MLD Advance Project Phase 2

Topic: Weather Classification using ML

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1. Overview of the Topic Domain

We have chosen the dataset which is based on weather classification. We would be using ML to predict the weather which is very essential for important decision-making across various sectors, which include agriculture, aviation and disaster management[1][2][3]. For instance, if we consider predicting the weather for aviation, it could be very useful for the pilots to plan the flight route and avoid any uninvited weather conditions during the journey and to help outline better for their flight plan[1]. Weather prediction can also be very important in the agriculture sector, where it helps farmers to decide multiple factors in terms of decision making which include Drought Preparedness, Crop Planning and Management, Yield Prediction etc[3]. This would help to yield quality crops and also help farmers avoid and take proper precautions if there are any unwanted weather conditions on their way[3]. The accurate classification and prediction of weather events, including cyclones, heavy winds, snow, and rain, are essential for mitigating risks and reducing the impact of adverse weather on communities, particularly those in coastal areas[2]. Predicting weather can be a decision for life and death as predicting early weather can lead us to take proper actions in the event of storms, heat waves or disasters[2]. So, this makes weather prediction crucial and adds much importance. Traditional methods rely mostly on the statistical part and physical-based models to predict or forecast the weather but most of the time, there has been seen struggle to felicitate high variability in the atmospheric data and becomes hard to make predictions.[4]

Based on the above scenarios, considering the importance of weather prediction and poorly performing old methods, Artificial intelligence and ML technology stand as very powerful tools in enhancing weather forecasting, where we can create various accurate performing models, for example, graphcast[6] which is more adaptive and precise in terms of predicting short term as well as long term weather preducitons[7]. Various studies, experimental predictions and verified information state that implementing AI and ML has outperformed weather prediction with a highly good accuracy and uses very few computable resources compared to the old methods.[5] Research has emphasized the importance of weather prediction as a key factor in building resilience against climate change impacts and the social care and health of people affected by extreme weather events worldwide.[8]In this way, weather classification and prediction

technologies not only have importance in protecting individuals; but also enhance the community against multidisciplinary applications and major use cases.

2. Current Approaches and Challenges being faced

Traditionally, weather forecasting has been done based on old methods such as statistical analysis and physic-based methods[4]. Most of the prediction methods for weather have been dominated by numerical weather prediction models (NWP) which simulate atmospheric conditions using mathematical and complex sets of numerical equations.[11] These numerical equations can be also fed into computer code and use governing equations, numerical methods, and parameterizations of other physical processes to have predictions related to weather[11]. However, Due to the chaotic nature of atmospheric systems, the precision of NWP models can be decreased significantly because of complex real-time equations, changes in parameters such as small errors in temperature, winds, and other initial inputs given in initial calculations lead to large variations in outcomes[13].

Other instances include computing various factors and parameters being considered to predict the weather such as Temperature, Precipitation, Wind speed, Direction, Severe weather, and UV index and feeding into computers which run various calculations to predict weather.[9] Various devices are being used such as Airborne devices, Satellite devices, Live weather data and Historic weather data.[9][12] This is generally used by Meteorologists to predict weather conditions[9]. However, these calculations can sometimes lead to inaccurate predictions as they solely are dependent on the input values. So even though there have been a good amount of weather prediction techniques, there are many drawbacks and do lack in predicting optimality which shows the high importance of Integrating Artificial intelligence and Machine learning algorithms into weather prediction to have more accurate precision, without worrying about input factors complex equations and fetching results in less compute time.

3. Existing Artificial Intelligence Technologies in Weather Classification

In recent years, due to the lack of dependence on the prediction of NWP (numerical weather prediction) and other factors, implementing AI has played a very important and significant role in weather classification and forecasting. The most prominent example would be Hybrid AI which is implemented by combining the traditional statistical/numerical weather prediction(NWP) models and integrating them with the various AI and machine learning algorithms which tend to improve weather forecasting.[14] Researchers have tried weather prediction by implementing AI with the data-driven model and combine with the statistical method to have a better prediction model built which can eradicate and avoid the error noticed within the old traditional models.[14] Another similar and successful example of an implemented application would be neuralCGM[15] which uses physics-based modelling with ML to achieve more accurate performance in prediction and accuracy[15]. The study also provides a firm opinion on the integration of ML technologies with

the NWP (MLNWP) specifically and has shown faster prediction results and also performed better.[16]

The above section describes the performance based on data and numerical calculations with AL and ML to predict the weather. This paragraph will describe how advanced ML techniques have been used specifically for weather classification including images, which is our main topic domain and describes prediction using digital data. Artificial technology prominently the convolutional neural networks(CNN) when applied to image datasets for weather prediction has shown high accuracy and has outperformed the traditional weather classification task[17]. CNN can process image data and has been widely used for satellite data analysis and shows the potential to classify weather-related images and predict them with great accuracy in terms of application and prediction.[18] A study also shows that CNN has performed exponentially well with up to 94% accuracy on weather classification based on weather-related image data[19.] Therefore; This adds a potential scope to our topic use case and to classify the weather to compare the accuracy of our df-analzye results with currently existing studies and their accuracy percentages.

4. Review of Related Paper

The published paper is based on our topic and has an approach to classify weather phenomena classification using a deep neural network (CNN) which is called METeCNN. This paper has used the same dataset on which we would be working. They have achieved a classification accuracy of 92.68% using the MeteCNN model which is great compared to other traditional methods such as VGG16, ResNet34, and EfficientNet-B7. The paper has succeeded based on the ability to use and analyze training on weather-related data and features to avoid errors that can be seen in human observations.[20]

Our parent publication above has also been cited more than 18 citations out of which, some of them have direct references to our topic domain have been explained in this paragraph. Firstly, there's a paper on the topic of “An intelligent method for detecting weather conditions using deep learning on a combined dataset”[21] where they were able to achieve 94.79% accuracy using EfficientNet-B4 model and with combined dataset on onResNet-101 with 90.42%[21]. Their proposed model has a high accuracy near about 99% on the Kaggle dataset[21] which we have been using which is exponentially good. Another study on detecting weather conditions for autonomous vehicles that have been implemented for vehicles to detect weather conditions[22] cited the parent paper where for the weather detection usingResNet-50 and CNN model they have achieved an accuracy of 98.48%, about 98.51%, for precision and 98.41% for sensitivity.[22] The Third paper is based on detecting foggy images for vision enhancement using deep learning models mainly CNN for classification[23]. For their model, they have achieved an accuracy of about 94.8%, the precision stands at 91.8%, and the recall percentage is at 75.8%, whereas the F1 score is about 80.3%.[23]

5. Hypothesis Statment

We hypothesize that using the open-source machine learning software [df-analyze] and [df-embed] applied to our Image Dataset related to Weather may produce useful technology to predict multi-classifications of weather based on Images. Also, we hypothesize that by having different runs based on random sampling from our original existing dataset, we may observe various significant insights by comparing accuracies. We would be taking into account our standard task to predict the weather based on the full dataset available and observe how the results differ based on our second run of random sampling i.e. one model for all samples and the other for random sampling.

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