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Cyclone Intensity Estimation Based on Deep Learning Utilizing INSAT-3D Data

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Abstract: -

Forecasting for tropical cyclones (TC) includes predicting storm surges and determining intensity. To reduce TC-related human loss and harm, it is essential to predict and identify TC intensity. In this study, we suggest a technique based on image processing for calculating TC strength from satellite photos of tropical cyclones. Multilayer perceptron models are applied to the geometric aspects of TC pictures for categorization. The proposed approach has an accuracy of 84° for classifying TC pictures of the Arabian Sea and Bay of Bengal.

Keywords: - Tropical cyclone, Deep learning.

I. Introduction

TCs are defined as rapidly rotating storms with low pressure centers, limited low-level atmospheric wind motion, and heavy rainfall. This could lead to natural disasters, casualties, and property damage.

A mature cyclone forms an "eye" at its centre, which is surrounded by a powerful wind ring. According to studies, powerful winds' creation of seawater inundation is to blame for almost 90% of the damage. The model presented here is utilized by Multilayer Perceptron to train and test the feature values of TC pictures (MLP). A supervised learning approach is MLP. Subsets of feedforward artificial neural networks called MLPs have at least one hidden layer as well as input, output, and output layers. Except for input nodes, each node in MLP is modelled as a neuron with a nonlinear activation function. Backpropagation algorithm is a supervised learning method that is used to train and test the model.

II. Problem Formulation

Tropical cyclones present one of the greatest threats to property and human life, even in their early stages of development. These risks range widely and each one has the capacity to seriously injure both life and property. B. Lightning, storm surges, severe winds, floods, and tornadoes. Together, these dangers greatly increase the possibility of fatalities and property damage.

III. Literature Review

1. Literature Review on Dvorak Technique

The Dvorak method is cloud pattern recognition (CPRT) method based on a conceptual model of tropical cyclone development and collapse. It was first developed and tested in 1969 to monitor storms in the western North Pacific. This methodology uses satellite imagery available from satellites in polar orbits to characterize the development of tropical storms (hurricanes, cyclones, and typhoons). Observe the sea with visible spectrum images during the day and thermal images at night. The technology uses satellite imagery to identify patterns in observed storm structure, helping to locate eyes and measure storm intensity. It does not measure or predict wind, pressure, or other weather parameters associated with hurricanes, but serves as a guide for assessing storm intensity and potential intensification. This helps local authorities plan evacuation measures at or near the coast. Local residents are important.

2. Literature Review on Advanced Dvorak Technique

The Advanced Dvorak Approach, developed by Olander and Velden as a development of the manual Dvorak technique, uses satellite imagery as input to an automated algorithm that gives a T-number. ADT has also been enhanced with the addition of passive microwave data, aircraft observations, and improved tropical cyclone centering, which is a crucial part of the automated process. Although the ADT outperforms the manual Dvorak technique, model performance struggles with lesser storms that have a tendency to have a more erratic cloud distribution. Empirical thresholds are therefore kept in place to limit how much the strength of cyclones shift over time.

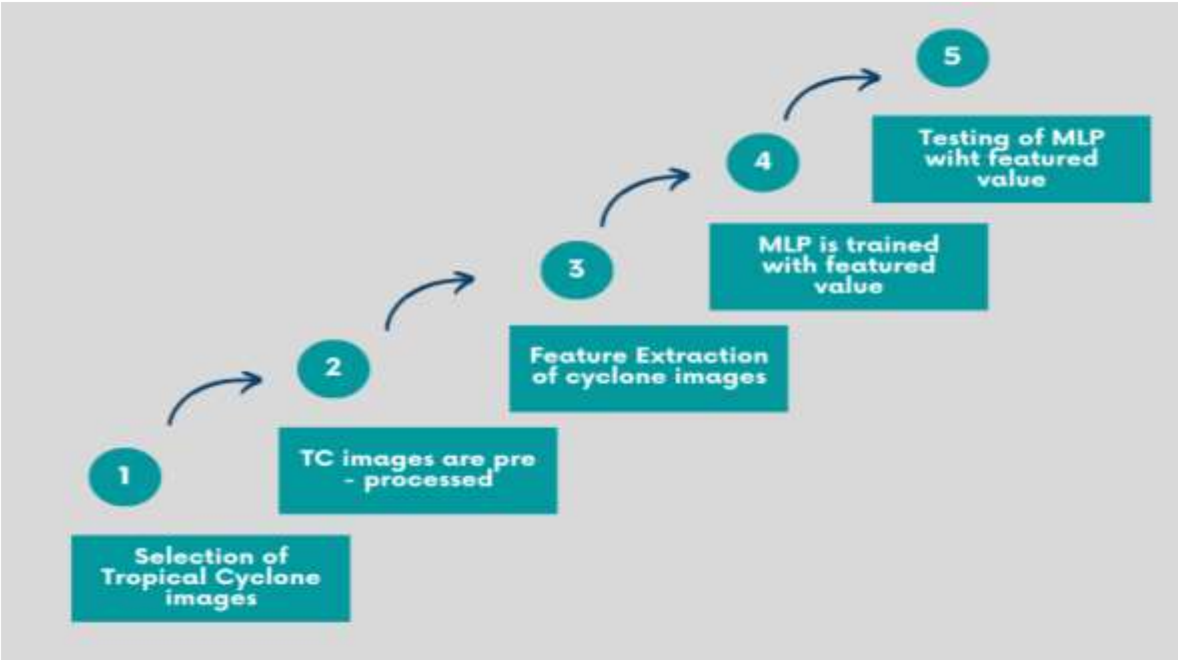
IV. Methodology

Our data consists of infrared (IR) images, which are subjected to a convolution process in the convolutional layer before being passed on to the following layer.

We will use two separate CNN models: one for classifying tropical storm intensity and the other for estimating it.

In the subsequent layer, the max pooling layer unifies the outputs of a group of neurons from the layer before into a single layer.

The last layer, fully connected, links every neuron in the layer below to every neuron in the layer above. In the completely connected layers, L2 regularization of 0.01 will also be carried out. Additionally, we will employ call-back strategies such early halting and dropout layers at a rate of 0.5 to prevent the model from becoming overfit.



V. Result Discussions

In our project, typhoon satellite imagery is analyzed using deep learning (CNN). Keep an eye on "investment zones," or regions where tropical cyclones might develop and start wind speed estimation operations, in the National Hurricane Center outlook. So that estimated wind speeds can be compared to operational forecasts, display estimated wind speeds and additional data on a map. The primary objective of this project is to offer an understandable interpretation of model results to the larger scientific community.

VI. Limitations of the Work

- One of the main criticisms of machine learning methods from subject matter experts is that it might be difficult to determine what a model is actually learning in order to arrive at a categorization conclusion. As a result, there is a lack of trust between experts in machine learning and the community of physical scientists, which prevents the use of these models in practical systems.
- As part of our model evaluation, we use techniques to understand how cyclone intensities are calculated within the CNN.

VII. Suggestion and Recommendations for Future Work

For an end-to-end machine learning project to be successfully completed, a diverse team of machine learning experts, domain experts, end users, software engineers, and user interface designers is needed.

Future research on a variety of topics, such as the estimation of wind speed for tropical cyclones with lesser intensities using passive microwave data, could be taken into consideration.

A detailed examination of a particular storm to understand model performance with storm structural changes during rapid intensification is another potential future study.

VIII. Conclusion

We offer a comprehensive, real-time deep learning solution for estimating tropical storm wind speed. This system will develop a revolutionary convolutional neural network model that will be used to precisely estimate tropical storm wind speeds using just satellite imagery. We also outline a fresh method for starting workflows that keep track of developing storms and offer situational awareness portal-based real-time wind speed estimations.

We also discover that building a sizable, trustworthy training dataset of photos and associated wind speeds takes substantially longer than formulating an algorithm. It is a challenging process to deploy the machine learning model since it involves numerous iterations using fresh training data and model parameters. The model was handled like source code from a software engineering standpoint and was correctly versioned.

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