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Johannes Schmidt-Hieber - A statistical analysis of an image classification problem

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The availability of massive image databases resulted in the development of scalable machine learning methods such as convolutional neural network (CNNs) filtering and processing these data. While the very recent theoretical work on CNNs focuses on standard nonparametric denoising problems, the variability in image classification datasets does, however, not originate from additive noise but from variation of the shape and other characteristics of the same object across different images. To address this problem, we consider a simple supervised classification problem for object detection on grayscale images. While from the function estimation point of view, every pixel is a variable and large images lead to high-dimensional function recovery tasks suffering from the curse of dimensionality, increasing the number of pixels in our image deformation model enhances the image resolution and makes the object classification problem easier. We propose and theoretically analyze two different procedures. The first method estimates the image deformation by support alignment. Under a minimal separation condition, it is shown that perfect classification is possible. The second method fits a CNN to the data. We derive a rate for the misclassification error depending on the sample size and the number of pixels. Both classifiers are empirically compared on images generated from the MNIST handwritten digit database. The obtained results corroborate the theoretical findings.
This is joint work with Sophie Langer (Twente).