

A Neural Networks Based Operation Guidance System for Procedure Presentation and Validation

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1. Introduction

In this paper, a neural network based operator support system is proposed to reduce operator's errors in abnormal situations in nuclear power plants (NPPs). There are many complicated situations, in which regular and suitable operations should be done by operators accordingly. In order to regulate and validate operators' operations, it is necessary to develop an operator support system which includes computer based procedures with the functions for operation validation. Many computerized procedures systems (CPS) have been recently developed [2]. Focusing on the human machine interface (HMI) design and procedures' computerization, most of CPSs used various methodologies to enhance system's convenience, reliability and accessibility. Other than only showing procedures, the proposed system integrates a simple CPS and an operation validation system (OVS) by using artificial neural network (ANN) for operational permission and quantitative evaluation.

2. System Construction

The recent development of information technology accelerates the design innovation in NPPs. More and more digitalized systems have been developed and installed, especially in I&C systems. In control room, instead of large button panels, more computerized compacted systems were going to be used. In order to reduce operators' errors under overwhelming pressure in abnormal environments, many CPSs have been developed. Our proposed system mainly includes two parts: the traditional CPS, and its affiliated OVS.

2.1 Computerized Procedure System

Some general rules for developing CPS have been given by Yuji Niwa et al [1]. A CPS should have an easily accessible and understandable HMI. Operator could conveniently access each procedure with enough but limited information extent. The information for each screen could not be so much; otherwise it would possibly confuse operators. In our prototype design, only two main panels are used (Fig.1). The left panel is used for showing all steps, which could be quickly and directly accessed by operators. The main panel in the middle of the screen is separated into two parts: the upper is for caution and the lower is presenting detail procedures of each step. After CPS was started, the first step would be shown. Operators need to follow the

procedures step by step and fill the checkbox one by one. In each step, if an operator does not fill some necessary checkboxes, he/she could not continue to go to next step.

In emergent environments, it is a general requirement that operators refer to emergency operating procedure (EOP), following its guide to appropriately do validation and operation. Omission errors and commission errors sometimes would possibly happen by using the paper based EOP. One of the design objectives of CPS is to avoid these errors. Checkboxes in procedures could help reduce these errors (Fig 1). However, too strict procedures were not recommended [1]. One reason is that operators sometimes need to check the previous procedures to decide the current action. The other reason is that over strict order of procedures would eliminate the creativity of some experienced operators. How to relieve the dilemma? OVS is therefore proposed.

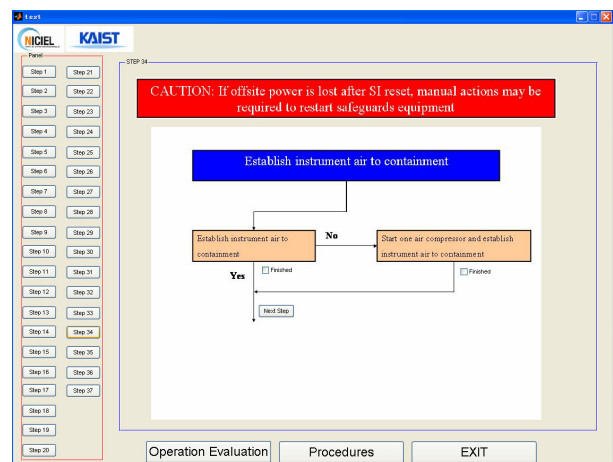


Figure 1. Computer Based Procedure

2.2 Operation Validation System

The objective of developing OVS is to provide an advisory system when operators want to do some operations which are not included in the EOP. Hence the commission errors could be reduced to some extent. The system provides two functions: operational validation and quantitative evaluation.

Operational validation is in a simulated environment. Operator could do operations and check the corresponding results. The main algorithm is demonstrated in Fig.2. Firstly, operator's action would be examined by database to decide whether it is included in EOP or not. The operations included in EOP

are considered to be necessary and would be permitted at once. After permission operator should decide whether to validate and confirm the operation or not. The operations not included in EOP would not be directly permitted. OVS would automatically give the simulated results and ask the operator to confirm his action. An example was given in Fig. 2: reactor coolant pump 1 (RCP1) was tried to turn off by operator during LOCA. OVS provides the possible results by simulation and asks for the confirmation from operator.

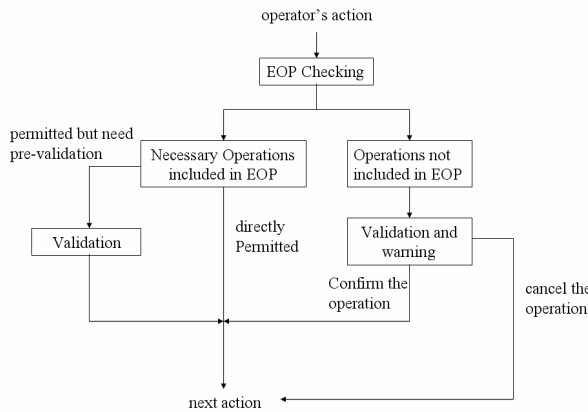


Figure 2. Algorithm in Operational Validation

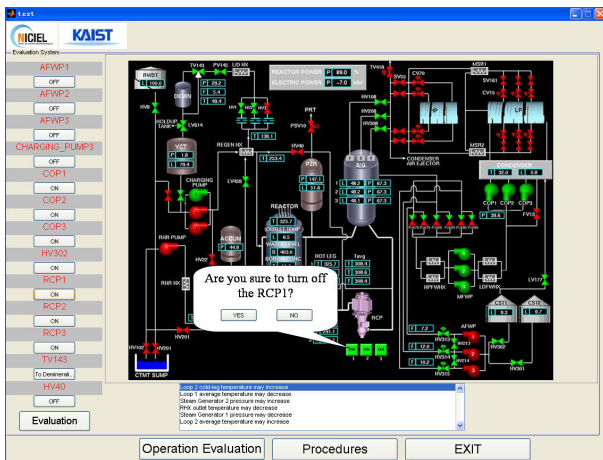


Figure 3. An Example of Operational Validation

Quantitative Evaluation is to simulate the trend of some key plant parameters under operators' action. This function provides operation's long time quantitative effects other than qualitative reports to the operator. Fig.4. gives the quantitative evaluation results after turn off the RCP1 during LOCA. The red curve in the figure shows original trend without any action, while the red one shows the changed trend after RCP1 is turned off.

The basic algorithm used in developing the CVS is ANN. The training data was obtained from compact nuclear simulator (CNS). With an inherent advantage of noisy tolerance, ANN has been widely used in control, pattern recognition and signal processing, etc. Another reason for using ANN here is that the time for

simulation is comparatively short. Compared to traditional expert system, ANN could generate the results quicker.

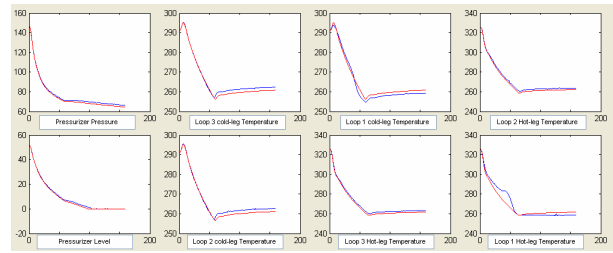


Figure 4. Quantitative Evaluation

3. Conclusion

Both operational validation and quantitative evaluation gave satisfied results during system tests. In the mentioned example (Fig. 3 and Fig.4), quantitative evaluation provides the trend of Loop 2 cold-leg temperature which increases faster than the original one as expected. The symptoms fit the experimental data well.

A prototype of integrated operation validation system based on neural networks has been developed. Two operator support systems are included: CPS and OVS. The system employed the ANN other than traditional expert system to establish the validation and evaluation functions.

In previous research, a fault diagnosis system based on dynamic neural network aggregation model has been established and would be linked to the OVS as integrated operator support system in future development. In the prototype system, only the most widely used multi-layer perceptron (MLP) are used. More types of ANN would be used and compared in future research.

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