AI61201: Visual Computing with AI/ML

Programming Assignment 3: Image Transformations in the Spatial Domain (20 Marks)

Due Date: *September 4 (by 9 PM IST)*

Instructions: *Complete the four questions given, keeping the following points in mind:*

- Implement the filtering operations from scratch (Without using OpenCV)
- Show the step-by-step output of all questions in the Jupyter Notebook .ipynb file.

Question 1: Detecting Diagonal Edges (3 Marks).
Show how you can detect diagonal edges by designing a simple Prewitt filter for detecting 45° edges in a given image (Assignment_2_Image_1.png).

Question 2: Edge Detection (5 Marks)

Detect the intensity transitions (edges) of an image (Assignment_2_Image_2.png) below by using a 5 x 5 Laplacian kernel whose central coefficient is 24 and all other coefficients are -1. Implement the filtering from scratch.

Also, sharpen using the Laplacian of the Gaussian (LoG) kernel below (implementation from scratch). Do you see any difference in the results you obtained? If yes, explain the difference.

$$\begin{bmatrix} 0 & 0 & -1 & 0 & 0 \\ 0 & -1 & -2 & -1 & 0 \\ -1 & -2 & 16 & -2 & -1 \\ 0 & -1 & -2 & -1 & 0 \\ 0 & 0 & -1 & 0 & 0 \end{bmatrix}$$

Question 3: Sharpening Using Smoothing (5 Marks)

Show how you can use Gaussian smoothing to sharpen an image using a Gaussian filter. Given: Gaussian kernel size 3x3 and standard deviation=1, The equation for Gaussian kernel is provided below:

$$G(x, y) = \frac{1}{2\pi\sigma^2} \exp\left(-\frac{x^2 + y^2}{2\sigma^2}\right)$$

Question 4: Gabor Filtering (7 Marks)

Implement Gabor filters at different scales, orientations, and frequencies (from scratch) and use them to detect edges on image (Assignment_2_Image_1.png). For this problem, you can simply use the real part of the complex Gabor filters. Use the following specifications to construct the Gabor filter kernels:

- Kernel size: 31 × 31
- Standard deviation (σ): 1.0 and 3.0
- Aspect ratio (γ): 0.5
- Orientation (θ): 0°, 45°, 90°, 135° (for each value of θ, use $u = f_0 \cos\theta$ and $v = f_0 \sin\theta$, with $f_0 = 0.1$).
- Phase offset (ϕ) = 0

For each of the two values of σ, show the Gabor filter kernels (as images) as well as the filtered outputs by taking the maximum of Gabor filtered outputs at each pixel over all four orientations. Compare your implementation against OpenCV's implementation of Gabor kernels with the same parameters.

Link to download the required input images for the assignment

https://drive.google.com/drive/folders/1nHBJgpmfyDjVuFFvV0kkMdVK--Oj98fe?usp=sharing

Submission Guidelines

1. *The content that you submit must be your individual work.*
2. *Submit your code in .py and .ipynb file format. Both these file submissions are required to receive credit for this assignment.*
3. *Ensure your code is well-commented and easy to follow. You can write your answers and explanations using text cells in the Jupyter Notebook files wherever required.*
4. *The files should be named as "<roll_number>_assignment_2". For example, if your roll number is 23AI91R01, the code the required file names will be 23AI91R01_assignment_2.py, and 23AI91R01_assignment_2.ipynb. You should place all these files within a single zip file and upload it to Moodle as 23AI91R01_assignment_2.zip.*

5. *All submissions must be made through Moodle before the deadline. The submission portal will close at the specified time, and submissions via email will not be accepted.*

TA for this assignment: Km Poonam

If you have any queries regarding Assignment 2, please email at poonamk@iitkgp.ac.in

---