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A NOVEL CYBER-MONITORING BASED ASSET MANAGEMENT SCHEME FOR WATER DISTRIBUTION NETWORKS USING EVOLUTIONARY OPTIMIZATION AND NEURAL NETWORKS

Abstract:
There has been an urgent need to monitor, model, and tackle the extreme deterioration of water pipeline systems in the United States and other parts of the world to the quickest and best extent. Since manual pipeline inspection takes excessive costs, effort and time to consider most uncertainties, a novel and swift scheme is required to engage in asset management, which should ensure the accuracy as well as the quickness of the inspection at minimum effort and cost. This paper presents and validates a framework to predict the condition of critical pipeline assets using water distribution monitoring data. A benchmark water distribution network is first operationally optimized and its pipe roughness values and diameters are subsequently reduced in a random manner in order to create a representation of an old and deteriorated water distribution network. The operational data (i.e., pipe flow and pressure) for such deteriorated network as obtained through simulations using EPANET 2.0 software is leveraged to predict the pipe roughness and effective hydraulic diameter values. Evolutionary optimization algorithms are used in conjunction with neural networks to predict the roughness and diameter values. Neural networks offer faster convergence for simulating the hydraulic behavior of the water distribution networks.
The novelty of this study entails:

(i) consideration of multiple condition parameters for prediction (i.e., roughness and effective hydraulic diameters);
(ii) employing modified genetic algorithms in MATLAB interface where multiple attempts are made towards finding the optimal solution by running on several distinct sets of initial population in conjunction with fine-tuning of mutation and crossover parameters;
(iii) embedding neural networks within the optimization process to circumvent the extremely time-consuming hydraulic simulations to achieve faster model convergence.

Successful outcomes of this study offer a great potential in predicting condition of critical water infrastructure assets based on the operational monitoring data that is increasingly being collected in the recent times.