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Efficient Parameter Space Exploration in BSM Theories with Batched Multi-Objective Constraint Active Search

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Phenomenological analyses in beyond the Standard Model (BSM) theories assess the viability of BSM models by testing them against current experimental data, aiming to explain new physics signals. However, these analyses face significant challenges. The parameter space in BSM models are commonly large and high dimensional. The regions capable of accommodating a combination of experimental results, is often sparse and potentially disconnected. Moreover, the numerical evaluation for each configuration computationally expensive.

To address these challenges, our work introduces a batched Multi-Objective Constrained Active Search approach. Physical observables and statistical tests, such as particle masses and χ^2-tests from experimental data respectively, are defined as the objectives with pre-defined constraints. We use probabilistic models as surrogates for the objectives to enhance sample efficiency, and a volume-based active sampling strategy, that uses the surrogates to effectively characterise and populate satisfactory regions within the parameter space of BSM models.

We employ the algorithm with the B-L SSM model to accommodate results an observed signal at ~ 95 GeV in neutral scalar searches in $h \to \gamma\gamma$ channel. We found that the algorithm efficiently identifies satisfactory regions in the parameter space of the B-L SSM model, improving previous studies in this model. We conclude by outlining future directions for this research, and sharing the developed tools for the community's use.

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