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Real-time estimation of line-averaged plasma density on EAST using LightGBM

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The reliability of the plasma density measurement is crucial for plasma density control in tokamak. Currently, the density feedback system in EAST uses lineaveraged density from either the Hydrogen Cyanide (HCN) laser interferometer or the polarimeter-interferometer (POINT) diagnostic system. However, insufficient laser energy or noise interference can lead to erroneous density signal diagnoses, i.e., abnormally high or low, which always results in misfunction of density feedback control. To determine the reliability of the density signal used for density feedback control and still obtain relatively reliable density information to meet control requirements, this study applied the ensemble learning algorithm LightGBM to estimate plasma density information. The input sample parameters for training the LightGBM model include plasma stored energy (Wmhd), plasma internal inductance (li), beta ratio (βN), plasma shape elongation (κ), boundary safety factor (q95), loop voltage (Vloop), and plasma current (Ip). The training dataset is collected from EAST experiments of 2024. From this dataset, 80% of the sample data were randomly chosen as the training set, the remaining 20% serving as the test set. The final results showed that the density inferred by the LightGBM model on the test set samples had an average error within 5% compared to the experimentally measured density. This LightGBM model is implemented in the plasma control system for real-time calculation with an inferring time of around 20 μs.

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