
UNIVERSITÀ DEGLI STUDI DI SALERNO

**Department of Industrial Engineering**

Ph.D. Course in Industrial Engineering
(XV Cycle-New Series, XXIX Cycle)

# ABSTRACT

**PhD Thesis on:**

# Advanced physical and mathematical methods for the implementation of forecasting models suitable for acoustics and engineering field

**- Applied Physics -**

**Supervisor**
*Prof. Joseph Quartieri*

**Ph.D. student**
*Ing. Carmine Tepedino*

**Ph.D. Course Coordinator**
*Prof. Ing. Ernesto Reverchon*

**ACADEMIC YEAR 2016-2017**

In several engineering fields, it is of great interest the development of models able to produce forecasts of univariate time series; these models are based on the statistical analysis of the sequence of observed data equidistant in time. The techniques implemented in this thesis can be classified in two distinct types, different but complementary: the first method is based on the analysis of the observed time series composed by measurements under study, the other method is based on Poisson's distributions for events of exceedance of a defined threshold.

The validity of such models has been tested on a noise dataset collected in the city of Messina. The measurements are based on day and night noise levels, detected at a monitoring station set up by the local government and made public on a special web platform. From this set of data, several intervals have been extracted for the calibration of the models, in order to test the validity on real measurements (by means of comparison between the observed and predicted data) and to study the sensitivity with respect to variation of the parameters (reference threshold, frequency of events, periodicity of the series, etc.).

The first adopted techniques, used to analyse the time series, are based on deterministic decomposition methods: the observed sequences are divided in trend and seasonal components. In this field, an enhancement of the preliminary forecasting model has been obtained: in particular, a set of electricity consumption data has been studied. This time series of absorbed electricity is due to the public transport system of the city of Sofia (Bulgaria): the main enhancement achieved is the improving of the extracted information from the series thanks to the introduction of an additional coefficient of seasonality.

Later, seasonal stochastic models were adopted, of the auto-regressive moving average (SARIMA) type. Therefore, the research focused on the implementation of predictive models of stochastic type: the seasonal ARIMA was applied to the prediction of wind speed in a site where a wind farm for the production of electricity is installed. Subsequently, acoustical models have been applied for the prediction of noise produced by the turbines under certain wind speed conditions.

A detailed investigation was performed with the aim to improve the integration of linear and non-linear forecasting techniques using artificial neural networks. In particular, one of the more advanced predictive model based on time series analysis is a hybrid model that uses in cascade deterministic methods, based on the decomposition of the series into trend and seasonal components, followed by a modelling via artificial neural networks for a better prediction of the non-linear part of the series.

A predictive model, useful to study events of exceedance of noise thresholds, has also been implemented. This model is based on the assumption that the exceedance events are distributed according to a non-homogeneous Poisson distribution. This approach can be pursued both with frequentist techniques or using Bayesian estimation of the parameters of the "Probability Density Function" (PDF). In particular, it has been studied a sound levels dataset measured near the international airport of Nice (France). The adopted model introduces the single "change-point" methodology for the estimation of the distribution parameters. These parameters have been estimated through a Markov-Chain Monte-Carlo sampling based on Bayesian statistical assumptions.