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Enhancing X-ray Binary Analysis through Deep Learning

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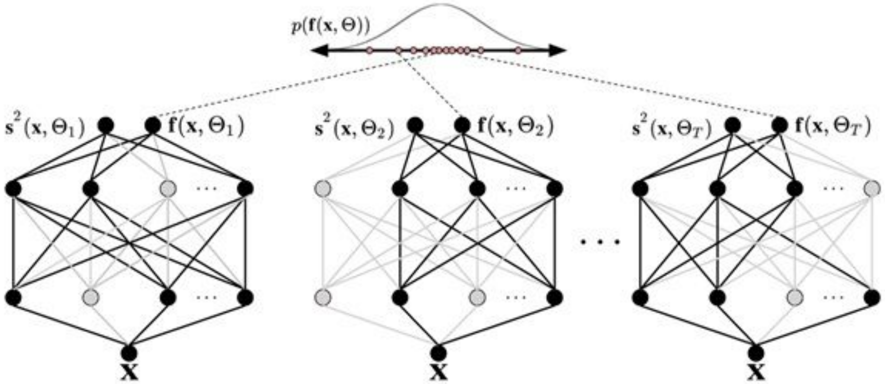
Motivations

- **Context:** Neural networks are widely used for data modeling.
- **Aim:** Assess neural networks' ability to estimate model parameters and uncertainties, compared to traditional X-ray spectral fitting methods.
- **Method**: Train a neural network with MC Dropout on simulated spectra from a multi-parameter emission model to map parameters and return posterior distributions.
- **Application**: Applied to data from the NICER X-ray instrument (0.2-12 keV) using simple emission models with up to 5 parameters.

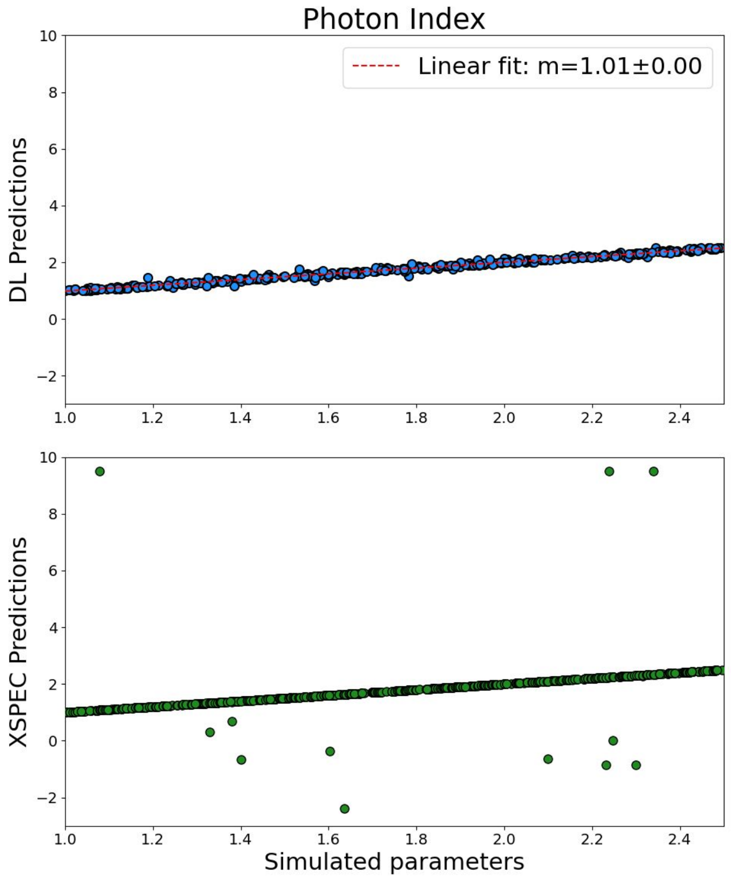


MC Dropout at the evaluation stage (regression) ([AWS Prescriptive Guidance - Quantifying uncertainty in deep learning systems (awsstatic.com)])

Results: local minima

The advantages of using a NN: Less sensitive to local minima trapping than standard fit statistic minimization techniques

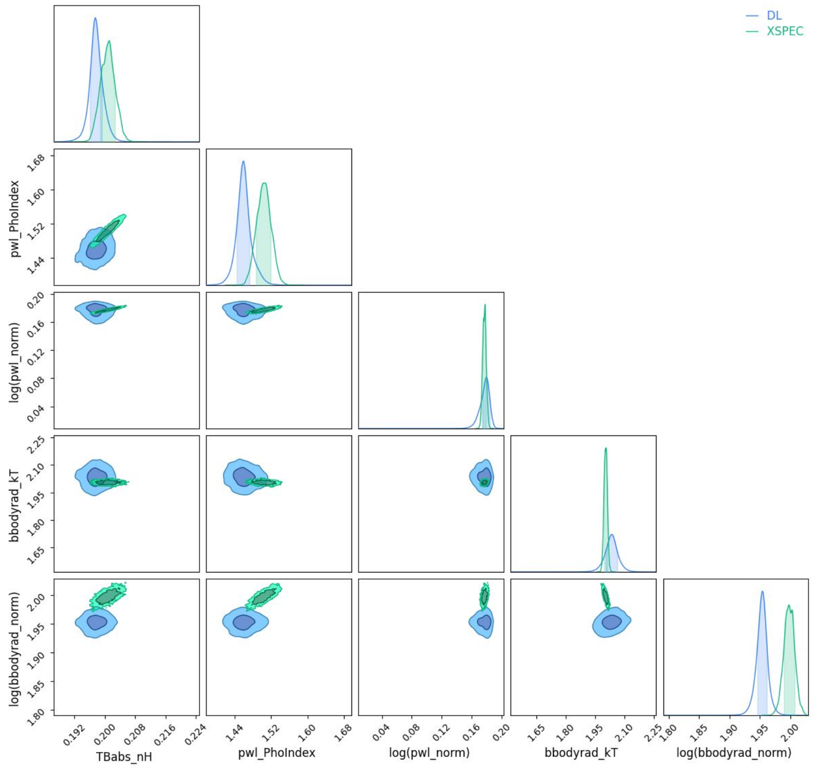
tbabs x (powerlaw + bbodyrad)		
Nh	[.15, .35]	Uniform
Gamma	[1, 3]	Uniform
NormPL	[.01, 10]	Log Uniform
kTbb	[.3, 10]	Uniform
NormBB	[1, 10^4]	Log Uniform



Results: posteriors comparison

Posterior distribution comparison between Bayesian X-ray Analysis (BXA) spectral fitting and out NN, as applied to a reference spectrum. The spectrum is modeled as tbabs∗(blackbody+powerlaw). There is a good match between the 2 methods, not only on the best fit parameters but also on the width of the posterior distributions.

The NN however is **~5 faster** than the BXA and MCMC methods.



Thank you