
University of Colorado
Boulder

Deep Learning Applications for Computer Vision

Lecture 6: Linear Filters, Convolution

Linear Filters and Convolution

Strategy:

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

Linear Filters and Convolution

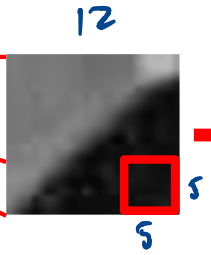
Strategy:

- 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

Linear Filtering

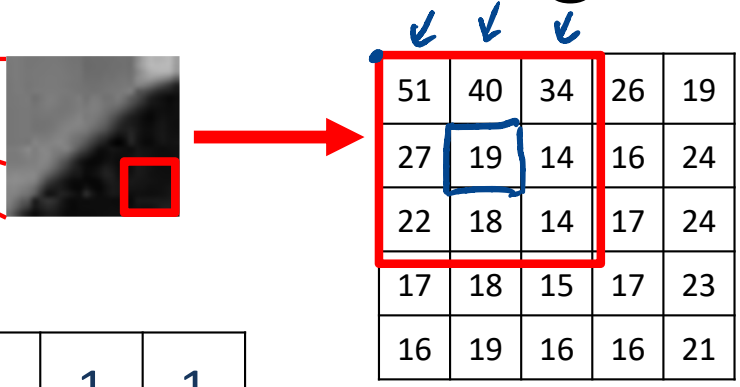


51	40	34	26	19
27	19	14	16	24
22	18	14	17	24
17	18	15	17	23
16	19	16	16	21

Original Image

New Image

Linear Filtering

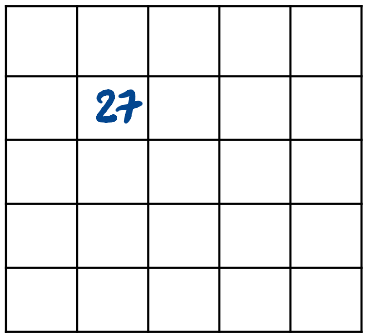


1	1	1
1	1	1
1	1	1

Weighted Sum:

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

239/9 = 26.555 -> 27



Linear Filtering

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

1	1	1
1	1	1
1	1	1

Weighted Sum:

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

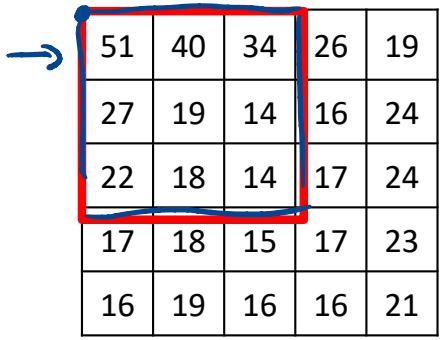
198/9 = 22

	27	22	..	

Linear Filtering

Properties:

- Shift Invariant



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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.

Linear Filtering

Properties:

- Shift Invariant
- Linear

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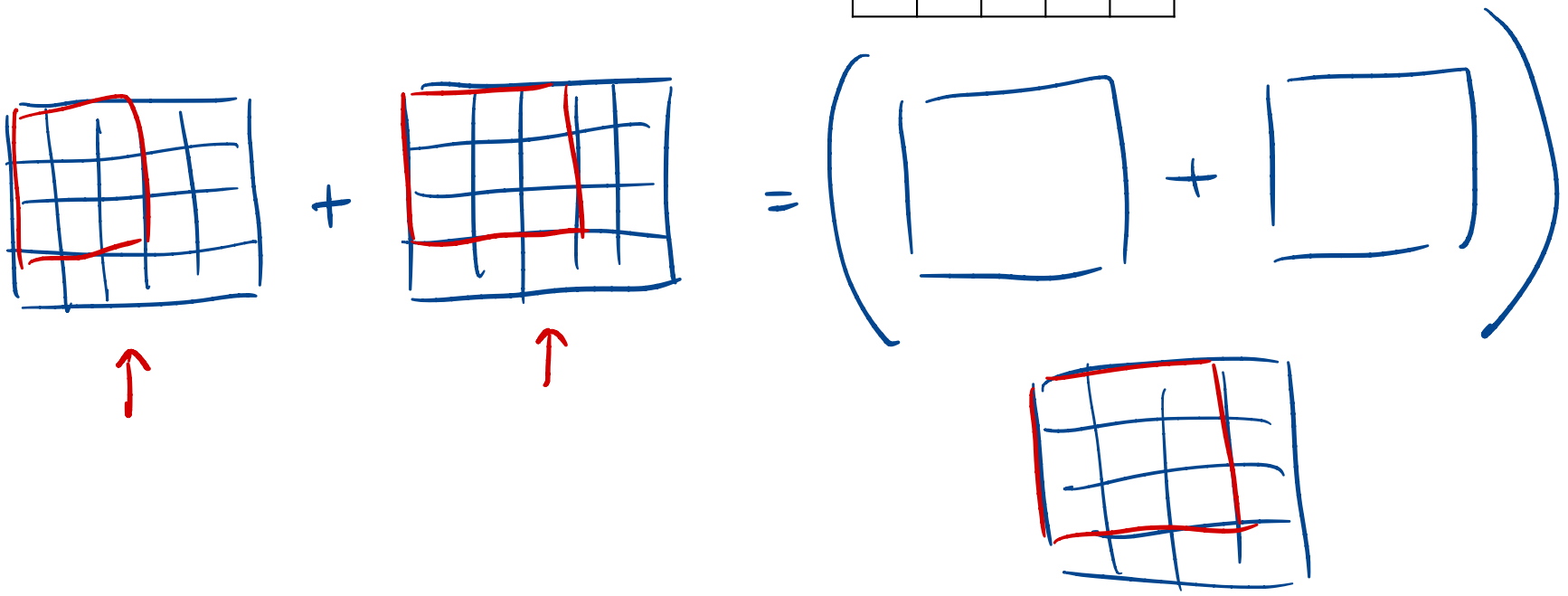

Convolution

Notations:

- Kernel *H*
- Original Image *F*
- New Image *R*

1	1	1
1	1	1
1	1	1

- Convolution

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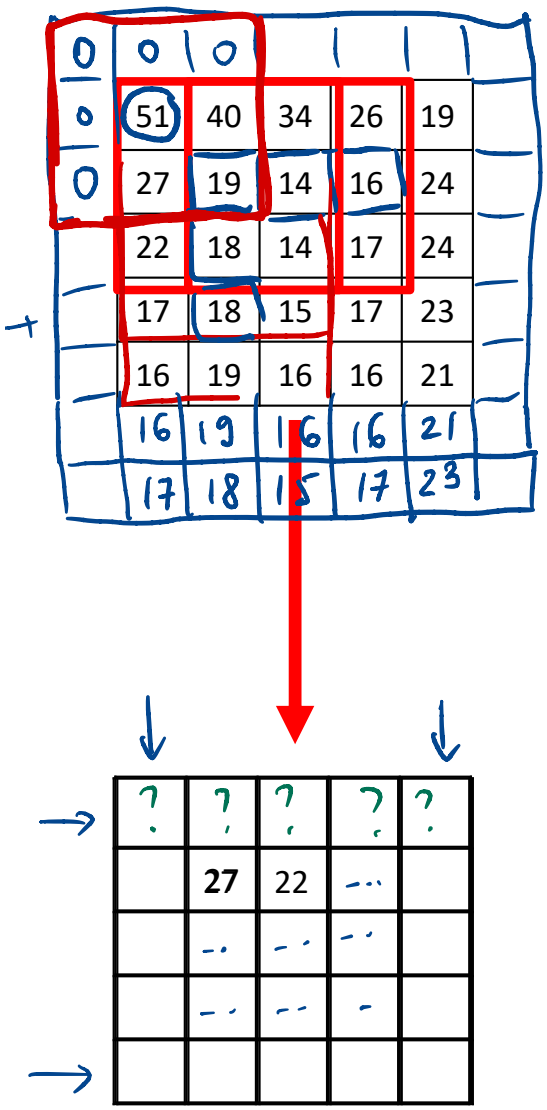
$$R_{ij} = \sum_{u,v} H_{i-u,j-v} F_{u,v}$$

weights — original image

H has been convolved with *F* to yield *R*

Size of Output



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