHODS

As days go on, the methods of weather forecasting become better and better with the help of the satellites that has been launched into the orbit. Meteorologists rely on the data's obtained from satellites, weather stations, aeroplanes and weather balloons.

The ways of forecasting the weather has been categorized into four methods. They are Climatology method, Analog method, Persistence and Trends method and Numerical Weather Prediction.

A. Climatology Method

This is considered to be the easiest method of forecasting the weather. This method is carried out by reviewing the weather statistics gathered over many years and calculating the averages. The weather for a particular day is predicted by looking the previous weather condition collected for that day in the previous years. This works well only when the weather pattern remains almost the same. Accuracy is not obtained to the best level in this methodology.

B. Analog Method

This weather forecasting method is considered to be the difficult among all the other methods. This is because it requires finding a day in the past with weather similar to current weather conditions, which is difficult to implement. Even small differences between the past and the present can change the outcome, which is why the analog method is not a best suited method for weather prediction.

C. Persistence and Trends Method

This weather forecasting method require little to no skill to predict the weather because it relies on past trends. To bring out the best accurate forecast, one must stay abreast of current temperatures and conditions and know the regions climate averages.

D. Numerical Weather Prediction Method

This method of weather prediction relies on the computer to predict the weather. Modern super computers and latest software's and hardware's help the meteorologists to make weather predictions more accurately. The method greatly relies on computer algorithm to predict the weather. Better the algorithm, more accurate is the weather predicted.

V. PROPOSED APPROACH

Our approach involves few steps to extract cloud cover percentage from the given weather satellite image to predict the weather. An image processing technique is done on the satellite image using MATLAB platform. Image Segmentation technique is applied on the cropped part from the original satellite image to get approximate values of cloud cover extraction. The list of steps involves Image Segmentation, Region Selection followed by calculation of Cloud Cover Percentage.

A. Image Segmentation

This section deals with reading satellite cloud top alert image as shown in fig 1, which is an RGB image. This image is then, converted into grayscale image. Grayscale image is nothing but, a binary image which helps in cloud cover extraction.

1) RGB to Grayscale Conversion

Image is read and shown in MATLAB using 'imread' and 'imshow' commands respectively. 'rgb2gray' command is used to convert RGB into binary image as shown in fig 2.

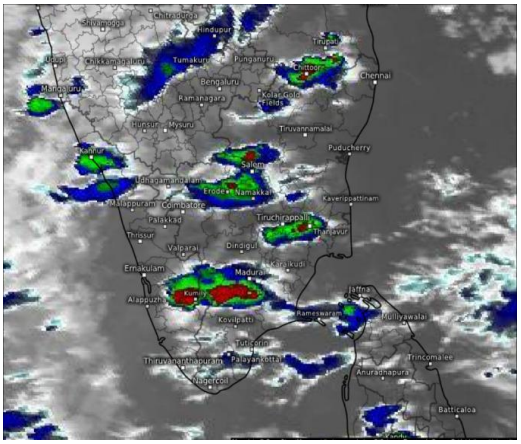


Fig. 1. Satellite Cloud Top Alert RGB Image (South India)

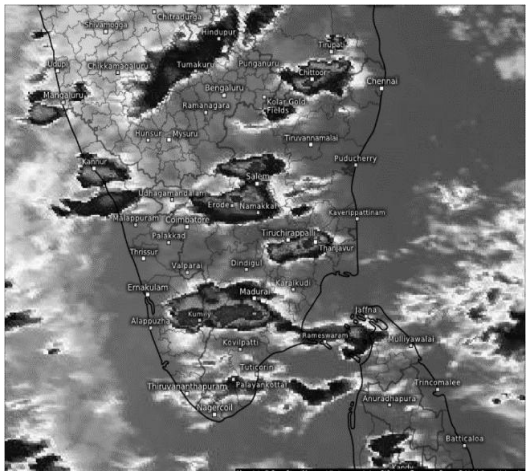


Fig. 2. Satellite Cloud top alert Grayscale image

2) Histogram Equilization

Histogram Equalization is done to see the distribution of intensity in its current state in an image. The intensity of the pixels can be in the range of 0-255.

```
% Histogram Equalisation
% Distribution of intensity in the image
figure,imhist(S1);
```

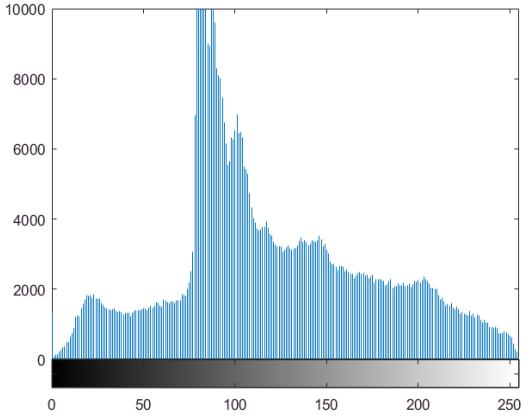


Fig. 3. Histogram of the input image.

'imhist' command is used to get the histogram and 'histeq' command is used to improve the intensity value. Fig 4 and fig 3 shows the histogram of input image and improved grayscale image respectively.

```
S2 = histeq(S1);
figure,imshow(S2);
```

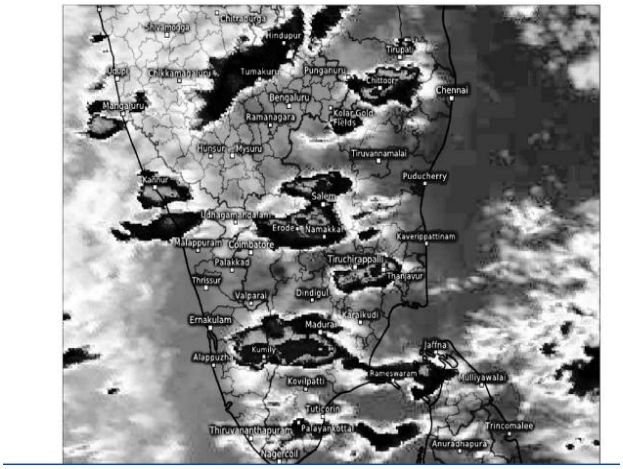


Fig. 4. Output of 'histeq' command

Adaptive Average brightness thresh-holding (AABT) looks promising in addressing satisfactory image segmentation and quick processing. This method is based on three observations [6]:

1. It is simple and provides faster processing.
2. It is highly effective when correct threshold levels are chosen.
3. Brightest objects found in these types of image are usually cloud.

An average cut-off function is used to determine cut-off threshold which is used to extract cloud cover. This function is given by [1]:

$$Avg.\ Cut\ Off = Avg.\ Brightness + f * (\ln(GMAX) - \ln(Avg.\ Brightness)) \quad \ldots..(1)$$

Where:

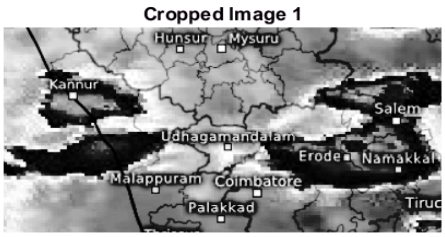
- ln ( ) is natural logarithm
- GMAX is number of grayscale values, GMAX= 256 in this case
- f is multiplicative coefficient, f=22.5 in this case, determined empirically

B. Region Selection

This technique is used to crop a part of the input image for which the weather is to be predicted as shown in fig 5. Also, smaller images are easier to process than larger images. But this technique reduces the resolution of the image as compared to original image.

The cropped image can be used to observe the surrounding areas as well to note the weather conditions.

```
S3=imcrop(S2,[100,200,400,200]);
imshow(S3),title('Cropped Image 1')
```




```
S4=imcrop(S2,[100,200,200,100]);
imshow(S4), title('Cropped Image 2')
```

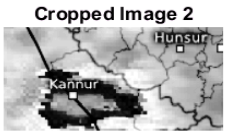


Fig 5. Cropped images

C. Cloud Cover Percentage

Cloud Cover Percentage value will determine the final output of weather prediction shown fig 5 . High value means high precipitation factor or prediction of stormy weather depending upon the weather data table. Low value would suggest prediction of a clear sky or no precipitation. This is the main aim of image processing. This value is calculated by the formula:

$$Cloud\ Cover\,(\%) = \frac{No\ of\ nonzero\ pixels}{Total\ no\ of\ pixels} * 100 \quad \ldots..(2)$$

Pixels represent the values of the image matrix.

D. Implementation Process for Prediction

Weather dataset containing different parameters like mean values of temperature, humidity, wind speed, cloud cover and precipitation are combined with the cloud cover information obtained by image processing and segmentation to predict the weather of the chosen region. Values of cloud cover ranges from 0 to 9 where '0' indicates clear sky and '9' indicates overcast sky. These values are recorded hourly. High mean precipitation value indicates heavy rainfall during that particular hour. Low value indicates low rainfall or clear sky. Prediction of weather dataset is shown in Table 1. Satellite images are used in this paper to calculate the cloud cover percentage of a specific region. The cloud cover is then added to the weather data sets as non target parameters. Assigned binary values for each weather condition for classifying weather into ThunderStorm (0001), Rainy (0010), Foggy (0100) and Sunny (1000). By analysing the binary values added, new weather files are generated which are compared with the orignal weather files to measure the accuracy. A snippet depicting the classification of weather is given in fig 6.

Table 1. Prediction of weather

Temperature (°C)	Humidity (%)	Wind speed (Km/h)	Cloud cover	Precipitation (mm)
28	77	11	6	13.97
29	75	10	5	0.25
31	71	13	3	0
29	75	10	4	0
28	79	11	5	12.95
29	76	13	2	0

```
#include<string>
#include<fstream>
#include<bits/stdc++.h>

using namespace std;

string fun(string s)
{
    if(!s.compare("Fog"))
        return "0100";
    if(!s.compare("Rain"))
        return "0010";
    if(!s.compare("Thunderstorm"))
        return "0001";
    return "1000";
}
```

Fig.6. Classifying weather Snippet

VI. CONCLUSION

Satellite imagery can be a very powerful tool for weather forecasting undergoing image processing and segmentation. In this, the important cloud features are extracted from the satellite image. This helps in obtaining cloud cover percentage which is combined with weather dataset parameter values to increase the accuracy of the prediction. Integrating the output of image processing and segmentation along with numerical weather dataset values result in a more accurate prediction. There can be numerous ways to predict the weather like using machine learning (deep learning) techniques or the mentioned method. Continuous research and efforts in this area will help the scientific community as well as the world.

REFERENCES

1. Yo-Ping Huang , Tsun-Wei Chang and Li-Jen Kao, "Using Fuzzy
2. SOM Strategy for Satellite Image Retrieval and Information
3. Mining", Systemics, Cybernetics And Informatics vol. 6 number 1 pp. 56-61.
4. Craig M. Wittenbrink, Glen Langdon, Jr. , "Feature of Extraction of Clouds From GOES Satellite Data for Integrated Model Measurement Visualization", Technology & Engineering 2010
5. Du Huadong, Wang Yongqi, Chen Yaming, "Studies on Cloud Detection of Atmospheric Remote Sensing Image Using ICA Algorithm', 2009 IEEE.
6. Chiang Wei , Wei-Chun Hung and Ke-Sheng Cheng, "A Multispectral Spatial Convolution Approach of Rainfall Forecasting
7. Using Weather Satellite Imagery", Journal of Advances in Space
8. Research, 2006.
9. "Localized Precipitation Forecasts from a Numerical Weather
10. Prediction Model Using Artificial Neural Networks" by Robert J.
11. Kuligowski and Ana P. Barros.
12. Isaac J.H. Leung, James E. Jordan, "Image Processing for Weather Satellite Cloud Segmentation", Canadian Conference on Electrical and Computer Engineering pp. 953-956.

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Prof. Basil Xavier obtained his bachelor's degree from Anna University in 2010.He completed his Master's degree from Karunya university in 2012,Currently He is doing his research in area of computing security mainly focused on cloud security and IoT security and also his passion towards photography which made him to contribute in Multimedia area also.

Prof. Shibin David is currently serving as a faculty member at Karunya Institute of Technology and Sciences, Coimbatore. His research interest includes applied cryptography,mobile computing and applied physics. His profounding interest towards the contribution in the fields aforementioned made him attend more than 10 FDPs, more than 35 participation in National/International workshops, conferences across India. The determination to bring out solutions to real world problems made him publish his research contributions in good number of International journals which are Scopus Indexed. His keen motivation towards the latest technology made him to intervene and take up the advanced Blockchain technology into his research basket.

Prof. Andrew J, M.E., (Ph.D.)., is an assistant professor at Karunya Institute of Technology and Sciences (Deemed University) in the department of computer science and engineering. He is currently pursuing his Ph.D. from VIT University, Vellore. He received his master of engineering from the Anna University in 2013. He has authored journal articles, book chapters and conference contributions. His research interests include data privacy, big data security and privacy preserving techniques.

Prof. Isaac Joel Raj has obtained his bachelor degree from SRM Institute of Technology, Chennai and his masters from Karunya University, Coimbatore. He is currently sphere heading the Department of Media and Communication at Karunya Insitute of Technology and Sciences. Also, his passion towards the media technology made him to undergo research studies from Vellore Institute of technology. His interest towards the academics and administration made him to play various administtive roles in the University.