

THESIS TOPICS (24/01/2023)

Here is a list of topics related to our current research that may be studied in your final thesis. Please, contact me if you are interested in pursuing one of these works.

Exploring domain adaptation in environmental modelling. A classical problem in environmental modelling is the lack of sufficient data to completely define a data-driven model, particularly when a neural network represents this. It is thus interesting to explore the possibility of using the model determined in a different location and/or a different period. This problem is known as “domain adaptation”. It is interesting to investigate in which cases and for which variables such adaptation is possible.

The role of spatial information. The value of many environmental variables, especially in air pollution, largely depends on the local emissions, which are determined by the population and activities in the area, and by local meteorological conditions, which normally vary in a limited range. The geographical coordinates of the specific location can simply substitute such information. The study aims at exploring the effectiveness of such substitution as well as the most convenient way of exploiting geographical information.

Comparing NN architectures for flood forecasting. Many different neural network architectures have been recently proposed to forecast river flows. Among them, LSTM (Long Short-Time Memory) and CNN (Convolutional Neural Networks) seem the most promising. The study aims to test these different architectures in the actual case of the Seveso river in Northern Italy, which is known to have severe and fast floods critical for the city of Milan.

Similarity of meteorological conditions. The idea is to analyse the meteorological data provided by several measurement stations spread over the territory of a region to cluster them in a number of specific meteorological conditions. Data refer to different spatial positions and time instants. This kind of aggregation would allow the analysis of air pollution data separating them, as much as possible, from the effects of the meteorological conditions. Data for the Lombardy region can be easily downloaded from www.arpalombardia.it and examined with Excel or Matlab.

Spatial distribution of PM concentration. Modern sensors allow measuring the PM concentration distribution in urban environments with unprecedented detail (see, for instance, <https://wiseair.vision/>). They also highlight the differences between different local conditions like, for instance, street sides and open spaces. To develop an accurate concentration map, it is thus necessary to join air quality measurements and local geographical information with a specific type of interpolation. This may also consider that measures may be available at different elevations above the street level.

Centralized versus decentralized control of a multi-reservoir system. We have studied the synthesis of reservoir operating rules for the downstream portion of the Nile river basin and compared the effect of different information structures, e.g., each release is decided only on the basis of the corresponding reservoir storage or of all the reservoirs in the system. The rules are represented by neural networks. We would like to test the differences between this case and centralized control, in which the neural operating rule determines all the releases from all the reservoirs at the same time. Matlab is necessary.

Forecasting rainfall cells using GPS signals. The idea is to develop a forecasting model (possibly a deep neural network) to determine the location and intensity of rainfall cells a few hours in advance. A relevant piece of information for this purpose may be the concentration of water vapor in the atmosphere, which can be assessed by measuring the delays of the GPS signal. The application will be in Lombardy and Kenya. Matlab or Python is required.