DESIGN AND IMPLEMENTATION OF HuREX ANALYSIS SUPPORTING INTERFACE

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ABSTRACT

Human error is recognized as one of the main causes to affect to the socio-technical system including nuclear power plant. Therefore, reducing human error through human reliability analysis (HRA) is a critical issue. Moreover, sufficient and reliable human performance data collection is a prerequisite for ensuring the safety of nuclear power plants. Korea Atomic Energy Research Institute developed the HuREX (HUman Reliability data EXtraction) framework to collect and analyze the responses of human operators from simulator training records of nuclear power plant. Thus, the development and computer software interfaces of the database are essential to efficiently support human reliability analysis. In this study, OPERA database was developed in accordance with the following process. First, the essential data required for the HRA analysis (e.g., plant data, procedures, system and equipment info, operating crews, results of simulator experiments, and so forth) was stored in the database. In addition, standardized procedures and related items were stored in the database to support HRA quantification. A data structure was developed to store crew responses conducted by operators to cope with an emergency situation during simulator experiments. In addition, various interfaces that escalate efficiency of the HuREX applications were developed. The HuREX analysis support interface was developed with HuREX Video Analyzer for observation of simulator collection data (e.g., audio-visual records, plant parameters, operator's action logs) and HuREX Data Analyzer for analysis of operator's conducted task. By using the OPERA database and HuREX analysis support interface developed through this research, maximizing the efficiency of human reliability analysis based on simulator training data.

Key Words: HRA, OPERA Database, HuREX, HuREX Analysis Supporting Interface

1 INTRODUCTION

One of the significant factors causing incidents or accidents is the human errors of operating personnel working in the main control room of nuclear power plants. In order to reduce human errors, therefore, all information on the human errors taken by operators in the power plant should be systematically collected and examined in its management. Korea Atomic Energy Research Institute (KAERI) is developing a data collection framework to establish a Human Reliability Analysis (HRA) database that could be a technical bases to generate human error probabilities (HEPs) and performance shaping factors (PSFs)]. The HRA database is a storage which maintains all human performance data collected from plant operating experiences or full-scope simulations. To calculate HEP from human performance data on simulated experiments, total number of tasks conducted and the number of human errors occurred in experiments are required. In general, the total number of tasks conducted cannot obtain easily because the whole operation logs should be analyzed by the HRA analyst, while the number of human errors can be easily counted from the experiment. In order words, the estimation method to get the total task conduction number using direct counting is not easy to realize and maintain its data collection framework. To resolve this problem, this study suggests a generic database structure and integrated analyzing interfaces that enables to estimate the total number of conduction based on instructions of operating procedures of power plants. Figure 1 represents a HuREX analysis supporting interface that enables integrated analysis of data collection and analysis of simulated environment. HuREX analysis supporting interface consists of OPERA database and HuREX Video analyzer and HuREX Data analyzer for unsafe act identification from collected data under simulator experiments.

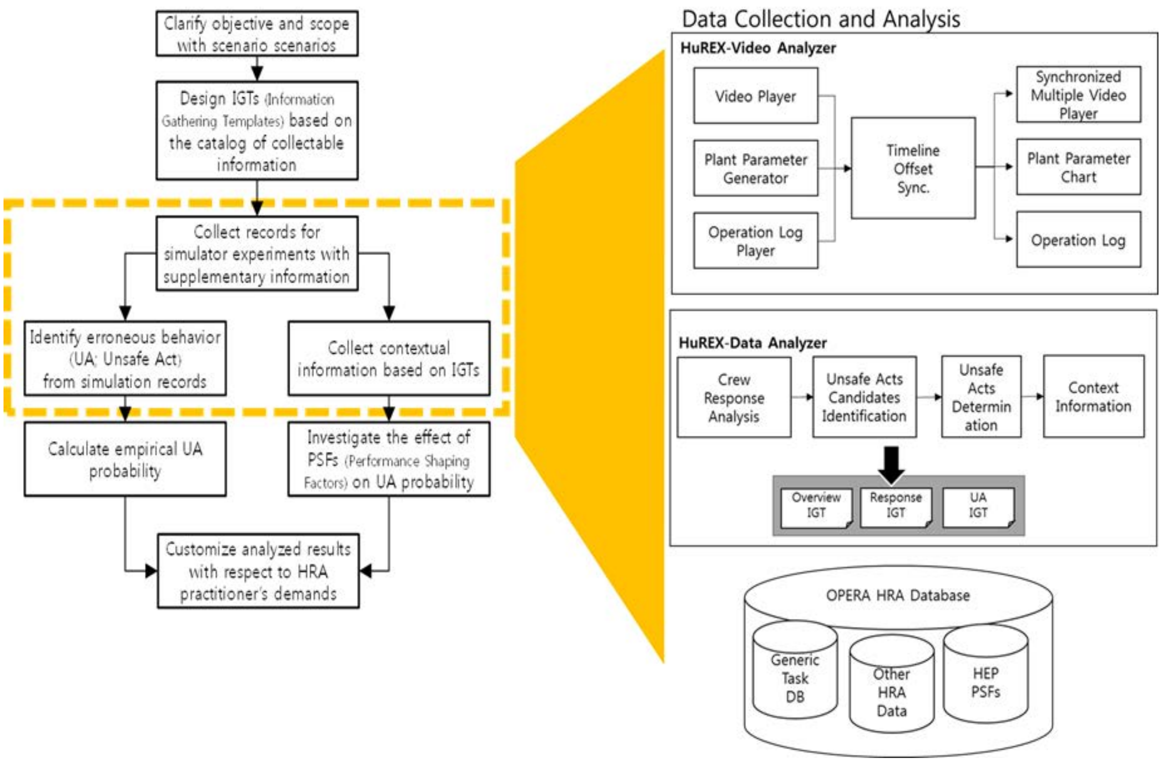

Figure 1. HuREX Analysis Supporting Interface

2 OPERA DATABASE

There are many approaches to estimating an HEP representing the performance of the operating personnel. The simplest method is to divide the total number of operations by the number of errors. To calculate the HEP from human performance data, the number of human errors occurring during such experiments and total number of tasks conducted are required. When using an estimation method to obtain the total number of tasks conducted using direct counting, it is not easy to realize and maintain the data collection framework. To resolve this problem, we suggest an indirect method and a database structure that enables estimating the total amount of conduction based on instructions of the operating procedures of nuclear power plants. In order to measure the total number of tasks conducted during emergency situations of a simulated environment, we designed essential table schema for the procedural step information group data tables, which store standardized common tasks extracted from each instruction of the operating procedures, procedure lists to include the links between each step, a unique global index of the common tasks and their hierarchical structure for visualizing the user interfaces, and other supporting tables.

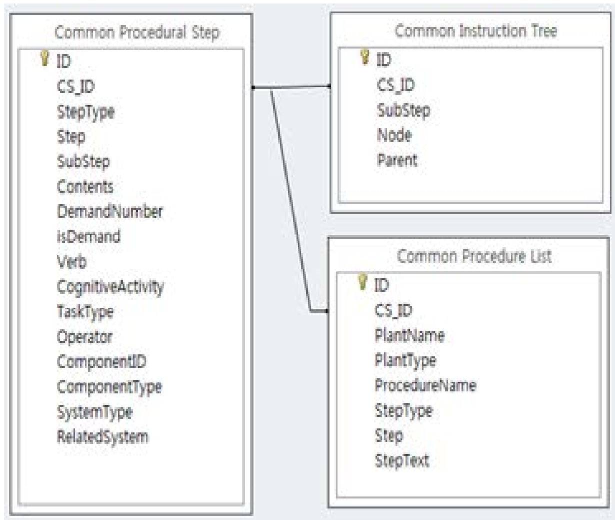

Figure 2. Entity-Relationship Diagram for Procedural Step Information Group

Figures 2 represents the procedural step information group and ER (Entity-Relationship) diagram of the tables in the OPERA database. As shown in Figure 2, the 'Common Procedural Step' is connected to the 'Common Procedure List' and 'Common Instruction Tree' using the CS_ID (Common Step Identifier), which is a unique identifier that exclusively has an internal link to the detailed step task information. To assume the required task numbers for conducting emergency operations, all instruction steps on the emergency operating procedures (EOPs) were classified into detailed task goals and task instruction steps and inserted into the procedural step information group through all of these important tables and user interfaces.

2.1 Design of Common Procedural Step

The 'Common Procedural Step' is a main table that contains standardized generic task information extracted from each instruction of the operating procedures to estimate the required total number of tasks conducted by operators during emergency situations. As shown in Table 1, each row has the task properties of the detailed instruction described in the emergency operating procedures.

- CS_ID: Unique common step identifier that has logical link to the detailed step task information
- Step: Task step number which has a same goal to be solved
- SubStep: Subtask step of specified step number. Each step (goal) can involve multiple sub steps
- Contents: This field represent an instruction content to be conducted by operating personnel
- DemandNumber: Required demand count to be performed by the operator
- TaskType: This field indicates cognitive activities of task type that include "Response planning and Instruction",

"Information gathering and reporting - checking state", “Information gathering and reporting – measuring parameter”, “Situation interpreting” and “Action”.

- SubTaskType: Detailed subtask types of each task type.
- Operator: Related operator to the specified CS_ID and Step (SubStep)
- ComponentID: Related component or equipment identifier
- SystemType: Type of system
- RelatedSystem: Related system

Table 1. An Example of Common Procedural Step

CS_ID	Step	SubStep	Contents	Demand Number	TaskType	sub TaskType	Operator	ComponentID	Component Type	System Type
91	7	3-	Reset CV Spray Signal	-	-	-				
91	7	3-cb-1	SB-HS-104	1;1	RI;MA	ulation;Push	RO	SB-HS-104	Signal	ESFAS
91	7	3-cb-2	SB-HS-204	1;1	RI;MA	ulation;Push	RO	SB-HS-204	Signal	ESFAS
91	7	4-	Stop CSPump and Maintain Readystate	-	-	-				
91	7	4-cb-1	BK-HS-104	1;1	RI;MA	ulation;Push	RO	BK-HS-104	Pump	CSS
91	7	4-cb-2	BK-HS-204	1;1	RI;MA	ulation;Push	RO	BK-HS-204	Pump	CSS
91	7	5-	Close CV Spray Additive Tank Discharge Valv	-	-	-				
91	7	5-cb-1	BK-HS-108	1;1	RI;MA	ulation;Push	RO	BK-HS-108	Valve	CSS
91	7	5-cb-2	BK-HS-208	1;1	RI;MA	ulation;Push	RO	BK-HS-208	Valve	CSS
91	7	5-cb-3	BK-V-033 (Near Auxilary Building 100ft)	1;1	RI;MA	ulation;Push	RO		Valve	CSS
91	7	6-	Close CSP Discharge Valve	-	-	-				
91	7	6-cb-1	BK-HS-107	1;1	RI;MA	ulation;Push	RO	BK-HS-107	Valve	CSS
91	7	6-cb-2	BK-HS-207	1;1	RI;MA	ulation;Push	RO	BK-HS-207	Valve	CSS
92	8	0(CA)	Verify whether RHR P/P to be stopped	1	RI	Entering	SS			
92	8	1-	Check RCS Pressure	-	-	-				

2.2 Design of Common Procedure List

The Common Procedure List include the logical relations between each step of procedures and global unique index identifier (CS_ID) to the common procedural tasks. It enables an actual linking to the required ‘common procedural step’ from the procedure list. As a connection table between ‘common procedural step’ and each task steps of emergency operating procedures, ‘Common Procedure List’ has the properties of CS_ID, PlantName, PlantType, ProcedureName, StepType, Step and StepText. The followings are detailed field property of the Procedure_List and Table2 shows an example data entry of the table.

- CS_ID: Unique generic task identifier that has logical link to the detailed step task information

- PlantName: Name of Plant

- PlantType: Plant type to be applied to data collection analysis. Usually, reactor type can be used as a designation

of the plant type (e.g., WH, CANDU)

- ProcedureName: Name of the operating procedure to be applied to data analysis.

- Step: Step number of specified procedure

- StepType: Type of procedure step number. ‘N’ for normal state of procedure or ‘R’ for response not obtained state

- StepText: Step Label to be displayed on user interface

Table 2. An Example of Procedure_List

ID	CS_ID	PlantName	PlantType	ProcedureName	StepType	Step	StepText
1	372	Hanbit1	WH	E-0	N	1	1
2	372	Hanbit1	WH	E-0	R	1	1R
3	27	Hanbit1	WH	E-0	N	2	2
4	27	Hanbit1	WH	E-0	R	2	2R
5	33	Hanbit1	WH	E-0	N	3	3
6	33	Hanbit1	WH	E-0	R	3	3R
				* * *			
15	91	Hanbit1	WH	E-0	N	7	7
16	91	Hanbit1	WH	E-0	R	7	7R
17	2	Hanbit1	WH	E-0	N	8	8
18	2	Hanbit1	WH	E-0	R	8	8R

As shown in Table2, procedure 'E-0'of the 'Hanbit1 (Westinghouse reactor type)' plant unit has several task instruction steps to be conducted by operators during emergency situations. Each row of the table has a unit common step identifier (CS_ID) to link to the detailed task instruction table ('common procedural step'). For example, a step #4 of the procedure 'E-0' has a CS_ID 91 which is presented in table 1. Therefore, all instructions with a combination of CS_ID (97) and Step# (7) in table 1 should be conducted by responsible operator. In this situation, the required total number of task conduction can be calculated from the 'Demand Number', 'TaskType' and 'Subtasktype' field of the table 1, respectively.

2.3 Design of Common Instruction Tree

The 'Common Instruction Tree' has a logical hierarchy of step node of CS_ID. It includes CS_ID, substep, node and parent of each node. Figure 3 shows an example of the table data entry and a tree structure represented by a graphical user interface.

ID	GT_ID	SubStep	Node	Parent
1	1	0-	1_0-	<<TOP>>
2	1	0-cb-1	1_0-cb-1	1_0-
3	1	0-cb-2	1_0-cb-2	1_0-
4	1	0-cb-3	1_0-cb-3	1_0-
5	1	0-cb-4	1_0-cb-4	1_0-
6	1	R0-[1]	1R_R0-[1]	1_0-
7	1	R0-[1]-cb-1	1R_R0-[1]-cb-1	1R_R0-[1]
8	1	R0-[1]-cb-2	1R_R0-[1]-cb-2	1R_R0-[1]
9	1	R0-[2]	1R_R0-[2]	1_0-

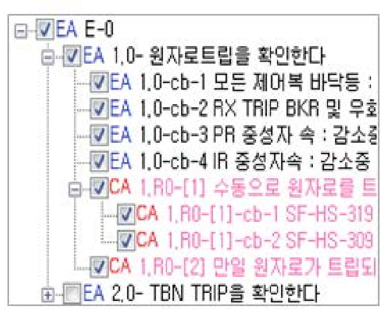

Figure 3. An example of Common Instruction Tree hierarchy

3 DEVELOPMENT OF USER INTERFACE

To help the HRA analyst to effective counting for unsafe actions of operator's activity, a user interface was developed. It extracts task properties from the generic task database and assists the HRA analyst to verify operator's actual tasks execution path during conduction of EOP and to check the unsafe action from the lists of the executed tasks. Figure 4 shows an example of HuREX Analysis Supporting Interface. It consists of video analyzer and data analyzer. Using this interface, HRA analysis can conduct unsafe identification using both HuREX video analyzer and HuREX data analyzer.

Figure 4. An example of HuREX Analysis Supporting Interface

3.1 Development of HuREX Video Analyzer

HuREX Video Analyzer is a video analysis interface that supports UA identification and HRA qualitative data analysis by integrating various raw data obtained from simulation. The data obtained from the experiment are video (video recording from each operator's individual conduction and large display panel screen), plant process parameter log, and operator action log. HuREX Video Analyzer provides the ability to integrate and simultaneously analyze these sources. This is to synchronize several videos of operators and simultaneously reproduce them on multiple screens, to convert power plant process variables into graphs and output them, and to output the operator action logs in accordance with the video playback time. The HRA analyst performs video analysis using this module, and when UA candidate and UA are observed, the relevant details are input using HuREX Data Analyzer. Figure 4-3 shows an example of the operation screen of HuREX Video Analyzer.

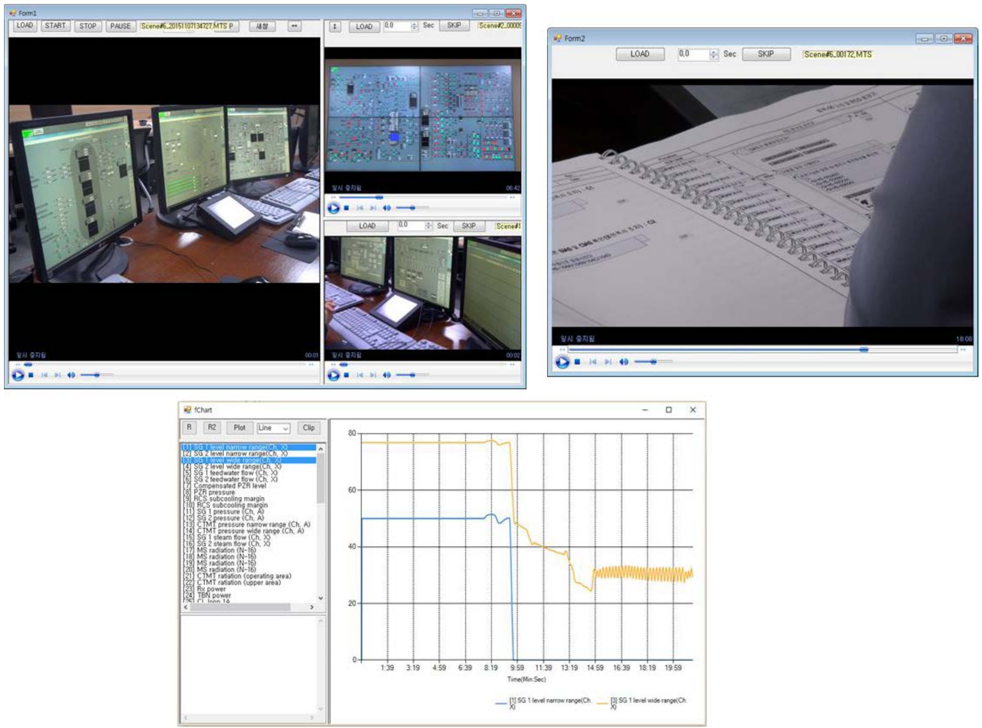

Figure 5. An example of HuREX Video Analyzer

3.2 Development of HuREX Data Analyzer

HuREX Data Analyzer is an information gathering template (IGT) entry supporting interface developed to effectively perform UA analysis using procedural step information group included in the OPERA database. HuREX Data Analyzer consists of analysis support module to input Response IGT, UA IGT and overview IGT derived from UA analysis process. Figure 6 shows an example of the operation screen of the HuREX Data Analyzer.

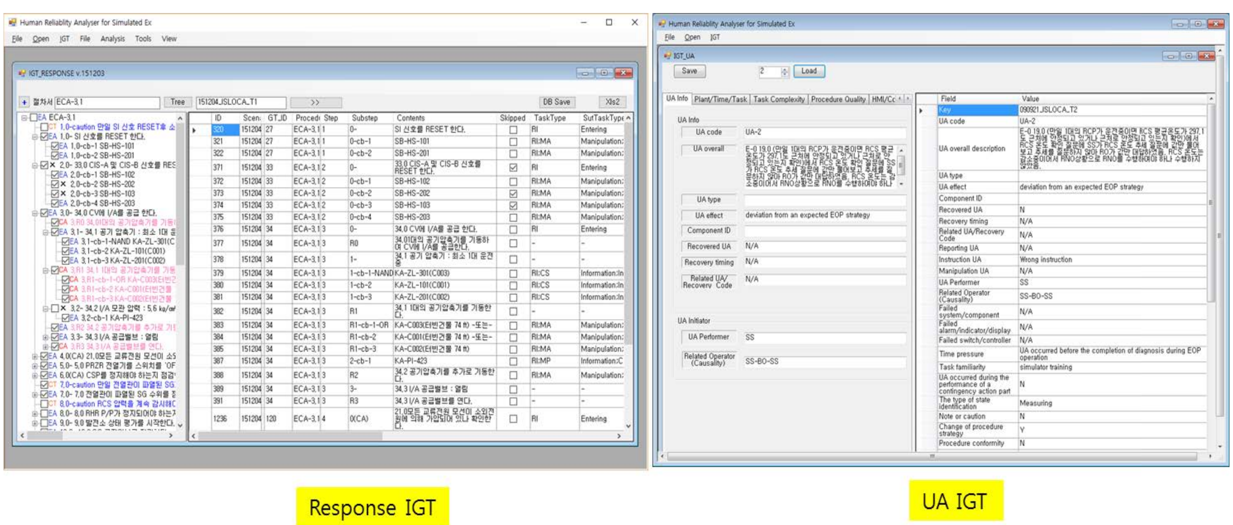

Figure 6. An example of HuREX Data Analyzer

4 CONCLUSIONS

Korea Atomic Energy Research Institute developed the HuREX (HUman Reliability data EXtraction) framework to collect and analyze the responses of human operators from simulator training records of nuclear power plant. Thus, the development and computer software interfaces of the database are essential to efficiently support human reliability analysis. In this study, OPERA database was developed in accordance with the following process. First, the essential data required for the HRA analysis (e.g., plant data, procedures, system and equipment info, operating crews, results of simulator experiments, and so forth) was stored in the database. In addition, standardized common procedures and related items were stored in the database to support HRA quantification. A data structure was developed to store crew responses conducted by operators to cope with an emergency situation during simulator experiments. In addition, various interfaces that escalate efficiency of the HuREX applications were developed. The HuREX analysis support interface was developed with HuREX Video Analyzer for observation of simulator collection data (e.g., audio-visual records, plant parameters, operator's action logs) and HuREX Data Analyzer for analysis of operator's conducted task. As a result of this study, we constructed OPERA database to store HRA analysis data and developed HuREX analysis supporting interface. By using the OPERA database and HuREX analysis support interface developed through this research, maximizing the efficiency of human reliability analysis based on simulator data. Currently, further development is underway to support full coverage of HRA using HuREX analysis interface. The current UI has only been developed to identify the UA and store it in the OPERA database, but a quantification module for calculating the HEP through further research is under development.

5 ACKNOWLEDGMENTS

This work was supported by the National Research Foundation of Korea Grant funded by the Korean Government (MSIP) (No. 2017M2A8A4015291).

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