A DETAILED ANALYSIS OF GEODESIC LEAST SQUARES REGRESSION AND ITS APPLICATION TO EDGE-LOCALIZED MODES IN FUSION PLASMAS

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Abstract
Geodesic least-squares regression (GLS) is a parametric regression technique that has recently been developed for handling cases with significant and complex uncertainty structures. It has been shown to perform well in the presence of outliers and uncertainty in the regression model [1]. In this contribution, we analyze in detail the characteristics of the GLS method enabling this good performance. On the one hand, GLS treats single measurements as samples from a probability distribution, hence it requires at least an error estimate on the measurements. On the other hand, GLS allows the ‘observed’ (‘true’) distribution of a measurement to deviate from the proposed model, aiming at maximizing the similarity between the observed and modeled distributions. To this end, GLS minimizes the Rao geodesic distance between both distributions. The geometric interpretation allows us to gain a clearer insight into the operation of GLS by visualizing the distributions on a model of the corresponding manifold. As an illustration, we apply GLS regression to estimate the relation between the waiting time and the energy of an important repetitive instability occurring in the periphery of tokamak plasmas, i.e. the edge-localized mode (ELM). This relation is usually derived in terms of the respective average quantities over many ELM instances in a plasma discharge [2]. An alternative is standard regression analysis on the collection of individual ELM measurements. However, we show that GLS operating on the corresponding distributions obtained in plasmas at the JET tokamak, is a better approach and we explain this by means of visualizations on the Gaussian manifold.

References:

$^*$See the Appendix of F. Romanelli et al., Proceedings of the 25th IAEA Fusion Energy Conference 2014, Saint Petersburg, Russia.