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Abstract:

Calculating the hydraulic state, through and across elements such as pipes, valves and control devices is an important task in managing a water distribution network. Although hydraulic models are widely used by water utilities and engineers, they are governed by a huge number of uncertain parameters like the diameter and roughness of pipes, consumer demands, leakages and the internal state of valves inside the distribution network. In the past, extensive work has been done on the calibration of these parameters but the results are still uncertain. The objective of the research done as part of the French-German project ResiWater is to analyse the effect of these parameter uncertainties in water distribution networks (WDN) on the distribution of the outputs given by the flows and the heads to give the users an evaluation on how dependable the given information is. Uncertainty analysis investigates the influence of model errors and parameter uncertainties on the results of numerical simulation models. Numerous methods have been developed to achieve this goal and some of the most influential ones are given by Monte Carlo methods, perturbation methods and adjoint methods. But most of these methods have limitations either in their convergence behaviour or the computational complexity. Here we concentrate on three basic approaches to the propagation of uncertainties. The base line will be given by sampling based Monte Carlo simulations that will be used as a basic validation method. For the second approach a closer look is given to the first and second order approximation for the moments of uncertainty, also known as the first order second moment (FOSM) and the second order second moment (SOSM) method. In the calculation of the moment equation the sensitivities play a vital role. The adjoint sensitivity analysis procedure is applied to hydraulic network equations and evaluated as an alternative to the direct calculation of the sensitivities. For comparison with these classic approaches, a spectral polynomial expansion is presented using generalized polynomial chaos (gPC). Theory suggests that gPC should give better results over a wider range in the parameter space than the moment approximation methods and at the same time converge considerably faster than the classic Monte Carlo approach. The performance of the different approaches to the quantification of uncertainty in system parameters will be evaluated and discussed on a small illustrative network.

Keywords*:* Uncertainty; Sensitivity; Polynomial Chaos; Monte Carlo; Water Distribution Network.

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