Climate Change Research @ GOKUL

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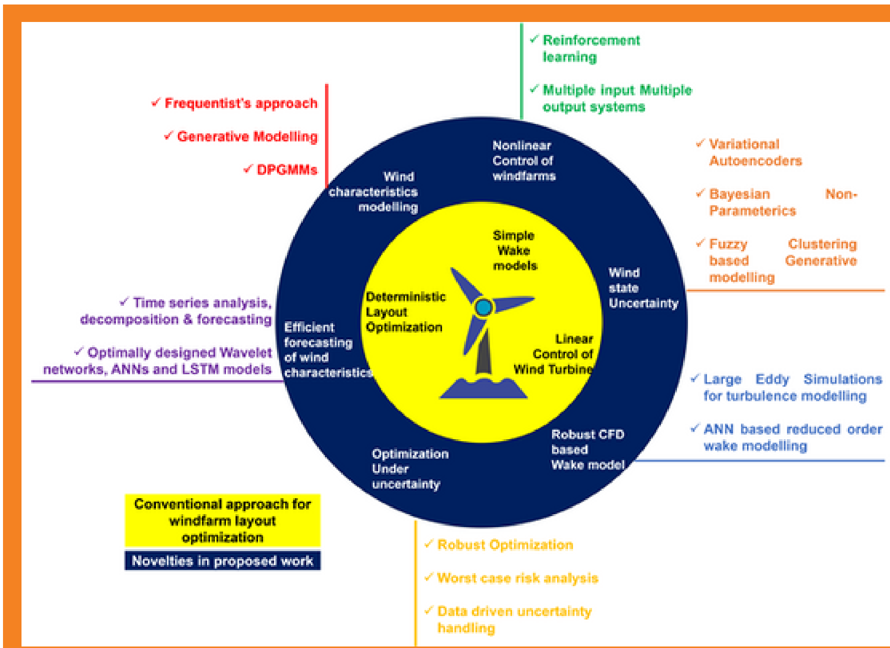
Climate change is increasingly gaining a central stage in the discussions pertaining to public health and national policy-making. To facilitate informed decision-making for the policymakers, it is necessary to provide predictive models which accurately represent the amount of Green House Gases (GHG), and Particulate Matters (PM) like PM10, PM2.5, CO, CO2, SO, SO2, CH4, pH of rainfall etc. in the environment The availability of vast amounts of data from sensors is driving the use of AI/ML based techniques for understanding climate change phenomenon. Researchers at Global Optimization and Knowledge Unearthing Lab (GOKUL) have designed optimal Recurrent Neural Networks (RNNs) and Long Short-Term Memory (LSTM) networks to capture the dynamic trends of ~15 environmental parameters from the data that cause long-term health hazards. Complicated cross-correlations among various GHGs, PMs and pH of rain were established by performing Global Sensitivity Analysis (GSA), which helped in building the most effective functional mapping among influential features and the output variables through multi-variate modelling (Ravi Kiran, I., Soumitri M. S., Mitra, K., Deep Learning Based Dynamic Behaviour Modelling and Prediction of Particulate Matter in Air, Chemical Engineering Journal, 2021, 426, 131221).

As the fossils fuels account for ~81% of the total energy consumption resulting in a 24% increase in CO2 emissions (Global Energy Yearbook 2021), climate change, on the other hand, heavily impacts global cities, the downsides of which can be minimized by adopting renewables like wind energy as alternative energy sources. Despite its green advantages, the uncertain and nonlinear nature of wind pose challenges for the wind farm owners to design and control wind farms effectively. Conventionally, the wind is modeled by constructing a Probability Mass Function (PMF) using time-series data of wind speed and direction, which in turn is used in applications such as wind-farm layout optimization (or micro-siting) and control. Though this method is adopted by the industry, the ability to capture long-term variability in wind is sacrificed, making the results unrealistic.



Novel works being performed at GOKUL

Further, lack of consideration of uncertain nature of wind during the design stage results in farms reporting non-operational during a large part of their life time. This necessitates the requirement of novel methods capable of forecasting uncertain wind nature accurately by considering the long-term variability in the data and LSTMs are proposed to handle such variations in wind data. The heuristics involved in setting the hyper-parameters in LSTMs, however, are extremely tedious and generally set by trial and error. An evolutionary optimization (e.g., genetic algorithms) based holistic methodology is, therefore, developed which can forecast the nonlinear nature of wind accurately and automatically set such hyper-parameters while performing a trade-off optimization between objectives like minimization of error and overfitting. With such an accurate forecasting tool in place, a designer can consider several wind scenarios while designing a wind farm making the design robust to wind state variations (Mittal, P., Mitra, K., In Search of Flexible and Robust Wind Farm Layouts Considering Wind State Uncertainty, Journal of Cleaner Production, 2020, 119195).

Loss of Crop, unless predicted and corrected ahead in time, can create a havoc in society's exchequer every year. To address this issue, models which can identify the irregular or abnormal growth of the crop would be of great help. The satellite imagery data of the crops throughout the entire year can be used to build such models. GOKUL's research is currently focusing on designing a predictive framework, which can capture the growth pattern of different crops from these satellite images. The model includes a combination of supervised and unsupervised learning methods to extract the spatial and temporal dynamics from the images. This model thus learns the growth pattern of the crops at every time step and identifies any abnormal growth indication at any time throughout their growth period. The causes of these abnormalities (such as drought conditions, weather changes, soil contamination etc.) can be found out and necessary measures to address these causes can be taken at early stages leading to prevention of crop loss and enhancement of yield.

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