Task Analysis of Soft Control Operations in Advanced Main Control Rooms

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1. Introduction

In advanced main control rooms (MCRs), operations are performed using soft controls such as mouses, touch panels and so on. The soft control operations require totally different operation process from that of conventional controls. Especially, the interface management tasks are most distinguishable characteristics of soft controls. In this work, simulation data of an advanced MCR was analyzed in order to observe operators' behavior during soft control operations.

2. Operation Process of Soft Controls

Generally, sequential tasks are performed in soft controls in order to perform an operation. The plant information of advanced MCRs is provided to operators by computer screens in hierarchical forms due to spatial limits. While device controllers are widely spread and located in fixed positions in conventional MCRs, operators in advanced MCRs need to navigate a screen to monitor plant variables and to select the target device. The operation actions of operators are divided into primary tasks (e.g. providing control inputs to plant systems) and secondary tasks (e.g. manipulating the user interface to access information or controls or to change control modes). Operators should perform secondary tasks to find appropriate screens or devices by screen navigations and screen selections before they perform the primary task to control a device. While conventional MCRs do not have secondary tasks, the secondary tasks of soft control take relatively large portion.

Lee[3] analyzed the soft control tasks using a systematic human error reduction and prediction approach (SHERPA)[4]. The soft control tasks consist of four sequential tasks as followings:

1) Operation selection: according to the operating procedures, an operator selects an operation which is appropriate for the current situation.
2) Screen selection: an operator navigates the screens in order to find the target control device. Only one navigation or two or more navigation may be required. Or this step may not be necessary if the appropriate screen is activated on the screen.
3) Control device selection: after selecting the appropriate screen including the target control device, an operator selects the device by pointing input devices.
4) Operation execution: an operator performs the required operation on the device.

3. Interface Management Tasks (Secondary Tasks)

If only primary tasks are considered for an soft control task analysis, the analysis is not much different from conventional controls. However, secondary tasks such as navigating screens and handling different types of input devices should be considered in soft controls. The secondary tasks are one of the general characteristics of all advanced MCRs, and also major differences from conventional MCRs. As described in the previous section, the process for soft controls consists of four steps. The second and third steps are related to the secondary tasks which are not considered in conventional controls. Since the required efforts and workload for these secondary tasks affect the operator performance, the whole process including secondary tasks should be considered for soft control evaluation.

The required secondary tasks are determined according to the interface design and the input device types. Soft controls can be designed with only one input device type or with a combination of multiple input device types. Well-organized input devices could reduce human error. Handling all controls with one input device may reduce the required control tasks (especially, secondary tasks), but it may also reduce the operator's situation awareness ability. On the other hand, multiple input devices may make an operation more complex because an operator has to handle different input devices according to the tasks. Different types of controls (e.g., different input devices on different systems or safety class components) may require more attention by operators or the operators may easily recognize which components they are handling.

4. Simulation Data Analysis

In this work, four simulation data (two LOCA(loss of coolant accident) scenarios and two SGTR(steam generator tube rupture) scenarios) were analyzed. In an MCR, a shift supervisor (SS) manages operating procedures and control actions are performed by a reactor operator (RO), a turbine operator (TO), and an electric operator (EO). In the target scenarios (LOCA and SGTR), most controls are performed by an RO and a TO, so the behaviors of the RO and the TO were analyzed. The analysis results are shown in Fig. 1. As shown in the graphs, the number of secondary tasks is
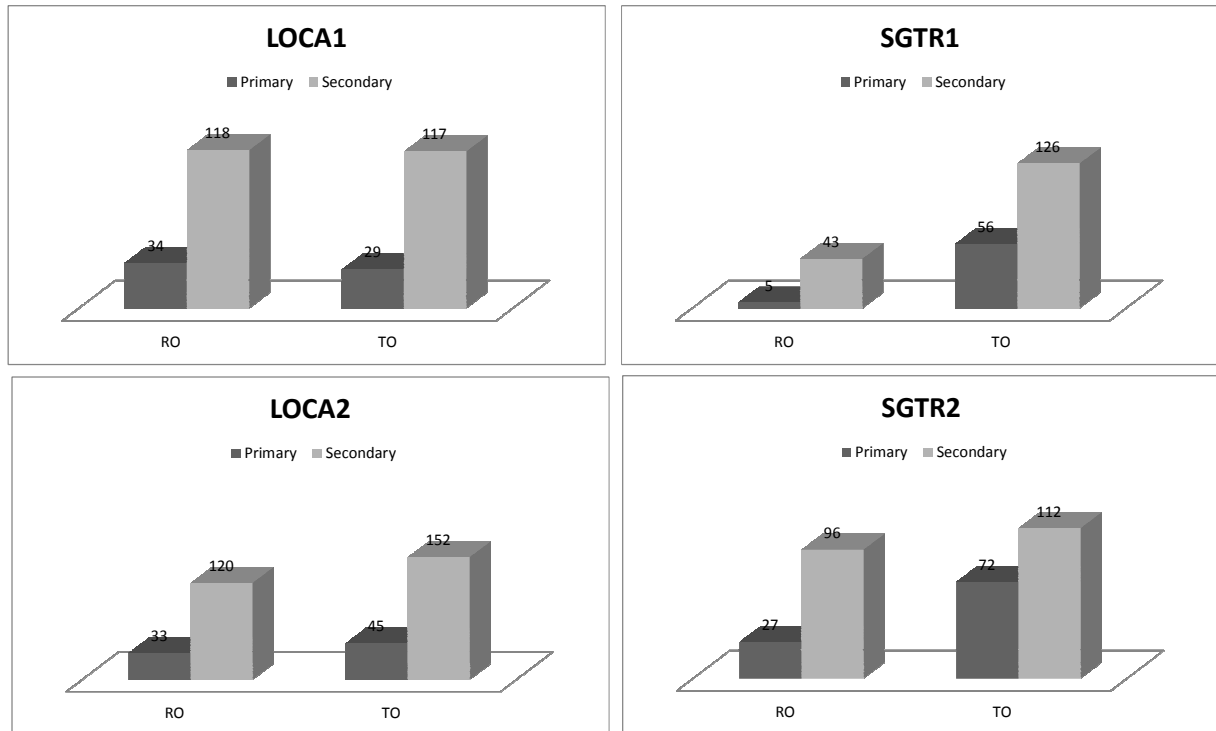
Fig. 1. The number of primary and secondary tasks

much greater than that of primary tasks. The average of the number of primary tasks is 37.63 and that of secondary tasks is 110.5. The ratio of primary tasks is 25.4% and that of secondary tasks is 74.6%. It is noted that the number of executed tasks can be varied according to the individual. However, secondary tasks occupy much larger portion (about three times) in every analysis result. The secondary tasks include interface management tasks for handling control panels (opening/closing control panels) and acknowledge buttons, and navigating screens. In secondary tasks, screen navigation tasks constitute about 44%.

5. Conclusions

In this work, the operations using soft controls were analyzed using simulation data. Four simulation data were analyzed and the results showed that the secondary constitute larger portion than the primary tasks in every scenario. The number of secondary tasks is about three times of that of primary tasks on average. In common sense, it can be said that more actions cause more opportunity for human error. More human error preventive design could be achieved through operator behavior observations and analyses.

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