CP467

Digital Image Processing

Assignment 1

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Q1. Image Interpolation

1. **Nearest Neighbour Interpolation:** Nearest neighbor interpolation is a simple method used to resize an image. For each pixel in the new enlarged image, the function finds the corresponding pixel from the original image using the scaling factor. It maps each pixel in the new image to the nearest corresponding pixel in the original image. The pixel values are directly copied without considering surrounding pixel information, which results in images enlarged using this method often being pixelated.
2. **Nearest Neighbour Interpolation Built in Function:** OpenCV provides a built-in function for resizing images. Built in function also has the same drawback as the one implemented from scratch. Since this function also just considers single pixel value, the image produced using this method also results in being pixelated.
3. **Bilinear Interpolation:** Bilinear interpolation enhances image quality by using the four closest pixel values from the original image to calculate each new pixel's value. It does this by performing linear interpolation twice—first along the x-axis and then along the y-axis.
4. **Bilinear Interpolation Built in function:** OpenCV provides a built function to enlarge images. Since the bilinear function considers the values of the four neighbouring pixels results are slightly better than nearest neighbour function but may produce pixelated results while significantly enlarging images.
5. **Bicubic Interpolation Built in function:** OpenCV provides this built-in function to resize images. In contrast to Bilinear Interpolation which only takes four neighbouring pixels, Bicubic takes 16 of the neighbouring pixels into consideration for calculating the new pixel's value. This results in production of better-quality images as compared to other functions mentioned above.

A0. Source Image

A1. Nearest neighbor interpolation implementation from scratch

A2. Nearest neighbor interpolation using OpenCV built-in function

A3. Bilinear interpolation implementation from scratch

A4. Bilinear interpolation using OpenCV built-in function

A5. Bicubic interpolation using OpenCV built-in function

Quality of Results:

In terms of image quality, nearest neighbour interpolation produces blocky and pixelated images. This method simply replicates the value nearest single neighbour without considering other neighbouring pixels which lead to unsmooth transitions. As compared to nearest neighbour interpolation, bilinear interpolation produces better quality images as it considers four neighbouring pixels to calculate the value of the resulting pixel. While this smooths out the transitions, it often produces blurriness in the areas of high contrast.

Out of all three image resizing methods mentioned above, bicubic interpolation produces the highest quality images. It achieves this by calculating pixel values using a weighted average of the 16 surrounding pixels, leading to much smoother and more detailed results. A side-by-side comparison of images generated by all three methods provides visual evidence of the differences in image quality.

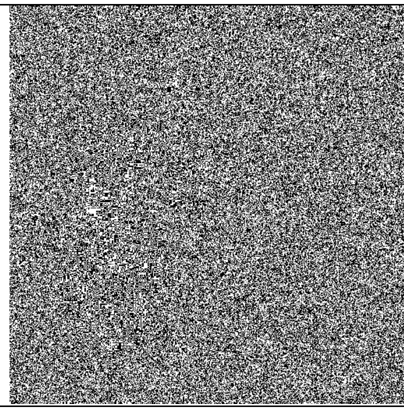
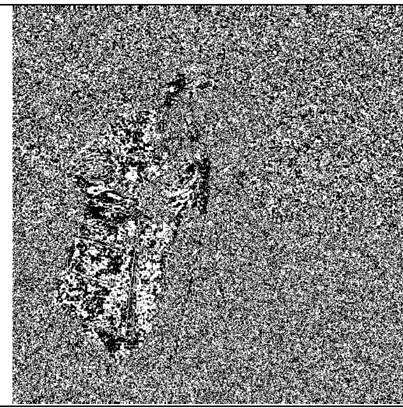
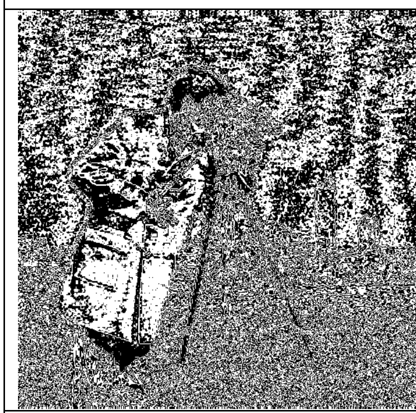
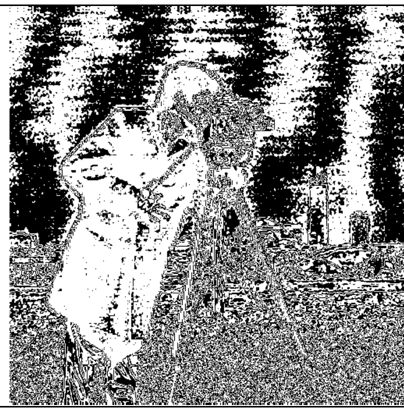
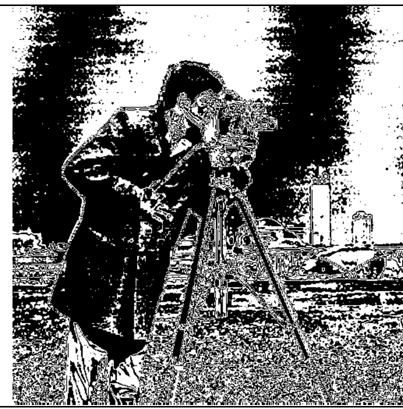
Q2. Point Operations

1. **Negative of Image:** This function performs a negative transformation by inverting the pixel value of the image. For an 8-bit image, the maximum pixel value in 255, so the value of each pixel is subtracted from 255 to create negative image. This technique is commonly used to create image negatives in medical image processing.
2. **Power Law Transformation:** This function modifies the contrast of an image using the formula $s = cr^{\gamma}$. This method enhances or suppresses the brightness in certain range depending on the value of gamma (γ). Values of gamma less than one darkens the image, while values greater than one tends to brighten an image. The correct gamma value may require trial and error based on the desired contrast enhancement.
3. **Bit plane slicing:** Bit plane slicing decomposes the provided image into multiple binary images by isolating the individual bits in the pixel intensity values. This done by first converting the pixel value into binary form and then dividing the converted values into planes. Through this process we can analyze the relative importance of each bit in the image. The higher order bits contribute most to image structure whereas the lower order bits contribute finer details of the image.

Source Image

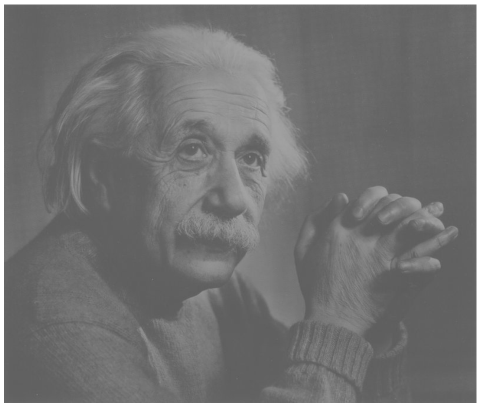
Negative of Image

Power-law Transformation

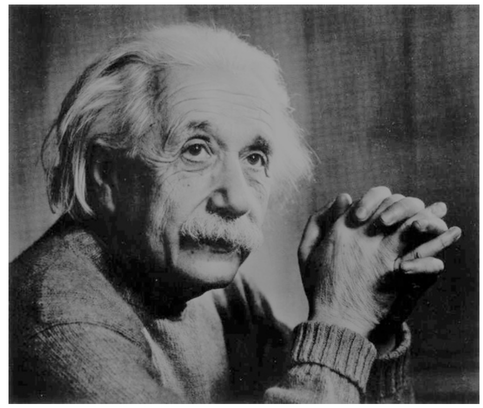
		
Source Image	Bit Plane 1	Bit Plane 2
		
Bit Plane 3	Bit Plane 4	Bit Plane 5
		
Bit Plane 6	Bit Plane 7	Bit Plane 8

Q3. Histogram Processing

1. **Histogram Equalization:** Histogram equalization is the method used to improve the contrast of an image. This is achieved by redistributing the pixel intensity values. This method usually increases the global contrast by stretching out the intensity range of the image. This allows for the areas of low contrast to gain a higher contrast. This method is highly effective for images that appear to be washed out.

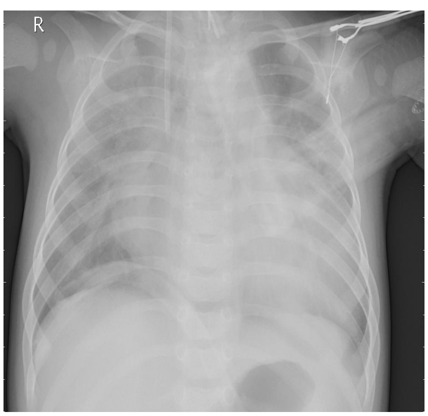


Source Image

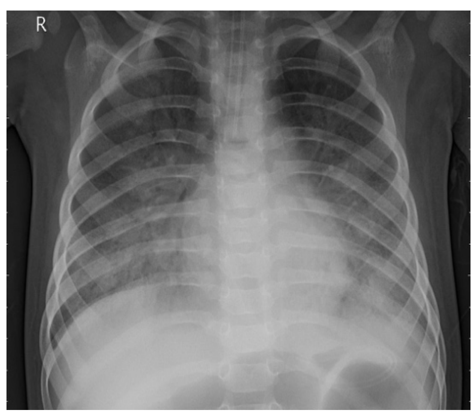


Equalized Image

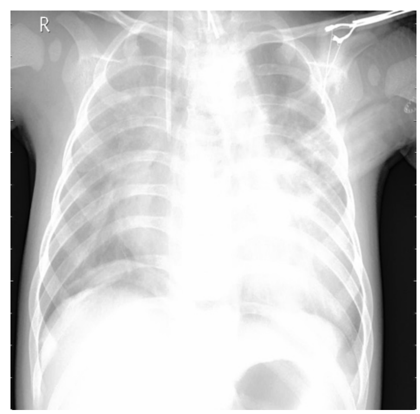
2. **Histogram Specification:** Histogram specification also known as Histogram matching is method used to match the contrast of an input image to source image. Unlike histogram equalization, which modifies the intensity distribution based on a uniform target, histogram specification modifies the image to achieve a specific target distribution. This can be used to give images a similar tonal quality. This method is particularly useful when trying to give images a consistent look across a set.



chest_x-ray1



chest_x-ray2



chest_x-ray3

Quality of Results

Histogram equalization significantly improved the contrast in low-contrast image. The transformation stretched the intensity values over the available range, making dark areas lighter and bright areas darker. This made image which appeared to be washed out earlier look sharper and more detailed.

The histogram specification process effectively matched the histogram of the input image to that of the source image. Visual comparisons of the output images with the source image showed similar contrast and tonal distributions.