Automatic Fusion Plasma Data Analysis based on Bayesian Statistics

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Many advanced plasma analysis methods has been developed, such as dynamic transport analysis, and linear and non-linear growth rate analysis. Also, the amount of the experimental data generated in the fusion plasma experiment has been increasing. Therefore, it is demanded to make these analysis run automatically for all the experimental data which is obtained routinely, so that more researcher can reach these results.

Most of these plasma analysis methods require local and smooth spatial profiles of density and temperature, rather than the line-integrated data or the noisy experimental data. However, such a basic data handling, such as inversion and fitting, still requires some human supervision, and prevent from realizing the automatic data analysis in fusion plasma experiment. Many robust algorithms for the inversion and fitting have been developed, and they actually work nicely in some cases, but it is not always the case. Thus, the robustness is important to realize the automatic data analysis.

The robustness of each algorighm, $\mathscr{M}$, can be quantified by the expectation of the merginal likelihood of the experimental data $\mathbf{y}$,

$$\mathbb{E}_{p(\mathbf{y})}\left[\log p(\mathbf{y}|\mathscr{M})\right] \quad (1)$$

where $p(\mathbf{y})$ is the probability distribution that the experimental data follows and $p(\mathbf{y}|\mathscr{M})$ is the generative model implicitly or explicitly assumed in the algorithm $\mathscr{M}$. Therefore, the robustness of the algorigthm is not independent from the data distribution, and there are no superior algorithms that work for any kind of data.

In this work, we utilized machine learning technique to estimate $p(\mathbf{y})$ for the data in the fusion plasma experiment, and developed robust algorithms optimized for the automatic data analysis in LHD. In paritcular, we will discuss about an automatic reconstruction algorithm for the local electron density from the line-integrated one observed with far infrared interferometer, and an automatic fitting algorithms for the electron and temperature profiles obtained by Thomson scattering method.