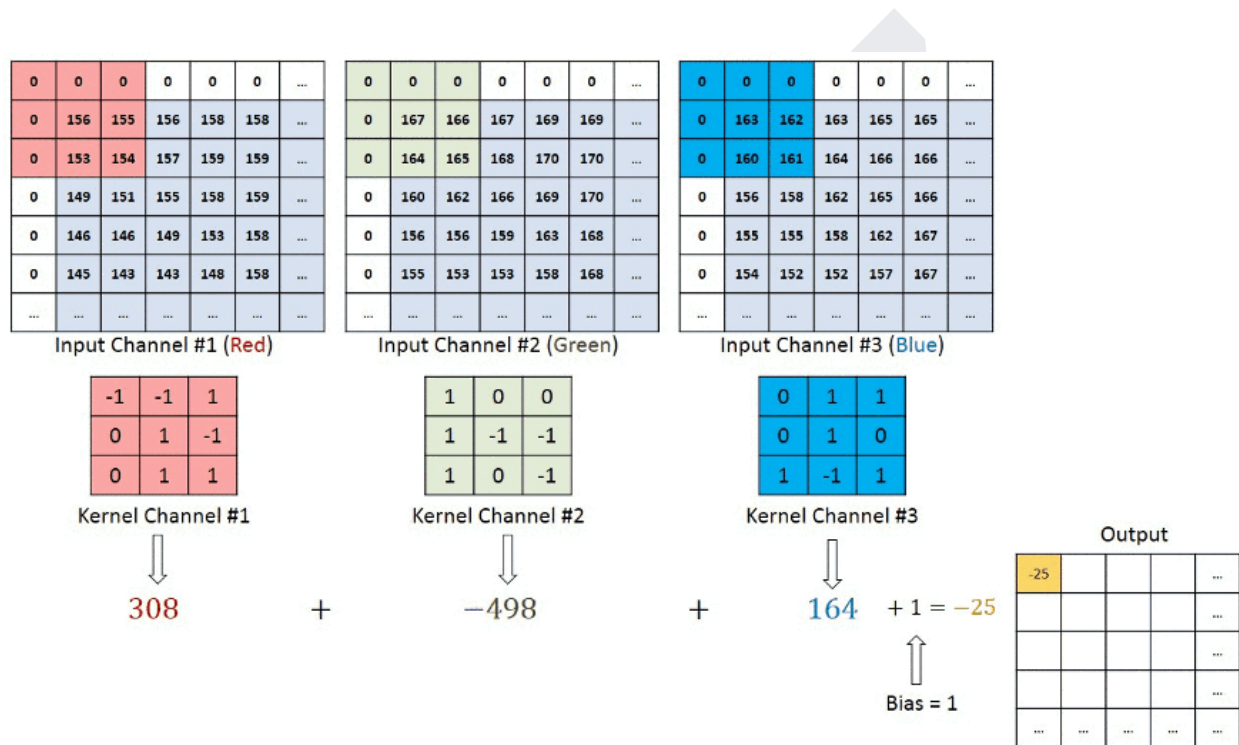


Image Processing for Computer Vision

Session 9

Low Pass Filter



Pylessons

Topics

- Low Pass filters
- Image Blurring

Types of Filters

Filters can generally be categorized into two main types based on their effect on image frequency components:

a) Low-pass Filters (Smoothing Filters)

- suppress high-frequency components (rapid changes like edges or noise)
- pass the low-frequency components of the image (i.e., slow changes in pixel values)
- blur the image, reducing noise and detail

Purpose: Noise reduction, smoothing, and blurring

Example: Box Filter (Mean Filter), Gaussian Filter, Median Filter, Bilateral Filter

b) High-pass Filters

- emphasize edges and fine details
- suppress the low-frequency components of an image
- preserve or enhance high-frequency components like edges, texture, or noise.

Purpose: Edge detection, enhancing fine details, sharpening.

Example: Sobel Filter, Laplacian Filter

Common Low-pass Filters:

1. Box Filter (Mean Filter): A simple average filter where each pixel is replaced by the mean of its neighbors. It removes noise but also blurs important details like edges.

Formula for 3x3 mean filter:

$$\frac{1}{9} * \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

2. Gaussian Filter: A more sophisticated blur that uses a Gaussian function to weight neighboring pixels. Closer pixels have higher weights, and farther pixels contribute less to the output, resulting in a natural blur. Gaussian blur is often used in pre-processing to remove noise while preserving edges better than a box filter.

1/16

1	2	1
2	4	2
1	2	1

1/273

1	4	7	4	1
4	16	26	16	4
7	26	41	26	7
4	16	26	16	4
1	4	7	4	1

1/1003

0	0	1	2	1	0	0
0	3	13	22	13	3	0
1	13	59	97	59	13	1
2	22	97	159	97	22	2
1	13	59	97	59	13	1
0	3	13	22	13	3	0
0	0	1	2	1	0	0

collected

3. Median Filter: This filter takes the median of all the pixels under the kernel area and the central element is replaced with this median value.

- Central element is not newly calculated
- the central element is always replaced by some pixel value from the neighborhood
- Highly effective against salt-and-pepper noise in an image

4. Bilateral Filter: This filter smooths images while preserving edges by considering both the spatial distance between pixels and the intensity difference.

- It is especially useful in edge-aware smoothing.
- The **bilateral filter** preserves edges while smoothing areas where intensity values are similar.
- The **kernel** is computed dynamically for each pixel, so there is no fixed kernel matrix to extract like in linear filters.

Filtering documentation: https://docs.opencv.org/4.x/d4/d13/tutorial_py_filtering.html

Syntax:

[*cv.bilateralFilter*](#)(*inp_img*, *d*, *sigmaColor*, *sigmaSpace*)

d: Diameter of each pixel neighborhood that is used during filtering. If it is non-positive, it is computed from *sigmaSpace*.

sigmaColor: applies filter based on the intensity difference or color difference. A larger value of the parameter means that farther colors within the pixel neighborhood.

sigmaSpaceFilter: applies filter based on pixel to pixel distance spatial distance. *sigma* in the coordinate space. A larger value of the parameter means that farther pixels will influence each other as long as their colors are close enough. When *d*>0, it specifies the neighborhood size regardless of *sigmaSpace*. Otherwise, *d* is proportional to *sigmaSpace*.

Filter size: Large filters ($d > 5$) are very slow, so it is recommended to use $d=5$ for real-time applications, and perhaps $d=9$ for offline applications that need heavy noise filtering.

5x5 Neighborhood:

```
[[180 176 4 171 52]
 [ 42 164 197 153 47]
 [170 13 20 6 17]
 [206 101 39 86 93]
 [205 55 75 81 27]]
```

Corresponding 5x5 Bilateral Kernel:

```
[[0.03913798 0.0410542 0.03910668 0.04045917 0.03901293]
 [0.04037025 0.03912232 0.04088214 0.03936563 0.04084944]
 [0.04034604 0.03921633 0.0390754 0.04053206 0.0394129 ]
 [0.03979309 0.04032184 0.03972152 0.03997656 0.03981697]
 [0.04014481 0.04098037 0.04089031 0.04039448 0.04001655]]
```

After applying the kernel

```
[[7.04483552 7.22553979 0.15642671 6.91851744 2.02867256]
 [1.69555067 6.41606098 8.05378104 6.02294215 1.9199239 ]
 [6.85882665 0.50981228 0.78150809 0.24319235 0.67001934]
 [8.19737611 4.07250571 1.54913947 3.43798397 3.70297829]
 [8.22968654 2.25392047 3.06677359 3.27195316 1.08044697]]
```