Cyclone Intensity Estimation Using INSAT-3D IR Imagery and deep learning

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ABSTARCT

This survey paper is based on the review of Cyclone strength prediction utilizing INSAT-3D satellite photos, using review articles that were published from 2018 to 2022. A natural disaster is an unanticipated event that can harm the environment at any time and at any place. There are several natural disasters that cause harm to society and its citizens. disasters including earthquakes, cyclones, floods, tsunamis, wildfires, landslides, and volcanic eruptions.

Some of the frequent natural calamities include avalanches, heat waves, and many others. Cyclones are enormous masses of air that move counterclockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere as they revolve around a powerful center of low atmospheric pressure. A cyclone is, in general, a large storm that produces heavy rain and gusts. Tropical cyclones, often known as typhoons or hurricanes, are extremely powerful, destructive, intense circular storms that develop over warm tropical oceans. INSAT is one of the numerous geostationary satellites owned by India. INSAT stands for Indian National Satellite System, and ISRO launched this multipurpose Geostationary satellite to meet India's demands for search and rescue operations as well as telecommunications and broadcasting. Including brightness temperatures of several IR channels, temperature and humidity profiles, atmospheric stability indices and parameters, precipitable water, geo-potential height, and many other variables, the INSAT 3D satellite accurately records cyclones and their evolution. This study's objective is to assess the cyclone's intensity utilizing the generated sequence of images.

INDEX TERMS: Satellite image classification; cyclone intensity prediction; satellite images; Deep Convolutional Neural Network (DCNN); features; layers; down-sampling process

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I.INTRODUCTION

Rain and dangerous winds are included in cyclones, which can inflict significant harm to the environment, nature, and personal life Floods, fires, waterborne illnesses, and malfunctioning communication systems are among the destructions. From 1998 to 2017, storms had an impact on about 726 million people. According to a recent analysis, the main reason for at least 10,000 fatalities in Odisha in 1999 was a cyclone. Cyclone detection will therefore benefit remote sensing organizations and give them plenty of time to prepare for and handle such a dangerous circumstance.

Cyclones are regarded as one of the riskiest types of natural disasters with the potential to wreak enormous havoc. A cyclone's eye is its centre, and once an eye forms, its severity and intensity typically rise. The geostationary satellites take exceptionally high-quality pictures.

There are numerous applications in weather, such as the investigation of wildfires, cloud formation, and the derivation of atmospheric motion winds. These acquired satellite images are further examined to ascertain the eye of the cyclone, which is the cyclone's center, as well as its intensity and other features. Estimating cyclone intensity is crucial for disaster management efforts. The severity of a cyclone fluctuates whenever the eye of the cyclone undergoes a significant change.

In order to provide early warning of these tropical cyclones for their effective management taking into account the size of the ocean basin, the social and economic vulnerability of that particular region, it is imperative to detect the storm as early as possible and estimate its maximum strength. With the aid of satellite data generated by the INSAT 3D imager, we attempt to describe the many observed characteristics in the evolution of a cyclone in this study, particularly during the rapid intensification (RI) stage. The classification of infrared images by cyclone involves numerous supervised and unsupervised algorithms. Modern deep learning techniques are commonly utilised to detect anomalies under statistical methodologies. Deep learning techniques have been shown to be reliable since they produce the best results even with unstructured data and produce high detection accuracy with minimal processing time when classifying satellite data. Additionally, background knowledge is not required to create cutting-edge deep pedagogical models The Deep Convolutional Neural Network (DCNN) is composed of an input, output, and hidden layer that are individually coupled to convolutions that are in charge of identifying visual features. Since deep learning approaches generate the best results even with unstructured data and produce high detection accuracy with little processing time when classifying satellite data, they have been proven to be dependable. The Deep Convolutional Neural Network (DCNN) is made up of an input, output, and hidden layer that are independently coupled to convolutions that are responsible for identifying visual information. In addition, preexisting knowledge is not necessary to develop cutting-edge deep educational models.

II.BACKGROUND

In weather forecasting, deep learning is extremely important for cyclone prediction. Many cutting-edge algorithms based on deep learning and machine learning have been presented for precise calculations of the existence of hurricanes. For the classification of cyclone images, a Dichotomous Logistic Regression (DLR) based on a fuzzy hypergraph model has recently been developed. The model shows a respectable accuracy of detection with minimal time complexity. CNN also uses Landsat 8 OLI Satellite Image Classification to identify natural disasters. In the meantime, Brovey Transformation aids in panchromatic band shaving spatial resolutions by combining Red-Green-Blue (RGB). The method of deep learning for spotting tropical cyclones and precursors simulates a cloud resolving global non-hydrostatic model and trains two deep neural networks for binary classification on 50,000 photos of tropical cyclones. The model predicts correctly 90% of the time with 10%–30% of false alarms. Using a satellite, DeepMicroNet, another deep learning network, calculates the strength of tropical cyclones.

A passive microwave picture that uses satellite images between 85 and 90 GHz to estimate the likelihood of a tropical storm. On a convolutional model, rotation-blended CNN has been suggested for detecting tropical cyclone intensity using an open dataset. It gives the model a chance to quickly and with promising time complexity detect cyclone intensity. Additionally, a convolutional model is investigated for categorising cyclone intensity, which eliminates complexity that emerges throughout the feature extraction process, which is necessary to calculate the intensity of the tropical cyclone, in the end. Additionally, using NOAA-AVHRR satellite imagery, a sequence of Artificial Neural Network (ANN) layers have been employed. To predict cyclone occurrences with 98% detection accuracy. With 84% detection accuracy, tropical cyclone intensity may be determined by analysing the geometrical characteristics of cyclone images with the use of multilayer perception. A high potential exists for the ANN technique to model rainfall brought on by typhoons in Taiwan, China. Through the outcome of the prediction, the method significantly aids in controlling the flooding calamity.

III. DATASET

The pictures of Tropical cyclone as a dataset is captured by the satellites INSAT 3D. Photos taken over the Indian Ocean by the INSAT-3D satellite's visible and infrared channels are part of a 24-hour time series with a half hour interval. The four imager channels which are considered are: First one is Visible which is covering 0.55- 0.75 m, second is Short-Wave Infrared, next is Mid-wave Infrared and finally Water Vapour which is covering around 6.5- 7.1 m. VIS and NIR channels have a spatial resolution of 1 km, MIR, TIR1 and TIR2 channels of 4 km, and WV channels of 8 km. During pre-processing, satellite-captured photos are converted from the .tif(Tag Image File) format to the.jpg format, which eventually yields output images.

In the pre-processing of the data the tool known as Quantum Geographic Information System will be used to determine the study region for the satellite picture, and it will also be used to do the shapefile operation and crop only the tropical cyclone-centred study area. We will apply the fish-eye effect to the resultant cropped image to make it more noticeable for the convolutional neural network model to process.

Based on knots in satellite pictures, tropical cyclones in India can be categorised into seven categories:

- Low Depression -The knots in the range (17-27 KT)
- severe depression – The knots in the range (28-33 KT)

- Tropical Storm - The knots in the range (34-47 KT)
- Significant Tropical Storm - The knots in the range (48-63)
- Strong Tropical Storm- The knots in the range (64-89 KT)
- Very Strong Tropical Storm- The knots in the range (90-119)
- (>120 KT) Super Tropical Storm

For simple access to the cyclone data, each satellite picture sample has a linked HDF (Hierarchical Data Format) meta datafile that can be easily converted to a comma-separated values file format using the python tool called Rasterio (example: set=rasterio.open('traningimage.tif')).Our convolutional neural network model would then receive the transformed image input and begin training.

IV.METHODOLOGY

First, we will collect the INSAT 3D imagery cyclone data then features of that data such as temperature, humidity, wind speed, and direction, and other relevant weather parameters will be extracted.The data after cleaning, will be divided into training data and testing data. The data obtained from the satellite must be converted into images using pre-processing techniques like image segmentation, feature extraction, and image normalization to the images. After this, a deep learning model has to be selected, in our case it is Deep Convolutional Neural Network (DCNN). In this step, the architecture of the model must be defined which includes total number of layers, neurons in each layer, activation functions, and metrics etc. The selected model has to be trained using fit () function. After this various performance metrics such as Mean Squared Error (MSE), Mean Absolute Error (MAE), and Root Mean Squared Error (RMSE) are calculated. Finally using the trained model predictions on new cyclone data is made and compared with the actual intensity to evaluate the accuracy of the model.

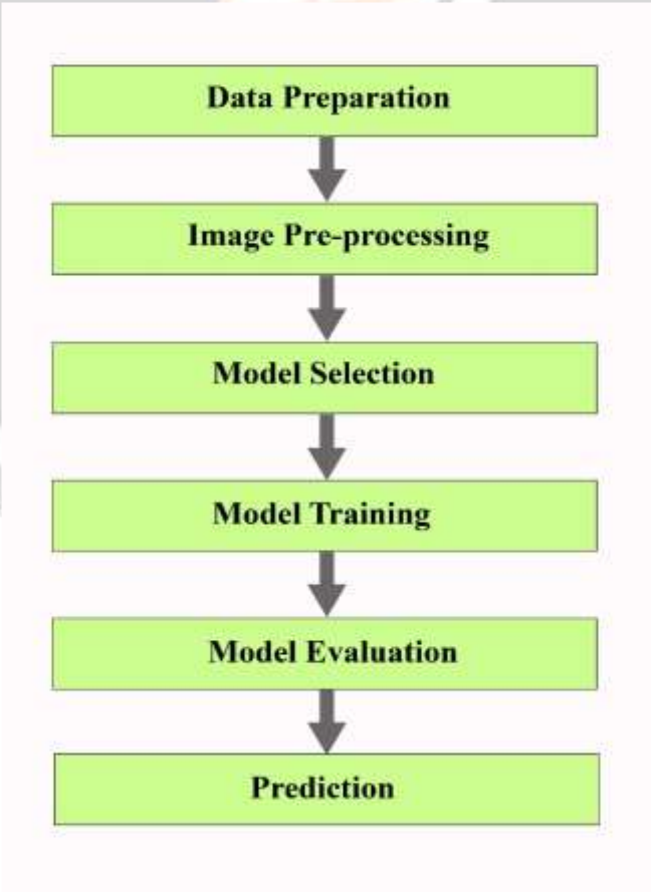

Fig 1: Methodology flow chart

V.IMPLEMENTATION IN TC DETECTION

Reading the images from the dataset which is obtained from the INSAT-3D satellite. The dataset is in the form of Tag Image File which will be later converted into graphics interchange format. For the input consider set of Training images (t1,t2,t3…tr), set of validation images (V1,V2,V3…Vq), and also set of testing images.

Region-Based Convolutional Neural Networks is used for Detection and segmentation of the image in the date set. The three layers are used in the R-CNN for segmentation. They are convolution layer, Pooling Layer and Fully connected layer. K-Means segmentation is also used in the segmentation of the input dataset. The programme will group the objects into k similarity clusters or groups. The centroids are computed by the K-means clustering algorithm, which then iterates until it finds the ideal centroid. It presumes that there are already known quantities of clusters. The flat clustering algorithm is another name for it. K in K-means stands for cluster number that the algorithm was able to identify from the data. Along With R-CNN and K-Means Detectron2 is used for object segmentation. The generated jpg image's cyclone component is automated manually. These annotated photos are used to train the Feature pyramid network used by the detectron2 algorithm.

Multiple images will be convolved when different kernels or filters are applied to the same image. We may identify various patterns in an image, such as edges, lines, curves, and so on, by using different kernels. The kernels will be initialised with random values, and during the training phase, the values will be updated with optimal values, allowing us to recognise the pattern. On top of the nodes in the convolutional layer, we will provide the neurons ReLU activation functions.

In the motion prediction Mean Path Adjustment and convolutional neural network are used. In Mean Path Adjustment four images are taken at different time span t,t-1,t-2 and the algorithm will predict the fourth image at time stamp t+1.Cyclone classification is done based on temperature and wind speed. If the temperature is less than 200k, it will be classified as cyclone and also wind speeds are taken into consideration. Finally in the output, estimated intensity of the cyclone is displayed.

VI.CONCLUSION

The classification of infrared images obtained from the INSAT-3D IR is important to predict the presence of cyclones in the particular region. These images obtained from INSAT-3D Satellite is recognized to be an ideal option for analysing irregular cyclone movements which is further used in theprocess of training and testing sets of the deep convolutional neural network. The main aim of this paper is to detect cyclones and predict their intensity before the eye formation using the proposed model of CNN by analysing the obtained infrared images from INSAT-3D satellite

Here processing speed must be increased so CNN will mandate tiny image sizes. To deal with the CNN environment, images of 997 pixel * 969 pixel size are reduced to 224 pixel * 224 pixel size in general. The prior data and information on disaster events like earthquake, cyclone, tsunami, and volcanic eruption are very restricted.

In some cases, reducing the size of the image for convolutional neural network may result in invisibilityof tiny details about a cyclone which makes predicting the intensity of cyclones may not always be attained precisely which is a limitation of this study. In future, CNN-based techniques which work directly on satellite images without modifying, resizing, rotating or compromising image attributes canbe developed

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