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Application of CPC Software in Chemical Production Fault Detection

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Chemical production is a high-security industry, which often causes huge losses to production. Effective process monitoring and troubleshooting methods are designed to prevent accidents. Most of the supervised learning algorithms used in the current chemical industry generally need to obtain more labeled samples, so the cost is higher. Aiming at the problems existing in fault detection and fault diagnosis, the algorithm proposed by the process control software for fault diagnosis. The algorithm can perform complex function approximations. The accuracy of the original features can be greatly improved. The proposed method was verified in the chemical process. The experimental results verify the effectiveness of the proposed algorithm.

1. Introduction

The advancement of modern technology increasingly expands and complicates the chemical production systems. Once an error occurs in the system, it will engender huge economic losses or even casualties if not discovered and troubleshot in a timely manner (Nakagawa et al., 2006; Tahan et al., 2017). The Distributed Control System(DCS) is widely used in the chemical production process since it, on the one hand, intensifies the automatic detection and adjustment on the chemical processes and expands the information channels for the operators, and on the other hand, it makes the system more complicated even to an extent that the operator sometime has no way to start in the face of abundant signal alerts issued when the production process runs abnormally, so that it is cumbersome to timely supervise anomalies and failures in the process (Li, 2017; Faheem and Gungor, 2017).

In order to prevent against accidents and make sure the system works safely and reliably, it is undeniable that we implement an effective process supervision and fault diagnosis method. For this purpose, the fault detection and diagnosis have great practical significance for chemical safety (Buttyán et al., 2010; Alcaraz, 2015). The CPC (Computer Process Control) consists of the computer body (including hardware, software and network structure) and controlled objects, as shown in Fig. 1. It enables the detection of chemical production processes in order to improve product quality and output, as well as the productivity. For this purpose, the CPC system on the chemical site should feature better performance and stronger anti-interference capacity (Dadhich et al., 2015; Chen, 2016).

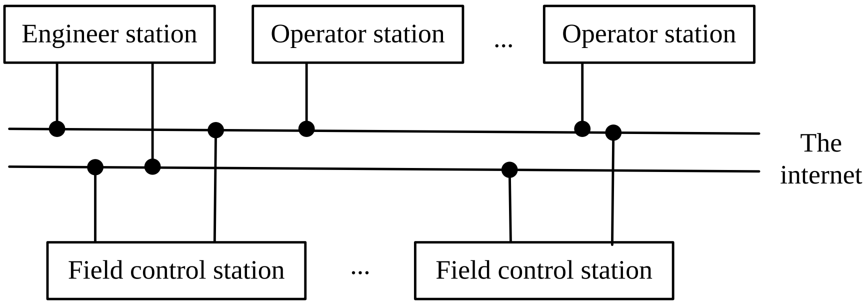

Figure 1: Computer distributed control system

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2. Experiments

2.1 Fault diagnosis technology in chemical production

2.1.1 Diagnosis process

The chemical production process belongs to a special dynamic system. Unlike general industrial production modes, it often operates in such a production environment where there are extreme conditions such as high temperature and high pressure, low temperature vacuum, toxic gases or corrosive chemicals. Once fault occurs, it may cause serious damage and immeasurable losses, even threaten personal life safety. Chemical fault diagnosis is one of the key technologies used to improve the system reliability and develop safety policies for chemical production system (Shen et al., 2014).

The fault diagnosis process is shown in Fig. 2. This process is mainly divided into three subprocesses, the first is to detect various signals that characterize the system state; the second is to extract the omens from the detected feature signals, that is, signal treatment and feature transformation; the third is identify the error state of system based on these omens and other diagnostic knowledge, in order to judge and locate the faults, and develop diagnostic policies to intervene in the system work.

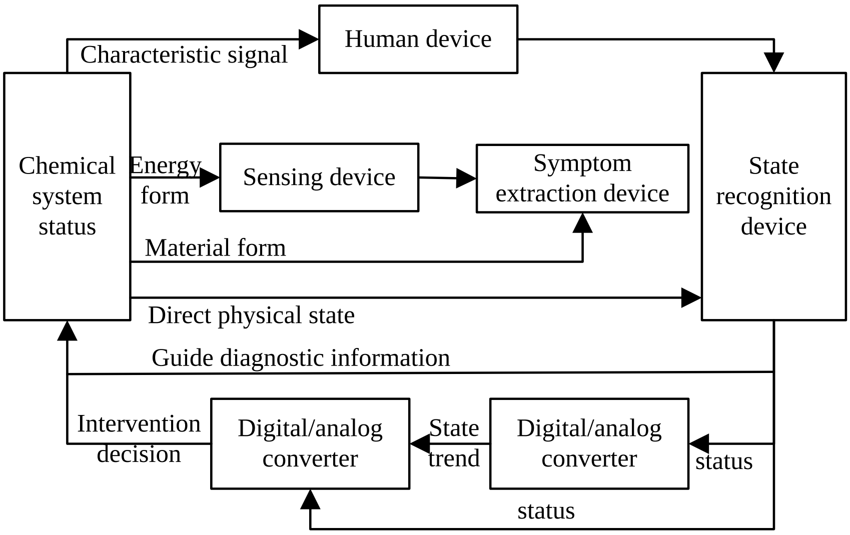

Figure 2: Fault diagnosis of chemical production process

2.1.2 Control process

In order to maximize production efficiency and product quality, the production equipment, control devices, and control systems in the chemical processes are developing in the right direction of large-scale, complicated, intelligent, and integrated modes, but in accompany with it, great changes will take place, for example, in the potential possibility of failures, the fault mechanism, the way the fault occurs, so that the fault diagnosis in chemical processes is more cumbersome (Lee et al., 2014). The process control system software is shown in Fig. 3.

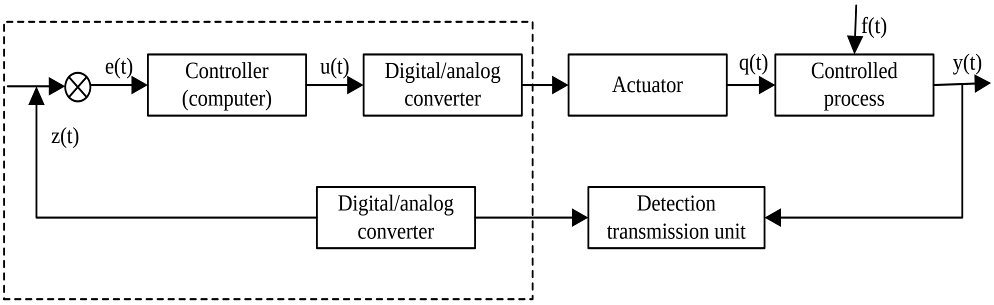

Figure 3: Computer process control system structure diagram

2.2 Composition of computer process control system

2.2.1 Composition

The computer control system for industrial production process has been constantly developed with the advancement of computers, the increasing thresholds for the industrial production processes and the improvement of production management (Jain et al., 2015). Now the industrial computer control system at structural level is basically divided into several types, i.e. Direct Digital Control (DDC), Supervisory Computer Control (SCC), Distributed Control System (DCS), Hierarchical Control System (HCS) and Fieldbus Control System (FCS) and the like. The fifth generation process control architecture that integrates the computer, communication and control technologies, namely the FCS, as shown in Fig. 4, leads the development trend of CPC at home and abroad.

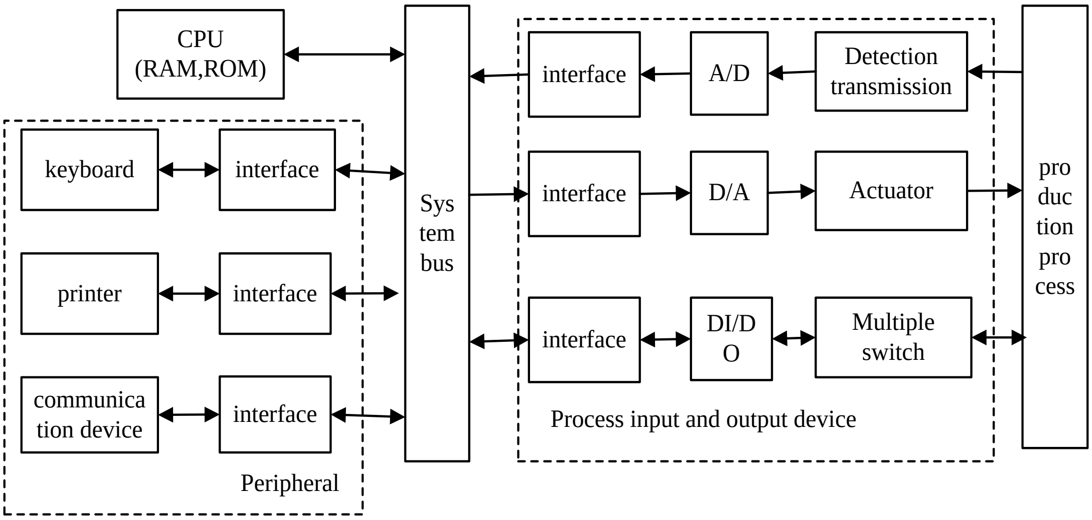

Figure 4: Computer process control system structure diagram

For the timed events, the system sets up the clock to ensure a timing processing. Interrupts are set for random events, and interrupt level is pre-assigned based on the fault levels. The emergency fault treatment is enabled once an incident occurs (Leveson et al., 2014).

2.2.2 Features of CPC

Unlike computer software generally used for scientific computing or management, CPC works in a rather harsh environment, so that it must confront various disturbances around it which threaten its normal operation at any time. Even more, its control task assumed does not allow it to have any anomaly. Therefore, safety and reliability come first in the design process. Easy maintenance lies in that it is easy to find faults and troubleshoot them. It uses standard functions and the template structure, all of which make it easy to replace the fault template. There are also the status indicators and monitoring nodes installed on the function template for easy maintenance. A diagnostic program is also configured for fault identification.

3. CPC detects faults in chemical production process

3.1 Fault property of CPC system

The CPC includes process control as a core. In addition to process control, the system also has input and output devices directly connected with process control and various load objects controlled by the output device (Hehenberger et al., 2016). Like other automatic control systems, this system has a failure rate curve similar to the law of “bathtub”, which includes three phases: early failure period, accidental failure period, and loss failure period, as shown in Fig. 5. As time grows, due to continuous improvement, these defects get less and less, so that the phenomenon that the failure rate swoops appears: during the accidental failure period, the fault occurs randomly at a low occurrence rate. During loss failure period, due to the long-term working and aging of the devices in the system, more devices gradually approach to the end of life. As time goes on, they end the service life one by one, and the fault rate increases with it (Dasheng et al., 2016).

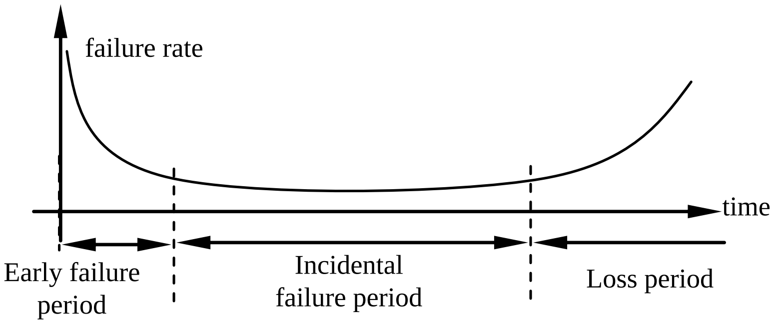

Figure 5: Failure rate curve of process control system

In view of this fault property of the industrial CPC, in practice, in order to prolong its service life and reduce its downtime, on the one hand, it is required to repeatedly demonstrate the system design, brainstorm and take necessary measures to make the system do its best; on the other hand, timely replace the components that will enter the end of life (Li, 2017) before the loss failure period starts.

3.2 Software diagnosis against CPC system fault

The Distributed Control System(DCS) is widely used in the chemical production process since it, on the one hand, intensifies the automatic detection and adjustment on the chemical processes and expands the information channels for the operators, and on the other hand, it makes the system more complicated even to an extent that the operator sometime has no way to start in the face of abundant signal alerts issued when the production process runs abnormally, so that it is cumbersome to timely supervise anomalies and failures in the process.

CPC system has rich software resources with which an early fault diagnosis and alarm can be done. These are more important, especially when using touch screens and configuration software. The process variable is saved in the VW100 unit, when it is less than or equal to 100, the lower limit fault alarm signal is issued; when it is greater than or equal to 1000, the upper limit fault alarm signal is issued. The alarm signal has a flashing alarm bell function. After the alarm signal is acknowledged, the alarm bell stops and the flashlight turns Normally ON until the process variable resumes to the specified range. A test button is set up to check the operation of the alarm device. The appropriate assignment and memory bit, as well as memory allocation, of process control input and output terminals are shown in Table 1.

Table 1: Process control input and output terminal assignment and memory bit and memory allocation

Input		Output		Memory location and memory unit	
I0.1	Fault confirmation button	Q0.0	Lower limit fault warning light	M10.0	Lower limit fault alarm flag
I0.2	Alarm device test button	Q0.1	Upper limit fault warning light	M10.1	Upper limit fault alarm flag
I0.3		Q0.2	Upper and lower limit fault alarm	VW100	Process variable storage unit

It is assumed that two process variables are stored in the VW104 and VW100, respectively, and a fault alarm program that resolves the first fault is now designed. The appropriate assignment and memory bit and allocation of computer process control input and output terminals are shown in Table 2.

If it is definite that the input and output nodes of CPC are damaged, they can be removed for repair.
The CPC system has a high reliability. There is much less maintenance workload in the field. However, due to the impact of the working environment, some problems will occur during long-term operation. The input and output in industrial control are shown in Fig. 6. In order to ensure the reliable operation of the system, routine maintenance and regular inspection should be performed on it in order to stifle the potential failures in the cradle. In this way, the CPC system will work in the best state for a long time.

Table 2: Computer process control input and output terminal assignment and memory bit and memory allocation

Input		Output		Memory location and memory unit			
I0.1	Fault confirmation button	Q0.0	Process variable 1 upper limit fault warning light	M10.0	Process variable 1 upper limit fault alarm flag	M10.2	Process variable 1 upper limit fault first memory flag
I0.2	Alarm device test button	Q0.1	Process variable 2 upper limit fault warning light	M10.1	Process variable 2 upper limit fault alarm flag	M10.3	Process variable 2 upper limit fault first memory flag
I0.3		Q0.2	Upper and lower limit fault alarm	VW104	Process variable 1 memory unit	VW100	Process variable 2 storage unit

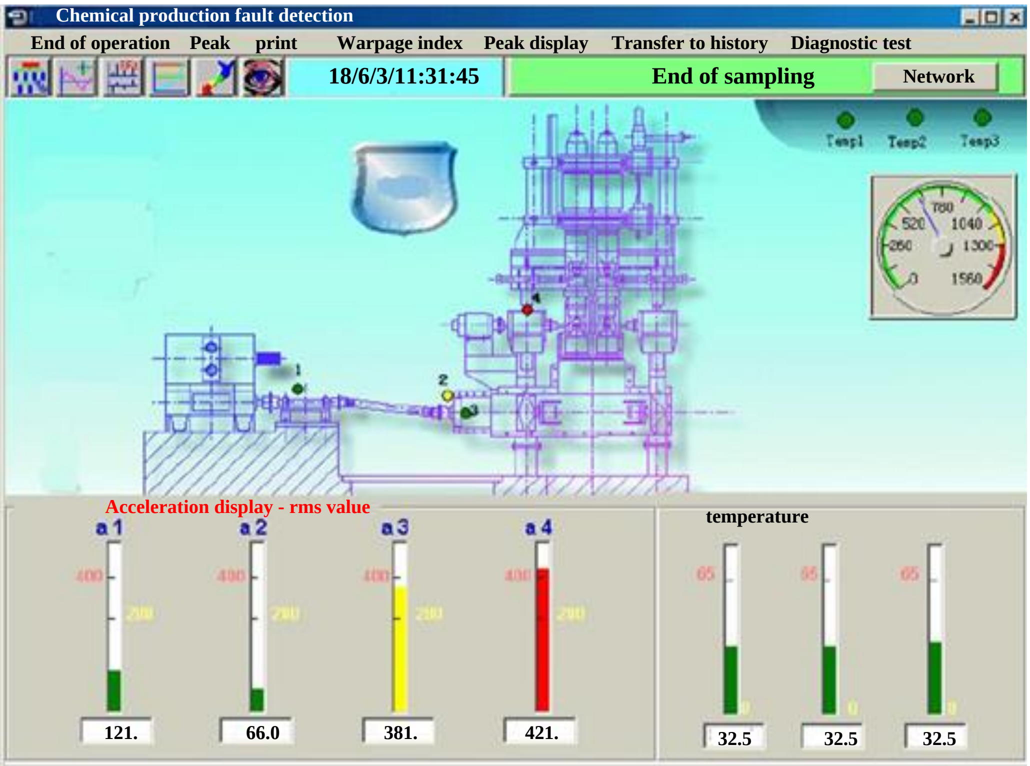

Figure 6: Industrial Process Control Software Interface

4. Conclusion

Based on the practical application of computer process control system, the fault characteristics of the system, the distribution of fault points and the diagnosis and maintenance of system faults are discussed. First of all, the fault characteristics of the computer process control system are the same as those of other automatic control systems. The occurrence of faults during the most part of the system operation is basically accidental and limited. The maintenance of the computer process control system is mainly to ensure the normal operation of the system. Through regular and irregular inspections, accidents can be effectively prevented and the operating efficiency of the system can be improved.

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