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Signal model parameter scan using Normalizing Flow

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The discovery of Beyond the Standard Model (BSM) is a major subject of many experiments, such as the ATLAS and CMS experiments with the Large Hadron Collider, which has the world's highest centre-of-mass energy. Many types of BSM models have been proposed to solve the issues of the Standard Model. Many of them have some or many model parameters, e.g. the Minimal Supersymmetric Standard Model, which is one of the most famous BSM models, has more than 100 model parameters. These model parameters are free parameters; they cannot be predicted from theories and need to be tested experimentally.

Data analysis of BSM model searches involves comparing observed experimental data with a particular BSM model. When the BSM model parameters are multidimensional, performing an analysis covering the whole phase space is difficult. Instead, it is often performed by fixing some of the model parameters to focus on one or two parameters or by defining and using some typical benchmark points, resulting in phase space holes that are not covered by the search.

This talk presents a parameter scan technique for BSM signal models based on Normalizing Flow. Normalizing Flow is a type of deep learning model that transforms a simple probability distribution into a complex probability distribution as an invertible function. By learning an invertible transformation between a complex multidimensional distribution, such as experimental data observed in collider experiments, and a multidimensional normal distribution, the Normalizing flow model gains the ability to sample (or generate) pseudo experimental data from random numbers and to evaluate a log-likelihood value from multidimensional observed events. The Normalizing Flow model can also be extended to take multidimensional conditional variables as arguments. That is, the Normalizing Flow model becomes a generator and evaluator of pseudo experimental data conditioned by the BSM model parameters. The log-likelihood value, the output of the Normalizing Flow model, is a function of the conditional variables. Therefore, the model can quickly calculate gradients of the log-likelihood to the conditional variables. Following this property, it is expected that the most likely set of conditional variables that reproduce the experimental data, i.e. the optimal set of parameters for the BSM model, can be efficiently searched. This talk will demonstrate this on a simple dataset and discuss its limitations and future extensions.

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