T-1. Explain sigma color and sigma space from the cv2.bilateralFilter()

Definition:
Bilateral Filtering is a type of filtering technique that uses a kernel based on color intensity and spatial information of an image. A bilateral filter is used for smoothening images and reducing noise, while preserving edges. The function has several parameters, including sigmaColor and sigmaSpace, which are important for controlling the behavior of the filter. Let's understand the role of sigma color and sigma space in Bilateral Filtering....

Sigma Color:

Sigma Color Controls the filter's sensitivity to color differences in neighboring pixels. It also determines how much the color difference between the center pixel and its neighbors will influence the filtering process. A larger value results in greater mixing of pixels with more color variation, while a smaller value keeps the filter more sensitive to color differences. It is useful to reduce color noise in an image or to prevent over-smoothing of the image if edges are important. So we can say that Sigma Color is responsible for controlling how much color differences matter

Sigma Space:

Sigma Space Controls the filter's sensitivity to spatial differences between the pixel's distances. In other words, it controls how much the distance between the center pixel and its neighbors matters when smoothing. Hence, A high Sigma Space is useful when we want the filter to consider a larger neighborhood in the spatial distance, Wheres. a low Sigma Space is good for maintaining local details and structure while still smoothing out small-scale noise. Sigma Space determines how much spatial distance matters which eventually helps to balance the smoothing process and preserve edges and fine details.

2. How bilateral filtering calculates the target pixel value

A bilateral filter calculates the value of a target pixel by taking a weighted average of its neighboring pixels. The weights are determined by both the spatial distance between the pixels (how close they are geographically) and the intensity difference between the pixels (how similar their color values are). Thus, the filter essentially preserves edges while smoothing out noise by giving more weight to similar nearby pixels.

Lets understands how bilateral Filter calculates the target pixel Values..

The filter uses two kernels, one for spatial distance and one for intensity difference, which are combined to create the final weight for each neighboring pixel. For each target pixel, the filter iterates through its neighborhood, calculating a weight for each neighboring pixel based on its spatial distance and intensity difference, then uses these weights to compute a weighted average of the neighboring pixel values, which becomes the new value for the target pixel. The intensity-based weighting ensures that pixels with large intensity differences are given less weight, allowing the filter to smooth regions of similar intensity while preserving sharp edges.