Title:	Sparse Modeling: Applications and Extensions to Perceptual (SSIM) Index
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Abstract: Sparsity based signal processing has gained much consideration and importance in recent time. Sparse processing can harness redundancy presents in real world data and present a low dimensional signal representation in the union of subspaces induced by the columns of a dictionary or transformation matrix. It is found that the classical analytical class of such matrices, for instance, discrete Fourier transforms, discrete wavelet transforms, and many more, are incapable of capturing all the important attributes of real world signals. With the availability of cheap computational hardware, learning based overcomplete dictionaries has gained much attention and popularity and are replacing then classical analytical representations. In this thesis, we investigate various aspects of the sparsity based modeling framework. First, we exploit localized information of image data to improve the performance of sparse modeling based applications such as denoising and segmentation. Mathematically, the general sparse modeling framework employs mean square based fidelity metrics and a sparse promoting term. However, it is now well known that the mean square error criterion is poorly aligned with human perceptual assessment. With this in mind, various tools for image quality assessment has been developed. The Structural Similarity Index Measure (SSIM) is arguably the most noticeable of such image quality assessment tools. This measure is mathematically simple, yet powerful enough to express the quality of a test image, in a manner that is found to be in close agreement with the assessment of human vision. However, very little is know about its attributes induced by lower dimensional mapping. For instance, how does intrinsic structural information present in the data reflect in the low-dimensional representation? What about its representation and discrimination capabilities? We have attempted to study SSIM using self-organizing maps with such questions in mind. The SSIM index is non-convex in nature, and due to this, its applicability is restricted if seen as a replacement for the conventional mean square fidelity component in any modeling framework. In the next stage of our work, we address this issue. Consequently, we have attempted to convexify the SSIM metric and further design alternative learning algorithm for the regularized linear model. This alternative learning scheme with a sparsity prior is finally tested on a denoising application. To further boost the performance, an iterative scheme is developed, based on the statistical nature of added noise. Finally, the proposed denoiser is compared with other state-of-the-art schemes. Possible extensions of this thesis work has been mentioned at the end.

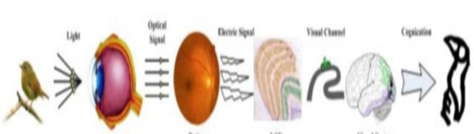
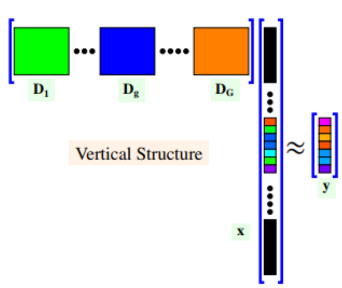
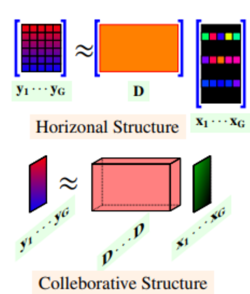


Figure 1.1: The HSV System [23]





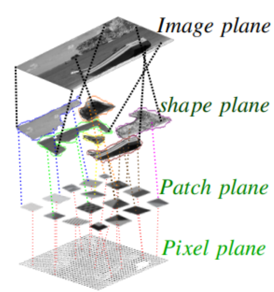


Figure 1.4: Pixel to Image Plane Model