第27届中国控制会议论文集

Proceedings of the 27th Chinese Control Conference

第七册

Volume 7

主　编　程代展　李　川

副主编　陈　杰　段广仁　黄　捷　贾英民　李少远

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内容简介

本书共收入1026篇论文。这些论文经过中国自动化学会控制理论专业委员会组织评审，为第27届中国控制会议正式发表论文。论文内容包括系统理论与控制理论，非线性系统及其控制，复杂性与复杂系统理论，分布参数系统，混杂系统与DEDS，大系统，随机系统，稳定性与镇定，建模、辨识与信号处理，最优控制与优化，鲁棒控制与 H_∞ 控制，自适应控制与学习控制，变结构控制，神经网络，模糊系统与模糊控制，模式识别，控制设计方法，遗传算法与演化计算，运动控制，智能机器人，分布式控制系统，信息处理系统，故障诊断，通讯网络系统，CIMS与制造系统，交通系统，生物与生态系统，社会经济系统，工业系统等领域的应用研究成果。

本书可供从事自动控制理论及应用研究的高等院校教师和研究生、科研单位的研究人员以及工业部门的工程技术人员研究参考。

本书进入IEEE会议出版程序，论文可从IEEE Xplore下载。2006年起，CCC论文集被EI(Enginnering Index)收录。

图书在版编目（CIP）数据

第27届中国控制会议论文集/程代展,李川主编.—北京：北京航空航天大学出版社，2008.7

ISBN 978-7-81124-390-1

Ⅰ.第… Ⅱ.①程…②李… Ⅲ.自动控制理论—学术会议—文集 Ⅳ.TP13-53

中国版本图书馆CIP数据核字（2008）第093148号

IEEE Catalog Number: CFP0840A

第27届中国控制会议论文集

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　　赵千川　黄　一　刘智敏

责任编辑　沈　涛　刘　标

北京航空航天大学出版社出版发行

北京市海淀区学院路37号（100083）　发行部电话：010-82317024　传真：010-82328026

http://www.buaapress.com.cn　E-mail:bhpress@263.net

涿州市新华印刷有限公司印装　各地书店经销

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开本：890×1240 1/16　印张：315　字数：10 201千字

2008年7月第1版　2008年7月第1次印刷　印数：600册

ISBN 978-7-81124-390-1　定价：990.00元（全七册）

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Proceedings of the 27th Chinese Control Conference
July 16-18, 2008, Kunming,Yunnan, China

On Operation Ticket Expert System for a Substation Using Object Oriented Technique*

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Abstract: In order to increase the accuracy of creating operation ticket program, improve the general utilization of system, an intelligent operation ticket expert system for power substation is presented in this paper. The system is developed by VC++ and SQL database using object oriented programming technique. For using the knowledge of the experts in real-time control, the fuzzy control technology is adopted. For the disadvantages of generative rule, the knowledge representing method of " rule skeleton plus rule body" group is also used in the system. The system is easy to use and maintain. The experiments show that it is an accurate, convenient and universal system for power substation.
Key Words: Substation, Operation ticket ,Expert system,Rule group, Fuzzy control, Object oriented

1 INTRODUCTION

In order to increase the accuracy of creating operation ticket program, improve the general utilization of system, an intelligent operation ticket expert system for power substation is presented in this paper. The system is developed by VC++ and SQL database using object oriented programming technique. For using the knowledge of the experts in real-time control, the fuzzy control technology is adopted. For the disadvantages of generative rule, the knowledge representing method of " rule skeleton plus rule body" group is also used in the system. The system is easy to use and maintain. The experiments show that it is an accurate , convenient and universal system for power substation.

2 OVERALL STRUCTURE OF OPERATION TICKET EXPERT SYSTEM SUBSTATION

The total structure of operation ticket expert system for substation is modular[1]. It consists of eight modules, they are parameter base module, network topology searching module (NTS), operation knowledge module, logic inference machine module, running and maintenance module (R&M), SCADA communication module (SCADA-C), network analyzing algorithm module (NAA) and operation ticket producing module. It is described as Fig.1.

The parameter base module includes first equipments base, secondary equipments base and language base. First equipments base contains the name, serial number, voltage grade and interval, whether or not related to secondary equipments equality attributed of the first equipments, such as breaker, switch, transformer, line, bus and so on. Secondary equipments base contains protection strap, control insurance and secondary switch and so on. Language base contains operation technical terms and so on.

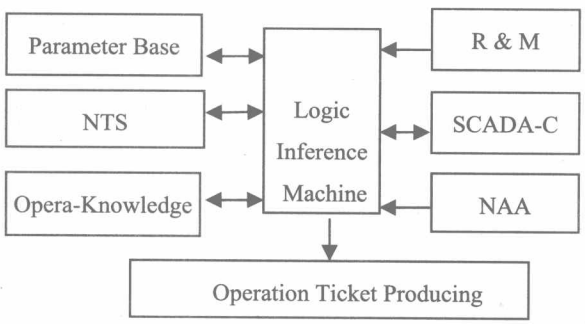

Fig. 1 Overall structure of operation ticket expert system for substation

Network topology searching module includes figure interface, topology linking and dynamic state color. First and secondary wiring figures of substation interfaces the user with figure pattern, intelligently follows the tracks of interval change situation on line, dynamic establishes topology linking on line, automatically applies five preventing incorrect tripping logic to produce operation ticket, and colors different interval electricity component automatically according to different running pattern.

Operation knowledge module includes five preventing incorrect tripping knowledge, running knowledge and knowledge learning. Running knowledge includes the rules and regulations which must be abided by the duties, attention items and the technical ability and so on. Knowledge learning expands and modifies the content of knowledge base to increase knowledge automatically.

Logic inference machine module is a group of programs to control and coordinate the whole expert system, it is the core. It adopts frame inference method to get answer according to the knowledge in knowledge base.

Running and maintenance module is a man-machine interfaced module. It is the interface between the expert system and outside, its main function is to exchange information between system and outside world. User

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Project supported by the Science and Technology department of Hebei 06273523.

interface adopts personification design, it operates conveniently.

SCADA communication module can communicate and exchange data by series port or network port with monitor system and management information system. It can reflectes the real fact of spot on line, it also can work in off line pattern and run independently as a simulation system.

Network analyzing algorithm module uses TCP/IP stack to connect network in C/S mode, which makes system more reliable, convenient and securer.

Operation ticket producing module produces correct operation ticket according to logic relation deduced by inference machine through imitation operation and automatic performance.

3 SOFTWARE DESIGN OF OPERATION TICKET EXPERT SYSTEM FOR SUBSTATION

3.1 Knowledge representation and inference of "rule skeleton plus rule body" rule group

The knowledge representation mode of "rule skeleton plus rule body" is put forward by Mr Xiong Fanlun in the "development tool of the agriculture fertilizer expert system". Its general indication pattern is described as follows:

rule group ::= <rule skeleton><rule body>

in the formula, ::= indicates "definite", | indicates "or"

rule skeleton ::= 'IF' <premise factor sets> 'THEN' <conclusion factor sets>

premise factor sets ::= < premise factor>|< premise factor>< premise factor sets >

conclusion factor sets ::= < conclusion factor >|< conclusion factor ><conclusion factor set>

rule body ::= <operation formula sets><rule body>|<body rule><rule body>

body rule::= 'IF' <premise sets> 'THEN' <conclusion sets>

premise sets ::= < premise >|< premise >|< premise sets >

conclusion sets ::= <conclusion>| <conclusion>< conclusion sets >

Electricity devices in substation have four states, they are running, hot standby, cold standby, overhaul state, and the state is decided by the state of breaker and disconnecting switch. Switching operation is a state transform process from one to another according to certain regulations. This rule group is described as follows:

rule skeleton:

IF running state, hot standby state , cold standby state or overhaul state

THEN breaker, disconnecting switch, soil line, sign brand, temporary block

rule body:

IF running state THEN breaker is on∧disconnecting switch is on

IF hot standby state THEN breaker is off∧disconnecting switch is off

IF cold stangby state THEN breaker is off∧ disconnecting switch is off

IF overhaul state THEN breaker is off∧disconnecting switch is off∧assemble soil line∧hang sign brand∧install temporary block

3.2 Fuzzy rule inference technology[4]

Attaching importance to inference in real-time fuzzy control, expert subjective fuzzy character is indicated by subjection functions. Thus, expert knowledge is recorded and narrated with former part which consists of "if" and latter part which consists of "then" in the fuzzy rule. For example, electricity device is indicated by the following operation rules from running to cold standby state[3]:

Rule.1 : if (switch is on) & (breaker is on) then electricity device is running

Rule2 : if (electricity device is running) then break switch if (switch is off) & (busbreaker is on) & (loadbreaker is on) then break loadswitch

if (switch is off) & (busbreaker is on) & (loadbreaker is off) then break busswitch

Thus we complete the switching operation of electricity device from running to cold standby state. And this operation order is completely decided by the following principles: (1) absolutely forbid operating disconnecting switch with load (breaker), giving and stopping electricity can only use breaker or switch connect break load current; (2) stopping electricity orders: switch, loadbreaker, busbreaker; giving electricity orders: busbreaker, loadbreaker, switch busbreaker.

3.3 Analysis and design based on object oriented technique[2]

The knowledge of expert system is not aimed at specific electrical devices. It adopts the class method in C++ language to divide electrical devices into different classes[5]. In this paper, it adopts the object oriented technique. Firstly we definite a substation class, then derive first device class and secondary device class from it. For example, first device class can derive bus class, line class, breaker class, switch class, transformer class and so on according to device type in substation. Then we definite subclass from these device classes. For example, we can derive busbreaker class, linebreaker class, soilbreaker class, besidebreaker class and so on from breaker class. It is described as Fig.2.

Class is described as follows:

```
Class CSwitch:public CSubstation
{
 protected:
  CString m_switchName; //switch name
  CString m_switchType; //switch type
  CString m_switchNo ;  //switch number
 Public:
 CSwitch();
  Virtual~CSwitch();
  Virtual void draw Switch
   (CDC * pdc,CSize size=CSize(0,0)) ; //drawing switch
  Virtual BOOL Switchstatus () ; //getting state of switch
  Virtual BOOL Switchrule () ; //sealing rule of switch
 operation
};
```

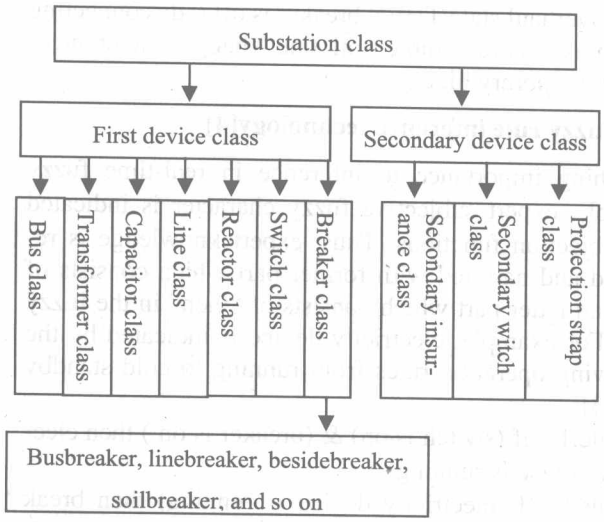

Fig.2 Class deriving chart in system

4 CHARACTERS AND FUNCTIONS OF OPERATION TICKET SYSTEM FOR SUBSTATION

4.1 It fully uses strong modern computer graphical user interface function and senior dispatcher's rich experience of electrical system, it only need simple operation for operator to produce operation ticket with mouse. It can also do imitation training of the process to produce operation ticket. In the course of producing operation ticket and imitation training, it can provide judgment function of incorrect tripping, find fault and usreasonable operation, thus derease loss of power network benefit because of incorrect tripping.

4.2 This system adopts whole graphical mode to produce operation ticket, it can produce various correct operation tickets according to running mode and practical situation of power system. It can produce operation ticket not only in real system, but also when system is off line. It has intelligent producing function, single step producing function and self definite maintenance function of typical ticket. Operation tickets can be saved as text file or in database, user can examine, classify, inquire, count and print the tickets.

4.3 The system provides operation replay function. Through establishing a demo environment for complete operation process or a certain operation ticket, it shows the state of first and secondary devices on the screen by graphical interface. Main joint figure and switch, breaker, soil breaker, soil wire and protection strap component on the screen can shine, change seat or dynamically add and delete to produce a direct observation for operator to familiarize and examine the operation process.

4.4 It has the function of figure maintenance of first side and secondary side system. The system contains all connection modes and it can expand by demand. When increasing new substation or device in power system, it only need increasing relevant installing in parameter base. So it can adapt the development demand of power network.

5 EXAMPLE OF OPERATION TICKET EXPERT SYSTEM FOR SUBSTATION

This expert system has two mode to produce operation ticket, they are:

5.1 Graphical imitation mode (locate place → imitation → imitation operation →automatic perform → write operation assignment name → produce sequence).

5.2 Auto mode using typical ticket (locate place → imitation → select typical ticket → automatic perform → produce sequence).

It must imitate before producing the switching operation ticket to insure the security for whichever mode.

Taking graphical imitation mode as example, the operation task is to change dazhangzhuang 512 switch's mode from running to cold standby. The process is as follows: drawing first joint figure in drawing module of expert system to make 512's state same to current situation, then using mouse to simulate operation in Fig.3; performing automatic imitation after operation as Fig.4, operation editor interface will appear after successful automatic imitation, finally correct operation ticket is produced as Tab.1.

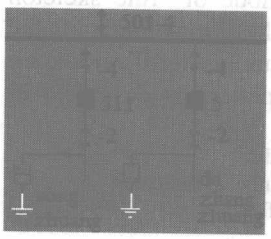

Fig. 3 First joint figure

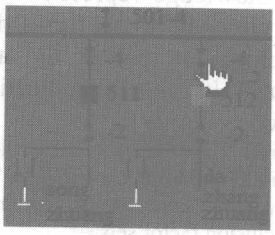

Fig. 4 Automatic performing figure

Tab.1 Switching operation tichet
Unit: Zhangliu substation number:2007002

Commander		receiver		time	
Operation beginning time:			Operation over time:		
( )operation in the control ( )single person operation ( )examiner and repairer operation					
Operation assignment: dazhangzhuang 512 switch change from running to cold standby					
Order	Operation project				√
One	Breaking 512 switch				
Two	Examining 512 switch is off				
Three	Breaking 512-2 breaker				
Four	Examing 512-2 breaker is really off				
Five	Breaking 512-4 breaker				
Six	Examing 512-4 breaker is really off				
Memo:					
Operator: guardian: person in charge on duty (work leader):					

6 CONCLUSION

The operation ticket system in power system is an important measure, it is very necessary to develop an operation management system which is highly reliable, easy to use and maintain. In this paper, it introduces such an intelligent operation ticket expert system which adopts "rule skeleton plus rule body" knowledge representation method, combines with fuzzy control inference technology and using object oriented technique. The system has friend interface, and it is simple and reliable. It is also easy to master and maintain for operator, it has highly general utilization, so it can be used in various voltage grade substations.

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