Neural network based real-time reconstruction of KSTAR magnetic equilibrium and imputation with Bayesian scheme

Semin Joung\textsuperscript{1}, Sehyun Kwak\textsuperscript{1}, Y.M. Jeon\textsuperscript{2}, S.H. Hahn\textsuperscript{2}, H.S. Han\textsuperscript{2}, H.S. Kim\textsuperscript{2}, J.G. Bak, S.G. Lee and Y.-c. Ghim\textsuperscript{1}

\textsuperscript{1}Department of Nuclear and Quantum Engineering, KAIST, Daejeon 34141, S. Korea
\textsuperscript{2}National Fusion Research Institute, Daejeon, S. Korea

Controlling the fusion-grade plasmas for tokamak operation requires observation of real time plasma position and shape which can be estimated using Grad-Shafranov solver such as EFIT [1]. Since off-line EFIT is, in general, computationally intensive, obtaining quality of off-line EFIT results in real time is challenging. Thus, we develop a neural network trained with the database which contains magnetic signals and off-line EFIT results from KSTAR as inputs and targets, respectively. Drifts in the magnetic signals are pre-processed based on Bayesian scheme [2] which can be performed in real time. The network with two hidden layers with 30 and 20 nodes for each layer is used and shown to provide reliable outputs up to 20\% of input errors. Furthermore, Gaussian process [3] based imputation scheme has been developed such that the neural network can reconstruct the magnetic equilibrium with a few of missing inputs. This imputation scheme has been developed based on the Bayesian probability whose likelihood is determined based on the Maxwell’s equations. We note that the developed neural network is yet to be implemented for KSTAR real time operation.

References