RECLAMATION
Managing Water in the West

U.S. Department of the Interior
Bureau of Reclamation

The Implementation of Flow-Temperature Artificial Neural Network Regression into Operations Planning Models

Optimizing the allocation of water in a complex system

Research Bulletin
Science and Technology Program

S&T Project 1859

Artificial Neural Networks (ANN) can replicate existing data models with increased computation time and minimal accuracy cost.

Mission Issue

The ANN technology addresses urgent issue of temperature management downstream of dams and can be transferred to other model operation tools.

Principal Investigator

James Shannon
Civil Engineer/Water Resources Modeler
Division of Planning
California-Great Basin
jshannon@usbr.gov

Research Office Contact

Kenneth Nowak
Water Availability Research Coordinator
Research and Development Office
knowak@usbr.gov

"The ANN is able to calculate downstream river temperature within ¼°F."

James Shannon
Civil Engineer/Water Resources Modeler
Bureau of Reclamation

Collaborators

Hao Xie
Bay Delta Office
California Department of Water Resources

More Information

https://www.usbr.gov/research/projects/detail.cfm?id=1859

Problem

Operation Planning Models (OPMs) optimize the allocation of water in a complex system based on flow constraining criteria when determining the long-term water supply reliability of reservoir and river systems. Since OPMs are often entirely flow-based, additional models calculate non-flow qualities in the flow regime; an example is a water quality model calculating water temperature through a system.

Traditionally, model communication between OPMs and water quality models move in one direction: from OPMs to water quality models. The one-way communication prevents water quality models from informing OPMs about aspects like temperature when allocating water. A "guess-and-check" approach is viable in some cases, where an engineer adjusts an OPM model running one cycle of the OPM and water quality models, but the effort quickly becomes time consuming when highly complex models take hours to execute.

Solution

This project researched the theory and practice of training and deploying Artificial Neural Networks (ANN) in order to construct an integrated surrogate model for existing uncoupled water quality models. The surrogate model would significantly cut down on model runtime with minimal cost to accuracy, allowing for water quality models to inform OPMs.

Focusing on the Central Valley (CVP) and State Water Projects (SWP) in California, an ANN captured the non-linear operational relationship of water temperature given flow along the Sacramento river. Integrating the ANN into the CVP/SWP OPM, CalSim3, allows for a systematic approach to optimize the flow regime under complex temperature operation requirements.

Application and Results

The research yielded an updated HEC-5Q Sacramento River Water Quality Model (SRWQM) given a CalSim3 flow regime. Newly created Python scripts now provide modelers the capability to automatically perturb Shasta Reservoir releases to the Sacramento River and calculate the resulting water temperatures. With this established automated data generation process, an ANN can quickly learn the non-linear operational relationship between Shasta inflow, storage, outflow, and downstream temperature to help inform CalSim3 if the flow regime needs changing under a temperature criterion.

Future Plans

Following this project, the Bureau of Reclamation California-Great Basin, Division of Planning would like to expand the ANN to include additional temperature regulation criteria. Sharing this framework with CVP, SWP, and partner agency managers would assist in the constant negotiations of improving the California water system for all interested stakeholders. The framework is also able to expand into other problem areas where there is a need to establish a flow and non-flow criteria relationship.