Real-time fault detection and isolation in biological wastewater treatment plants

F. Baggiani and S. Marsili-Libelli

ABSTRACT

Automatic fault detection is becoming increasingly important in wastewater treatment plant operation, given the stringent treatment standards and the need to protect the investment costs from the potential damage of an unchecked fault propagating through the plant. This paper describes the development of a real-time *Fault Detection and Isolation* (FDI) system based on an adaptive *Principal Component Analysis* (PCA) algorithm, used to compare the current plant operation with a *correct performance* model based on a reference data set and the output of three ion-specific sensors (Hach-Lange gmbh, Düsseldorf, Germany): two Nitratax® NO_x UV sensors, in the denitrification tank and downstream of the oxidation tanks, where an Amtax® ammonium-N sensor was also installed. The algorithm was initially developed in the Matlab environment and then ported into the LabView 8.20 (National Instruments, Austin, TX, USA) platform for real-time operation using a *compact Field Point* ®, a Programmable Automation Controller by National Instruments. The FDI was tested with a large set of operational data with 1 min sampling time from August 2007 through May 2008 from a full-scale plant. After describing the real-time version of the PCA algorithm, this was tested with nine months of operational data which were sequentially processes by the algorithm in order to simulate an on-line operation. The FDI performance was assessed by organizing the sequential data in two differing moving windows: a short-horizon window to test the response to single malfunctions and a longer time-horizon to simulate multiple unrepaired failures. In both cases the algorithm performance was very satisfactory, with a 100% failure detection in the short window case, which decreased to 84% in the long window setting. The short-window performance was very effective in isolating sensor failures and short duration disturbances such as spikes, whereas the long term horizon provided accurate detection of long-term drifts and proved robust enough to allow for some delay in failure recovery. The system robustness is based on the use of multiple statistics which proved instrumental in discriminating among the various causes of malfunctioning.

Key words | fault detection, principal component analysis, process control, programmable automation controllers, wastewater treatment

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INTRODUCTION

Real-time monitoring is an increasingly important aspect in the domain of advanced control of Waste Water Treatment Plants (WWTP) (Olsson & Newell 1999; Olsson 2006; Olsson & Jeppsson 2006) in preventing the possible damage caused by a failure propagating through the plant. In particular, Fault Detection and Isolation (FDI) techniques are now emerging as the foremost feature in upgrading SCADA (Supervisory Control And Data Acquisition) systems. Traditionally, many popular FDI methods

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