Research and Implementation of Virtual Instruments Based on Agent Technology

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Abstract:
The virtual instrument based on agent technique has such characteristics like adaptability, coordinative and learnable abilities in addition to these inherent advantages of virtual instrument. This paper introduces the architecture of virtual instrument agent, the mechanism of multiple agents cooperation , the rules of auto-generation and competition of virtual instrument agents. This technique provides a solution of complexity for software design and difficulty for software maintenance, and enhances its expansibility, adaptability and life cycle of the virtual instrument.

Key words: agent, virtual instrument, breaker

1 Introduction

Virtual instrument [1] is a combination product in deep level of computer technique and instrument technique , and is a important technology in the field of computer aided test(CAT) today. It is a significant breakthrough about the traditional concept of instruments and also a revolution in respect of measuring instruments, which presentation decreases the difference between measuring instruments and computers. Virtual instrument brings the cooperation of various kinds of basic instrument units supplied by different manufacturers, enables simultaneous inputs of measure and control signals in various forms (such as numerical value, wave form, graphic and image), and realizes the data share.

The current virtual instruments are mostly designed for special objects [2] [3] to solve the special problems. To design an appropriate virtual instrument needs good knowledge of instruments and meters, specialistic computer technique and full comprehension to those problems to be solved. Once a virtual instrument be achieved, as well as it's hardware structure and software flowchart are fixed, this system can complete the predetermined task well, but there exist some disadvantages as follows:

Less adaptability, since virtual instrument has a long life cycle, and object is changed dynamically (such as process changes, parameters changes after virtual instrument used, environment changes, etc), it needs the ability to fit these changes to virtual instrument and its software.

Difficult expanding as user's new demands of increment or decrement of basic instrument units put forward, it should rebuild the virtual instrument and modify its software.

These problems affect directly the effect and life cycle of virtual instruments. In the testing and fault diagnosing system developed for the product of electric tripping device series STR22, we adopted the technique of virtual instrument agent and the two problems mentioned above were solved effectively. This paper introduces the architecture of virtual instrument agent, the mechanism of multi-agent cooperation, the rules of auto-generation and competition of virtual instrument agents and its practical effect of application.

2 Virtual instrument based on agent technology

2.1 The architecture of virtual instrument agent

The agent technology is a new method to analyze, design and establish a complex software system [4] [5] [6] . In recent years, the agent technology is followed with interest by people, and applied to many fields successfully. In addition to these abilities of autonomy, predication and response, the agent technology has a few qualities such as learning, cooperation and movement. These are what the virtual instruments need. The virtual instrument agent-based technology would define two agent sets at least: one is **task agent** set and the other is **virtual instrument agent** set**.**

Task agent uses initiative system structure, as figure 2-1 illustrates. Task agent is concerned in description of problems to be solved, which is fulfilled by user or by user together with software engineers. Task agent may be in any form, even with hidden and fuzzy representation, that is favorable for user's acceptance, description and easy to maintenance.

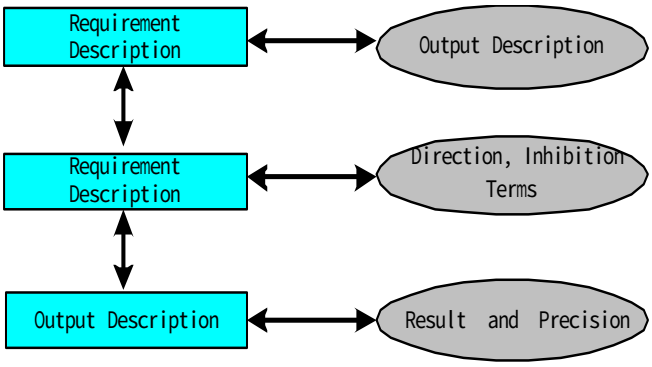

Figure 2-1 Task Agent

Virtual instrument agent uses response system structure, as shown in figure 2-2. There are multiple virtual instrument agents in one system, in which every virtual instrument agent, based on one or some basic unit instruments, can compose a new agent with other virtual instrument agents. These agents work as follows: perception layer matches the task or derivative task of task agent with the intension located in intension library, and then using the resources and control mechanism itself in the case of no external direct operation, they infer and conjecture with the methods located in methods library according to internal status itself and external surrounding information perceived. Every agent associates with other agents in a special language, cooperates with each other and accomplishes the task of every layer together.

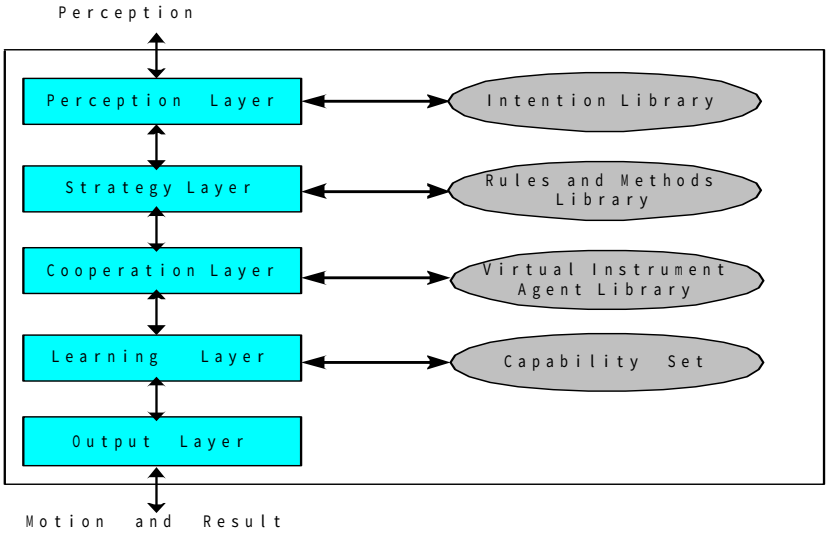

Figure 2-2 Virtue Instrument Agent

2.2 Mechanism of multiple agents cooperation

In multiple agents system, cooperation mechanism can increase the integrative performance, rise its capability to solve problem of the composed system, that enables the system more flexible and to be applied to more practical course [7] .The composing method of multiple agents body is different according to the mechanism of association and cooperation. This system adopted the simplified model of multiple agents cooperation, the model is formed as follows:

$$M = \langle Ag^{s}, Ag, Ag^{n}, (T, \overrightarrow{A(x)}, \overleftarrow{A(x)}) \rangle$$

M – model of multiple agents cooperation.

Ag^{s} – upper agent, there are n agents ($n \geq 1$) that can fulfill the intention in the system.

Ag – agent that meet the intention of Ag^{s}, which entering into work state is evaluated by $(T, \overrightarrow{A(x)}, \overleftarrow{A(x)})$.

Ag^{n} – lower agent that can fulfill the diagnosing task joined with Ag, there are m agents ($m \geq 1$) conformable in the system.

$(T, \overrightarrow{A(x)}, \overleftarrow{A(x)})$ – quantification function that coordinates agents, T is the time grade function ($1,2\cdots\cdots10$) to accomplish the diagnosing task, $\overrightarrow{A(x)}$ is the satisfaction degree for upper agent, $\overleftarrow{A(x)}$ is the satisfaction degree for lower agent, they may be a value or a logic formula.

The cooperation mechanism of this system didn't give consideration to optimum diagnosing path, for it needs only to accomplish testing and fault diagnosing in few steps. The quantification function coordinating agents in the testing and fault diagnosing system of the products of electric tripping device series STR22 is:

$$(T, \overrightarrow{A(x)}, \overleftarrow{A(x)}) = 0.5/T + 0.25\overrightarrow{A(x)} + 0.25\overleftarrow{A(x)})$$

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2.3 Rules of auto-generation and competition of virtual instrument agents

The generation and live of agents in the virtual instrument agent set are dynamic. In the initial stage of the system, it constructs N agents in accordance with the number of the basic unit instruments. In the operating stage of the system, it generates new agent and add it to the virtual instrument agent set after add the basic unit instrument agents to the agent set and multiple agents fulfill a task by cooperation successfully. The same as deleting a basic unit instrument, it will delete all agents with relation to the basic unit instrument from the agent set. In general case, the virtual instrument agent set will expand constantly and it needs to establish a competition rule. The competition rule we adopted is: giving every agent a weight; it will add 1 as the agent fulfilled a task successfully; when eliminating needed, the agent of lowest weight is sifted out.

3 Example of application

The electric tripping device series STR22 consists of mutual inductors(CT), electric circuits, plastic shell and other auxiliary elements etc. Now it includes 18 specifications products of three poles and four poles according to pole number. Its rate current AC ranges from 67A to 418.5A. Some products are still in developing stage and the parameters are unknown. When tripping device works, the output of tripping signal is 20VDC, which output terminal is called MITOP. For ensuring the normal work in the assembling procedure of breaker products, the electric tripping device is also fit with some plastic spare parts (BPVIGI). According to user's demand, we developed the testing and fault diagnosing system

of the electric tripping device series STR22, its general structure is shown as figure 3-1:

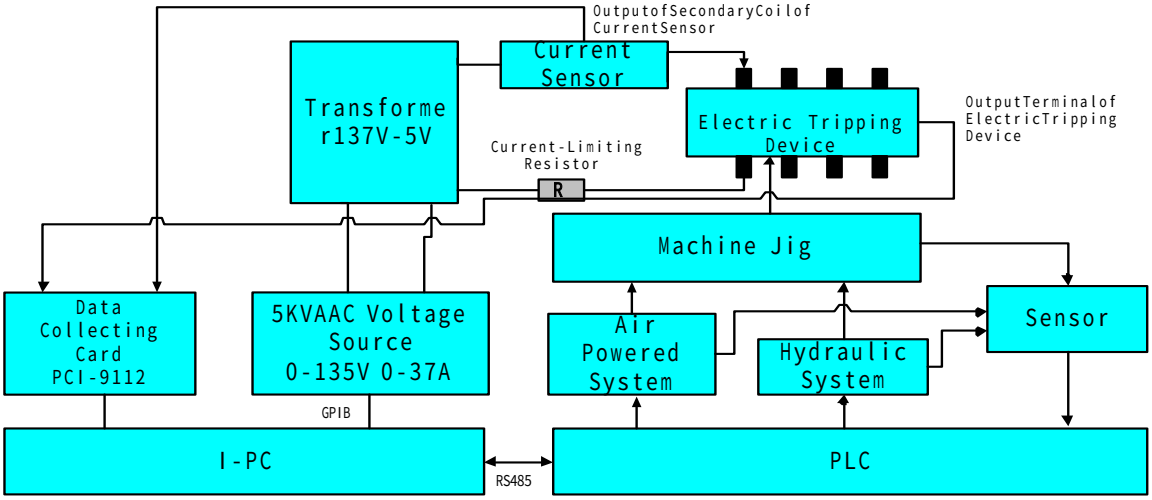

Figure 3-1 the general system structure

In the system the virtual instrument agents cooperate each other and realize auto test, single-step test and manual test of the electric tripping device series STR22. Here we introduce some main agents as follows:

Product type testing agent, to scan barcode of the products and read the coding information on the shell, compare the two pieces of information with those in products information library, allow the matched products to next test and the unmatched to learning.

Electricity building agent, the technical specification of electricity building includes wide range: 0-500A, high precision: $\pm 1\%$, time of rate current: 60ms. The basic hardware composition is 'high precise AC voltage source + transformer + current_limiting resistors'. In which the rate power of the source (California Instruments 5001i) is 5KVA, voltage output range is 0-135V, current range allowed is 0-37A, output precision is $\pm 0.5\%$, resolving power of output voltage is 0.1V. Transformer rate is 27.4, the secondary output voltage of the transformer is 4.93V when the source maximum output is 135V**.** There exist two current-limiting resistors in testing circuit, 0.005Ω/1000W and 0.03Ω/500W, which are applied to gain wide testing current range. The load resistance value of the testing circuit would affect directly the testing current value in case of the same output voltage, so the agent of electricity building should learn continuously to meet the followed changes of load resistance value: such as a tolerance of the position of workpiece, wear of the tong, temperature of copper array and changes of internal parameters of STR22.

High speed dada collecting agent, to measure the current value at regular intervals and catch the light-electric signals of workpiece position at high speed.

Waveform display agent, to simulate the function of oscilloscope, display on line and store various waveforms, distinguish unusual waveform by comparing with those in waveforms library.

Air units motion agents, to complete the various motions of workpieces in testing process (such as positioning, forwarding, prepressing, releasing, etc.)

Hydraulic unit motion agents, to control the operations of hydraulic station, hydraulic circuit, oil cylinders and hydraulic pressure sensors, give the motion of gripping the product to be tested and ensure the gripping pressure above 250Kg, check the statuses of oil basin, motors, pressure pumps, back valves, electric-magnetic valves and pressure meters.

Fault checking agent, to check the fault information of products by threshold value, output the fault information and refresh the fault information library.

Data processing agent, to calculate various kinds of

data and store them in the spare time of the computer.

We designed the software by use of the integrated developing environment **Agentbuilder** [8]. **Agentbuilder** consists of two main parts: run system and developing tool packet. Using developing tool packet we can realize such functions: to define the behavior of single agent; to design and develop interactive and cooperative agent network; to manage the developing process based on agent; to debug and test the software agent-based system. There is a agent engine in this run system, which affords run environment for agent software. The agents built by **Agentbuilder** communicate each other in **KQML** (Knowledge Query and Manipulation Language) language, and it is also allowed to define new interactive communicating commands by developer in demand. Figure 3-2 shows the output interface of a virtual instrument agent.

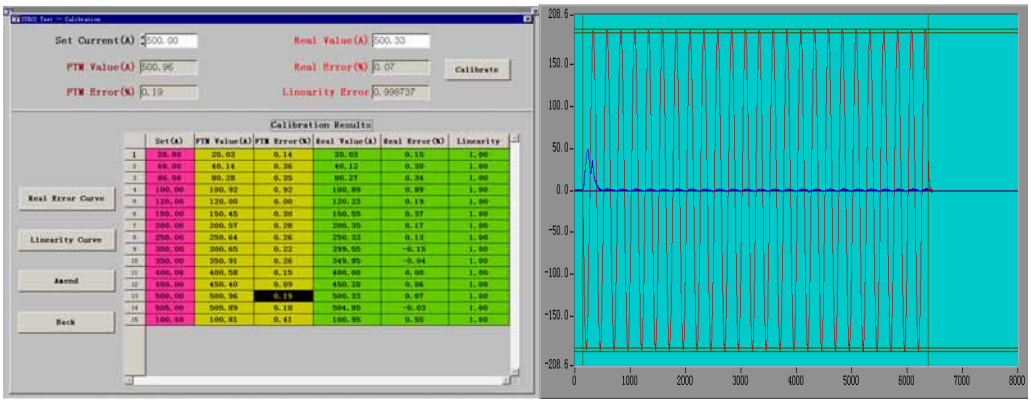

Figure 3-2 the interface of a virtual instrument agent

After the testing and fault diagnosing system of the electric tripping device series STR22 was put in use in August, 2003, it has been added three sets of German FESTO air elements, two sets of light-electrical sensors of French Scheider Corporation and five products of new specification by user. The addition of new instruments and testing of new products were put successfully without modifying the software.

4 Conclusion

In recent years, the agent technology is followed with interest by people, and applied in many fields successfully. It has not been reported about virtual instrument based on agent technique. The virtual instruments based on agent technique, carrying on the advantages of virtual instruments, have more adaptability, cooperation and learning properties, and enhance the expansibility, adaptability and life cycle of virtual instruments. The mechanism of multi-agent cooperation is the key problem that brings every agent into full play and enables the system in optimum status. The mechanism of multi- agent cooperation and the learning mechanism this system adopted are still simple, they would be developed further.

5 Reference Literature

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