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Learnable Wavelet Filter Banks in Convolutional Neural Networks

Deep learning methods such as a Convolutional Neural Network (CNN) typically learn filters directly from data, which reduces the need for engineers to design filters for specific problems. This is great for general use, but learned filters in deep learning methods are usually unintelligible due to their lack of mathematical structure, and multiresolution/multiscale behaviour is learned implicitly. An easy solution to both of these problems is to incorporate wavelet transforms into ones deep learning model because wavelet transforms provide a framework for multiresolution analysis, where wavelet filter banks naturally arise from, as well as provable approximation properties in terms of the vanishing moments of a wavelet. However, in practice, said wavelet filter bank are often fixed and do not learn from the data given to them. This motivates the question of whether or not we can formulate learnable wavelet filter banks. In our research, we explore using the vanishing moments of wavelets as a viable avenue for learnability as wavelet filters can be factorized in a way to fix the number of vanishing moments along with certain degrees of freedom. To investigate the relationship between the number of vanishing moments (denoted L) and the degrees of freedom (denoted N), we compute the classification accuracy of a labeled dataset of images with different combinations of L and N. In the end, we find that the vanishing moments of wavelets are indeed a viable avenue for learnable wavelet filter banks as well as a heuristic proportional relationship between L and N.