ADVANCES IN THE TEMPORAL DISTORTION INDEX AND THEIR USE TO ANALYZE AND COMPARE WIND ENERGY FORECASTS MODELS.

Laura Frías, Fermín Mallor, Ivan Moya,

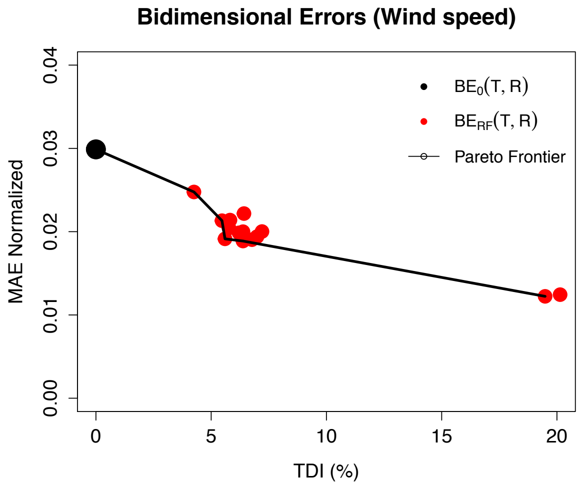
[1] Wind Energy Department, National Renewable Energy Centre (CENER). Address: c/ Ciudad de la Innovación 7, Sarriguren, 31621, Navarra (Spain).

1. Introduction

Wind has been the largest contributor to the growth of renewal energy during the early 21st century. However, the natural uncertainty that arises in assessing the wind resource implies the occurrence of wind power forecasting errors which perform a considerable role in the impacts and costs in the wind energy integration and its commercialization.
The main goal of this paper is to provide a deeper insight in the analysis of timing errors which leads to the proposal of a new methodology for its control and measure.
A new methodology, based on Dynamic Time Warping, is proposed to be considered in the estimation of accuracy as attribute of forecast quality. A new dissimilarity measure, the Temporal Distortion Index, among time series is introduced to complement the traditional verification measures found in the literature. Besides a set of new families of the basic functions of the Dinamic Time Warping has been defined. This functions are defined to be more efficient in the case of wind energy series. Furthermore we provide a bi-criteria perspective to the problem of comparing different forecasts.

2. Approach

Dynamic Time Warping (DTW) is a technique which works by warping the time axis iteratively until an optimal match between the two sequences is found. This technique which had been used extensively for speech recognition during the 70s, was introduced to the database community by Berndt and Clifford. It has been applied to the analysis and monitoring of batch processes, chromatography, gesture recognition, surveillance, medicine [33], in gene expression studies.
The warping of the time axis is made by using the concept of optimal path that make a relationship between points of the two series acomplising a set of conditionns of continuity, monotonicity and boundary. The optimal path is obtaining by dynamic programing and the basics rules of the conditions that can be present te path are collected by the Step paterns.
As first step, this work peresnt a new Index, the temporal distortion index (TDI), to compare thw predcited and the real series taking into account the temporal distortion presented between them. In a summary, this index measures the temporal distortion carried out in the predicted series to obtain the real one. This parameter sreves to described the temporal component of the error.
Once the warping is made and the TDI obtained, it is posible design a pair of erros by using the MAE of the transformed serie and the TDI.
So each transformation of the prediction and the measured produces a point of this bi-dimensional error that contains both information about erron in time dimensión and in magnitude.
Different time transformations will produce different points and the posibility of analize the behaviour of a model and compare different forecasts. To be able of identify the more quantity of temporal distortion we have defined new families of the basic función of the DTW the step patterns that allow us cmaprision of different forecasts by fit Pareto functions. The next figure is an example of the Pareto function. The different points correspond to the diffrent bi-dimensional errors obtained by the use of the family of step patterns. The x axis represent the TDI, that is the temporal “difference” between prediction and forecast that it is identified and the y axix correspond to the MAE obtained after the time alignment.
This Pareto Frontier better characterizes the error in the forecast than only one value or pair of values. Nevertheless, in order to simplify the assessment of forecast errors and for ease the comparison between different methods one or few representative points should be selected. These representative points could be identified through bounds on the allowed temporal error or analyzing the trade-off between both error components. One should choose a bidimensional error assessment with a temporal error so that increasing it doesn't give much better value for the static error. More precisely, in the plot of the Pareto Frontier the first error assessment will reduce much static error but at some point the marginal gain will drop, giving an angle in the graph. A representative bidimensional error assessment should be chosen at this zone, and hence the "elbow criterion".



Besides

3. Conclusions

A new index of temporal error, named Temporal Distortion Index, TDI, has been defined. It is used as first component of a two-dimensional error vector, BE, whose second component is a static error measurement, as the MAE. The information provided by this vector allows for a joint analysis of errors in time and scale. Broadly speaking, the algorithm performs transformations in the time axis of the predicted series in order that it closely resembles the real series. This process is based on Dynamic Time Warping techniques and uses recursion formulas which control the types of changes that can be made in the time axis. In addition, the availability of different formulas of recurrence leads to the use of Pareto Frontiers to assess the behavior of the prediction models. The goodness of the new methodology is shown by using both synthetic and real data that reflect the typical temporal effects in the prediction of wind energy. The methodology proposed here can be applied to compare different prediction models in wind energy The comparison can be done in terms of temporal distortion and in terms of scale distortion.

4. References

D. J. Berndt, J. Clifford, Using dynamic time warping to find patterns in time series., in: KDD workshop, Vol. 10, Seattle, WA, 1994, pp. 359–370.