

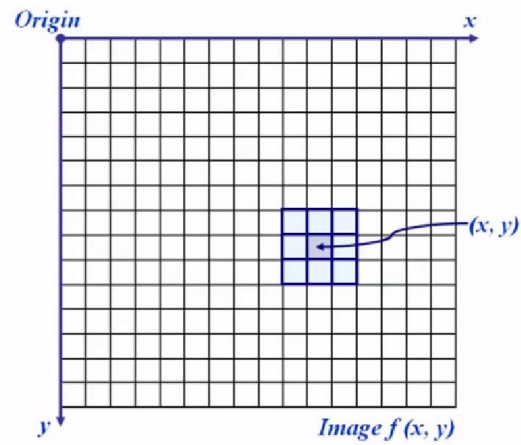


Computer Vision and Image Processing (CSEL-393)

Lecture 5

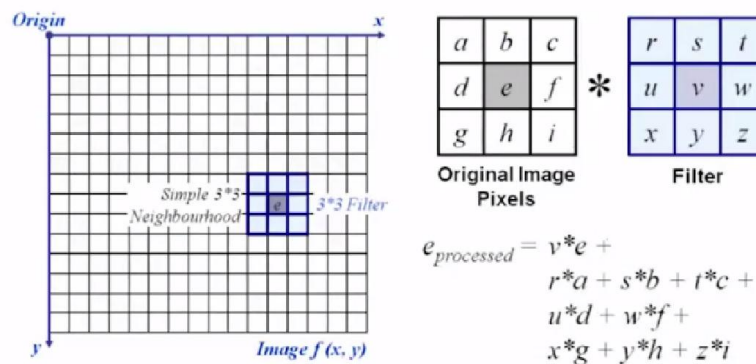
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Spatial Filter Process

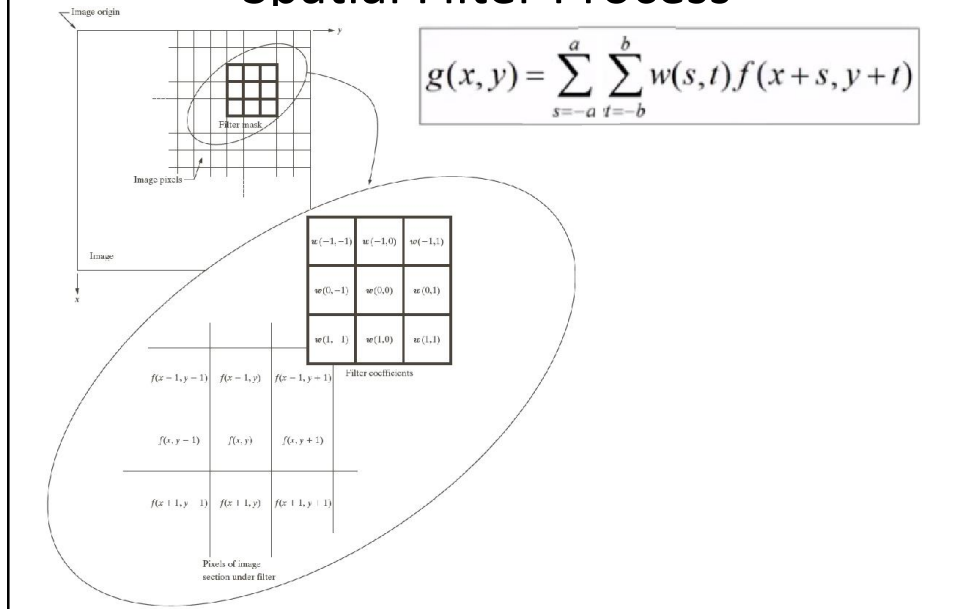


Spatial Filter Process

Sum of Product Operations (SoP)



Spatial Filter Process

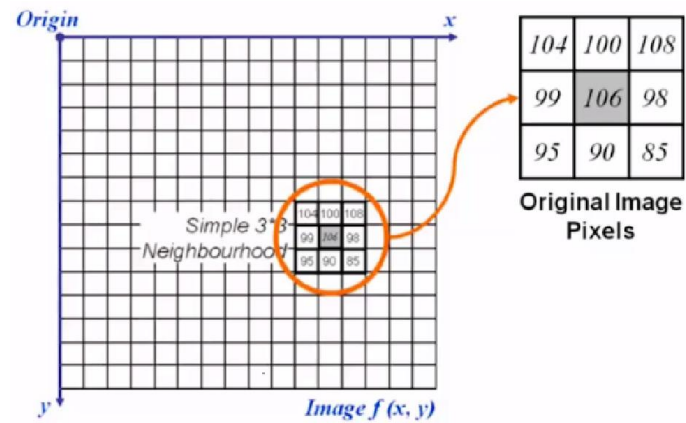


Smoothing Spatial Filter

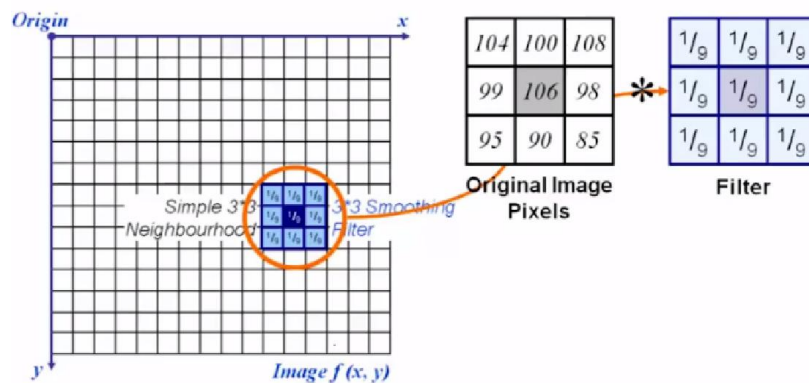
- One of the simplest spatial filtering operations which we can perform is a smoothing operation
 - Simply average all of the neighboring pixels intensities of a central pixel value
 - Useful in **removing noise from images**
 - Useful for **highlighting overall details** of image

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

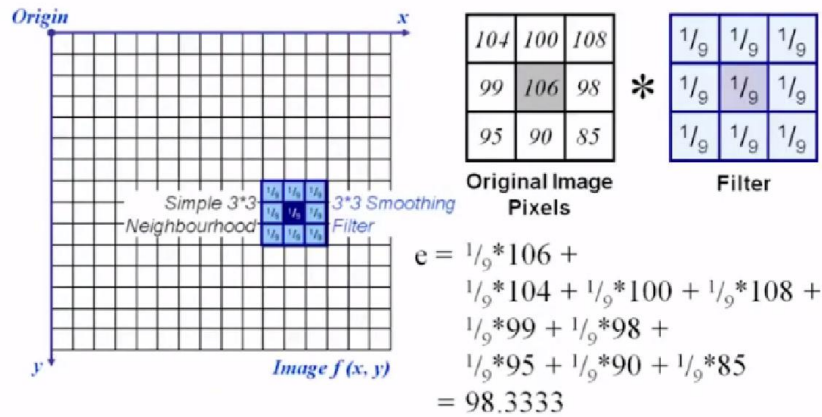
Smoothing Spatial Filter- Example



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

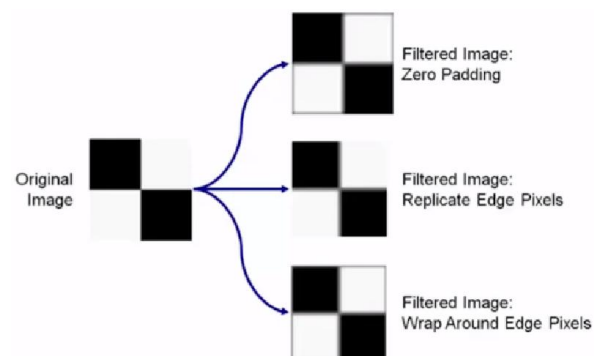
I(0,0)	104
I(0,1)	100
I(0,2)	108
I(1,0)	99
I(1,1)	106
I(1,2)	98
I(2,0)	95
I(2,1)	90
I(2,2)	85

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