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A Method and Support Tool for the Analysis of Human Error Hazards in Digital Devices

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1. Introduction

In recent years, many nuclear power plants have adopted modern digital I&C technologies since they are expected to significantly improve their performance and safety. Modern digital technologies were expected to significantly improve both the economical efficiency and safety of nuclear power plants. However, the introduction of an advanced main control room (MCR) is accompanied with lots of changes in forms and features and differences through virtue of new digital devices. Many user-friendly displays and new features in digital devices are not enough to prevent human errors in nuclear power plants (NPPs). It may be an urgent to matter find the human errors potentials due to digital devices, and their detailed mechanisms. We can then consider them during the design of digital devices and their interfaces.

The characteristics of digital technologies and devices may give many opportunities to the interface management, and can be integrated into a compact single workstation in an advanced MCR, such that workers can operate the plant with minimum burden under any operating condition. However, these devices may introduce new types of human errors, and thus we need a means to evaluate and prevent such errors, especially within digital devices for NPPs. This research suggests a new method named HEA-BIS (Human Error Analysis based on Interaction Segment) to confirm and detect human errors associated with digital devices. This method can be facilitated by support tools when used to ensure the safety when applying digital devices in NPPs.

2. The Development of human error analysis

2.1 HEA-BIS

HEA-BIS (Human Error Analysis Based on Interaction Segment) is a method to detect the hazard of human errors in using digital devices. It helps decide the occurrence possibility by checking the user's operating areas and ergonomic rating scale after verifying the details of the available tasks. We defined *Error Segment (ES) and Interaction Segment (IS)* to predict a specific human error potential in a digital device and its human interface. Table 1 shows an example of human error potential from the IS and ES of A and B type mobile phones.

To introduce the possibility of human errors of a digital device, HEA-BIS was used and consisted of TBHI (Task-Based Hazard Identification), which selects and analyzes the expected operations using the devices and DBHI (Device-Based Hazard Identification), a digital device self analyzer. The process is as shown in Fig. 1. HEA-BIS consists of items to review such as coincidence between the operation and signal, compatibility of spatial recognition, consistency between the operation and result and sustainability from the setting or system load. Other items for the ergonomic design are such that safety against the operator's mistake or mechanical failures and the items to check the suitability of alarm or feedback. For the design, the possible errors that can be occurred by the obscurity of control buttons (including icons) or by the lack of differentiation between other buttons, and the easiness of portability and operation at the site were also evaluated.

Table 1. An Example of The ISs/ESs List for Human Error Potential Analysis (a smart phone)

ES	IS					
Code.	Operation method	Operation situation				
		No option(Vertical)	Manner mode	Horizontal mode	Multi task	Lock
P	One Click	Screen on/off				
	Long Click	Pup-up window for option				
V+	One Click	Volume up by stages	Manner mode cancel and volume up by stages	Volume up by stages (space compatibility violation <u>Operation intention: down</u>	Volume up by stages	None
	Long Click	Volume up rapidly	Manner mode cancel and volume up rapidly		Volume up rapidly	None
V -	One Click	Volume down by stages → manner mode	Vibration	Volume down by stages (space compatibility violation) <u>Operation intention: up</u>	Volume down by stages → manner mode	None
	Long Click	Volume down rapidly → manner mode	Vibration		Volume down rapidly → manner mode	None
T	Rotation	Move	Move	Move	Move	None
	Click	Selection	Selection	Selection	Selection	None

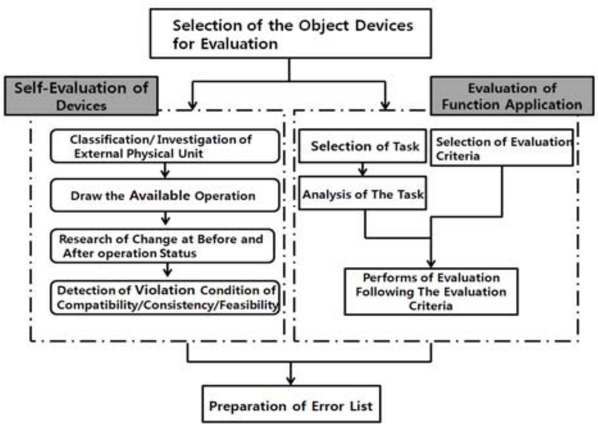

Figure 1. Analysis Flow of HEA-BIS

2.2 Hazard Analysis Support Tool

The Hazard Analysis Support Tool software which can draw the hazard of human errors for the digital device itself and the expected operation based on HEA-BIS, was developed as shown in Fig. 2.

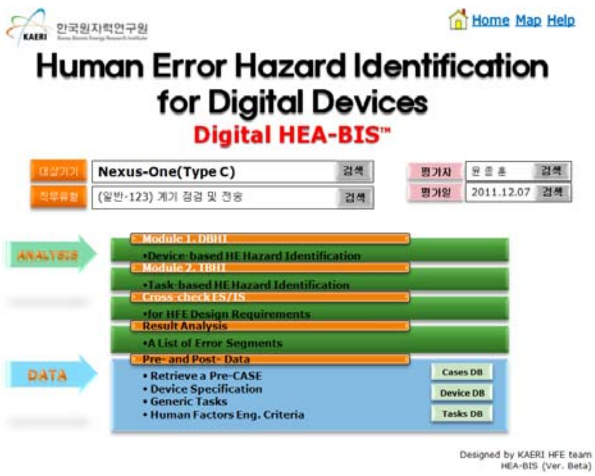

Figure 2. Hazard Analysis Support Tool (S/W)

3. Verification Test and Application

3.1 Evaluation of EEG

Verification of the predictive analysis has been tested through experimental observations with measures of task performance time, error rate, EEG, ECG, NASA-TLX. We also tried to check if human error potentials drawn by HEA-BIS may actually exist by comparing the bio-signals of the performance results when conducting the predesigned experimental tasks with digital devices, and detecting the possible changes in bio-signals.

The tasks that include human errors were verified through EEG. They showed a series of results, and the soundness of EEG through human errors as shown in Fig. 3. However, the frequency data were mixed by noise, and are not easy to separate precisely. Second, the section could be confirmed by brain mapping. The red area showed that the brain activity was high. A high brain activity appeared when the subjects concentrated on the task and became nervous because they made an error.

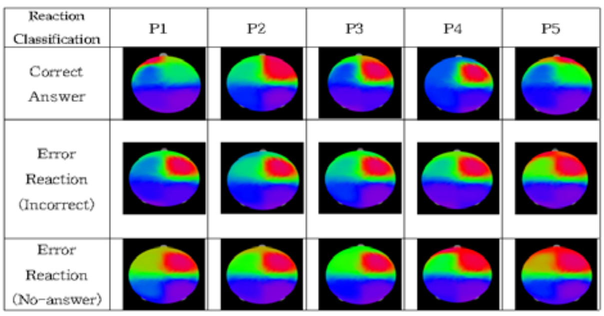

Figure 3. A Result of EEG Mapping

3.2 Evaluation of Human errors of APR 1400 MCR device

The hazard of human errors was evaluated by applying the developed HEA-BIS technique to APR1400 MCR devices. As shown in Fig. 4, the selected devices are FPD and ESCM of an APR 1400. To analyze the error possibility of FPD and ESCM, the status report of the defects of the devices and human errors were investigated. The typical input devices for the VDT based operation are a mouse and touch screen, but the keyboard was included as well. The performed operations are based on the navigation and numerical inputs such as settings. Defects of mouse the, touch screen, and keyboard together with human errors were found.

Figure 4. FPD (Left-mouse), ESCM (Right–Touch screen)

4. Conclusion and Discussions

In this research, following the trend of introducing a cutting-edge digital device to NPPs, we verify the human error potential within the digital device itself and the applied tasking. The analyzing methods, based on IS/ES and a support tool for HEA-BIS, are suggested. Their benefit was verified by analyzing and drawing the possible human error potential for the FPD and ESCM of an APR 1400, a digital based MCR. Based on the results of this research, they are expected to be used as the safety measures and index of a license in introducing the digital devices in NPPs.

REFERENCES

[1] K. T. Jung, Y. H. Lee, A Basic study on human error proneness in computerized work environment, Journal of the Ergonomics, vol.19.No. 1, 2000

[2] B. Kirwan, Human Reliability and Safety Analysis Handbook, 1992

[3] Y. H. Lee, A Scrutinized Analysis Method of the Human Error Potential due to the Introduction of New Digital Devices to NPPs, Proc. HCI International-2012, FL, 2012

[4] Y. H. Lee, T. I. Jang, H. K. Lim, A modification of human error analysis technique for designing man-machine interface in nuclear power plants, Journal of the Ergonomics Society of Korea, vol.22, 1, pp.31-42, 2003

[5] J. H. Yun, Y. J. Oh, Y. H. Lee, A development of the analysis method of extremely-low-frequency human errors during using smart phones in NPPs, Proceeding of a Symposium for Recent I&C Techniques in NPPs, 2010