# CS474/674 Image Processing and Interpretation
## Fall 2024 – Dr. George Bebis
## Programming Assignment 2
## Due Date: 10/21/2024 @ 11:59pm

### 1. [25%] Correlation

Write a program to perform spatial filtering (i.e., correlation) of an image. Both the size of the mask and its values (i.e., weights) need to be variables that can be input into your program. Test your program by computing the correlation between the two images below (can be downloaded from the course's webpage). Use the left image to define the weights of the mask. Show and discuss your results (i.e., visualize the results of correlation as an image, e.g., scale the values in [0, 255] and store them in PGM format). How could you use the results of correlation to find the location(s) of the pattern shown (i.e., left image) in the right image? Explain.
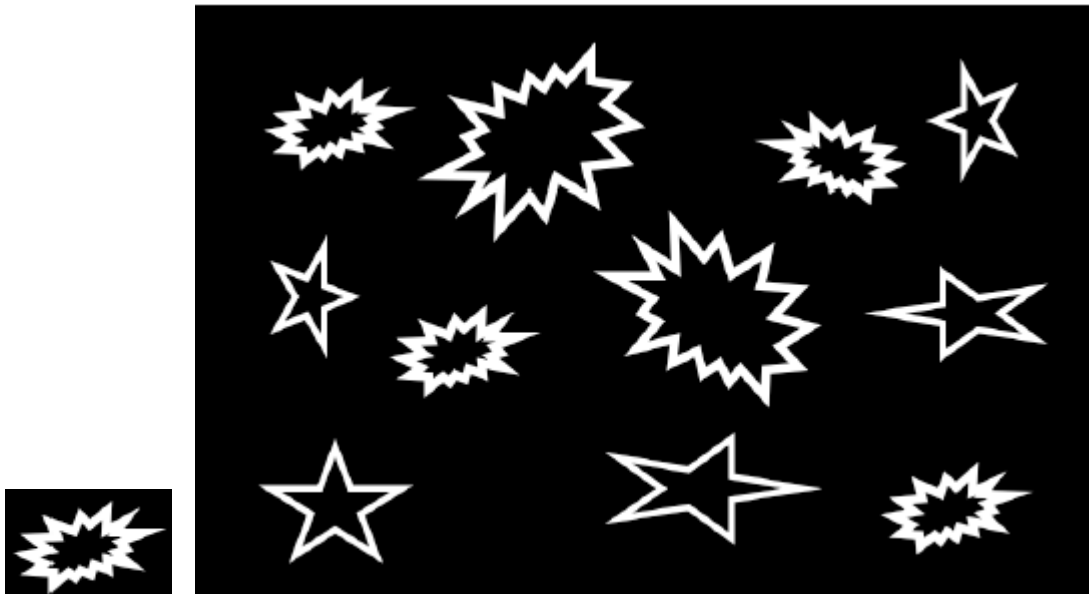


### 2. [25%] Averaging and Gaussian Smoothing

Smooth the "lenna" and "sf" images using (1) 7x7 and 15x15 averaging filters and (2) 7x7 and 15x15 Gaussian filters (using the masks provided below). You should normalize the mask weights, so they sum to one. Show and discuss your results both for averaging and Gaussian smoothing.

**15 × 15 Gaussian mask**

| 2 | 2 | 3 | 4 | 5 | 5 | 6 | 6 | 6 | 5 | 5 | 4 | 3 | 2 | 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 3 | 4 | 5 | 7 | 7 | 8 | 8 | 8 | 7 | 7 | 5 | 4 | 3 | 2 |
| 3 | 4 | 6 | 7 | 9 | 10 | 10 | 11 | 10 | 10 | 9 | 7 | 6 | 4 | 3 |
| 4 | 5 | 7 | 9 | 10 | 12 | 13 | 13 | 13 | 12 | 10 | 9 | 7 | 5 | 4 |
| 5 | 7 | 9 | 11 | 13 | 14 | 15 | 16 | 15 | 14 | 13 | 11 | 9 | 7 | 5 |
| 5 | 7 | 10 | 12 | 14 | 16 | 17 | 18 | 17 | 16 | 14 | 12 | 10 | 7 | 5 |
| 6 | 8 | 10 | 13 | 15 | 17 | 19 | 19 | 19 | 17 | 15 | 13 | 10 | 8 | 6 |
| 6 | 8 | 11 | 13 | 16 | 18 | 19 | 20 | 19 | 18 | 16 | 13 | 11 | 8 | 6 |
| 6 | 8 | 10 | 13 | 15 | 17 | 19 | 19 | 19 | 17 | 15 | 13 | 10 | 8 | 6 |
| 5 | 7 | 10 | 12 | 14 | 16 | 17 | 18 | 17 | 16 | 14 | 12 | 10 | 7 | 5 |
| 5 | 7 | 9 | 11 | 13 | 14 | 15 | 16 | 15 | 14 | 13 | 11 | 9 | 7 | 5 |
| 4 | 5 | 7 | 9 | 10 | 12 | 13 | 13 | 13 | 12 | 10 | 9 | 7 | 5 | 4 |
| 3 | 4 | 6 | 7 | 9 | 10 | 10 | 11 | 10 | 10 | 9 | 7 | 6 | 4 | 3 |
| 2 | 3 | 4 | 5 | 7 | 7 | 8 | 8 | 8 | 7 | 7 | 5 | 4 | 3 | 2 |
| 2 | 2 | 3 | 4 | 5 | 5 | 6 | 6 | 6 | 5 | 5 | 4 | 3 | 2 | 2 |

**7 × 7 Gaussian mask**

| 1 | 1 | 2 | 2 | 2 | 1 | 1 |
|---|---|---|---|---|---|---|
| 1 | 2 | 2 | 4 | 2 | 2 | 1 |
| 2 | 2 | 4 | 8 | 4 | 2 | 2 |
| 2 | 4 | 8 | 16 | 8 | 4 | 2 |
| 2 | 2 | 4 | 8 | 4 | 2 | 2 |
| 1 | 2 | 2 | 4 | 2 | 2 | 1 |
| 1 | 1 | 2 | 2 | 2 | 1 | 1 |

### 3. [25%] Median Filtering

Implement median filtering; the size of the filter should be a parameter. Take the "lenna" and "boat" images and corrupt them with "salt and pepper" noise (i.e., randomly change X% of the pixels values to either black or white; for each image, use X=30 and X=50), Apply median filtering to each of the corrupted images. For comparison purposes, apply averaging too. Try two different mask sizes for each case: 7 x 7 and 15 x 15. Show and discuss your results for both median filtering and averaging.

### 4. [25%] Gradient and Laplacian

Sharpen the "lenna" and "sf" images using the Prewitt Sobel, and Laplacian masks shown below. Show and discuss your results in each case. Note that in the case of the Prewitt and Sobel masks, you need to show (i.e., visualize as images) both the "**gradient magnitude**" as well as the **partial derivatives** in the x- and y-direction.

Prewitt

| −1 | −1 | −1 |
|----|----|----|
| 0 | 0 | 0 |
| 1 | 1 | 1 |

| −1 | 0 | 1 |
|----|---|---|
| −1 | 0 | 1 |
| −1 | 0 | 1 |

|      |      |      |
|------|------|------|
| −1   | −2   | −1   |
| 0    | 0    | 0    |
| 1    | 2    | 1    |

**Sobel**

|      |      |      |
|------|------|------|
| −1   | 0    | 1    |
| −2   | 0    | 2    |
| −1   | 0    | 1    |

**Laplacian**

|      |      |      |
|------|------|------|
| 0    | 1    | 0    |
| 1    | −4   | 1    |
| 0    | 1    | 0    |

### 5. [20% extra credit] Unsharp Masking and High Boost Filtering

Implement unsharp masking (K=1) and high-boost filtering (K>1). For smoothing, use the 7x7 Gaussian mask._Use the "lenna" and "f_16" images and perform unsharp masking and high-boost filtering. In the case of high-boost filtering experiment with different K values and choose the results that seems to be visually best. Show and discuss your results for both unsharp masking and high-boost filtering.