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Zastosowanie systemów monitoringu w systemach wspomagania decyzji

J. Studziński, L. Bogdan

Instytut Badań Systemowych
Polska Akademia Nauk

Systems Research Institute
Polish Academy of Sciences

POLSKA AKADEMIA NAUK

Instytut Badań Systemowych

ul. Newelska 6

01-447 Warszawa

tel.: (+48) (22) 8373578

fax: (+48) (22) 8372772

Kierownik Pracowni zgłaszający pracę:
Prof. dr hab. inż. Zbigniew Nahorski

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Raport

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Pod redakcją Jana Studzińskiego i Lucyny Bogdan

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Raport zawiera 3 nieopublikowane artykuly omawiające zastosowania systemów monitoringu w systemach wspomagania decyzji. Pierwszy z artykulów będzie przedstawiony na konferencji pn. Quality, Reliability, Maintenance, która odbędzie w dniach 1 – 2 kwietnia 2004 w Oxfordzie. Dwa pozostałe artykuly ukażą się w publikacji książkowej IBS PAN w serii Badania Systemowe w 2004 r.

Spis treści

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Application of monitoring technologies in environmental engineering

Jan Studzinski
Systems Research Institute, Polish Academy of Sciences, Warsaw, Poland

ABSTRACT

This paper provides an insight into the significance of monitoring as it pertains to environmental engineering. Three examples of using monitoring techniques for modelling and maintaining environmental processes are presented in this work, Firstly, computer aided decision making to maintain a wastewater treatment plant. Secondly, computer aided management of a communal water network, and thirdly modelling the forecasting of air temperature. The paper illustrates how the essential parameters of the above three disparate but related examples can be controlled through techniques illustrated in this paper.

INTRODUCTION

The rapid acceleration of the facilitation of mathematical modelling is contemporary with the advent of large storage computers as can be endorsed over the last thirty years. The models and algorithms developed here have become key tools for computer aided decisions making that are used to forecast and/or maintain various environmental processes. As a result they contribute considerably to the better protection of the environment and to satisfy better the social needs of the mankind. The base of the algorithms of modelling and optimisation of the practical use are the measurements that have to be taken fast, flawless and mostly in the real-time of the processes investigated. This can be made using computerised monitoring systems. This way they are an essential component of all computer aided decisions systems. In the following we will show the use of the monitoring data by the control of the wastewater treatment, by maintaining a water network and by forecasting the air temperature.

MONITORING IN A WASTEWATER TREATMENT PLANT

The modelled wastewater treatment plant is shown in Fig. 1. The process of the wastewater treatment is as follows: The raw wastewater enters the primary clarifiers where unsolvable solids settle down. The rest of the wastewater flows to the activated sludge basins where the organic material is decomposed biologically under aerobic conditions. The mixed liquor from the aeration tanks consisting of the activated sludge and the wastewater passes to the secondary clarifiers. Within the purification zone the sludge is separated from the wastewater by gravitational forces and the sludge particles settle down in the sedimentation zone. Part of the sludge is recirculated to the inlet of the aeration basins while the excess sludge is removed from the process as a waste. To maintain this process a computer-aided system supporting the decisions making by the process operator has been developed. This system works on the base of various mathematical models which are responsible for the realisation of the following tasks (see Fig. 2): forecasting the wastewater inflow and its waste composition, generation of the process controls which are the flow rate of the sludge recirculated and the level of the oxygen dissolved in the aeration basins, verification of the controls generated by means of the computer simulation. This latter task occurs with the help of a very detailed phenomenological model of the whole treatment process (1).

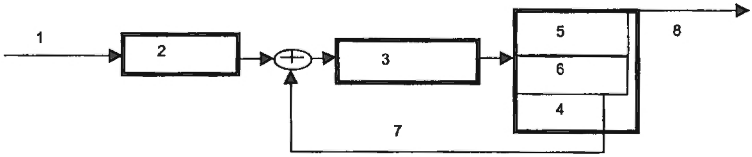

Fig. 1 Diagram of the investigated wastewater plant: 1 – wastewater inflow; 2 – primary clarifiers; 3 – aeration basins; 4 – secondary clarifiers; 5 – purification zone; 6 – sedimentation zone; 7 - extern recirculation; 8 – outlet of the purified wastewater

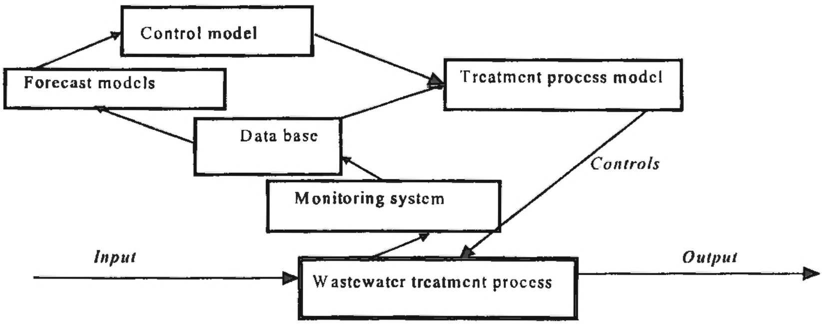

Fig. 2 Diagram of the computer system to control the wastewater plant

The development of these models and their adaptive validation is possible only with an efficient monitoring system. Such an automatic system has been installed in the wastewater plant (see Fig. 2). With this system the flows and the conductivity as well as the values of pH and REDOX of the wastewater are measured on-line. These data enable to develop and validate the forecast models of the computer system. To develop the other models some additional lab measurements had to be done and the data needed was gathered as a result of some measure experiments run on the wastewater plant.

MONITORING IN A DRINKING WATER NETWORK

An automatic monitoring system is also a key component of an integrated computer system developed for a communal water network to support the decisions making of the water net operator (see Fig. 3) (2). The system consist of 3 modules co-operating each other with the help of the Branch Data Base (BDB). These modules are: numerical map of the water net generated by a GIS named Geomedia, programmes for mathematical modelling, optimisation and control of the water net, and the monitoring system. BDB holds technical data about the structure and all elements of the water net that is used to carry out the specific tasks of the system modules such as visualisation, simulation and optimisation of the water net. With the help of the monitoring system the results of the water net hydraulic calculation are verified, the calibration of the water net model is periodically made and also the characteristics of daily water demands for typical water net nodes are set up and verified. These characteristics are used then to forecast the temporal water demand of the whole water net. The computer system was introduced as a pilot project only on a part of the investigated water net and it consists of 9 measurement points where water pressures and flows in the water net nodes and lines are monitored. The data transmission from the measurement points to the work station of the computer system occurs by means of the GSM telephony. It is an innovative and reliable solution in relation to the monitoring systems applied for communal water networks.

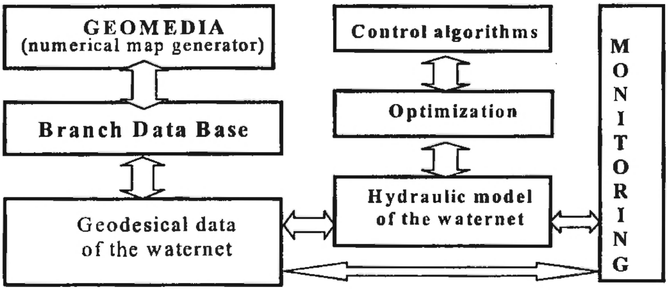

Fig. 3 Diagram of the computer system for maintaining the water network

ATMOSPHERICAL MONITORING

Automatic monitoring systems are used also successfully for measuring various atmospheric parameters such as air and soil temperatures, air humidity, wind direction and speed, rain and snow falls etc. On the base of such the data mathematical models of atmospheric events and processes are then developed that can be applied for weather forecasting and also as elements of experts systems which help to take precautions against the natural disasters. It happens sometimes however that the automatic monitoring systems work defective and they produce then the data series with sections of lacking or wrong measurements. To improve these defective data series we can use also the mathematical modelling. Such the situation occurred by monitoring the air temperature with an automation station in which the power supply has broken down for a couple of hours. By means of the models describing with neuronal networks the lacking measurements could be reliable interpolated. Some modelling experiments have been done to prove the usefulness of neuronal models by interpolating broken measurement series. In the temperature measurements produced by an automatic monitoring system some measurement sets have been eliminated and the eliminated values were then reconstructed with the help of neuronal nets (3). The number of eliminated values ranged from 1 to 12 with the measurement step of 1 hour and such the procedure has simulated some unexpected breakdowns of the monitoring system and the interpolation of the measurements lost. The results of the interpolation attained are quite satisfactory what proves the usefulness of neuronal modelling for repairing the defect data from the atmospheric monitoring (see Fig. 4 with some exemplary results of the reconstruction of 12 measurements eliminated).

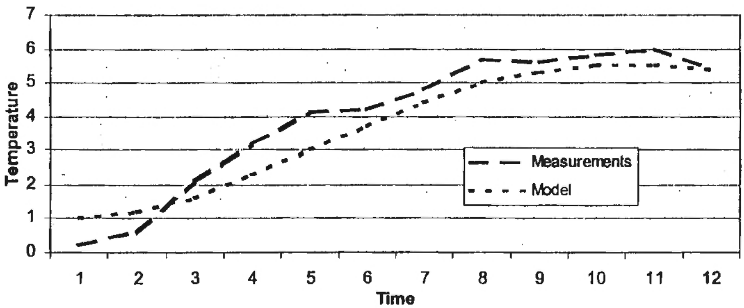

Fig. 4 Temperature values of the measurements and of the mathematical model

REFERENCES

1. L. Bogdan, J. Lomotowski, Z. Nahorski, J. Studzinski, R. Szetela, "Mathematical and neural network modelling of a wastewater treatment plant" *Archives of Control Sciences*, Vol. 10, No. 1-2, 89-118, 2000.
2. J. Studzinski, L. Bogdan, "Computer aided modelling, optimisation and control of the large municipal water net" *In: Simulation and Modelling: Enablers for better Quality of Life Proceedings of 14th European Simulation Multiconference ESM'2000* (Ed. R.v.Landeghem) Ghent, 586-588, 2000.
3. P. Licznar, J. Lomotowski, J. Studziński, „Anwendung neuronaler Netze zur statistischen Verarbeitung meteorologischer Datenfolgen aus automatischer Datenerfassung" *In: Simulation in Umwelt- und Geowissenschaften: Workshop Cottbus* (Hrsg. J. Wittmann, A. Gnauck) Aachen: Shaker-Verlag, 9-17, 2002.