Image Inpainting Using Sparse Coding

Zahra sadat sajadifar
Dr. Mohammadali Khosravifard

Isfahan University of Technology

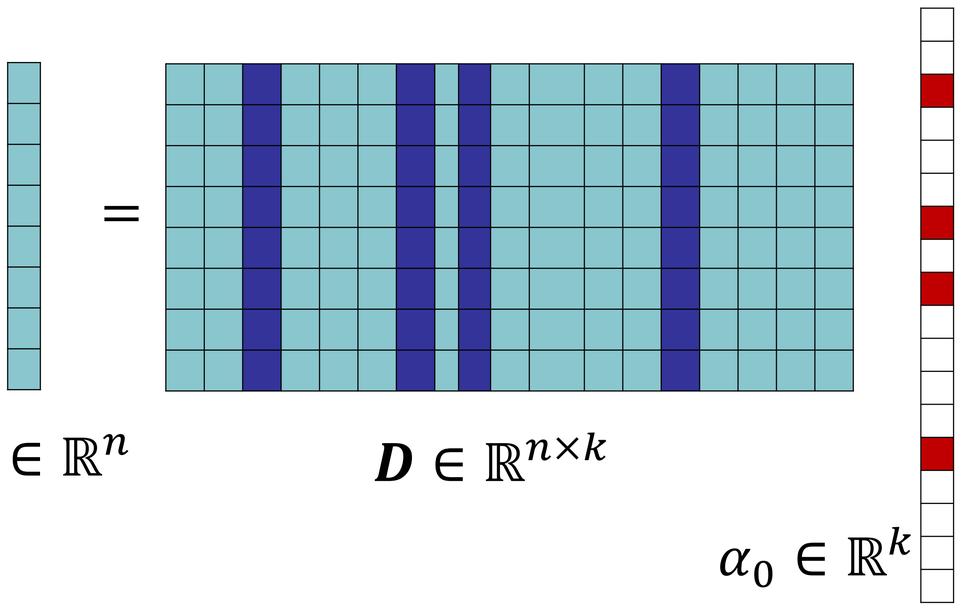
1. Introduction

- The sparseland is a powerful model for describing signals based on their sparseness and redundancy.
- According to this model, the signal can be depicted on non-orthogonal basis (atoms) of a defined space (dictionary), so that the obtained coefficients are sparse.
- In this project, we concentrate on application of sparse coding in image inpainting.

2. Sparseland

- **Sparse representation:** We need to solve an under-determined linear system of equation:

  $\boldsymbol{D}\alpha_0 = x$. Among all possible solutions we want the sparsest.
- We will measure sparsity using the ℓ_0 norm.
- Put formally: $\min_{\alpha} \left||\alpha|\right|_0 \quad s.t. \quad x = \boldsymbol{D}\alpha$
- To solve this problem, we can use relaxation (Basis Pursuit) or greedy methods (Matching Pursuit).
- The choice of the dictionary $\boldsymbol{D}$: pre-structured dictionary such as DCT or adaptive dictionary learnt on signal patches using K-SVD algorithm.



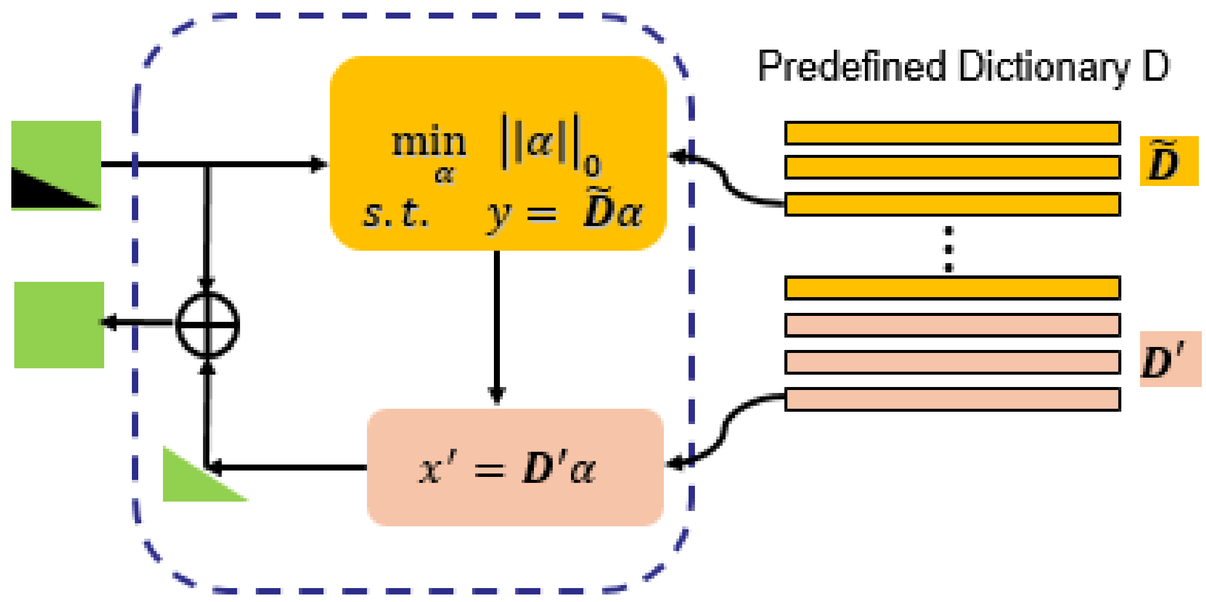
3. Inpainting

- Inpainting refers to filling-in missing values or pixels in known locations in the signal or image.
- **Assumption:** The signal x was created by

  $x = \boldsymbol{D}\alpha_0$ with a very sparse α_0.
- we define a diagonal mask operator $\boldsymbol{M}$ representing the lost sample:

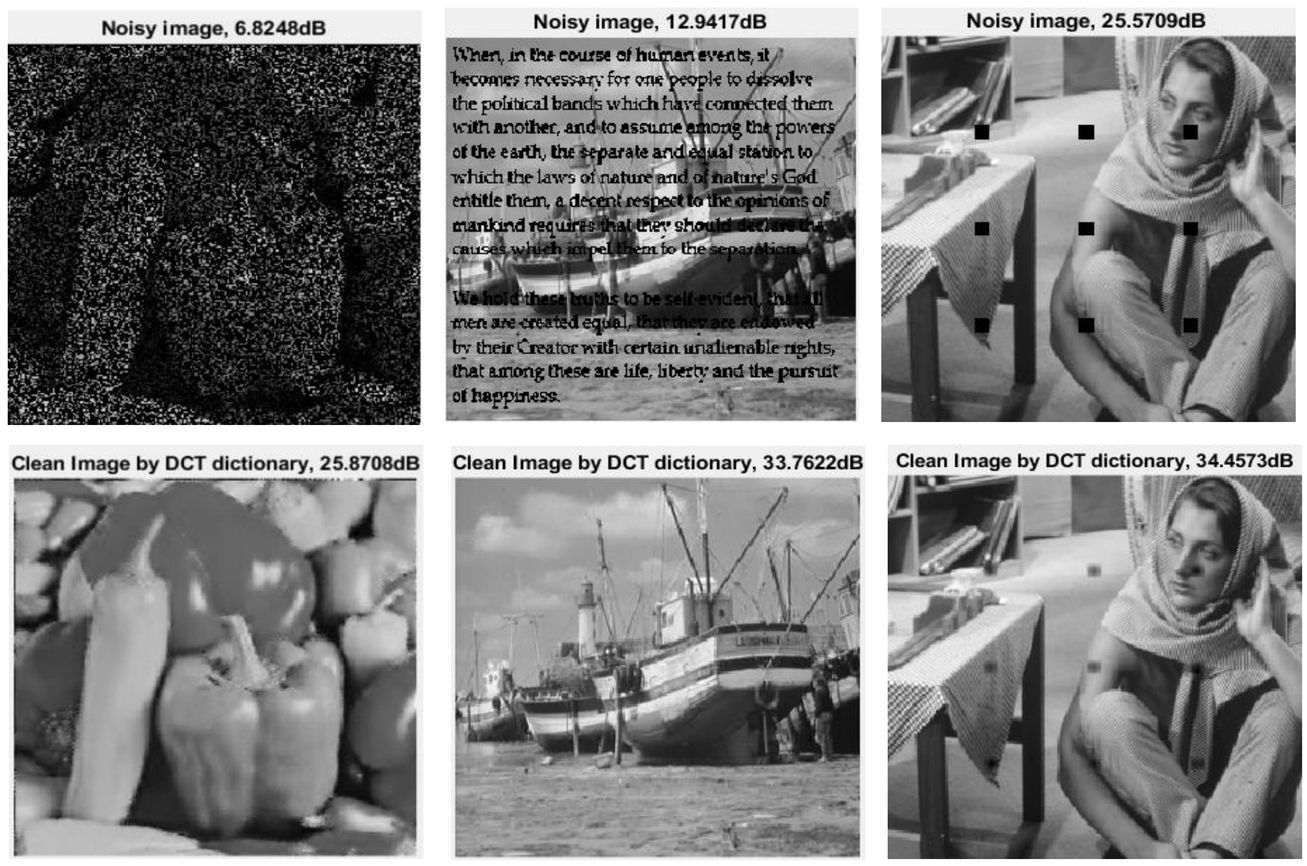
  $$y = \boldsymbol{M}x \ , \boldsymbol{M}_{ii} \in \{0,1\}$$

- Missing values in x imply missing rows in this linear system showed by $\boldsymbol{D}'$, x' .
- By removing these rows, we get $y = \boldsymbol{M}\boldsymbol{D}\alpha_0 = \tilde{\boldsymbol{D}}\alpha_0$.
- Now solve $\min_{\alpha} \left||\alpha|\right|_0 \quad s.t. \quad y = \tilde{\boldsymbol{D}}\alpha$.
- If α_0 was sparse enough, it will be the solution of the above problem! Thus computing $\boldsymbol{D}\alpha_0$ recovers x perfectly.
- For images, we consider the image as $\sqrt{n} \times \sqrt{n}$ overlapped patches and apply these steps for each patch.



4. Simulation Results and Conclusion

- Experiments and simulations showed that by sparse representation over image patches we can obtain acceptable results for image inpainting.
- One expected limitation is filling large holes especially larger than size of patches because the whole patch is corrupted and lost. To solve this problem, global modeling (considering the whole image as a patch) or larger size for the image patches according to the dimension of holes, can be used.
- Larger values of the sliding distance between processed blocks result faster performance without remarkable effect on quality.



M. Elad, “Sparse and Redundant Representations from Theory to Applications in Signal and Image Processing,” .