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Approximating Decomposed Likelihood Ratios using Machine Learning

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In High Energy Physics and many other fields likelihood ratios are a key tool when reporting results from an experiment. In order to evaluate the likelihood ratio the likelihood function is needed. However, it is common in HEP to have complex simulations that describe the distribution while not having a description of the likelihood that can be directly evaluated. This simulations are used to obtain a high dimensional observation by emulating the underlying physics of the process. Commonly, in this setting it is impossible or computationally expensive to evaluate the likelihood. We show how this problem can be solved by using discriminative classifiers in order to construct an equivalent version of the likelihood ratio that can be easily evaluated. We also show how this can be used to approximate the likelihood ratio when the underlying distribution is a weighted sum of probability distributions (e.g. signal plus background model). We demonstrate how the results can be considerably improved by decomposing the test and use a set of classifiers in a pairwise manner on the components of the mixture model and in which way this can be used to estimate the unknown coefficients of the model (e.g. the signal contribution). Finally, we present an application of the method on the estimation of non-SM coupling constants of the Higgs boson based on an effective field theory (EFT) approach and using a recently developed morphing method.

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