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

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◆ Introduction

- An irradiation test using the instrumented capsule has been performed for a fuel or material performance test in the HANARO reactor.
- KAERI's internet cyber reinforcement makes it difficult to operate remote surveillance systems from the KAERI outside.
- 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.

◆ Conceptual design of remote monitoring system

- Remote monitoring system for irradiation test capsule
  - ✓ Remote monitoring is possible within KAERI by internal network.
  - ✓ A separate PC captures the monitoring display and sends SMS.
  - ✓ To connect to the internet, a portable router was purchased and installed.
  - ✓ Possible 24 hours monitoring
- configuration of remote monitoring system
  - ✓ One port of the 2 Port VGA splitter connected to the convention remote PC and the other port connects to the new remote surveillance PC.
  - ✓ The maximum image processing resolution is set to 1080p.

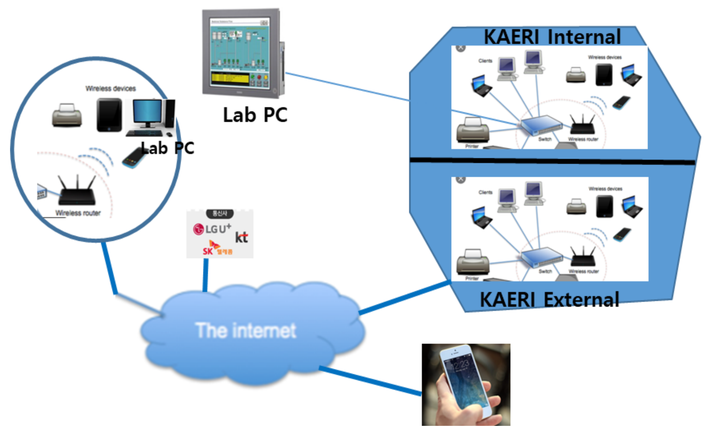

Fig. 1 Remote monitoring system for irradiation test capsule

◆ Image processing of lab PC display

- the image processing display of a capsule irradiation test monitoring display
  - ✓ Extracting the contour by setting the ROI (region of interest) from the original display
  - ✓ The program was used Python.
  - ✓ HANARO power and main temperatures were recognized by the pytesseract library.
  - ✓ Data from areas of ROI are sending by SMS on a regular basis.

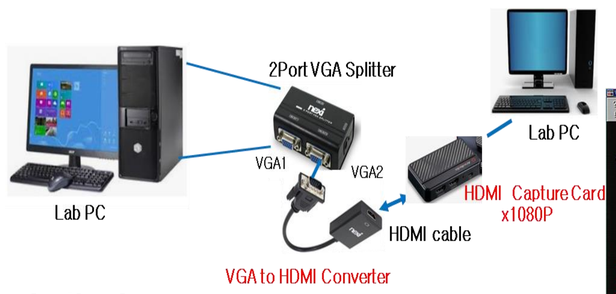

Fig. 2 Configuration of a remote monitoring system by image processing

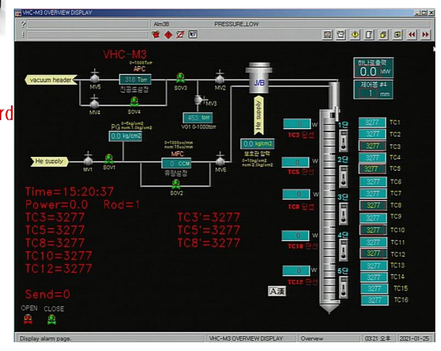

Fig. 3 Image processing display of a capsule irradiation test monitoring display

◆ Analysis of irradiation test data using deep learning

- ✓ For research on the application of AI-based irradiation test monitoring, we used irradiation test data of the 13M-01K capsule.
- ✓ We select five dependent variables (TC3-TC12) and seven independent variables (MW-H5)
- ✓ The 3 hidden layers have 310, 50, 50 neural networks.
- ✓ R2_score was used to get the hidden layers.

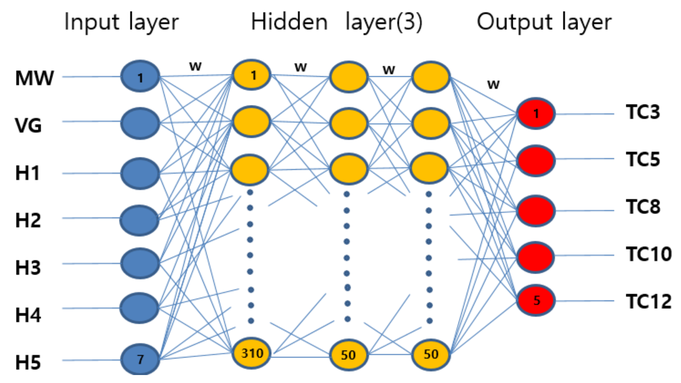

Fig. 4 Deep learning neural network of the 13M-01K capsule

◆ Deep learning Results

- ✓ The programs were used Tensorflow 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 is minimum and accuracy is maximum value.

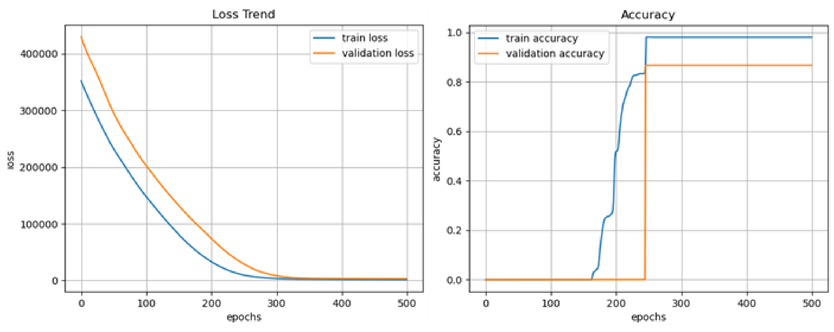

Fig. 5 Loss and accuracy trend of deep learning

◆ 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.
- 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.