# BME516 Final Exam: Iterative Reconstruction Coding

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**GitHub Link:** https://github.com/xinformatics/iterative_recon_bme516

**Summary:** The coding assignment contains three jupyter notebooks:

**Part 01: 01_Original_Python_Code.ipynb: Implementation of the original MATLAB program in Python.**

The code performs iterative reconstruction of an image from partially corrupted k-space data. The iterative reconstruction process alternates between correcting the k-space data and generating a new image estimate. First, the code generates a phantom image and its corresponding k-space data. Then, it simulates a case where part of the k-space data is corrupted. It assumes that line#256 of the k-space data is corrupted but the correct value is unknown. The code applies an iterative approach to address this problem to produce an image with reduced artifacts. The process involves two steps:

In the first step, the code takes the corrupted k-space data and uses the fixed part of the image to reconstruct an estimate of the full image. The fixed part of the image is obtained by setting to zero the k-space values corresponding to the corrupted part of the k-space data. The fixed k-space data is obtained by taking the Fourier transform of the fixed part of the image. This step produces a new image estimate close to the true image in the fixed part of the image.

In the second step, the code takes the corrupted k-space data and replaces the corrupted part of the k-space data with the corresponding fixed part of the k-space data obtained in the previous step. This produces new, less corrupted, k-space data. The code then takes the new k-space data and reconstructs a new image estimate using the same method as in the first step. The process is repeated for several iterations until the artifacts in the image are significantly reduced.

Part 02: **02_Residual_Computation_Threshold_Stopping.ipynb**

This notebook is similar to Notebook 1, the additions being computing the residual artifact (e.g., the signal level in the background area) across those 200 iterations and plotting them. This notebook also contains Early stopping of the reconstruction loop if the signal does not

improve by some threshold percentage. The early stopping procedure ensures that the algorithm computation time is reduced.

A threshold-based stopping criterion is commonly used in iterative reconstruction algorithms to terminate the reconstruction process. The algorithm stops when the residual signal level falls below a pre-defined threshold value. The residual signal level represents the difference between the measured data (in this case, k-space data) and the estimated data (in this case, the reconstructed image).

Here is the pseudocode for a threshold-based stopping criterion:

```
threshold = 1e-5  # pre-defined threshold value
max_iter = 100    # maximum number of iterations

for i in range(max_iter):
    # Perform reconstruction using iterative method

    # Calculate residual signal level
    residual = np.sum(np.abs(k_space_data)) - np.sum(np.abs(reconstructed_image))

    # Check if residual signal level is below threshold
    if residual < threshold:
        break

# The reconstruction process has finished
```

In this pseudocode, the threshold is the pre-defined threshold value compared to the residual signal level at each iteration. max_iter is the maximum number of iterations set to avoid an infinite loop. Inside the loop, the iterative reconstruction algorithm is performed. After each iteration, the residual signal level is calculated as the absolute difference between the sum of the absolute values of the original k-space data and the sum of the absolute values of the reconstructed image. If the residual signal level falls below the threshold value, the loop is terminated using a break statement. After the loop, the reconstruction process is finished.

Part 03: **03_Residual_Computation_Thresold_Stopping_More_Noise.ipynb**: Two k-space lines are corrupted in this notebook with 100x high artifact value. The rest of the procedure is the same as in notebook 2. The only observation is that with higher artifacts, the algorithms take more iterations (hence a higher run time) to reconstruct the image.