Wavelets 2016-2017 – Project list

1. **Wavelet transform of large images using small memory allocations –** In this project the goal is to design and implement an algorithm that allows taking as input a very large image (gigabytes) and then applying a seemless wavelet forward and inverse transforms through local processing of blocks.

2. **Corrupted image inpainting (recovery) by l1 minimization of Wavelet/Shearlet coefficients –** Here we suppose some random subset of the pixels in the image were corrupted (e.g. at the time of transmission) and we wish to recover them. Based on the assumption that images are sparse in the wavelet or shearlet domains, we apply an l_1 minimization algorithm See *E. King, G.Kutyniok, and W.-Q Lim, Image Inpainting: Theoretical Analysis and Comparison of Algorithms, Wavelets and Sparsity XV (San Diego, CA, 2013), SPIE Proc. 8858.* For l_1 minimization, see selection in http://dsp.rice.edu/cs (one option is to use the TVAL package). For implementation of Shearlets see http://www.shearlab.org/ .

3. **Adaptive compressed sensing using wavelet trees –** The goal is to sample from an unknown image only the small subset of significant wavelet coefficients without sampling the entire image. In this project we follow: *S. Dekel, S. Deutsch and Amir Averbuch, Adaptive compressed image sensing using dictionaries, SIAM Journal of imaging sciences 5 (2012), 57-89*.

4. **Adaptive CT reconstruction using Ridgelets –** In this project we follow: *A. Averbuch, O. Barkan, S. Dekel and Y. Tenzer, A mathematical model for extremely low dose adaptive computed tomography acquisition, Lecture notes in computer science 8177 (2014), 13-33.* The goal is to implement a mathematical model of an adaptive CT machine that projects x-rays adaptively only where needed, so as to reduce the dosage admitted to the patient. The algorithm is based on Ridgelet analysis.

5. **Image compression using Embedded Zero Trees –** In this project we follow: *J. Shapiro, Embedded image coding using zerotrees of wavelet coefficients, IEEE Transactions on signal processing 41 (1993), 3445-3462*. This is a landmark paper that is considered a significant breakthrough in image coding. The algorithm is not too difficult to follow and implement.

6. **Image denoising using frames** - The goal of the project is to recover an image that was corrupted by Gaussian (white) noise. We follow the paper discussed in class: *R. Coifman and D. Donoho, translation invariant de-noising, Wavelets and Statistics, Lecture Notes in Statistics 103 (1995), 125-150*. Note that the paper discusses the 1d case and the project requires the 2d case.

7. **Scattering networks invariant under image rotation** – The goal of the project is to support texture recognition, where the input texture image could be rotated. To this end, the scattering network algorithm (see http://www.di.ens.fr/data/scattering/) needs to be adapted to support this feature (e.g. via the right permutation algorithm).

8. **Sparse representation using geometric wavelets –** As explained in class, the goal of geometric wavelets is to go beyond the classical isotropic wavelets and construct a wavelet-like representation that adapts to the image. We follow: *S. Dekel and D. Leviatan, Adaptive multivariate approximation using binary space partitions and geometric wavelets, SIAM Journal on Numerical Analysis 43 (2005), 707-732*.

9. **Feature importance using wavelet decomposition of random forests –** This project is based on Oren Elisha's lesson. The goal is to take certain large data sets, apply Oren's cloud random forest infrastructure and compare the wavelet approach to existing statistical methods of "feature importance" (e.g variable permutation, Gini, variance, etc.).

10. **Wavelet decompositions of random forests promoting diversity –** The goal of this project is to test concepts of the statistical community that encourage adding randomness to the creation of the forest trees (e.g. the random subspace method). The goal is to compare various flavors of diversity and get a sense of what's working and what's not.