WHITE PAPER: DEVELOPING VIRTUAL SENSORS TO MONITOR DISINFECTION BY-PRODUCTS

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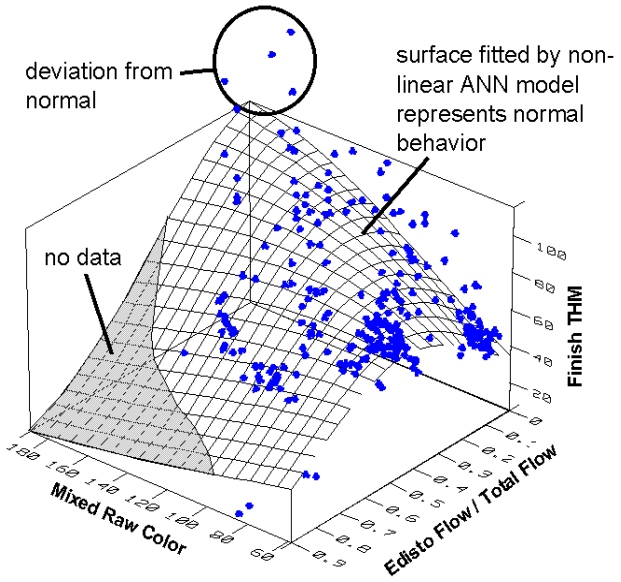
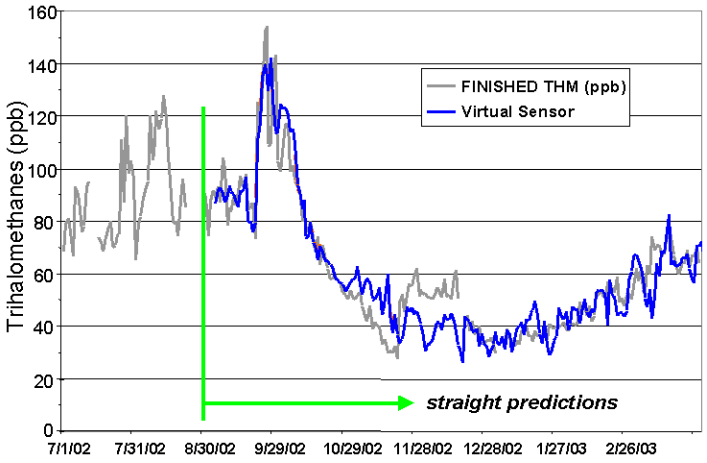


3D plot of ANN-based virtual sensor response surface fitted to measured THM data.

The U.S. Environmental Protection Agency is placing stricter limits on the formation of disinfection byproducts (DBPs) in water treatment facilities. The new limits pose a serious challenge to plant operators because the most critical (highest) areas of the water system must be sampled and each site must stand independent of system-wide averaging.

One of the most prominent DBPs is trihalomethanes (THM), a group of carcinogenic compounds that form when chlorination oxidizes organics in source water. THMs are measured by laboratory instruments that are expensive to purchase, operate and maintain; therefore, most facilities send water samples to outside labs for analysis on a regular basis or simply depend upon regulatory monitoring. This means that process operators generally do not know THM levels until weeks later, a condition that can lead to significant operational excursions.

One approach to solving this dilemma is to develop “virtual sensors” that predict THMs in real-time. A virtual sensor uses a computer model to predict values of an output variable, such as THMs, that are difficult or expensive to monitor, by correlating the output to other process variables that are more easily measured. The model must accurately describe the input/output behaviors of the process it represents, and it must execute in real-time to accommodate constantly changing input data. A model can also be used to do “what ifs”; that is, estimate the consequence of taking a control action to change the process.



Case Study: The 3-D figure plots actual THM measurements versus raw water color and the relative ratio of influent from the plant’s two different sources. Also shown is a “response surface” fitted to the data by a virtual sensor that predicts THMs as a function of color, source ratio, and other inputs.

The response surface is calculated by ranging the virtual sensor’s inputs and will generally be seen to run through the middle of the data. Plotting the data and surface together reveals details such as excursions from normal behaviors and how process variables interact. In this example, the relationships between color, source ratio, and THM are shown to be non-linear. The graph at right shows that the virtual sensor’s predictions during a seven-month trial match lab measurements quite well, with a $R^2 = 0.82$ between predicted and actual THM monitoring.

Operations professionals with a supervisory control and data acquisition system (SCADA) can develop a unique, integrated, multivariate view of the process. Such a system automatically adapts to process changes by updating and regenerating its models as new data is collected.