The Development of Abnormal Scenarios and generating AI training data for Operator Support System

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1. Introduction

Recently, Artificial Intelligence(AI) technology has been developed in a variety of fields. The nuclear industry, like many industries, has benefited from fourth industrial revolution and digitalization solutions. One of the promising application is AI based Operator Support System(OSS) which provides useful advice and gives accurate plant status to the operators such as abnormal status diagnosis[1, 2, 3].

AI training data is the information that used to train a machine. This study shows how to develop abnormal scenarios and generate AI training data for abnormal status diagnosis system. The abnormal procedures were already prepared by operation and system design expert for operate the nuclear power plant. The scenarios were developed based from the plant procedures.

In order to generate the training data, it requires the amount of training data and significant number of data classes. The amount of training data is from abnormal procedures.

In this paper, development of abnormal scenarios and generating AI training data sets were showed, so that the abnormal status diagnosis system could be trained by a model to predict the abnormal status.

2. Training data requirements

Training data used in the model evaluation as well as analyst to check the accuracy of the model. Planning is required before generating the data because the data will be used for the complex calculation and the large number of layers in the model. Therefor many requirements need to be considered before generating the training data. Table 1 shows the example of the training data requirements[5].

Table I: Training Data Requirements

1. Training Data should be the case that possibly occur in the nuclear power plant
2. Abnormal status that need to predict must be included in the data(e.g., predict value of abnormal events, and etc.)
3. Training Data should have the list of the parameters and variables which has high weighting factor for the classification
4. Plant status should be distinguishable and classified (e.g., normal status, type of abnormal status, and etc.)

Machine learning algorithms process the large volumes of data to learn patterns, events, differences, and so on. Therefore, training data should have more layers, be predictive and analytics because the dataset include both the input data and corresponding expected output. The figure 1. shows the main process of how the training data will be generated, used for training.

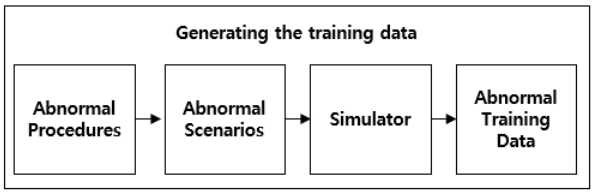

Fig. 1 Process for generating the training data

Training data needs to be used for convolutional neural network modeling and also needs for explainable AI[4]. It needs to have classification of status such as types of abnormal status, normal status and so on, to develop neural network model. Simulating the abnormal events in the simulator is necessary because getting abnormal events in real plant is very limited. Abnormal status diagnosis system results could be accurate if the real plant data could be used but real plant data could only be used if the abnormal status that had happened in the plant before.

3. Development of Abnormal Scenarios

There are more than 200 abnormal status are categorized from the abnormal operating procedures. The contents of abnormal procedures include purpose, alarms and symptom, urgent manual actions, automatic actions, follow up actions, etc. Abnormal procedures were reviewed and prepared by the operation and system design experts. Operating experience of the events used as the reference before abnormal procedures are prepared because there is not enough operating history for every expected abnormal event. The simulator can be a tool to verify abnormal events however; the number of abnormal events are so many to simulate, so each event was simulated manually.

In order to apply the AI model to abnormal status diagnosis system, abnormal scenarios are need to be developed before generating the training data. Plant status were classified by specific abnormal status(e.g., Tube Leak, Valve Open, Turbine Trip, and etc.). The list of parameters, variables and all the training data should be the same data that could possibly occur in the nuclear

power plant because the abnormal status diagnosis system would be trained from the generated simulation data.

The scenarios include the failure mode, cause of failure, sequence of failure, type of failure, failure size and etc.

Each classification or abnormal status is unique event but some of the events were correlated to each other. Every classification has the list of the parameters which has high weighting factor for the classification[4]. The list of parameters in the training data is going to be used as the basis of diagnosis.

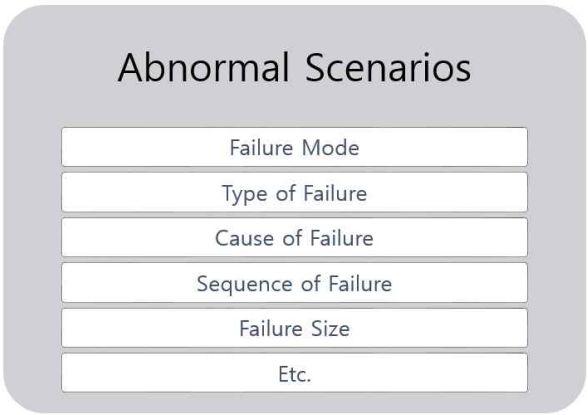

Fig. 2 Elements of Abnormal Scenarios

4. Generating the training data

Selective abnormal scenarios would have the sequence of failures. All the simulation parameters and variables are saved into files when the abnormal scenarios are inserted to the simulators. Figure 3. Shows the tool that insert the scenarios to the simulators and generate the training data.

Some of the operation parameters could be the key parameter to the effect of the events when there is abnormal status in nuclear power plant. Fig. 4. shows the visualization of the operation data for the normal operation and one of the abnormal operation. Visualization shows that the generating dataset includes both the input data and corresponding expected output.

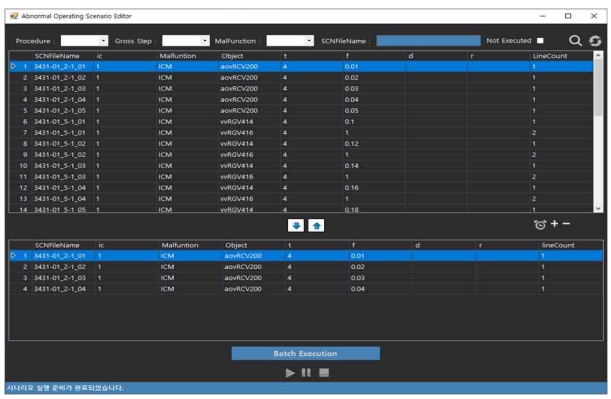

Fig. 3 Tool for generating the training data

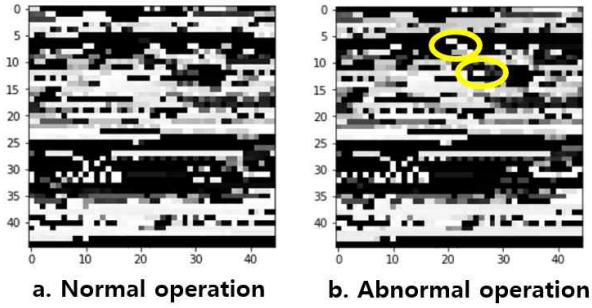

Fig. 4 Visualization of Normal Operation and Abnormal Operation

5. Conclusion

Abnormal scenarios were developed and the training data was generated for the operator support system that is abnormal status diagnosis system in this paper. The training data requirements were reviewed, showed the process of the scenarios development and training data generation. Training data were used to train the operator support system. Operators can check the plant status with main parameters and may have clear understanding for the diagnosis result from neural network[4]. Different versions of training data set could be used to improve the results of abnormal status diagnosis system.

REFERENCES

[1] Y.G. Kim, et al, “Consideration on data mapping of convolutional neural networks to diagnose abnormal status in nuclear power plant operation,” KNS spring meeting, 2018

[2] Y.G. Kim, et al, “Operator support system with diagnosis of abnormal status by convolutional neural networks”, NPIC, 2019

[3] Y.G. Kim, et al, “Development of Convolutional Neural Networks to Diagnosis Abnormal Status in Nuclear Power Plant Operation”, KNS spring meeting, 2019

[4] Y.G. Kim, et al, “Consideration on the use of Explainable AI in Operator Support System”, KNS Autumn meeting, 2020

ACKNOWLEDGEMENT

This work was supported by the Energy Efficiency & Resources of the Korea Institute of Energy Technology Evaluation and Planning (KETEP) grant funded by the Ministry of Trade, Industry and Energy. (No. 20211510100020)