An Application of Time Series Analysis For Weather Forecasting

J.Julie
Assosciate Professor
Department of Information Technology
Sri Sai Ram Engineering College, Chennai
julie.it@sairam.edu.in

M.Venkatesh
Student
Department of Information Technology
Sri Sai Ram Engineering College, Chennai
venkatesh261198@gmail.com

P.Vishuvapandi
Student
Department of Information Technology
Sri Sai Ram Engineering College, Chennai
vishuvapandi.palanivelu@gmail.com

Abstract **- Weather forecasting has become an important field of research in the last few decades. In most of the cases the researcher had attempted to establish a linear relationship between the input weather data and the corresponding target data. But with the discovery of nonlinearity in the nature of weather data, the focus has shifted towards the nonlinear prediction of the weather data. The advent of new satellite imaging technologies has made satellite images more accessible. These images can be utilized for weather predictions. This work proposes a simple approach for weather prediction that relies on satellite images and weather data as inputs. The method is divided into two parts. The first part involves the use of image processing techniques such as image segmentation on the satellite images to extract the cloud cover. On basis of the cloud cover obtained, percentage cloud cover is calculated and this calculated percentage value is stored, which is later used in the second stage of the approach. The second part involves the use of the cloud cover percentage along with other inputs such as temperature, humidity and wind speed to train an artificial neural network. The weather prediction is done by artificial neural networks. Most of the current cloud extraction algorithms are quite complicated to implement and execution time is potentially slow. In this paper, we present a novel approach which is simple to implement, fast in execution and provides good results in tests.**

Keywords-Satellite Images, Image Processing, Artificial Neural Networks

I. INTRODUCTION

One of the most interesting features of Earth, as seen from ground, is the ever-changing distribution of clouds. They are as natural as anything we encounter in our daily lives. As they float above us, we hardly give their presence a second thought. And yet, clouds have an enormous influence on Earth's energy balance, climate, and weather. Weather forecasting is the application of science and technology to predict the state of the atmosphere for a given location. Weather forecasts are made by collecting quantitative data about the current state of the atmosphere and using scientific understanding of atmospheric processes to project how the atmosphere will evolve. The chaotic nature of the atmosphere, the massive computational power required to solve the equations that describe the atmosphere, error involved in measuring the initial conditions, and an incomplete understanding of atmospheric processes mean that forecasts become less accurate as the difference in current time and the time for which the forecast is being made increases. 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. The main objective of the thesis is to recognize the type of cloud and estimate rainfall using certain features from the digital cloud images. Use of wavelet to separate the points needed for the cluster and using k-means clustering to combine those points will provide a better performance than previous techniques used. The Scope of the work is predicting rainfall using the digital images rather than using the satellite images. The Satellite images costs lot so everyone can't get them easily. When some new techniques are used we could get more accurate prediction.

II. LITERATURE SURVEY

A. Survey on Clouds

D K. Richards and G.D. Sullivan [1] describes the methods for using color and texture to discriminate cloud

and sky in images captured using a ground based color camera. Neither method alone has proved sufficient to distinguish between different types of cloud, and between cloud and sky in general. Classification can be improved by combining the features using a Bayesian scheme. Malay K. Kundu and Priyank Bagrecha[2] proposed the feature Extraction algorithm is a very important component of any retrieval scheme. The Mband Wavelet Transform based feature extraction algorithm is explained in this paper. Kuo-Lin Hsu, X. Gao, and Soroosh Sorooshian[3] proposed some experiments. It shows that coldtopped cloud pixels with the same values of infrared brightness temperature may belong to different cloud type, thereby, indicating different rain rates at the underlying ground surfaces. It is suggested that the relationship between the satellite cloud-top brightness temperature and surface rainfall rate are non-unique for most pixel-based rainfall estimation algorithms. A scheme is developed, which first classifying cloud types based on the texture features of regional cloud images, then regressing the relationships of cloud brightness temperature and surface rain rate respective to different cloud types using the radar rainfall data. With the separation of cloud-texture types, estimated rainfall rates can be improved. A cloud-texture classification approach is introduced to process cloud images and estimates the surface rain rate underlying a cloud pixel referencing the cloud-texture type of the pixel. Instead of determining the surface rain rate based on cloud brightness temperature at a local pixel, as many rainfall estimation algorithms do (see Hsu et al., 1997; Bellerby et al., 2000), this approach extracts the features of cloud texture in a 4° × 4° window to classify the cloud imagery into a number of cloud (texture) groups. The relationship between rainfall rate and cloud pixel brightness temperatures at each assigned cloud-texture group is identified separately using ground-based radar rainfall data. Liu Jian and Xu Jianmin[4] describes an updated operational cloud detection method of FY-2C. Compared with FY2B three channels, FY2C adds one shortwave infrared channel and split infrared channel. Research results testified that shortwave infrared and split infrared channels can be help to detect low cloud and cirrus cloud, especially at night. Anuj Srivastava and Ian H. Jermyn[5], describes the problem of identifying shape classes in point clouds. These clouds contain sampled contours and are corrupted by clutter and observation noise. Taking an analysis-by-synthesis approach, we simulate highprobability configurations of sampled contours using models learnt from the training data to evaluate the given test data. Yanling Hao, Wei ShangGuan, Yi Zhu, and YanHong Tang[6] describes that cloud image is a kind of useful image which includes abundant information, for acquired this information, the image processing and character extraction method adapt to cloud image has to be used. Content- based cloud image processing and information retrieval (CBIPIR) is a very important problem in image processing and analysis field. The basic character, like color, texture, edge and shape was extracted from the cloud image, and then the cloud image database was provided to store the basic character information. Since traditional image retrieval method has some limitation, for realized image retrieval accurately and quickly, the CBIR method is adaptive. Aleksey Golovinskiy, Vladimir G. Kim and Thomas Funkhouser[7] states that the design of a system for recognizing objects in 3D point clouds of urban environments. The system is decomposed into four steps: locating, segmenting, characterizing, and classifying clusters of 3D points. Specifically, we first cluster nearby points to form a set of potential object locations (with hierarchical clustering). Then, we segment points near those locations into foreground and background sets (with a graph-cut algorithm). Next, we build a feature vector for each point cluster (based on both its shape and its context). Finally, we label the feature vectors using a classifier trained on a set of manually labeled 2010 IEEE International Conference on Computational Intelligence and Computing Research objects. Peter S. Masika [8] states that this study attempts to utilize available MSG data for developing simple cloud mask and height algorithms and thereafter compare and determine the relationship between cloud height and observed rainfall on a ground station. A multispectral threshold technique has been used: the test sequence depends on solar illumination conditions and geographical location whereas most thresholds used here were empirically determined and applied to each individual pixel to determine whether that pixel is cloud-free or cloud-contaminated. The study starts from the premise of an acceptable trade-off between calculation speed and accuracy in the output data. Wei Shangguan; Yanling Hao; Zhizhong Lu; Peng Wu[10] states that the recent development of cloud image processing technology has become very quick; the research aspects concentrate on judge the cloud type and classify the cloud mainly. These image processing methods relate to the subject category like image processing and pattern recognition etc; it has become one of the fields of most quickly development in the research of image processing technology. In cloud image, texture is an very important feature, since cloud image has clear texture structure, the computer texture analysis provide perfect future for study and analyze all kinds of cloud image. Variation method is a new image segmentation method development in recent years, which is adapt to modeling and extract deformable contour of random shape. In cloud image, recognize the target object has great application meaning.

B. IMAGE PROCESSING TECHNIQUES

A.Image enhancement: It refers to sharpening or blurring, of image features like contrast or boundaries to make graphic display more visible for display & analysis. Process of enhancement does not increase the inside information in data. That includes contrast manipulation and gray level, noise reduction, filtering, interpolation, edge sharpening and magnification.

B.Image restoration: It is mostly combined with filtering to observe image to minimize effect of noise or degradations. Effect of image restoration is depended on accuracy and extent of the knowledge of on filter design and process of degradation. The difference between Image restoration and image enhancement is concerned with more accentuation or extraction of image features [3].

C.Image compression: It is associated with minimizing number of bits that are required to represent an image in digital form. Use of compression are in different places like broadcast TV, military communication via aircraft, remote sensing via satellite, medical images in computer tomography, radar, facsimile transmission, teleconferencing, for educational or business documents, magnetic resonance imaging and also pictures, satellite images, digital radiology, motion, geological surveys, weather maps and so on.

C. COMMON FILE FORMATS

Common file formats that use mostly are: JPEG that is a very efficient and much information per byte compressed 24 bit format that widely used in web and Internet.GIF that is 8-bit or 256 color and non-destructive compressed format that is mostly used for web.TIFF that is standard 24 bit publication format that compresses nondestructively. PSD that is a dedicated Photoshop format which keeps including all the layers all the information in the image.PS that is a standard vector format that has numerous sub-standards that could be difficult to transmit across platforms[4].

D. CLOUD AND CLOUD TYPES

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
Altocumulus	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.

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

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

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

III. PROPOSED SYSTEM

Time series Analysis refers to obtaining up of result from a number of observations that are in chronological order. Acquired samples are processed in MATLB 2019a using image processing techniques. Images thus collected get processed and the information are collected. Using the shape, colour, morphology and other properties of the cloud, name of the type of cloud can be obtained. By using the name of the cloud, individual properties can be enlisted. Depending on density, humidity and temperature can be obtained as numerical value.

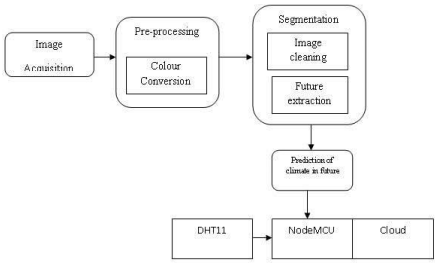

Fig.1.a. Architecture of the proposed solution

To increase the accuracy in prediction, using Arduino, Node MCU and DHT11, real time temperature and humidity can be obtained.

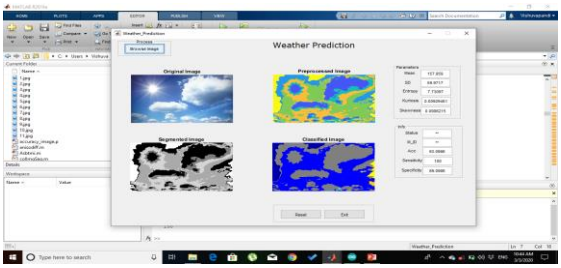

Fig.1.b. Screenshot of Image Processing MATLAB Tool

From obtained data, steady and accurate temperature & humidity can be collected. Data obtained through image processing and DHT11 are sampled together to get a average sum of the upcoming climate.

As five different samples are calculated, time series average value is obtained. The calculated value is given to be the climatic condition of the next day as per done experiments and calculations. This can be considered to be one of accurate methods unlike online prediction methods since it also employs real time observations.

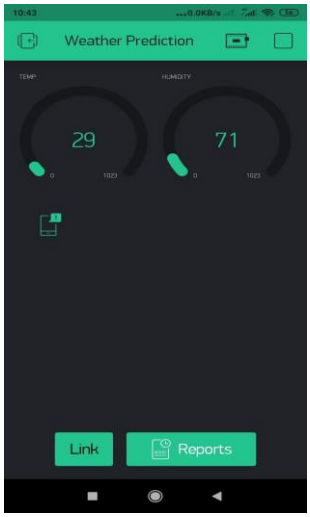

Fig.1.c. Screenshot from Android App Blynk for IOT

IV. CONCLUSION

Most Artificial Neural Network approaches preprocess the input and target data into a range -1 to +1 or 0 to 1 and then post-process it. However, we investigated on finding a model that can reduce this processing cost by working on raw data. Finally, the prediction that we made for the maximum temperature can be extended to other weather factors like humidity, wind speed etc. using the same model and precautions discussed. Further measures to optimize the performance of such a weather forecasting model can be based on various macro and micro-environmental factors. This study can be best used to develop supportive statistical plots and concentrate on the trend of weather over a long period of time in a particular area.

V. REFERENCES

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