# Digital Image Processing and Pattern Recognition

**E1528**

**Fall 2021-2022**

## Lecture 9

# Image Sharpening Using High-pass Filters

## INSTRUCTOR

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# ➢ Contents

- ➢ Introduction
- ➢ Ideal, Gaussian, and Butterworth Highpass Filters from Lowpass Filters

## Introduction

- We showed in the previous lecture that an image can be smoothed by attenuating the high-frequency components of its Fourier transform.
- Because edges and other abrupt changes in intensities are associated with high-frequency components, image sharpening can be achieved in the frequency domain by highpass filtering, which attenuates low-frequencies components without disturbing high-frequencies in the Fourier transform.

# Ideal, Gaussian, and Butterworth Highpass Filters from Lowpass Filters

- subtracting a lowpass filter transfer function from 1 yields the corresponding highpass filter transfer function in the frequency domain

$$H_{HP}(u,v) = 1 - H_{LP}(u,v)$$

- An ideal highpass filter (IHPF) transfer function is given by

$$H(u,v) = \begin{cases} 0, & if\ D(u,v) \le D_0 \\ 1, & if\ D(u,v) > D_0 \end{cases}$$

# Ideal, Gaussian, and Butterworth Highpass Filters from Lowpass Filters

| | | |
|---|---|---|
| a | b | c |
| d | e | f |
| g | h | i |

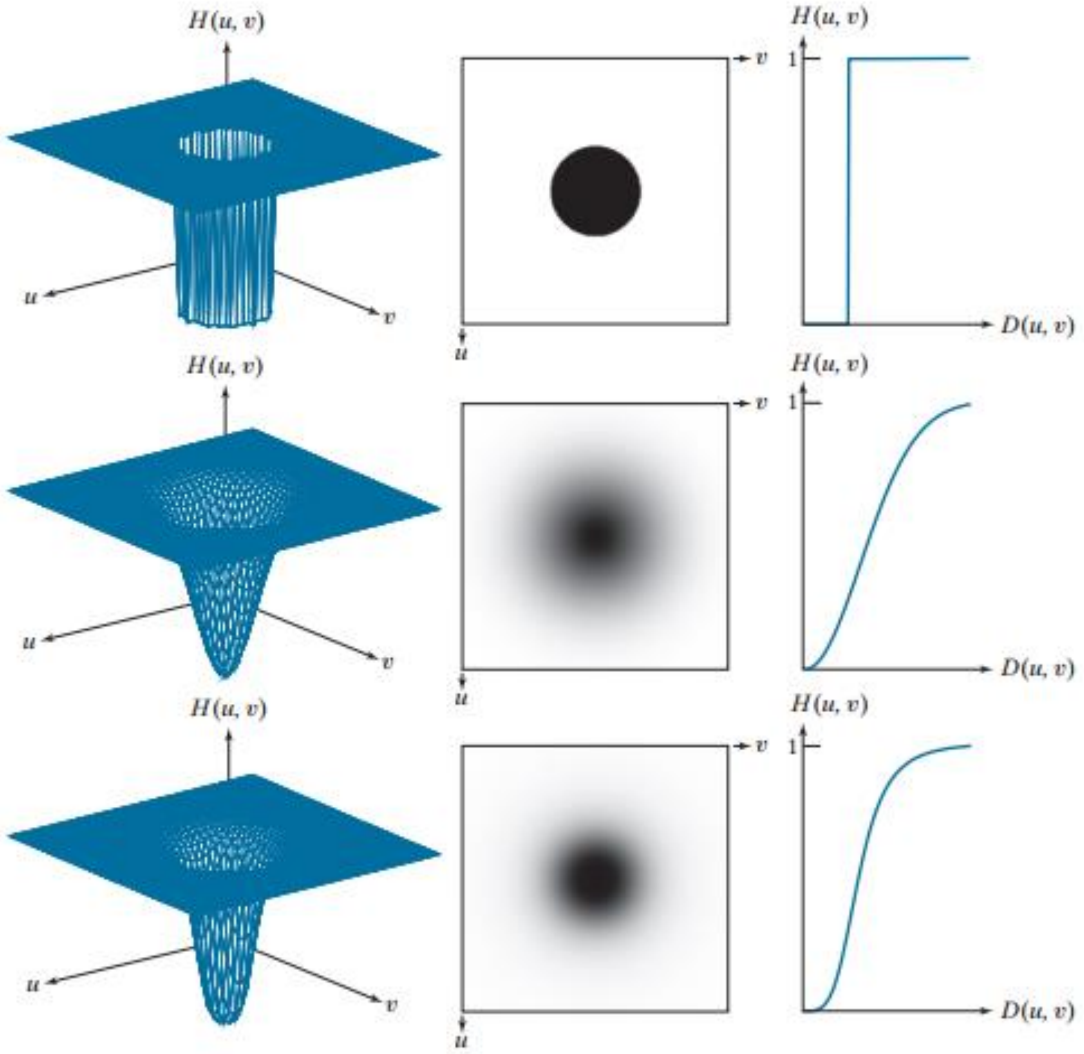
- **Top row:**

Perspective plot, image, and radial cross section of an IHPF transfer function.

- **Middle and bottom rows:**

The same sequence for GHPF and BHPF transfer functions.

(The thin image borders were added for clarity. They are not part of the data.)



## ➢ Ideal, Gaussian, and Butterworth Highpass Filters from Lowpass Filters

- ➢ the transfer function of a Gaussian highpass filter (GHPF) transfer function is given by

$$H_{(u,v)} = 1 - e^{-D^2(u,v)/2D_0^2}$$

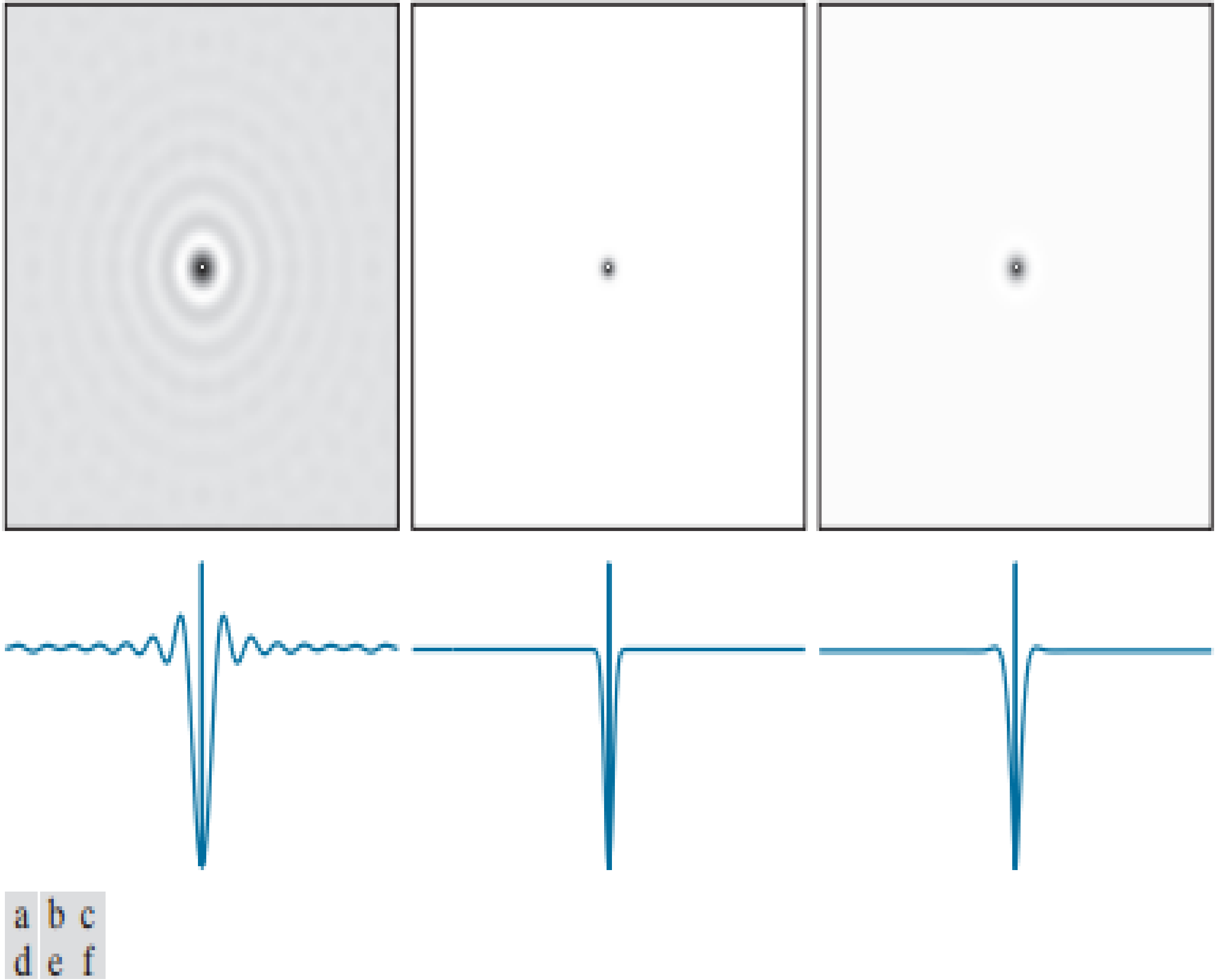
- ➢ the transfer function of a Butterworth highpass filter (BHPF) is

$$H(u,v) = \frac{1}{1 + [\frac{D_0}{D_{(u,v)}}]^{2n}}$$

## ➢ Ideal, Gaussian, and Butterworth Highpass Filters from Lowpass Filters

- (a)–(c): Ideal, Gaussian, and Butterworth highpass spatial kernels obtained from IHPF, GHPF, and BHPF frequency-domain transfer functions. (The thin image borders are not part of the data.)

- (d)–(f): Horizontal intensity profiles through the centers of the kernels.



# Ideal, Gaussian, and Butterworth Highpass Filters from Lowpass Filters

- Highpass filter transfer functions. D0 is the cutoff frequency and n is the order of the Butterworth transfer function

| Ideal | Gaussian | Butterworth |
|---|---|---|
| $H(u,v) = \begin{cases} 0 & \text{if } D(u,v) \le D_0 \\ 1 & \text{if } D(u,v) > D_0 \end{cases}$ | $H(u,v) = 1 - e^{-D^2(u,v)/2D_0^2}$ | $H(u,v) = \dfrac{1}{1 + \left[D_0/D(u,v)\right]^{2n}}$ |


Thank you