American Water Resources Association
2009 SUMMER SPECIALTY CONFERENCE
Adaptive Management of Water Resources II
June 29 – July 1, 2009
Snowbird, UT

Wednesday, July 1
1:30 PM – 3:00 PM
SESSION 37: Real-time Monitoring Strategies Supporting Adaptive Management in Utah

1. Adaptive Management in Real-time: Utah's Experience - Roger Hansen, Bureau of Reclamation, Provo, UT (co-author: Mac McKee)

Over the last 15 years, Federal, State, and local entities in Utah have created elaborate real-time monitoring and control systems which span the following river basins: Sevier (www.sevierriver.org), Duchesne, San Rafael, Bear, Spanish Fork, and Virgin rivers. These systems include over 400 monitoring sites and 100 control stations. Additionally, there are SCADA (supervisory control and data acquisition) systems on Reclamation's Central Utah and Weber Basin water projects, plus the USGS, Hydromet, SCAN, RAWS and MesoWest stations. The real-time and historic data from these various sources are fused together on river basin websites. The goal of these websites is provide a complete hydrologic picture of event happenings and trends in the river basins in near real-time (updated hourly). Utah State University staff and students have been developing and testing a variety of application and decision-support packages to provide rapid information turnaround on: (1) status of water rights; (2) suggested reservoir releases; (3) forecasting canal diversions; (4) ET modeling; etc. Some of these models have innovative learning components. Of particular interest is the use of UAVs (unmanned aerial vehicles) equipped with sensitive camera equipment to provide information on the status of farm crops. This information is then tested against real-time information and used to fine-tune reservoir releases. It is then anticipated that the aerial photographs will be made available to the farmers on the real-time websites. The information on the real-time websites provides timely feedback on important management issues like the effectiveness of salinity control programs or erosion control projects or reservoir management. The benefits of "adaptive management" have long been touted. But adaptive management depends upon carefully monitoring the effects of management actions on the environment, and then using that information to refine the understanding of the system and adjust decision-making and management plans accordingly (Western Water Policy Review Advisory Commission, 1998, pp 30-31). What better way to assess the effectiveness of management strategies than with real-time monitoring systems coupled with comprehensive decision-support software?

2. Use of Unmanned Autonomous Vehicles for Inexpensive Remote Sensing for Improved Real-Time Operation of Large Irrigation Systems - Mac McKee, Utah Water Research Laboratory, Utah State University, Logan, UT (co-author: YangQuan Chen)

In many arid western states, irrigated agriculture accounts for as much as 85 percent of total water diversions. With these large quantities of water, a small improvement in overall system efficiency represents a potentially significant amount of water that could be used to increase agricultural productivity or diverted to other, higher valued uses. However, it is difficult to acquire accurate measurements of such things as soil moisture or evapotranspiration rates over large areas of irrigated land at time intervals and geographic resolutions that are of use for improving real-time management of these large water delivery systems. Of particular interest is the ability to accurately forecast short-term future irrigation demands--say, on a daily basis for a period of up to a week--at the canal level. The research reported here documents the development and application of inexpensive unmanned autonomous vehicles (UAVs)--essentially, very intelligent flying robots--that can be used to acquire multi-spectral, high-resolution imagery. Further, this imagery can be combined with other, easily obtained data to provide spatially and temporally detailed short-term forecasts about soil moisture and evapotranspiration rates. These, in turn, could be used to forecast water demands at the canal command area level. The on-going application of this technology is being demonstrated on the Canal B irrigation area, about 30 square miles of irrigated lands near Delta, Utah.

3. Bayesian Analysis of Sensor Errors in an Automated Irrigation Canal Using Multivariate Relevance Vector Machines - Alfonso Torres, Utah Water Research Laboratory, Logan, UT (co-authors: Wynn R. Walker, Mac McKee)

Losses from irrigation conveyance systems can be substantially reduced with automated flow measurement and regulation. The sensors used to monitor water levels in the canal and measurement structures as well as the position of gates and water levels in the canals are critical components but are not unconditionally accurate or sensitive within the relatively harsh environment of the irrigation system. Fluctuations in power to the sensors, hydraulic transients in the canal, and damped sensor locations create short-term readings that can confuse both human and computer controllers. These errors have historically been ignored in canal management with the result that water level fluctuations in the canal vary and thus impact the accuracy of water measurement devices, regulating gate positions, and diversions form the source of irrigation water. Using continuous water level and discharge measurements from the “A” canal diversions from DMAD Reservoir in Central Utah, a hydraulic model was calibrated against water levels at the downstream end of the canal and continuous flow recordings. The downstream water levels simulated by the model were forced to equal the recorded levels during the calibration process in order to determine the data stream of aggregate errors in the combined data acquisition/model system of the canal. The initial 25% of these errors formed a time series that was modeled with the multivariate relevance learning vector machine (MVRVM), which was then applied to the entire seasonal series. The results show that the seemingly random errors can be accurately determined by the MVRVM and thus used alongside the canal automation system to predict diversions from DMAD Reservoir that achieve a reliable and stable hydraulic condition in the canal during the irrigation season. Historic losses that have been as high as 11% of the diversions are now within 2%. In addition a simple operating rule emerged for the use of the water master during periods of manual operation. This proposed paper would outline the theoretical application of the MVRVM to an automated hydraulic system and demonstrate the practical application in an irrigation system in Central Utah.

4. Forecasting Irrigation Canal Demand Using Multivariate Sparse Bayesian Learning Approach - Andres Ticlavilca, Utah Water Research Laboratory, Logan, UT (co-authors: Mac McKee, Wynn Walker)

This research presents a model that predicts the required current-day and next-day flow demands from three irrigation canals simultaneously. These predictions will assist the operator of the reservoir located upstream of the irrigation canals, as well as the canal operators, to plan and manage the available water resources efficiently. The model is developed in the form of a multivariate relevance vector machine (MVRVM) that is based on a sparse Bayesian learning machine approach for regression. The model is applied to the irrigation canal system located in the Lower Sevier River Basin near Delta, Utah. The results show that the model learns the input-output patterns--in terms of historical irrigation canal flows and predicted future diversion demands--with high accuracy. A bootstrap analysis is used to provide information on the uncertainty in the model estimates. The results demonstrate good performance of predictions and statistics that indicate robust model generalization abilities.