Digital Image Processing
Assignment-3 Report

1 Question 1: Frequency Domain filtering

1.1 Given Filters

The given filters are:

- Ideal Low Pass Filter (ILPF):

$$H_{\text{ILPF}}(u,v;D_0) = \begin{cases} 1 & \text{if } D(u,v) \leq D_0 \\ 0 & \text{if } D(u,v) > D_0 \end{cases}$$

- Ideal High Pass Filter (IHPF):

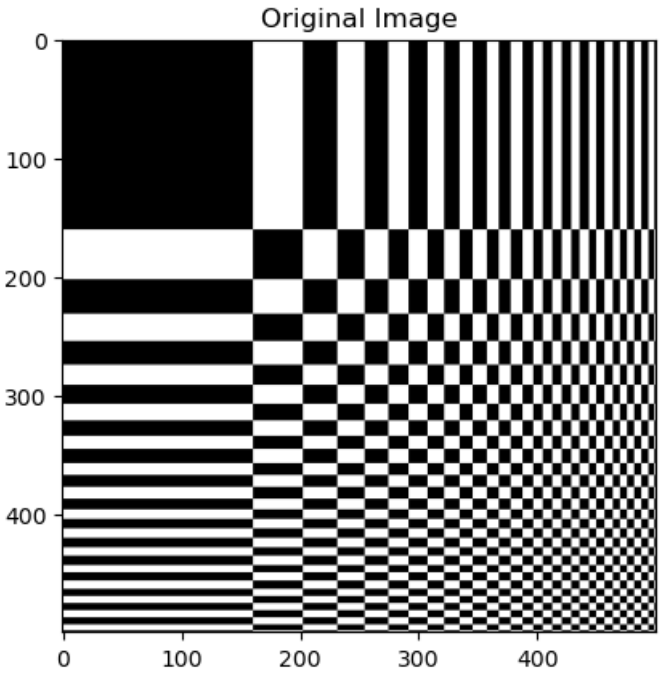
$$H_{\text{IHPF}}(u,v;D_0) = 1 - H_{\text{ILPF}}(u,v;D_0)$$

- Ideal Band Pass Filter (IBPF):

$$H_{\text{IBPF}}(u,v;D_l,D_h) = H_{\text{ILPF}}(u,v;D_h) \times H_{\text{IHPF}}(u,v;D_l)$$

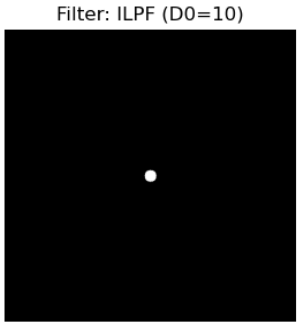
1.2 Given Image

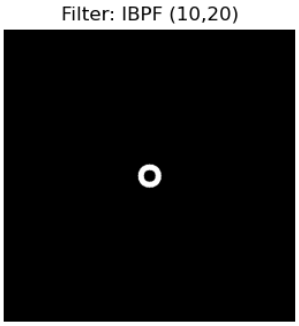
The given image is:

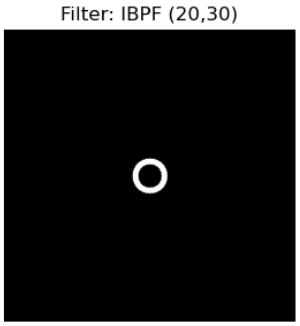


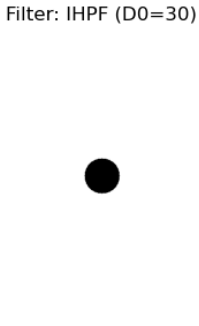
1.3 Filtered Images

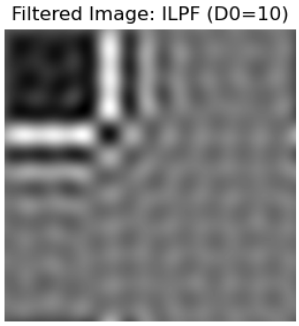
The filters and results obtained by using the filter on the given image are:

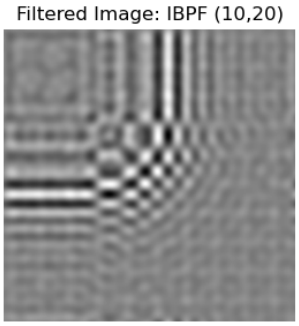


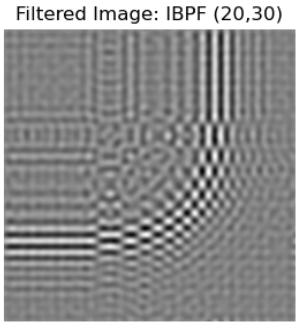


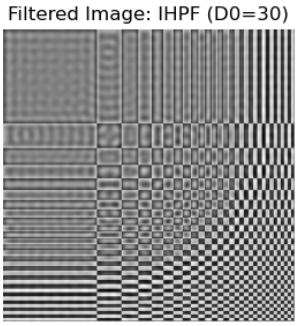












1.4 Results and Inferences

- **Original Image:** This serves as a reference for comparison.
- **ILPF (D0=10):**
  - The image appears blurred, as the low-pass filter removes high-frequency components (sharp edges and fine details).
- **IBPF (10,20):**
  - This bandpass filter preserves some low and mid frequencies, resulting in a partially smoothed image with moderate details.
- **IBPF (20,30):**
  - Retains higher frequency components, so some details are preserved, and the result is sharper than the first bandpass filter.
- **IHPF (D0=30):**
  - The high-pass filter enhances high-frequency components, making the image appear sharper with more defined edges, but it might lose some global structure.

Conclusion:

- ILPF smooths the image.
- IBPFs strike a balance between detail and smoothness.
- IHPF sharpens the image by enhancing edges.

2 Question 2: Ideal low pass filter and Guassian low pass filter

2.1 Given Filters

The given filters are:

- Ideal Low Pass Filter (ILPF):

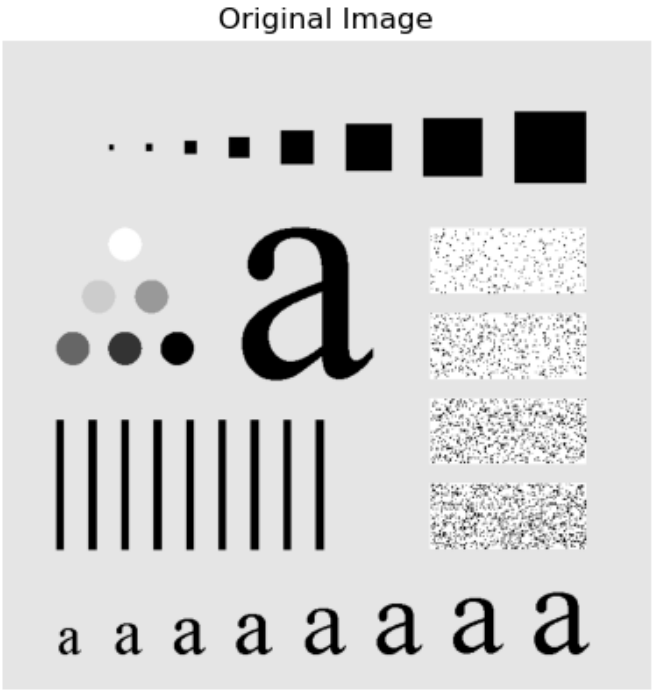
$$H_{\text{ILPF}}(u, v; D_0) = \begin{cases} 1 & \text{if } D(u, v) \leq D_0 \\ 0 & \text{if } D(u, v) > D_0 \end{cases}$$

- Gaussian Low Pass Filter (GLPF):

$$H_{\text{GLPF}}(u, v; D_0) = \exp\left(-\frac{D^2(u, v)}{2D_0^2}\right)$$

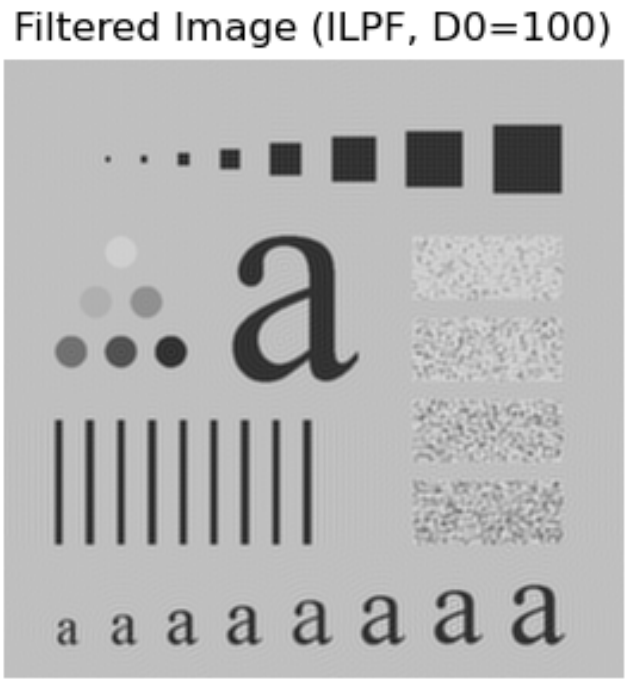
2.2 Given Image

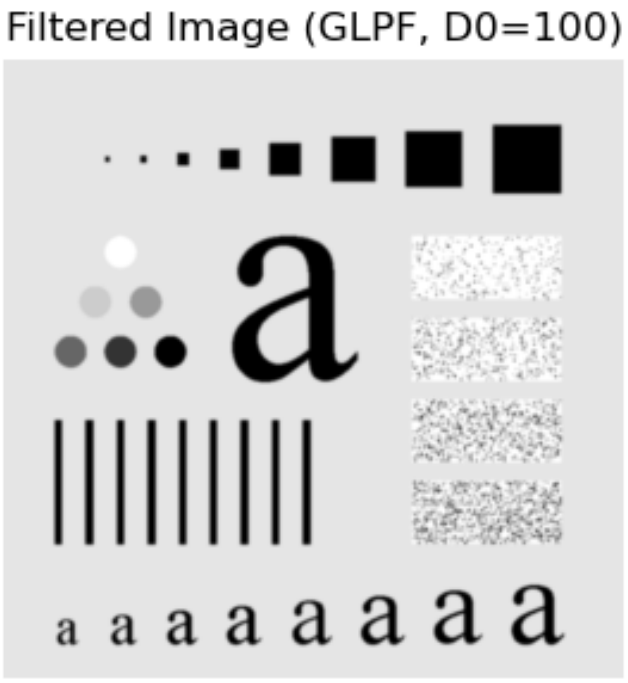
The given image is:



2.3 Filtered Images

The images obtained after applying low pass and Gaussian filters are:





2.4 Results and Inferences

- **Original Image:**
  - The original image displays a range of frequencies with distinct features, such as solid shapes, text, and varying intensities.
- **Filtered Image (ILPF, Do = 100):**
  - **Blurring:** The ILPF has effectively reduced high-frequency components, leading to a significant blur across the image. The text and fine details appear less distinct.
  - **Ringing Effect:** A notable ringing effect can be observed, especially around sharp edges (like the edges of the squares and the text). This is a common artifact of the ideal filter due to its abrupt cutoff in the frequency domain.
  - **Loss of Detail:** Fine elements like lines and dots become less visible.
- **Filtered Image (GLPF, Do=100):**
  - **Smoother Transition:** The GLPF has provided a softer, smoother transition in filtering, leading to less pronounced artifacts. The image retains more of its structural integrity compared to the ILPF.
  - **Less Blurring:** While the image is still blurred, it maintains a more natural appearance, and details, particularly in the text and shapes, are somewhat preserved.
  - **Reduced Ringing:** The ringing effect is less severe than in the ILPF, demonstrating the advantage of the Gaussian filter in handling sharp edges and transitions.

Summary of Artifacts:

- **Ringing Effect:** More pronounced in the ILPF due to its sharp frequency cutoff, which creates oscillations near edges in the spatial domain. The GLPF mitigates this effect due to its smoother transition.
- **Detail Preservation:** The GLPF generally preserves more detail than the ILPF, allowing for better visual retention of features in the image.