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Data fusion and uncertainty quantification of density data on EAST tokamak

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In Tokamak, plasma density is a key parameter influencing confinement and transport. The rapid acquisition of reliable plasma density profiles is crucial for the real-time feedback control of density. However, measurement uncertainty leads to inconsistence between different density diagnostic systems, making it difficult to use and understand data. This report introduces data fusion and uncertainty quantification algorithms in machine learning to integrate experiment data from multiple density diagnostic systems in EAST Tokamak. The forward diagnostic models of the Polarimeter-Interferometer (POINT), the interferometer (HCN), and the microwave reflector (DPR) are constructed according to the diagnostic principles and layouts of corresponding density diagnostic systems. Bayesian inference is used to fuse diagnostic data from POINT, HCN, and DPR systems, providing uncertainty-quantified density distributions with higher confidence than individual diagnostic system. Convolutional Neural Network (CNN) is employed to integrate diagnostic data from POINT and HCN systems, achieving plasma density distributions and their uncertainty in milliseconds. The advantage of Bayesian-based method is its probabilistic characterization of physical quantities and measurement uncertainties, while providing an intuitive and flexible inference framework that enables data fusion across heterogeneous diagnostic systems through the product of likelihood functions. In contrast, deep learning-based method has the advantage of rapidly generating determination results, making it suitable for real-time data processing. This work is beneficial for providing a self-consistent and reliable density distribution for the research of confinement and transport and for the real-time feedback control of density. The algorithms and models established by this work, would provide reference for data fusion of multiple diagnostic systems and uncertainty quantification of key physical quantities in future fusion reactors.

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