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4.33 Bayesian uncertainty calculation in neural network inference of ion and electron temperature profiles at W7-X

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We show a method that combines Bayesian modelling and neural networks (NNs) to have a reliable and real time capable inversion scheme of X-ray imaging diagnostic data for the inference of ion and electron temperature profiles at Wendelstein 7-X. The feasibility of such an approach relies on the implementation of the diagnostic model within the Minerva Bayesian modelling framework: in this context a model is defined as the combination of the prior distributions over the free parameters, the physics relations describing the processes and the likelihood distribution on the observed quantities. Such implementation is used to create the neural network training set, sampling from properly chosen prior distributions. In this way the NN will learn a surrogate model of the model and its inverse. In order to provide a sensible NN inversion, the uncertainties of the NN model are calculated in a Bayesian fashion. The uncertainty of the NN prediction is calculated under the Laplace approximation of the posterior distribution of the learnt weights. The NN is then evaluated on real data and the prediction is compared to the standard Bayesian inference results. The analysis time with NN is reduced from a few hours to tens of microseconds allowing for real time application.

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