Stochastic Operation for multi-purpose reservoir using neuro-fuzzy systems

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1. Introduction

A new approach for system optimization, named stochastic fuzzy neural network (SFNN), is proposed. It can be defined as a neuro-fuzzy system stochastically trained to yield a quasi optimal solution. The method intends to overcome some of the problems related to stochastic dynamic programming (SDP) models, such as the required backward calculation scheme. For validation of the proposed method, a real case of storage reservoir optimal operation is considered with inflow discharge as the stochastic variable.

2. Methodology

Figure 1 shows the flowchart of the overall calculation procedure for the SFNN optimization model where inflow values are considered as stochastic variables based on conditional probabilities. According to Figure 1, first the SFNN model is initiated with a set of parameters, which can be randomly created. Then the expected probabilities are calculated based on the given conditional probabilities tables. Having a set of parameters for the neuro-fuzzy system, it is possible to obtain the end-of-period storage level S_{t+1}, as S_t and I_{t-1} values are known. For each stochastic inflow value $I_{t,k}$, we can obtain a release value $R_{t,k}$ based on the reservoir mass balance equation.

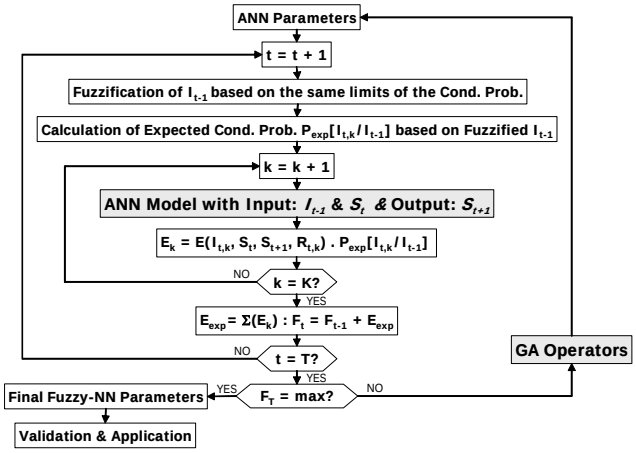

Figure 1. Flowchart for calculation of SFNN

This operation is carried out for the whole training period T. If the parameters of the neuro-fuzzy system are considered to be optimal, giving the maximum or quasi maximum value for the recursive function then the training process can stop.

To deal with the uncertainties related to discretization of inflows in finding the stochastic inflows, we propose the use of conditional probability of fuzzy events. Figure 2 shows how the intervals are divided in both cases, discrete and fuzzy representative interval.

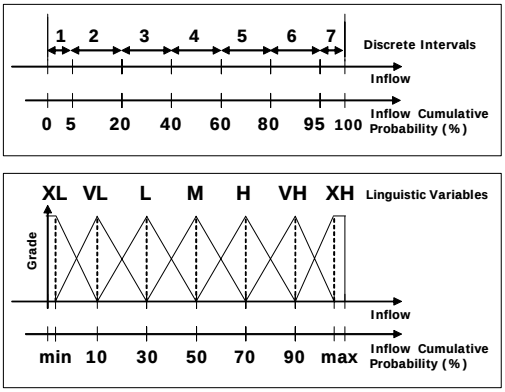

Figure 2. Discretization of discharge

The multiple purpose characteristic of the system is handled with fuzzy theory for easier comparison of different objectives.

3. Results

After comparing results with other dynamic programming (DP) approaches for the same optimization problem, the SFNN model showed improvements in the final optimization results, Figure 3.

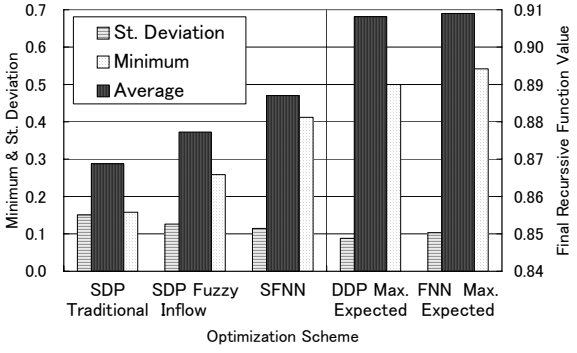

Figure 3. Results after five optmization schemes