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On the Calculation of Higher-Order Convolutions

The quadratic nonlinearity of the incompressible Navier–Stokes equations is transformed into a binary convolution in Fourier space. The compressible Navier–Stokes equations and equations with higher-order nonlinear terms exhibit ternary or other high-order convolutions when transformed into Fourier space.

If the input vectors are periodic or of infinite length, then an n-ary convolution is equal to $n-1$ binary convolutions. However, we show that this does not hold for the case of fixed-length vectors. While the full n-ary convolution for fixed-length vectors is more computationally complex and requires more memory than computing $n-1$ binary convolutions, we demonstrate that this can be cost can be greatly reduced by making use of implicitly padded convolutions.