Physics-Informed Neural Network (PINN) for Cyclone Intensity Forecasting in the Chattogram–Cox's Bazar Region, Bangladesh

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The coastal belt of Chattogram and Cox's Bazar in Bangladesh is highly susceptible to tropical cyclones, which pose serious threats to lives, infrastructure, and socioeconomic stability. Accurate and timely forecasting of cyclone intensity in this region is crucial for effective disaster preparedness and mitigation. Traditional numerical weather prediction models and data-driven machine learning approaches, while useful, often struggle to fully capture the complex physical dynamics underlying cyclone behavior, especially in data-scarce conditions. This study presents a novel application of Physics-Informed Neural Networks (PINNs) to improve cyclone intensity forecasting in the Chattogram–Cox's Bazar area. Additionally, land topography data from SRTM DEM will be used to model potential inland flooding, while optional river and shoreline datasets (Hydro SHEDS and BWDB) will improve boundary conditions. Historical storm events, such as Cyclone Amphan (2020), Cyclone Sidr (2007), and Cyclone Mocha (2023), will serve as key case studies for training and validating the model. The proposed PINN framework integrates governing physical laws—such as the Navier-Stokes equations describing fluid flow—directly into the training process of the neural network. This physics-guided approach enables the model to leverage both observational data and physical constraints, enhancing prediction accuracy and generalizability. The study utilizes a combination of ERA5 reanalysis datasets, satellite-derived measurements, and historical cyclone track records relevant to the Bay of Bengal region. Preliminary results demonstrate that the PINN-based model reduces forecast errors compared to conventional machine learning models, particularly under conditions of limited or noisy data. This research contributes to advancing AI-enabled meteorological forecasting and highlights the potential of PINNs as a powerful tool for disaster risk reduction.

Keywords: Physics-Informed Neural Networks (PINNs), Cyclone Intensity Forecasting, Chattogram–Cox's Bazar, Tropical Cyclone Prediction, ERA5 Reanalysis Data.