DCT, Wavelets and X−lets: The Quest for Image Representation, Approximation and Compression

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Abstract : Expansion of signals in orthonormal bases is central to signal and image processing. From the KLT and its approximation, the DCT, basic transform coding has been very successful. Over the last 15 years or so, wavelets have appeared as a powerful alternative to the more traditional Fourier like representations, having impact for example on image coding standards, like JPEG2000. We first briefly review Fourier and wavelet bases, and address approximation theoretic properties, in particular the interesting behavior of certain simple non−linear approximation schemes for piecewise smooth signals. We extend this to compression schemes, indicating the basic difference between approximation and compression. We then move to the "real" problem, namely schemes suited for true two−dimensional signals, with objects having smooth 1−dimensional singularities, or contours. We review recent constructions in this area, including curvelets, contourlets, directionlets as well as signal adaptive schemes. The challenge of constructing generic two−dimensional bases that have optimal approximation behavior is described, and the various proposals contrasted. In particular, the proof that contourlets can achieve the optimal 1/M^2 NLA rate will be briefly outlined. We end by pointing out areas of current research. First, a challenge is certainly finding practical schemes.
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This entails dealing with finite size data, as well as sampled and possibly noisy data. Only this will allow using new bases for "real" compression tasks. In addition, new types of imagery start appearing, where true multidimensional processing will be required, like for example plenoptic images. The applicability of directional analysis in such cases will be discussed. This talk is based on work done with a number of collaborators, in particular B.Beferull–Lozano (UVaMencia), M.Do (UIUC), P.L.Dragotti (Imperial), L.Sbaiz (EPFL), P.Vandewalle (EPFL) and V.Velisavljevic (DTelekom).