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**Sobolev spaces with non-Muckenhoupt weights,
fractional elliptic operators, and applications**

We propose a new variational model in weighted Sobolev spaces with non-standard weights and applications to image processing. We show that these weights are, in general, not of Muckenhoupt type and therefore the classical analysis tools may not apply. For special cases of the weights, the resulting variational problem is known to be equivalent to the fractional Poisson problem. The trace space for the weighted Sobolev space is identified to be embedded in a weighted L^2 space. We propose a finite element scheme to solve the Euler-Lagrange equations, and for the image denoising application we propose an algorithm to identify the unknown weights. The approach is illustrated on several test problems and it yields better results when compared to the existing total variation techniques.