Research on the automation technology of intelligent instrument software development

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ABSTRACT

With the explosive development of computer software technology and microelectronics, the intelligence instrument software is asked to be intelligent, networked and integrated by the complicated industrial automation system so that software development becomes the busiest part on the process of intelligence instrument development. To lessen the workload, the research on the automation technology of intelligence instrument software development becomes the focus. Some mature software development automation tools have been invented, developing exclusive theory and system structure. Through the study on the development process of intelligence instrument, especially on the software development, this paper introduces not only the basic information and development of intelligence instrument but also all parts on the automation process of intelligence instrument software development. It also builds the automation model of intelligence instrument development and provides a practical advice to reduce the workload during the software development.

KEYWORDS

Intelligence instrument; Software development; Automation; Intelligence.

INTRODUCTION

Instrument is a device to obtain information. It is a system or equipment. Intelligence instrument is a measuring instrument with microprocessor or microcomputer. The functions of intelligence instrument include data storage, data computing, logic judgment, automatic operation and intelligence. With the current rapid development of industrial automation, industrial field instruments represented by intelligence instruments have gradually replaced the traditional instruments. The characteristic of the instruments is to have microprocessor system which can decrease the enterprises' demand of operators' ability under the circumstance of increasingly complicated industrial automation system. As developing, intelligence instrument has grown from data processing to knowledge processing which equips with higher level functions such as fuzzy judgment, fault diagnosis and the prediction of the life of machine components.

The different functions of intelligence instrument demand having different software, because software directly influences the intelligence level of intelligence instrument. Especially to the large intelligence instrument software development, the complexity is beyond current processing ability, even impossible to handle.

From the simplest instruction system design to the final system design, the current software development of intelligence instrument still depends on manual operation. Therefore, it is necessary to invent new developing methods to solve the difficulty of intelligence instrument software development. For instance, it can be assisted by auxiliary equipments such as CAD, CAE, CAM and CASE. In particular, CAE can solve complex interactive problems between projects. With the rapid development of computer system, CAE has stepped into a higher level, applied in the automation technology of intelligence instrument software development. TABLE 1 shows the common CAE used in the subsequent design.

TABLE 1 : The common CAE applied in software automation development

Time	Category	Name of CAE
Analysis phase	Signal	UMIST, SIPAC, KEDDC, DPACS-F, MATLAB
Design phase	Software	Realtime, Rhapsody, RATIONAL SYSTEMS DEVELOPER
	Hardware	Multisim, orcad, PCAD, Protel, Viewlogic, Mentor, Graphics, Synopsys, LSILogic, Cadence, MicroSim
	Software	Realtime, Rhapsody, RATIONSL SYSTEMS DEVELOPER, VISUALSTATE

THE DEVELOPMENT STATUS OF INTELLIGENCE INSTRUMENT

In recent decades, normal instruments combine with microprocessor system to develop intelligence instruments, which gradually replace the original cumbersome equipments on the industrial production. A large number of buttons and switches are removed and the appearance and the internal structure are improved. Intelligence instrument has gradually become the key element to increase the national economy and the priority of scientific research. Academician Wang Daheng said, "The creation of scientific instruments and equipments in high technology reflects the innovation ability of a nation and a country. It shall be considered as the national strategy to develop scientific instruments and equipments." Then, this paper discusses the development status of intelligence instruments.

The classification of the intelligence instrument

Intelligence instruments usually have four categories: smart instrument, primary intelligence instrument, modeling intelligence instrument and advanced intelligence instrument. The characteristics are as shown in Figure 1.
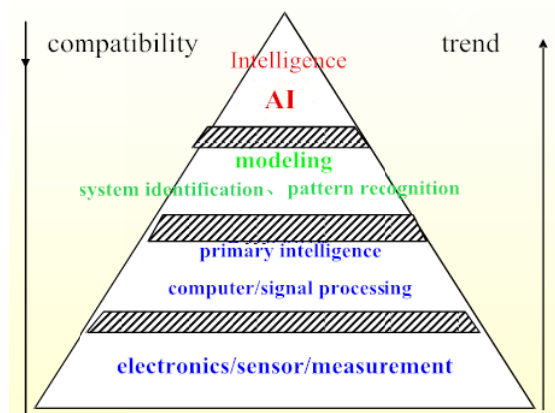

Figure 1 : The characteristics of intelligence instrument

The basic theory of intelligence instrument

In essence, intelligence instrument is an equipment to obtain information from unknown world and to transfer it to perceptive world. For example, convert the physical quantities such as temperature, pressure and flow into the visible digital quantities through microprocessor or SCM. In result, many kinds of sensors with different theories are applied. TABLE 2 makes a list for common sensors.

TABLE 2 : The classification of sensors

Sense	Sensor	Effect
Visual sense	inductive transducer; capacitive sensors	physical effect
Auditory sense	pressure sensor; magneto-dependent sensor	physical effect
Tactile sense	heat sensitive sensor	physical effect
Olfaction	gas sensor	biological effect
Gustation	taste sensor	biological effect; chemical effect

Intelligence instrument presents the electric physical quantities by these sensors, and amplifies or filters the physical quantities which finally display through the display device. The basic theory schematic is as shown in Figure 2. As is shown in Figure 2, the processing center of electric physical quantity must exist in every intelligence instrument system, which mainly converts the physical quantities unable to directly recognize such as temperature, pressure and flow into the information able to directly recognize and judge.
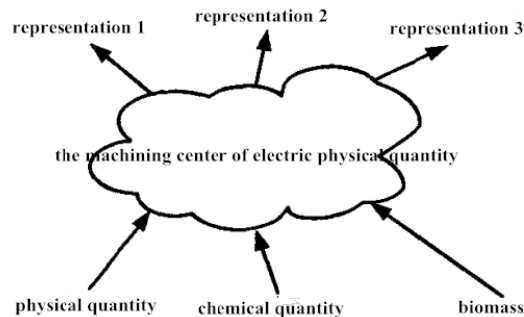

Figure 2 : The basic theory schematic of intelligence instrument

The engineering technology of intelligence instrument

Combined with the conception of the basic theory of intelligence instrument, intelligence instrument is defined in terms of engineering technology. To obtain the measurement, a set of signal circuit which is able to appropriately filter and amplify is designed, ensuring the signals passing through the particular sensors to be processed by the subsequent circuit.

In the engineering technology field, recognizing physical quantities such as temperature, pressure and flow is not enough. Moreover, multi different units need to be recognized and processed at the same time, which demands to cooperate with various intelligence instruments to work together. In terms of engineering technology, the components of intelligence instrument are as shown in Figure 3. It is shown that the common way to analyze the detailed information of the signal is to convert them into digital signals, then process by the digital signal processing technologies like the scale transformation and the average filtering, finally display in functional equipments such as human-computer interface and system communication.

Figure 3 : The components of intelligence instrument

The basic structure of intelligence instrument

At present, the basic structure of intelligence instrument can be divided into microcomputer embedded type and microcomputer extended type. The microcomputer embedded type is a single machine which combines single chip microcomputer or multi-chips microcomputer with instrument. The microcomputer extended type is a measuring instrument belonging to application extension type which considers the personal calculation as the core.

The development status and trend

With the rapid development of information science, nanoscience and material science, there is a tremendous revolution in intelligence instrument. In particular, new technologies have constantly been invented in the intelligence instrument field around the world, making the present intelligence instrument completely break through the traditional structure of light, machine and point, which develops rapidly in the direction of high-technology, intelligence, network, virtualization and multi-function. The main developing trend is as following:

(1)Diversify productions; the stability and reliability is increasing.

(2)Adopt virtual instrument to finish testing and measurement more effectively and flexibly.

(3)Portable, handheld and personalized customized intelligence instrument will come to people's lives.

(4)Measure and control unit becomes miniaturization and intelligence, available to utilize independently, embedded and by connecting to the Internet.

(5)The appearance of more and more multi-functional intelligence instruments can test several parameters at the same time.

(6)Measurement and control function develops into systematization and network.

THE AUTOMATION TECHNOLOGY OF SOFTWARE DEVELOPMENT

In 1980s, the software automation development technology of intelligence instrument came into people's life, and several methods of software automation development of intelligence instrument was provided, such as Object Modeling Technique (OMT), object oriented analysis and design, object oriented application design, object oriented analysis and object oriented design. Facing complex and complicated software system, it is still very difficult to develop automation completely, which has many reasons. There are two categories to understand the concept of software automation development technology.

The broad concept: the whole development process will be completed automatically, releasing mankind's work and leaving the most complex part to the computer system.

The narrow concept: automatically completing the executable program code realizes that the software functional specification proves the automation of the whole process.

The development method of software automation

The following aspects can realize the automation technology of software development.

(1)Decrease the traditional methods of software development; adopt new design ideas such as object oriented and component to improve the whole process.

(2)Replace the original work which must be completed by human beings such as model (production) mapping, switching and so on with automation or semi-automation so that it is convenient for advanced work to transfer bottom work as defined principles.

(3)Gradually improve and develop secondary automation. For instance, integrate the present automation tools of intelligence instrument software development to realize the advanced automatic design methods.

A series of software development automation tools gradually appears by utilizing the above methods such as UI automatic generation tool, automatic testing tool and so on. Generally, there are three developing methods as following, as shown in TABLE 3.

TABLE 3 : The development methods of automation

Design methods of automation development	Design ideas	Designer
component composition	Software Factory represented by Microsoft	Microsoft
tool integration	Integrate several software automation tools to form a new software automation tool, so don't need to construct complete software development automation method from the basis.	James Purtilo Richard Snodgrass
automatic model transformation	MDA proposed by OMG	OMG

The automation project of software development

The core design idea of the project includes that the realization of the connector of the signal processing software, the IVR model of the interactive interface and the production of automation. The whole design process is shown in Figure 4.
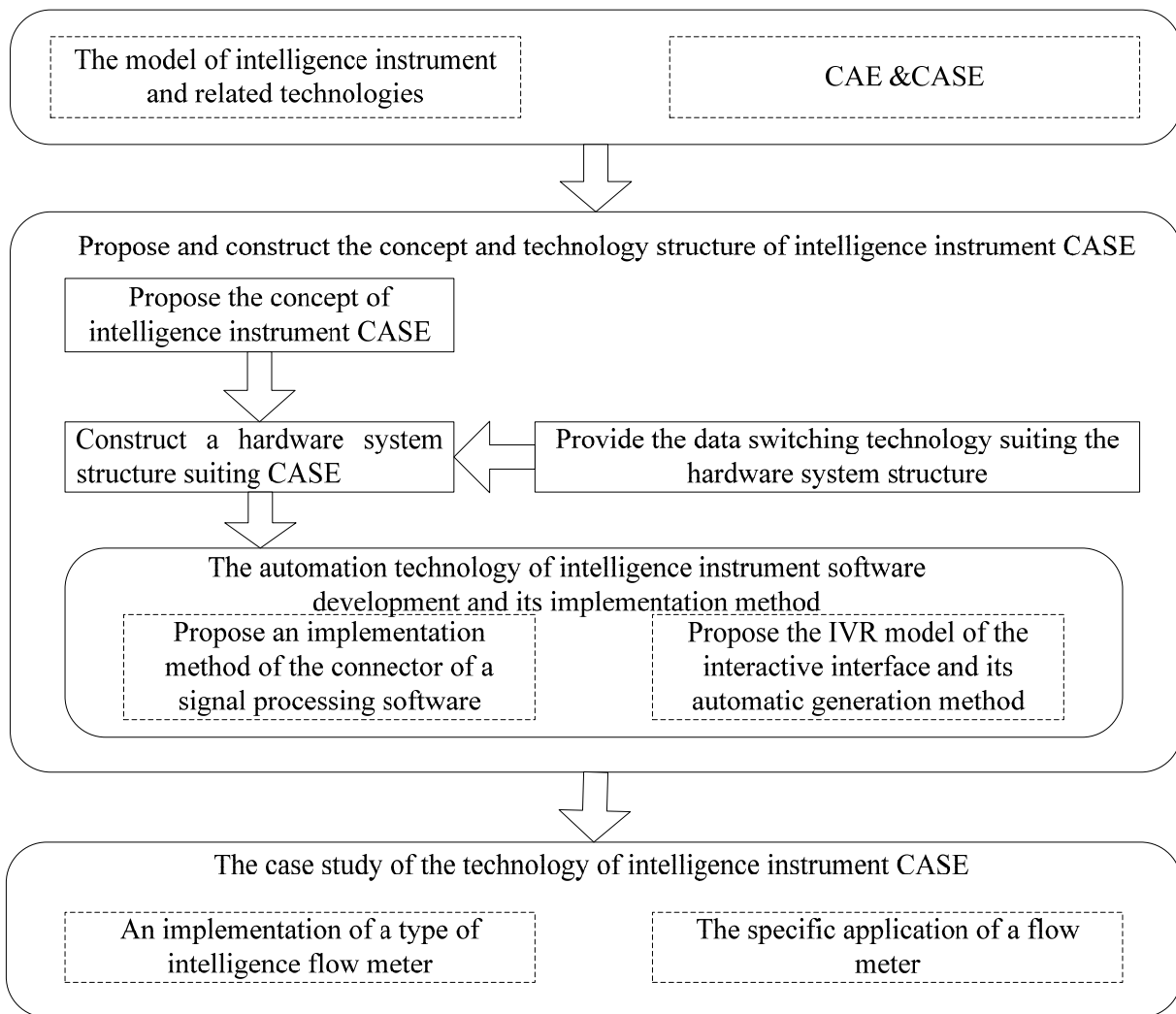
Figure 4 : The project schematic of software development automation

The specific research on the project of software development automation

In order to be easy for learning the project of the automation technology of intelligence instrument software development, this paper will research on two automation development technologies, signal processing and interactive interface model.

Signal processing

As far as we known, facing different physical quantities like temperature, pressure and flow, on the later process of signal processing, intelligence instruments appear various. The common signal processing circuit of intelligence instrument contains sensor, analog signal processing, AD/DA, controlling circuit, communication interface and so on. Generally, the basic schematic of signal processing circuit is shown in Figure 5.

Usually, output signal from sensor is so weak that it must fully be considered to eliminate and suppress the interference. The common ways to resist interference include the differential transmission method, isolated transmission method, shielding filter and so on. Preamplifier can amplify the weak signal outputting from sensor to decrease the interference of power frequency, static electricity and electromagnetism during long distance transmission.

In the system design of intelligence instrument signal processing software, the basic units of different levels can be taken as modules to be developed independently. Integrating and reconstructing the bottom modules can increase the efficiency of signal processing by the instrument. The signal system can be divided into system, decision, function and information. The specific structure is as shown in Figure 6.

We can see from the above information that the following steps are needed in order to realize the software development automation of signal processing:

(1)Construct the component library in the signal processing MCU;
(2)Realize the connection matrix of machinery production;

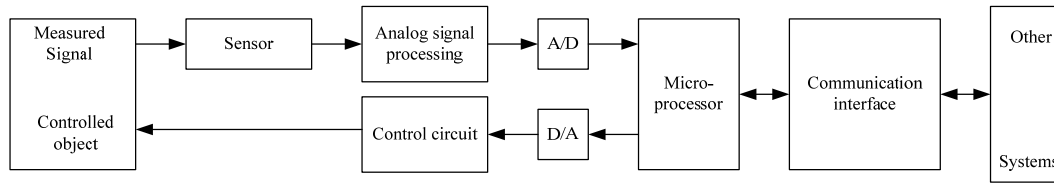(3)Utilize the connection matrix to assemble the components.

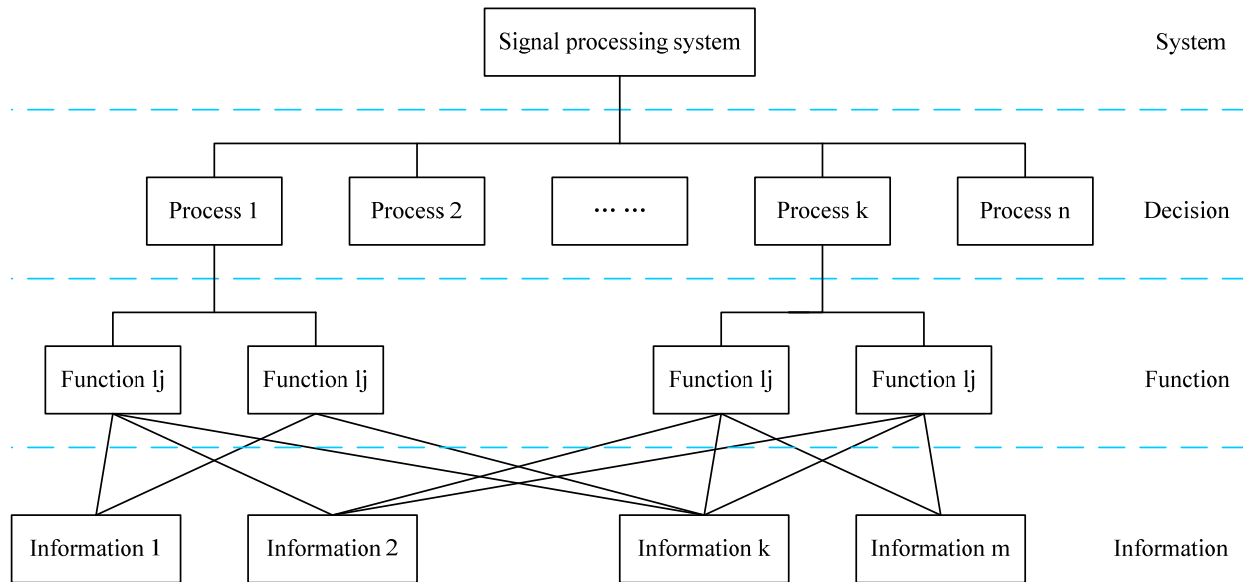**Figure 5 : The circuit process of signal processing**

Figure 6 : The hierarchical structure of signal processing system

Interactive interface model

      Interactive interface is the channel used to exchange information between human beings and intelligence instrument. Users can input information and operate the intelligence instrument through the interactive interface, while the intelligence instrument can provide information for users reading, analysis and judgment through it. Interactive interface is a comprehension way for users to understand the interactive interface system of intelligence instrument.

      With the development of information technology, interactive interface software has gradually developed from the original command language user interface to pictured interactive interface, direct operation interactive interface and multimedia UI, even the virtual reality technology, which are more conducive to recognizing the physical quantities as temperature, pressure and flow.

      The pictured interactive interface has already been the main trend of intelligence instrument. The present classical interactive interface is as shown in TABLE 4.

TABLE 4 : The classical interactive interface model

Name	Characteristics
Seeheim model	A software structure which has obvious departed interface and application presents the demanding logical components in Human-computer interactive interface. These components have different functions and description methods.
MVC model	Utilize the business logic, data and interface to present separated method organization code. Integrate business logic into one component. There is no need to rewrite the business logic as improving and personalized customizing interface and planning interaction.
PAC model	The concept model of multi-intelligent interaction can present the structure, functions and behave features of system by communicating, cooperating, dispatching, managing and controlling the intelligence instruments. It suits for the complicated and opening distributed system. An abstract description way can describe exactly the complex concurrent systems.

THE PROBLEMS OF SOFTWARE AUTOMATION DEVELOPMENT

With the increasing demands in the industry field, the design of intelligence instrument has become more and more complicated in result that its automation technology of software development is facing more difficult situation. Usually intelligence instrument software is an exclusive software system in a particular field, which is constructed to be a huge software system by signal processing software, interactive interface software and other similar communication software. Moreover, every particular field has exclusive data structure and algorithm. Therefore, the main difficulties confronting by intelligence instrument software reflect the following two aspects.

(1) The specific theory and the hardware system structure: the system design of intelligence instrument software is object-oriented, which means an exclusive software system in particular field. The current common software automation development theory structure cannot show its advantages in this aspect. It can only complete part of software automation development. Besides, the present intelligence instrument hardware cannot support thoroughly the tool of software automation development.

(2) The automation tool orienting software development: the development of software system is finished mostly by professional software engineers. Moreover, the present software development automation tool is still completed by these engineers. Only engineers in particular fields can realize its automatic development. It results that all software development automation tools cannot be applied by all the related people of intelligence instrument development, so the software development automation tool is disconnected with application.

CONCLUSION

The instruments as measuring devices at first not only promote the development of science and production, but also has become the complete instrumental science and technical discipline by the encouragement of modern science and technology and productivity. As a discipline to reflect the measuring and testing technology, the functions of instruments have been increasingly obvious in the word's economy and science and technology development.

Intelligence instrument software automation technology still demands a long term of development. Confronting with the fierce international competition, the science of national intelligence instrument is still in medium and low level. Only a few productions can approach the international level. Although many projects are carried out including the general software automation named Qingniao in Peking University, they are not produced in the commercial way. Therefore, this process demands to be discussed and researched by the national intelligence instrument industry. The tenth five-year-plan outline of the national economy and social development clearly proposed that it should take developing instruments as the key. Meanwhile, National Development and Reform Commission has also proposed that the automation controlling system and fine measuring instrument of the critical engineering are supported as special development.

With the enhancement of software automation development and the popularity of intelligence instrument, the value of intelligence instrument can be reflected in aerospace, military and medical treatment. In the coming future, intelligence instrument will equip with the features of multifunction and artificial intelligence, further replacing mankind's work and resolving the difficult problems in the traditional way.

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