IMAGE PROCESSING LABORATORY | SPRING '15

ASSIGNMENT - 3

GROUP-7

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ASSIGNMENT – 3
SPATIAL FILTERING

Aim:

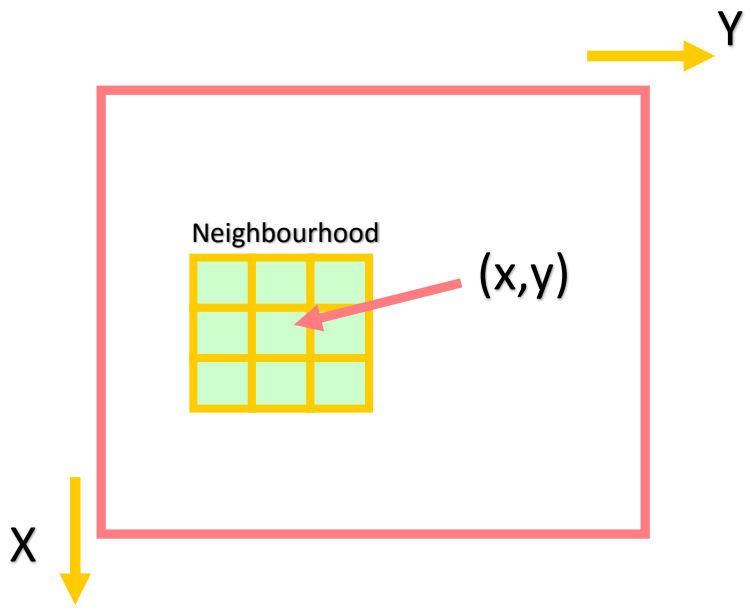
Write C/C++ modular functions/subroutines to design spatial filters - **mean, median, gradient, Laplacian, Sobel kernels (horizontal, vertical, diagonal)** on a stack of grayscale images (say, 15 images per stack)

Use OpenCV (or) ImageJ for image reading, writing and GUI development only. Use the OpenCV **tracker (slider)** functionality to show outputs for varying sizes of neighborhoods.

You may have different sliders to select **(i) Image (ii) Filter (iii) Neighborhood size**

(a) **Input:** Path to the stack of images. Input stack should contain the (provided) noisy images, and may also contain the normal test images, e.g. jetplane.jpg, lake.jpg, livingroom.jpg, mandril_gray.jpg, pirate.jpg, walkbridge.jpg

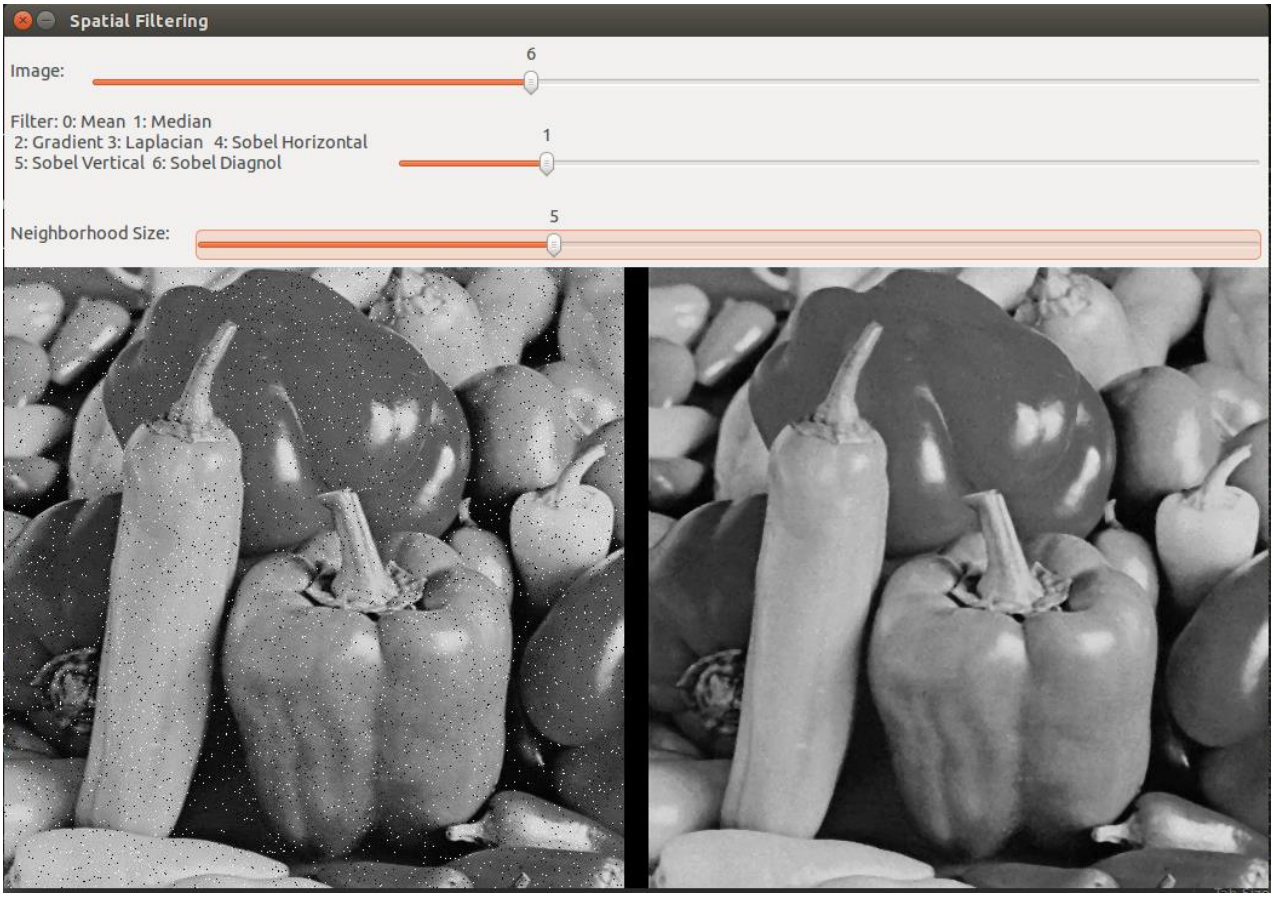
(b) **Output:** Filtered stack of images should be shown beside input stack in the same pane of GUI with a slider to vary filter/kernel size/change image.



Median Operator:

The median filter is a nonlinear digital filtering technique, often used to remove noise. Such noise reduction is a typical pre-processing step to improve the results of later processing (for example, edge detection on an image). Median filtering is very widely used in digital image processing because, under certain conditions, it preserves edges while removing noise

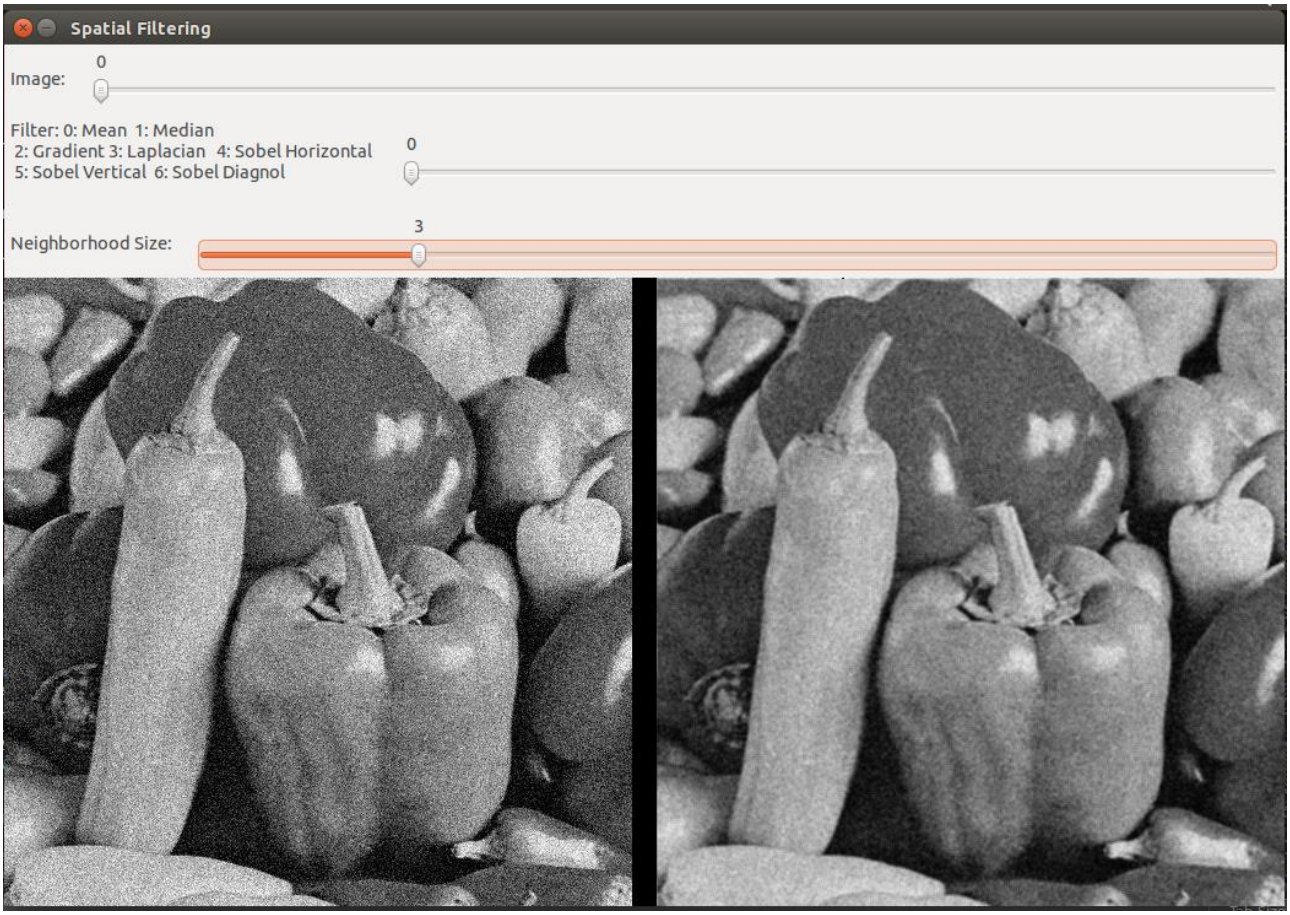
- Response is based on ordering of the pixels in the neighborhood
- Replacing the value of the center pixel with the value determined by the median of all the neighbourhood pixels
- For 3 x 3 filter mask – 5th largest value
- For 5 x 5 filter mask – 13th largest value



Mean Operator:

Mean filtering is a simple, intuitive and easy to implement method of *smoothing* images, *i.e.* reducing the amount of intensity variation between one pixel and the next. It is often used to reduce noise in images

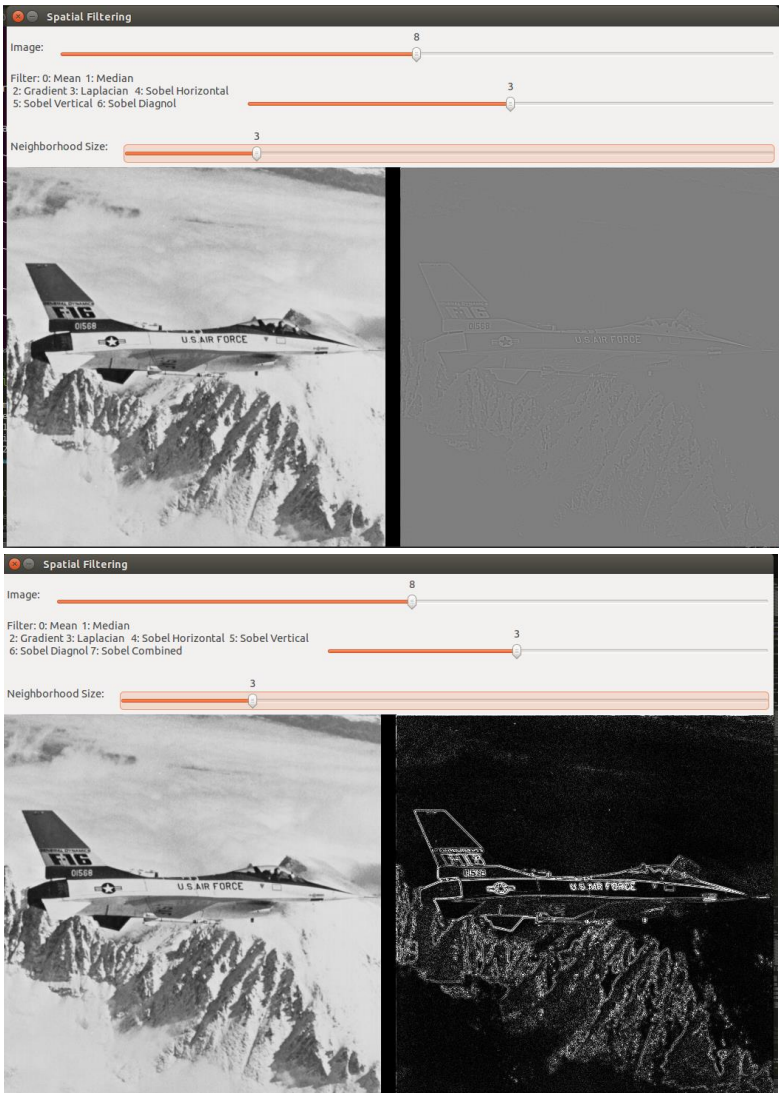
- The idea of mean filtering is simply to replace each pixel value in an image with the mean (`average') value of its neighbors, including itself
- This has the effect of eliminating pixel values which are unrepresentative of their surroundings
- Often a 3×3 square kernel is used although larger kernels (*e.g.* 5×5 squares) can be used for more severe smoothing
- Note - A small kernel can be applied more than once in order to produce a similar but not identical effect as a single pass with a large kernel



Laplacian Operator:

Discrete Laplace operator is often used in image processing e.g. in edge detection and motion estimation applications.

- The discrete Laplacian is defined as the sum of the second derivatives Laplace operator
- Coordinate expressions and calculated as sum of differences over the nearest neighbours of the central pixel
- Highlights gray level discontinuities
- Deemphasizes regions of slowly varying gray levels
- Generates images having grayish edge lines and other discontinuities superimposed on a dark background



Sobel Operator –

The Sobel operator, sometimes called the Sobel–Feldman operator or Sobel filter, is used in image processing and computer vision, particularly within edge detection algorithms where it creates an image emphasising edges. Technically, it is a discrete differentiation operator, computing an approximation of the gradient of the image intensity function. At each point in the image, the result of the Sobel–Feldman operator is either the corresponding gradient vector or the norm of this vector. The Sobel–Feldman operator is based on convolving the image with a small, separable, and integer-valued filter in the horizontal and vertical directions and is therefore relatively inexpensive in terms of computations. On the other hand, the gradient approximation that it produces is relatively crude, in particular for high-frequency variations in the image

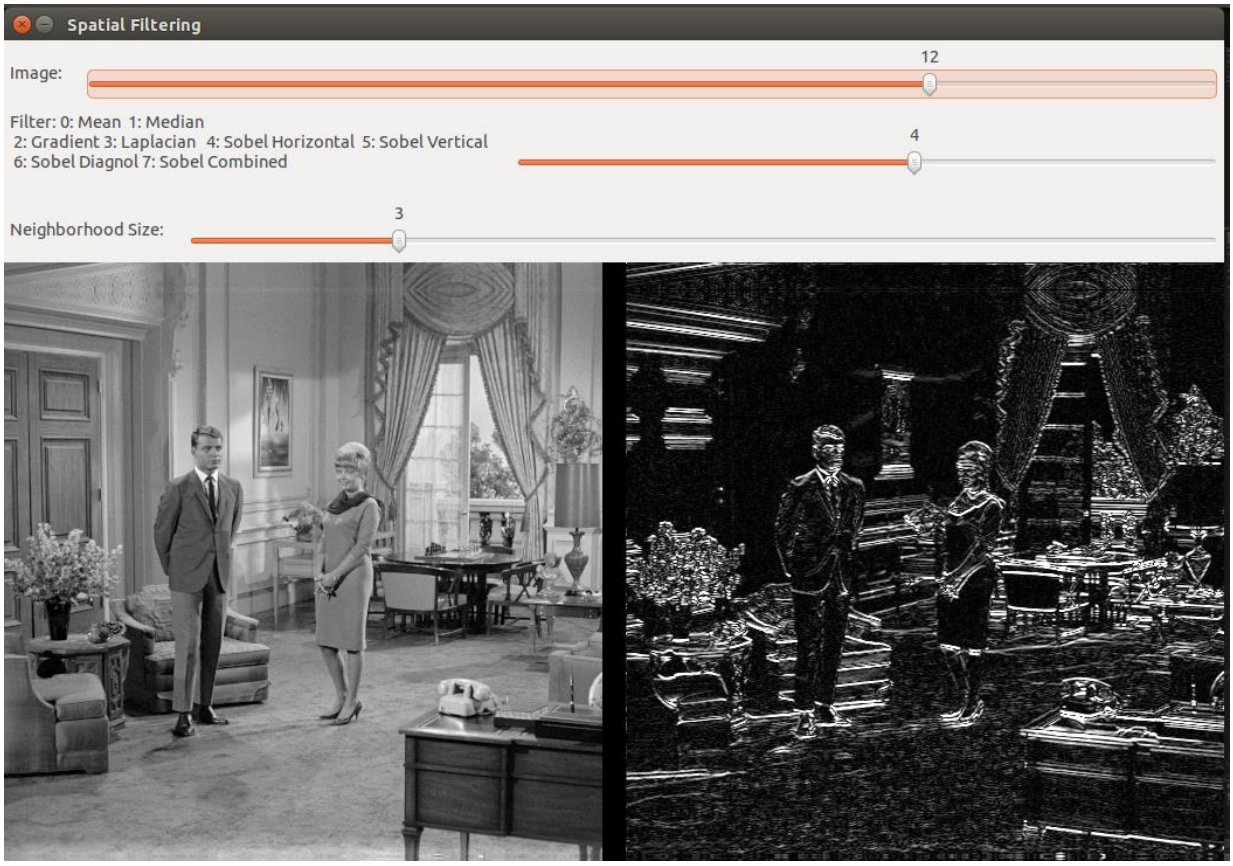
-1	-2	-1
0	0	0
1	2	1

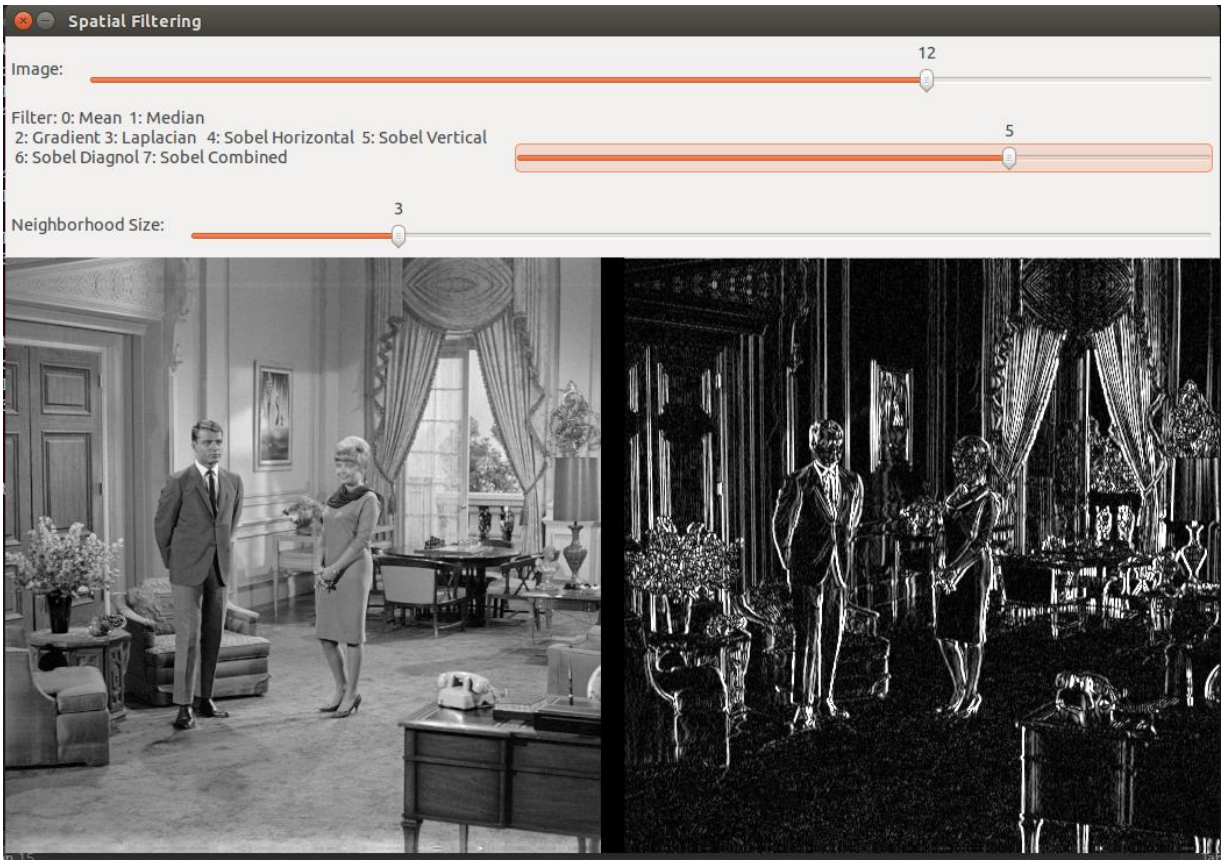
Horizontal

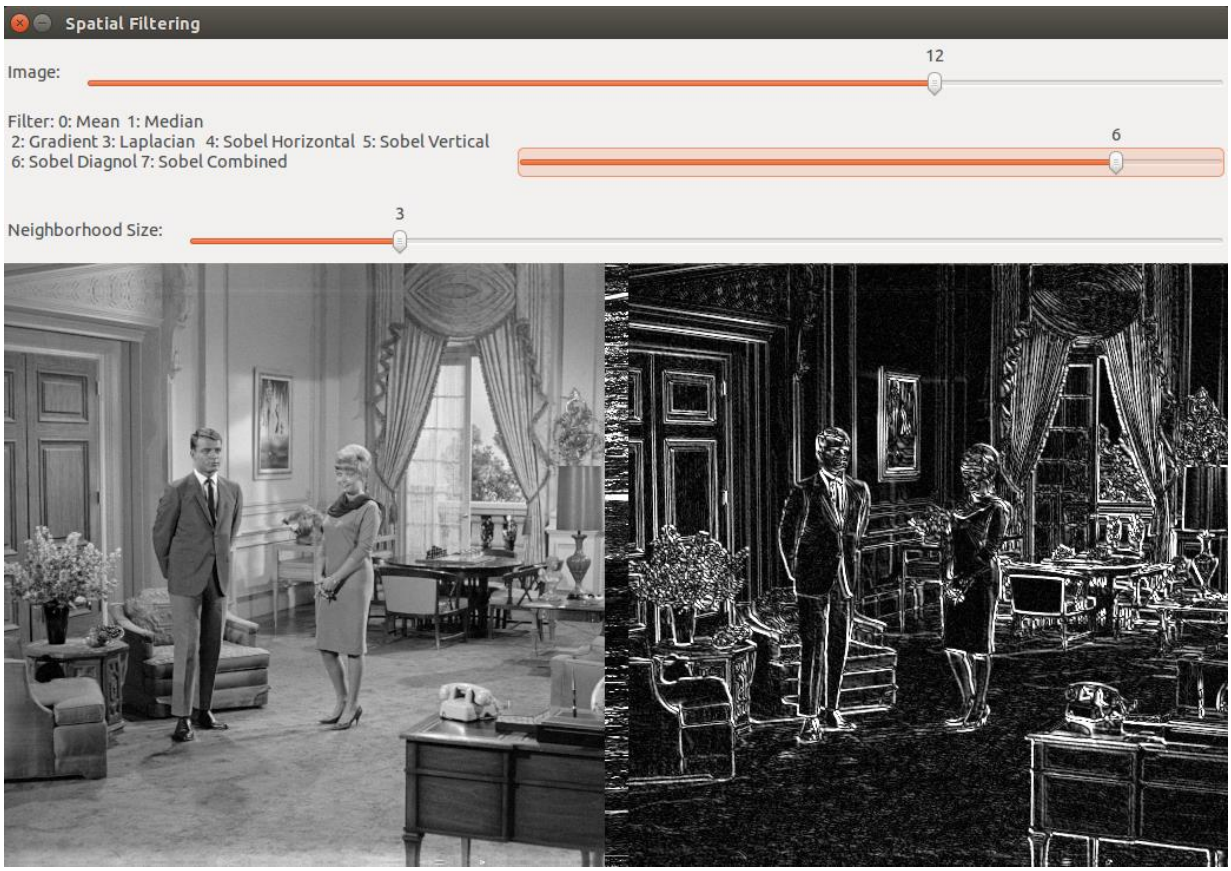
-1	0	1
-2	0	2
-1	0	1

Vertical

.




Spatial Filtering
Image:
12
Filter: 0: Mean 1: Median
2: Gradient 3: Laplacian 4: Sobel Horizontal 5: Sobel Vertical
6: Sobel Diagnol 7: Sobel Combined
5
Neighborhood Size:
3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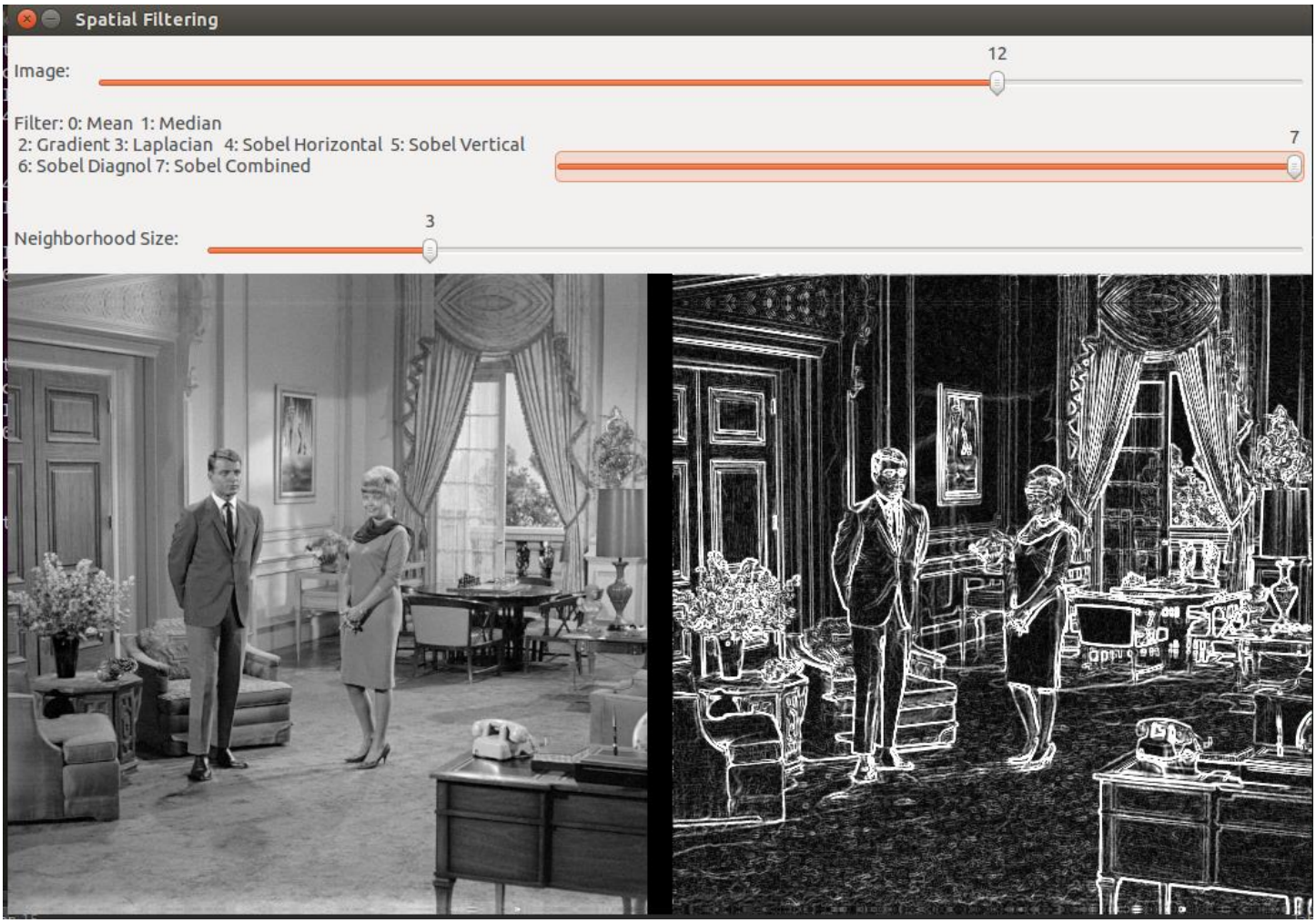
Spatial Filtering
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6: Sobel Diagnol 7: Sobel Combined
7
Neighborhood Size:
3

Gradient Operator –

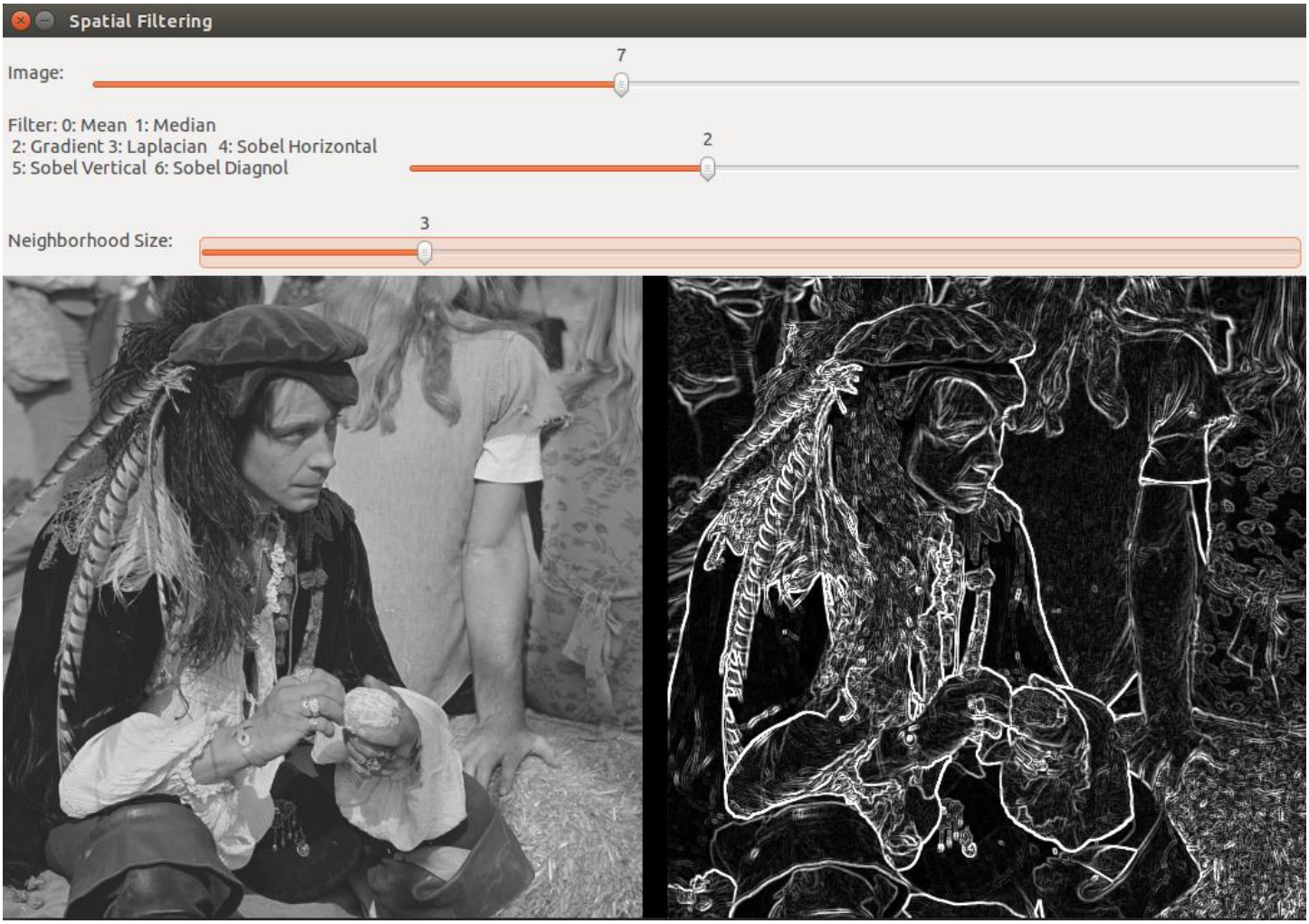
Gradient domain image processing is a relatively new type of digital image processing that operates on the differences between neighboring pixels, rather than on the pixel values directly.

-1	0	+1
-1	0	+1
-1	0	+1

Gx

+1	+1	+1
0	0	0
-1	-1	-1

Gy



Analysis:

- First order derivative generally produce thicker edges in an image. First order derivative have stronger respose to gray level step

- Second order derivatives give stronger response to fine details such as thin lines and isolated points. Second order derivative produce a double response at step edges
  - ✓ Second order derivatives are better suited for image enhancement

- **Laplacian Filer is isotropic** - Response is independent of the direction of discontinuity in the image. Isotropic filters are rotation invariant
  - ✓ To maintain background features while preserving the sharpening effect – Add original image and laplacian image

- **Median Filter** - Very effective to remove impulse noise

- **Sobel Operator vs Gradient Operator** – Sobel Operator gives gradient response with averaging effect

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