

# Deep Learning Based Weather Classification System

V. R. Patil<sup>1</sup> P. S. Powar<sup>2</sup>

<sup>1,2</sup>Department of Computer Science and Engineering

<sup>1,2</sup>Ashokrao Mane Group of Institutions, Vathar, MH, India

**Abstract** — The recent work using Deep Learning has shown promising results in various domains. The present scenario of weather detection is laborious and time consuming. Therefore, it's crucial to include a preprocessing step that determines the weather for an incoming picture, followed by the appropriate deweathering procedures. This research considers the most prevalent weather scenarios to offer a deep learning-based environmental image classification system. The proposed system utilized four DCN pretrained networks for weather image classification. The best optimized ResNet attained with accuracy of 97.31%, precision of 86.99%, sensitivity of 86.44% and f1-score of 86.70%. Further, the proposed weather classification will be helpful in deployment of real time environment.

**Keywords:** Weather Image Classification, Deep Learning, CNN, Prediction

## I. INTRODUCTION

Weather prediction is the process of predicting the hours, several days and seasons ahead of time for an area using instruments, observable data, sciences, and technologies. Weather prediction was carried out by observations prior to computer models. In 1955, the initial weather report produced by a computer was created. Long-term prediction and knowledge of our everyday weather are two purposes for weather predictions. In order to predict the climate, continuous observations of humidity, hardship, storms, gusts of wind, and the visibility of clouds must be kept track of and reported to the public. The weather forecast for later in the day is then made using the reports on the existing circumstances. Every person is impacted by weather. Prediction for dangerous and extreme conditions are crucial because they have the ability to protect people, assets, and crops.

The recent work in prediction and classification using Deep Machine Learning(DML) has evolved in various fields such as healthcare, bio-medical image classification[6, 7], plant disease detection, chatbots, NLP, character recognition[8] etc. By looking at the broadness of Deep Learning(DL), this work focuses on automated weather image classification using various DL networks. The legacy technique for weather prediction contains human interventions and tends to error prone and laborious. By considering this limitations, we tried to intend the possibility of creating automated weather image classification. The recent work shows various advancement in weather classification using well known DL, image processing and Machine Learning(ML) techniques.

A natural disaster[1] is an abrupt occurrence caused by elements other than mankind that results in extensive destruction, significant repercussions, or fatalities. Natural disasters can be caused by storms landslides, volcanic eruptions, earthquakes, flooding, etc. For an event to be considered a disaster, it must have significant negative effects on the planet, result in fatalities, and regularly cause

economic harm. To minimize the above natural disasters and financial losses, the early detection of weather condition is utmost important. The final outcome of this article is as follows:

- 1) Finding best suitable DL networks for weather prediction.
- 2) Optimizing the DCNN hyperparameters for obtaining best results.
- 3) The generated automated weather detection system will be helpful for real time weather prediction.

The other sections are as follows. The section two describes the recent work over a weather classification. The simulated experimentation and utilized dataset are provided in section three. Section four provides the result analysis. Finally, the concluding remarks are added in section 5.

## II. LITERATURE WORK

This section introduces the recent work on weather image classification. Gadamsetty et. al.[3] introduced Hash-Based Deep Learning Approach for Satellite weather Detection. They utilized 70:30% data partitioning technique for data partitioning. The suggested hash based system helps in detecting aerial images for ship detection and bounding box generation. Kim and colleagues [4] conduct a case study on high-resolution weather simulations, specifically employing a certain model (replace [Specific Model] with the actual model discussed in the paper). The study explores the benefits and challenges associated with high-resolution simulations, focusing on their ability to capture localized weather patterns.

By presenting concrete examples and results, this paper contributes to the ongoing discourse on the importance of high-resolution simulations for improving the accuracy of weather forecasts at smaller spatial scales. Patel and colleagues [5] focus on the integration of remote sensing technologies to augment traditional weather forecasting methods. This paper discusses the incorporation of data from satellites, IoT devices, and other remote sensing tools. By analyzing the impact of these technologies on forecasting accuracy, the authors provide insights into how the field is evolving to leverage real-time, high-resolution data sources for more precise and timely weather predictions.

Tripathi et. al. [9] proposed classification approach for weather downgraded fruit images. The suggested system used CNN+RNN based approach to simulate the experimentation. The RNN attained 89.01% accuracy over other methods using fuzzy systems. Sharma et. al. [10] suggested another approach for weather classification system using CNN with handcrafted feature extraction. The suggested system worked with 4 labels: cloud, rain, shine, and sunrise labels. Sharma attained best training:Validation accuracy of 94:92% over the train:val dataset. Kuril[11] et al. suggested another approach of weather image classification using cloud based ANN-framework. The system works with amalgamation of DWT and ANN attained 94.37% overall accuracy.

### III. METHODOLOGY

#### A. Dataset

The collected dataset of weather image classification are retrieved from Kaggle repository[2]. The weather dataset contains total of 6862 image sample divided into 11 labels. Some of the image labels such as Dew, Fogsmog, Lightning, Rain etc. The assembled image samples was in the form of imbalanced class. Hence, we applied data augmentation technique to equalize the instance size per class. Zoom, crop, flip, rotation are the techniques utilized over image augmentation. Later, the whole dataset was divided into 80:20% for train and testing sets. Some of the weather samples are shown in figure 1.



Fig. 1: Samples instance from kaggle dataset[2].

#### B. Units

The overall weather image classification framework is divided into five different folds. The first and second folds deals with data collection for different image labels and data preprocessing. The third fold contains the DL based model selection and fine tuning the DL-networks. The provided the weather image from training set are fed to DCNN for training. We utilized four DCN networks: VGG16, MobileNet, ResNet101, Inception. The initial layer all the pretrained network are set to trainable: false and last layer contains 11 neurons. All the DNN's with the middle layer added with Dense(128), dropout(0.3), Dense(64), dropout(0.2), finally last dense with the softmax containing 11 neurons for classification.

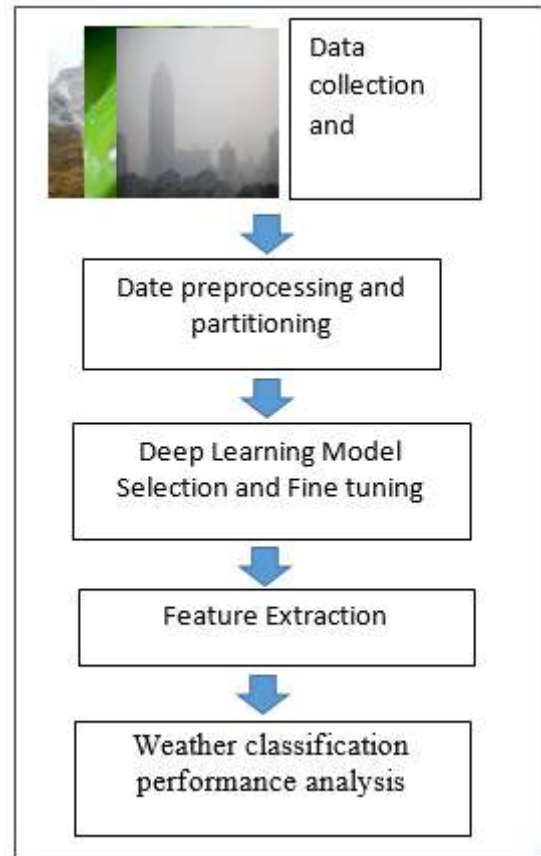
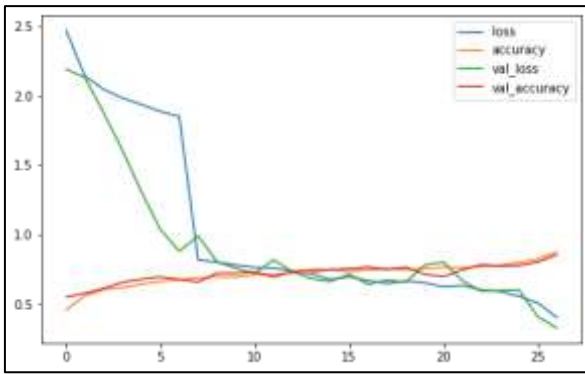


Fig. 2: Overall weather image classification framework.

The hyperparameters used for training are prior training halt to avoid model overfitting. Figure 3 shows the training and validation loss and accuracy plot. All the models were trained at 25 epochs and the training automatically halted. The best training accuracy attained by VGG19 and ResNet101 with 77.80 and 87.39% respectively. After observation with train:val loss, none the networks shown overfitting issue. The best attained train:val loss plots are shown in Figure 3.



(a) VGG16



(b) ResNet101

Fig. 3: Train:Val accuracy and loss plots.

IV. RESULT ANALYSIS

The confusion matrix(CM) plays a crucial role in finding true positive and false positives. The CM offers the projection between actual and predicted values. And the parameters of CM are false positive and negatives. These CM parameters helps in finding the accuracy, precision, recall, specificity etc. as a performance metrics.

$$\text{Accuracy} = (TP + TN) / (TP+FP+FN+TN)$$

$$\text{Precision} = TP/(TP+FP)$$

$$\text{Sensitivity} = TP/(TP+FN)$$

$$\text{F1-score} = 2 * (\text{Sens.} * \text{Precision.}) / (\text{Sensitivity.} + \text{Precision.})$$

$$\text{Specificity} = TN/(TN+FP).$$

		Confusion Matrix										
true label	dew	116	0	2	0	8	0	0	3	0	0	0
	fogsmog	0	153	0	0	0	0	0	0	0	2	0
	frost	0	0	68	0	0	0	0	1	0	0	0
	glaze	0	0	0	91	0	0	0	1	0	0	1
	hail	5	0	0	0	95	0	0	4	0	1	0
	light	2	0	2	1	8	69	0	18	0	0	0
	rain	0	1	0	0	0	0	70	1	1	1	0
	rainbow	0	0	0	1	1	0	0	93	0	0	1
	rime	0	0	0	0	0	0	0	0	187	0	0
	sandstrm	0	0	0	0	0	0	0	0	1	98	0
	snow	0	0	0	0	0	1	0	2	0	0	96
		dew	fogsmog	frost	glaze	hail	light	rain	rainbow	rime	sandstrm	snow
		predicted label										

Fig. 4: Confusion matrix attained by ResNet101 (best results).

Out of eleven label weather image classification the best 187 correctly identified by rime label followed by 153 for fogsmog, 116 for dew, ad 98 for sandstorm. The overall accuracy, precision, sensitivity, and f1 score are shown in Table 1. Out of four networks the ResNet attained best accuracy with 97.31% followed by VGG16 with 94.77%. And remaining two network reached accuracy with 85.12% and 76.56% by Mobilenet and inception net due to more misclassified instances. The best precision attained by Resnet with 86.99% followed by 77.66% by VGG. The whole training simulation was implemented on Google Colab, with Keras, Tensorflow, Seaborn, matplotlib, numpy and pandas are libraries utilized.

Sr. No.	Model / Performance Metrics	VGG16	ResNet101
1	Accuracy	94.77	97.31
2	Precision	77.66	86.99
3	Sensitivity	76.91	86.44
4	F1-Score	77.60	86.70

Table 1: Table Type Styles

V. CONCLUSION

In this article, we created deep learning based deep weather image classification system. This approach tends to overcome the issues identified in the legacy system that contains manual interventions. The suggested system utilized 6862 weather images. The whole weather images are initially preprocessd and later fed to well-known deep learning networks for feature extraction. Once the well optimized and fine-tuned networks are trained on the training dataset. The extracted features are then used for testing unknown weather images. The best attained results shows the 97.31% accuracy over eleven weather label classification. Further the suggested weather prediction framework may be used in real time meteorological department.

REFERENCES

- [1] Natural Hazards | National Risk Index". hazards.fema.gov. Retrieved 2022-06-08.
- [2] Kaggle Wether image dataset, retrieved on 24 May 2023, Online, <https://www.kaggle.com/datasets/jehanbathena/weather-dataset>
- [3] Gadamsetty, S.; Ch, R.; Ch, A.; Iwendi, C.; Gadekallu, T.R. Hash-Based Deep Learning Approach for Remote Sensing Satellite Imagery Detection. Water 2022, 14, 707. <https://doi.org/10.3390/w14050707>
- [4] Kim, J., et al. (2021). "High-Resolution Weather Simulations Using [Specific Model]: A Case Study." Weather and Forecasting, 36(8), 1675-1692.
- [5] Patel, C., et al. (2022). "Integration of Remote Sensing Technologies for Enhanced Weather Forecasting." Remote Sensing, 14(1), 120.
- [6] Bhosale, Y.H., Patnaik, K.S. Application of Deep Learning Techniques in Diagnosis of Covid-19 (Coronavirus): A Systematic Review. Neural Process Lett 55, 3551–3603 (2023). <https://doi.org/10.1007/s11063-022-11023-0>
- [7] Yogesh H. Bhosale, K. Sridhar Patnaik, PulDi-COVID: Chronic obstructive pulmonary (lung) diseases with COVID-19 classification using ensemble deep convolutional neural network from chest X-ray images to minimize severity and mortality rates, Biomedical Signal Processing and Control, Volume 81, 2023, 104445, ISSN 1746-8094.
- [8] Zanwar, S.R., et al. English Handwritten Character Recognition Based on Ensembled Machine Learning. J. Inst. Eng. India Ser. B 104, 1053–1067 (2023). <https://doi.org/10.1007/s40031-023-00917-9>
- [9] Pankaj Kumar Tripathi, Chakresh Kumar Jain, Role of AI-Based Methods in Colorectal Cancer Diagnostics, Advancements in Bio-Medical Image Processing and

Authentication in Telemedicine, 10.4018/978-1-6684-6957-6.ch004, (54-75), (2023).

- [10] Sharma, Ashish, and Zaid Saad Ismail. "Weather Classification Model Performance: Using CNN, Keras-Tensor Flow." ITM Web of Conferences. Vol. 42. EDP Sciences, 2022.
- [11] Kuril, Sanju, Indu Saini, and B. S. Saini. "Cloud classification for weather information by artificial neural network." International Journal of Applied Physics and Mathematics 3.1 (2013): 28.

