Computer Vision and Image Processing (CSEL-393)

Lecture 5

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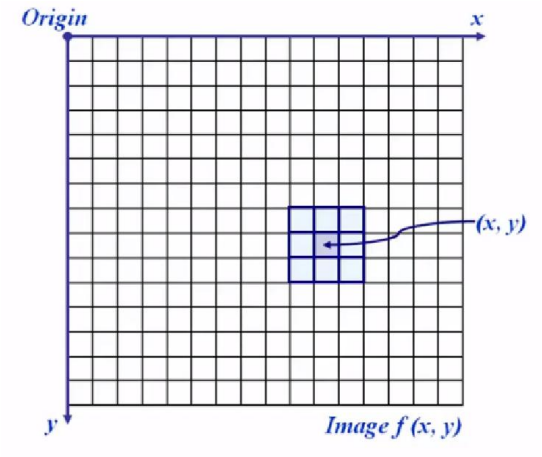
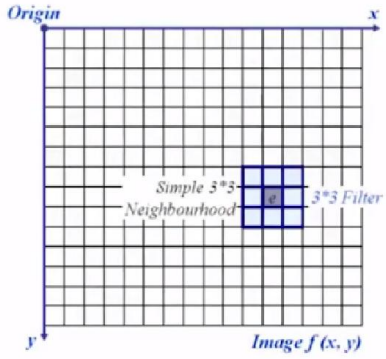
Spatial Filter Process



Spatial Filter Process

Sum of Product Operations (SoP)



a	b	c
d	e	f
g	h	i

Original Image Pixels

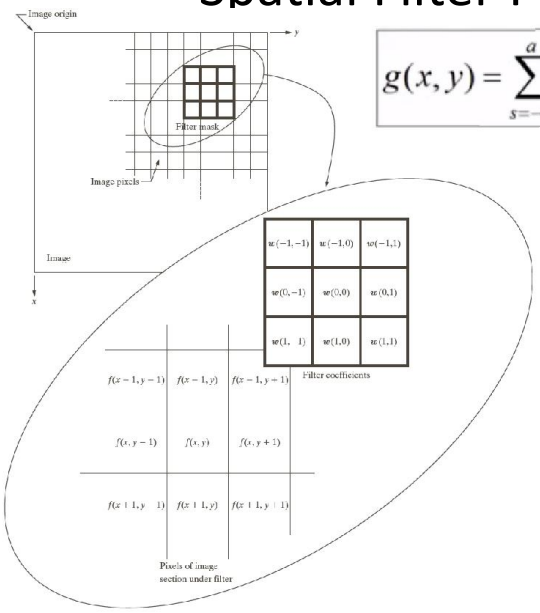
*

r	s	t
u	v	w
x	y	z

Filter

$$e_{processed} = v*e + r*a + s*b + t*c + u*d + w*f + x*g + y*h + z*i$$

Spatial Filter Process



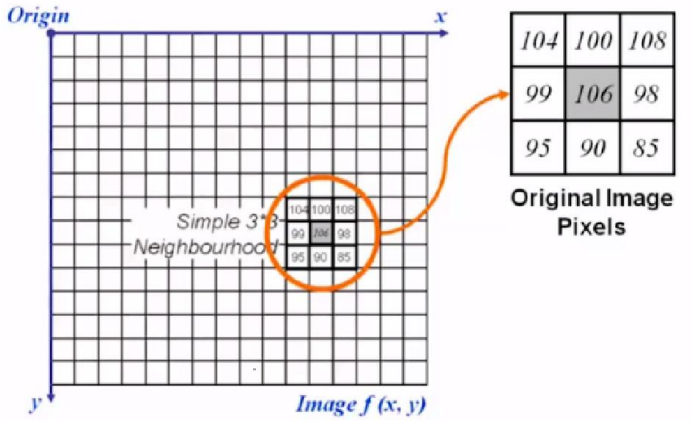
$$g(x,y) = \sum_{s=-a}^{a} \sum_{t=-b}^{b} w(s,t) f(x+s, y+t)$$

Smoothing Spatial Filter

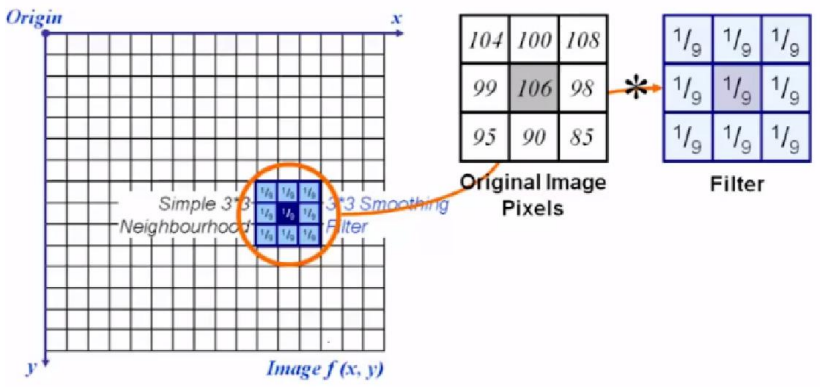
- One of the simplest spatial filtering operations which we can perform is a smoothing operation
  - Simply average all of the neighboring pixels intensities of a central pixel value
  - Useful in **removing noise from images**
  - Useful for **highlighting overall details** of image

1/9	1/9	1/9
1/9	1/9	1/9
1/9	1/9	1/9

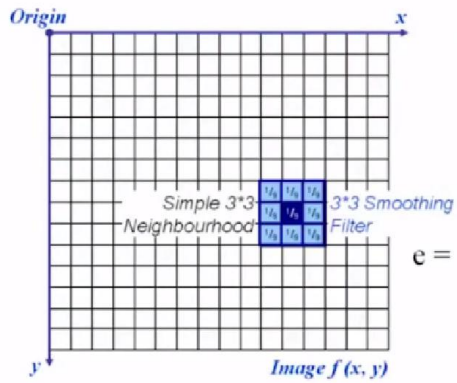
Smoothing Spatial Filter- Example



Smoothing Spatial Filter- Example



Smoothing Spatial Filter- Example



104	100	108
99	106	98
95	90	85

Original Image Pixels

$*$

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

Filter

$$e = 1/9*106 + 1/9*104 + 1/9*100 + 1/9*108 + 1/9*99 + 1/9*98 + 1/9*95 + 1/9*90 + 1/9*85$$
$$= 98.3333$$

Smoothing Filtering process- Example

Image I

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

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

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

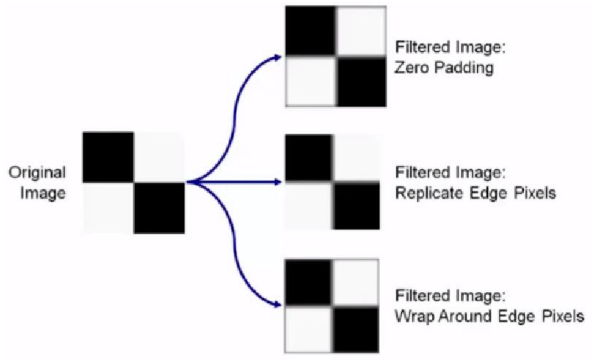
Average Mask	0.11	0.11	0.11
	0.11	0.11	0.11
	0.11	0.11	0.11

Window Size (W)= 3 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

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					
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

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					
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	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		
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	
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			
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	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	98	
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	98	65
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	98	65
2	43		

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	98	65
2	43	64	

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