Nonlinear Autoregressive Neural Network Models for Short Term Forecasting

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Abstract

Catchment flow forecasting holds an utmost importance in a reservoir system as the operational decisions such as releasing water for hydroelectricity and agricultural requirements heavily depend on the availability of water in the up-most reservoir. Currently there is no strategically approached mechanism to forecast daily catchment flow in Sri Lanka. Therefore, accurate forecasting of the daily catchment flow is vital and holds a national importance, for both agricultural and hydroelectricity generation requirements of the country.

To address this national requirement, this research developed a novel methodology to forecast short term daily catchment flow. The daily catchment flow from 1995– 2015 was considered for this research where the modelling approaches were based on **Nonlinear Autoregressive Neural Network with Exogenous Inputs (NARX-ANN).** The forecasts made using varied dimensional NARX-ANN models, considering the exogenous variables precipitation, temperature and humidity were initially compared and was revealed that a considerably higher dimension of the model is needed to achieve further improvements. More importantly, there were limitation with regard to extending the dimensions, due to unavailability of required form of information on the exogenous variables.

As an alternative to the multidimensional approach, various segmentations and transformations of the response variable, itself, were coupled into the model building process. Through exploratory research it was identified that this catchment flow series is nonlinear, nonstationary and containing inherent groupings. A novel de-noised discrete transformation based algorithm named as **De-noised 1D Multilevel DWT Segmented NAR-ANN Algorithm** that reduces the adverse effects of non-stationary nature to the nonlinear model and a novel **Cluster Embedded NAR-ANN Algorithm** that incorporates cluster information to the nonlinear model were developed, and proved to generate promising results when applied to catchment flow series. The objective of daily catchment flow forecasting was finally achieved through a hybrid approach, based on combining the two algorithms mentioned above. The performance of the forecasts using this novel approach was 70% for an entire year. It was justified that for a series with less noise, this performance level can be further increased to higher levels.

Several other important contributions towards the area of forecasting were generated through the research. The development of a novel graphical plot named as **Visualized PER matrix plot,** that can be used for model selection, more effectively than the usual error analysis. Moreover, a modified error measure named as **Medcouple based Trimmed MSE** that reduces the effect of extreme observations to the model structure identification task was also developed. Another important algorithm named as **Grid Search based algorithm for NARX-ANN Model Structure Identification** was also developed that can be effectively used for model structure identification of NARX-ANN for any data driven problem.