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Hydrology and Earth System Sciences Discussions

Interactive comment on "Dissolved oxygen prediction using a possibility-theory based fuzzy neural network" *by* U. T. Khan and C. Valeo

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RC 1. "What is the novelty of this study? What do the authors expect international readers (who are not interested in the study region) to learn from reading this paper. "

There are three novel contributions presented in this study, and in addition to this an approach for hydrological prediction, uncertainty and risk analysis that can be extended to many other applications.

In more specific detail:

- a new method to construct fuzzy numbers from observed environmental and hydrological data is presented. Many fuzzy number based applications suffer from the fact that there is no widely accepted, consistent and objective method to construct fuzzy

numbers from observations. We have attempted to address this issue by introducing a new two-step procedure where we first estimate the underlying, unknown probability mass function using a bin-size optimisation procedure, and then use a probability-to-possibility transformation to convert this to fuzzy number membership function. A number of different examples are used to demonstrate the advantage and suitability of this method.

- An existing fuzzy neural network (FNN) method is improved in this paper by proposing the use of possibility theory-based intervals for training the neural network. This replaces a somewhat arbitrary training criteria with a more objective criterion. Specifically, the original FNN uses pre-selected confidence intervals to define the amount of data captured within each fuzzy interval (i.e. α-cut), for example 100% at μ= 0, 99% at μ = 0.25. We use a relationship proposed by Serrurier & Prade (2013) to define the amount of data captured within α-cut. In doing so, the full spectrum of possible values are included in these calculations. This is so that modellers and end-users who are interested in events not included in the original, pre-determined criteria can use an objective (i.e. based on possibility theory) method to design their FNN.

- The existing FNN is further refined by allowing the use of fuzzy inputs, along with the fuzzy weights, biases and outputs. Current methods only allowed crisp (i.e. non-fuzzy inputs) in the FNN. This has significant advantages over current methods, namely that the uncertainty in the input data is also accounted for in predicting DO concentration. In other words, the model output has accounted for the total uncertainty, in the weights and biases, as well as the inputs.

- The approach used in this study (data-driven modelling with fuzzy numbers when the underlying physical system is complex and poorly understood) can be extended to many other applications dealing with water quality in rivers, in flood risk predictions, or hydrological and environmental applications that suffer from similar issues, namely a complex system with many source of uncertainty. International readers will benefit from potentially applying this technique in their own watersheds to improve water quality prediction, and the associated risk analysis presented in this research. As mentioned above, this paper also presents a new method to construct fuzzy numbers that relies on minimal assumptions of the underlying data. This directly addresses a major need in the hydrological community. Lastly, readers will benefit from seeing the refinements to an existing FNN model; these refinements create a more transparent model structure (i.e. objective criteria for training) and include the use of fuzzy inputs (which is necessary in many hydrological cases where input uncertainty is present).

RC 2. "The authors didn' t define statistical parameters of input and output variables. The study will make more sense in interpretation of statistical parameters. "

We apologize for these omissions. The following will be included in the final revised manuscript (Section 2.1): "The mean annual water temperature ranged between 9.23 and 13.2 C, the annual mean flow rate was between 75 and 146 $m3s{-}1$, and the mean annual minimum daily DO was between 6.89 and 9.54 mgL-1, for the selected period."

RC 3. "How many datas are used in this study? The authors didn't define to use training datas and test datas this study."

We apologize for this omission as well. A total of 9 years of data was used for this research (from 2004 to 2012); the data were filtered to include data only from the ice-free period (April to October of each year). The total amount of daily data was 1639 days (a yearly breakdown is shown in Table 1 in the linked Supplement file and this will be included in the revised manuscript).

The amount of data used for training, validation and testing followed a 50–25–25% Split (randomly divided into each section). This is outlined in Section 2.3.3 of the manuscript.

RC 4. "The authors didn' t write key board. What are key board for the manuscript?"

The key words associated with this manuscript are listed below, and we will include these in the final version: dissolved oxygen; water quality; artificial neural networks; fuzzy numbers; risk analysis; uncertainty

RC 5. "Why is not continuous in Figüre 7, 8, and 9."

There are a number of missing data throughout the dataset due to numerous reasons, ranging from sampler error or no data recorded (as received from the data providers Environment Canada or the City of Calgary), or due to the data filters used for reasons highlighted in Section 2.1 (only ice-free period was considered). We ignored all missing data from our analysis. The data that we used was thus for days where error-free data existed for each of the three parameters (flowrate, temperature and DO). Thus, Figures 7, 8 and 9 show some gaps in the trends for days when no data was collected, and hence no subsequent prediction was made.

RC 6. "Fuzzy neural networks method is too large, it should be less the part."

RC 7. "Results and discussion is too large, The authors should reduce the part."

Thank you for these suggestions, we will endeavour to reduce the length of the final manuscript.

Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/12/C6685/2016/hessd-12-C6685-2016-supplement.pdf

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