JORHAT ENGINEERING COLLEGE

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

ASSIGNMENT: 2

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SUBJECT – IMAGE PROCESSING

Q. How image enhancement is done in frequency domain? Describe various techniques of enhancement in frequency domain filtering?

Ans: Image enhancement in the frequency domain involves manipulating the frequency components of an image to enhance certain features or reduce noise. This is done using mathematical operations in the frequency domain, which is a representation of the image in terms of its frequency components.

The basic idea is to apply a filter to the frequency domain representation of the image. The filter is designed to either amplify or attenuate certain frequency components. This can be used to enhance certain features of the image, such as edges or details, or to reduce noise.

The frequency domain representation of an image is obtained using the Fourier Transform. The Fourier Transform converts the image from the spatial domain to the frequency domain. Each point in the frequency domain represents a frequency component of the image.

To enhance the image, a filter is applied to the frequency domain representation. The filter can be designed using various techniques, such as frequency domain filtering, which involves designing a filter that suppresses certain frequency components or enhances others.

There are many types of filters that can be used for image enhancement in the frequency domain, including low-pass filters, high-pass filters, and band-pass filters. Several techniques for enhancing images in the frequency domain using filtering:

1. **Low-pass filtering**: A low-pass filter attenuates the high-frequency components of an image while preserving the low-frequency components. This technique is useful for removing high-frequency noise from an image. There are several types

of low-pass filters that can be used for image enhancement in the frequency domain.

A. **Ideal low-pass filter**: An ideal low-pass filter removes all frequencies above a cutoff frequency and passes all frequencies below the cutoff frequency. The formula for the ideal low-pass filter is:

$$H(u,v)=1, if \left(u^2+v^2\right)^{0.5} \leqslant Do$$

$$H(u,v)=0, if \left(u^2+v^2\right)^{0.5} > Do$$

where H(u,v) is the filter function, (u,v) are the coordinates in the frequency domain, and D0 is the cutoff frequency.

B. **Butterworth low-pass filter**: The Butterworth low-pass filter is a smooth filter that attenuates higher frequencies gradually as they approach the cutoff frequency. The formula for the Butterworth low-pass filter is:

$$H(u,v)=\frac{1}{\left(1+\left(\frac{\left(u^2+v^2\right)^{0.5}}{Do}\right)^{(2n)}\right)}$$

where H(u,v) is the filter function, (u,v) are the coordinates in the frequency domain, D0 is the cutoff frequency, and n is the order of the filter.

C. **Gaussian low-pass filter**: The Gaussian low-pass filter is a smooth filter that attenuates higher frequencies based on a Gaussian function. The formula for the Gaussian low-pass filter is:

$$H(u,v)=\exp\frac{\left(\text{-}\left(\left(u^2+v^2\right)^{0.5}\right)^2\right.}{\left(2\times Do^2\right)}\left((u,v)=\exp\frac{\left(\text{-}\left(\left(u^2+v^2\right)^{0.5}\right)^2\right.}{\left(2\times Do^2\right)}\right)$$

These are just a few of the types of low-pass filters that can be used for image enhancement in the frequency domain. The choice of filter depends on the specific characteristics of the image and the desired outcome.

2. **High-pass filtering**: A high-pass filter attenuates the low-frequency components of an image while preserving the high-frequency components. This technique is useful for enhancing the edges and details in an image. There are several types of high-pass filters that can be used for image enhancement in the frequency domain.

A. **Ideal high-pass filter**: An ideal high-pass filter removes all frequencies below a cutoff frequency and passes all frequencies above the cutoff frequency. The formula for the ideal high-pass filter is:

$$H(u,v)=1, if\left(u^2+v^2\right)^{0.5} > Do$$

$$H(u,v)=0, if\left(u^2+v^2\right)^{0.5} \leqslant Do$$

B. **Butterworth high-pass filter**: The Butterworth high-pass filter is a smooth filter that attenuates lower frequencies gradually as they approach the cutoff frequency. The formula for the Butterworth high-pass filter is:

$$H(u,v)=\frac{1}{\left(1+\left(\frac{\left(u^2+v^2\right)^{0.5}}{Do}\right)^{(2n)}\right)}$$

C. **Gaussian high-pass filter**: The Gaussian high-pass filter is a smooth filter that attenuates lower frequencies based on a Gaussian function. The formula for the Gaussian high-pass filter is:

$$H(u,v) = 1 - \exp\frac{\left(-\left(\left(u^2+v^2\right)^{0.5}\right)^2\right.}{\left(2\times Do^2\right)}\left((u,v) = 1 - \exp\frac{\left(-\left(\left(u^2+v^2\right)^{0.5}\right)^2\right.}{\left(2\times Do^2\right)}\right)$$

D. **Laplacian filter**: The Laplacian filter is used to enhance the edges in an image. The formula for the Laplacian filter is: $H(u,v) = -4\times\pi^2\times\left(u^2+v^2\right)$

These are just a few of the types of high-pass filters that can be used for image enhancement in the frequency domain. The choice of filter depends on the specific characteristics of the image and the desired outcome.

3. **Homomorphic filtering**: Homomorphic filtering is a technique that is used to enhance images that have non-uniform illumination. It works by separating the illumination and reflectance components of an image and then applying a filter to the reflectance component.

4. **Band-pass filtering**: A band-pass filter attenuates both the low and high-frequency components of an image, while preserving a range of intermediate frequencies. This technique is useful for enhancing certain features of an image that are within a specific frequency range.

In summary, homomorphic filtering is a powerful technique for enhancing the contrast and brightness of images, particularly in low-light conditions. By transforming the image from the spatial domain to the frequency domain and applying a filter, homomorphic filtering can produce images with improved visual quality.