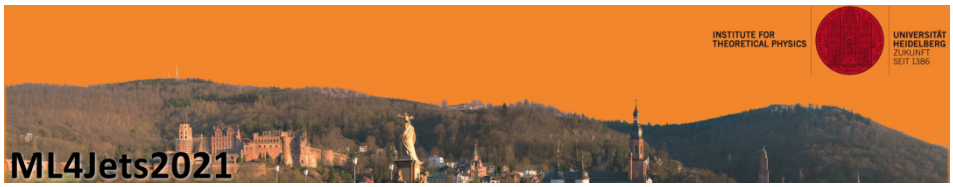


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# Morphology for Jet Classification

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We introduce a morphological analysis based on a neural network analyzing the Minkowski Functionals (MFs) of pixellated jet images. The MFs describe the geometric measures of binary images, and their changes by dilation encode the jet constituents' geometric structures that appear at various angular scales. We explicitly show that this morphological analysis can be considered a constrained convolutional neural network (CNN). Conversely, CNN could model the MFs, and we show their correlation in the example of tagging semi-visible jets emerging from the strong interaction of a hidden valley scenario. The MFs are independent of the IRC-safe observables commonly used in jet physics. We combine this morphological analysis with an IRC-safe relation network, which models two-point energy correlations. While the resulting network uses constrained input parameters, it shows comparable dark jet and top jet tagging performances to the CNN. The architecture has a significant advantage when the available data is limited, and we show that its tagging performance is much better than that of the CNN with a small number of training samples. We also qualitatively discuss their parton-shower model dependency. The results suggest that the MFs can be an efficient parameterization of the IRC-unsafe feature space of jets.

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