Assignment 5

1. Take the same image as you selected for doing the FFT and the Cosine Transform for previous homework, select a radius of your own choice in the frequency domain:

a. Display the image.
b. Perform the Cosine Transform & display it.
c. Pick a radius value & delete all frequency components outside of the radius & display it.
d. Compute the inverse transform & display it.
e. Please comment on the results.
f. Delete all frequency components inside the radius & display it.
g. Compute the inverse transform & display it.
h. Please comment on the results.
i. Give a general short discussion on what you learned from this question.

Code:-

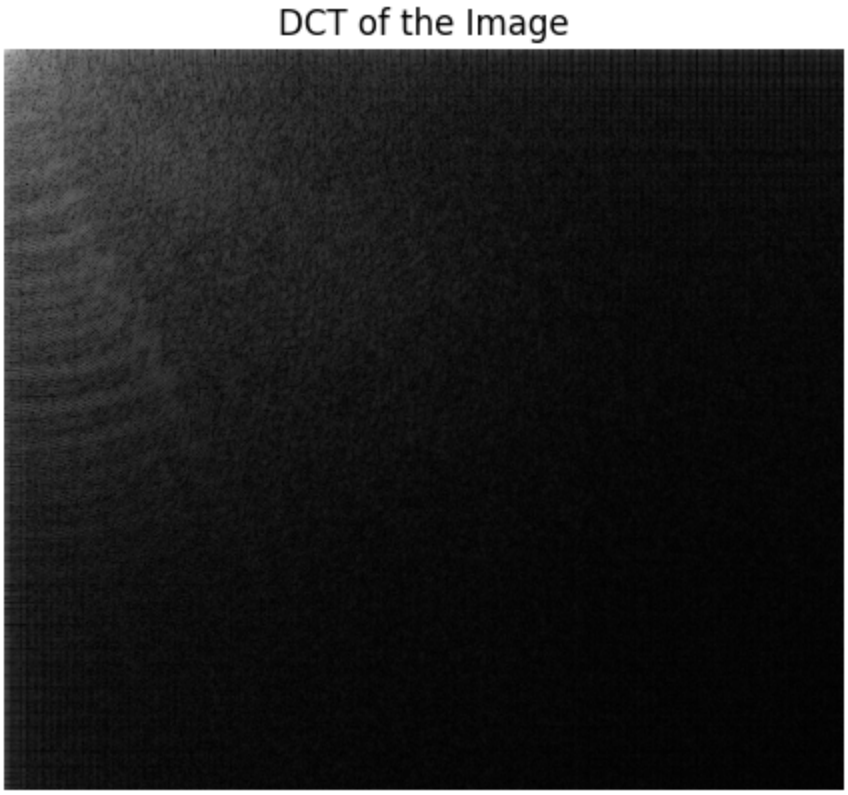
```
!pip install opencv-python

import matplotlib.pyplot as plt
import cv2
from PIL import Image
import numpy as np
from scipy.fftpack import dct, idct
from skimage.color import rgb2gray
from skimage.io import imread
from scipy.fft import fft2, fftshift, ifft2, ifftshift

image = cv2.imread('/content/lungs.jpg', cv2.IMREAD_GRAYSCALE)

plt.imshow(image, cmap='gray')
plt.title('CT Image')
plt.axis('off')
plt.show()
```

```
# Perform the 2D Discrete Cosine Transform (DCT) on the image
cosine_transform_image = dct(dct(image.T, norm='ortho').T, norm='ortho')

# Display the DCT of the image
plt.imshow(np.log(np.abs(cosine_transform_image)+1), cmap='gray')
plt.title('DCT of the Image')
plt.axis('off')
plt.show()

def remove_outer_frequency_radius(radius,img,i):
  mask = np.zeros_like(img)
  center = tuple(np.array(mask.shape) // 2)
  cv2.circle(mask, center, radius, (1, 1, 1), thickness=-1)

  filtered_dct_img = img * mask

  p1=[-1,1,3,5,7,9]
  plt.figure(figsize=(12, 18))
  plt.subplot(5,2,p1[i])
  plt.imshow(np.log(np.abs(filtered_dct_img) + 1), cmap='gray')
  plt.title(f'DCT with Frequencies Outside Radius {radius} Removed')
  plt.axis('off')

  idct_image = idct(idct(filtered_dct_img.T, norm='ortho').T, norm='ortho')

  p2=[-1,2,4,6,8,10]
  plt.subplot(5,2,p2[i])
  plt.imshow(idct_image, cmap='gray')
  plt.title('Reconstructed Image with Frequencies Removed')
  plt.axis('off')
  plt.show()

for i in range(1,6):
  remove_outer_frequency_radius(100*i,cosine_transform_image,i)
```

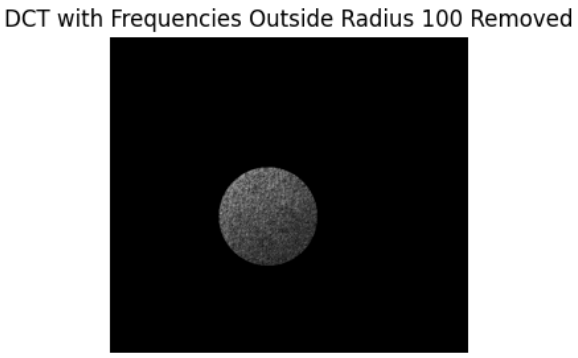
```
def remove_inner_frequency_radius(radius,img,i):
  mask = np.ones_like(img)
  center = tuple(np.array(mask.shape) // 3)
  cv2.circle(mask, center, radius, (0, 0, 0), thickness=-1)

  filtered_dct_img = img * mask

  p1=[-1,1,3,5,7,9]
  plt.figure(figsize=(12, 18))
  plt.subplot(5,2,p1[i])
  plt.imshow(np.log(np.abs(filtered_dct_img) + 1), cmap='gray')
  plt.title(f'DCT with Frequencies Inside Radius {radius} Removed')
  plt.axis('off')

  idct_image = idct(idct(filtered_dct_img.T, norm='ortho').T, norm='ortho')

  p2=[-1,2,4,6,8,10]
  plt.subplot(5,2,p2[i])
  plt.imshow(idct_image, cmap='gray')
  plt.title('Reconstructed Image with Frequencies Removed')
  plt.axis('off')
  plt.show()

for i in range(1,6):
  remove_inner_frequency_radius(100*i,cosine_transform_image,i)
```

Input Image:

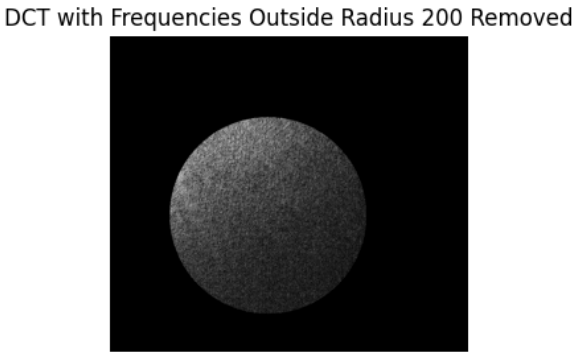
DCT of the whole Image:



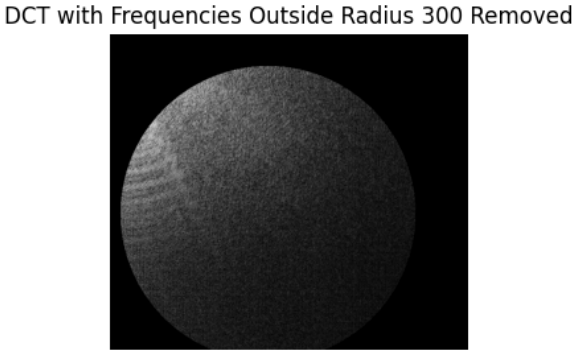
Inner Radius Image DCT and IDCT:

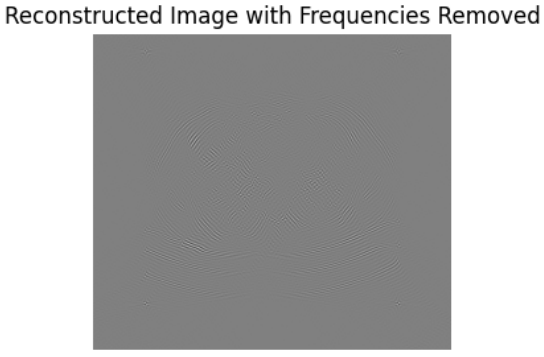


Only very few low-frequency elements inside the radius hence the reconstruction of the image is just



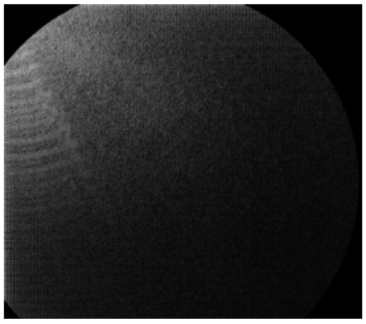
A combination of a few Low-Frequency elements and High-frequency elements are visible inside the radius hence the reconstruction of the image now has very fine defined lines visible too.



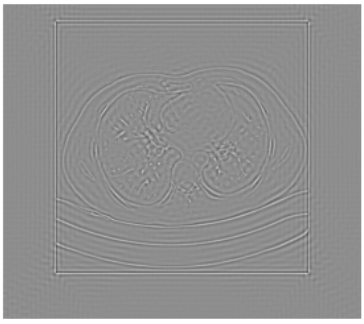


High-frequency elements towards the left are visible inside the radius hence the reconstruction of the image if you zoom in has few visible edges.

DCT with Frequencies Outside Radius 400 Removed

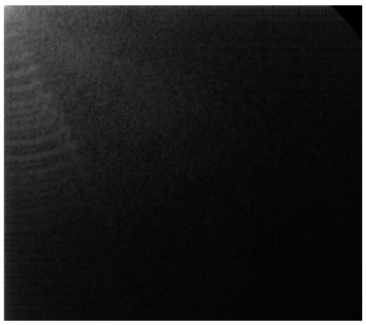


Reconstructed Image with Frequencies Removed

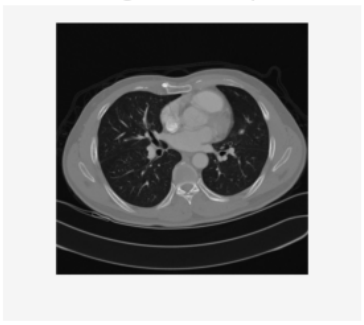


Almost all of the DCT is covered now, and a lot of high frequencies are visible; hence a very well-defined structure is seen in the reconstruction.

DCT with Frequencies Outside Radius 500 Removed

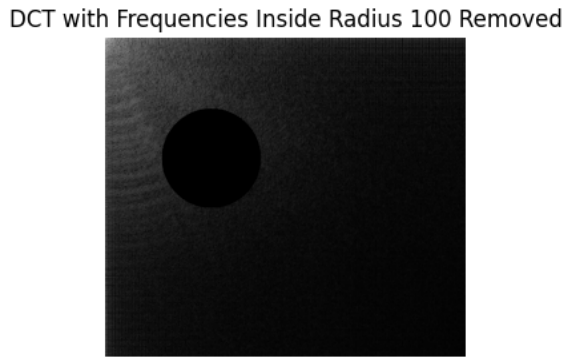


Reconstructed Image with Frequencies Removed

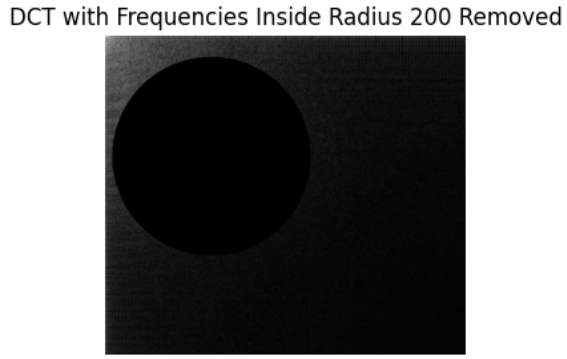


The whole of the DCT is covered now, hence the reconstruction is properly done.

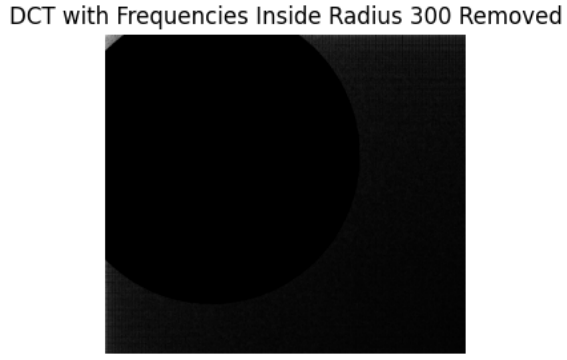
Outer Radius Image DCT and IDCT:



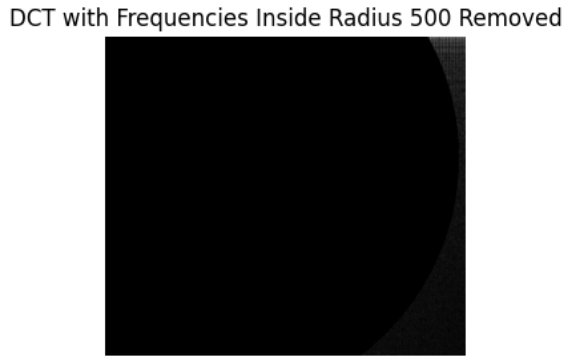
Compared to the inner radius one, in this, we have a lot of high-frequency present in the outside of the circle. The reconstruction has a lot of details present.

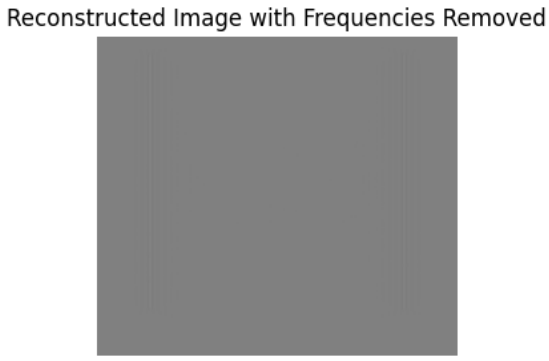


A good mix of high-frequency and low-frequency components is present, but a major chunk of high-frequency is missing hence the details aren't defined in the IDCT, and the image is slightly blurred.



A lot of high-frequency components are missing in the DCT, and a lot of low-frequency components are present. The reconstruction is a blurred image without the details being defined, as the high-frequency edge components are missing.





Almost all of the components are missing in DCT, and the reconstruction is not good.

Discussion:-

I have tried taking the radius of different values to completely understand the effect. In the IDCT, I also changed the position of the circle.

In DCT, the inner DCT image mostly retains the low-frequency components within this radius, while the high-frequency components have been set to zero.
It appears significantly blurred compared to the original, indicating that the high-frequency details, which include edges and fine textures, have been lost. This blurring effect is consistent with the removal of high-frequency information, which typically sharpens and defines an image.

In the outer DCT image, the reconstructed image with only low-frequency components retained is much smoother and lacks the sharp details present in the original CT scan. This tells us the importance of high-frequency information in preserving the details that are critical for medical diagnosis.

2. Take the same image as above. Extract the DICOM header. List all the Tag Names and the associated Tag Data (eg, Patient Name: John Doe, etc.)

I have skipped '[Pixel Data]' cause the information is too huge to copy-paste. I have submitted my code file, and you can find that there at the bottom.

[Image Type] : [['ORIGINAL', 'PRIMARY', 'AXIAL', 'CT_SOM5 SPI']]
[SOP Class UID] : [1.2.840.10008.5.1.4.1.1.2]
[SOP Instance UID] : [
1.3.6.1.4.1.9590.100.1.1.218664440213845548401456810263383085997]
[Study Date] : [20050325]
[Series Date] : [20050325]
[Acquisition Date] : [20050325]
[Content Date] : [20050325]
[Study Time] : [100547.500000]
[Series Time] : [100919.234000]
[Acquisition Time] : [101059.577017]
[Content Time] : [101059.577017]
[Accession Number] : [24365]
[Modality] : [CT]
[Manufacturer] : [SIEMENS]
[Institution Name] : [USC RADIOLOGY ASSOCIATES, INC.]
[Institution Address] : [San Pablo
Los Angeles/E8D954/
Los Angeles
USA]
[Referring Physician's Name] : [DEARTOLA^IGNACIO]
[Station Name] : [HCC2CTNAV1]
[Study Description] : [CT CHEST, WITH CONTRAST]
[Series Description] : [ThorRoutine ST 3.0 B41f]
[Physician(s) of Record] : [DEARTOLA^IGNACIO]
[Name of Physician(s) Reading Study] : [ ]
[Operators' Name] : [EP]
[Manufacturer's Model Name] : [Sensation 10]
[Patient's Name] : [anonymus]

[Patient ID] : [626457]
[Patient's Birth Date] : [19500220]
[Patient's Sex] : [M]
[Patient's Age] : [055Y]
[Additional Patient History] : [lung ca]
[Body Part Examined] : [ABDOMEN]
[Slice Thickness] : [3]
[KVP] : [120]
[Data Collection Diameter] : [500]
[Device Serial Number] : [53153]
[Software Versions] : [VB10B]
[Protocol Name] : [01_ACAP_WOCB]
[Reconstruction Diameter] : [354]
[Distance Source to Detector] : [1040]
[Distance Source to Patient] : [570]
[Gantry/Detector Tilt] : [0]
[Table Height] : [130]
[Rotation Direction] : [CW]
[Exposure Time] : [500]
[X-Ray Tube Current] : [140]
[Exposure] : [61]
[Filter Type] : [0]
[Generator Power] : [34]
[Focal Spot(s)] : [1.2]
[Date of Last Calibration] : [20050325]
[Time of Last Calibration] : [064006.000000]
[Convolution Kernel] : [B41f]
[Patient Position] : [FFS]
[Study Instance UID] : [1.2.840.113696.397786.500.18062.20050325091841]
[Series Instance UID] : [
1.3.12.2.1107.5.1.4.53153.30000005032514354823400000145]
[Study ID] : [24365]
[Series Number] : [3]
[Acquisition Number] : [3]
[Instance Number] : [53]

[Image Position (Patient)] : [[-159.654, -306.654, 1493.5]]
[Image Orientation (Patient)] : [[1, 0, 0, 0, 1, 0]]
[Frame of Reference UID] : [
1.3.12.2.1107.5.1.4.53153.30000005032514354823400000080]
[Position Reference Indicator] : [ ]
[Slice Location] : [-1493.5]
[Image Comments] : [ISOVUE 370(100ml)]
[Samples per Pixel] : [1]
[Photometric Interpretation] : [MONOCHROME2]
[Rows] : [512]
[Columns] : [512]
[Pixel Spacing] : [[0.691406, 0.691406]]
[Bits Allocated] : [16]
[Bits Stored] : [16]
[High Bit] : [15]
[Pixel Representation] : [0]
[Smallest Image Pixel Value] : [0]
[Largest Image Pixel Value] : [2288]
[Window Center] : [[40, -600]]
[Window Width] : [[400, 1200]]
[Rescale Intercept] : [-1024]
[Rescale Slope] : [1]