

Human Error Assessment in Unexpected Plant Conditions through Identification of Interaction Error-Related Potentials in EEG

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Abstract— This approach investigates on the role of Error-Related Potentials (ErrPs) induced in NPP operators when confronted with unexpected plant conditions. Simplified nuclear operation simulator was assigned to provoke interaction ErrPs of operators from wrong operation and subject selection errors. Identification of the operator and system interaction ErrPs will aid behavioral assessment of possible errors concurrent in mitigating the unexpected plant conditions.

I. INTRODUCTION

Unexpected plant conditions are circumstances digressing from base scenarios, as delineated in NUREG-1624 [1]. Human errors that arise are classified as operation omission and wrong object selection [2]. Existing studies have focused on operator's perception on diagnosing the unexpected plant conditions. Also, regarding human errors, studies have translated psychological tasks to NPP operation field. However, attempts to examine the human errors in realistic interaction process during unexpected plant conditions were not dealt in detail.

In Brain-computer interface (BCI), human errors from the interaction with the machine are defined as execution error and outcome error [3]. Correlation between the BCI approach and NPP approach are established as the following. Operational omission is analogous to outcome error as omitted step leads to wrong outcome. Also, wrong subject selection is equivalent to execution error since it is recognized instantly without failure feedback [4]. Consequently, we propose interaction ErrPs to identify the human errors recurrent in unexpected plant conditions mitigation.

II. METHODS

Simplified nuclear operation simulator with emphasis on abnormal operation scenarios was utilized to simulate unexpected plant conditions. Interaction settings are modified from protocols used by Ferrez et al. [4] Participants are instructed to resolve the accident scenarios through adjusting the water levels of the system. To succeed, they should achieve the target level within total 10 steps of water level adjustments. Up and down arrow keys are set as controls. To induce human error in unexpected plant conditions, the interface returned opposite response to intended commands

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twice for 10 steps operation, in other words, 20 % error occurrence. Broken indicator is set to indicate the fluctuation of operation parameters in response to error occurrence. Total 60 trials are designed with 20 trials per session. Psychopy stimuli presentation software in accordance with 4 – channel international 10-20 coordinates system MUSE 2 EEG headband (Interaxon, Canada) is used to collect interaction ErrPs signals.

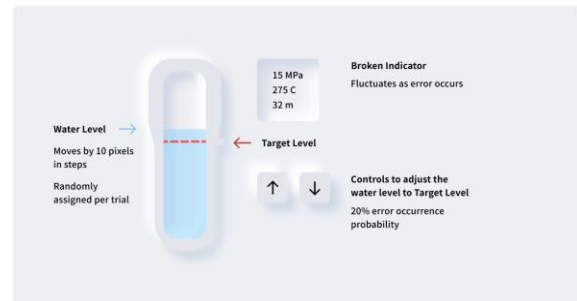


Figure 1. Simplified Win-NPA interaction tasks in LOCA and SGTR

III. DISCUSSION & CONCLUSION

Interaction ErrPs induced from unexpected plant conditions are to be determined through performing the experiment. Future works could categorize the error origins through machine learning technique from different interaction ErrPs.

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REFERENCES

- [1] U.S. NRC, *Technical basis and implementation guidelines for a technique for human event analysis (ATHEANA)*, NUREG-1624, Washington, D.C., USA., 2000
- [2] Choi, M.K. et al. *Development of an EEG-based workload measurement method in nuclear power plants*. *Annals of Nuclear Energy*, 111, pp. 595-607, 2018.
- [3] Milekovic, Tomislav, et al. Error-related electrocorticographic activity in humans during continuous movements. *Journal of neural engineering*, 9(2), 026007, 2012.
- [4] P. W. Ferrez et al., *Error-Related EEG Potentials Generated During Simulated Brain-Computer Interaction*, in *IEEE Transactions on Biomedical Engineering*, vol. 55, no. 3, 2008, pp. 923-929, 2008.