Batch: C-1 Roll No.:16010122323

Experiment No. 8

Grade: AA / AB / BB / BC / CC / CD /DD

Signature of the Staff In-charge with date

Title: Apply neighbourhood processing techniques**:** low pass, high pass and median filtering in spatial domain on a digital image

Objective: To learn and understand the effects of filtering in spatial and frequency domain on images using Matlab.

Expected Outcome of Experiment:

CO	Outcome
CO4	Design & implement algorithms for digital image enhancement, segmentation & restoration.

Books/ Journals/ Websites referred:

1. http://www.mathworks.com/support/
2. www.math.mtu.edu/~msgocken/intro/intro.html.
3. R. C.Gonsales R.E.Woods, "Digital Image Processing", Second edition, Pearson Education
4. S.Jayaraman, S Esakkirajan, T Veerakumar "Digital Image Processing "Mc Graw Hill.
5. S.Sridhar,"Digital Image processing", oxford university press, 1st edition."

Pre Lab/ Prior Concepts:

Filtering in Spatial Domain:

Low pass filtering as the name suggests removes the high frequency content from the image. It is used to remove noise present in the image. Mask for the low pass filter is:

1/9	1/9	1/9
1/9	1/9	1/9
1/9	1/9	1/9

One important thing to note from the spatial response is that all the coefficients are positive. We could also use 5 x 5 or 7 x 7 mask as per our requirement. We place a 3 x 3 mask on the image. We start from the left hand top corner. We cannot work with the borders and hence are normally left as they are. We then multiply each component of the image with the corresponding value of the mask. Add these values to get the response. Replace the centre pixel of the o/p image with these responses. We now shift the mask towards the right till we reach the end of the line and then move it downwards.

High pass filtering as the name suggests removes the low frequency content from the image. It is used to highlight fine detail in an image or to enhance detail that has been blurred. Mask for the high pass filter is:

-1/9	-1/9	-1/9
-1/9	8/9	-1/9
-1/9	-1/9	-1/9

One important thing to note from the spatial response is that sum of all the coefficients is zero. We could also use 5 x 5 or 7 x 7 mask as per our requirement. We place a 3 x 3 mask on the image. We start from the left hand top corner. We cannot work with the borders and hence are normally left as they are. We then multiply each component of the image with the corresponding value of the mask. Add these values to get the response. Replace the centre pixel of the o/p image with these responses. We now shift the mask towards the right till we reach the end of the line and then move it downwards.

Median filtering is a signal processing technique developed by tukey that is useful for noise suppression in images. Here the input pixel is replaced by the median of the pixels contained in the window around the pixel. The median filter disregards extreme values and does not allow them to influence the selection of a pixel value which is truly representative of the neighbourhood.

Implementation Details:

Write Algorithm and Matlab commands used:

```
img = imread('cameraman.tif');
figure, imshow(img), title('Original Cameraman Image');
h_low = fspecial('gaussian', [3 3], 2);
img_low = imfilter(img, h_low);
figure, imshow(img_low), title('Low-pass Filtered Image');
h_high = fspecial('laplacian', 0.2);  % Using a 3x3 mask implicitly
img_high = imfilter(img, h_high);
figure, imshow(img_high), title('High-pass Filtered Image');
img_median = medfilt2(img, [3 3]);
figure, imshow(img_median), title('Median Filtered Image');
```

Original Cameraman Image

Low-pass Filtered Image

High-pass Filtered Image

Median Filtered Image

Conclusion:- In this experiment, we learned to apply neighbourhood processing techniques: low pass, high pass and median filtering in spatial domain on a digital image

Post Lab Descriptive Questions

1. List & explain different types of noise associated with a digital signal.

Ans)

- **Gaussian Noise**: Random noise with a normal distribution, often caused by thermal fluctuations or electronic components. It affects the signal uniformly and is characterized by a bell-shaped probability distribution.
- **Salt-and-Pepper Noise**: A type of impulse noise where random pixels in an image are set to either the maximum (salt) or minimum (pepper) intensity values. It usually appears as black and white specks on the image.
- **Poisson Noise**: Occurs due to the discrete nature of signals and is more noticeable in low-light conditions. The noise follows a Poisson distribution, where the variance is proportional to the signal intensity.
- **Speckle Noise**: Caused by random variations in the pixel intensity, often due to interference in the signal. It can result in grainy images and is common in medical imaging (e.g., ultrasound).
- **Quantization Noise**: Introduced when an analog signal is quantized into digital values. It results from the rounding off of the signal to the nearest digital value and is typically small but noticeable in low-bit-depth systems.
- **Impulse Noise**: Random, high-intensity spikes in the signal, often caused by electrical interference or transmission errors. It manifests as sudden, brief disturbances in the signal.
- **Thermal Noise**: Caused by the random motion of electrons in conductors, which results in voltage fluctuations. It's also known as Johnson-Nyquist noise and is present in all electronic devices.
- **Burst Noise**: Sudden, brief bursts of noise that may occur sporadically, often related to defects in semiconductor components or electrical circuits.

2. Explain with the help of an example how filtering helps in enhancing the quality of an image.

Ans) Filtering enhances image quality by reducing noise or improving certain features. Here's an example using **Gaussian filtering** to remove noise:

Example: Noise Reduction with Gaussian Filter

1. **Noisy Image**: Imagine a "Cameraman" image with **salt-and-pepper noise** (random black and white dots).
2. **Gaussian Filter Application**: A **Gaussian filter** is applied, which smooths the image by averaging pixel values with their neighbors. The filter gives higher weights to closer neighbors and reduces sharp noise.
3. **Result**: After applying the filter, the salt-and-pepper noise is reduced, and the image becomes smoother, enhancing its visual quality without distorting the important features.