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Evaluating Image Classification Techniques for Improved Urban Wastewater System Model Calibration

Mohammed Chachan Younis (1), Edward Keedwell (1), and Dragan Savic (2)

(1) University of Exeter, College of Engineering, Computer Science, Exeter, United Kingdom (mcy201@exeter.ac.uk), (2) University of Exeter, College of Engineering, Centre for Water Systems, Exeter, United Kingdom

Abstract

There are urban hydrological models, such as InfoWorks, which have been widely used in urban wastewater planning and management. However, such system models require calibration with real world data to achieve reliable and accurate results. One potential method of automating this process is to classify real-world satellite data to categorize image pixels into different classes of permeability within a catchment. This paper employs a two-stage urban wastewater approach with a combination of image classification techniques and modeling using InfoWorks ICM. In image classification, pixel-based and object-based image classification techniques for extracting three land-use categories (roofs, roads, and vegetation area) over six real-world satellite images are evaluated, and the performance of eight supervised machine learning classifiers are compared. Experimental results show that the Bagged Tree classification algorithm provides maximum overall accuracy results when combined with 10,000 objects using the SLIC segmentation method. Also, results show that the classification process requires approximately 12 times less computational time to run all the test images for object-based approach compared to a pixel-based one, demonstrating the power of the implemented combined approach. Pareto optimality, as an efficient analytical method, was used to establish the dominant classifiers. The results show that the knee point (error and time both to be minimum) always belong to object-based classification methods. This indicates that image segmentation produces superior performance, in terms of accuracy and runtime, compared to pixel-based approach. In the second section of this study, the classification results are used as an aid, with real-world InfoWorks model to improve the calibration of the wastewater network, by classifying the land-cover into pervious and impervious segments. By classifying such areas with an urban catchment, and by using the Wallingford PR Equation across all tests of Area 1 (roads), 2 (roofs) and 3 (permeable area), we explore the potential for a partially automated network system calibration process of a wastewater network.

Keywords: wastewater system; InfoWorks ICM; pixel/object based classification; SLIC segmentation; machine learning algorithms