That's a spicy cloud: A comparative study to approaches for Tropical Storm intensity estimation from Raw and Infrared Satellite images

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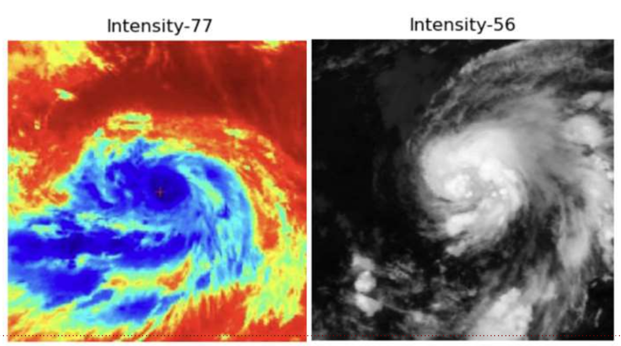
1. Introduction

- **Tropical cyclones**, which originate over tropical oceans, have become a topic of great concern due to their devastating impact on human populations. The intensity of these cyclones is **primarily determined by the initial intensity of the cyclone and the wind speed**.
- The records indicate a **concerning 13-15% increase** in the intensity of these cyclones since the late 1970s, underscoring the urgent need for advanced models to better comprehend and forecast tropical cyclone intensity.
- Our project utilized a dataset comprising wind speed annotations and single-band satellite images obtained from over **600 storms, which was curated by the NASA IMPACT team in collaboration with the Radiant Earth Foundation**.
- Our research show that **VGG-16 surpasses the other two conventional models (LeNet-5 and AlexNet) for the given task.**



Sample Images from INSAT 3D Infrared Satellite images, NASA tropical storm competition dataset Raw satellite images with their intensities.

2. Project Aim

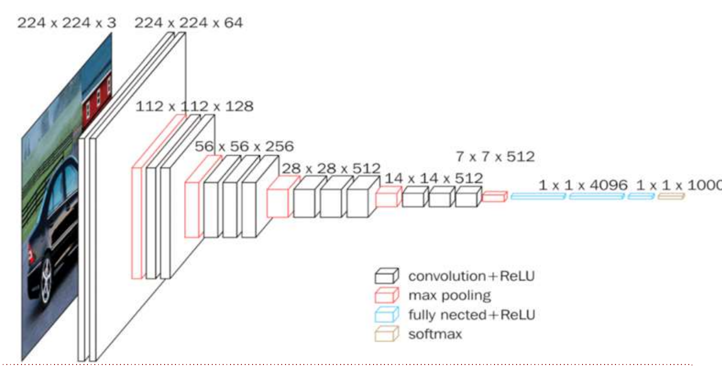
- Creating an optimized CNN model with an in class regressor and comparing it to the VGG16 implementation for a tropical cyclone classifier with wind speed regressor.

3. Challenges

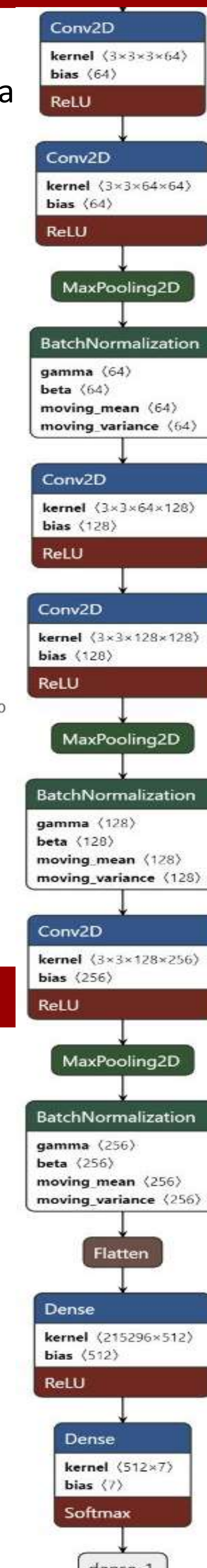
- Curating/Scraping the dataset for IR images.
- Class Imbalance for the Tropical Storm data.
- Computational Complexity.

4. Model description / Comparison

- Convolutional Neural Network (CNN) architecture with three sets of Convolutiona layers, BatchNormalization layers, and MaxPooling layers followed by two dense layers.
- Fewer layers than VGG16 without the VGG16's fully connected layers.
- The model is optimized using the Adam optimizer and trained to minimize the categorical cross-entropy loss.
- **Our model was fine tuned to run as a regressor and a classifier.**



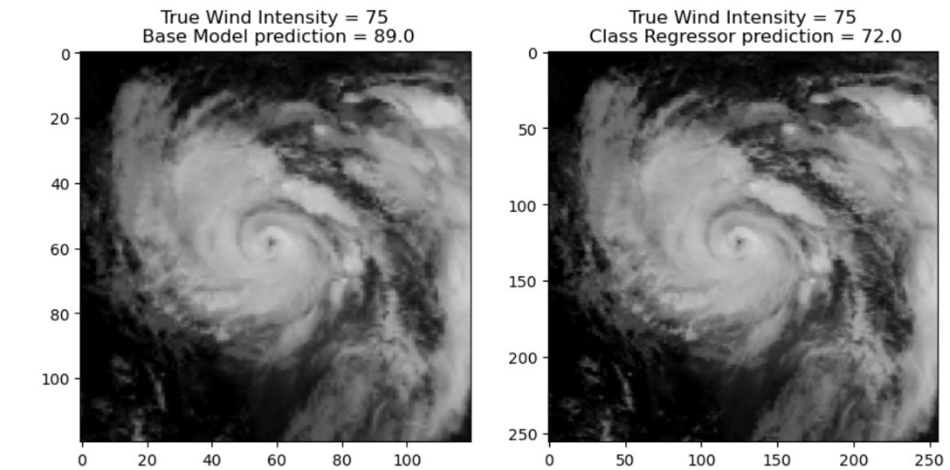
Comparison of VGG16 architecture (above) with Spicy Cloud Base model (right)



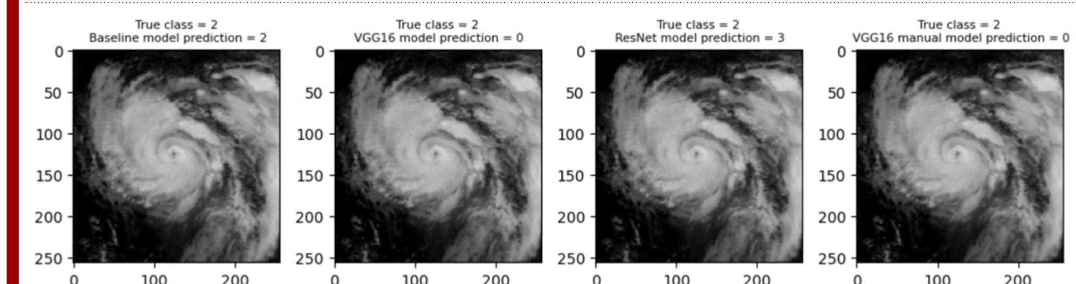
5. Experiments

- Running a base model regressor to compare the model RMSE with actual wind speed values.
- Splitting the wind speed into 6 classes based on literature survey.
- Using a VGG16 inference model and a recreated model to classify the dataset.
- Optimizing Spicy Cloud to run as classifier based on appropriate error metrics and hyperparameter tuning.
- Optimizing Spicy Cloud to run as a in class regressor after classification.

5. Results



Base model regressor VS Spicy Cloud model



Class prediction comparison between Spicy Cloud model, VGG16 (inference), ResNet (inference) and VGG16 manual model.

Class	Level	Test - RMSE	Wind Speed(kt)
Storm			
0	-	4.54	< 38.9
1	Tropical depression	6.54	38.9–61.6
2	Tropical storm	7.24	61.7–87.8
3	Severe Tropical Storm	8.27	87.9–117.4
Typhoons			
4	Typhoon	22.5	117.5–149.0
5	Severe Typhoon	135.4	149.1–183.2
6	Super Typhoon	-	≥183.3

Left: *Test RMSE storm obtained on Tropical Storm Classification.*

6. Future Work

- Capturing / Scraping more IR Data.
- Creating a model ensemble.
- Model evaluation comparison with Xgboost CNN.
- Probabilistic Modeling for Super Typhoons.

References : *Classification and Estimation of Typhoon Intensity from Geostationary Meteorological Satellite Images Based on Deep Learning, DEEPTI (NASA)*