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A graph neural network for B decays reconstruction at Belle II

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Over the past few years, intriguing deviations from the Standard Model predictions have been reported in measurements of angular observables and branching fractions of B meson decays, suggesting the existence of a new interaction that acts differently on the three lepton families. The Belle II experiment has unique features that allow to study B meson decays with invisible particles in the final state, in particular neutrinos. It is possible to deduce the presence of such particles from the energy-momentum imbalance obtained after reconstructing the companion B meson produced in the event. This task is complicated by the thousands of possible final states B mesons can decay into, and is currently performed at Belle II by the Full Event Interpretation (FEI) software, an algorithm based on Boosted Decision Trees and limited to specific, hard-coded decay processes.
In recent years, graph neural networks have proven to be very effective tools to describe relations in physical systems, with applications in a range of fields. Particle decays can be naturally represented in the form of rooted, acyclic tree graphs, with nodes corresponding to particles and edges representing the parent-child relations between them. In this work, we present a graph neural network approach to generically reconstruct B decays at Belle II by exploiting the information from the detected final state particles, without formulating any prior assumption about the nature of the decay. This task is performed by reconstructing the Lowest Common Ancestor matrix, a novel representation, equivalent to the adjacency matrix, that allows reconstruction of the decay from the final state particles alone. Preliminary results show that the graph neural network approach outperform the FEI by a factor of at least 3.

Significance

Preliminary results show that this work significantly improves the reconstruction of decays with invisible particles in the final state at Belle II.

References

Experiment context, if any

Belle II

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