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Development of Remote Monitoring System for Deep Learning-Based Radiation Test Capsule

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1. Introduction

An irradiation test using the instrumented capsule or rig has been performed for a fuel or material performance test in the HANARO reactor. Instrument sensors and instrument attachment technology have been developed for an irradiation test and instrument sensor values are monitoring by remote surveillance systems. But KAERI's internet cyber reinforcement makes it difficult to operate remote surveillance systems from the KAERI outside. Also due to the recent increase in telecommuting due to CIVID-19 virus, external surveillance is more necessary.

This study is about the development of a remote monitoring system for deep learning-based radiation test capsule monitoring and the results of deep learning application of the 13M-01K irradiation test capsule.

2. Conceptual design of remote monitoring system

KAERI's internet network is separated into internal network and external network for network security. So it is difficult to remote monitoring about capsule irradiation data from the KAERI outside. Current, only remote monitoring is possible within KAERI by internal network as shown in Fig. 1. However, if a separate PC captures the monitoring display and sends SMS (short message send) in conjunction with the external internet, it can be monitoring 24 hours a day. This remote surveillance system operates independently of KAERI network, so there are no restrictions on security systems. To connect to the internet, a portable router was purchased and installed.

Fig. 2 is configuration of remote monitoring system for image processing a Lab PC display. As shown in Fig. 2, one port of the 2 Port VGA splitter connected to the convention remote PC (left Lab PC) and the other port connects to the new remote surveillance PC (right Lab PC) that includes video capture system. Because the resolution of a convention remote PC is low, the maximum image processing resolution is set to 1080p. If a convention remote PC has a high resolution, we can use an enhanced capture card to further improve image processing.

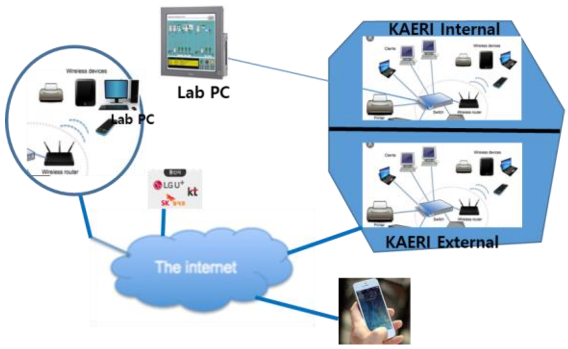

Fig. 1 Remote monitoring system for irradiation test capsule

Fig. 2 Configuration of a remote monitoring system by image processing

3. Image processing of lab PC display

Fig. 3 is the image processing display of a capsule irradiation test monitoring display. As shown in Fig. 3, after extracting the contour by setting the ROI (region of interest) from the original display, the monitoring display was captured in real time. The program used Python and HANARO power and main temperatures were recognized by the pytesseract library. Occasionally, there are character recognition errors in the ROI, but monitoring program corrects with them with the program Errors in character recognition can be solved by increasing the resolution. Also, data from areas of ROI are sending by SMS (short message service) on a regular basis. Of course, alarm data is send immediately.

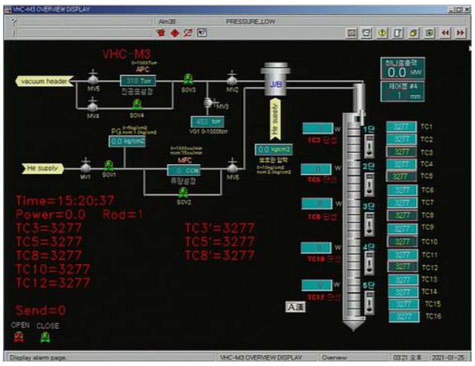

Fig. 3 Image processing display of a capsule irradiation test monitoring display

4. Analysis of irradiation test data using deep learning

For research on the application of AI-based irrdiation test monitoring, we used irradiation test data of the 13M-01K capsule. The 13M-01K is a instrumented capsule for high temperatue irradiation test. The irradiation test performed during HANARO 2 cycles of 56 days in 2014. To apply deep learningof AI from irradiation test data of above HANARO power 5MW, we select five depentent variables (TC3-TC12) and seven independent variables (MW-H5) as shown in Fig. 4. The 3 hidden layers have 310, 50, 50 neural networks. R2_score was used to get the hidden layers [1-2].

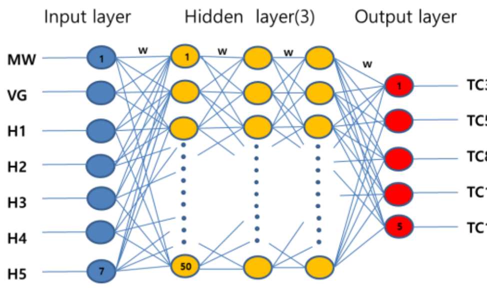

Fig. 4 Deep learning neural network of the 13M-01K capsule

5. Deep learning Results

Fig. 5 shows the loss and accuracy trend results of deep learning. The programs used are Tensoflow and Keras library. As a variable of Keras for linear regression, we use activation=relu in hidden layer and activation=linear in output layer and optimizer is Adam. After 10^{-6} learning rate and 500 epochs, the accuracy of the learning was shown to be about 90% and the accuracy of the validation was 91%. After many simulations, the optimal hidden layer found a value where the loss and accuracy were maximum value.

Table 1 is test data and Table 2 is prediction value about Table 1 after deep learning.

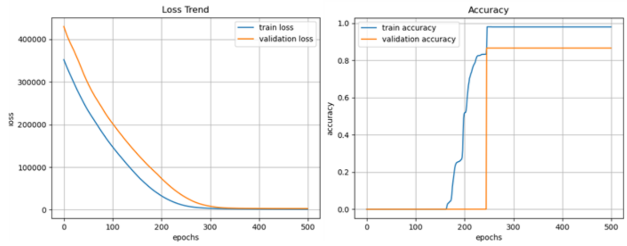

Fig. 5 Loss and accuracy trend of deep learning

Table 1 Test Data

MW	VG	H1	H2	H3	H4	H5	TC3	TC5	TC8	TC10	TC12
15	741	47	43	0	62	36	330	386	385	221	231
30	68	2141	1178	0	61	2381	600	700	771	401	425
30	74	2813	2740	2810	64	2673	761	859	852	401	425

Table 2 Prediction Value

TC3	TC5	TC8	TC10	TC12
375	310	274	197	280
589	685	753	396	428
680	790	881	441	491

5. Conclusions

A remote monitoring system was developed to monitor for 24-hour an instrumented irradiation capsule from outside. The developed monitoring system captures a remote PC display and characterizes key data by image process. Also it is possible regular and alarm SMS to operator. We analyze irradiation test data to apply AI to monitoring system. The application result of deep learning has been predicted to be more than 90% accuracy.

The next study is to monitoring capsule irradiation test with this remote monitoring system and additionally applies a deep learning program.

Acknowledgements

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REFERENCES

1. M. S. Cho et al., “Design, Fabrication and Test Report on Double Layer Structured Instrumented Capsule (13M-01K) for High Temperature Irradiation Test”, KAERI/TR-6836/2017.
2. S. H. Ryu et al., “Preliminary research on Data-Driven Anomaly Detection in the HANARO via Deep Learning”, KAERI/TR-8439/2020.