Image Representation Techniques: Data-Driven vs Sparsity Based Models

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Project Summary

The linear forward model $\mathbf{y} = \mathbf{H}\mathbf{x} + \mathbf{n}$ is used in many imaging and image processing problems, for example: image denoising problem when $\mathbf{H}$ is the identity operator and image deconvolution/deblurring when $\mathbf{H}$ is a convolution operator. Recovery or synthesis of the true image $\mathbf{x}$ can be posed as an inverse problem: for which data-driven methods including autoencoders, and sparsity driven optimisation methods, like K-SVD are popular choices for solvers. Data-driven methods like autoencoders learn to synthesise latent variables that is of lower dimension that represents the image, whereas sparsity based methods utilises the prior that images are sparse in some domain that can be preset or learnt. Learning compact image representations enables denoising images as well as recovering high resolution images during the reconstruction process through the decoder network in autoencoders and dictionaries learnt in sparsity based methods. The reconstructed image quality of data-driven techniques are shown to be better than sparsity based methods, however, data-driven methods require large image datasets and training can be computationally expensive; whereas sparsity based methods, even with learnt dictionaries can be done using a single image.

We wish to investigate performance of autoencoders and sparse representation models of image representation for image denoising and super resolution. In particular, we wish to investigate the performance of method proposed in [1] where an autoencoder is used to represent images in a low-dimensional latent space to the method proposed in [2] where two dictionaries, one for a low-dimensional representation and the other for a high-dimensional representation, are learnt from single image patches.

Contributions

We wish to understand effective ways of learning image representations, specific to the task of image denoising and super resolution. We plan to do a comparative analysis of autoencoders vs sparsity based image representations in terms of PSNR and robustness to noise by implementing the methods described in [1] and [2]. We also wish to compare the run-time complexity of the methods.

Plan

We initially plan on replicating results obtained in [1] and [2] separately. We then plan to compare the methods for different levels of noise degradation and upscaling factors over the same image dataset.

References

[1] Pascal Vincent, Hugo Larochelle, Yoshua Bengio, and Pierre-Antoine Manzagol. Extracting and composing robust features with denoising autoencoders. In *Proceedings of the 25th International Conference on Machine Learning*, pages 1096–1103, 2008.

[2] Jianchao Yang, John Wright, Thomas S Huang, and Yi Ma. Image super-resolution via sparse representation. *IEEE Transactions on Image Processing*, 19(11):2861–2873, 2010.