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Feature Extraction from the Satellite Image Gray Color and Knowledge Discovery Using Association Rule Mining

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Abstract: *Satellite take images of the Earth in selected spectral bands that are in both the visible and the infrared portions of the electromagnetic spectrum. Many Satellites provide three types of Satellite Images. These Images are Visible Satellite Image, Infrared Satellite Image, and Water Vapor Satellite Image. These images are important for different reasons, and, in some cases, all three are needed to accurately interpret atmospheric conditions. These Satellite images contain different types of cloud. This paper shows cloud feature extraction using Histogram. A table that shows cloud existence in different image is created, called Association table in which Y represents cloud is exist and N represent not exist. Association rule mining is applied to this table to make relations between different clouds and discover the knowledge about cloud existence.*

I. Introduction

Satellite images are a pictorial representation measuring the electromagnetic energy recorded by a sensor, not by photography. A photograph is normally taken within a certain spectral range (visible light). Satellites take images outside this limited range [5].

The Satellite Images may look like an actual picture of the Earth; a weather satellite image is composed of thousands of points known as pixels. There are three types of satellite image Visible, Infrared, and water vapor. All three types of imagery are important for different reasons, and, in some cases, all three are needed to accurately interpret atmospheric conditions [7].

Satellite images are often described in term of their resolution. Resolution refers to the size of the smallest feature that can be seen in an image. Since one pixel is the smallest element in an image, the area represented by one pixel is equal to the image resolution. Each pixel represents the average brightness over an area. Image resolution is determined by the satellite sensor, the type of transmission used, and also type of display hardware used to view the imagery.

Knowledge discovery is extraction of implicit knowledge, image data relationship or other pattern not explicitly stored in images and uses ideas from computer vision, image processing, image retrieval, data mining and machine learning database [3].

A. Types of Satellite Images

Based on the Image Channel satellite Images are of three types:

i) Visible Satellite Images: Visible images show the visible light that is reflected off of clouds and the surface of the earth. Visible imagery is only taken during the day (in the area where the satellite is located). They show all types of clouds and are the best type of images for seeing low level systems, which do not show up well on infrared imagery. Visible satellite images are photographs of the earth that provide information about cloud cover. Areas of white indicate clouds while shades of gray indicate generally clear skies. Thicker clouds have a higher reflectivity (or albedo) and appear brighter than thinner clouds on a visible image. However, it is difficult to distinguish among low, middle, and high level clouds in a visible satellite image, since they can all have a similar albedo and for this distinction, infrared satellite images are useful [5][6][7].

ii) Infrared Satellite Images: Infrared imagery shows the amount of heat emitted by the different cloud features and the surface of the earth. Infrared images show clouds at higher levels better because they are colder. Infrared satellite measurements are related to the brightness temperature. The images shows really negatives of the images, because areas that are white are ones that are colder (emit less infrared light), and areas that are dark are warmer. This is done so that the images look similar to visible images. Since temperature in the troposphere decreases with height, high level clouds are colder than low level clouds. Therefore, low clouds appear darker on an infrared image and higher clouds appear brighter [5][6][7].

ii) Water Vapor Satellite Images: Water Vapor images are images that show water vapor in the upper troposphere. This troposphere is the only area of the atmosphere generally important in everyday weather forecasting. The systems shown by water vapor images are upper level systems and are often different from those found at the surface. These systems have a large effect on the systems that are found at the surface. Water vapor images are useful for pointing out regions of moist and dry air, which also provides information about the swirling middle troposphere wind patterns and jet streams. Brighter area on the image represents greater area of moisture in the mid and upper level of atmosphere. Darker area represents drier area of moisture in the mid and upper levels. Very cold air can also show up fairly bright [5][6][7].

B. Visible Vs Infrared Vs Water Vapor Satellite Images

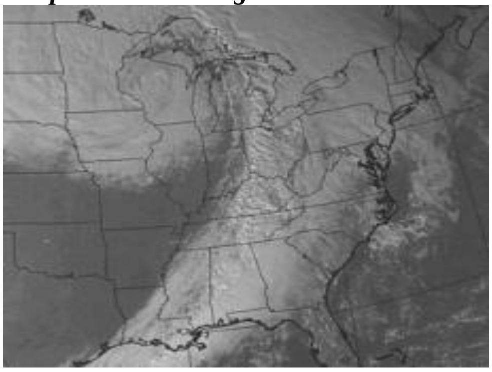

Figure 1: Visible Satellite Image

Visible images measure scattered light and the above figure 1 depicts a wide line of clouds stretching across the southeastern United States and then northward into Ontario and Quebec.

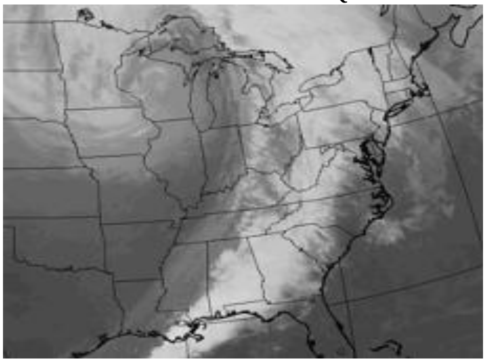

Figure 2: Infrared Satellite Image

In contrast, infrared images are related to brightness. Therefore, the clouds in image appear gray in the infrared image because of they are lower and have relatively warm cloud tops. The warmer the temperature, the lower the clouds, the darker the color.

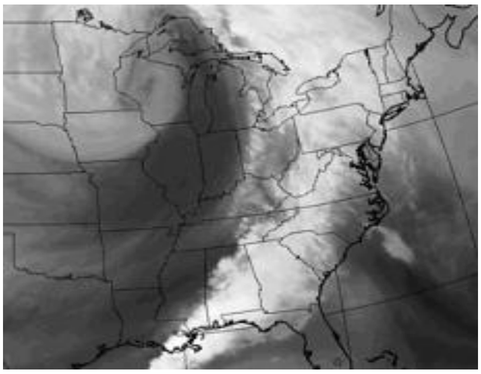

Figure 3: Water Vapor Satellite Image

These clouds are associated with a large area of moist air covering most of the eastern third of the United States visible in the water vapor image as the extensive area of white [5][6][7]. This paper, uses a widely accepted MATLAB for image processing and cloud feature extraction, and data mining tool called Weka[20] for applying Apriori algorithm for finding relationship between different attributes and useful information is derived from the results.

II. Literature Survey

Using fuzzy SOM strategy for satellite image retrieval and information mining projected by yo-ping hung, tsun-wei and li-jen kao. They proposed a model for efficient satellite image retrieval and knowledge discovery. It has two major parts. First, it uses computation algorithm for off-line satellite image feature extraction, image data representation and image retrieval. Important parameter can be extracted from the satellite image by the CBIR (content based image retrieval) technique to discover knowledge about the current whether condition. The extracted features are high pressure, cloud layer, linear cloud and typhoon. A dataset is created by these parameters to apply the association rule. A self organization feature is used to construct a two layer satellite image concept hierarchy. The events are stored in one layer and the corresponding feature vectors are categorized in the other layer. Second, a user friendly interface is developed that retrieves images of interest and mines useful information based on the event in concept hierarchy [1].

"Content Based Image Retrieval of Satellite Imageries Using Soft Query Based Color Composite Techniques" by Y N Mamatha and A.G Ananth, focused on developing image indexing techniques which have the capability to retrieve image based on their contents. The technologies are now generally referred to as Content-Based Image Retrieval (CBIR). Due to its extensive potential applications, CBIR has attracted a great amount of attention in recent years. Using colors as the content, content based image processing have been carried out for a sample of high resolution urban image and low resolution rural image scenes obtained from satellites. The color based processing has been utilized to identity important urban features such as buildings and gardens and rural features such as natural vegetation, water bodies and fields applying various techniques. The techniques included color based extractions using neighborhood rules and histograms. An estimation of the features and available resources from the imageries have been made using the color spectral graphs [17].

Wavelet based features for color texture Classification with application to CBIR. This paper describes an algorithm for texture feature extraction using wavelet decomposed coefficients of an image and its complement. Four different approaches to color texture analysis are tested on the classification of images from the VisTex database. The first method employs multispectral approach, in which texture features are extracted from each channel of the RGB color space. The second method uses HSV color space in which texture features are extracted from the luminance channel V and color features from the chromaticity channels H and S. The third method uses YCbCr color space, in which texture features are extracted from the luminance channel Y and color features from the chromaticity channels Cb and Cr. The last one uses gray scale texture features computed for a color image. The classification results show that the multispectral method gives the best percentage of 97.87%. Further, this multispectral method for texture classification is applied to RBIR system. Experiments are carried out on Wang's dataset using JSEG for segmentation. The results are encouraging. Experiments are also carried out to study the effect of segmentation on the retrieval performance [18].

YU Changhui , Yuan Yuan ,Miao Minjing , Zhu Menglu " Cloud detection method based on feature extraction in remote Sensing images" presented a cloud detection method based on feature extraction for remote sensing images. At first, they find out effective features through training pattern, the features are selected from gray, frequency and texture domains. The different features in the three domains of the training samples are calculated. Through the result of statistical analysis of all the features, the useful features are picked up to form a feature set. In concrete, the set includes three feature vectors, respectively, the gray feature vector constituted of average gray, variance, first-order difference, entropy and histogram, the frequency feature vector constituted of DCT high frequency coefficient and wavelet high frequency coefficient, and the texture feature vector constituted of the hybrid entropy and difference of the gray-gradient co-occurrence matrix and the image fractal dimension. Secondly, a thumbnail will be obtained by down sampling the original image and its features of gray, frequency and texture are computed. Then the cloud region judged by the comparison between the actual feature values and the thresholds determined by the sample training process. Experimental results show that the clouds and ground objects can be separated efficiently, and our method can implement rapid clouds detection and cloudiness calculation [15].

Noureldin Laban, Ayman Nasr, Motaz ElSaban, Hoda Onsi "Spatial Cloud Detection and Retrieval System for Satellite Images " developed spatial cloud detection and retrieval system (SCDRS) that introduce a complete framework for specific semantic retrieval system. It uses a Query by polygon (QBP) paradigm for the content of interest instead of using the more conventional rectangular query by image approach. First, they extract features from the satellite images using multiple tile sizes using spatial and textural properties of cloud regions. Second, they retrieve tiles using a parametric statistical approach within a multilevel refinement process. This approach has been experimentally validated against the conventional ones yielding enhanced precision and recall rates in the same time [16].

III. Method Used To Extract Cloud Features From Satellite Images And Knowledge Discovery

A. Histogram to extract the cloud features

A histogram is bar graph that shows a distribution of data. In image processing, histograms are used to show how many of each pixel value are present in an image. Histograms can be very useful in determining which pixel values are important in an image. From this data we can manipulate an image to meet our specifications. Data from a histogram can aid you in contrast enhancement and thresholding. The gray-scale histogram of an image represents the distribution of the pixels in the image over the gray-level scale. It can be visualised as if each pixel is placed in a bin corresponding to the colour intensity of that pixel. All of the pixels in each bin are then added up and displayed on a graph. The histogram is a key tool in image processing. It is one of the most useful techniques in gathering information about an image. It is especially useful in viewing the contrast of an image. If the grey-levels are concentrated near a certain level the image is low contrast. Likewise if they are well spread out, it defines a high contrast image

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B. Knowledge Discovery using Association Rule Mining

Association rule learning is a popular and well researched method for discovering interesting relations between variables in large databases. It is intended to identify strong rules discovered in databases using different measures of interestingness. Based on the concept of strong rules, association rules for discovering regularities between products in large-scale transaction data. For a given transaction database T, an association rule is an expression of the form $X \rightarrow Y$, where X and Y are subsets of A and $X \rightarrow Y$ holds with confidence τ, if τ% of transaction in D that support X also support Y. The rule $X \rightarrow Y$ has support σ in the transaction set T if σ% of transaction in T supports XUY [11].

IV. Proposed Work

Most weather satellite images are collected in a gray tone display. In this format, each pixel is assigned a tone that represents a level of energy (called the brightness value) sensed by the satellite. The tone is white, black, or an array of intermediate gray shades (known as gray scale). Typically, there are 256 possible brightness values or shades of gray in a satellite image. Different features on the Earth or in the atmosphere have different brightness values, therefore the relative brightness aids in the identification of feature in a satellite image [7]. In all types of imagery the degree of contrast, or gray tone difference, between an object and its background is important. The greater the contrast, the easier it is to identify features in satellite imagery. When contrast is poor, enhancement techniques can be used to make accurate interpretation easier. To enhance an image, all the pixels in a specific range of brightness values are highlighted to locate the features of interest. For example, flood forecasters use IR imagery to look for specific cloud top temperatures that indicate heavy precipitation. By highlighting all the pixels with the corresponding brightness values, one can locate the area within a storm where heavy precipitation is most likely [7].

The proposed work extracts the cloud feature from all types of satellite images. To extract High Cloud and Low Cloud, IR images are used. Visible Image gives to cloud feature, Thin Cloud and Thick Cloud. Likewise Water Vapor satellite image is used to extract Moisture and drier. These can also be seen in table 1.

Table 1: the features that will be extracted

Features to be extracted	**How to identify feature**	**From which image**
High cloud	Bright white	IR Images
Low Cloud	Very dark	
Thin Cloud	White	Visible Image
Thick Cloud	Bright White	
Moisture	Brighter area	Water Vapor Image
Drier	Darker Area	

Table 1 contains feature in the first column, in second column how to identify that feature and in last column from which image that particular feature will be extracted [5][6][7].

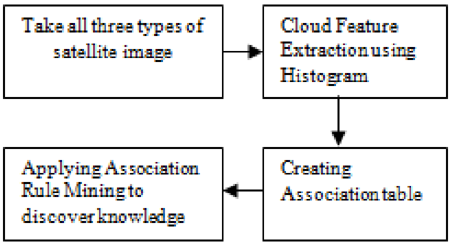

Figure 4: Block Diagram of proposed work

Figure 4 showing the block diagram of the proposed work. All the imagery used in the work are taken as input in the system.

A. Clout Feature Identification

Generally all the satellite images grey color. Above discussed feature can be identified by there intensity value of histogram. We normally can that the specified feature exists in the image or not by seeing a satellite image. As shown in table 1, High cloud can be identified by Bright White. We can say that high cloud exists in the infrared image if we see a bright white area in image. We can say the same think for visible image and Water vapor image. Bright white in visible image means thick cloud exists otherwise thin cloud. In the same way, brighter in water vapor is the moisture area [5][6][7].

B. Cloud Feature Extraction

To extract the entire feature discussed above histogram is used. Histogram of each images are calculated and all the histogram values are stored in the database. These values are used to decide which cloud feature is existing in an image. There is a fixed threshold value is chosen on the basis of experiment on no. of satellite images. This threshold value is 4300 pixel in 255 bin.
If no. of pixel is greater than 4300 in 255 bin in histogram of infrared image then image contain high cloud otherwise low cloud. If in histogram of visible satellite image, no. of pixel is greater than 4300 it contain thick cloud other wise thin cloud. Likewise if there is no. of pixel is greater than 4300 in histogram of water vapor then there is moisture is exists in the image otherwise drier.

C. Knowledge Discovery using Association Rule

All the features extracted from three types of satellite image using Histogram method, collected in a table to create an Association Transaction table. In this table row represents image ID and column represents extracted cloud feature from satellite images. If feature exists in image there is Y in the respective cell otherwise N. This table helps to get the knowledge about the weather. Association Rule mining is applied on this table which help to know that which event can occur together.
Below are some general rules to determine cloud characteristics when comparing visible and infrared satellite images [19].

1. If the cloud is bright white on infrared then it is a high cloud or has a cloud top that is developed high into the troposphere.
2. If a cloud is bright white on visible but is not bright on infrared then it is likely this is a cloud that is close to the earth's surface. This can happen when there is a thick layer of fog or stratus near the surface.
3. If cloud is seen on visible but very hard to see on infrared then it could be a layer of fog or shallow stratus nears the surface.
4. Thunderstorms will show bright white on both visible and infrared. A thick cloud will be bright white on visible and cold cloud tops will show bright white on infrared. Look for other features also to make sure it is a thunderstorm such as anvil blowoff, overshooting top and extremely textured on visible imagery.
5. If a cloud is not very white on visible then it is likely a thin cloud. If a cloud is not very white on infrared then it is likely a cloud near the surface or it is a very thin cloud.
6. When the sun is close to setting, clouds will not show up as white on visible imagery due to less reflection.
7. Wispy looking clouds on visible that are very white on infrared are likely high level clouds such as cirrus or anvil blow off.
8. Cumulus clouds have a lumpy texture. Stratus clouds have a flat texture especially on infrared. Cirrus clouds tend to be thin and show up white on infrared [19].

D. Proposed work algorithm

Algorithm

1. Input satellite images
2. Translate and resize images
3. Calculate histogram and store histogram values in a table with there bin as index.
4. Check no. pixel in 255bin of each image histogram
   - *A. For infrared image*
     - *a. If no. of pixel in 255 bin of infrared histogram < 4300*
       <Low Cloud>
     - *b. Otherwise*
       <High Cloud>
   - *B. For Visible Image*
     - *a. If no. of pixel in 255 bin of visible image histogram < 4300*
       < Thin cloud>
     - *b. Otherwise*
       <Thin Cloud>
   - ***C.** For Water Vapor Image*
     - *a. If no. of pixel in 255 bin of Water Vapor image histogram < 4300*
       <Drier>
     - *b. Otherwise*
       <Moisture>
5. Put Y in the association table if feature found otherwise put N.
6. Repeat step 4 and 5 for different images.
7. Apply association rule and discover knowledge.
8. End

V. Result And Discussion

All the images used in this work are downloaded from the website of Indian metrological department www.imd.gov.in

A. Input images

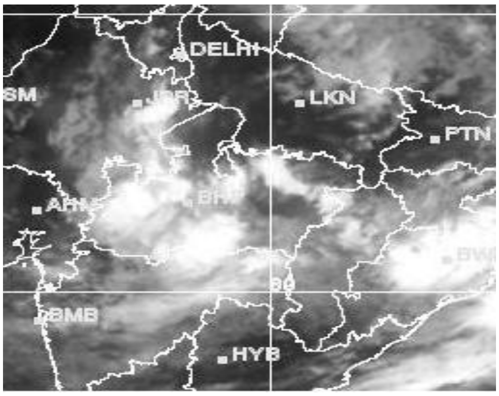

Figure 5: Infrared Satellite image

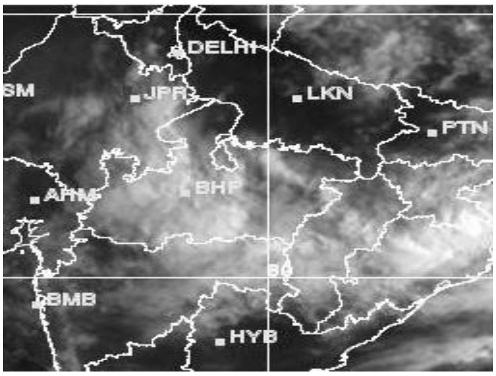

Figure 6:Visible Satellite image

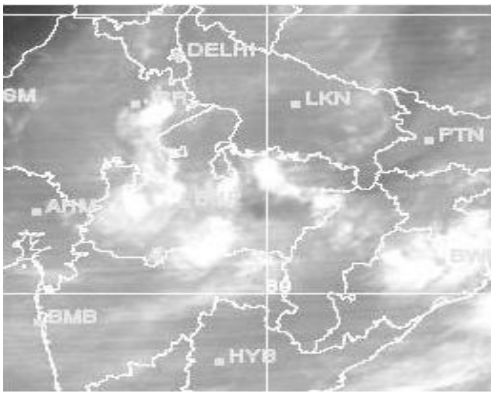

Figure 7: Water Vapor Satellite Image

All the satellite images used in this work are taken as input. In the proposed work all three types of satellite imagery are used which are downloaded from the website of Indian Metrological Department and this website is http://www.imd.gov.in/section/satmet/dynamic/insat.htm

B. Feature table

Table 2 The features that will be extracted

High Cloud	Low Cloud	Moisture	Drier	Thick cloud	Thin cloud	Rainfall
Y	N	N	Y	N	Y	No
N	Y	Y	N	Y	N	No
Y	N	N	Y	N	Y	No
N	Y	N	Y	N	Y	No
Y	N	Y	N	Y	N	Yes
Y	N	Y	N	Y	N	Yes
N	Y	Y	N	Y	N	No
Y	N	Y	N	Y	N	Yes
Y	N	Y	N	Y	N	Yes
N	Y	Y	N	Y	N	No

Table 2 represents six attributes which are High cloud, Low cloud, Thick Cloud, Thin Cloud, Moisture, and Drier. Here, Y is representing the cloud exist in image and N is representing not exist the cloud.

C. Association Rule

Minimum support: 0.75 (7 instances)

1. Thick cloud=Y 7 ==> Moistured=Y 7 <conf:(1)> lift:(1.43) lev:(0.21) [2] conv:(2.1)
2. Moistured=Y 7 ==> Thick cloud=Y 7 <conf:(1)> lift:(1.43) lev:(0.21) [2] conv:(2.1)
3. Thin cloud=N 7 ==> Drier=N 7 <conf:(1)> lift:(1.43) lev:(0.21) [2] conv:(2.1)
4. Drier=N 7 ==> Thin cloud=N 7 <conf:(1)> lift:(1.43) lev:(0.21) [2] conv:(2.1)
5. Drier=N Thick cloud=Y 7 ==> Moistured=Y 7 <conf:(1)> lift:(1.43) lev:(0.21) [2] conv:(2.1)
6. Thick cloud=Y 7 ==> Moistured=Y Drier=N 7 <conf:(1)> lift:(1.43) lev:(0.21) [2] conv:(2.1)
7. Drier=N Thin cloud=N 7 ==> Moistured=Y 7 <conf:(1)> lift:(1.43) lev:(0.21) [2] conv:(2.1)
8. Drier=N 7 ==> Moistured=Y Thin cloud=N 7 <conf:(1)> lift:(1.43) lev:(0.21) [2] conv:(2.1)
9. Moistured=Y 7 ==> Drier=N Thin cloud=N 7 <conf:(1)> lift:(1.43) lev:(0.21) [2] conv:(2.1)
10. Moistured=Y Thick cloud=Y 7 ==> Thin cloud=N 7 <conf:(1)> lift:(1.43) lev:(0.21) [2] conv:(2.1)

Minimum support: 0.35 (3 instances)

1. Thick cloud=Y 7 ==> Moistured=Y 7 <conf:(1)> lift:(1.43) lev:(0.21) [2] conv:(2.1)
2. Moistured=Y 7 ==> Thick cloud=Y 7 <conf:(1)> lift:(1.43) lev:(0.21) [2] conv:(2.1)
3. High Cloud=N 4 ==> Rainfall=No 4 <conf:(1)> lift:(1.67) lev:(0.16) [1] conv:(1.6)
4. High Cloud=Y Thick cloud=Y 4 ==> Moistured=Y 4 <conf:(1)> lift:(1.43) lev:(0.12) [1] conv:(1.2)
5. High Cloud=Y Moistured=Y 4 ==> Thick cloud=Y 4 <conf:(1)> lift:(1.43) lev:(0.12) [1] conv:(1.2)
6. High Cloud=Y Moistured=Y 4 ==> Rainfall=Yes 4 <conf:(1)> lift:(2.5) lev:(0.24) [2] conv:(2.4)

7. High Cloud=Y Thick cloud=Y 4 ==> Rainfall=Yes 4 <conf:(1)> lift:(2.5) lev:(0.24) [2] conv:(2.4)
8. High Cloud=Y Moistured=Y Thick cloud=Y 4 ==> Rainfall=Yes 4 <conf:(1)> lift:(2.5) lev:(0.24) [2] conv:(2.4)
9. High Cloud=Y Thick cloud=Y 4 ==> Moistured=Y Rainfall=Yes 4 <conf:(1)> lift:(2.5) lev:(0.24) [2] conv:(2.4)
10. High Cloud=Y Moistured=Y 4 ==> Thick cloud=Y Rainfall=Yes 4 <conf:(1)> lift:(2.5) lev:(0.24) [2] conv:(2.4)
11. High Cloud=N Moistured=Y 3 ==> Rainfall=No 3 <conf:(1)> lift:(1.67) lev:(0.12) [1] conv:(1.2)
12. High Cloud=N Thick cloud=Y 3 ==> Rainfall=No 3 <conf:(1)> lift:(1.67) lev:(0.12) [1] conv:(1.2)
13. Moistured=N Thick cloud=N 3 ==> Rainfall=No 3 <conf:(1)> lift:(1.67) lev:(0.12) [1] conv:(1.2)
14. Thin cloud=N 7 ==> Drier=N 7 <conf:(1)> lift:(1.43) lev:(0.21) [2] conv:(2.1)
15. Drier=N 7 ==> Thin cloud=N 7 <conf:(1)> lift:(1.43) lev:(0.21) [2] conv:(2.1)
16. Low Cloud=N Thin cloud=N 4 ==> Drier=N 4 <conf:(1)> lift:(1.43) lev:(0.12) [1] conv:(1.2)
17. Thin cloud=Y 3 ==> Drier=Y 3 <conf:(1)> lift:(3.33) lev:(0.21) [2] conv:(2.1)
18. Drier=Y 3 ==> Thin cloud=Y 3 <conf:(1)> lift:(3.33) lev:(0.21) [2] conv:(2.1)
19. Drier=Y 3 ==> Rainfall=No 3 <conf:(1)> lift:(1.67) lev:(0.12) [1] conv:(1.2)
20. Low Cloud=Y Thin cloud=N 3 ==> Drier=N 3 <conf:(1)> lift:(1.43) lev:(0.09) [0] conv:(0.9)
21. Drier=Y Thin cloud=Y 3 ==> Rainfall=No 3 <conf:(1)> lift:(1.67) lev:(0.12) [1] conv:(1.2)

Interpretation of above rules:

1. An important conclusion of these rules is that if High cloud, thick cloud and moisture are high then rainfall is high.
2. These rules represent if low cloud, thin cloud and drier are high then rainfall is low.
3. These rules show the strong relationship between High cloud, thick cloud and moisture.
4. These rules also show the relation between low cloud, thin cloud and drier attributes.
5. Rainfall and moisture is associated with thick cloud.
6. If thick cloud is exist in the visible satellite image then there is possible that moisture is available in the water vapor image.
7. This is possible that if drier exists in the satellite image then thin cloud is available in the visible image.
8. High cloud is associated with the moisture. This is possible that if high cloud is high then moisture will also high.
9. Thin cloud and low cloud are associated with drier.
10. Thick cloud and moisture play an important role for rainfall.

VI. Conclusion

This paper discovers different types of cloud from three types of satellite image and associates them to discover the relation between them. This paper has two results. One is association table that is create by histogram of satellite images and second is getting knowledge by applying association rule mining. The association table shows different cloud attributes and cell contain Y and N. Y shows existence of cloud and N shows not existence of cloud. Final results show the relation between the different clouds. An important conclusion of these rules is that if High cloud, thick cloud and moisture are high then rainfall is high.

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