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Radar Data Analysis Using Correlation Heatm

Mayank Tambe, Sunil M. Wanjari, Brijesh Kanaujiya, Dewanshu Satpute, Aadarsh Jain , Daisy Francis

Dept. of Computer Engineering, SVPCET, Nagpur, India, 441108
Corresponding Author Email: mayanktambe16@gmail.com

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***Abstract-** The ever-changing nature of weather and atmospheric conditions has underscored the significance of weather forecasting as a pivotal area of research. Over recent decades, scientists have innovated various techniques to enhance model precision, particularly in handling complex nonlinear statistical datasets, aiming to mitigate environmental risks and global crises. Artificial intelligence and machine learning have introduced a transformative aspect to weather forecasting, simplifying intricate mathematical equations. The objective of this study is to delve into radar data analysis, aiming to provide valuable insights that can contribute to the advancement of climate prediction and the refinement of weather forecast models.*

This model serves to further elucidate the complexities of weather phenomena, enhancing our understanding and predictive capabilities in weather forecasting. By revealing the interdependencies between different parameters, our model significantly enhances our ability to predict weather conditions accurately.

***Keywords-** Weather forecasting, Radar data and Weather parameters*

INTRODUCTION

Weather forecasting is useful to the military, airports, and agricultural industries, among other agencies. Precise forecasts facilitate troop deployments, mission scheduling, and strategy planning in the military, hence enhancing operational preparedness and efficiency. Weather predictions are crucial to airport operations as they help schedule flights, control air traffic, and guarantee passenger safety while reducing inconveniences from inclement weather. Forecasts help farmers maximize yields and minimize losses by guiding their decisions about crop planting, irrigation, and insect control.

The process of deciphering data gathered by radar devices is called radar analysis. It entails examining the echoes that come back from targets within the radar's range of vision as well as the signals that radar transmitters send out. Determining the distance, direction, speed, size, and other details of identified targets, such as ships, airplanes, weather systems, or other objects, is part of this study. Radar analysis
is a useful tool for deriving insights from radar data for a variety of applications, including military operations, weather forecasting.

There are several reasons why radar analysis is significant:

A. Weather forecasting: It helps meteorologists deliver precise forecasts and alerts by giving real-time information about precipitation, storm systems, and other weather phenomena.
B. Aviation Safety: Radar assists air traffic controllers in keeping an eye on aircraft movement, identifying possible dangers such as turbulence or storms, and ensuring a safe distance between planes.
C. Military Operations: By identifying and monitoring airborne and surface targets, radar analysis helps military defense, reconnaissance, and surveillance systems.
D. Navigation: By identifying surrounding ships, landmasses, and obstructions, radar helps boats and ships navigate across water bodies securely.
E. Security: Radar is employed in border monitoring, perimeter surveillance, and the detection of unauthorized entry into sensitive areas.

Overall, radar analysis is an essential piece of technology in today's world since it improves productivity, security, and safety in a multitude of areas.

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LITERATURE REVIEW

Radar systems are essential for meteorology, providing critical data for weather forecasting. Parameters extracted from radar data, including reflectivity, velocity, power, and geographical coordinates (longitude and latitude), play key roles in understanding atmospheric phenomena. Here's a concise summary of their significance:

A. Power in Meteorology:

Power refers to the intensity of radar signals returned from precipitation particles. It's crucial for estimating precipitation intensity, with higher values indicating heavier rainfall. Smith et al. (2018) emphasized accurate power measurements for improving precipitation estimation.

B. Reflectivity in Meteorology:

Reflectivity, measured in dBz, quantifies radar return signal strength and provides information about precipitation size and distribution. High reflectivity values indicate intense precipitation. Johnson et al. (2019) highlighted its significance for rainfall estimation and precipitation type identification.

C. Velocity and Spectrum Width:

Velocity indicates particle speed and direction detected by Doppler radar. Spectrum width measures velocity variability, useful for identifying storm intensity and precipitation types.

D. Py-ART (Python ARM Radar Toolkit):

Py-ART is a powerful open-source toolkit for working with weather radar data in Python. It provides tools for reading, processing, and visualizing radar data, including reflectivity, velocity, and spectrum width. Py-ART is widely used in meteorological research and applications, enabling scientists to analyze radar data and develop algorithms for precipitation estimation and storm analysis. Reflected by precipitation particles. It helps identify precipitation types, estimate rainfall rates, and track storm movement and intensity. Reflectivity is crucial for rainfall estimation, storm tracking, and issuing timely weather warnings.

E. Heatmap

A heatmap employs color gradients to visually represent data values on a two-dimensional grid, effectively spotlighting patterns, trends, and correlations present in the dataset. It offers an intuitive method for examining spatial relationships and pinpointing areas of significance. Through color spectrum mapping, heatmaps facilitate rapid identification of both high and low values, empowering users to analyze correlations and spatial distributions with precision.

METHODOLOGY

We propose a model that addresses the limitations encountered by various meteorological centers in meteorological analysis. The model aims to enhance the accuracy of weather condition predictions using radar data. It utilizes characteristics such as reflectivity, power, spectrum width, and velocity. A model has been developed to analyze current weather conditions and, utilizing the trained model, forecast the weather for the upcoming period.

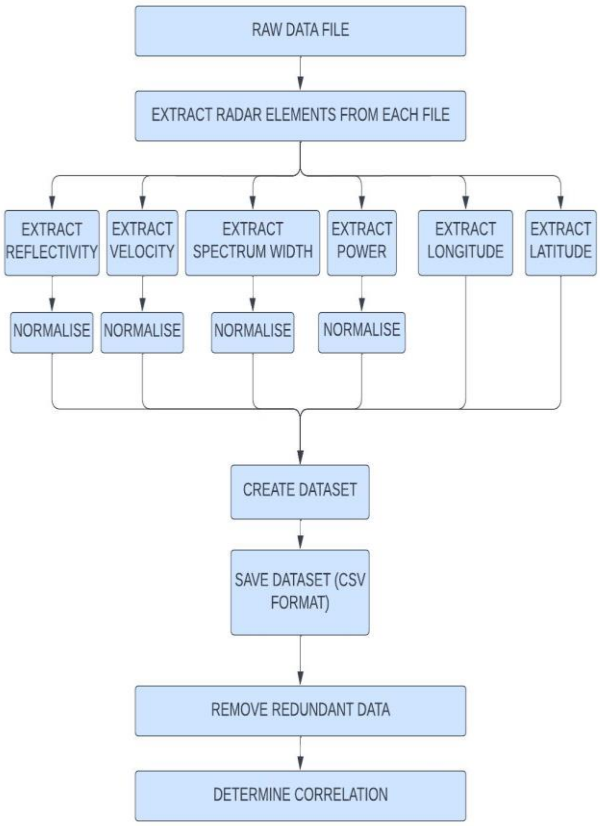

Fig 1. Dataflow Diagram

Users can monitor radar data and download the necessary data components using the web-based platform. The downloaded radar data then can be utilized as input by the meteorologists to forecast future weather conditions. The outcomes we obtain are stored in csv file.

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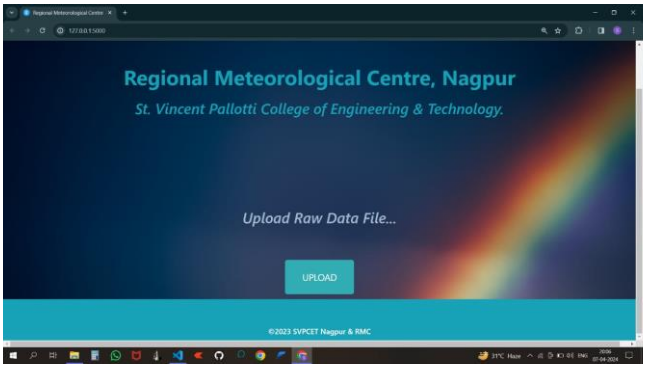

Fig 2. User-Interface for uploading the folder containing raw radar files

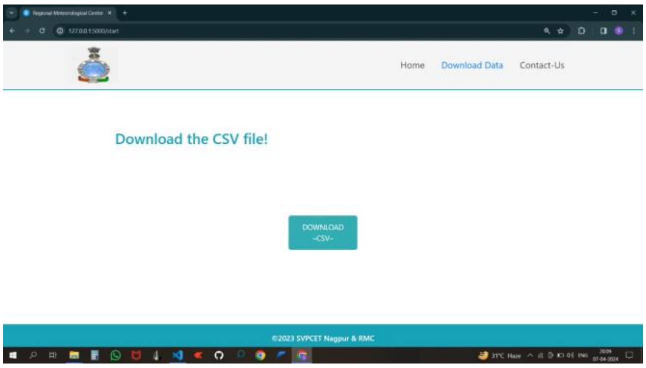

Fig 3. Downloading the csv file

	A	B	C	D	E	F
1	time	name	reflectivity	velocity	power	spectrum_width
2	23:50:08	NGP180213235003.RAWCG1T	30.5	1.007874012	31.5	7.822500229
3	22:50:15	NGP180213225007.RAWD9BK	30.5	7.820000172	30.5	7.820000172
4	23:40:09	NGP180213234003.RAWCFZG	31.5	1.007874012	33	7.822500229
5	23:20:11	NGP180213232003.RAWD9BS	31	7.820000172	31.5	7.820000172
6	23:30:10	NGP180213233003.RAWD9BU	30.5	7.820000172	34.5	7.820000172
7	23:30:10	NGP180213233003.RAWCFX6	30.5	1.007874012	34.5	7.822500229
8	23:50:08	NGP180213235003.RAWD9BY	30.5	7.820000172	31.5	7.820000172
9	23:02:13	NGP180213230201.RAWCFR4	30.5	1.007874012	30.5	1.724645615
10	23:52:37	NGP180213235209.RAWCG2M	31	1.007874012	32	1.724645615
11	23:02:13	NGP180213230201.RAWD9BN	30.5	1.720000029	30.5	1.720000029
12	23:22:11	NGP180213232208.RAWCFVR	31	1.007874012	31.5	1.724645615
13	23:00:43	NGP180213230014.RAWD9BM	32.5	7.820000172	33	7.820000172
14	23:42:08	NGP180213234201.RAWCG0B	31	1.007874012	31.5	1.97102356
15	23:42:08	NGP180213234201.RAWD9BX	31	1.970000029	31.5	1.970000029
16	22:52:14	NGP180213225201.RAWD9BL	31	1.230000019	32	1.230000019
17	23:10:11	NGP180213231006.RAWD9BP	30.5	7.820000172	30.5	7.820000172
18	23:12:12	NGP180213231201.RAWD9BR	30.5	1.720000029	31	1.720000029
19	23:20:11	NGP180213232003.RAWCFUW	31	1.007874012	31.5	7.822500229
20	23:40:09	NGP180213234003.RAWD9BW	31.5	7.820000172	33	7.820000172
21	22:40:15	NGP180213224013.RAWD9BH	31	7.820000172	30.5	7.820000172
22	22:52:14	NGP180213225201.RAWCFMS	31	1.007874012	32	1.231889725
23	23:12:12	NGP180213231201.RAWCFTE	30.5	1.007874012	31	1.724645615
24	22:50:15	NGP180213225007.RAWCFLX	30.5	1.007874012	30.5	7.822500229
25	22:30:16	NGP180213223003.RAWCFGA	30.5	1.007874012	30.5	7.822500229
26	23:10:11	NGP180213231006.RAWCFSK	30.5	1.007874012	30.5	7.822500229
27	22:42:15	NGP180213224201.RAWCFKF	30.5	1.007874012	32	1.47826767
28	22:20:18	NGP180213222007.RAWD9BD	32.5	7.820000172	31	7.820000172

dataset

Fig 4. Extracted final CSV file

The model uses a Heat map, which illustrates various correlations between the parameters utilized in our model, ranging from -1 to +1. A positive value implies a direct relationship, whereas a negative value denotes an indirect relationship. Consequently, all of these correlations seem to have interpretations. Such interpretations improve radar analysis efficiency, which is beneficial for meteorologists anticipating weather.

Fig 5. Correlation Heatmap for Weather Parameters

Size of Correlation	Interpretation
.90 to 1.00 (−.90 to −1.00)	Very high positive (negative) correlation
.70 to .90 (−.70 to −.90)	High positive (negative) correlation
.50 to .70 (−.50 to −.70)	Moderate positive (negative) correlation
.30 to .50 (−.30 to −.50)	Low positive (negative) correlation
.00 to .30 (.00 to −.30)	negligible correlation

Fig 6. Correlation Value and its Interpretation

DESIGN

The User Interface and Neural Network backend form the core components of the model, playing pivotal roles in creating an efficient system. Our project involves building an application that converts raw files into CSV format and extracts radar components.

Several observations have been noted:

1. Spectrum width denotes the distribution of velocities within a single radar pixel.
2. The power spectrum depends on the mean radial velocity and radar reflectivity factor.
3. Raw files are significantly more intricate than CSV files due to challenges related to storage and accessibility.
4. Batch transformation of files offers a more convenient and efficient method of conversion.
5. Reflectivity is directly correlated with power.
6. Velocity is directly proportional to spectrum width.

CONCLUSION

In Conclusion, there exists a robust relationship between radar power and reflectivity, where higher power yields a more intense reflected signal and heightened sensitivity to targets. However, achieving precise target identification and measurement through radar technology entails meticulous consideration and control of various complex factors.

It's crucial to recognize that interpreting radar data requires careful consideration of various intricate factors, emphasizing the importance of rigorous analysis and meticulous attention to detail in meteorological research endeavors.

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