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Calibrating Bayesian Tension Statistics with Neural Ratio Estimation

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Quantifying tension between different experimental efforts aiming to constrain the same physical models is essential for validating our understanding of the Universe. A commonly used metric of tension is the ratio, R, of the joint Bayesian evidence to the product of individual evidences for two experimental datasets under some common model. R can be interpreted as a measure of our relative confidence in a dataset given knowledge of another. The statistic has been widely adopted by the community as an appropriately Bayesian way of quantifying tensions, however it has a non-trivial dependence on the prior that is not always accounted for properly. We propose using Neural Ratio Estimators (NREs) to calibrate the prior dependence of the R statistic. We show that the output of an NRE corresponds to the tension statistic between two datasets if the network is trained on simulations of both experiments observables. Such an NRE can then be used to derive the distribution of all possible values of R, within one's model prior, for observations from the two experiments that are consistent. The observed R for the real datasets, derived using Nested Sampling, can then be compared with this distribution to give a prior independent determination of how in tension the experiments truly are. We demonstrate the method with a toy example from 21-cm Cosmology and a joint analysis of Planck and BAO data.

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