

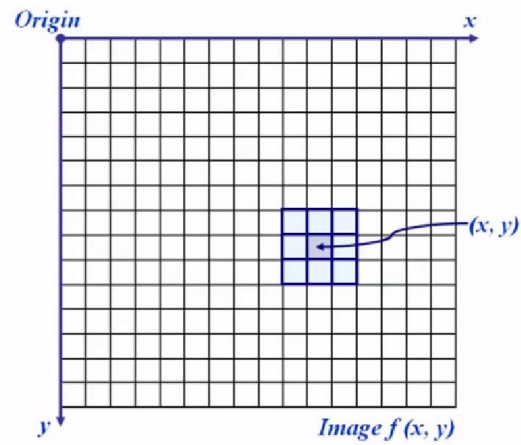


## **Computer Vision and Image Processing (CSEL-393)**

### **Lecture 5**

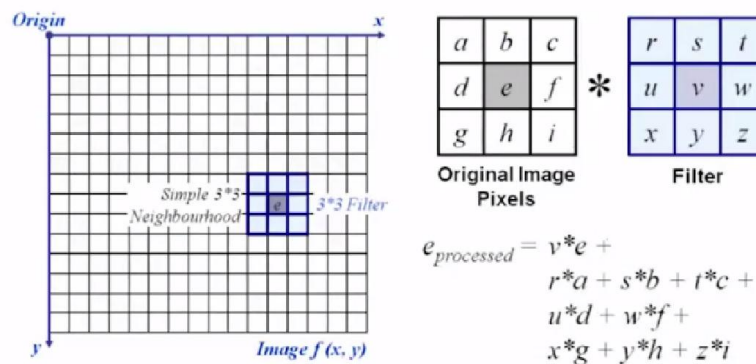
Dr. Qurat ul Ain Akram  
Assistant Professor  
Computer Science Department (New  
Campus) KSK, UET, Lahore

## Spatial Filter Process

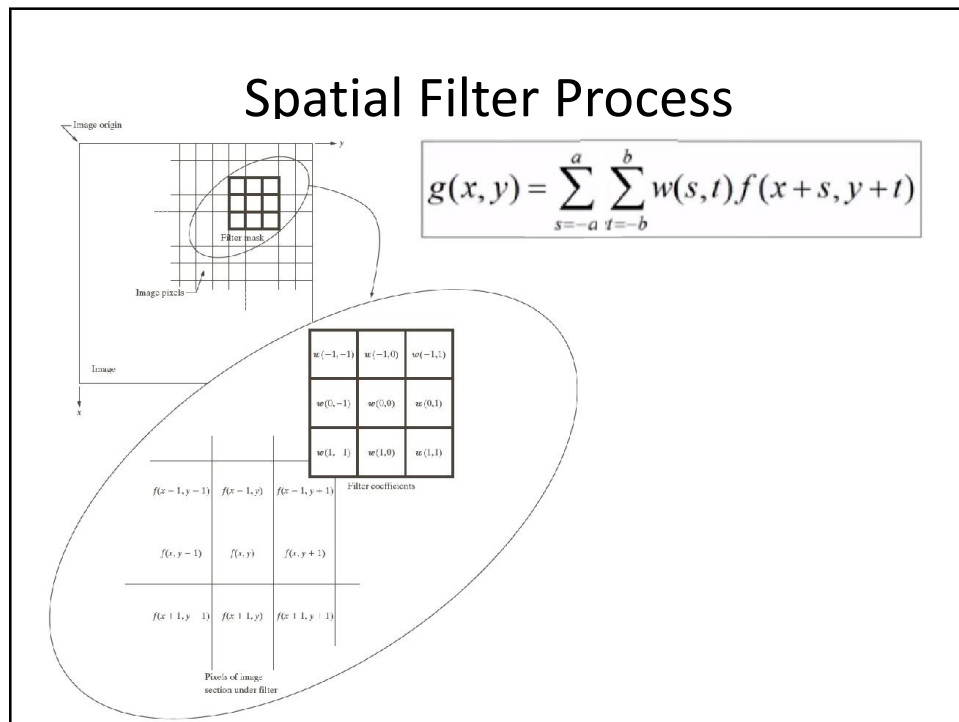


## Spatial Filter Process

Sum of Product Operations (SoP)



## Spatial Filter Process

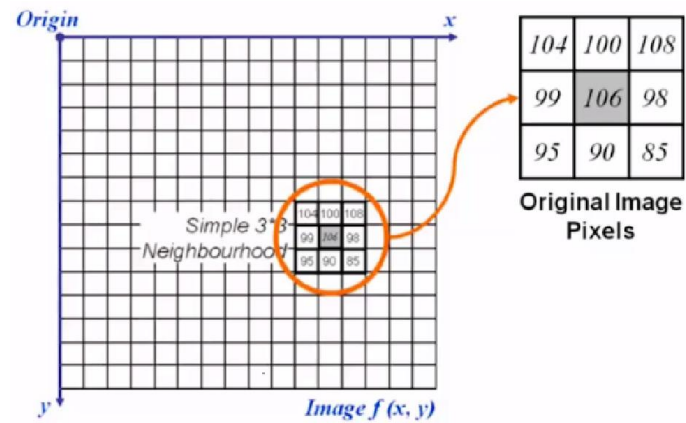


## Smoothing Spatial Filter

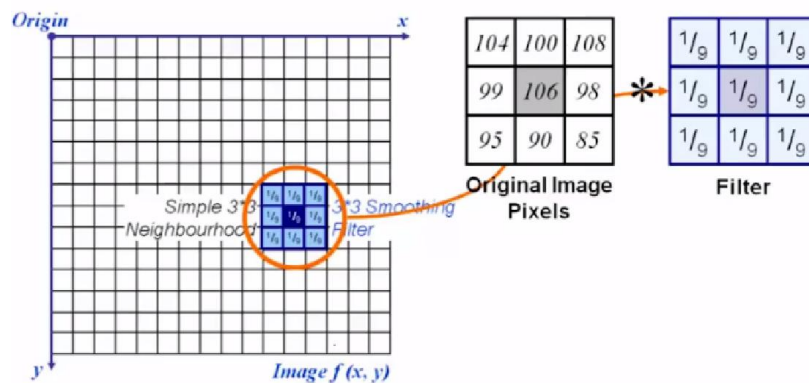
- One of the simplest spatial filtering operations which we can perform is a smoothing operation
  - Simply average all of the neighboring pixels intensities of a central pixel value
  - Useful in **removing noise from images**
  - Useful for **highlighting overall details** of image

$1/9$	$1/9$	$1/9$
$1/9$	$1/9$	$1/9$
$1/9$	$1/9$	$1/9$

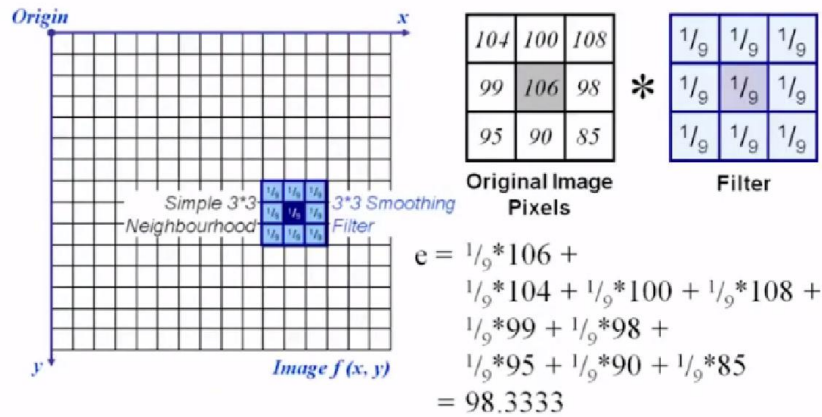
## Smoothing Spatial Filter- Example



## Smoothing Spatial Filter- Example



## Smoothing Spatial Filter- Example



## Smoothing Filtering process- Example

Image I			
	0	1	2
0	104	100	108
1	99	106	98
2	95	90	85

Number of Rows (M)	3
Number of Columns (N)	3

Average Mask	0.11	0.11	0.11
	0.11	0.11	0.11
	0.11	0.11	0.11

I(0,0)	104
I(0,1)	100
I(0,2)	108
I(1,0)	99
I(1,1)	106
I(1,2)	98
I(2,0)	95
I(2,1)	90
I(2,2)	85

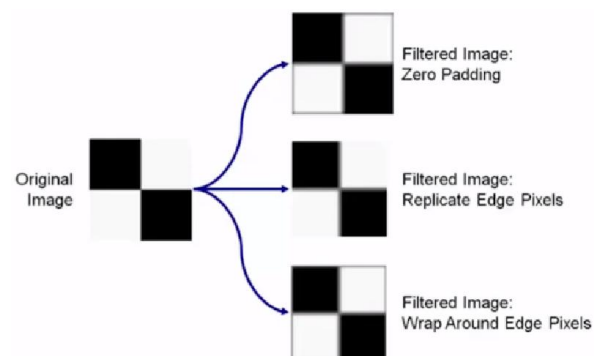
  

Window Size (W)= 3 x 3

## Smoothing Filtering process- Example Filtering at boundaries of images

- Possible solution
  - Ignore missing pixels
  - Pad the image: Zero-padding or One-Padding depending on the intensity values of the image
  - Replicate border pixels
  - Truncate the image
  - Wrap around pixels at boundary of the image

## Smoothing Filtering process- Example Filtering at boundaries of images



## Smoothing Filtering process- Example

	Image I		
	0	1	2
0	104	100	108
1	99	106	98
2	95	90	85

Number of Rows (M)	3
Number of Columns (N)	3

Average Mask	0.11	0.11	0.11
	0.11	0.11	0.11
	0.11	0.11	0.11

Window Size (W)= 3

Padded Image Size

Number of rows=  $M+W-1 = 3+3-1=5$

Number of columns=  $N+W-1 = 3+3-1=5$

	I_p(Padded Image)				
	0	1	2	3	4
0					
1					
2					
3					
4					
	5x5				

## Smoothing Filtering process- Example

	Image I		
	0	1	2
0	104	100	108
1	99	106	98
2	95	90	85

Number of Rows (M)	3
Number of Columns (N)	3

Average Mask	0.11	0.11	0.11
	0.11	0.11	0.11
	0.11	0.11	0.11

Window Size (W)= 3

Padded Image Size

Number of rows=  $M+W-1 = 3+3-1=5$

Number of columns=  $N+W-1 = 3+3-1=5$

Copy pixels values of I in I\_p in respective locations

	I_p(Padded Image)				
	0	1	2	3	4
0					
1		104	100	108	
2		99	106	98	
3		95	90	85	
4					
	5x5				

## Smoothing Filtering process- Example

	Image I		
	0	1	2
0	104	100	108
1	99	106	98
2	95	90	85

Number of Rows (M)	3
Number of Columns (N)	3

Average Mask	0.11	0.11	0.11
	0.11	0.11	0.11
	0.11	0.11	0.11

Window Size (W)= 3

Padded Image Size

Number of rows=  $M+W-1 = 3+3-1=5$

Number of columns=  $N+W-1 = 3+3-1=5$

Zero-Padding

	Image I		
	0	1	2
0	104	100	108
1	99	106	98
2	95	90	85

	I_p(Padded Image)				
	0	1	2	3	4
0	0	0	0	0	0
1	0	104	100	108	0
2	0	99	106	98	0
3	0	95	90	85	0
4	0	0	0	0	0

5x5

## Smoothing Filtering process- Example

### Apply Mask

Average Mask	0.11	0.11	0.11
	0.11	0.11	0.11
	0.11	0.11	0.11

	I_p(Padded Image)				
	0	1	2	3	4
0					
1		104	100	108	
2		99	106	98	
3		95	90	85	
4					

5x5

	Image I		
	0	1	2
0	104	100	108
1	99	106	98
2	95	90	85



## Smoothing Filtering process- Example Apply Mask

Average Mask	0.11	0.11	0.11
	0.11	0.11	0.11
	0.11	0.11	0.11

	0	1	2
0	45		
1			
2			

		0	1	2	3	4
0	0	0	0	0	0	
1	0	104	100	108	0	
2	0	99	106	98	0	
3	0	95	90	85	0	
4	0	0	0	0	0	
						5x5

## Smoothing Filtering process- Example Apply Mask

Average Mask	0.11	0.11	0.11
	0.11	0.11	0.11
	0.11	0.11	0.11

	0	1	2
0	45	68	
1			
2			

		0	1	2	3	4
0	0	0	0	0	0	
1	0	104	100	108	0	
2	0	99	106	98	0	
3	0	95	90	85	0	
4	0	0	0	0	0	
						5x5

## Smoothing Filtering process- Example Apply Mask

Average Mask	0.11	0.11	0.11
	0.11	0.11	0.11
	0.11	0.11	0.11

	0	1	2	3	4
0	0	0	0	0	0
1	0	104	100	108	0
2	0	99	106	98	0
3	0	95	90	85	0
4	0	0	0	0	0
					5x5

	0	1	2
0	45	68	46
1			
2			

## Smoothing Filtering process- Example Apply Mask

Average Mask	0.11	0.11	0.11
	0.11	0.11	0.11
	0.11	0.11	0.11

	0	1	2	3	4
0	0	0	0	0	0
1	0	104	100	108	0
2	0	99	106	98	0
3	0	95	90	85	0
4	0	0	0	0	0
					5x5

	0	1	2
0	45	68	46
1	66		
2			

## Smoothing Filtering process- Example Apply Mask

Average Mask	0.11	0.11	0.11
	0.11	0.11	0.11
	0.11	0.11	0.11

	0	1	2
0	45	68	46
1	66	98	
2			

	0	1	2	3	4
0	0	0	0	0	0
1	0	104	100	108	0
2	0	99	106	98	0
3	0	95	90	85	0
4	0	0	0	0	0
					5x5

## Smoothing Filtering process- Example Apply Mask

Average Mask	0.11	0.11	0.11
	0.11	0.11	0.11
	0.11	0.11	0.11

	0	1	2
0	45	68	46
1	66	98	65
2			

	0	1	2	3	4
0	0	0	0	0	0
1	0	104	100	108	0
2	0	99	106	98	0
3	0	95	90	85	0
4	0	0	0	0	0
					5x5

## Smoothing Filtering process- Example Apply Mask

Average Mask	0.11	0.11	0.11
	0.11	0.11	0.11
	0.11	0.11	0.11

	0	1	2
0	45	68	46
1	66	98	65
2	43		

	0	1	2	3	4
0	0	0	0	0	0
1	0	104	100	108	0
2	0	99	106	98	0
3	0	95	90	85	0
4	0	0	0	0	0

5x5

## Smoothing Filtering process- Example Apply Mask

Average Mask	0.11	0.11	0.11
	0.11	0.11	0.11
	0.11	0.11	0.11

	0	1	2
0	45	68	46
1	66	98	65
2	43	64	

	0	1	2	3	4
0	0	0	0	0	0
1	0	104	100	108	0
2	0	99	106	98	0
3	0	95	90	85	0
4	0	0	0	0	0

5x5

## Smoothing Filtering process- Example Apply Mask

Average Mask	0.11	0.11	0.11
	0.11	0.11	0.11
	0.11	0.11	0.11

	0	1	2
0	45	68	46
1	66	98	65
2	43	64	42

	0	1	2	3	4
0	0	0	0	0	0
1	0	104	100	108	0
2	0	99	106	98	0
3	0	95	90	85	0
4	0	0	0	0	0
					5x5