Drink. Water Eng. Sci. Discuss.,
https://doi.org/10.5194/dwes-2017-18-RC2, 2017

Open Access
Drinking Water
Engineering and Science
Discussions

Interactive comment on "Real-Time Hydraulic Interval State Estimation for Water Transport Networks: a Case Study" *by* Stelios G. Vrachimis et al.

Anonymous Referee #2

Received and published: 9 July 2017

The present document proposes a novel methodology to estimate flow and pressure estates at pipes/nodes on water distribution networks while accounting for uncertainties contained in the monitoring dataset and model estimations. This is performed on an interval-bound approach. Variable state estimation intervals are iteratively refined as to comply with measurement and mechanistic model bounds in a non-linear scheme. The method is applied to a real system in which estimations and prediction bounds are produced. Additionally, the authors propose an application of their methodology to diagnose unknown system patterns (unaccounted infiltration). The work presents a novel tool, which facilitates the integration of measurement uncertainties in water distribution network state estimation. It is of the opinion of the reviewer that the manuscript

has a potential for publication. Provided that the authors generate a minor revision of the paper and respond successfully to the following comments.

1- In Line 34, Page 2, "Any uncertainty parameters in pipe j. . ." should be substituted by "Any uncertain parameters in pipe j. . ."

2- In equation (1), Page 3, description of matrices A12 and A21 is missing.

3- In Line 3, Page 4 it is stated; "the special structure of (1) can be exploited", however no reference to the nature of this exploit or structure characteristics was provided.

4- The criterion for convergence in the change of bounds found at Line 14, Page 4, describes that was chosen to be "smaller than a specified small number ε". However, no description of the actual chosen value or criteria for its definition is found. For reproducibility of results or use of the method, a further explanation of the selection of the convergence criteria would be adequate.

5- In Line 8, Page 3 the description of the measurement uncertainty informs that the actual measurement is considered as the median of the interval value. However, in Line 30 of the same page, it is mentioned that the measurement is taken as the mean value of the interval. Although median and mean will present the same value in a 2-point interval, a consistent description would be more adequate.

6- The method under discussion is supposed to consider measurement and modelling uncertainties. It is recognised that modelling uncertainties are understood only as parametric uncertainties (e.g. Line 9, Page 5 and Line 5, Page 1). However, this is an incomplete description of the uncertainties arising from a mechanistic model simulator. Additionally, at Line 10, Page 5, it is stated that parametric uncertainty was assumed to have a value of "$\pm$2% of the Hazen-Williams coefficient". This could be a legit expert-elicited model parametric uncertainty. However, this does not guarantee a correct model uncertainty description since it neglects the effect of structural uncertainty. This could be corrected in two ways; a) including an extra term in the equation (1) which represents a model structural error-generating process, or b) explicitly stating in the document that modelling uncertainties are approximated only by an expert-elicited parametric range, and discussing the adequacy of this range to represent the full model predictive uncertainty in a realistic manner.

7- At the introduction section, Line 12, Page 2, there is a reference for previous works on "A straightforward method for interval state estimation" by using Monte-Carlo simulations. This is accepted to converge to the true uncertainty bounds of the prediction variables under certain assumptions. A simple random sampling approach of the model-measurement space could provide a full description of the probability density function of the predicted variables, which can readily be transformed to a confidence interval of values and easily integrated into a probabilistic system assessment (facilitating risk assessment etc.). However, the methodology proposed by the authors, although mathematically feasible will only provide a range of parameter values, which do not have a probabilistic interpretation. It is missing a proper justification of the benefits of using the new interval-based approach rather than a Monte-Carlo based sampling. This could perhaps be illustrated with a gain in computational speed, however, no information was provided to justify those gains.

8- In Figure 4, Page 7 the authors show a comparison of the interval values of estimated outlet bounds by IHISE and of the outlet bounds calculated by a volume balance between level and inflow measurements. Flow estimations from the data assimilation scheme of the full system present an appreciable narrower interval than those from the tank volume balance. This difference can be due to three reasons:

a. The method works well and a data assimilation scheme produces enough information to narrow down significantly the predicted state variable.

b. The measurement uncertainties in the inflow monitoring stations and in the tank depth are relatively large and this is transferred to the estimated outflow.

c. The uncertainty in the measurement-derived outflow is reasonable. However, a

limited description of modelling uncertainties in the state estimation produces overconfident interval values, thus underestimating the uncertainties of the estimated outflow. This should be carefully addressed in the discussion of the presented results since it is critical for validating the credibility of the estimated estate intervals.

Interactive comment on Drink. Water Eng. Sci. Discuss., https://doi.org/10.5194/dwes-2017-18, 2017.