Surrogate Modeling of Plasma System with Bayesian Deep Neural Network

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Plasma systems have a highly nonlinear and hybrid dynamics since the plasma variables are interacting each other physicochemically, and also coupled with the equipment variables which have their respective control logic. Therefore, to model such system globally, it is necessary to use a surrogate model capable of reflecting nonlinear and hybrid characteristics of the system. As a universal approximate function, the neural network can deal with these particular characteristics conveniently if there are enough data to train the network. In this study, we developed a Bayesian deep neural network that can meet these requirements by assigning diagonal Gaussian probability distributions, instead of fixed values, to the weights of the network. By this Bayesian approach, we could also incorporate existing stochastic characteristics of the plasma process such as process drift and measurement noise into the model. Furthermore, we proposed a real-time algorithm that instructs next searching point by utilizing the uncertainty information so that it can scan the input space efficiently. We also showed that obtained network could be compressed by selecting only a few nodes having significant weights, and this could help in implementing the automatic modeling algorithm we proposed in the form of an embedded system.

This research was respectfully supported by the IT R&D program of MOTIE/KEIT (10049155, Development of equipment control algorithm based on plasma monitoring for efficiency improvement of 10 nm etch process), and by Engineering Development Research Center (EDRC) funded by the Ministry of Trade, Industry & Energy (MOTIE). (No. N0000990)