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USER MODELING AND PERSONILIZED OPTIMIZATION FOR STAKEHOLDER-DRIVEN WATERSHED DESIGN

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We have developed a web-based, interactive, watershed planning system called WRESTORE (Watershed Restoration Using Spatio-Temporal Optimization of Resources) (http://wrestore.iupui.edu) that allows stake-holder communities to participate in a democratic, collaborative form of optimization process for designing best management practices (BMPs) on their landscape, while also optimizing based on subjective, qualitative landowners' criteria beyond the usual socio-economic, physical, and ecological criteria. This system utilizes multiple advanced computational approaches including the SWAT (Soil and Water Assessment Tool) hydrologic model for watershed simulations, interactive genetic algorithms and reinforcement-based machine learning algorithms for search and optimization, and deep learning artificial neural networks for user modeling, within an encompassing human-computer interaction framework. A substantial user study of the WRESTORE system was conducted recently involving multiple real stakeholders varying from consultants, government officials, watershed alliance members, etc., with the objective of gaining insight about WRESTORE's usability and utility. In particular focus was the user modeling component that develops a computational model of a user's preferences. Based on real-time, the user provides ratings for a subset of possible designs (similar to the idea of user profiling commonly done for Information Filtering Systems). The user model constructed based on the real user's personalized feedbacks can then be used to influence the automated search for and optimization of BMP alternatives in WRESTORE. In this work, we describe the overall WRESTORE system architecture, the methods developed for user modeling for interactive optimization, and the experimental set-up as well as results with real user studies. These results clearly demonstrate that development of user models for such personalized, interactive optimization is both feasible and valuable for developing community-based computational water sustainability solutions.

Introduction

It has been suggested that strategically developed networks of conservation management practices will contribute to the restoration of impaired watersheds (Bekele and Nicklow [2];

Lemke and Richmond [4]; Kaini *et al.* [3]; Tyndall *et al.* [7]) However, due to the complexity of physical and social-economic environments it is challenging to find unique optimal solutions that satisfy all the constraints. The use of Genetic Algorithms had been found to be broadly applicable to solve problems that involved stochastic search in multi-objective optimization, such as watershed planning and management designs. Moreover, Interactive Genetic Algorithms (IGA) combined with modelling tools, will allow a more democratic and informed selection of plans and designs in a watershed.

In order to include the community subjective criteria (such as flood concern, erosion control, fertilizer loss and economic benefits) a web-based tool called WRESTORE (Watershed REstoration using Spatio-Temporal Optimization of Resources) had been developed. This project incorporated IGAs where 5 objectives must be optimized: 3 objectives are related to physical features (reduction of peak flows, sediment loads in stream and nitrates loads in stream); 1 objective is related to the net of economic benefits; and 1 objective addressed the preference of the user on a design plan.

Methodology

Figure 1 introduces WRESTORE's workflow. The combination of IGA and user's preferences helps to develop a decision space that suit the subjective criteria that is not quantifiable by the search algorithms. The main idea is to generate solutions that satisfy the user's preferences.

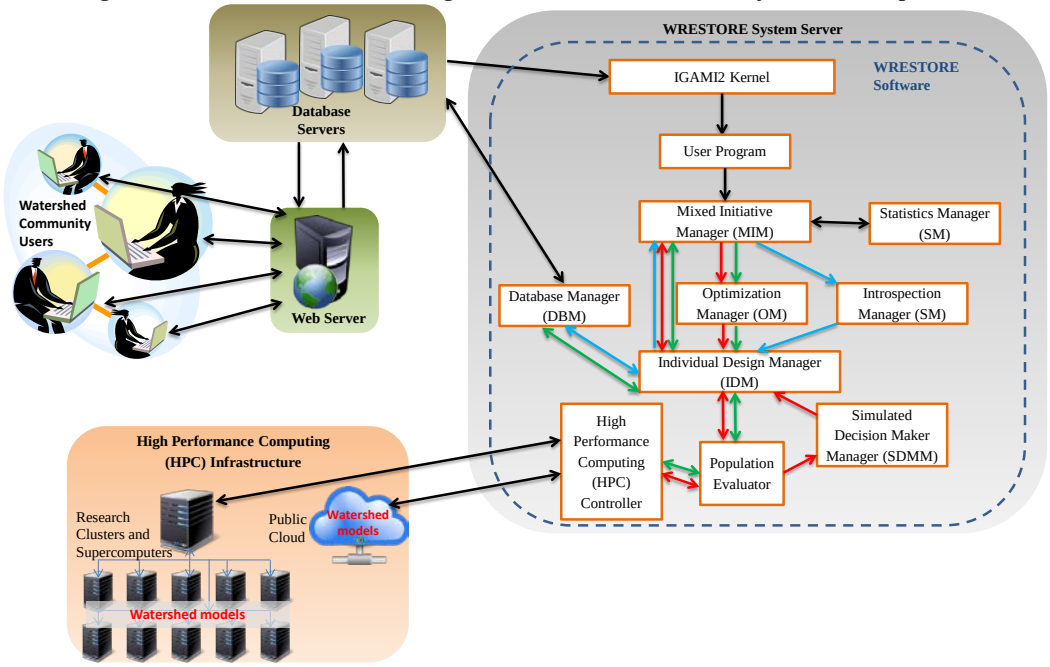

Figure 1 WRESTORE's workflow

However, due to human fatigue, users are not able to evaluate objectively all possible generated designs. Therefore, the Mixed Initiative Manager (Babbar-Sebens, M., and Minsker, B.S.,[1]) and user simulators will allow to expand the searching space and provide a classification of those designs that were no explicitly presented to the user.

In order to test the usability and capacity of this kind of tools, a semi-controlled experiment was performed where a set of designs for 2 combined conservation practices were optimized in a watershed. The experiment was performed by collaborators from the research community, government officials and watershed alliance members. They provided their classification at three different levels to measure their acceptability of the design. This provide the based to create a simulated user using techniques such as deep learning, ANFIS and Neural Networks that provide feedback of designs over an extended set of designs.

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