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Space K analysis and its impact in the generated image.

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Scientific Initiation Report

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Contents

1 Abstract

In this study we are going to analyse the impact of the k-space at the formation of the final image. We are using a image from a brain in gray scale level.
We want to display and compare four types of image. The first one is the original brain image, the second one is the k-space generated from it, the third one is the k-space truncated.We are picking some region and changing its complex values, setting up to zero, and then generating the third image. For the last, we have the fourth image, it is the generated image from the truncated k-space.
After this proccess we are going to analyse its implications the k-space truncated have in the final image.

2 Introduction

When we have a MRI (Magnetic Resonance Imaging) we first want to generated its k-space. The K-space is created from the magnetic field and have all frequencies that make up the image, we want to analyse those frequencies in the space of complex numbers, and want to use the IFT (Inverse Fourier Transform) to create some meaning to those frequencies, generating the image.
After we apply the Inverse Fourier Transform to the k-space we have the resultanting image, the inverse process is possible, applying the Fourier Transform to an image resulting its k-space, after that we can manipulate its k-space and generating a new image from the k-space manipulated, in this context we are going to call "truncated k-space" the manipulated k-space.

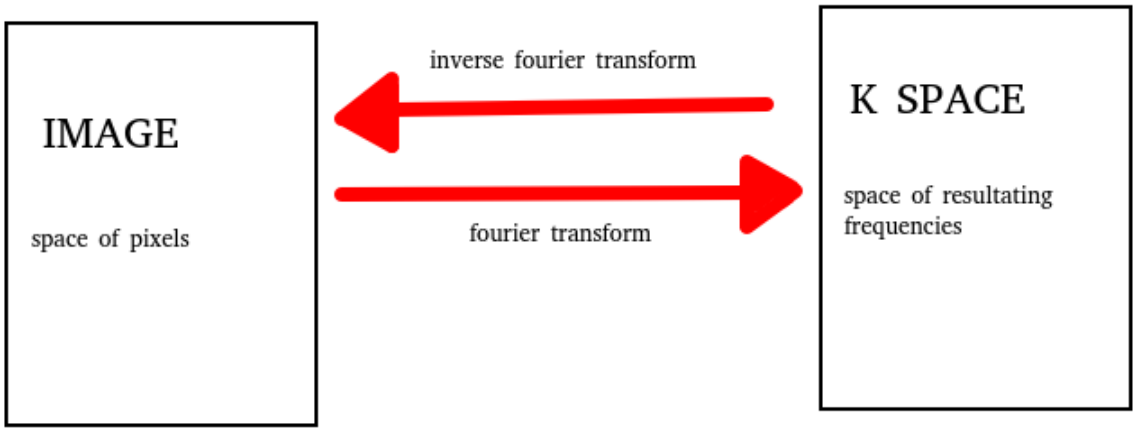

Figure 1: relation between image and k-space

3 Results

Now we are going to generated a certain region in the original image k space, and manipulated its width, viewing the generated image from it, how the choosen region influenciate in the final image. The code used to generate all the results is bellow:

3.1 PYTHON CODE

```
import numpy as np
import matplotlib.pyplot as plt
import cv2
from matplotlib.gridspec import GridSpec

#load image, must be GRAY_SCALE

img = cv2.imread("brain.jpg",0)

height,width = img.shape

#variables:

#rect region to be truncated

#rectangle coordinates, top left (a1,a2) -> (b1,b2) bottom right
#coord = (a1,a2,b1,b2)
coord = (200,250,300,400)

#width of the rect
width_rect = 40

#end variables

x1=coord[0]
y1=coord[1]

x2=coord[2]
y2=coord[3]


fourier = np.fft.fft2(img)

#fourier needs a shift to move the low and high frequencies of the k space
fourier_shift = np.fft.fftshift(fourier)

#log is only for display result
spectrum = np.log(abs(fourier_shift))

#go all over the choosen area
for i in range(x1,x2):
    for j in range(y1,y2):
        #pick area
        if not (i>=x1+width_rect and i<=x2-width_rect and j>=y1+width_rect and j<=y2-width_rect):
            fourier_shift[j][i] = np.complex(0,0)

```

```
47
48 spectrum2 = np.log(abs(fourier_shift))
49
50 img2 = abs(np.fft.ifft2(fourier_shift))
51
52
53 #Create figure and GRID
54
55 fig = plt.figure(figsize=(10,40))
56 gs = GridSpec(1,4)
57 ax1 = fig.add_subplot(gs[0,0])
58 ax2 = fig.add_subplot(gs[0,1])
59 ax3 = fig.add_subplot(gs[0,2])
60 ax4 = fig.add_subplot(gs[0,3])
61
62
63 #original image
64 ax1.imshow(img,cmap='gray')
65 ax1.set_title("original image", fontsize=10)
66
67 #k-space from original image
68 ax2.imshow(spectrum,cmap='gray')
69 ax2.set_title("k-space original", fontsize=10)
70
71 #truncated k-space
72 ax3.imshow(spectrum2,cmap='gray')
73 ax3.set_title("k-space truncated",fontsize=10)
74
75 #image from truncated k-space
76 ax4.imshow(img2,cmap='gray')
77 ax4.set_title("image from truncated k-space", fontsize=10)
78
79
80 plt.show()
```

3.2 Border

Creating a region of 0 values in the border of k-space and going down to the center, the region width is variable, bellow there is the following results.

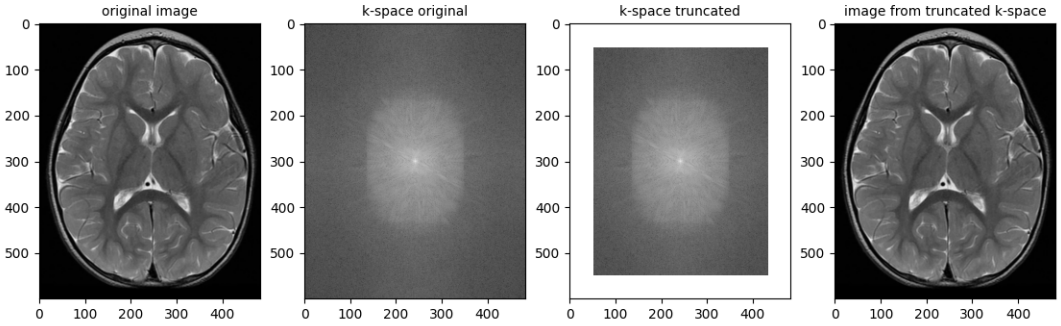

Figure 2: border 1

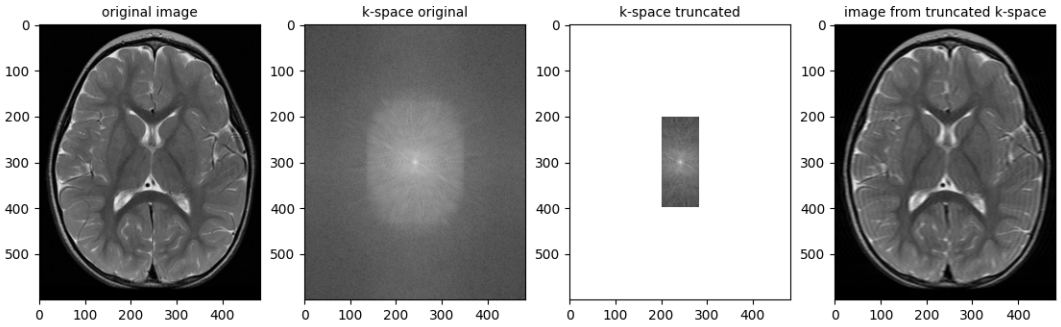

Figure 3: border 2

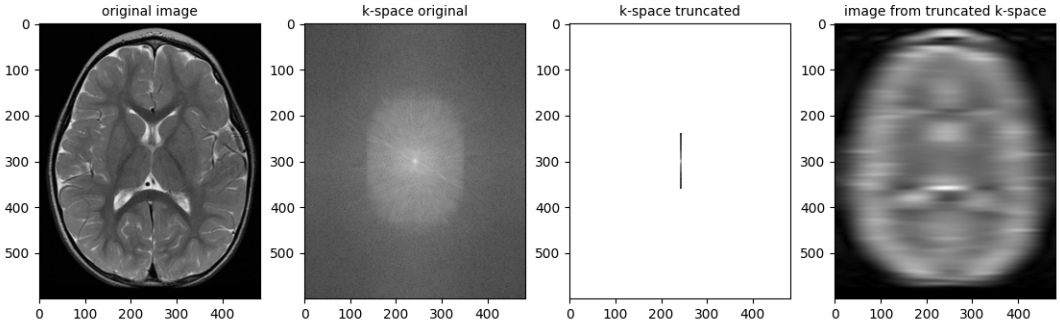

Figure 4: border 3

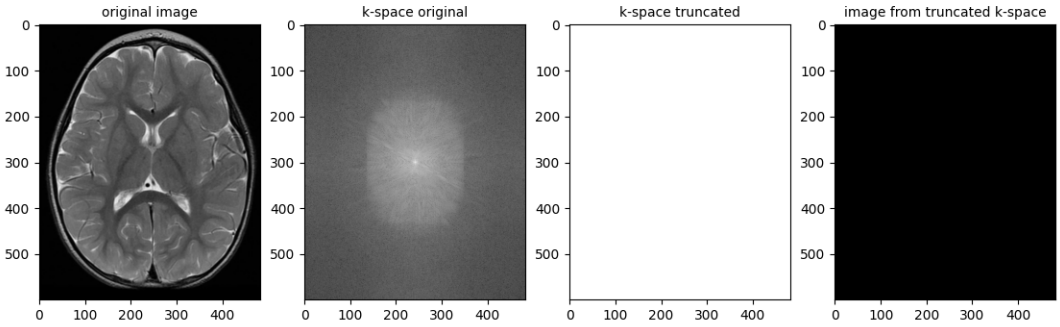

Figure 5: border 4

3.3 Middle

Now it is created a region in the middle of the k space, with variable width, following the results:

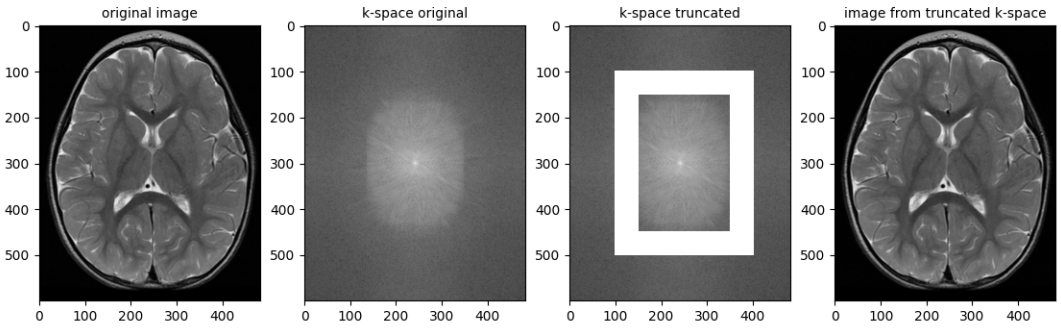

Figure 6: middle 1

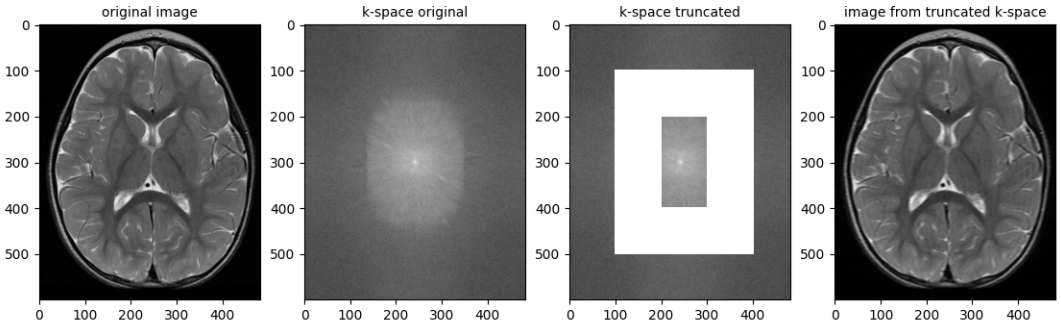

Figure 7: middle 2

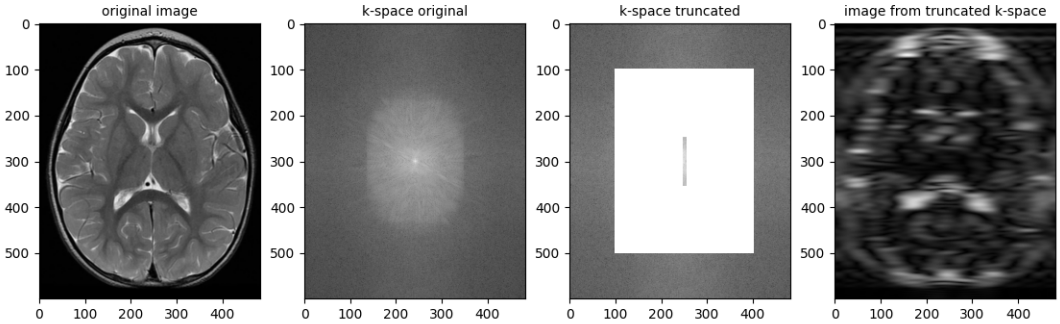

Figure 8: middle 3

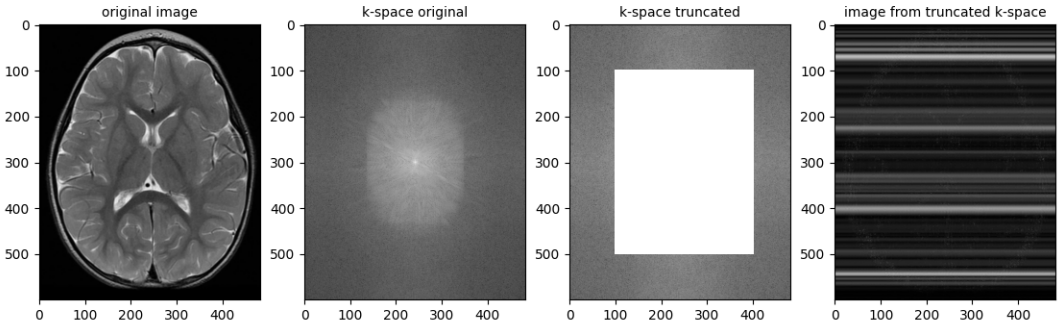

Figure 9: middle 4

3.4 Center

For the last results we created a region at the center.

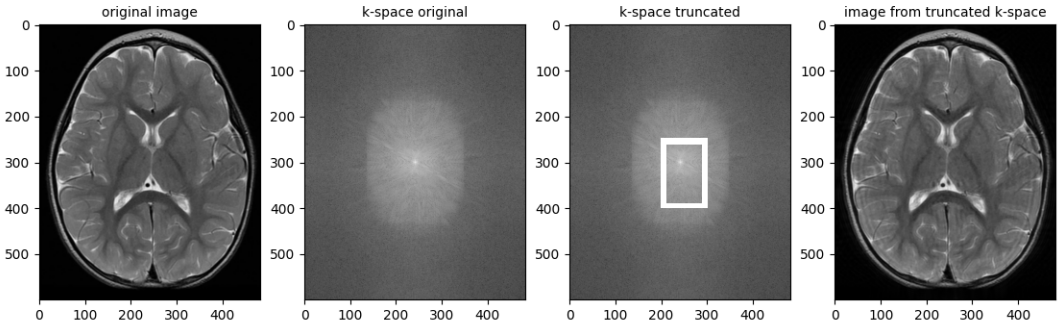

Figure 10: center 1

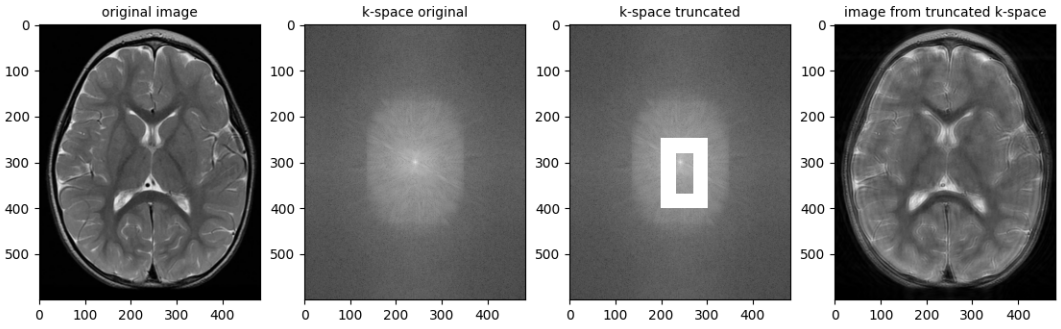

Figure 11: center 2

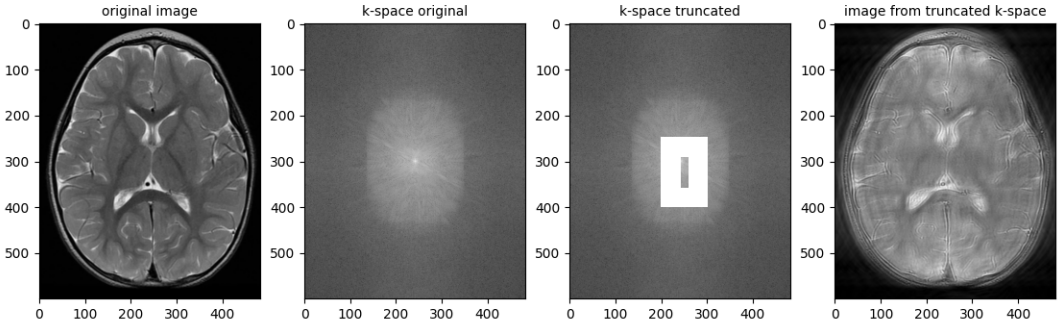

Figure 12: center 3

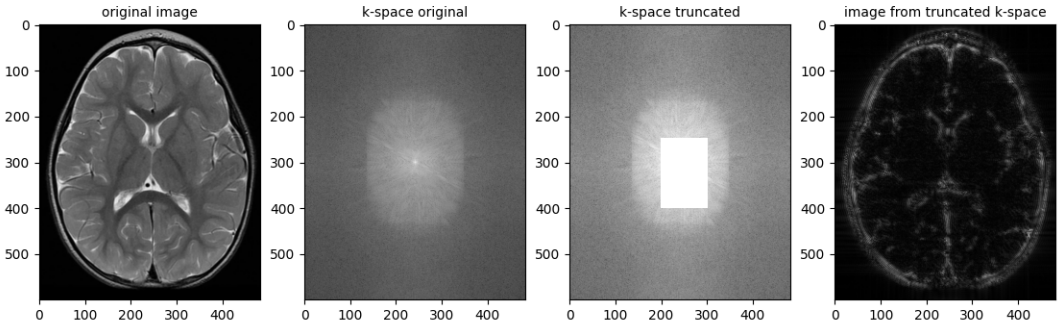

Figure 13: center 4

4 Conclusion

From these experiments we can conclude that the low frequencies (brighter in k space) form the image, its contrast and its colors, and the high frequencies form the contour region, that is, the image details. We also can generate and have a nice idea of the image only with half of its k space.
When the border region is set to 0 both complex coordinates we have a low contourn details (width is growing), kind of a blurry image. On the other side, when a region in center is set to 0 (both complex coordinates) we have a low intensity image and its colors are set to black, but we still have a fine detail contour.

5 References

*Estudo e implementação da reconstrução de imagens de MR adquiridas com múltiplas bobinas, Rafael Ferreira da Costa Vescovi, UNICAMP.