Contribution ID: **543** Type: **Oral (Plenary Session)**

Real-time ELM recognition system based on deep learning

Tuesday, 14 May 2019 10:00 (5 minutes)

Based on the deep learning method, this paper introduced a set of ELM real-time recognition system on HL-2A. The system uses 5200 shots data (about 241,900 data slices) for learning. After more than 70 adjustments, a 22-layer convolutional neural network is obtained. The network can recognize whether a 30ms data slice contains the ELM signal, After smoothing, the system can recognize the ELMy H-mode and output the start/end time of H-mode.
The system has recognized all historical data of the HL-2A since it achieved stable H-mode discharge in 2009. A total of 1665 shots of H-mode has been recognized, of which 35 shots were misidentified, with the false positive rate (FPR) was 2.10%. In the actual 1634 shots of H-mode, the system missed to recognize 4 of them, with the false negative rate (FNR) was 0.24%. In a total of 25,321 shots, the recognition accuracy rate was 99.85%. For the data of latest years, the system obtains good results with a FPR of 3.69% and a FNR of zero. In the correctly recognized shots, the error of the H-mode start/end time less than 20ms. The data quality of HL-2A in different discharge periods has a certain correlation. These results demonstrate that the system has good generalization ability and recognition precision to fulfill the requirements for applying to new data.
In this experiment, a total of 14,900 data slices were used to test the speed of the neural network in the simulated real-time environment. The average calculation time of a single slice is 0.46ms less than PCS control cycle which is 1ms. This result show that the system can satisfy the calculation speed requirements of the real-time ELM recognition.
Since the HL-2A experimental has not yet ended, the system has not been transplanted to PCS, but the recognition precision and the calculation speed of the system have satisfied the requirements of real-time ELM recognition and real-time ELMy H-mode control.
This research introduces the deep learning method into the fusion research of HL-2A, and obtains the results that can satisfy the actual production requirements. It proves the feasibility and advantages of the combination of artificial intelligence method and fusion research field represented.

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Session Classification: Minioral

Track Classification: Advanced Computing and Massive Data Analysis