A Diagnosis Support System for Abnormal Situations of Hanbit Units 3 & 4

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1. Introduction

When an abnormal situation occurs in a nuclear power plant, the operators in the main control room (MCR) diagnose the cause of the abnormal situation based on the occurring alarms. However, because there are many different alarms and abnormal operating procedures (AOPs) in an MCR, it is necessary to develop education techniques or diagnosis supporting tools for aiding operators to efficiently cope with abnormal situations. Owing to the recent development of new power plants and new human resources, the necessity of these techniques and tools has been magnified.

There have been some efforts to support operators in diagnosing abnormal situations from annunciated alarms [1-3]. This paper introduces an integrated system that not only educates operators but also aids operators in searching AOPs under actual situations. For the purpose of education, this system provides flowcharts to find an AOP from annunciated alarms and a mimic alarm window that displays annunciated alarms during a selected abnormal situation. For the purpose of aiding a real-time search, this system has a function that shows AOPs related to the inputted alarm data and calculates the similarity of the AOPs and the alarm data.

The system was implemented by Livecode 6.1 [4]. A flowchart of the AOPs was generated through the C 5.0 package in R software [5]. The data about the alarms and AOPs were obtained from Hanbit units 3 and 4.

2. Developed System

2.1 Flowchart of AOPs

The flowchart describes how to find an AOP from annunciated alarms. The first page of the flowchart presents rhombuses that ask at which upper layer any alarm was annunciated (refer to as Fig. 1). Through the following first flowchart, the user can find a category of AOPs such as a 34 or 35 system related with the given alarms. When the user selects a category, the system provides a detailed flowchart that asks which alarm was annunciated and answers which AOP is related. This flowchart was developed using C 5.0, one type of algorithm used to generate a decision tree [6].

2.2 Mimic Alarm Window for AOPs

The mimic alarm window displays all AOPs in Hanbit units 3 and 4 (Fig. 2). When the user selects an AOP in the left field, the system shows which alarms are related and where they are.

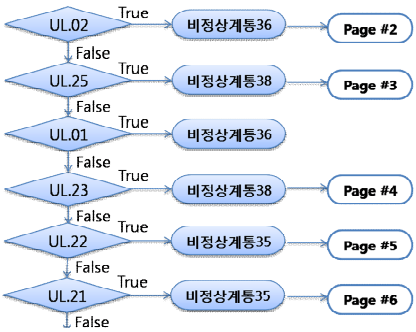

Fig. 1. A part of the flowchart to find an AOP category

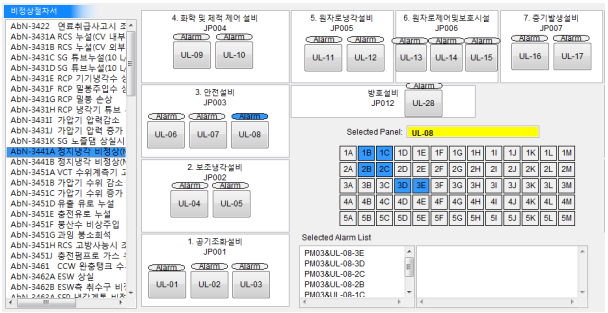

Fig. 2. The mimic alarm window

2.3 Alarm Search

The user can diagnose an abnormal situation using a flowchart. However, because the alarms can occur at different times, it is necessary to develop a search engine that dynamically shows the expected AOPs from the currently annunciated alarms. The developed engine works as follows. When a user inputs one or more alarms in the system, the system shows AOPs that include the set of inputted alarms. The system then calculates the relevance of each AOP based on the ratio between inputted alarms and all alarms that the AOP indicated. Fig. 3 shows the expected AOPs when UL-04-1B and UL-04-2F alarms were annunciated.

This system also shows combinations of two or more AOPs related to the inputted alarms. This function was developed to aid operators when multiple abnormal events are suspected [7].

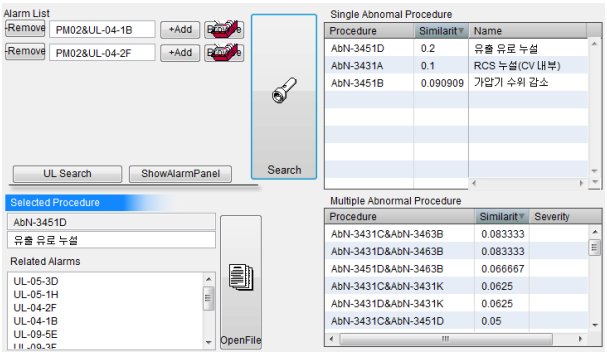

Fig. 3. The result of the alarm search function.

3. Discussion and Conclusion

With the developed search engine, the operators can easily find AOPs from the given alarms. However, because the operators need to be able to efficiently cope with abnormal situations without digital devices, usable educational tools for new human resources should be developed. The developed system shows some examples of such education tools. The flowchart can be used not only for understanding the relation between AOPs and alarms in Hanbit units 3 & 4 MCRs, but also for an actual diagnosis of abnormal situations under a lack of information without computerized search tools. The mimic alarm window also delivers characteristics of AOPs to operators.

It is expected that the developed system can cognitively support the operator to diagnose abnormal situations compared with previous attempts. Choi et al. developed a flowchart similar to the flowchart in this system [1]. In contrast with previous research, we separated the flowchart into a search phase of an AOP category and the phase of an AOP in order for the operators to informatively and efficiently find an AOP. Meanwhile, Kang et al. developed a technique to associate alarm response procedures from annunciated alarms and data related with their causes [2]. The search engine in this system, however, associates complex abnormal situations with multiple alarms and considers multiple abnormal situations to be diagnosed.

The developed system shows how some advanced digital functions can collaboratively enhance a human operator's cognition. We expect that improvements and integration of these kinds of functions into the instrument and control of an MCR will continue.

Acknowledgements

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REFERENCES

[1] H. Choi, J. Kwak, J. Yun, J. Kim, "Development of Diagnostic Process for Abnormal Conditions of Ulchin Units 1&2", Transactions of the Korean Nuclear Society Autumn Meeting, Gyeongju, Korea, October 25-26, 2012.

[2] I. Kang, S. Kang, T. Huh, Y. Shin, "Advanced alarm system of main control room in nuclear power plant", patent KR 10-2001-0076717, 2001.

[3] Y. Kim, W. Jung, S. Choi, "System for searching emergency operating procedure in nuclear power plant and method thereof", patent application 2013-0022227, 2013.

[4] Runrev, "Livecode 6.1.0", available on: livecode.com, build 2005.

[5] M. Kuhn, S. Weston, N. Coulter, "C5.0 Decision Trees and Rule-Based Models", R package version 0.1.0-15. http://CRAN.R-project.org/package=C50, C code for C5.0 by R. Quinlan, 2013.

[6] J. R. Quinlan, "C5", http://rulequest.com, 2007.

[7] J. Yang, "Development of an integrated risk assessment framework for internal/external events and all power modes", Nuclear Engineering and Technology, vol. 44, no. 5, June 2012.