NEURAL NETWORK SYSTEM FOR WASTE-WATER RECOGNITION

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Abstract: This paper presents modern method of using neural network for waste-water recognition by using sensor array. Each sensor in sensor array detects chemicals in waste-water with different sensitivity. Set of measured data is digitized and recognized by a neural network. Measuring process doesn't need any human operator. The result gives the only information: contaminated or not contaminated.

1 INTRODUCTION

Many Internet service providers and online services require you to manually enter information, such as your user name and password, to establish a connection. With Scripting support for Dial-Up Networking, you can write a script to automate this process.
Many manufacturing companies and manufacturing plants produce a lot of impure waste-water. This water is processed thru sewerage plant and after cleaning it is delivered to the wide open space. It is necessary to test quality regularly for quality assurance. It is possible to use different methods of a chemical analysis for these tests. The price and necessity of human operators are the main disadvantages.
The main motivation for sensor array based devices developed is to design low cost, precise, mobile devices for reproducibility of analyzing of impure waste-water in real-time mode. These devices are produced for classification and recognition of liquids, gasses, foods and other substances.

2 SENSOR ARRAY APPLICATION

In many applications for chemical sensors, information can be gathered not only from a steady-state value of a sensor response, but also from the kinetics of response. However, using steady-state sensor value to classify different mixture liquid chemicals results in losing of a great deal of information in the sensor signal.
The main function of these devices is to identify and quantify structure of chemicals. The system consists of the array of electrochemical sensors. This array contains sensors of various types. Each sensor detects more than one chemical, some of them with higher sensitivity, and some others with lower sensitivity, depending on individual sensor characteristics. Sensors are fixed in a temperature stabilized vessel filled with measured liquid mixture. Sensor response is digitized by an AD converter. There are another temperature and humidity sensors located in gas chamber, too. The set o digitized data is forwarded to the bus-connected computer for final recognition and analysis.
To recognize all chemicals of waste-water, it is necessary to make analyses of all measured data. It is possible to exploit several methods to reach analyzed results. One of these methods is to extract the main measured curve parameters by hand. Four fundamental curve parameters (Vernat-Rossi, et al., 1996) are depicted in Figure. 1: kmax for maximum slope, max for maximum value, sr30 for the response on time 30 s and mean for average value of the whole set of points. This method is not much competent, because the target is to design an autonomous system, which works without operator's assistance.

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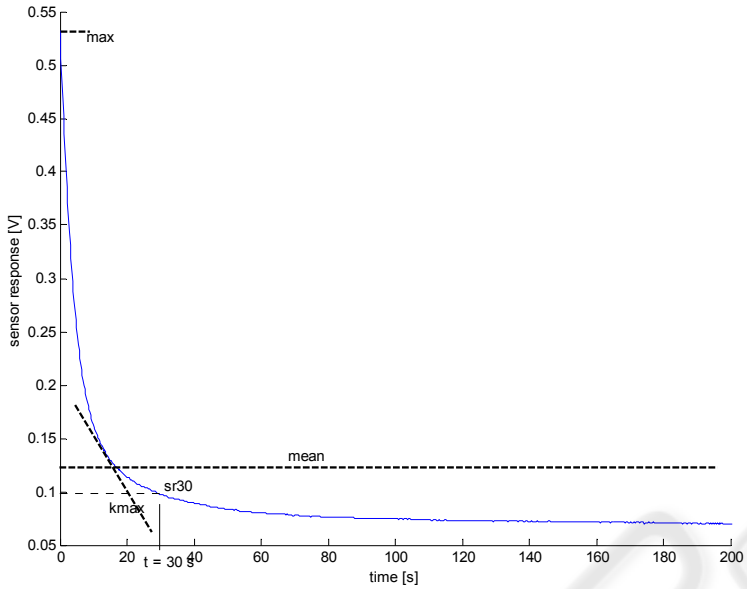

Figure 1: Sensor response curve with fundamental analyzing parameters.

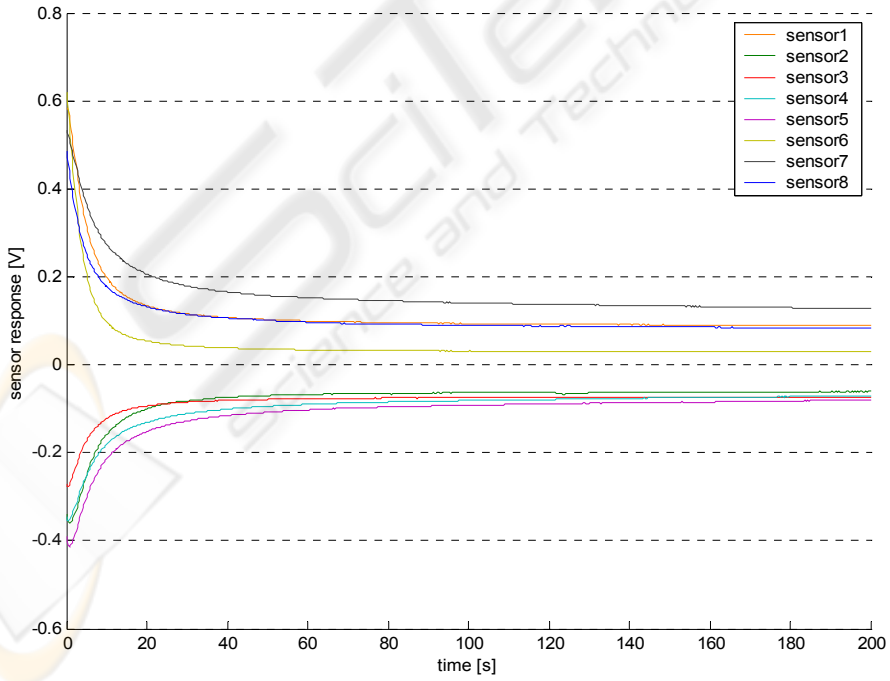

Figure 2: Sensor array response curve.

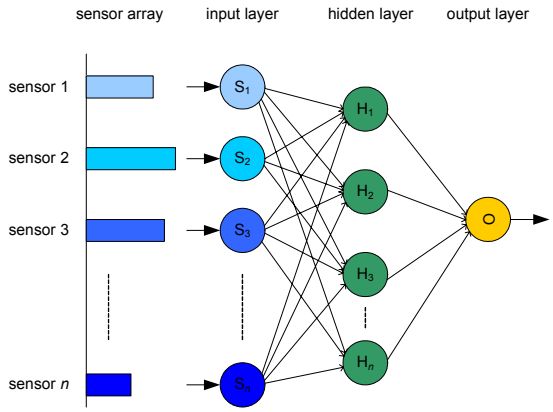

Figure 3: Block diagram of neural network processing signals stimulated by n sensors.

Another method selects main typical points, then tries to approximate measured values and finally compares them with those derived from the mathematical model. If too many features are used, mathematical model will be huge and complex. For this reason it is necessary to reduce number of points which are used for recognition without losing resolution.

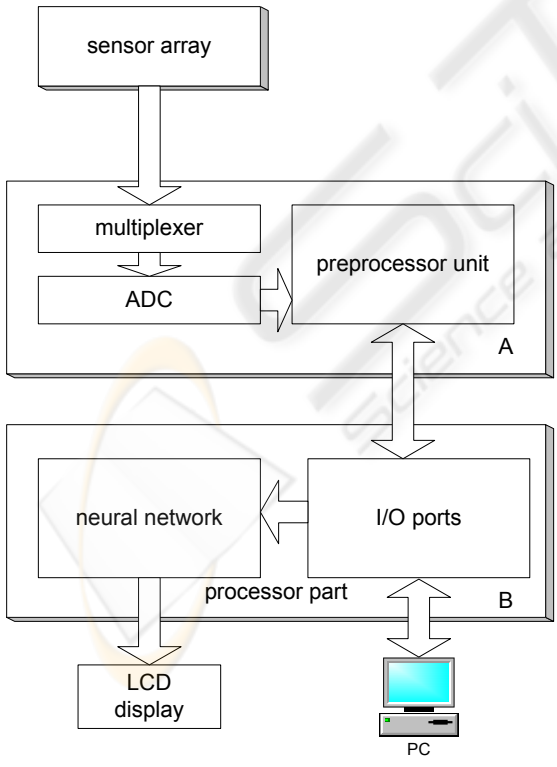

Figure 4: Block diagram of recognizing system.

If the sensor array contains eight different sensors with various characteristics, their responses to analyzed liquid mixture generate eight different characteristics. The reason is that each sensor works with different sensitivity to different chemical components. Sensor array response curves are drawn in Fig. 2. For description of these characteristics it is possible to use e.g. four parameters, which describe measured data with sufficient resolution. We know the wage of measurement exactly in time which is near stable-state. Therefore, from each curve, 4 fundamental parameters are extracted (Fig.1), and for 8 sensors we collect totally 32 values.
These 32 parameters may form input values for appropriate statistical method for data processing and analysis.

3 NEURAL NETWORK

An artificial back-propagation neural network is very often used for detailed recognition. There is a block diagram of the neural network shown in Fig. 3. The input layer has the same number of neurons like the number of input values. Number of neurons in the output layer depends on the desired values. In this application we usually want to know, if waste-water is contaminated or not. It means that number of the output neurons will by only one. The artificial neural network will be realized by a microprocessor or a DSP digital signal processor.
Block diagram of the system is shown in Fig. 4. The system co-operates with external or internal sensor array. Sensors´ responses are converted and digitized in part A of the recognition system. Superimposed signal noise is suppressed by a noise filter in part A, too.
Recognition part and the neural network are situated in part B of the system. The system is connected to a personal computer via a standard (RS-232 or USB) interface for measured data storing. Essential information resulting the sensor signal processing is displayed on embedded LCD display. In much more details the results are available in a connected PC frame.

4 CONCLUSION

For waste-water recognition several methods may be exploiting. This paper presents the basic description of a low cost method, which works in real-time mode without device operator assistance. This

method can be used to recognize liquid components in a sewerage plant. It is based on sensor array, used to measure concentration and composition of chemicals. Neural network is used for final recognition. The final result of recognition gives the binary information: contaminated or not contaminated, which is sufficient.

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REFERENCES

Šnorek, M., Jiřina, M.: Neuronové sítě a neuropočítače. Praha, Vydavatelství ČVUT 1996, ISBN 80-01-01455-X

Bíla, J.: Umělá inteligence a neuronové sítě v aplikacích. Praha, Vydavatelství ČVUT 1996, ISBN 80-01-01275-1.

Sinčák, P., Andrejková, G.: Neurónové siete Inžiniersky prístup (1. diel). Košice, ELFA Press 1996, (in Slovak)

Sinčák, P., Andrejková, G.: Neurónové siete Inžiniersky prístup (2. diel. Košice, ELFA Press 1996, (in Slovak)

Neruda, R.: Umělé neuronové sítě a jejich použití v lékařských datech.

Xiaobo, Z., Jiewen, Z., Shouyi, W., Xingyi, H.: Vinegar Classification Based on Feature Extraction and Selection From Tin Oxide Gas Sensor Array Data. International symposium on sensor science – I3S 2003, Paris (France), ISSN 1424-8220

Gardner, J.W.; Bartelet, P.N.: Electronic nose: Principles and Applications. Oxford University Press 1999, 1-4, pp. 185-207

Christophe, S. et al.: Potential of semiconductor sensor arrays for the origin Authentication of pure valencia orange Juices. Journal of Agricultural & Food Chemistry 2001, 49, pp. 3151-3160,

Giuseppe, Z. et al.: Determination of organic acids, sugars, diacetyl, and action in cheese by high performance liquid chromatographic. Journal of Agricultural & Food Chemistry 2001, 49, ISSN 2722-2726, Sensors 2003, 3 109

Vernat-Rossi, V., Garcia, C., Talon, R. et al.: Rapid discrimination of meat products and bacterial strains using semi-conductor gas sensors. Sensors and Actuators B 1996, 37, pp. 43-48.

Vrba, R. et al.: ANTOPE Research of New Methods for Instrumental Analysis of Toxicity for Integral Measurement of Toxicity in Food Industry and Their Confirmation by a Prototype of Analyzer of the Toxicity of Pesticides. MPO FD 42K/253 R&D Project, Research Report, FEEC BUT and MPO, 2002