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A Method for Designing Complex Machine Olfaction System

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Abstract

In recent years, various gas sensors have been widely used to detecting odours, and machine olfaction system based on sensor arrays adopt kinds of intelligent instruments and advanced e-noses. While machine olfaction system meets the information sharing problem and is difficult to flexibly and uniformly assign these devices. In the paper a template technology has been applied to the complex platform of machine olfaction system. The simulation sensor array template receives field odor data or simulates the data via recorders in database, then transmits to the platform which consists of several distributed monitoring subsystems. Each subsystem matches a set of gas sensors array, and has functions of logging data, communicating and simulating industry application. The data from the subsystem and the preprocessed data are sent to the web server center and stored in the databases. Then sensors perform analysis by several layer algorithms. And the exchanging algorithms convert the field odor data to gas concentrations with ppm values, the expert systems or recognition algorithms analyze the ppm values and show the application results. All data of each layer are stored in server database systems, and each layer algorithms can be updated and saved. Finally, the supporting platform that applied to industrial monitoring systems, was developed with a kind of industrial configuration softwares, web MIS and databases, and was utilized to realize monitor to the environmental systems by the simulation template.

Keywords*: machine olfaction, gas sensor array, simulation template, supporting platform*

1. Introduction

Since the original definition of electronic nose (e-nose) by Prof. J.W. Gardner in 1994 [1], electronic nose is an essential component of artificial olfaction instrument. It is clear that pattern recognition, signal and data processing of machine olfaction. A sensor array is an essential part of the electronic olfaction process. Gas sensor has been devoloped to apply accordingly in various fields as an instrument or a system. Marta reported on an optical sensor for remote residual dry salt monitoring, with applications in road winter maintenance [2]. The proposed sensor system has a compact design and short response time, capable of being mounted on-board maintenance vehicles for real-time road condition assessment. Nanomaterials of conjugated polymers are found to have superior performance relative to conventional materials due to much larger exposed surface area [3]. Machine olfaction were designed to solve medical problems [4-6] and environment monitoring [7-9]. The system in the paper [10] presented a wireless monitor and control system using mobile communication and included the remote measurement units, GPRS network, Internet and a server computer.

The above researches emphasize sensor development and application and ignore that informationization planning of sensors and applications is more important and more popular. The paper focuses on technologies of supporting platform of machine olfaction that provide signal, data processing solutions and applications. We have structured the contents into following sections: we design firstly the structure of supporting platform of machine olfaction; secondly, the templates of sensor arrays and applications adopt to solve the complex problem of various odour monitoring environments; thirdly, we select the environmental system applications aiming to simulation template of machine olfaction systems.

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2. Supporting Platform of Machine Olfaction

A machine olfaction system consists of an array of cross-sensitive gas sensors and an appropriate pattern recognition method, to automatically detect and discriminate various odors, and user interface (UI) to show processed data. Signal and data processing with various algorithms are key elements in a machine olfaction system as well as in most sensing instruments, for example e-nose. Supporting platform of machine olfaction is designed with multilayered structure and database system, and its function becomes more powerful and informational.

2.1. The Structure of Supporting Platform of Machine Olfaction

In Figure 1, the platform has 5 logic layers that include device layer (data acquiring layer), I/O bus layer (data transmitting layer), data processing layer, algorithm layer and user interface layer. The bottom layer refers to various devices. The sensor array, application templates, control instruments and assist instruments are applied to monitor intelligent data acquisition systems. The second layer is communication modules adopting PCI, UART, and various kinds of I/O interface. In the third layer, data acquired in the bottom layer and sent to servers or workstations via the communication layer is saved in databases and can be processed by algorithms the fourth layer. In algorithm layer, it discusses the methods and means of data preprocessing and analyzing with preprocess algorithm and expert systems. User interface layer can process user data and user requests, and manage users, data, database, algorithms, and application systems.

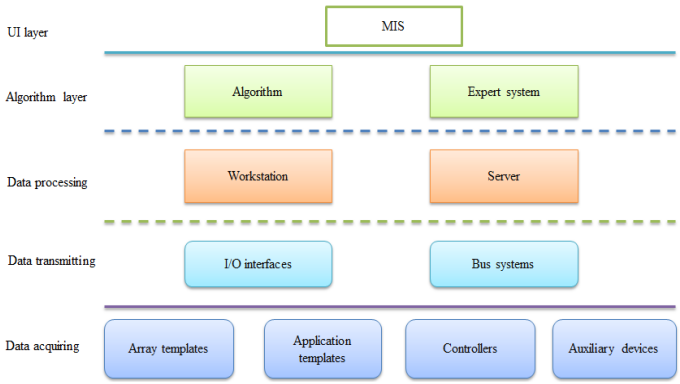

Figure 1. The Logic Structure of the Platform

In Figure 2, the physical structure is shown. High performance e-noses that have the communication function, system on chips (SOCs) and intelligent sensors have acquired field gas data and transmitted to workstation or gateway. Using UART, PCI bus, WLAN, and even wireless sensor network [10], the workstation receives the field data. The distributed system saves the data and continues to send to databases in server.

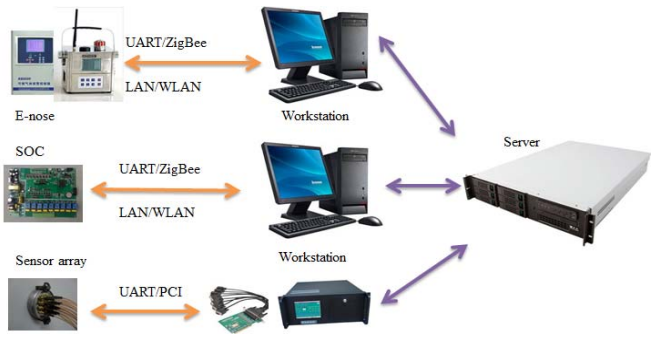

Figure 2. The Physical Structure of the Platform

2.2. Database System

Database system is vitally important for the supporting platform. In logic structure in fig. 3, database system saves kinds of data that includes acquired data from field via bottom layer and communication layer, gas senor array data, gas information, application system information, algorithms, expert systems, user information, and system files.

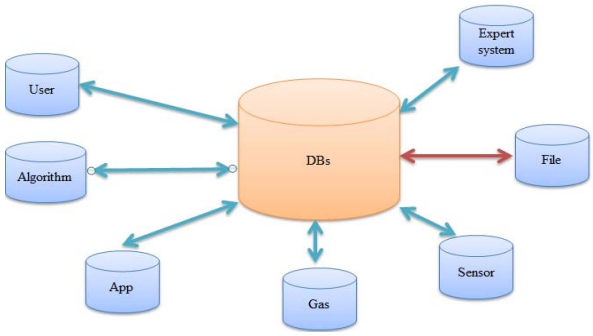

Figure 3. The Database System and Database Subsystems

Users, researchers and administrators can update their information, upload files, manage sensors and set arrays, match some kind of algorithm to the interrelated application. The uploaded file is used to preprocessing algorithm and expert system with C language script, execute file, ASP file and so on. Many uploaded pattern recognition methods have been introduced in supporting platform machine olfaction for the interrelated application. Even, other users can download files of the same application, compare sensor array accuracy and efficiency, and return new algorithm file with the description to server. The description provides to more users to refer.

In contrast to e-nose, the olfactory system can detect and interpret the information from volatile sensors with a high degree of sensitivity, selectivity and stability. Therefore, to conquer difficulties in machine olfaction, researchers start to pay more attentions to research odor processing models for testing and verifying data from sensor database subsystem. So the database system of supporting platform of machine olfaction provides much data for researchers which mine machine olfaction data, create algorithms, and release new data to the server database system.

2.3. Web User Interface Based on Web Service and Workflow

MIS based on web faces users, researchers and administrators, and provides interface to access database. The method of designing the MIS that suits the demand of the modern internet and wireless network, has become more and more important and popular. According to the workflow requirement in dynamic environment and advantages of present design method of MIS, the technologies of workflow and web service, the platform uses flexible MIS to service all of users, researchers and administrators.

3. Simulation Template

The template can receives filed data of detected odours or simulation data or recorder data. The system has been evaluated in extensive simulations and the shown results.

3.1. Data Acquisition and Sensor Array Template

Accuracy, performance, and stability requirements of the gas sensors have increased in industrial production, environmental monitoring, medical checking and other areas. The researching and development of the gas sensors have been more and more important, inconstant and complicated. In Figure 4, sensor set has 24 sensors that can divide in four arrays each with 6 sensors, three sensor arrays each with 8 sensors, two arrays each with 12 sensors, two sensor arrays with 6 sensors and 18 sensors, and one array with 24 sensors. The senor

array template that can be divided in multichannel to get field odor data, applies to many industrial environments. Workstation receives field gas sensor arrays transmitting data, and the functions of workstation are shown in fig. 5.The sensor array template can simulate field data and history data in database for user updating new algorithms and expert systems.

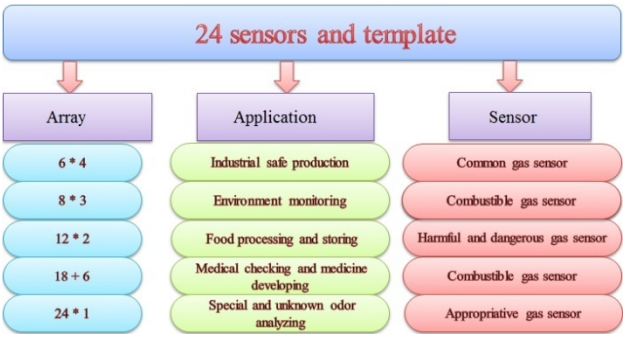

Figure 4. The Simulation Template and Application

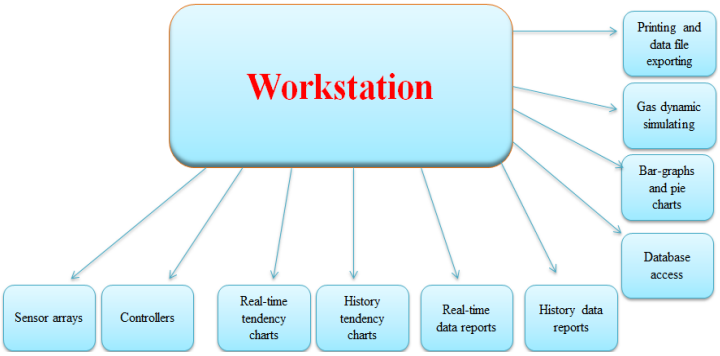

Figure 5. The Functions of Workstations

3.2. Application and Template of Application

The data process of machine olfaction the structure is discussed in the above sections. The signal model of sensor arrays associated with specific odor classes is presented in Figure 4. The specific classes acquire data of sensor array template, and these classes and specific applications are conceived as an interrelated whole. Industrial safe production adopts common gas sensors as TGS3870 is used to detect CH4 in coal mines. And harmful and dangerous gas sensors of MQ series are used to environment monitoring. Template of application unifies industrial safe production, environment monitoring, food processing and storing, medical checking and medicine developing, and even special and unknown odor analyzing as well as spice testing.

3.3. Verification

The supporting platform of machine olfaction was utilized to realize monitor to the environmental systems with simulation template. The kind application was designed by Kingview software, SQL database and web service design tool set including asp.net. The Kingview is a kind of industrial configuration software for developing supervisory control and data acquisition system. Principal component analysis (PCA) is widely used for dimensionality reduction in pattern recognition and has been applied in many linear areas successfully [11]. So the Verification system adopts the algorithm to recognize polluted air. The linear algorithm is visual to air testing and easy to realize. Figure 6 shows parts of gas monitoring results, based on the supporting platform of machine olfaction. The monitoring system run in the workstation that marked No.3 in Figure 7 and decribed in Table 1.

The supporting platform of machine olfaction presented an ambient real-time air quality monitoring system that detected 12 kinds of normal gases in air including O_2, H_2, CO_2, CO, an so on. The system consisted of several distributed monitoring stations that communicated each other. The SOC marked No.4 was equipped with gaseous and meteorological sensors and correlative parameter sensors as well as data logging and wireless/UART communication capabilities. The server marked No.1 collected real time data from the station and converted it into, and delivered to users through a web portal and a mobile application as the moblie phone marked No.6. The server computer could be very far away from stations and it could be also flexibly assigned. The server computer supported several the remote measurement units with flexibly assigned functions. Therefore, the measurement results and gas changing trends was widely spread via Internet access in real time.

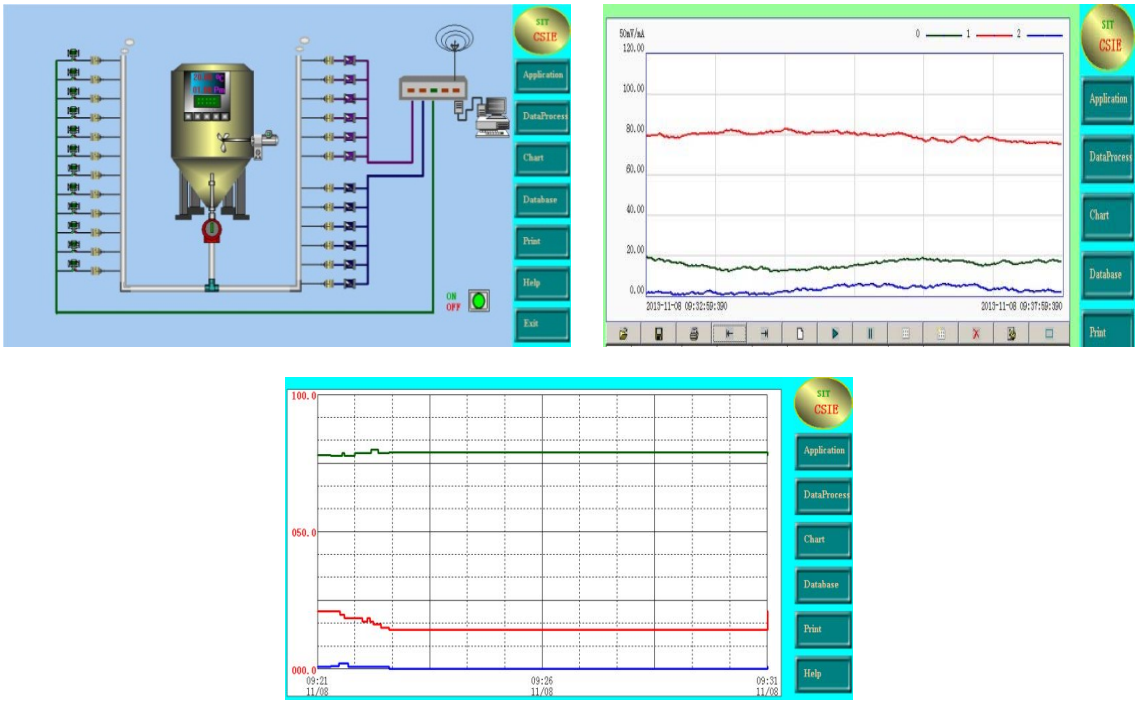

Figure 6. The Kingview Monitoring System and Tendency Charts of Three Odours

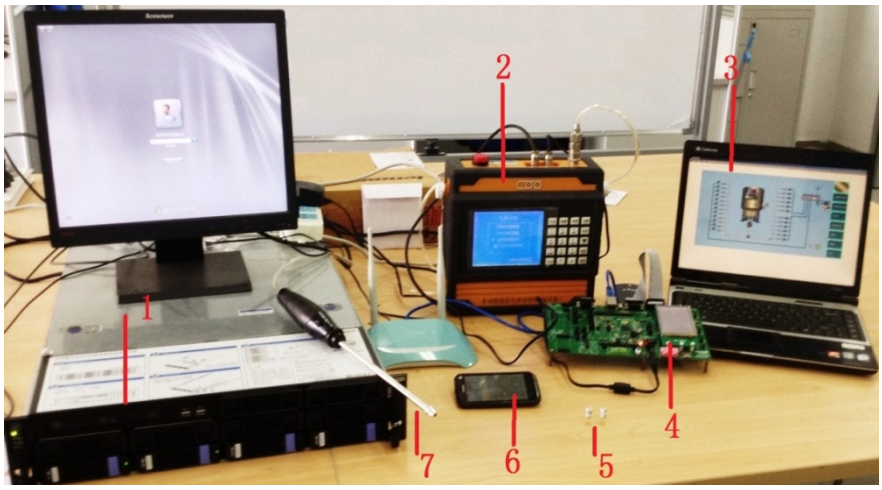

Figure 7. An Application System

Table 1. The Component Parts of the Verification System

Number	Description	Function
1	server	The server is the integration of the database and web service. IIS (V5.1 for former site and V7.0) runs on it and users UI is an inner web site.
2	e-nose	The device assembles 12 gas sensors. It can acquire gas concentrations via inner expert system, show test results and send all data to workstation via RS232.
3	workstation	In the distributed supporting platform, the workstation is a gateway that receives field data and transmits to server. The Kingview runs on it. Fig. 7 shows monitoring software based on the Kingview.
4	SOCs	The kind of devices assembles 6 unfixed sensors. Parts of TGS series and MQ series can match its port.
5	sensors	The sensors via SOC A/D acquire field odor data, and transmit to workstation via RS232/USB.
6	terminal	The mobile phone as user terminal accesses database, and browse the web site.
7	probe	The assist instrument can go deep into various kinds of containers, and imbibe gases when the controller turns on the pump.

4. Conclusion

This paper purposes a novel approach to construct supporting platform of machine olfaction, and applies this method in industrial environments. Therefore, the classified data have complicated structures and the simulation template may be more useful for data with complicated and various structures. Main Conclusions drawn from the Paper: 1) The gas concentration was simulated by using preprocess of the template of sensor array; 2) We focused on technologies of supporting platform of machine olfaction that provided signal, data processing solutions and applications; 3) Expanding supporting platform of machine olfaction benefited building the data warehouse and on-line analytical processing to solve these problems in the future.

Acknowledgements

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