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Multi-station Multivariate Multi-step Convection Nowcasting with Deep Neural Networks

Sandy Chkeir, Aikaterini Anesiadou, and Riccardo Biondi
University of Padova, Geoscience Department, Padova, Italy (sandy.chkeir@unipd.it)

Extreme weather nowcasting has always been a challenging task in meteorology. Many research studies have been conducted to accurately forecast extreme weather events, related to rain rates and/or wind speed thresholds, in spatio-temporal scales. Over decades, this field gained attention in the artificial intelligence community which is aiming towards creating more accurate models using the latest algorithms and methods.

In this work, within the H2020 SESAR ALARM project, we aim to nowcast rain and wind speed as target features using different input configurations of the available sources such as weather stations, lightning detectors, radar, GNSS receivers, radiosonde and radio occultations data. This nowcasting task has been firstly conducted at 14 local stations around Milano Malpensa Airport as a short-term temporal multi-step forecasting. At a second step, all stations will be combined, meaning that the forecasting becomes a spatio-temporal problem. Concretely, we want to investigate the predicted rain and wind speed values using the different inputs for two case scenarios: for each station, and joining all stations together.

The chaotic nature of the atmosphere, e.g. non-stationarity of the driving series of each weather feature, makes the predictions unreliable and inaccurate and thus dealing with these data is a very delicate task. For this reason, we have devoted some work to cleaning, feature engineering and preparing the raw data before feeding them into the model architectures. We have managed to preprocess large amounts of data for local stations around the airport, and studied the feasibility of nowcasting rain and wind speed targets using different data sources altogether. The temporal multivariate driving series have high dimensionality and we've made multi-step predictions for the defined target functions.

We study and test different machine learning architectures starting from simple multi-layer perceptrons to convolutional models, and Recurrent Neural Networks (RNN) for temporal and spatio-temporal nowcasting. The Long Short-Term Memory (LSTM) encoder decoder architecture outperforms other models achieving more accurate predictions for each station separately. Furthermore, to predict the targets in a spatio-temporal scale, we will deploy a 2-layer spatio-temporal stacked LSTM model consisting of independent LSTM models per location in the first LSTM layer, and another LSTM layer to finally predict targets for multi-steps ahead. And the results obtained with different algorithm architectures applied to a dense network of sensors are to be reported.