Water Quality Assessment through Smart Sensing and Computational Intelligence

O. Postolache[1,2], P. Silva Girão[1], and J.M. Dias Pereira[1,2]

[1] Instituto de Telecomunicações, IST, Av. Rovisco Pais, 1049-001 Lisboa, Portugal
Tel.: +351 21 8417974
poctav@mail.ist.utl.pt
[2] Escola Superior de Tecnologia de Setúbal (LabIM), Instituto Politécnico de Setúbal, 2910-761 Setúbal, Portugal
Tel.: 351 265 790000
dias.pereira@estsetubal.ips.pt

Abstract. Surface water quality monitoring is one of the important activities in the environmental monitoring domain and implies complex measurement activities in order to obtain physical, chemical and biological characteristics of the water. Some of these characteristics are able to be measured in the field but imply the utilization of specific water quality sensors that are used by operators as individually units or, preferably, are part of distributed water quality monitoring networks particularly when monitoring extensive areas.

Two concepts are nowadays associated with environment monitoring networks: smart sensing nodes and computational intelligence algorithms. Thus, different smart sensing nodes deliver data that are used by advanced processing units for different purposes, namely: (1) to evaluate the characteristics of water based on measurement channel indirect modeling; (2) to perform the short time and long term forecasting of these characteristics; (3) to detect pollution events and anomalous functioning; (4) to perform data recovering using intelligent algorithms such as neural network and adaptive neuro-fuzzy. The overall operation of the network is optimized if its nodes are provided with functionalities such as auto-identification, networking plug-and-play, auto-calibration, and fault detection.

IEEE 1451 family of standards define all aspects necessary not only to transform a sensor into a smart sensor, but also to interface or integrate sensors in networks. In the paragraphs that will follow, we propose the architecture of a smart sensing node suitable for a distributed water quality monitoring network that is IEEE 1451 compatible. The emphasis is placed on the identification of each sensor – which permits individual addressing - and on the algorithms for multivariable characteristics modeling that prove to be very useful for accurate direct digital readout of water quality parameters.

Keywords: IEEE 1451, smart sensor, RFID tag, neural network, adaptive neuro-fuzzy, water quality monitoring.

1 Introduction

Quality monitoring of surface waters is an important issue to guarantee that they are adequate to the required uses [1][2]. Different measuring solutions have been

S.C. Mukhopadhyay et al. (Eds.): New Developments and Appl. in Sen. Tech., LNEE 83, pp. 191–206.
springerlink.com

proposed by equipment providers and integrators, and by the R&D community. They include, as a rule, expensive equipments that also include proprietary protocols associated with sensing channel data acquisition, data processing and data logging. YSI, Campbell Scientific [3][4] are examples of manufacturarers that provides equipments in the area of field water quality monitoring which assure the measurement of multiple water parameters (e.g. pH, temperature, conductivity, turbidity, etc.) as so as parameters as depth and water flow. Such equipments present wired communication interfaces such as RS485 or SDI12 [5] that permits to develop water quality monitoring networks. The acquired data is usually sent from individual equipments to a central location using RS232 to wireless modems for relatively short distances such tenth of km (e.g *RS232 3G/HSDPA* modem from SIMCOM, RS232-RF modems from XStream) or even using RS232 Satellite Modem (e.g SLIN 0011AA - NAL Satellite Modem).

In order to assure the auto-identification, auto-calibration and compatibility between different devices of and extended water quality monitoring network the smart sensor network technology is considered. Thus a standard for smart sensors, IEEE1451.X [6] that was developed in the late 1990's was considered as an interesting solution for the water quality monitoring field. The standard permits an easy development of smart transducer manufacturing and an increasing connectivity of smart sensors to networks. Nowadays, the IEEE1451.X family is a set of protocols for wired interfacing (IEEE1451.0, IEEE1451.1, IEEE1451.2, IEEE1451.3, IEEE1451.4, IEEE1451.6) and wireless interfacing (IEEE1451.5 and IEEE1451.7) of smart sensors suitable for distributed applications including environment quality monitoring. The identification of different smart sensors is performed through the utilization of a memory embedded in the smart sensor and includes information about the transducer included in the so-called Transducer Electronic Data Sheet (TEDS).

The direct access to the transducer manufacturing and calibration information is available only for IEEE1451 compatible transducers through TEDS [7], which limits the interest and importance of this standard, since many real systems are characterized by analogue outputs (4-20mA). To overcome this problem, IEEE1451.4 [8] protocol represent an interesting solution. Two different implementations of IEEE1451.4 are considered in the present chapter. The first one uses a 1-wire memory while the second uses the memory of an UHF RFID tag to store the Basic TEDS information [9] providing wired and wireless connection capabilities, respectively.

As part of distributed water quality monitoring network, the hardware of a water quality monitoring node (sensing elements, conditioning circuits, acquisition, RFID tags and reader, and communication) must usually be complemented with signal processing blocks to perform different tasks such as data linearization, data compensation, short and long term prediction of pollution events (duration and concentration)[10-12]. Considering the nonlinearity of the single or multivariable characteristics associated with water quality measuring channels (e.g. conductivity measurement channel), intelligent data processing algorithms, such as neural networks and adaptive neuro-fuzzy [13] represents good option to improve the accuracy of the measurements through accurate models of measurement channels.