Deep-Learning Spatio-Temporal Prediction Framework for PM under Dynamic Monitoring

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Introduction

- This study shows spatio-temporal prediction for fine particulate matter pollutants performed using deep-learning techniques.
- Usage of hybrid CNN-LSTM model is proposed to improve the performance of prediction models.
- Consistent predictions can assist in providing information to urban residents.

Study area

- South Delhi area of Delhi, India, with four static monitors.
- Area is divided into 15 hexagonal grids of 5 km.

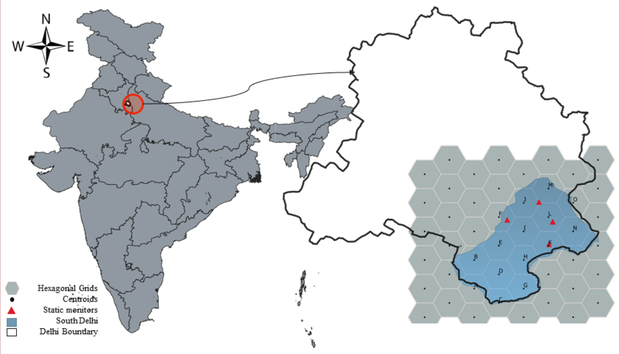


Fig 1: Study area in Delhi, India

Data

- Secondary data of hourly PM concentration and meteorological data is collected from Central Pollution Control Board, India.

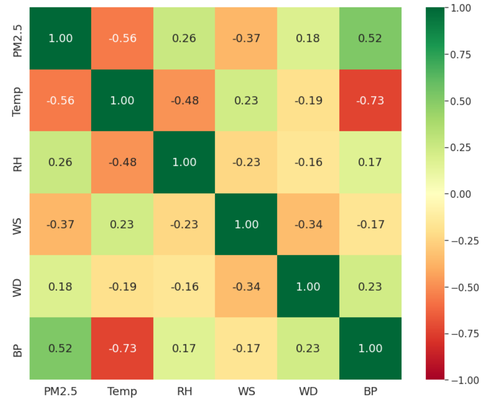
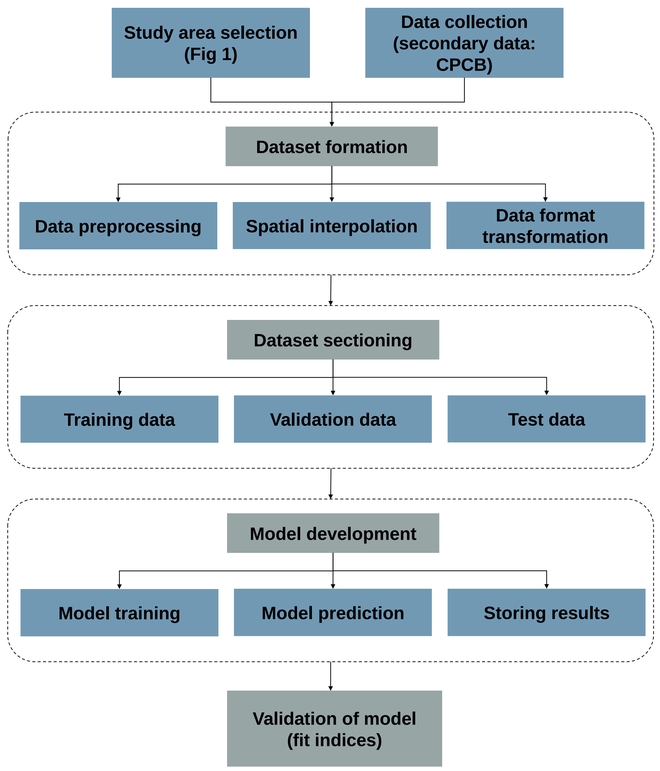


Fig 2: Correlation between $PM_{2.5}$ and meteorological parameters

Methodology

- **Steps for development of prediction models using secondary data:**



Model architecture

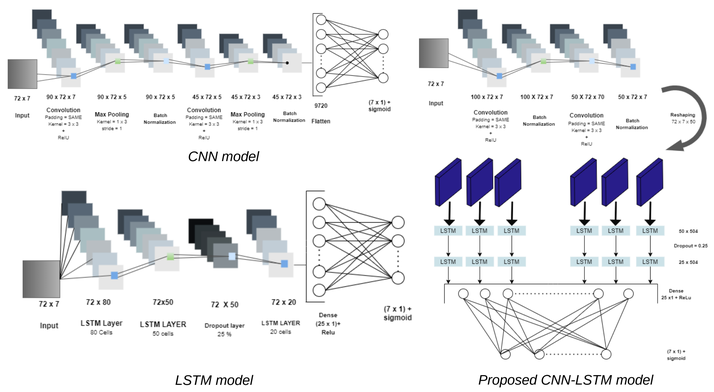


Fig 3: Architecture for CNN, LSTM, and proposed CNN-LSTM model

Results

- **MAE and RMSE values are lower for majority of grids compared to CNN and LSTM models.**

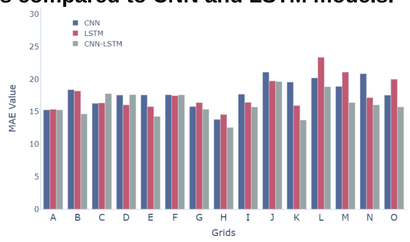


Fig 4: Mean absolute error in each model for all grids

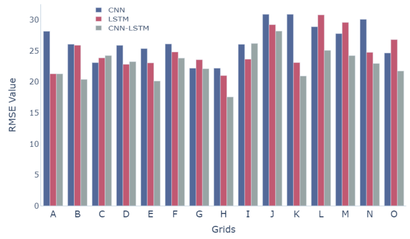


Fig 5: Root mean square error in each model for all grids

- Order of performance and accuracy of results:

CNN-LSTM > LSTM > CNN

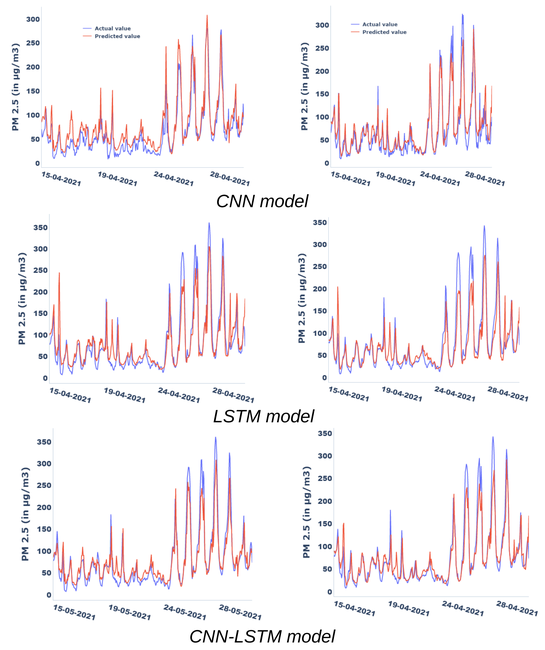


Fig 6: Results of CNN (top), LSTM (middle), and CNN-LSTM (bottom) for cell H (left) and N (right), for time period from May 01, 2021 to June 30, 2021.

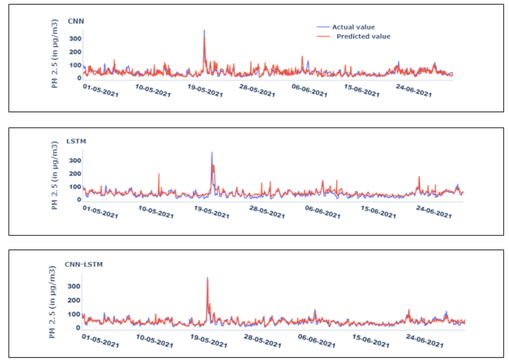
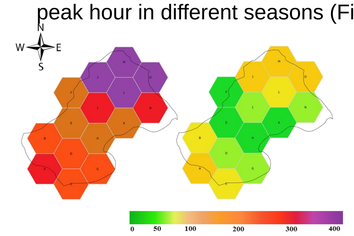
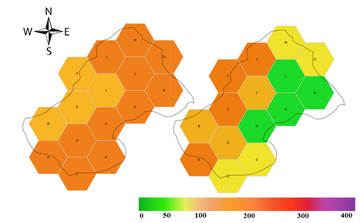


Fig 7: Results of CNN (top), LSTM (middle), and CNN-LSTM (bottom) for cell K, for time period from May 01, 2021 to June 30, 2021.

- Spatial variation is observed between peak hour and off peak hour in different seasons (Fig 8).



a) Feb. 01, 2021



b) June 28, 2021

Fig 8: Spatial prediction of $PM_{2.5}$ from CNN-LSTM for two days in peak hour (left) and off peak hour scenario (right).

Conclusions

- It is observed that proposed architecture of CNN-LSTM outperforms conventional CNN and LSTM approach.
- The prediction models considering dynamic monitoring data can assist travelers in receiving information about air pollution in real-time.
- Based on previous 72 hours data, next hour PM concentration is predicted.
- The model is flexible, and dynamic monitoring network can be accommodated in proposed framework.

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Link for full paper: http://faculty.iitr.ac.in/~amitfce/pdfs/MittalEtc2021PMPrediction.pdf