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Outlines of Presentation

- Introduction
- Literature Review
- Problem Statement
- Research Gap
- Objective Outcome
- Proposed Mechanism
- Result

MINOR PROJECT

A HYBRID SYSTEM BASED ON ENSEMBLE LEARNING FOR TIME SERIES FORECASTING OF SOLAR IRRADIANCE

WHAT WILL BE THE PREDICTED VALUE?

INTRODUCTION

- Objective: Develop a resilient forecasting model.
- Methodology: Employ ensemble learning methods.
- Integration: Fuse Aerosol Optical Depth (AOD) data with meteorological parameters.
- Focus: Deepen insights into solar irradiance dynamics.

INTRODUCTION

- Impact: Advance renewable energy optimization and atmospheric science.
- Innovation: Utilize innovative forecasting techniques.
- Collaboration: Join us in this endeavor to elevate forecast performance and dependability.
- Contribution: Your expertise can enrich our project and drive progress in renewable energy and atmospheric science.

LITERATURE REVIEW

Sr No.	Paper Title	Contribution
1.	A hybrid system based on ensemble learning to model residuals for time series forecasting [1].	The paper proposes Ensemble method for Residual Forecast (ERF), combining linear models and ML ensembles. ERF demonstrates superior performance over traditional and hybrid approaches in time series forecasting. Future research should explore alternative ensemble strategies and additional linear/nonlinear models for further optimization.
2.	Hybrid structures in time series modeling and forecasting [2].	The study provides insights into three hybrid structures for time series forecasting and highlights factors influencing their performance. It offers guidance on selecting appropriate hybrid models and identifies research gaps for future exploration in forecasting methodologies.

Sr No.	Paper Title	Contribution
3.	Solar irradiance forecasting using a novel hybrid deep ensemble reinforcement learning algorithm [3].	The study introduces HYDEREL, a hybrid model integrating PMI input selection, optimized deep LSTM-CNN models, and deep RL algorithm for solar irradiance prediction. Evaluation against benchmark models demonstrates HYDEREL's enhanced forecasting performance and robustness across different scenarios, validating its efficacy for solar irradiance prediction.
4.	Effects of clouds and aerosols on downwelling surface solar irradiance nowcasting and short-term forecasting [4].	The study enhances SENSE nowcasting and NextSENSE short-term forecasting systems for solar energy exploitation in Europe and the MENA region. It addresses cloud-related uncertainties, improves accuracy using ground-based measurements, and offers high-resolution, real-time GHI estimates and forecasts for solar energy management and planning.

Sr No.	Paper Title	Contribution
5.	Studying the influence of aerosol types on solar radiation prediction [5].	The study investigates the impact of aerosol types on solar radiation prediction in China, distinguishing between urban and rural areas. Using ArcGIS and the WRF model, it demonstrates significant improvement in forecasting accuracy by considering different aerosol types across regions, validated against NASA's "Clouds and the Earth’s Radiant Energy System" data.

PROBLEM STATEMENT

A hybrid system based on ensemble learning to model for time series forecasting of Solar Irradiance?

STATEMENT:

Develop a hybrid forecasting system that leverages ensemble learning techniques to improve the performance of time series forecasting of solar irradiance by effectively modeling meteorological parameters with Aerosol optical depth.

RESEARCH GAP

AEROSOL

An aerosol includes both the particles and the suspending gas, which is usually air.
In the atmosphere, aerosols play an important role in climate change, the Earth’s environment.

Why AOD?

Integrating AOD (Aerosol Optical Depth) data with other meteorological parameters can enhance time series prediction of solar irradiance.

RESEARCH GAP

- Integration of AOD Data: Combine Aerosol Optical Depth (AOD) data with meteorological variables.
- Meteorological Variables: Include temperature, humidity, wind speed, and atmospheric pressure.
- Performance Improvement: Enhance model accuracy and reliability.
- Predicting Aerosol Behavior: Better understanding of aerosol dynamics over time.
- Impact on Solar Irradiance Forecasting: Facilitate more precise predictions.
- Comprehensive Approach: Incorporate diverse data sources for comprehensive analysis.
- Enhanced Model Performance: Improve the ability to forecast solar irradiance.
- Importance of AOD Data: Provides insights into aerosol concentration and distribution.
- Contribution to Renewable Energy: Aid in optimizing solar energy production through better forecasts.

GATHER EVIDENCE

An increase in anthropogenic aerosol emissions contributes to a reduction of solar radiation at the surface. Due to the continuous increase of environmental pollution in China in recent years, **the enhanced aerosol concentration in the atmosphere has led to a great reduction in the amount of solar radiation** that can reach the ground , and this reduction has a direct effect on PV energy production.

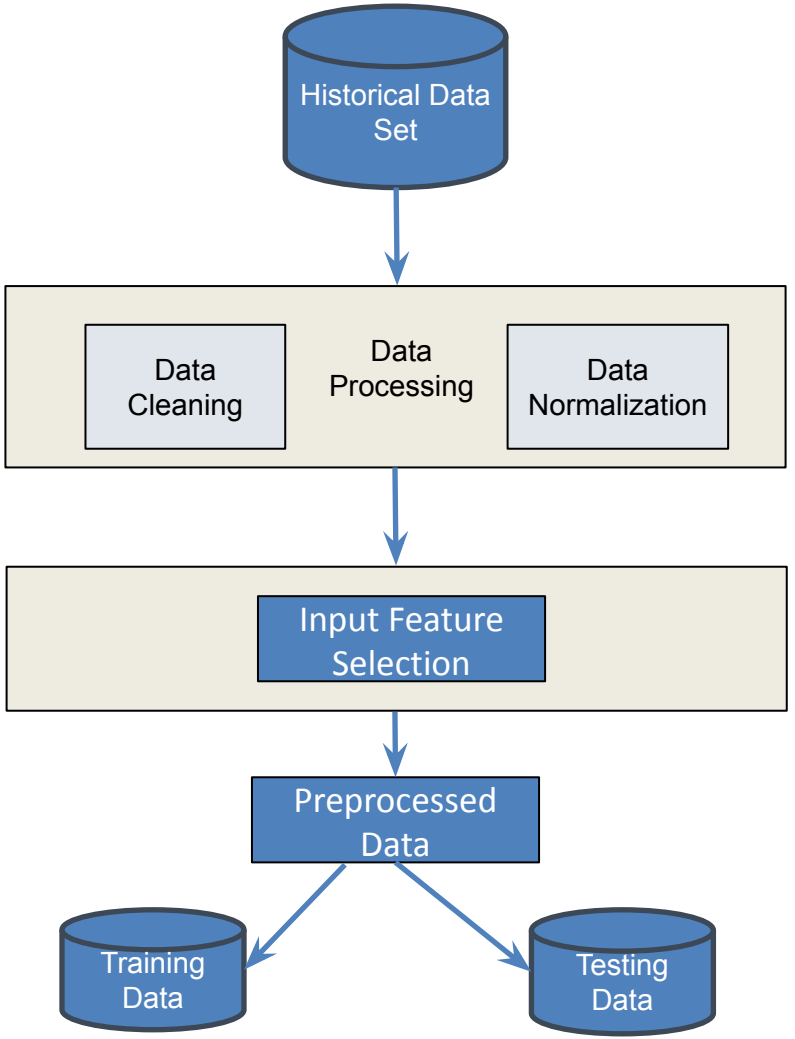
Recent studies showed that on average the PV has been potentially decreased by 11–15% in China between 1960 and 2015, and the loss ratios of PV power generation caused by haze were 17% in eastern central China, 8.1% in Shanghai, 5.25%～6% in Hangzhou and 8.77% in Tianjin in the most serious air pollution month of the winter from 2017 to 2019.

OBJECTIVE

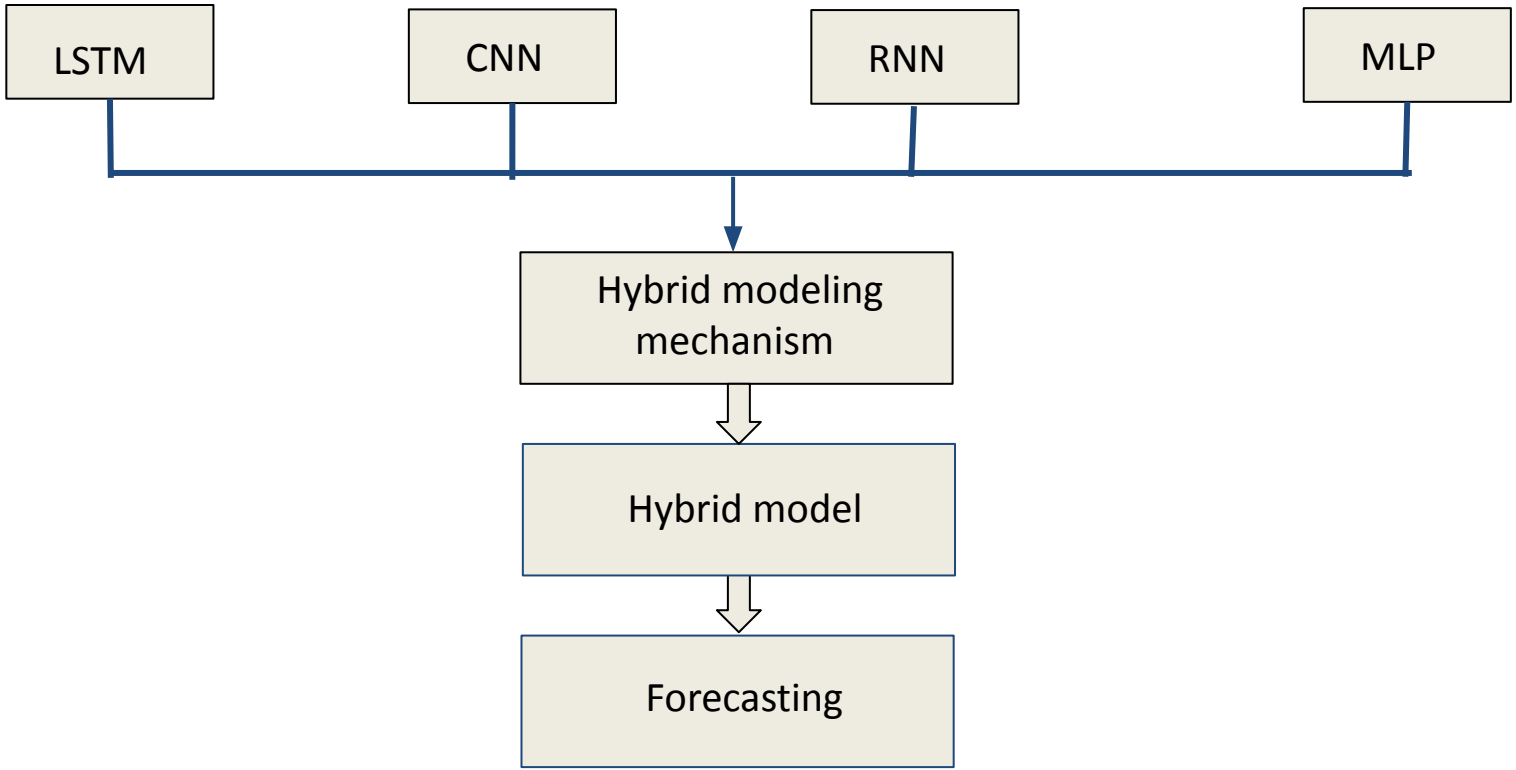
OUTCOME

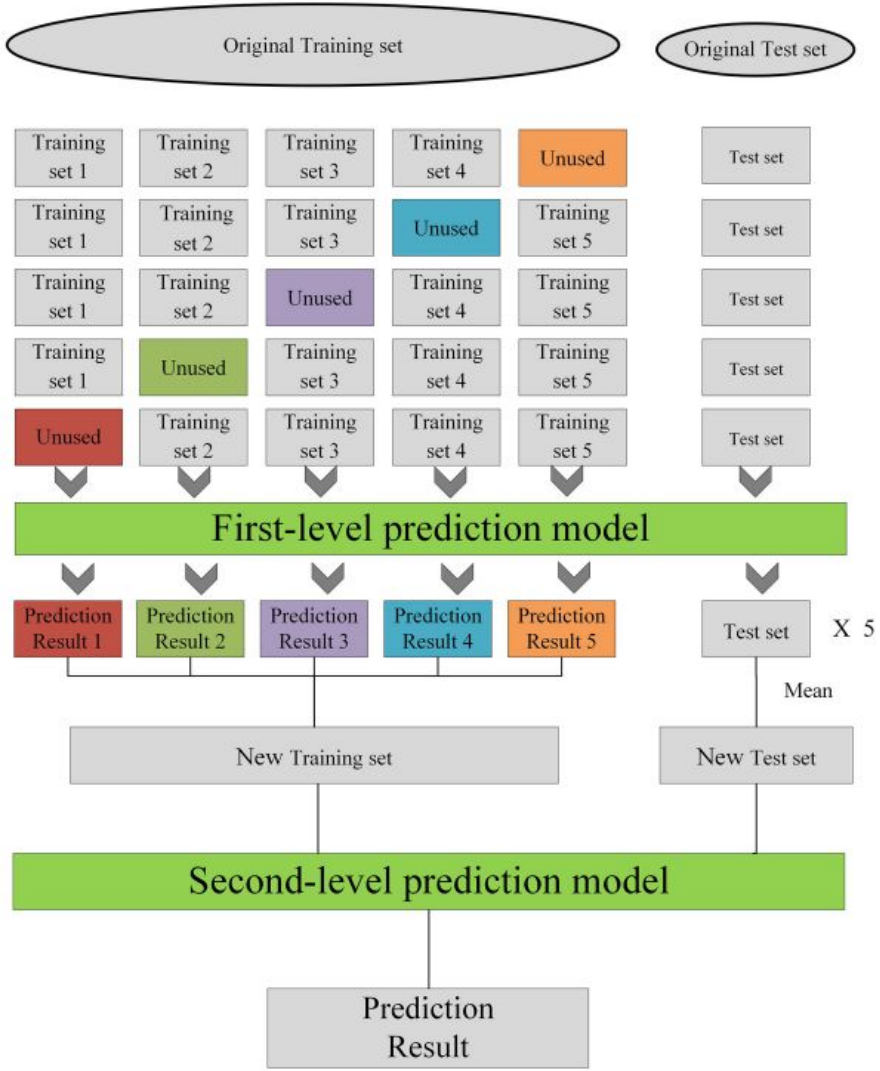
To develop an advance forecasting model that adeptly incorporates solar irradiance data, leveraging its predictive capabilities to elevate forecast performance and reliability.

PROPOSED MECHANISM



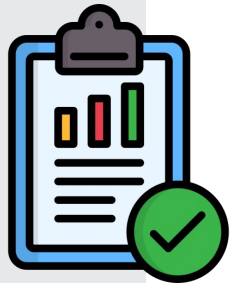
MODELING


LSTM
CNN
RNN
MLP
Hybrid modeling mechanism
Hybrid model
Forecasting


Original Training set
Original Test set
Training set 1
Training set 2
Training set 3
Training set 4
Unused
Test set
Training set 5
First-level prediction model
Prediction Result 1
Prediction Result 2
Prediction Result 3
Prediction Result 4
Prediction Result 5
X 5
Mean
New Training set
New Test set
Second-level prediction model
Prediction Result

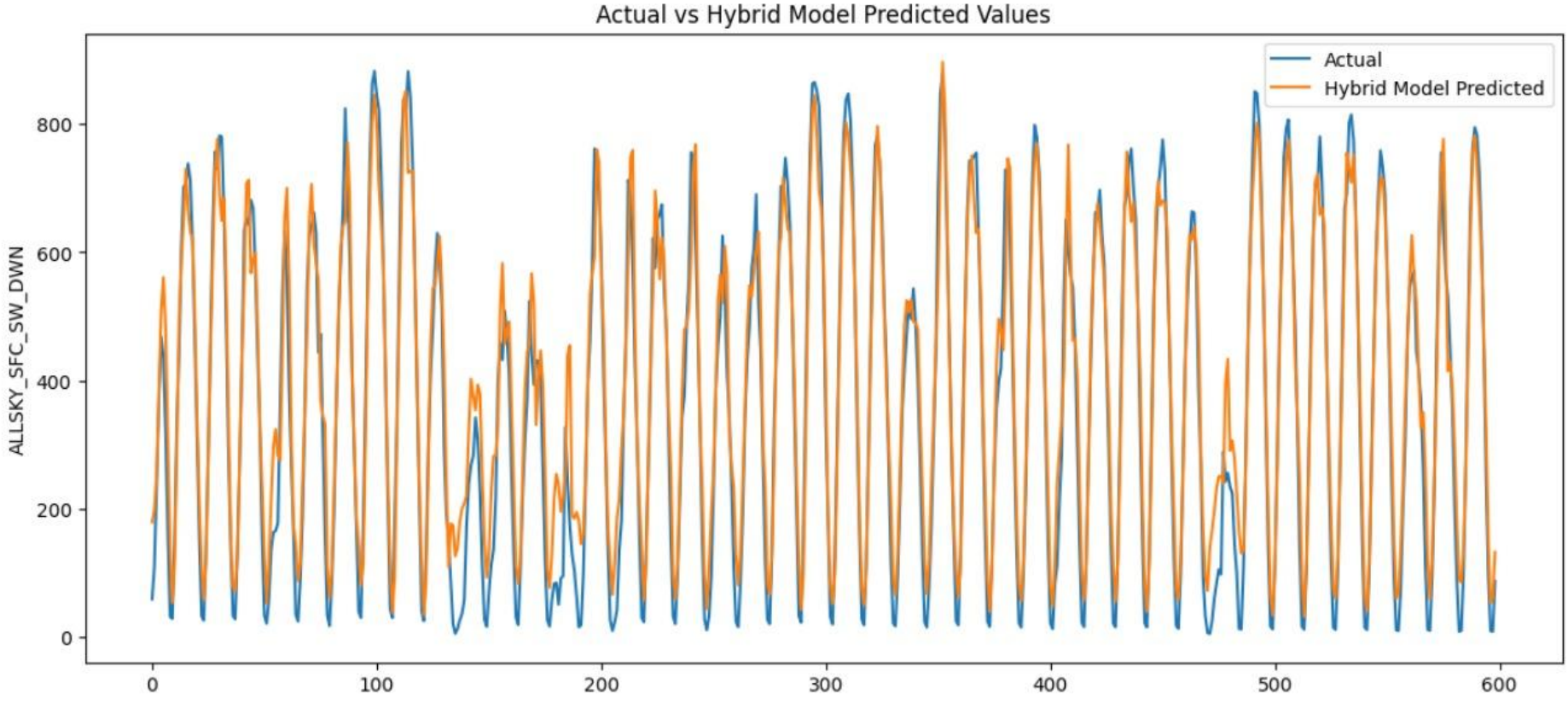
RESULT

The outcome of the hybrid system based on ensemble learning for time series forecasting demonstrates superior performance compared to existing methods, showcasing improved performance in predicting future solar irradiance data.



Data Type	Models	R2 Score	MAPE
Train	LSTM	0.9600892949993479	0.33159240982770205
Test	LSTM	0.9600848089381362	0.347913054554996
Train	CNN	0.9496714284525264	0.46701748866140963
Test	CNN	0.9479989890749951	0.4753076454170134
Train	RNN	0.9543611095803042	0.4111506467977487

Data Type	Models	R2 Score	MAPE
Test	RNN	0.9537133233476993	0.4234880236778825
Train	MLP	0.9552141180408437	0.47777138823677445
Test	MLP	0.9544750595867789	0.48485358200266565
Train	Hybrid	0.9600848089381362	0.36274303605437797
Test	Hybrid	0.9587312831527175	0.365449933268422


Actual vs Hybrid Model Predicted Values
Actual
Hybrid Model Predicted
ALLSKY_SFC_SW_DWN
0
200
400
600
800
0
100
200
300
400
500
600

References

[1]. [Júnior, Domingos S. de O. Santos, et al. "A hybrid system based on ensemble learning to model residuals for time series forecasting." Information Sciences 649 (2023): 119614]

[2]. [Hajirahimi, Zahra, and Mehdi Khashei. "Hybrid structures in time series modeling and forecasting: A review." Engineering Applications of Artificial Intelligence 86 (2019): 83-106]

[3]. [Jalali, Seyed Mohammad Jafar, et al. "Solar irradiance forecasting using a novel hybrid deep ensemble reinforcement learning algorithm." Sustainable Energy, Grids and Networks 32 (2022): 100903]

[4]. [Papachristopoulou, Kyriakoula, et al. "Effects of clouds and aerosols on downwelling surface solar irradiance nowcasting and short-term forecasting." Atmospheric Measurement Techniques 17.7 (2024): 1851-1877]

[5]. [Wang, Mingjie, et al. "Studying the influence of aerosol types on solar radiation prediction." E3S Web of Conferences. Vol. 252. EDP Sciences, 2021]

Thank you