Convolution Networks with Stable Invariants

Joan Bruna and Stéphane Mallat
CMPA, Ecole Polytechnique, 91128 Palaiseau
http://www.cmap.polytechnique.fr/scattering

Convolution networks have been shown to be highly successful for complex recognition problems [2] and seem to build invariant representations, but there is still little mathematical understanding of their properties. Back-propagation learning algorithms require relatively large training samples and structuring the architecture of such networks requires an important computational experience.

We construct a particular class of convolution networks, that implement non-linear scattering operators. They linearize small deformations and are proved to build invariant representations to translations and to any prescribed compact group [3]. For translation invariance, a scattering operator iterates over wavelet and modulus operators and does not require any learning. Affine space models are computed with a PCA in the scattering domain [1]. The classification is performed with a non-linear model selection procedure, which adapts the model dimension to the data and improves SVM error rates. State of the art results are obtained for handwritten digit recognition over small training sets, and for texture classification.

For more complex data sets, such as Caltech101, it is necessary to learn invariant groups from training data and hence the network architecture. This issue will be discussed in conjunction with manifold learning.

References:

[1] J. Bruna, S. Mallat, "Classification with Scattering Operators", http://arxiv.org/abs/1011.3023
[2] Y. LeCun, K. Kavukvuoglu and C. Farabet, Convolutional Networks and Applications in Vision, Proc. Int. Symp. on Circuits and Systems, 2010.
[3] S. Mallat, "Group Invariant Scattering", http://arxiv.org/abs/1101.2286

Topics: learning theory, visual processing and pattern recognition