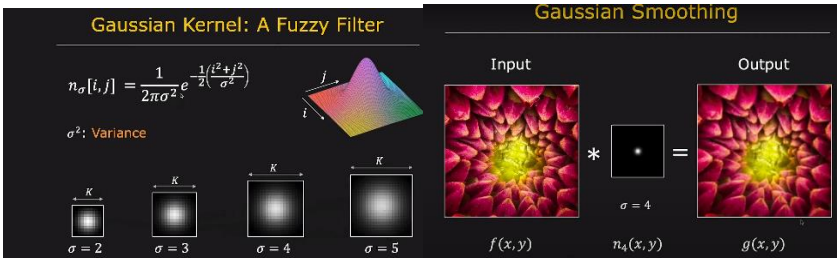
1. How do different types of filters (e.g., Gaussian, Sobel, Laplacian) impact image processing in computer vision, and what are their specific applications?

   ANS: image processing is the process of transforming a digital image to a clear or easier to analyse image. We use different type of filter in image processing for different purpose. Filter or kernel or mask is a matrix which will perform some mathematical operation on the image to get the desired output like remove noise, smoothing etc.
   Here are some filters:

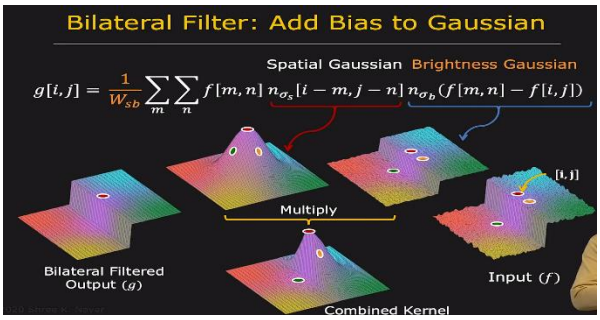
   - **Gaussian filter**: It is a filter which is used in image processing for smoothing the image and reducing the noise. Gaussian filters are very good at removing random, subtle image noise patterns. The smoothing of edges causes the blurring of the image, when we increase the value of "σ" I.e. standard deviation the smoothing of edges increases while blurring also increase which cause the loss of useful information.
     The gaussian filter mathematics and demonstration is as below:



     Reference of images: Linear Image Filters | Image Processing I (youtube.com)

   Application: The gaussian filter is a important filter in preprocessing used for reducing noise in the image and used for smoothing the image.

   - **Bilateral filter**: The bilateral filter is used in image processing is a non-linear filter to remove the noise while preserving the edges of the images. Unlike the normal gaussian filter it use two gaussian filter- "spatial gaussian and brightness gaussian". The pixel that are not of similar intensity with the middle pixel lower weight and thus it helps to maintain the edges and remove the noise better.
     The mathematics of bilateral filter is as follows:



     Reference: Non-Linear Image Filters | Image Processing I (youtube.com)

Application: The bilateral filter is used for reducing the noise while preserving the details and features of the images. In case of gaussian it fails to preserve the details as we increase the size.

- **Mean filtering**: mean filtering involves the replacement of each pixel's value with the average value of its neighbouring pixel. In case of mean filtering, it is used for the smoothing and noise removal while preserving its essential features. It is a non-linear filter. When we increase the size of the kernel the noise removal and smoothing degree increase but essential feature and details lost.

  Application: It is used in case of removing the noise while preserving the details of the image.

- **Sobal filter:** Its is use to detect edges within images, which is further used in various edge detection algorithms. Sobel filter is a compact integer based filter which is applied both in horizontal and vertical direction of an image. The sobel filter calculates the gradient descent at each point of the image and apply two convolution horizontall and vertical. Horizontal convolution help to detect vertical edges and vertical convolution helps to identify horizontal edges.

Sobel Filter apllied to an image.

Application: The main application of the sobal filter is used for the edge detection in a image.

- **Laplacian filter**: Laplacian filter is one of the filter which is used for edge detection. They highlight regions of rapid intensity change and can enhance edges. It is better in case where precise location of edges are required. Sobel filters are single derivative filters, that means that they can only find edges in a single dimension. But with Laplacian filter, we can get edges in both dimensions, thus we take double derivative of the intensity. Laplacian filter is a very sensitive to the noise so first we use gaussian to smooth and remove noise in the picture and then we try to use the Laplacian filter.

  Application: It is used in the scenario where precise location of edges are important. It detect based on zero-crossing.

Original

Laplacian