Image Filters (Week 4)

Laplacian of Gaussian Filter

- Laplacian of Gaussian Filter first smoothes the image before proceeding to Laplacian filtering process. This two-step process is known as Laplacian of Gaussian (LoG) operation.

- We know, a two-dimensional Gaussian kernel can be defined as:

$$g(x,y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}}$$

- To estimate the expression of Laplacian of Gaussian Filter, we have to evaluate partial first and second derivative of $g(x,y)$, i.e.

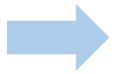
$$LoG(x,y) = \nabla^2 g(x,y) = \frac{\partial^2 g(x,y)}{\partial x^2} + \frac{\partial^2 g(x,y)}{\partial y^2}$$

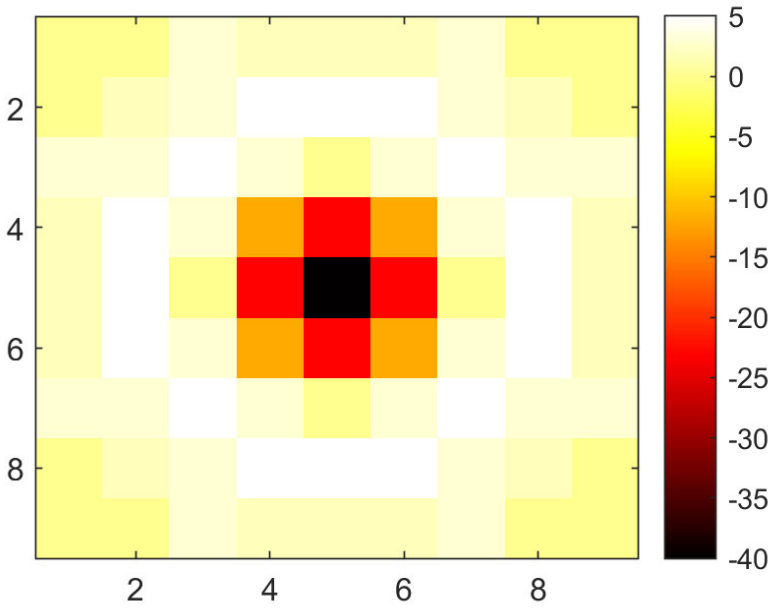
Estimate $\frac{\partial^2 g(x,y)}{\partial x^2}, \frac{\partial^2 g(x,y)}{\partial y^2}$

Laplacian of Gaussian Filter

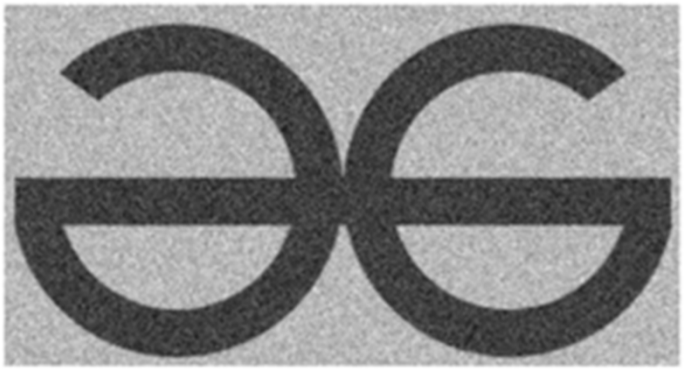
- For discrete kernel using $\sigma = 1.4$, LoG 9×9 filter is given by:

0	0	3	2	2	2	3	0	0
0	2	3	5	5	5	3	2	0
3	3	5	3	0	3	5	3	3
2	5	3	-12	-23	-12	3	5	2
2	5	0	-23	-40	-23	0	5	2
2	5	3	-12	-23	-12	3	5	2
3	3	5	3	0	3	5	3	3
0	2	3	5	5	5	3	2	0
0	0	3	2	2	2	3	0	0

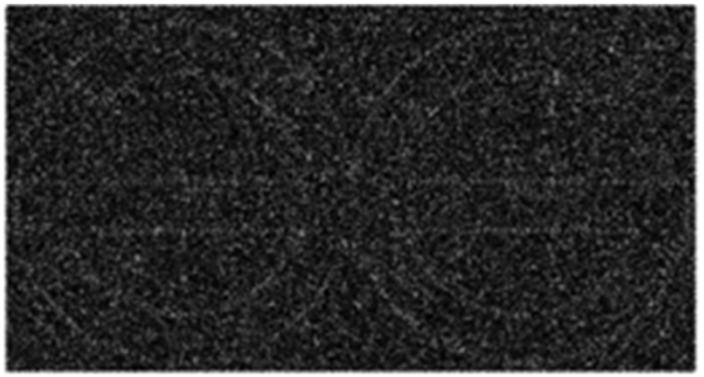




Laplacian of Gaussian Filter: Application



Image



Laplacian Filter

LoG Filter

Image Padding

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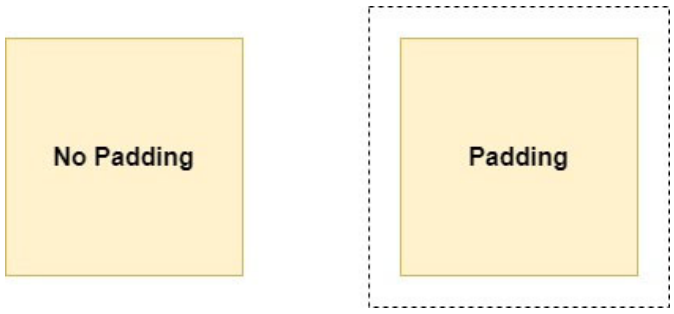
Image Padding

- Image padding is a process of putting the numerical values across the edges of the image, examples include, zeros, mirrored reflection of edge array, etc.
  - Valid padding (or no padding)
  - Zero padding
  - Constant padding
  - Reflection padding
  - Replication padding



Binary Thresholding of Images

Drone Remote Sensing and Thresholding

- Drone remote sensing is the acquisition of information about an object or phenomenon without making physical contact with the object.
- One of the limitations while working with a consumer-grade drone is the amount of noise one can encounter in data.
- Due to the small size of the drone's sensor, the captured image looks noisy with non-linear illumination.
- Is it necessary to apply filters to whole image?

Image Histogram Binary Thresholding

- In digital image processing, thresholding is the simplest method of segmenting images.
  - For a grayscale image, thresholding can be used to create binary images.
- The simplest thresholding methods replace each pixel in an image with a black/white pixels depending upon pixel intensity.
- Challenges in image thresholding which leads to imperfect binary image with false positive and false negative regions. Some challenges are as follows:
  - High level of noise,
  - Lower variance between background and foreground groups,
  - Non-homogeneous lighting, etc.

Binary Thresholding: Restoration of Biometric Data

- Fingerprint biometrics is used to both authenticate (match a person's biometric template) and identify (determine the identification of a person).
- Retaining fingerprints from surfaces require pre-processing before authentication.
- Input image is noisy as well as blurry.

Within-/Intra-Class Variance Based Thresholding

- In the simplest form, the algorithm tells you a possible intensity threshold that separate matrix into two classes, foreground and background.

- This threshold is determined by finding a minimal or maximal within-class variance (which we will find out).

- In computer vision and image processing, within-class variance is used to perform image thresholding.

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Within-Class Variance

- Consider histogram having L bins. Then, within-class variance is defined as:

$$\sigma_W^2 = \omega_b \sigma_b^2 + \omega_f \sigma_f^2$$

where, σ^2s are respective variances, ω_b and ω_f are the probabilities of two classes separated via threshold t.

$$\omega_b = \sum_{i=0}^{t-1} p(i)$$

$$\omega_f = \sum_{i=t}^{L-1} p(i)$$