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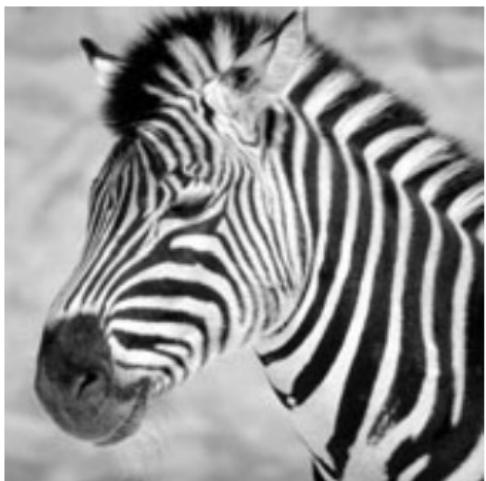
Deep Learning Applications for Computer Vision

Lecture 6: Linear Filters, Convolution



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Linear Filters and Convolution



Strategy:

- Replace pixel with weighted sum of neighboring pixel values
- Will result in a new image



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Linear Filters and Convolution



Strategy:

- Replace pixel with weighted sum of neighboring pixel values
- Will result in a new image

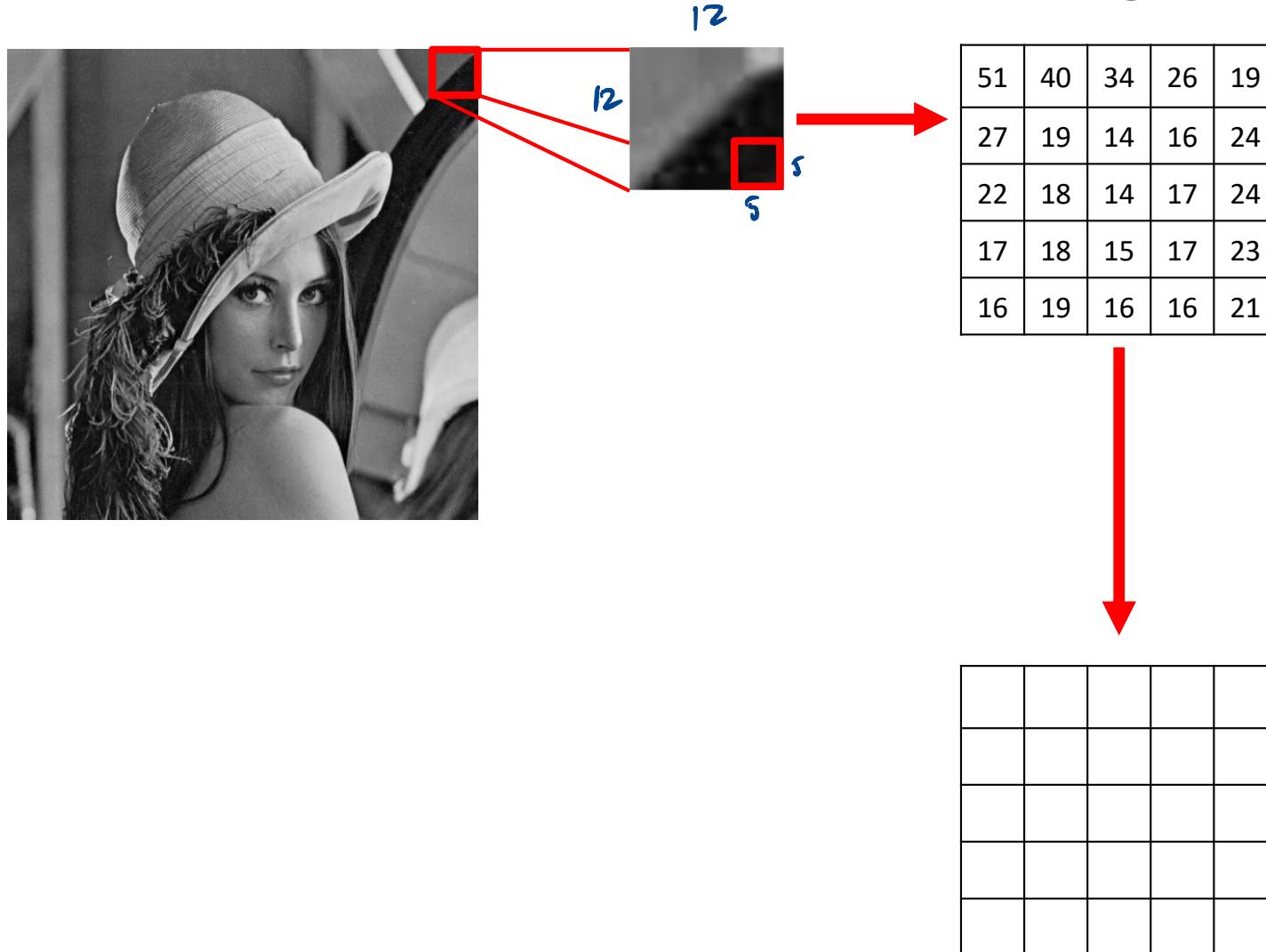
- The weights can change
- Different weights patterns will emphasize different image patterns

Examples: smoothing, differentials, the presence of lines, blobs, or other image patterns



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Linear Filtering



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Linear Filtering



1	1	1
1	1	1
1	1	1

Weighted Sum:

$$51 + 40 + 34 + 27 + 19 + 14 + \\ + 22 + 18 + 14 = 239$$

$$239/9 = 26.555 \rightarrow 27$$

51	40	34	26	19
27	19	14	16	24
22	18	14	17	24
17	18	15	17	23
16	19	16	16	21



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Linear Filtering



1	1	1
1	1	1
1	1	1

51	40	34	26	19
27	19	14	16	24
22	18	14	17	24
17	18	15	17	23
16	19	16	16	21

	27	22	..	

Weighted Sum:

$$40 + 34 + 26 + 19 + 14 + 16 + \\ + 18 + 14 + 17 = 198$$

$$198/9 = 22$$



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Linear Filtering

Properties:

- Shift Invariant

The outcome depends on the pattern (the image values), not on the location of the pattern in the image.

Same pattern (same intensity values) will give us the same filter response if it is located in the upper left corner or the lower right corner.

→

51	40	34	26	19
27	19	14	16	24
22	18	14	17	24
17	18	15	17	23
16	19	16	16	21

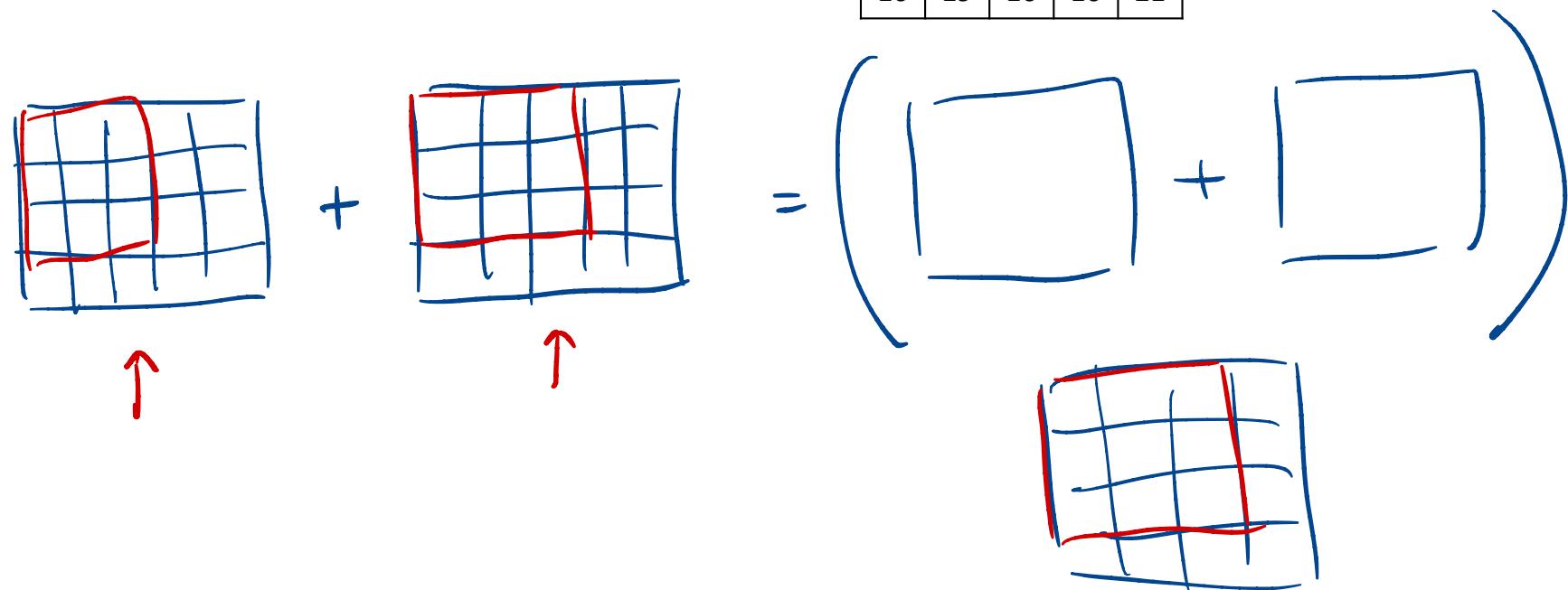


Linear Filtering

Properties:

- Shift Invariant
- Linear

51	40	34	26	19
27	19	14	16	24
22	18	14	17	24
17	18	15	17	23
16	19	16	16	21



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Convolution

Notations:

- Kernel H
- Original Image F
- New Image R



1	1	1
1	1	1
1	1	1

- Convolution

51	40	34	26	19
27	19	14	16	24
22	18	14	17	24
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16	19	16	16	21

H has been convolved with F
to yield R

$$R_{ij} = \sum_{u,v} \text{weights}_{i-u,j-v} F_{u,v}^{\text{original image}}$$



Size of Output

0	0	0	0	0	0
0	51	40	34	26	19
0	27	19	14	16	24
22	18	14	17	24	
17	18	15	17	23	
16	19	16	16	21	
16	19	16	16	21	
17	18	15	17	23	

Observations:

- Can we apply the filter at all locations in the image?
- Will the resulting image will be of the same size as the original image?

Options:

- Ignoring – but smaller image
- Padding – introducing extra data?
 - with zeros
 - mirror values

New Img
= same size as Original Image

