IMAGE PROCESSING ASSIGNMENT-1

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ABSTRACT

I have developed tool to perform the basic intensity transformation on the Images. Images here can be grey scale or color but only images of the type png,jpeg,jpg,xmp are accepted as input. Intensity transforms that can be performed on this images using the tool are Histogram Equalization, Gamma transform, Log transform, Blurring Image, Sharpening Image and Edge detection using Sobel operators is added as the additional transform. All of these transforms are applied on some of the images and the results are shown in this report.

1. INTRODUCTION

Main idea behind this tool is to implement various transformation techniques on any of the image.Images can be of many types like color, grey scale etc. Different Images have different underlying data representations like color images can be represented with 3 arrays if the pixel intensities are represented in RGB format, Same image if represented in HSV format will have arrays corresponding to H,S,V respectively each array element will be the value of Hue,Saturation and Value. Similarly grey scale is one in which the value of each pixel represents intensity information. This tool will convert any image given to it into its HSV data and performs all the operations on the Intensity(V) array and then merge it with the original Hue(H) and Saturation(S) arrays to get back the original image.

2. BACKGROUND READ

This tool is implemented using Python[**?**]. I have used PyQt4[**?**] binding for implementing GUI it runs on Windows, Linux, Mac OS X and various UNIX platforms. It does not support Android and iOS. To handle color and grey scale images opencv[**?**] library is used. Any image uploaded will be considered as color image and its HSV arrays[**?**] are extracted. To perform operations on the Intensity values numpy[**?**] library is used

3. APPROACH

Apart from transformations there are some file handling and operation control features in this tool. Every operation is associated with a button or scroll bar(only for sharpening image). Each button in turn when clicked calls the corresponding method to perform the operation on the image. Before any change is made to the data it is stored in a global variable so that the Undo functionality can be implemented easily. Each of the transform that is implemented by this tool and approach followed to implement it is listed below

3.1. Histogram Equalization

Histogram equalization[**?**] is implemented by taking the CDF of the pixel intensities, for each intensity level number of such pixels in the image are found and this result is stored in a variable(CDF) and it is updated for every intensity level by adding the previous value also the new intensity is calculated by dividing it with the size of the image and then multiplying it with maximum intensity i.e.,255.

3.2. Gamma transform

Each intensity value of the original image is normalized and raised to the power of $1/gamma$ given by the user this result is multiplied with a constant value to return the intensity range of the original image. In this tool constant for gamma transform[**?**] is chosen to be 255.So if the user gives gamma to be less than 1 all the intensity values are reduced and the image appears darker. Similarly if gamma is greater than 1 image appears brighter.

3.3. Log transform

Each intensity value of the original image is multiplied by a constant and log of that value is taken as new intensity. In this tool constant for log transform is chosen to be 46 because the intensity range from images is from 0 to 255. log of these values would result in values from 0 to 5.54 to keep the range of intensities same constant is chosen to be 46.

3.4. Blurring Image

To blur an image blurring kernel is used. Gaussian kernel is used and the window size of the kernel is determined by the sigma(variance) value given by the user larger the sigma value more blurring happens and vice-verse. After sigma is taken from the user kernel of size $(2 * sigma, 2 * sigma)$ is formed and the image is convolved with the filter(kernel) to get the blurred image.

3.5. Sharpening Image

To Sharpen an image kernel is used. Laplacian kernel is used and the window size of the kernel $(3,3)$ is formed and the image is convolved with the image to get the sharpened image. Extent of sharpening is controlled with the scroll bar minimum value of the scroll bar is 1 and maximum is 10. If scroll bar is set to 1 the resultant image is the sum of original image and convolved image. Similarly if the scroll bar is set to 10 the resultant image is sum of the original image and 10 times the convolved image.

3.6. Sobel operators(Horizontal and vertical edge detection)

To detect edges kernel is used. Here Sobel kernel is used and the window size of the kernel $(3,3)$ is formed and the image is convolved with the image to get the sharpened image. Two kernels are used to detect 2 edges (horizontal and vertical) and the result of both of them is added to display the horizontal and vertical edges.

4. SELECTION OF TEST IMAGES

Following are the images used for testing the various transformation techniques.

4.1. Histogram Equalization

This is image is chosen for histogram equalization because its Histogram is more skewed towards low intensity levels. Results of histogram equalisation will be clearly visible with this image.

4.2. Gamma Correct

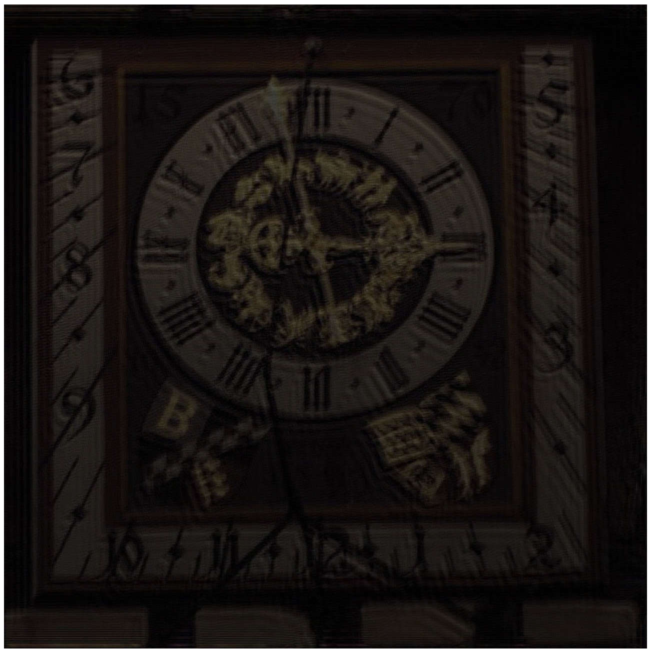
This is image is chosen for Gamma correction because it is brighter image and the effect of gamma transform for different gamma values can be clearly observed.

4.3. Log Transform

Effect of Log transformation is more clearly visible in Grey scale image, So grey scale image is chosen for testing Log transformation.

4.4. Blur Image

Any image can chosen for blurring image but image which has more details in it will give the best output so this image is chosen.



Test image for Histogram equalization[**?**]

4.5. Sharpen Image

4.6. Sobel operation

Image which has more horizontal and vertical edges will be required since Sobel operators for detecting horizontal and vertical edges is used as kernel

Test image for Blurring[?]

Test image for Gamma correction[?]

Test image for Sharpening[?]

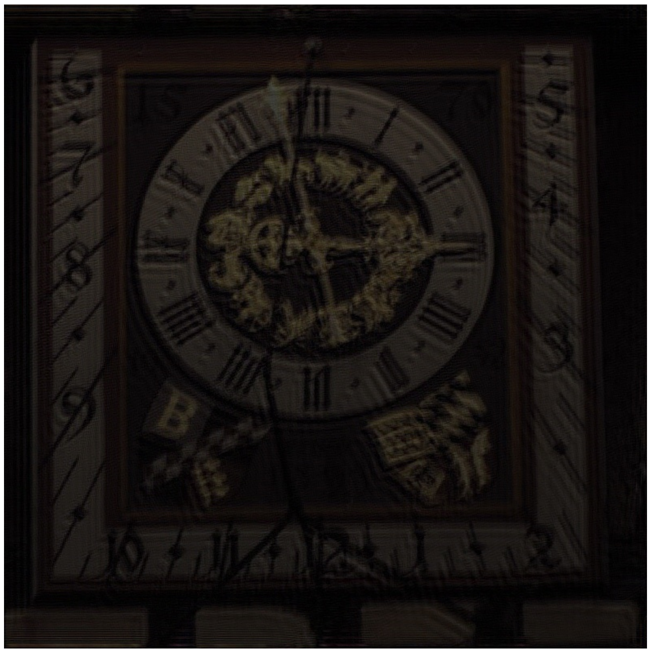
Test image for Log Transform[?]

Test image for Sobel opeartion[?]

5. RESULTS ON TEST IMAGES

Following are the images after appying various transformation techniques.

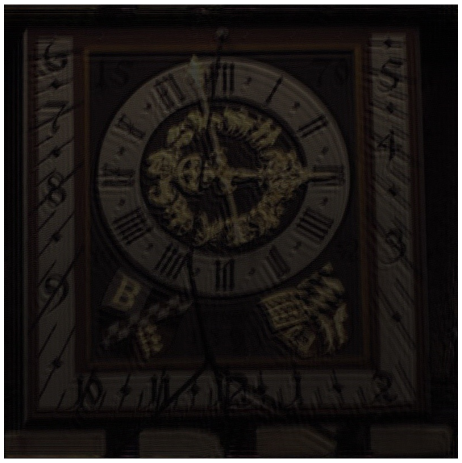
5.1. Histogram Equalization



Test image after applying Histogram equalization

5.2. Gamma Correct

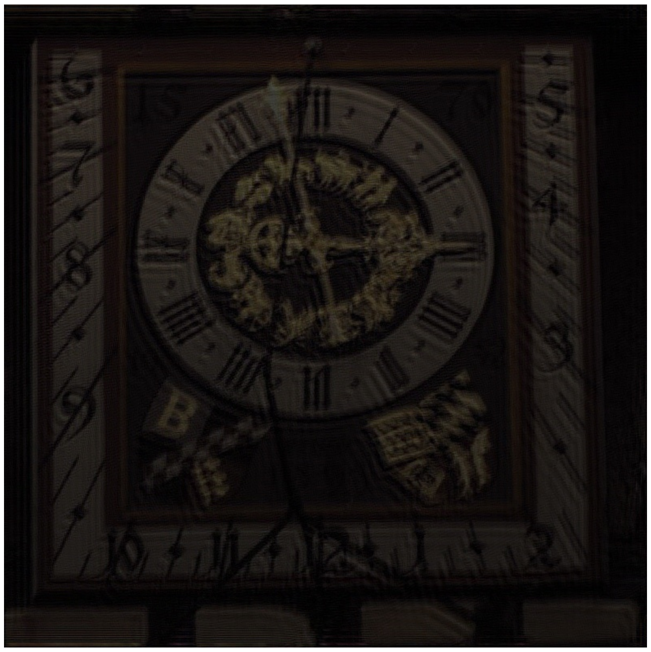
5.2.1. gamma = 0.1



Test image after applying Gamma correction with gamma = 0.1

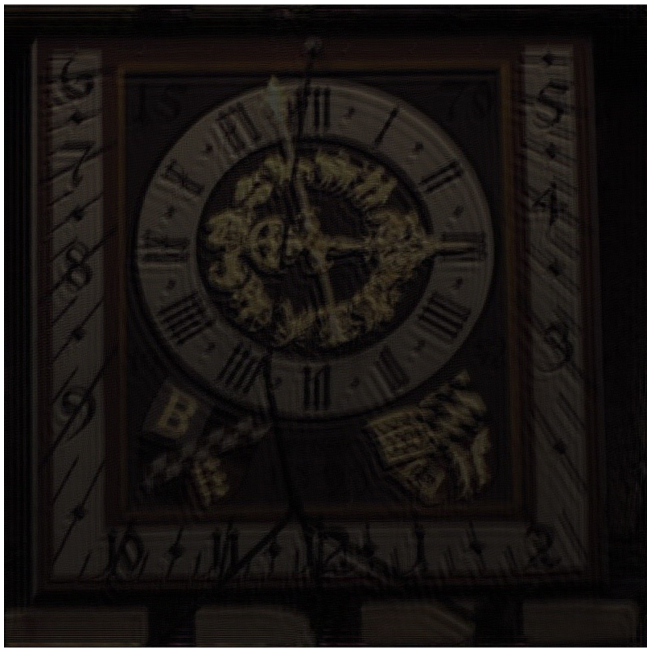
5.2.2. gamma = 2.2

Image after applying gamma transform



Test image after applying Gamma correction with gamma = 2.2

5.3. Log Transform



Test image after applying Log Transform

5.4. Blur Image

Results of blurring with different Gaussian kernels

5.4.1. Blur using Gaussian kernel with variance 5

Test image after Blurring with Gaussian kernel with variance 5

5.4.2. Blur using Gaussian kernel with variance 20

Test image after Blurring with Gaussian kernel with variance 20

5.5. Sharpen Image

Result after applying Laplacian $(3, 3)$ kernel

5.6. Sobel operation

Result of applying Sobel kernel to detect horizontal and vertical edges. Here the test image is convolved with the kernel to detect horizontal edges at the same time another kernel is applied to the test image to detect vertical edges to detect vertical edges. Result of the convolution of these is added to get the horizontal and vertical edges in image

Test image after applying sharpening filter

Test image after applying Sobel operator

6. DISSCUSSION

Main problem faced during development is choice of language. I got to know that Matlab has a drag and drop type of making GUI, but it is licensed i wanted to work with open source. The choice I was left with was c++ and python. I was not well versed in both of them. Since python syntax is easy i chose python. Implementation of GUI created a lot of problems I did not know which python binding to use, after searching online and found that tkinter is the basic and primitive binding in python so i chose that and started working with it but after spending entire day on it nothing much was happening so i shifted to pyqt after finding a tutorial[**?**] on pyqt and completed the GUI part using pyqt. For image operations Opencv [**?**]and numpy[**?**] libraries are used though it was not easy documentation is available online.

If more time was given i would have implemented convolution using vectors to reduce the computations and GUI also

can improved by making the window responsive adding short
cuts to all the operations etc.,

7. APPENDIX

```
#!/usr/bin/python

import sys # import libraries needed
import PyQt4
import math
import numpy as np
import cv2 as cv
from scipy.signal import convolve2d
from skimage.measure import compare_ssim
# import PythonQwt as qwt
from PyQt4 import QtGui, QtCore
from PyQt4.QtGui import *
from PyQt4.QtCore import *
from PyQt4.QtCore import pyqtSlot,SIGNAL,SLOT

class Window(QtGui.QMainWindow): #create a class to display a window

    def __init__(self): #method to declare attributes of the class
        super(Window,self).__init__()
        self.setGeometry(50,50,1400,650) # to set the size of the window to 1400*650
        self.setWindowTitle("Image Restoration Tool") # give title to the window
        self.home() #method called home will have all the main features of the GUI
        self.__pixmap = None # create pixmap attribute to display image to GUI
        self.__img_height = None # height of the Image
        self.__img_width = None # widht of the Image
        self.lbl = QtGui.QLabel(self) # create a Qlabel object to display input image
        self.lbl1 = QtGui.QLabel(self) # create a Qlabel object to display title for input image
        self.lbl_ker_img = QtGui.QLabel(self) # create a Qlabel object to display kernel
        self.lbl_ker = QtGui.QLabel(self) #create a Qlabel object to display title for kernel
        self.lbl2 = QtGui.QLabel(self) # create a Qlabel object to display title for output image
        self.lbl3 = QtGui.QLabel(self) # create a Qlabel object to displat output image
        self.lbl_s3 = QtGui.QLabel(self) # create a Qlabel object to display text for text editor
        self.lbl_s4 = QtGui.QLabel(self) # create a Qlabel object to display text for text editor
        self.lbl_s5 = QtGui.QLabel(self) # create a Qlabel object to display text for text editor
        self.lbl_s6 = QtGui.QLabel(self) # create a Qlabel object to display metrics ssim and mse
        self.e2 = QtGui.QLineEdit(self) # create a QLineEdit object to display scroll title
        self.e3 = QtGui.QLineEdit(self) # create a QLineEdit object to display scroll title
        self.e4 = QtGui.QLineEdit(self) # create a QLineEdit object to display scroll title

    def home(self): # home method of the QMainWindow
        btn = QtGui.QPushButton("Upload Image",self) # button for uploading image
        btn.clicked.connect(self.file_open) # go to file_open method when clicked on Upload Image button
        btn.resize(200,40) # resize the button to the required size
        btn.move(500,50 ) # reposition the button at the required position
        btn1 = QtGui.QPushButton("Upload Kernel ",self)
        btn1.clicked.connect(self.file_open_kernel) # go to file_open_kernel method when clicked on Upload Kernel
        btn1.resize(200,40) # resize the button to the required size
        btn1.setSizePolicy(QtGui.QSizePolicy.Expanding, QtGui.QSizePolicy.Expanding)
        btn1.move(500,100 )
        btn2 = QtGui.QPushButton("Inverse Filter",self)
        btn2.clicked.connect(lambda: self.inverse_fliter(-1)) # go to inverse_fliter method when clicked on Inverse
            ↪ Filter button
        btn2.resize(200,40) # resize the button to the required size
        btn2.move(500,150 ) # reposition the button at the required position
        btn3 = QtGui.QPushButton("Get␣blur␣image",self)
        btn3.clicked.connect(self.inv_inbuilt) # go to inv_inbuilt method when clicked on Get blur image button
        btn3.resize(200,40) # resize the button to the required size
        btn3.move(500,200 ) # reposition the button at the required position
        btn4 = QtGui.QPushButton("Radial␣Filtering",self)
        btn4.clicked.connect(self.radial_filter_threshold) # go to blur_img_scr_bar method when clicked on Blur
            ↪ Image button
        btn4.resize(200,40) # resize the button to the required size
        btn4.move(500,250 ) # reposition the button at the required position
        btn5 = QtGui.QPushButton("Weiner␣Filtering",self)
        btn5.clicked.connect(self.weiner_filtering) # go to weiner_filtering method when clicked on Sharpeninge
            ↪ button
        btn5.resize(200,40) # resize the button to the required size
        btn5.move(500,300 ) # reposition the button at the required position
        # btn6 = QtGui.QPushButton("Sobel Operator",self)
        # btn6.clicked.connect(self.edge_detect) # go to save_image method when clicked on Sobel operator
            ↪ button
        # btn6.resize(200,40) # resize the button to the required size
        # btn6.move(500,350 ) # reposition the button at the required position
        btn7 = QtGui.QPushButton("LS␣Filtering",self)
        btn7.clicked.connect(self.ls_filtering_gamma) # go to ls_filtering_gamma method when clicked on LS
            ↪ Filtering button
        btn7.resize(200,40) # resize the button to the required size
        btn7.move(500,350 ) # reposition the button at the required position
        btn8 = QtGui.QPushButton("Calculate␣Metrics␣",self)
        btn8.clicked.connect(self.metrics) # go to metrics method when clicked on Calculate Metrics button
        btn8.resize(200,40) # resize the button to the required size
        btn8.move(500,400 ) # reposition the button at the required position
        btn9 = QtGui.QPushButton("Save␣Image",self)
        btn9.clicked.connect(self.save_image) # go to save_image method when clicked on Save Image button
        btn9.resize(200,40) # resize the button to the required size
        btn9.move(500,500 ) # reposition the button at the required position
        btn10 = QtGui.QPushButton("Close␣Window",self)
        btn10.clicked.connect(self.win_close) # go to win_close method when clicked on Close Windo button
        btn10.resize(200,40) # resize the button to the required size
        btn10.move(500,550 ) # reposition the button at the required position
        self.show() #show the window

    def file_open(self): #method to open file
        name = QtGui.QFileDialog.getOpenFileName(self,'Open␣File','','Images␣(*.png␣*.xpm␣*.jpg␣*.jpeg)') #this
            ↪  will open a dialog box to upload image only png,xpm,jpg,jpeg images are supported
        upld_img = QtGui.QImage() # create Qimage object to store the uploaded image data
        self.__ip_img = (cv.imread(str(name),cv.IMREAD_COLOR)).astype(np.float) # upload the image from the
            ↪ dialog box using imread in opencv library
        # get image properties.
        self.__img_b,self.__img_g,self.__img_r = cv.split(self.__ip_img)
        self.__img_height,self.__img_width = self.__img_r.shape
        # Image.merge("RGB",(imr,img,imb))
        if upld_img.load(name): # if the image is uploaded properly then upld_img.load will be true
            self.lbl1.clear() # clear the past content in label if any is present
            self.lbl1.setText("Orignal␣Image") # Set title for the input image to display
            self.lbl1.move(200,140) # position the title
            self.lbl1.show() # show the title
            pixmap = QtGui.QPixmap(upld_img) #convert the opencv image to pixmap to display it on GUI
            self.__pixmap = pixmap.scaled(400, 650, QtCore.Qt.KeepAspectRatio) # scale the pixmap to display it
                ↪ on GUI keep the Aspect Ratio of the original image
            self.lbl.clear() # clear the past content in label if any is present
            self.lbl.resize(400,650) # set the size of the input pixmap to 400∗650
            self.lbl.move(50,50) # position the input pixmap
            self.lbl.setSizePolicy(QtGui.QSizePolicy.Minimum, QtGui.QSizePolicy.Minimum)
            self.lbl.setScaledContents(False)
            self.lbl.setPixmap(self.__pixmap) # set the pixmap to the label
            self.lbl.show()# show the pixmap as image
            print(”Selected␣Image␣uploaded”) #print status to the terminal or IDE
        else: #if the image is not uploaded then
            print(”Could␣not␣upload␣Image”) # print status to the terminal or IDE

    def file_open_kernel(self): #method to open file
        name = QtGui.QFileDialog.getOpenFileName(self,’Open␣File’,’’,’Images␣(∗.png␣∗.xpm␣∗.jpg␣∗.jpeg)’) #this
            ↪ will open a dialog box to upload image only png,xpm,jpg,jpeg images are supported
        upld_img = QtGui.QImage() # create Qimage object to store the uploaded image data
        self.__kernel = (cv.imread(str(name),cv.IMREAD_GRAYSCALE)).astype(np.float) # upload the image from
            ↪ the dialog box using imread in opencv library
        # self.__kernel = np.true_divide(self.__kernel,np.sum(self.__kernel),dtype=np.float)
        # get image properties.
        self.__kernel_height,self.__kernel_width = self.__kernel.shape
        # Image.merge(”RGB”,(imr,img,imb))
        if upld_img.load(name): # if the image is uploaded properly then upld_img.load will be true
            self.lbl_ker.clear() # clear the past content in label if any is present
            self.lbl_ker.setText(”kernel”) # Set title for the input image to display
            self.lbl_ker.move(225,10) # position the title
            self.lbl_ker.show() # show the title
            pixmap = QtGui.QPixmap(upld_img) #convert the opencv image to pixmap to display it on GUI
            self.__pixmap = pixmap.scaled(100, 125, QtCore.Qt.KeepAspectRatio) # scale the pixmap to display it
                ↪ on GUI keep the Aspect Ratio of the original image
            self.lbl_ker_img.clear() # clear the past content in label if any is present
            self.lbl_ker_img.resize(100,125) # set the size of the input pixmap to 100∗125
            self.lbl_ker_img.move(200,25) # position the input pixmap
            self.lbl_ker_img.setSizePolicy(QtGui.QSizePolicy.Minimum, QtGui.QSizePolicy.Minimum)
            self.lbl_ker_img.setScaledContents(False)
            self.lbl_ker_img.setPixmap(self.__pixmap) # set the pixmap to the label
            self.lbl_ker_img.show()# show the pixmap as image
            print(”Selected␣Kernel␣uploaded”) #print status to the terminal or IDE
        else: #if the image is not uploaded then
            print(”Could␣not␣upload␣kernel”) # print status to the terminal or IDE

    def FFT_matrix(self,N,sign=1): #function to compute FFT matrix
        i, j = np.meshgrid(np.arange(N), np.arange(N)) #create index matix
        omega = np.exp( sign ∗ −2 ∗ np.pi ∗ 1J / N ) #compute the twiddle factor
        W = np.power( omega, i ∗ j ) / np.sqrt(N) #multiply it with the sum of index
        return W #return the twiddle factor matrix

    def DFT(self,img,ker=0):# this method performs the Discreet fourier Transform
        if(ker == 1): #if given image is kernel
            rows = self.FFT_matrix(img.shape[0]) #to do fft to rows
            cols = self.FFT_matrix(img.shape[1]) #to do fft to columns
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            img = rows.dot(img).dot(cols) #first perform fft to rows then for columns
            img = np.fft.fftshift(img) #since the dft is not centered shift it
            # cv.imwrite("DFT.jpg",np.absolute(img))
            return img #return the DFT
        else: #if other images are given they are color images
            b,g,r = cv.split(img) #split the image to get r,g,b channels
            rows = self.FFT_matrix(self.__img_height) #get fft matrix for rows
            cols = self.FFT_matrix(self.__img_width) #get fft matrix for columns
            b = rows.dot(b).dot(cols) # do fft to blue channel
            b = np.fft.fftshift(b) #since the dft is not centered shift it
            g = rows.dot(g).dot(cols) # do fft to green channel
            g = np.fft.fftshift(g) #since the dft is not centered shift it
            r = rows.dot(r).dot(cols) # do fft to red channel
            r = np.fft.fftshift(r) #since the dft is not centered shift it
            # cv.imwrite("DFT.jpg",img)
            return b,g,r

    def IDFT(self,img,ker=0):# this method performs the Inverse Discreet fourier Transform
        rows = self.FFT_matrix(img.shape[0],-1)#get ifft matrix for rows
        cols = self.FFT_matrix(img.shape[1],-1)#get ifft matrix for columns
        img = rows.dot(img).dot(cols) #first perform fft to rows then for columns
        img = np.fft.ifftshift(img) #since the idft is not centered shift it
        # cv.imwrite("IDFT.jpg",np.absolute(img))
        return img

    def padder(self,img,truth=0): #to padd every image
        if(truth == 1): #if the given image is ground truth just resize it
            rem_row = self.__img_height-img.shape[0] #count the number to delete in image
            rem_col = self.__img_width -img.shape[1] #count the number to delete in image
            padd_img = np.delete(img, abs(rem_row), 0) # delete from image
            padd_img = np.delete(padd_img, abs(rem_col), 1) # delete from image
        else: #if the given image is not groung truth
            rw_add = np.ceil((self.__img_height-img.shape[0])/2) #no of rows to add above and below
            rw_add = rw_add.astype(int) #convert float to int
            col_add = np.ceil((self.__img_width-img.shape[1])/2) #no of columns to add above and below
            col_add = col_add.astype(int) #convert float to int
            # if(rw_add > 0 & col_add> 0 ):
            padd_img = np.append(np.zeros((rw_add,img.shape[1])), img, axis=0)#padd with zeros
            padd_img = np.append(padd_img,np.zeros((rw_add,padd_img.shape[1])), axis=0)#padd with zeros
            padd_img = np.append(np.zeros((padd_img.shape[0],col_add)), padd_img,axis=1)#padd with zeros
            padd_img = np.append(padd_img,np.zeros((padd_img.shape[0],col_add)),axis=1)#padd with zeros
            rem_row = self.__img_height-padd_img.shape[0] #count how many rows to remove
            rem_col = self.__img_width -padd_img.shape[1] #count how many rows to remove
            if(rem_row>0):
                self.__ip_img = np.delete(self.__ip_img, rem_row, 0) #delete the rows from the image
                self.__img_height -= rem_row #set the image size accordingly

            if(rem_col>0):
                self.__ip_img = np.delete(self.__ip_img, rem_col, 1) #delete the columns from the image
                self.__img_width -= rem_col #set the image size accordingly
        return padd_img #return the padded image

    def inverse_fliter(self,sigma = -1): # method to do inverse filtering
        padd_kernel = self.padder(self.__kernel) # get the padded image
        H = self.DFT(padd_kernel,1) # find the DFT of the padded image
        string = ”␣” # string to show title text
        F = np.ones_like(H) #get a array with all elements as one
        if(sigma != −1): # if the method is called only for radial inverse filtering
            for index, x in np.ndenumerate(F): #get each index for F
                if (np.sqrt(index[0]∗index[0]+index[1]∗index[1])>sigma): #if the index is in range keep it as 1
                    F[index[0],index[0]] = 1
                else: # since it is not in range make it 0
                    F[index[0],index[0]] = 0
        B,G,R = self.DFT(np.true_divide(self.__ip_img,255.0)) #get the DFT the normalised image
        INV_B = (B/H)∗F # do the radial or only inverse filtering depending on sigma
        INV_G = (G/H)∗F # do the radial or only inverse filtering depending on sigma
        INV_R = (R/H)∗F # do the radial or only inverse filtering depending on sigma
        ib = self.IDFT(INV_B)∗255.0 #get back to normal range and perform IDFT
        ig = self.IDFT(INV_G)∗255.0 #get back to normal range and perform IDFT
        ir = self.IDFT(INV_R)∗255.0 #get back to normal range and perform IDFT
        self.__img_b = (np.absolute(ib)).astype(self.__ip_img.dtype) #put them in global variables
        self.__img_g = (np.absolute(ig)).astype(self.__ip_img.dtype) #put them in global variables
        self.__img_r = (np.absolute(ir)).astype(self.__ip_img.dtype) #put them in global variables
        cv.imwrite(”temp.jpg”,cv.merge((self.__img_b,self.__img_g, self.__img_r))) #write it to the temp image
        self.__img_b,self.__img_g,self.__img_r = cv.split(cv.imread(”temp.jpg”,cv.IMREAD_COLOR)) # read the temp
            ↪ image to show in GUI
        if(sigma != −1): # for title and display text
            string += ”Radial␣Inverse␣Filter␣Applied␣with␣cutoff␣=␣”+str(sigma)
        else:
            string = ”Inverse␣Filter␣Applied”
        self.disp(string) # display image
        print(string) #print status to terminal

    def inv_inbuilt(self): #to get the blurred image from kernel
        motion_blr = cv.filter2D(self.__ip_img,−1,np.divide(self.__kernel,np.sum(self.__kernel).astype(self.__ip_img.
            ↪ dtype))) #perform convolution
        cv.imwrite(”temp.jpg”,motion_blr) # write to temp image
        self.__img_b,self.__img_g,self.__img_r = cv.split(cv.imread(”temp.jpg”,cv.IMREAD_COLOR)) #read from temp
            ↪ to show
        self.disp(”Blurred␣Image”) # display it in GUI
        print(”Blurring␣using␣kernel”) # Print status to terminal or IDE

    def radial_filter_threshold(self):#to get the cutoff from user
        self.lbl_s3.resize(500,50)#label to display title for output image
        self.lbl_s3.setText(”Please␣Enter␣an␣Integer␣value␣Threshold”)#title text
        self.lbl_s3.move(100,590) #positioning
        self.lbl_s3.show() #display title
        self.e2.setValidator(QIntValidator())#text box setting to allow only integer values
        self.e2.move(500,600) #positioning
        radial_threshold = QPushButton(’OK’, self) #button to click ok to start operaion on the input
        radial_threshold.resize(50,30) #resize the button
        radial_threshold.move(610, 600) #positioning
        self.lbl_s5.clear()
        self.lbl_s4.clear()
        self.e4.clear()
        self.e3.clear()
        radial_threshold.show() #display button
        self.e2.show() #display text box
        radial_threshold.clicked.connect(lambda: self.inverse_fliter(int(self.e2.text()))) #call inverse_fliter when
            ↪ clicked

    def weiner_filtering(self): #to get the k image from user
        self.lbl_s4.resize(500,50)#label to display title for output image
        self.lbl_s4.setText("Please␣Enter␣an␣Integer␣value␣of␣K")#title text
        self.lbl_s4.move(100,590) #positioning
        self.lbl_s4.show() #display title
        self.e3.setValidator(QIntValidator())#text box setting to allow only integer values
        self.e3.move(500,600) #positioning
        weiner_k = QPushButton('OK', self) #button to click ok to start operation on the input
        weiner_k.resize(50,30) #resize the button
        weiner_k.move(610, 600) #positioning
        weiner_k.show() #display button
        self.lbl_s5.clear()
        self.lbl_s3.clear()
        self.e4.clear()
        self.e2.clear()
        self.e3.show() #display text box
        weiner_k.clicked.connect(lambda: self.weiner(int(self.e3.text()))) #call weiner when clicked

    def weiner(self,k): #to perform weiner filtering
        padd_kernel = self.padder(self.__kernel) # get the padded image
        H = self.DFT(padd_kernel,1)# find the DFT of the padded image
        B,G,R = self.DFT(np.true_divide(self.__ip_img,255.0))# find the DFT of the image
        INV_B = np.multiply(B,np.divide(np.power(np.absolute(H),2),(np.multiply(H,np.power(np.absolute(H),2)+k))
            ↪ )) #perform weiner filter and get the channel
        INV_G = np.multiply(G,np.divide(np.power(np.absolute(H),2),(np.multiply(H,np.power(np.absolute(H),2)+k)
            ↪ ))) #perform weiner filter and get the channel
        INV_R = np.multiply(R,np.divide(np.power(np.absolute(H),2),(np.multiply(H,np.power(np.absolute(H),2)+k)
            ↪ ))) #perform weiner filter and get the channel

        ib = self.IDFT(INV_B)*255.0 #perform IDFT
        ig = self.IDFT(INV_G)*255.0 #perform IDFT
        ir = self.IDFT(INV_R)*255.0 #perform IDFT
        self.__img_b = (np.absolute(ib)).astype(self.__ip_img.dtype)#put them in global variables
        self.__img_g = (np.absolute(ig)).astype(self.__ip_img.dtype)#put them in global variables
        self.__img_r = (np.absolute(ir)).astype(self.__ip_img.dtype)#put them in global variables
        cv.imwrite("temp.jpg",cv.merge((self.__img_b,self.__img_g, self.__img_r))) #write it to temp image
        self.__img_b,self.__img_g,self.__img_r = cv.split(cv.imread("temp.jpg",cv.IMREAD_COLOR))# read the temp
            ↪ image to show in GUI
        self.disp("Weiner␣Filter␣Applied␣for␣k␣=␣"+str(k)) #display it to GUI
        print("Weiner␣Filter␣Applied␣for␣k␣=␣"+str(k)) #print status to terminal

    def ls_filtering_gamma(self): # to get gamma values
        self.lbl_s5.resize(500,50)#label to display title for output image
        self.lbl_s5.setText("Please␣Enter␣an␣Integer␣value␣of␣gamma")#title text
        self.lbl_s5.move(100,590) #positioning
        self.lbl_s5.show() #display title
        self.e4.setValidator(QIntValidator())#text box setting to allow only integer values
        self.e4.move(500,600) #positioning
        gamma = QPushButton('OK', self) #button to click ok to start operaion on the input
        gamma.resize(50,30) #resize the button
        gamma.move(610, 600) #positioning
        gamma.show() #display button
        self.lbl_s3.clear()
        self.lbl_s4.clear()
        self.e2.clear()
        self.e3.clear()
        self.e4.show() #display text box
        gamma.clicked.connect(lambda: self.ls_filter(int(self.e4.text()))) #call blur_img when clicked

        print("gamma␣value␣given␣is␣=␣"+ str(self.e4.text())) # Print status to terminal or IDE
    def ls_filter(self,gamma=1): # to perform LS filtering
        p = np.array([[0,−1,0],[−1,4,−1],[0,−1,0]]) # blur kernel
        padd_p = self.padder(p) # get the padded image
        P = self.DFT(padd_p,1) # find the DFT of the padded image
        h = self.padder(self.__kernel)# get the padded image
        H = self.DFT(h,1) # find the DFT of the kernel image
        B,G,R = self.DFT(np.true_divide(self.__ip_img,255.0)) #get the DFT the normalised image
        filter = np.divide(np.conj(H),(np.power(np.absolute(H),2)+gamma∗np.power(np.absolute(P),2))) #get LS
            ↪ filter
        R_trans = np.multiply(filter,R)# do the LS filtering depending on gamma
        G_trans = np.multiply(filter,G)# do the LS filtering depending on gamma
        B_trans = np.multiply(filter,B)# do the LS filtering depending on gamma
        ib = self.IDFT(B_trans)∗255.0#get back to normal range and perform IDFT
        ig = self.IDFT(G_trans)∗255.0#get back to normal range and perform IDFT
        ir = self.IDFT(R_trans)∗255.0#get back to normal range and perform IDFT
        self.__img_b = (np.absolute(ib)).astype(self.__ip_img.dtype)#put them in global variables
        self.__img_g = (np.absolute(ig)).astype(self.__ip_img.dtype)#put them in global variables
        self.__img_r = (np.absolute(ir)).astype(self.__ip_img.dtype)#put them in global variables
        cv.imwrite("temp.jpg",cv.merge((self.__img_b,self.__img_g, self.__img_r))) #write it to the temp image
        self.__img_b,self.__img_g,self.__img_r = cv.split(cv.imread("temp.jpg",cv.IMREAD_COLOR)) # read the temp
            ↪ image to show in GUI
        self.disp("LS␣Filter␣Applied␣for␣gamma␣=␣"+str(gamma))# display image
        print("LS␣Filter␣Appliedfor␣gamma␣=␣"+str(gamma))#print status to terminal

    def metrics(self): #to undo the last change done on the image
        name = QtGui.QFileDialog.getOpenFileName(self,'Open␣File','','Images␣(∗.png␣∗.xpm␣∗.jpg␣∗.jpeg)') #this
            ↪ will open a dialog box to upload image only png,xpm,jpg,jpeg images are supported
        upld_img = QtGui.QImage() # create Qimage object to store the uploaded image data
        grd_truth = (cv.imread(str(name),cv.IMREAD_COLOR)).astype(np.float) #get the image name from user
            ↪ and read it
        restored_img = cv.merge((self.__img_b,self.__img_g, self.__img_r)).astype(np.float) #merge to get restored
            ↪ image
        grd_truth_resize = self.padder(grd_truth,1) #resize the ground truth to our size
        difference_squared = (grd_truth_resize.astype(np.float) −restored_img) ∗∗ 2 #get the square of the
            ↪ difference
        summ_diff_square = np.sum(difference_squared) #sum the difference
        pixels_size = np.prod(grd_truth_resize.shape) #get the pixel size of the image
        mse = summ_diff_square / pixels_size #find out the mean square error
        psnr = 20.0∗np.log10(255/np.sqrt(mse)) #calculate PSNR
        ssim = compare_ssim(grd_truth_resize.astype(np.float), restored_img, multichannel=True) #get the SSIM
        self.lbl_s6.clear() # clear the past content in label if any is present
        self.lbl_s6.resize(200,70)
        self.lbl_s6.setText("PSNR␣="+str(psnr)+"dB\n"+'SSIM␣=␣'+str(ssim)) # Set PSNR and SSIM
        self.lbl_s6.move(500,440) # position the text
        self.lbl_s6.show()
        print('ssim=␣'+str(ssim),'psnr␣=␣'+str(psnr)+"dB") #print status to terminal

    def save_image(self): # this method is used for saving the image to the file
        name = QtGui.QFileDialog.getSaveFileName(self, 'Save␣File','','Images␣(*.png␣*.xpm␣*.jpg␣*.jpeg)') # tp
            ↪ open a dialog box to input image
        itos = cv.merge([self.__img_b,self.__img_g, self.__img_r])#merge intensity with the hue and saturation
        itos = cv.cvtColor(itos, cv.COLOR_BGR2RGB)#convert hsv to rgb image
        img_to_save = QtGui.QPixmap(QtGui.QImage(itos,self.__img_width, self.__img_height,3*self.__img_width,
            ↪ QtGui.QImage.Format_RGB888)) # convert opencv image to pixmap to display in gui
        if img_to_save.save(name):#if the image is saved
            print("Image␣Saved␣at␣"+str(name)) # Print status to terminal or IDE
        else:#if the could not be saved
            print("Could␣not␣save␣the␣Image␣to␣folder") # Print status to terminal or IDE

    def win_close(self): # this method is used for closing the window
        print("Window␣closed") # Print status to terminal or IDE
        sys.exit() #exit the application

    def disp(self,txt,flag = 0,fft=0,img = np.empty_like([256,256])): # this method is used to display the transformed
        ↪ image to GUI
        if (fft == 0): #whether to clear some labels or not is decided by this flag variable
            self.lbl_s3.clear() #to clear the label to show new objects
            self.e2.clear() #to clear the label to show new objects
            self.e2.hide() #to hide the text box
            if (flag == 0 ):
                img_pix1 = cv.merge((self.__img_b,self.__img_g, self.__img_r)) #merge the v with h and s using cv.
                    ↪ merge
                img_pix1 = cv.cvtColor(img_pix1, cv.COLOR_BGR2RGB)
                pix_img = QtGui.QPixmap(QtGui.QImage(img_pix1,self.__img_width, self.__img_height,3*self.
                    ↪ __img_width, QtGui.QImage.Format_RGB888)) # convert opencv image to pixmap to
                    ↪ display it to the user
        else:
            pix_img = QtGui.QPixmap(QtGui.QImage(img,self.__img_width, self.__img_height,3*self.__img_width,
                ↪ QtGui.QImage.Format_Indexed8))
        self.lbl2.clear() #to clear the label to show new objects
        self.lbl2.setText(txt) #set the text to display
        self.lbl2.resize(300,50) #resize the label to required size
        self.lbl2.move(930,0) #positioning the label
        self.lbl2.show() #show the label
        pix_img = pix_img.scaled(600,600, QtCore.Qt.KeepAspectRatio)
        self.lbl3.clear() #to clear the label to show new objects
        self.lbl3.resize(600,600) #resize the label to required size
        self.lbl3.move(720,40) #positioning the label
        self.lbl3.setSizePolicy(QtGui.QSizePolicy.Minimum, QtGui.QSizePolicy.Minimum)
        self.lbl3.setScaledContents(False) #keep the image as it is while scaling
        self.lbl3.setPixmap(pix_img) #shoe the image
        self.lbl3.show() #show the label

def main(): # define a main class to call window created
    app = QtGui.QApplication(sys.argv) # start a qtgui application
    GUI = Window() #create an object of the window
    # GUI.disp() # display it
    sys.exit(app.exec_()) #close the window
main()
```