Scientific Report

Short Term Scientific Mission (STSM)

COST Action TD1207

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1. Introduction

The objective of this STSM was to identify suitable methods for short term forecasting of natural gas flow in gas transmission networks for nodes with high percentage of zero flow hours.

The main goal of the analysis is computing accurate forecasts for zero gas flow in the next 24 hours to support other forecasting methods and furthermore, operational decisions.

The STSM resulted in the following:

• identification of nodes with high percentage of zero flows

• proposal of an suitable zero flow detection method

2. Short term forecast of gas flow time series for nodes with high percentage of zero flow hours

Idea

Among the forecasting methods being evaluated in previous period of research there are Functional Auto-Regression (FAR) , Support Vector Regression (SVR) and Artificial Neural Networks (ANN). These methods have been applied on both the daily total flow and the hourly flow of some of the major nodes and result in an average error rate around 5% of the actual flow, which is considered to be excessively high. A comparison between forecast errors and real gas flow showed a correspondence between high errors and sudden level shifts in the flow, especially occurace of zero flows. Outstanding level shifts suggest the presence of outliers due to data error, maintenance or other external factors. In particular, maintenance periods have zero gas flow and can cause high error rates in the forecast. Having in mind all the facts previously mentioned, it will be advisible to develop a methodology that can predict occurace and duration of zero flow.

Methodology

The selected methodology was the artificial neural network where the main issue was configuration of the network. Selected network was Nonlinear Autoregressive Neural Network with external input (NARX). The NARX can learn to predict one time series given past values of the same time series, the feedback input, and another time series, called the external or exogenous time series.

The defining equation for the NARX model is

$$y(t)=f(y(t-1),y(t-2),\ldots,y(t-n_y),u(t-1),u(t-2),\ldots,u(t-n_u))$$

where the next value of the dependent output signal $y(t)$ is regressed on previous values of the output signal and previous values of an independent (exogenous) input signal.

Furthermore, the parameters and the network configuration are also dependent on the result of the classification of the node's typology. In fact, different types of nodes require different neural network configurations and parameters. For instance, for the nodes that have been classified as municipal, the network should be configured in such way that higher weights are assigned to the input temperatures because the forecast will be highly dependent on them. The other problem is related to the identification of the optimal parameters of the selected neural network.

Data

The observed period 01.10.2013- 30.09.2014.

Fetures (inputs)

- Hourly flows from previous gas day (24 variables, scaled from 0 to 1)
- Hourly zero_detect from previous gas day(24 variables, scaled from 0 to 1)
- Dates
    - Month (12 variables, binary)
    - Day of the month (31 variables, binary)
    - Day of the week (12 variables, binary)
    - Weekend (1 variable, binary)
    - Holiday (1 variable, binary)

Outputs

- Hourly flows of next gas day (24 variables, scaled from 0 to 1)

Results

- Forcast model for zero flow detection
- Period of test - 90 days
- Accuracy calculated based on the number of recognized zero flows during the 1 gas day

The obitaned results showed that proposed metodology is very suitable for detection of zero flow hours. It can be combined with other forecasting methods to achive more accurate forecasting results.

NODE 1. Entry

This entry node has mean flow of 3.99*10^3 during the the observed period. In that period percentage of zero flow hours is 24.7%.

Achived mean accuracy of recognized zero flows during the gas day is 98%.

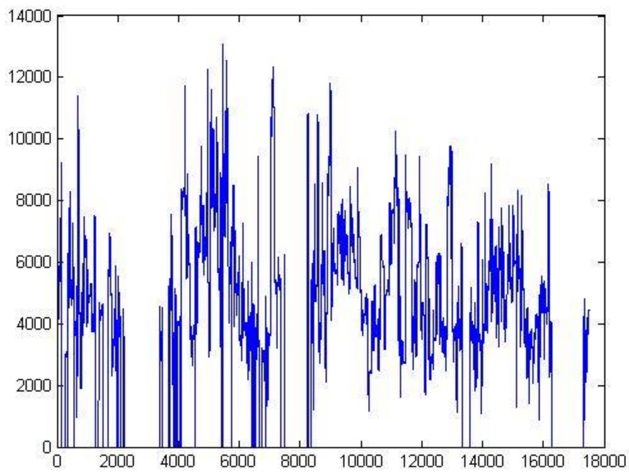

Figure 1. Gas flow for Node 1. Perc. of zero flow hours 24.7%

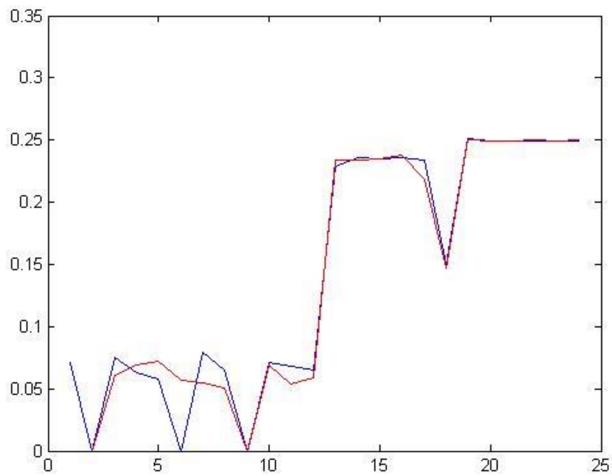

Figure 2. Forefcast of one day Gas flow for Node 1

NODE 2. Entry

This entry node has mean flow of 2.03*10^3 during the the observed period. In that period percentage of zero flow hours is 28.2%.

Achived mean accuracy of recognized zero flows during the gas day is 95%.

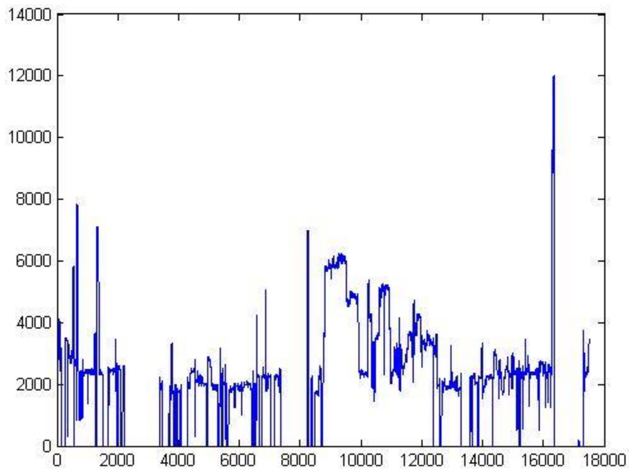

Figure 3. Gas flow for Node 2. Perc. of zero flow hours 28.2%

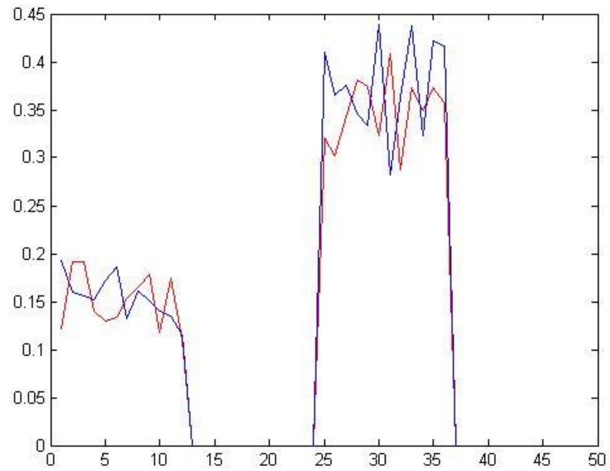

Figure 4. Forefcast of one day Gas flow for Node 2

NODE 3. Storage

This storage node has mean flow of -2.73*10^2 during the the observed period. In that period percentage of zero flow hours is 54.36%.

Achived mean accuracy of recognized zero flows during the gas day is 98%.

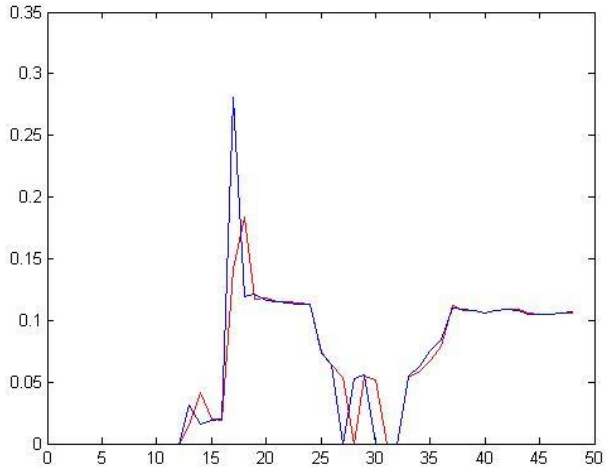

Figure 5. Forefcast of one day Gas flow for storage Node 3

The work initiated during this STSM is still ongoing. Current activities consist of improving the accuracy of the forecasting models combinig with proposed model for forcasting zero flow hours.