CS 543 ONL : Assignment 0

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Part 1 : Linear Interpolation

Hope solution image

Linear interpolation training images error plot

It is learnt from below error plots that errors occur at edges or transition regions of colors, as expected from interpolation after Bayer's filtering. The yellow spots in various scales correspond to error and purple patch is no error region. *pyplot.imshow was used, and options vmin = 0, vmax = 2048* were used for color map to accentuate the error visibility in the images. The error plots are shown below

Pixel difference for crayon

Pixel difference for iceberg

Pixel difference for Tony
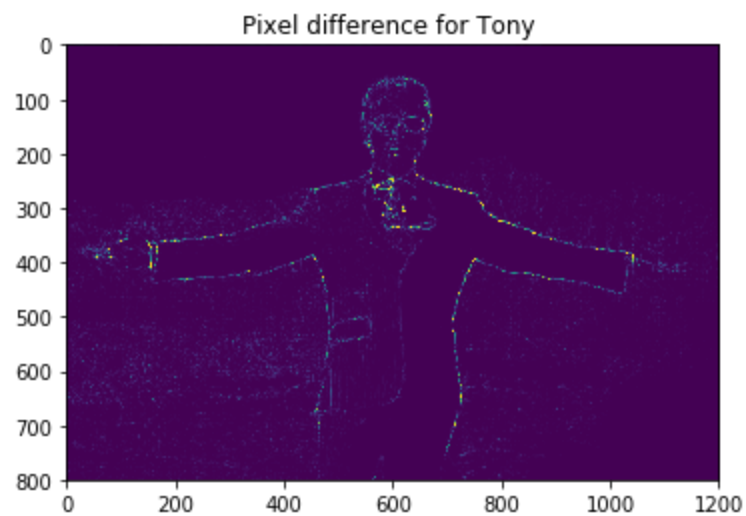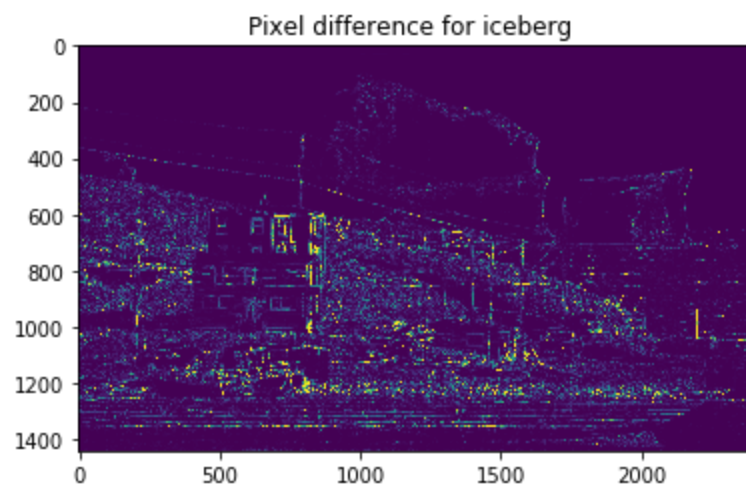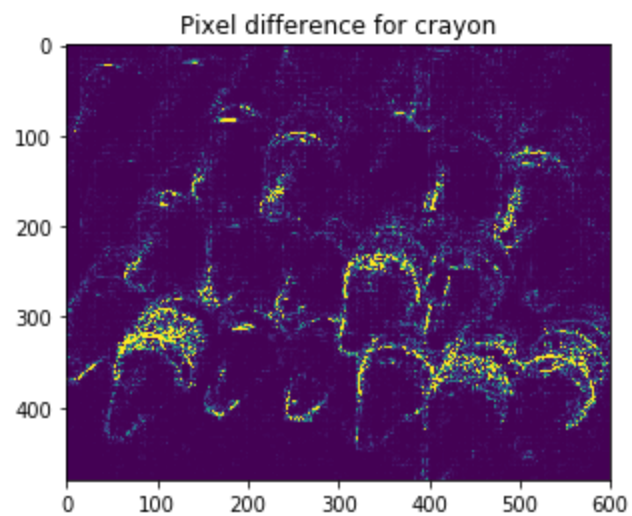
Solution images after interpolation

Closeup of artifacts

Crayons image : The artifact at lower blue crayon is shown in a square. The color on solution image is subtly different from color on original image. This coincides with the error plot obtained for crayon. The solution image is on the left and the original image is on the right. The dark blue to light blue transition region (pencil to pencil wrapper) for the lower crayon has some artifacts. The reason being there is not enough dark blue pixels or rather the area of dark blue is tiny, causing reconstruction issues due to color changes in neighborhood. The edges in reconstructed image appears blurry. The convolution filter size is dictated by interpolation to be 3x3 and the colors in the 3x3 neighborhood eventually influence the reconstruction color.
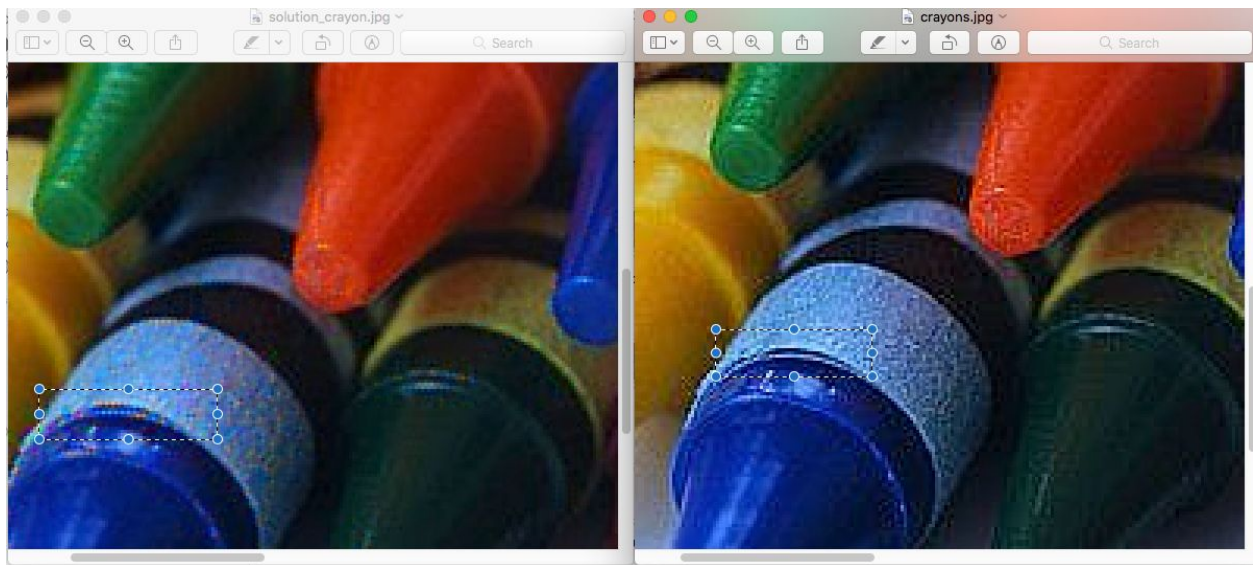
Iceberg image

The artifact for iceberg is shown below. The solution image is on left and original image is on right. The lone pole in the lower right of the image has more gray pixels in solution image when compared to original image. The region of interest is highlighted with a dotted line. Image reconstruction is tricky when small number of pixels change to a different color than its immediate neighborhood, causing the artifact. The filter size in convolution is 3x3, but the white pole horizontal length is less than 3, causing color artifact, due to influence from neighboring blue sea.
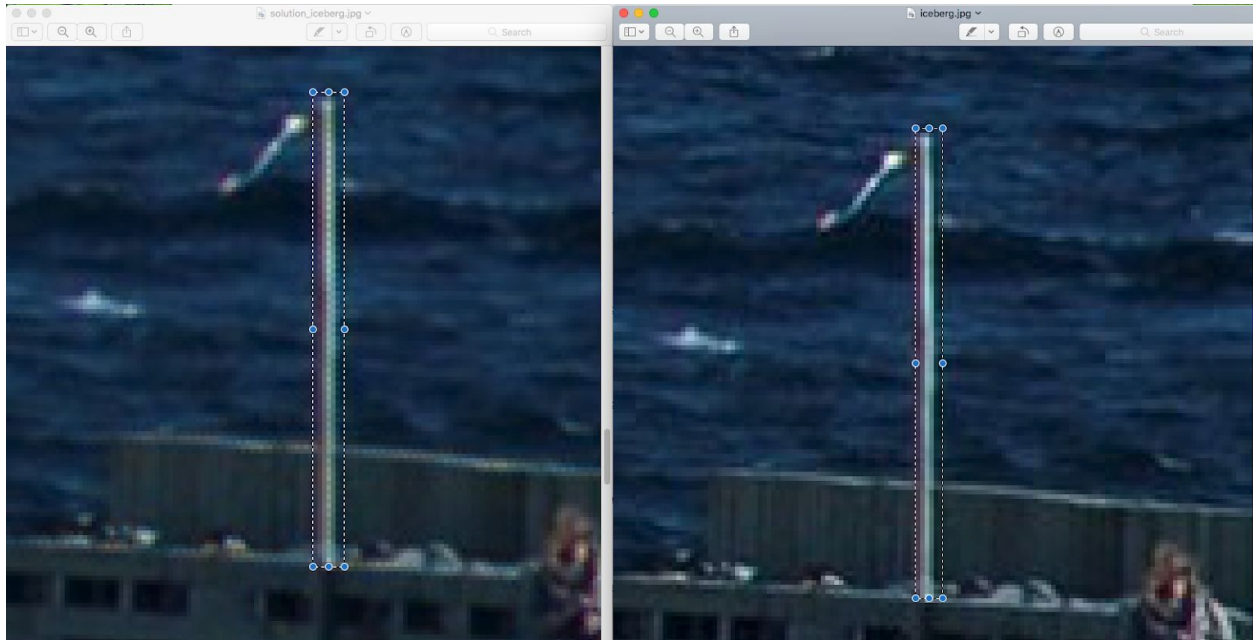
Tony image

The solution image is on left and original image is on right.
The artifact for Tony image is pronounced near the the coat on the right shoulder. The transition from background to black coat creates a minor different curvature due to difference of gray and black pixels in the border. The interpolation is not perfect at transition regions due to influence of neighborhood pixels, causing the difference.
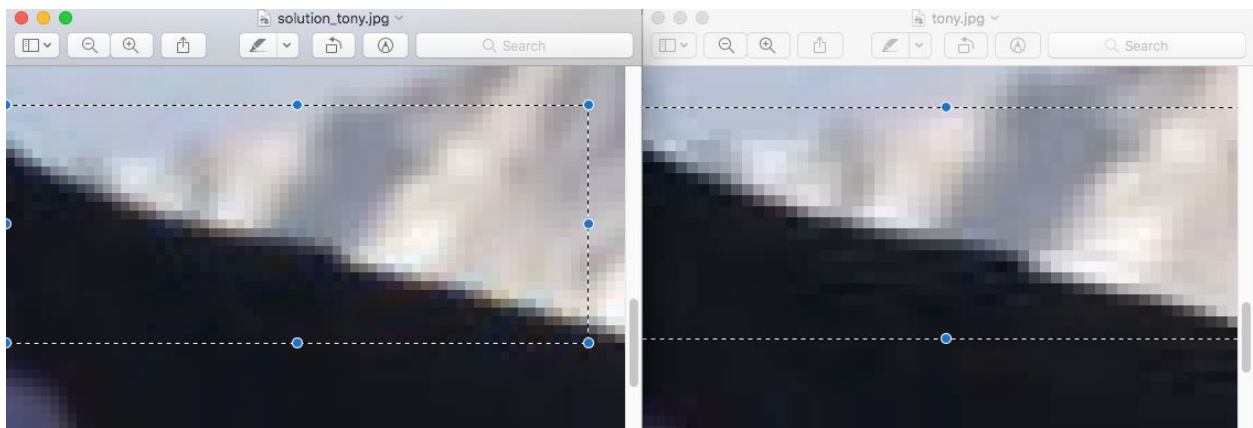
Image reconstruction statistics

The pixel values are stored as *unit8*. Thus, the image is internally represented as numpy matrix of values in the range 0-255. Sum of squared difference is used for below calculations

| Image	Average_per_pixel_error	Max_pixel_error
Crayon	212.753	53765
Tony	58.209	36973
Iceberg	114.972	30553

Part2 : Freeman Method

Hope Solution Image

Freeman interpolation training images error plot

It is learnt from below error plots that errors occur at edges or transition regions of colors, as expected from interpolation after Bayer's filtering. The yellow spots in various scales denote

error and purple patch is no error region. *pyplot.imshow was used, and options vmin = 0,m vmax = 2048* were used for color map to accentuate the error visibility in the images. The error plots are shown below

Pixel difference for crayons

Pixel difference for iceberg

Pixel difference for Tony
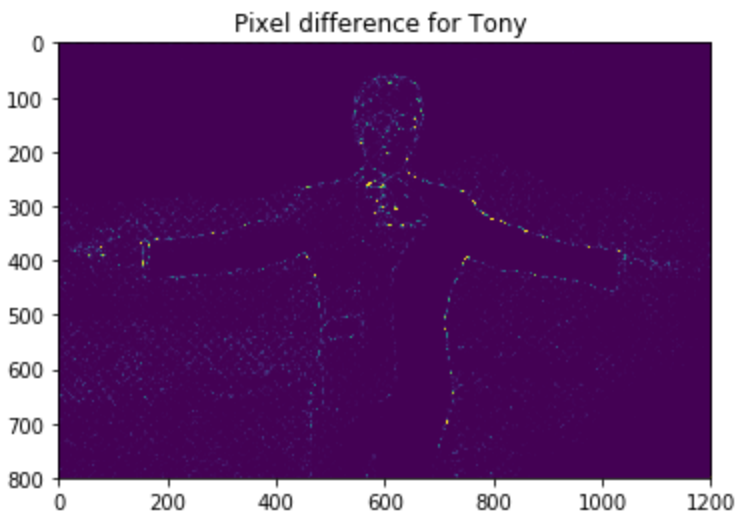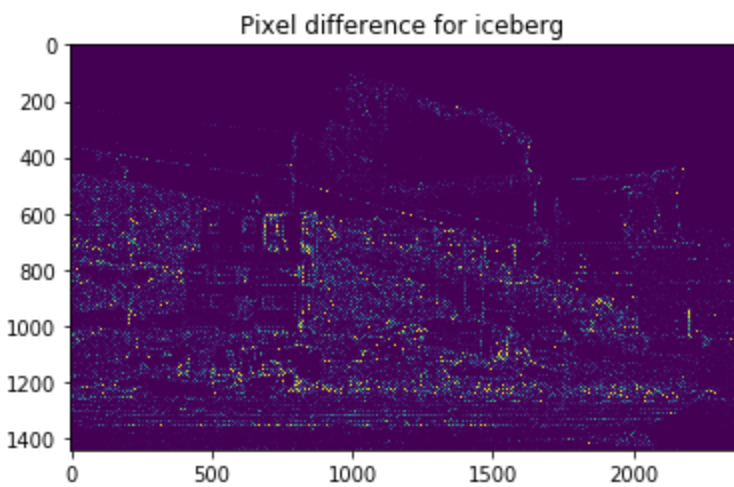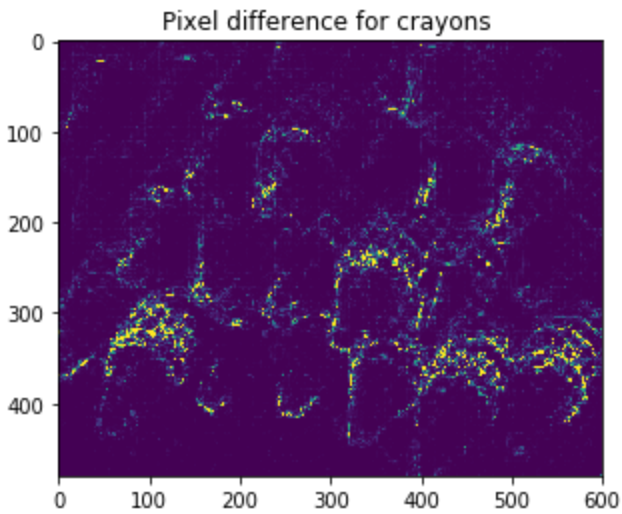
Solution Images with Freeman Interpolation

Artifact comparison

Crayon:

The freeman solution is contrasted against the original image and against the linear interpolation solution. There is a some improvement in color of pixels in the transition from crayon color to crayon wrapper. More pixels tend to be closer to blue and white, and the transition appears to be slightly less blurry. This is due to the fact that blue and red interpolation were corrected in Freeman.

Freeman on left vs Original on right
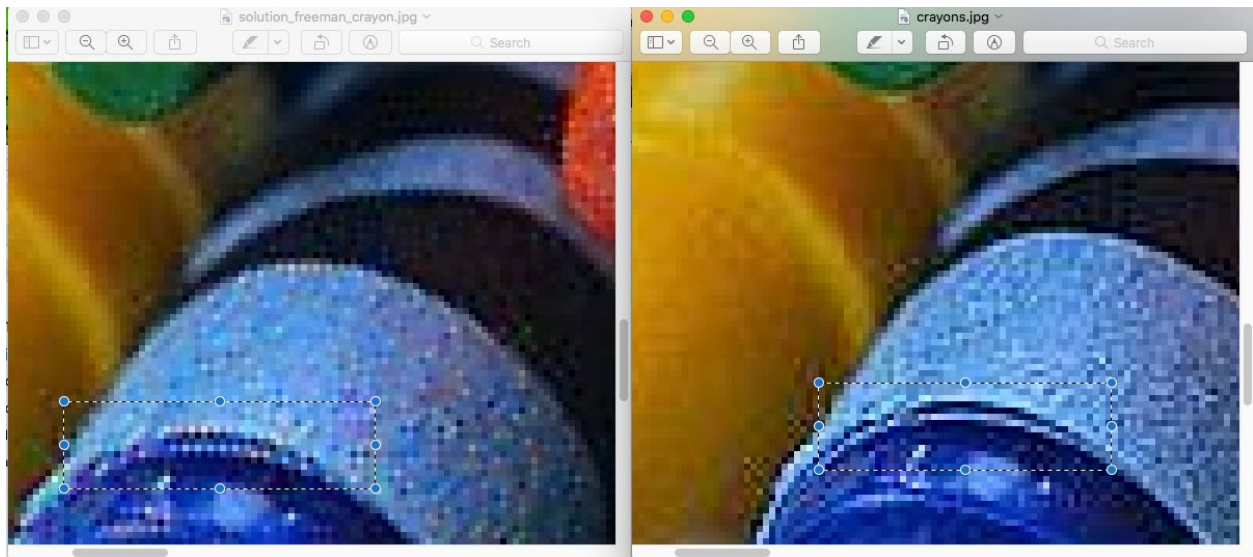
Freeman on left vs Linear on right
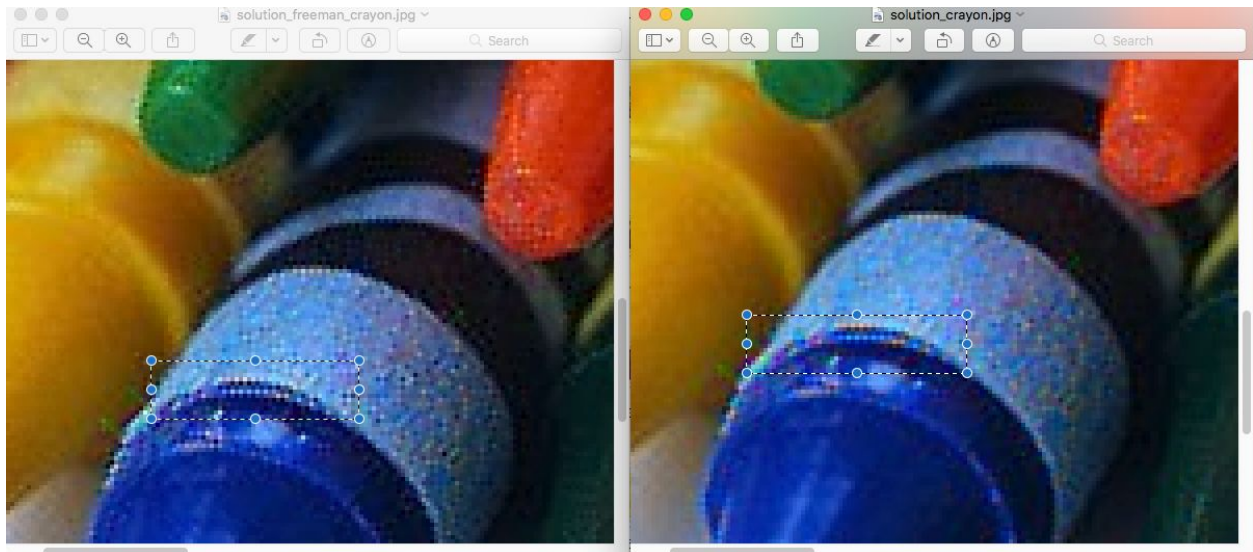
Iceberg:

The lone pole on the right edge of the picture was compared. The number of gray pixels in the white pole was reduced and the white color is less blurry in the Freeman interpolation, when compared to linear interpolation. However, the reconstruction still does not produce a smooth

transition of colors in original image due to neighborhood effect of convolution filter. The pole has sharp transition of colors along its length.

Freeman on left to original on right

Freeman on left to linear on right
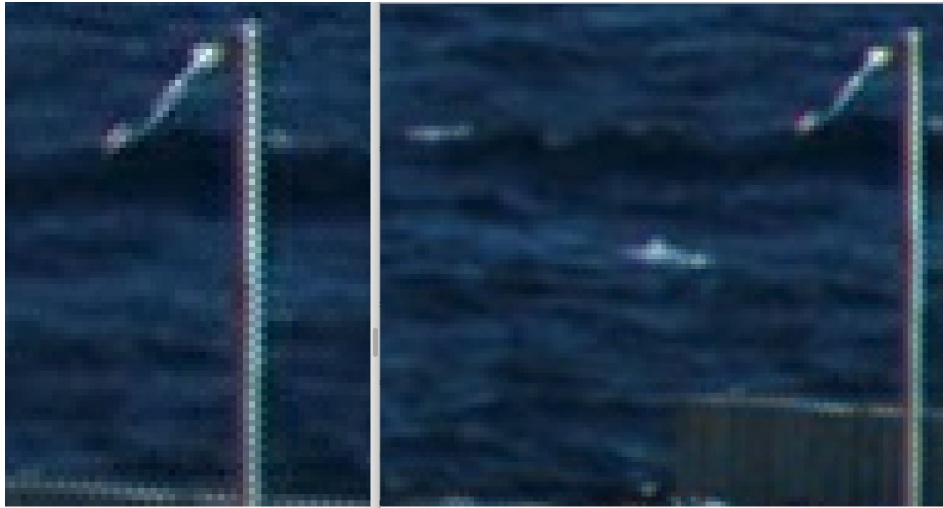
Tony:

The transition region is sharper in Tony image near the right shoulder in Freeman interpolation. The edges are less blurry in Tony image of Freeman, when compared to linear. However, there are still some pixel errors at transition region when compared to original image.

Freeman on left vs Original on right
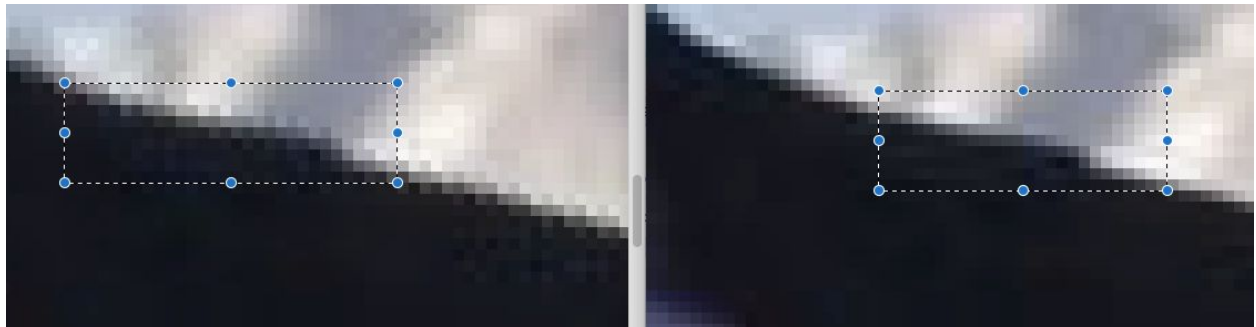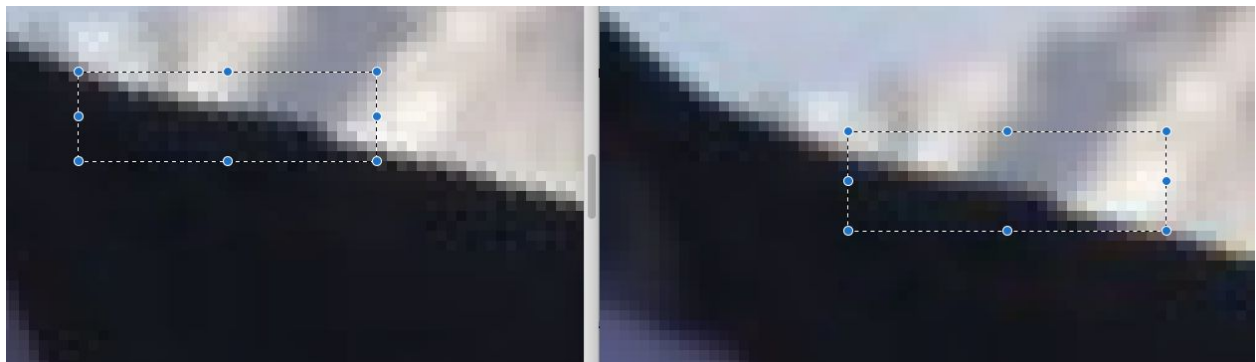

Freeman on left vs linear on right

Image reconstruction statistics

The pixel values are stored as unit8. Thus the image is internally represented as numpy matrix of values in the range 0-255. Sum of squared difference is used for below calculations

Image	Average_per_pixel_error	Max_pixel_error
Crayon	142.271	48173
Tony	26.503	32278
Iceberg	77.440	33989

The average per pixel error for crayon, tony and iceberg reduced by ~33%, ~55%, ~33% respectively. The max pixel errors reduced by a few thousands for crayon and tony, increased by a few percent for iceberg. The above experiment illustrates that the average per pixel errors are reduced in Freeman interpolation technique when compared to linear interpolation, producing a better reconstructed image.
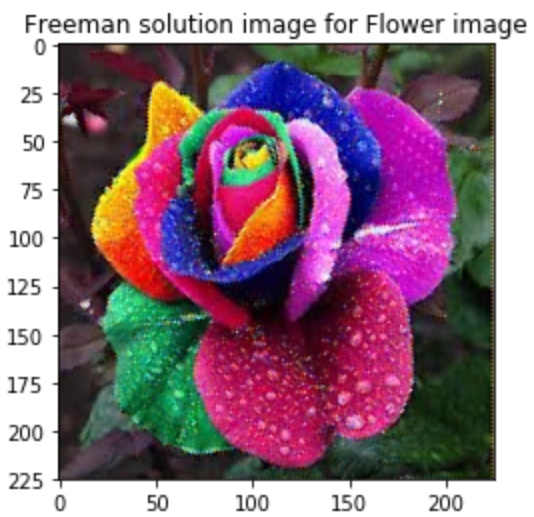
Part 3 :

Three images were tried.
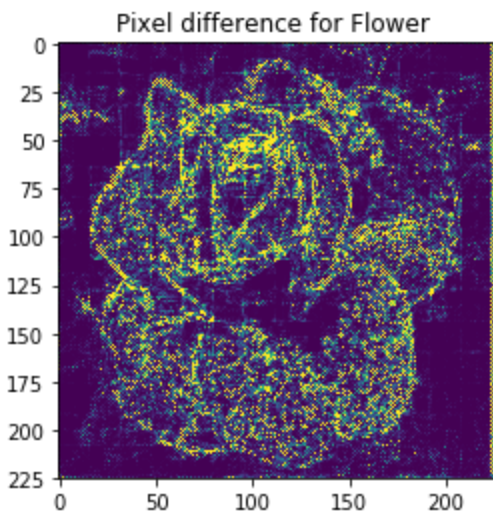
1) Flower : Image that works well.

Original image

Reconstructed image

Freeman solution image for Flower image

Error plot of Flower

Pixel difference for Flower

The error is along the transition region of colors and near dewdrops, which represent a region of different color compared to the neighborhood

Average per-pixel error : 636.34
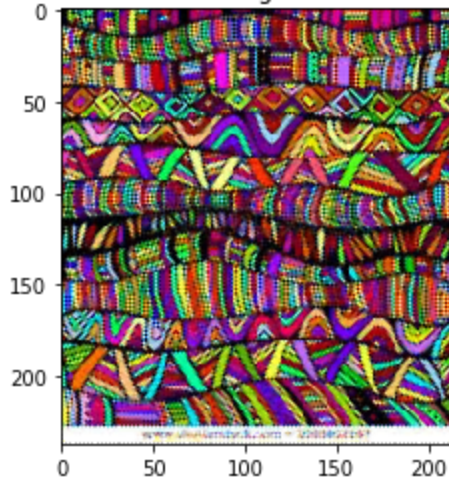Maximum pixel error : 47289

2) Rainbow wall art image : Image that works ok, with lot of errors
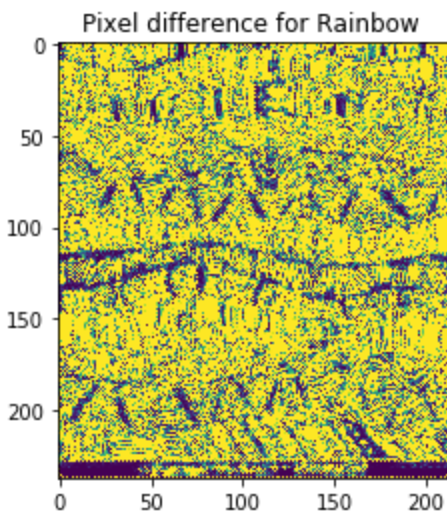
Original image

Reconstructed image

Freeman solution image for rainbow image

Error plot

Why image is imperfect : The image has non-rectilinear shape (wave-like pattern) and color changes within shapes are too frequent. Thus, the interpolation does not work quite well as the convolution window is a square in this case, looking at rectilinear neighborhoods. The edges are blurry and entire art pattern appears blurry and smudged, through a decent reconstruction of high level details occur
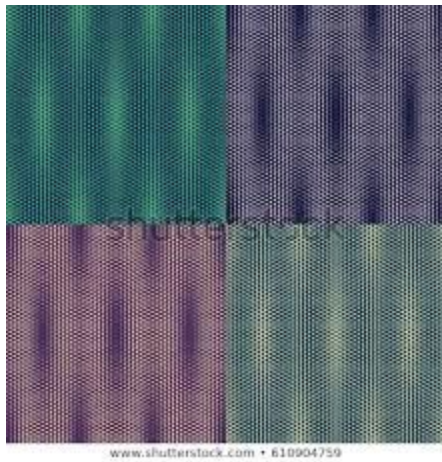
Pixel difference for Rainbow

Average per pixel error: 5080.67
Maximum pixel error : 112696

3) Abstract waveform picture : Image that breaks

Original

Reconstructed image
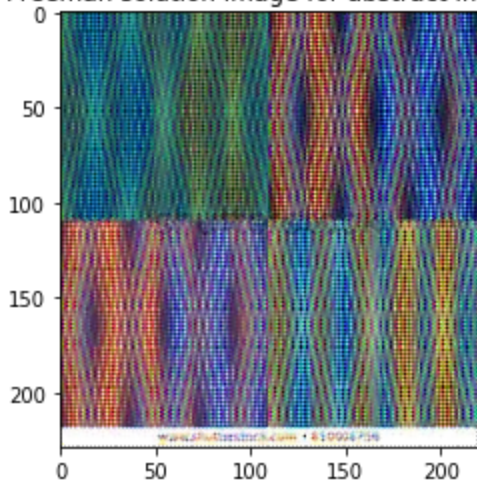
Error plot:

Why image breaks : The reconstructed image does not look like the given image due to shape of the color contour in original image and degree of change of color. The shape is non-rectilinear to a great extent and color changes are finer to few pixels. The convolution window is unable to capture the frequent changes in geometry and color.

Average per pixel error : 6485.304
Maximum per pixel error : 101803

Pixel difference for abstract
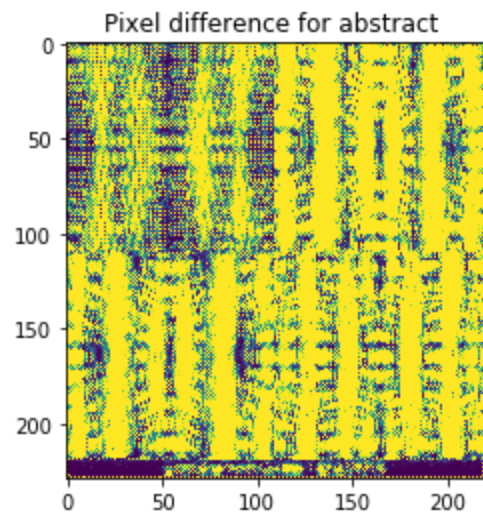
References:

Images are obtained from shutterstock.com