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Real-time classification of L-H transition and ELM in KSTAR

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It has been widely accepted that a high confinement mode(H-mode) operation is necessary for advanced tokamaks or ITER. However, when plasma is in H-mode, the edge localized mode (ELM) occurs at the plasma edge, which release particles and energy [1]. In case of ITER, a full tungsten divertor cannot tolerate the heat load from the type-I ELM [2]. Besides, in terms of plasma density feedback control, the fuel into the plasma cannot be absorbed by gas puffing only due to the edge transport barrier(ETB) and the diagnostic values of the real-time plasma density are abnormally observed by the ELM burst. In order to help to control these problems, an algorithm for classification of L-H transition and the first ELM burst in real-time has been developed with KSTAR campaign data. The algorithm has been firstly verified through off-line version using processed experimental data. After the verification, we found that the algorithm can work in real-time using raw experimental data. In order to classify the L-H transition and the first ELM burst, we applied a method of Long-Short Term Memory(LSTM) [3] which is a special kind of neural network for storing long sequence. D_α, a deuterium spectral line of Balmer series, and $\bar{n_e}$, line averaged electron density, in KSTAR [4-6] are used for pattern recognition and learning. The time area in which the algorithm will classify is from ramp-up phase to the ELM phase in the whole plasma discharge because typically, there is no L-H transition in the ramp-up phase and we did not make the algorithm learn H-L back transition. In addition, we tested our trained LSTM network in ITER-compatible environment as part of the ITER-CODAC experiment during 2018 KSTAR campaign [7]. Although the trained network was tested in the different environment, the network worked properly. In conclusion, the result of off-line version showed that the LSTM can remember the sequence of plasma discharge related to L-H transition and ELM. In the real-time version, we found that the algorithm can classify the L-H transition and the first ELM although the raw data is noisier than the processed data.

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Author: SHIN, Giwook (University of Science and Technology)

Co-authors: JUHN, June-Woo (National Fusion Research Institute); KWON, Giil (National Fusion Research Institute); HAHN, Sang-hee (National Fusion Research Institute)

Presenter: SHIN, Giwook (University of Science and Technology)

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