Question 5

- Here is our mandatory Google search question. Note that this is the only question for which you can perform a google search to get the answer. Your task is to search for a research paper which applies compressed sensing in any one application not covered in class. Some examples include air quality monitoring, optical microscopy, or any other. Answer the following questions briefly:
    1. Mention the title of the paper, where and when it was published, which venue (name of journal or conference or workshop) and include a link to the paper.
    2. Very briefly describe the hardware architecture used in the paper. You may refer to figures from the paper itself.
    3. What reconstruction techhnique or cost function does the paper adopt for the sake of compressive reconstruction in this application? [3+4+4=10 points]

Answer:

a)

Title: Compressive Scanning Transmission Electron Microscopy
Authors: D. Nicholls, A. Robinson, J. Wells, A. Moshtaghpour, M. Bahri, A. Kirkland and N. Browning
Date: 22 Dec 2021
Venue: ICASSP 2022
Link: https://arxiv.org/pdf/2112.11955

b) Hardware architecture

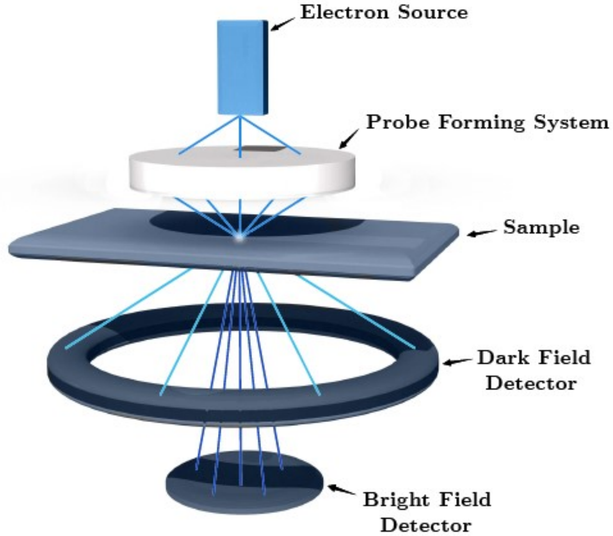

Figure 1: Scanning Transmission Electron Microscopy (STEM)

As shown in figure 1, STEM consists of an electron source, a probe forming system, a scan coil system, and an image forming system. The emitted electrons are condensed by the probe forming system. The probe is raster scanned over the sampling area. The authors used a line hop sampling scheme in which subsampling randomly the adjacent locations to the probe's line trajectory is performed. Fewer measurements are taken using this scheme to avoid the electron overdose problem. The transmitted electrons are then detected by a bright field detector. The formed image is the intensity of the resulting electron wave-function at each pixel, corresponding to a certain set of scan coordinates.

c) Image reconstruction technique

The model is,

$$\mathbf{y} = \mathbf{P}_{\Omega}\mathbf{x} + \mathbf{n}$$

,where $\mathbf{P}_{\Omega} \in \{0, 1\}^{MxN}$ is the mask operator depending on the subsampling scheme and $\mathbf{n}$ is the noise.

The authors performed dictionary learning adopting a Bayesian non-parametric method called Beta Process Factor Analysis(BPFA) for reconstruction of the images. Each image patch is assumed to be sparse in a shared dictionary ($x_i = D\alpha_i$). BPFA approach allows to infer D, α and the noise statistics.Here BPFA is applied on problem P2 in a regularised form or the LASSO. BPFA prunes unneeded elements, and updates the sparsity pattern by using the posterior distribution of a Bernoulli process. It updates the weights and the dictionary from their Gaussian posteriors. These updates are done using Expectation Maximisation(EM). EM involves an expectation step to form an estimation of the latent variables ($\alpha_i s$),and a maximisation step to perform a maximum likelihood estimation to update other parameters.