

# Cloud Image Analysis for Rainfall Prediction: A Survey

Minakshi Gogoi<sup>1</sup> and Gitanjali Devi<sup>2</sup>

<sup>1</sup>Dept. of Computer Science and Engineering Girijananda Chowdhury Institute of Management and Technology

<sup>2</sup>M.Tech., 3rdsem, Dept. of Computer Science and Engineering Girijananda Chowdhury Institute of Management and Technology  
E-mail: <sup>1</sup>minakshi\_cse@gimt-guwahati.ac.in, <sup>2</sup>gdevi43cse@gmail.com

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**Abstract**—The existence of clouds in the sky has a great impact, as it contains useful information for prediction of rainfall. Rain is the essential part of our ecosystem and it is responsible for most of the fresh water on the Earth. The rainfall plays a vital role for the balancing the heat ratio of Earth as well as water for hydroelectric power plants and crop irrigation. As almost 70% of population of any nation depends on agriculture, so rain can be the deciding factor of any nation's economic condition. Earlier prediction of rainfall was done by traditional means when technology was not developed. Later, with the development of various technologies prediction of rainfall became an easier and accurate way by studying different types of cloud image. Prediction of rainfall is possible with cloud images which may be either digital/satellite image. Prediction of rainfall can provide us with various pros and cons directly or indirectly hampering living beings on Earth. Early prediction of rainfall can provide us to preparedness of various disasters. But accurately forecasting of rainfall is complex as the clouds keep on changing. Clouds keep on changing depending upon different seasons. Prediction of rainfall can be done during the monsoon season where we may get the required result. As, previous work done, it is known that the rainfall clouds are the Nimbostratus and Cumulonimbus. Clouds like Cumulus can produce rain at very rare chance. Till now research is going onto predict rainfall using various technologies. But accurate forecasting of cloud image is a complex process. Image processing is one of the eras with its new technologies that can be used for detecting the early information about rainfall. In this paper a brief view of different types of clouds is discussed. Also, a brief analysis to highlight the possibilities of image processing methods is carried out that can be focused for effective prediction of rainfall.

**Keywords:** Cloud images, Cloud Types, Rainfall prediction, Image processing methods.

## 1. INTRODUCTION

Clouds are important for balancing the Earth's climate, weather and temperature. A small change in the clouds could change the weather heavily. The presence of clouds in the sky can predict that there will be changes in the weather. The prediction of weather will be possible by understanding different type of clouds. Clouds are needed to be classified so that it become easier to detect which type of cloud it belongs to. So, that weather can be accurately predicted. Depending

upon their height and characteristics, the clouds can be classified into various types. Clouds can be characterized based upon their shape, color, density, degree of cover, altitude at which they occur. There are three basic types of clouds and seven other types of clouds. The basic clouds are the Stratus, Cirrus, and Cumulus. Clouds can also be classified based on their altitude i.e., High Clouds are the "Cirrus", the Middle Clouds are the "Alto", and the Low Clouds are the "Stratus". It has been found that the rainfall clouds are the Nimbostratus and Cumulonimbus. Other clouds like Cumulus will produce rain at rare chances. Clouds can block the sunlight rays reaching the Earth's surface due to which the Earth's surface tends to be cooler. Clouds have different shapes and structure due to which prediction of weather become complex.

Rainfall forecasting is important for agriculture and living things. Rainfall being an important part of agriculture helps in productivity of various vegetables, fruit, flowers etc. Some of the products of flower, crop, and vegetables are exported. Crops like rice, corn are grown in heavy rainfall area. Rainfall prediction is needed so that no damages occur to living beings, crops, land etc. If prediction is done accurately it can save many lives which may occur due to floods. Rainfall prediction is necessary to determine how much of the moisture is available for agriculture and how much of them have been run off to the rivers and streams. However, in excess rainfall may cause damages to agriculture moisture which may be carried out by the rainfall to the streams or rivers. As a result of which floods from the rivers and streams may cause damages to roads, and loss of various sediment and chemicals. Observation of rainfall is needed to know the amount of moisture present in soil, drought and flood conditions. Effective and accurate prediction of rainfall is necessary to prepare for floods and agriculture. Traditionally, various measures have been used to predict rainfall. Prediction of rainfall becomes a harder because the status of cloud/sky keeps on changing. The images taken for prediction may be digital/satellite images. These images are taken and types of cloud/sky are found. Previously many techniques of image processing have been carried out successfully. Image

processing techniques can be used to measure the cloud, sky, rain status. Types of cloud can be found by using various technique of image processing. Image processing is used to enhance various features of the images taken to predict rainfall. Once type of cloud is known it becomes easier to predict rainfall. To accurately predict rainfall, the cloud status and sky status must be known.

Clouds are the source for prediction of rainfall. If clouds are present in the sky, chance of rainfall is more. We cannot predict rainfall just on seeing the clouds. In this paper, reviews about the clouds for prediction of rainfall have been focused and various image processing methodologies are discussed.

## 2. RAINFALL PREDICTION

Rainfall prediction helps us in various ways if it is forecast accurately. Prediction becomes possible by studying various types of clouds by knowing their status and types which depends on height, altitude, density, color. Observations of rainfall are necessary in various fields and for various purposes. Though prediction of rainfall provides us useful measures, but they are hard to predict accurately

*Advantages:* Meteorology focuses on weather processes and forecasting. Meteorology department is useful in giving information of floods, agriculture and prediction of rainfall. Rainfall prediction is useful for agriculture purposes to observe soil moisture, effectiveness for applying fertilizers, pesticides and herbicides to crops. Accurately forecasting of heavy rainfall can allow for warning and preparedness of floods. Rainfall can monitor and forecast drought, river stages, and water quality [1].

*Disadvantages:* Prediction of rainfall is not accurate as clouds are very complex and keeps on changing, which can cause streams and rivers to overflow. Overflow of rain water can cause severe damages to human beings, transport and loss of sediments and chemicals causing loss to country's economic growth [1].

## 3. ISSUES IN DESIGNING A RAINFALL PREDICTION ANALYSIS

The proposed system design steps are as follow:

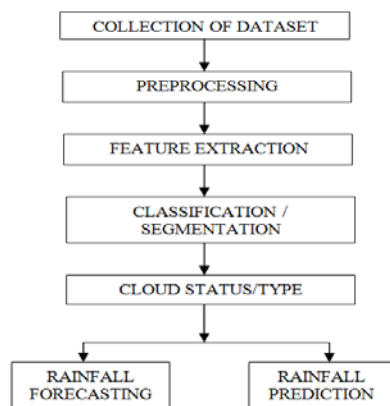


Fig. 1: Proposed system design

- In the first step, the cloud images are collected and stored (digital/satellite).
- The image stored will be preprocessed. Preprocessing is the step where noise filtering, sharpening, contrasts stretching, histogram modification and correction of distortion may be applied.
- Next, feature extraction method is applied to an image. Feature extraction involves extraction of shape, color or texture of an image.
- Segmentation methods can be applied to various cloud images to segment some of properties of the cloud into group of pixels which are homogeneous with respect to some criterion.
- Cloud status/type are used with the image data to forecast rainfall
- After combining all, the data are inputted and find rainfall prediction.

## 4. TYPES OF CLOUD IMAGE

Table 1: Basic cloud types and description [14]

Cloud type	Description
Cirrus	Thin, white and feathery appearance and mostly white patches or narrow bands.
Cirrocumulus	Thin white bands or ripples, sheet, or layered of clouds without shading.
Cirrostratus	High, milky white like appearance. They are transparent, whitish veil clouds with a fibrous (hair-like) or smooth appearance
Alto cumulus	Bumpy rounded masses, cotton ball appearance, white and/or gray patch sheet or layered clouds.
Altostratus	Transparent blue/gray clouds sheets or fibrous clouds that totally or partially cover the sky.
Nimbostratus	They are continuous rain cloud also known as storm cloud.
Stratocumulus	Gray or whitish layer with sheet, or layered clouds which almost always are dark.
Stratus	Cover large portion of sky, thin, sheet-like, gray and thick.
Cumulus	Cauliflower like appearance with bulging upper parts.
Cumulonimbus	The thunderstorm cloud, heavy and dense cloud in the form of a mountain or huge tower.

Clouds are classified by their shape, temperature, color, density, spectral clustering analysis, training of rule based systems or neural networks and image processing techniques. Classification of clouds are highly time dependent because temperature, type of cloud dependence changes in different latitudes through different seasons. Different types of cloud are present out of which three basic cloud forms are the Cirrus, Stratus, and Cumulus. These forms are further refined into 10 other types based on their height and texture as shown in Table 1.

High Level Clouds (above 20, 000 feet) are the Cirrus, Cirrocumulus, Cirrostratus, and Cumulonimbus.

Middle Level Clouds (between 6500–20,000 feet) are the Alto cumulus, Altostratus.

Low Level Clouds (below 6500) are the Nimbostratus, Stratocumulus, Stratus, and the Cumulus.

#### 4.1 Prior of related work

K.Kaviarasu et.al [1] describes some novel methods like K-means Clustering and Wavelet using digital cloud image. The status of sky was found using Wavelet. The status of cloud is found using Cloud Mask Algorithm and histogram equalization. The type of cloud can be found using K-means Clustering.

In 2015 Niyati Salot et.al [3] has studied various techniques of image processing to predict rainfall. Various methodologies/techniques of image processing have been discussed in processing of the dataset.

Dr. Mohamed Mansoor Roomi et.al [4] in 2012 explained an automatic detection of weather forecasting by segmenting the various cloud images, which do not depend upon translation, rotation and scale. SURF (Speeded up Robust Features) is used here for feature extraction. The extracted images are then segmented using the Otsu thresholding.

Further Dimple Jayaswal et.al [5] proposed a way for retrieving satellite images. It first works on feature extraction of the image and then compares the image with the images in the database. The image retrieved process contains the satellite image where it is pre-processed, feature is extracted and calculation is done. Interpretation and evaluation is done and the final image is retrieved.

It has been found that in 2006 D.K.Richards and G.D.Sullivan [6] used the feature extraction method of color and texture to the cloud and sky images using digital image. A single method alone cannot distinguish different types of cloud. By using Bayesian scheme the classification of various features can be improved.

Again in 2015 Dimple Jayaswal et.al [7] gives a review of various image retrieval image techniques which can be applied for satellite images. In feature extraction the shape, color, textures are extracted. Content-based image retrieval (CBIR) method is used for image retrieval.

Again, some ways of image retrieving techniques was focused by Neha Jain et.al [8] in 2013. A brief study of the techniques plus its various advantages and disadvantages has been discussed here.

Yanling Hao et.al [15] said that cloud images are useful image which contains a lot of information. To acquire this information various image processing methods and feature extraction method are used. CBIPIR (Content Based Cloud Image Processing and Information Retrieval) is an important

retrieval technique in image processing. Features like shape, color, texture, edge are extracted from the cloud images and stored in database for further analysis.

## 5. LEVEL OF PREDICTION

There are various ways to predict rainfall. Long before when technology was not developed to predict the weather, people relied on observation, patterns. Once these methods are practice and become attuned to the sky, the air, and animal behaviors, it's possible to predict the weather quite reliably. We have many traditional ways to predict rainfall like the presence of red sky, observing the sky and many more. But, later with the development of technologies prediction of rainfall became an easier and accurate. We have various methods like

**a) Traditional method:** These methods used clouds to predict rainfall. By looking at the various patterns of clouds rainfall prediction was done. The other ways were like the presence of red sky, the existence of clouds, look for rainbow in the west, and the direction of flow of winds. These were the methods in where no techniques were applied. By natural means the prediction of rainfall was done.

**b) Statistical method:** These methods are based on collection of data for monthly values or yearly values of rainfall. These can be aggregated into region wise, district wise, state wise or country wise. The climate conditions have been measured adequately for many years, making it possible to define what is “normal” and what an “extreme” is. The rainfall data is collected over a period through which estimation of heavy rainfall can be got. The data are compared over the previous stored or collected information of rainfall.

**c) Numerical method:** Numerical weather prediction uses mathematical models of the atmosphere and oceans to predict the weather, based on current weather conditions. A number of global and regional forecast models are run in different countries worldwide, using current weather observations relayed from weather satellites and other observing systems as inputs.

Mathematical models based on the same physical principles can be used to generate either short-term weather forecasts or longer-term climate predictions; the latter are widely applied for understanding and projecting climate change. But, predicting rainfall by manipulating the dataset and performing complex calculation requires powerful supercomputers in the world. The forecast still only extends for six days. The accuracy of numerical prediction can be affected by density and quality of input.

### 5.1. Cloud images using image processing methods

Work has been carried out for various cloud images to predict rainfall using various techniques. Cloud images can be either digital or satellite images. The various image processing methods which can be applied are: Image storage and

manipulation, Image enhancement, Image restoration, Image analysis, and Image reconstruction. Cloud based image processing techniques which were carried earlier for cloud images are [5, 8], and [9].

### 5.1.1. Feature extraction

It is one of the important methods of image processing. Various feature extraction method are present but choosing the right image features for any system is important because it may affect every aspect of a retrieval system. Low level features are explored as they can be computed automatically. We discuss below some of the characteristic of the features.

**a) Shape based feature:** To retrieve image by shape is the most obvious requirement at the starting level. Natural objects are recognized by their shape mainly. For various stored image the feature characteristic of object shape are computed for the objects in the image. When queries are given for stored images, the images are retrieved by computing the same set of features whose features closely match to that of the query. Two main types of shape feature are used commonly, the global features (aspect ratio, circularity and moment invariants) and the local features (like sets of consecutive boundary segments) [8]. Shape matching of three-dimensional objects is a more challenging task.

**b) Color based feature:** Here for stored image in database a color histogram is computed which shows the proportion of clouds of each pixels in the image. The color histogram for every image is then stored in the database. When querying for the image the user can either give the proportion of each color, or give an example image from where a color histogram is calculated.

**c) Texture based feature:** Texture based features may not be very useful. But to match texture similarity can be useful to distinguish between different areas of images with similar color. Different techniques are present to brightness of the selected pair of pixels from each image can be calculated. From these the texture of various images can be calculated.

### 5.1.2. Classification methods

Two learning methods are compared- supervised and unsupervised. The main difference between supervised and unsupervised classification is the use of collection of training dataset images. In supervised classification a collection of images are taken. A single image is compared with a number of images to get the required output. But, in unsupervised classification collection of training dataset is not available. The output result is based on software analysis of images without sampled images.

## 6. CLOUD IMAGE DATABASE

Cloud image collected may be digital/satellite images. In case of digital images the image are collected from ground level through digital camera or through web. While, satellite images

are collected either from meteorology department or collected on daily basis from some meteorology websites. The images are stored and manipulated in different formats in the database. Images can be stored in different formats which may be Binary, TIFF, JPEG, GIF, PNG or BMP image. After storing the image in the database, different functions can be applied to read the images from the database.

## 7. EVALUATION OF PREDICTION ACCURACY

Prediction of rainfall has been carried out for more than 20 years. Weather forecasts have improved over the last 20 years. The three-day forecast delivered today is much better than that that of one-day 20 years ago. There are various methods to predict rainfall. But, accurately predicting rainfall is a complex process. The monsoon forecast can be closer to perfection and rains can be predicted more accurately. Prediction of accurate monsoon is important for an individual farmer as well as for the government to take policy decisions. However, forecast is always unpredictable.

Earlier traditional methods were used which gave results. The methods were carried on natural means. Earth's atmosphere is not as it was 20 years back. Due to changes in the Earth's atmosphere by various sources prediction through traditional method does not play well.

Statistical method required data over a long period of time. The data collected over years are compared to the current situation. The climate changes and does not remain constant. So, prediction of rainfall through this method cannot be dependent totally.

Prediction of rainfall through cloud images are growing fast and works are carried by researcher's to give accurate results. Cloud image may be digital or satellite images. Digital image are easily available but resolution of image is less. To predict rainfall the clouds should be clear in the sky but digital image may lack this property. Prediction of rainfall done by digital cloud image may not be clear in structure which may result in poor prediction of rainfall. Prediction of rainfall through satellite image can be accurate. Since satellite image has clear cloud structure. Image processing method for cloud image can be carried out to evaluate the prediction of rainfall accurately. Methods of image processing can be applied to various cloud images to study the status and type of clouds. Works have been carried out in this field and further research can also be done to get accurate results.

## 8. CONCLUSION & FUTURE OF RAINFALL PREDICTION ANALYSIS

This paper gives a review of different cloud image used for prediction of rainfall. Some of the researchers used satellite images of cloud and sky and some of them used digital image which is a cheaper one. Through the above article, an idea of the direction of research regarding to the types and status of cloud are studied for detecting the early information of rain.

This study shows that, the instantaneous research on rainfall prediction of cloud image as compared to others is found to be less. It needs further research on this line.

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