Air quality forecasts in Milan: the AIR Sentinel project

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Outline

- Overview of the aims of the project
- The current stage of the project
- The current modelling framework
- Ongoing research efforts
Introduction

- Milan experienced over the last years strong reductions of pollutants such as SO2, NOx, CO, TSP.

- However, a major concern for air quality is constituted by PM10. About 100 exceedings of the 50 µg/ m³ limit value are observed yearly (State of the Environment Report, AMA 2003).

- An air quality forecast system may be useful:
  - to the Municipal Authorities, which can plan in advance the management of heavy pollution episodes.
  - to the citizens, which can avoid exposure to unhealthy air, or prepare for incoming traffic blockages.
The Air Sentinel project

- It will deliver air quality forecasts up to 48 hours in advance for many pollutants in Milan

- The project involves expertises from different areas such as environmental modelling, time series forecasting, micrometeorology

- A wide set of data is collected from different sources such as:
  - Air quality monitoring network
  - Radiosondes (Linate airport)
  - Meteorological forecasts
  - Sodar
The Sodar

- A Sodar has been installed in the very center of the city in order to track the vertical profiles of wind components.

- Although sodar data are currently not included in the predictor because of the time series shortness, it will constitute a precious source of data in the near future.
The data acquisition system

- Data sources are polled at given intervals either via the Internet or dedicated telephone lines

A server running Sun Solaris and Oracle hosts the database of the project.
The current modelling framework

- The developed models are aimed at predict PM10 concentrations on the two different Milan measuring stations.
- The models run at 9 a.m. making available the prediction for the current day.
- They return both a numerical prediction and an associated distribution probability in order to manage the prediction uncertainty.
PM10 time series: yearly analysis

- No trends can be recognized on the yearly average: since the beginning of the monitoring (1998) PM10 is substantially stable.
- The time series is periodic during the year because of changes in both meteorology and anthropic emissions.
PM10 time series: weekly analysis

- PM10 time series underlies also typical weekly patterns, due to the cycles in anthropic activities.
- PM10 daily average are in fact about 20% lower on Sunday than in the remaining days of the week.
Input variables suitable for prediction

- **PAST PM10** (time series auto-correlation)

- **EMISSIONS PROXIES:**
  - NOx (see traffic volumes)
  - SO2 (see building heatings)

- **METEOROLOGICAL CONDITIONS:**
  - Wind
  - Temperature
  - Atmospheric pressure
  - Etc.
Input selection methodology

- The input variables of the model are chosen by means an exhaustive correlation analysis.

- Inputs variables are grouped to daily values from the hourly ones by using those time windows which maximizes the input/output correlation.
Predictor identification

- The model is a simple linear regressors

\[
PM10(t) = aPM10(t-1) + bSO2(t-1) + c\text{ Pressure}(t-1) + d\text{ Temperature}(t-1)
\]

- \(a, b, c, d\) are parameters to be estimated during the training
- \(t\) is the current day and \((t-1)\) refers to yesterday
- each input is averaged on a specific optimal time window
- Model performances are then assessed by means of k-fold cross validation
- The correlation level for instance varies between 0.8 and 0.9 depending on the period of the year
Model Validation (2002 sample)

- Milano –Verziere simulation: January 2002

![Graph]

\[ R \text{ (linear correlation): 0.863} \]
Model validation (2003 sample)

- Milano–Juvara simulation: January 2003

![Graph showing PM10 Concentration vs Prediction Days]

Graph: Milano - Juvara Station, January 2003: Measurements VS. Predictions

- R (linear correlation): 0.8615

- PM10 Concentration [mg/m³]:
  - Measurements
  - 50 mg/m³ threshold
  - Model Predictions

Prediction Days (January 2003)
Ongoing research efforts

- The predictors are currently being improved by:

  - Defining micro-meteorological indicators able to capture the main features of the dispersion phenomena, in order to increase of one day the prediction horizon.

  - Training neural networks architectures instead of linear predictors
Conclusions

- At the current stage, the Air Sentinel project provides:
  - a wide repository of meteorological and air quality data for Milan
  - an automated networking system which acquires the real time data
  - a modelling framework able to satisfactory compute PM10 predictions for the current day, with a correlation level between 0.8 and 0.9 depending on the period of the year
- Research efforts are currently undertaken to further improve the prediction accuracy and to extend the forecast horizon.