EXPERIMENT 3

Spatial Filtering

- *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).*

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INTRODUCTION

The objective of this experiment is to perform following Spatial Filtering operations on an image:

1. Mean Filter

2. Median Filter

3. Gradient Filter

4. Laplacian Filter

5. Sobel Filter

Each of the above filter helps in modification or extracting features.

- **Mean Filter:** This filter is used for high-frequency noise reduction and image smoothing.
  3x3 Kernel :

$$\begin{matrix} 1/9 & 1/9 & 1/9 \\ 1/9 & 1/9 & 1/9 \\ 1/9 & 1/9 & 1/9 \end{matrix}$$

- **Median Filter:** This is a non-linear filter used for noise reduction. It finds particular use in Salt & Pepper noise reduction. For applying it, we find the median of all the values covered my mask and assign it to the center. Unlike mean filter, it preserves edges.

- **Gradient Filter:** As evident by the name, this filtering operation is used to find directional change in intensity in the image. This helps in detection of edges in the image. Edge detection helps in feature extraction and sharpening of the image.
  3x3 Kernel for vertical gradient filter :

$$\begin{matrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{matrix}$$

  3x3 Kernel for horizontal gradient filter :

$$\begin{matrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{matrix}$$

- **Laplacian Filter:** Laplacian filter works on the principle of Laplace operator i.e. it uses second-order derivative instead of first order derivative to detect edges. 3x3 Kernel :

$$\begin{matrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{matrix}$$

- **Sobel Operator:** This operator is also used for edge detection. Sobel operator finds more edges or make edges more visible as compared to gradient operator because in Sobel operator
  we have allotted more weight to the pixel intensities around the edges.
  3x3 Kernel for vertical Sobel operator :

$$\begin{matrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{matrix}$$

  3x3 Kernel for horizontal Sobel operator :

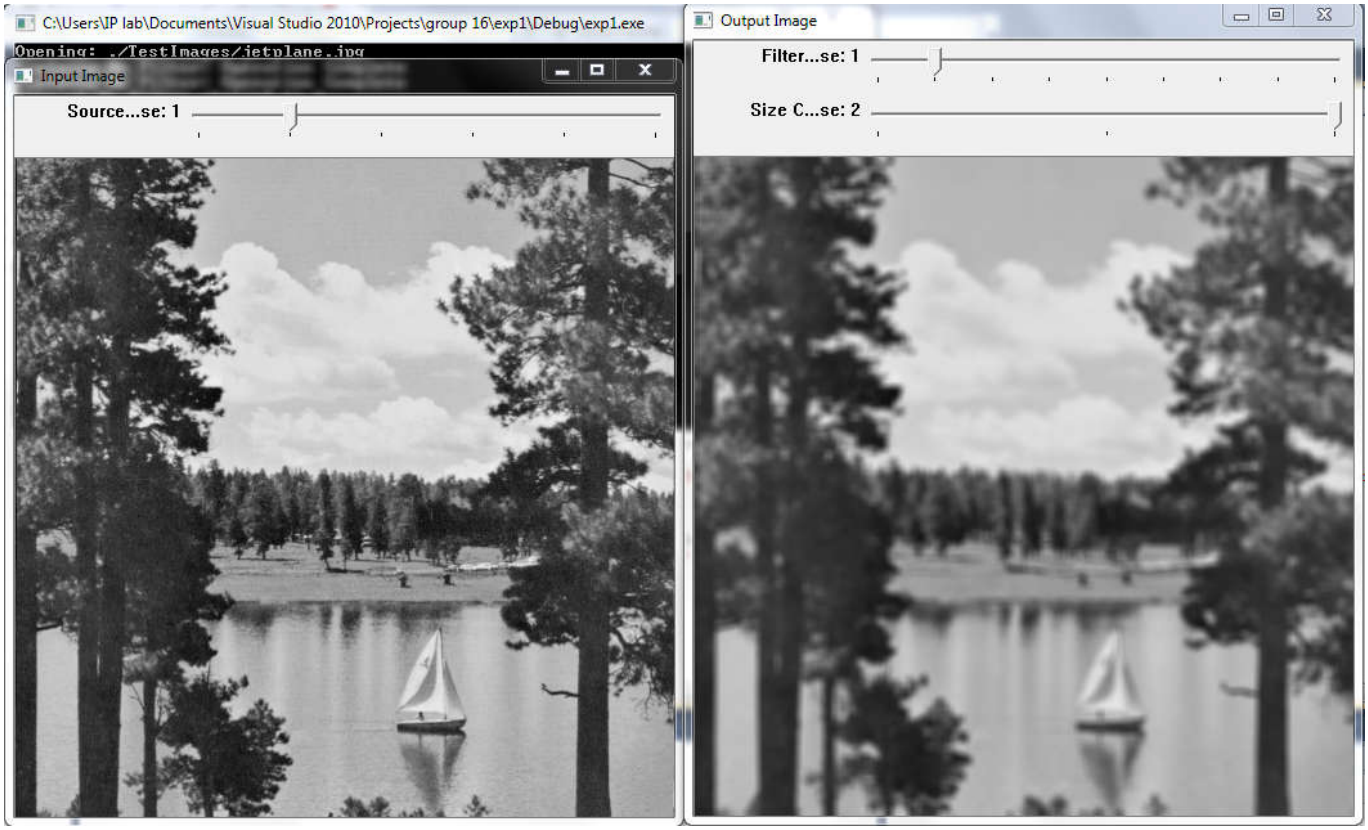
$$\begin{matrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{matrix}$$

ALGORITHM

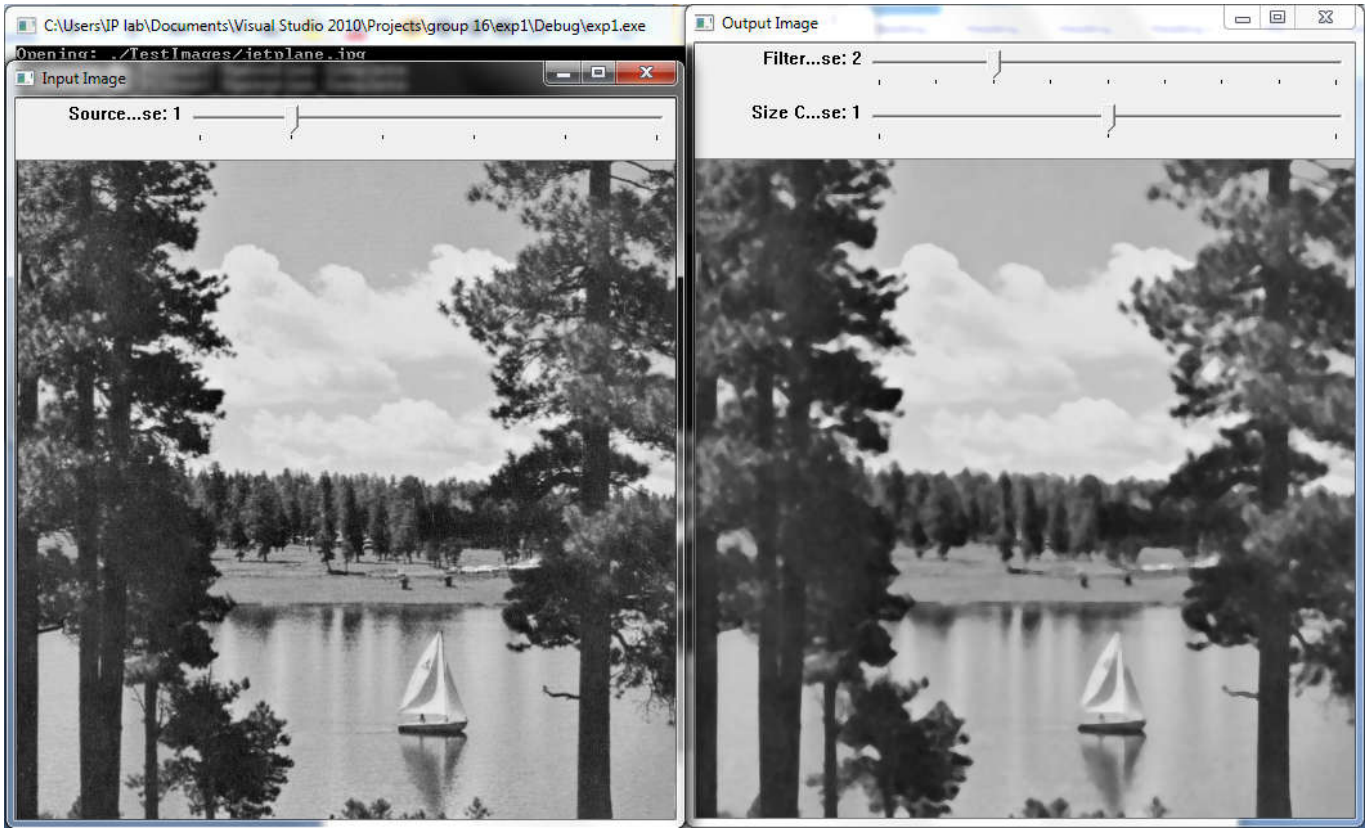
All the masks have predefined except for mean and median. Tracker window has been used to continuously feed in what is the size of window and what filter is being used. Any change in the size and filter will be recorded and the changes will be reflected immediately. Once the filter and size are fixed a window is allocated containing the mask for applying on the image.

OUTPUT RESULTS

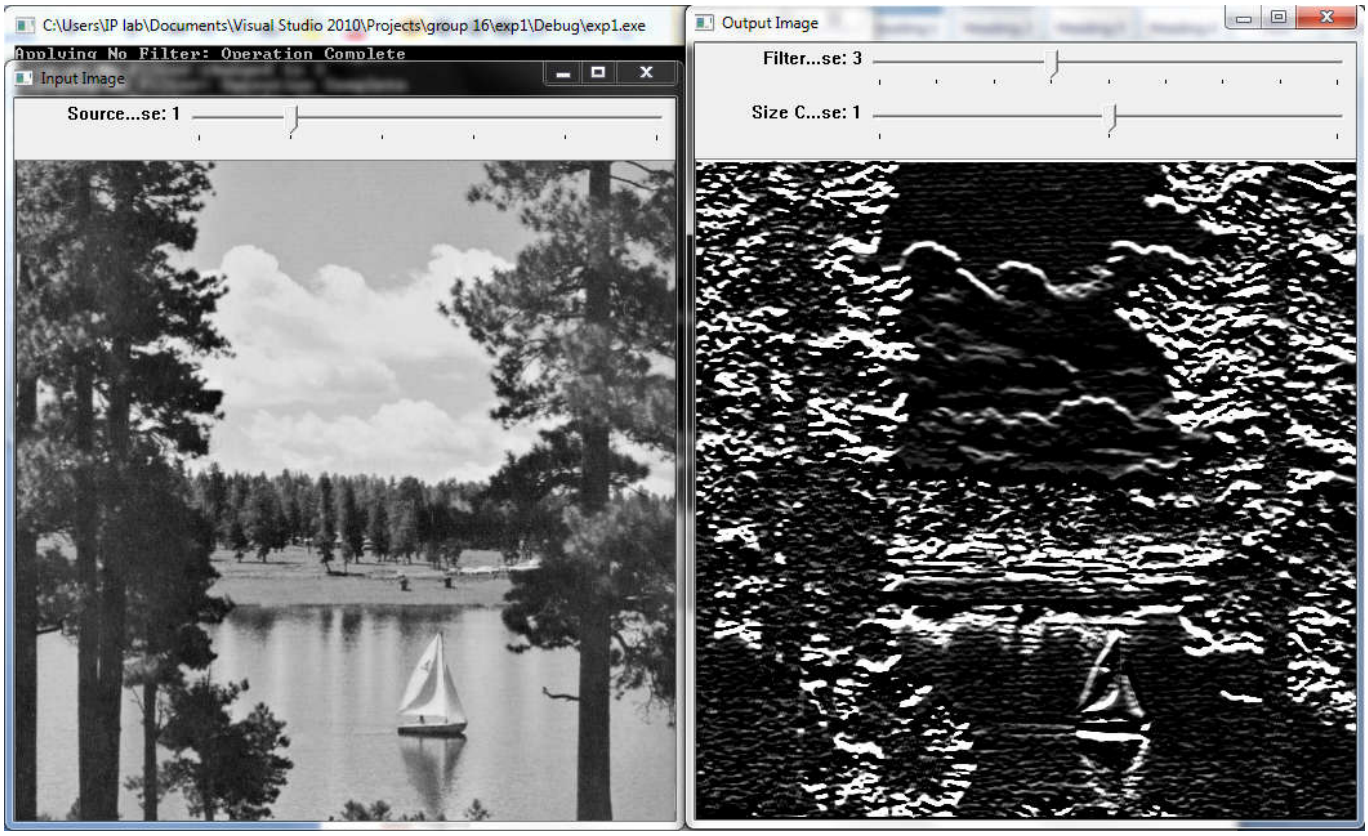
Mean Filter



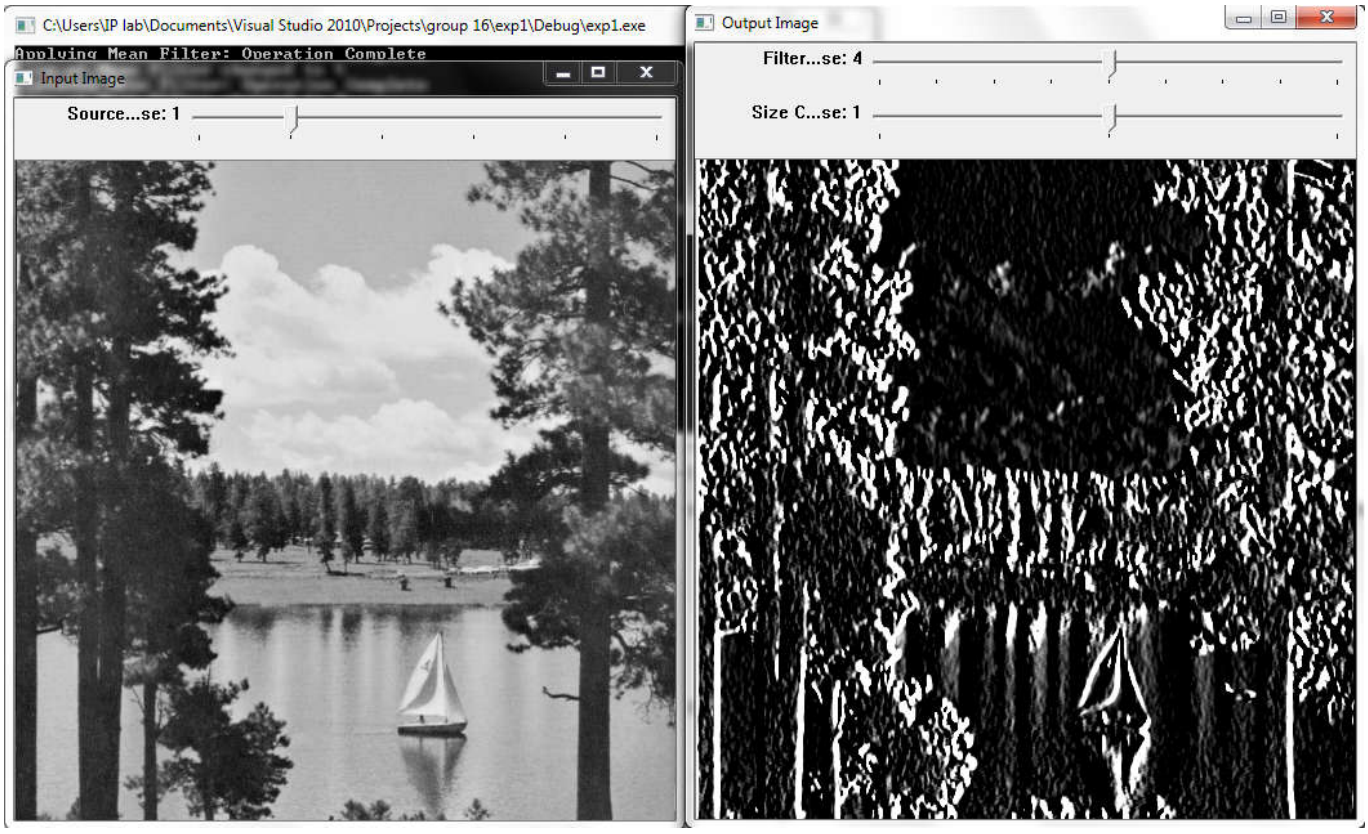
Median Filter



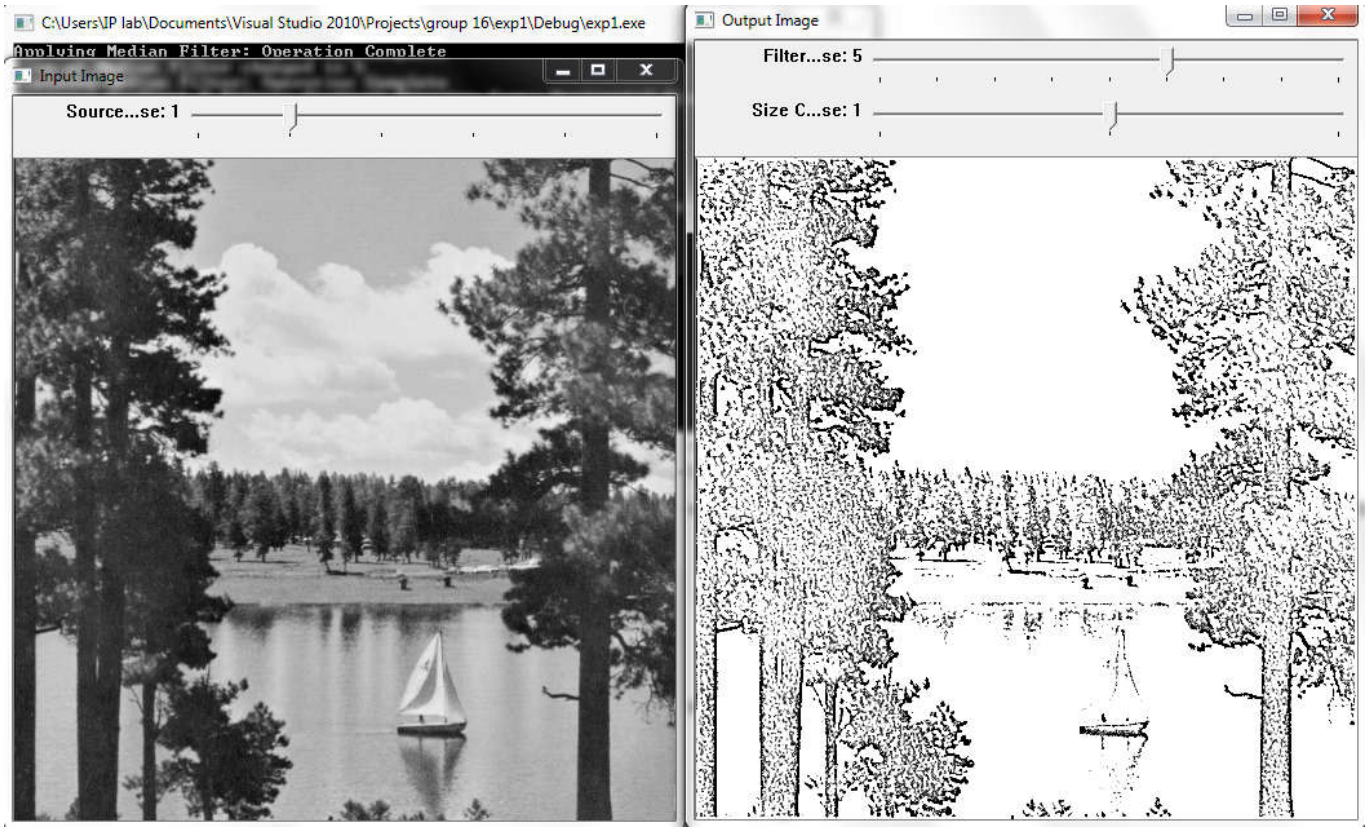
Gradient Horizontal



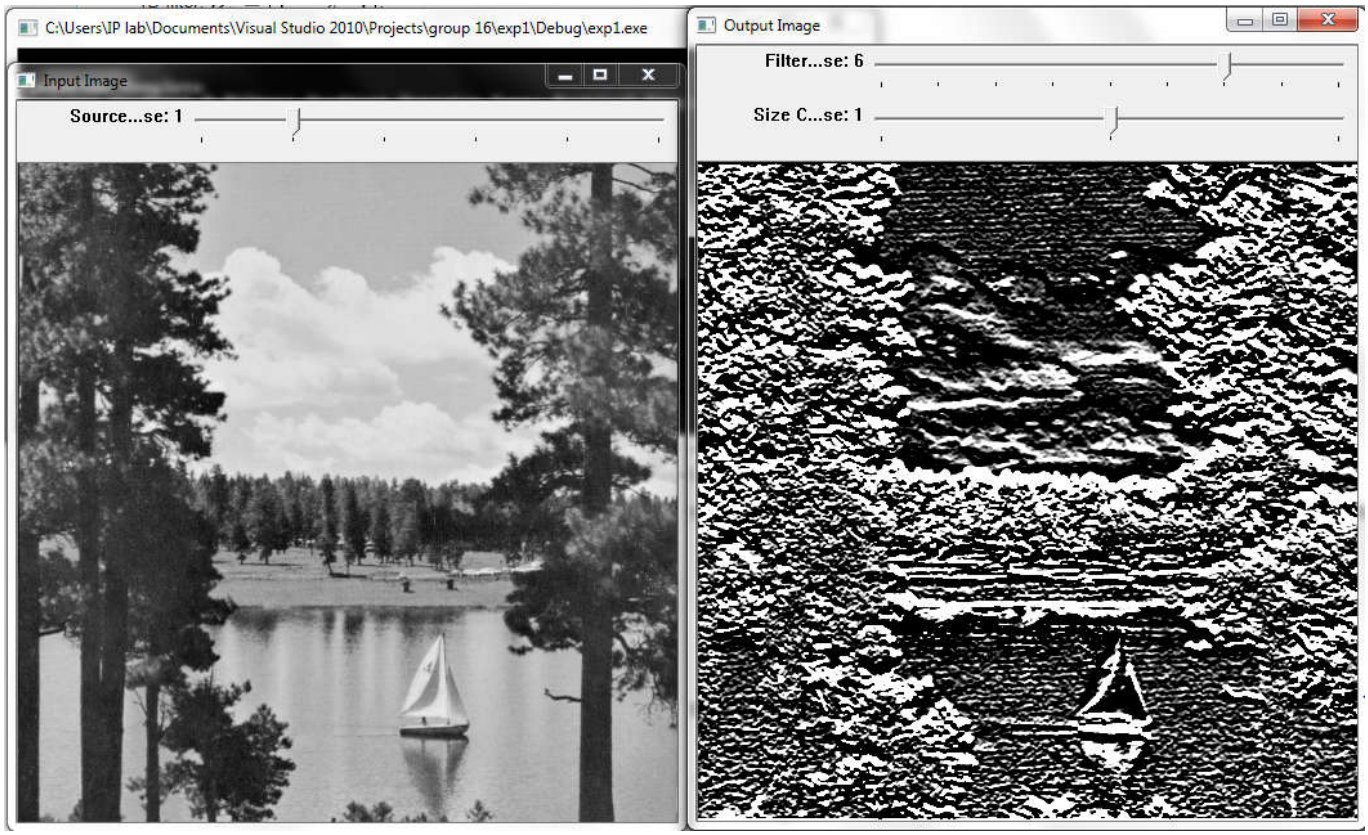
Gradient Vertical



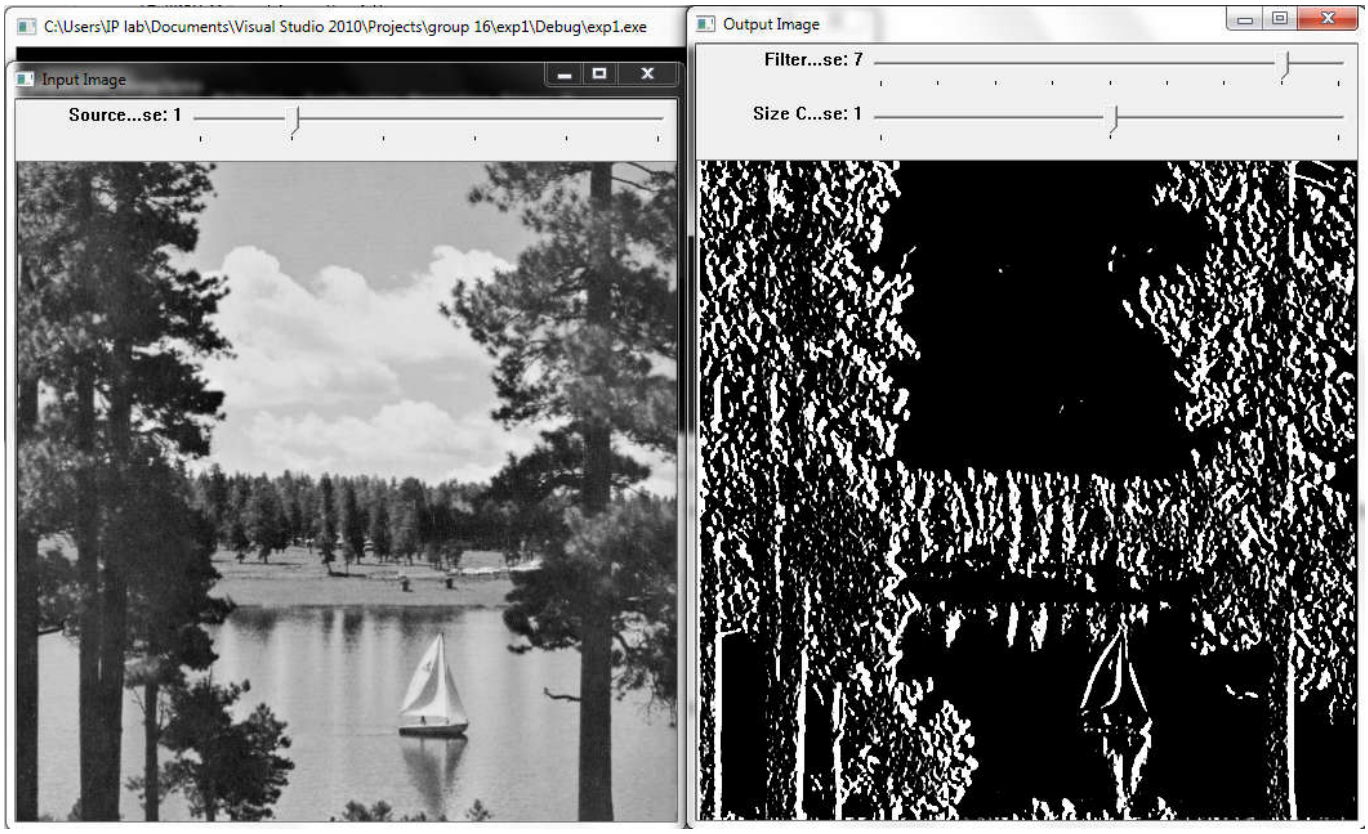
Laplacian



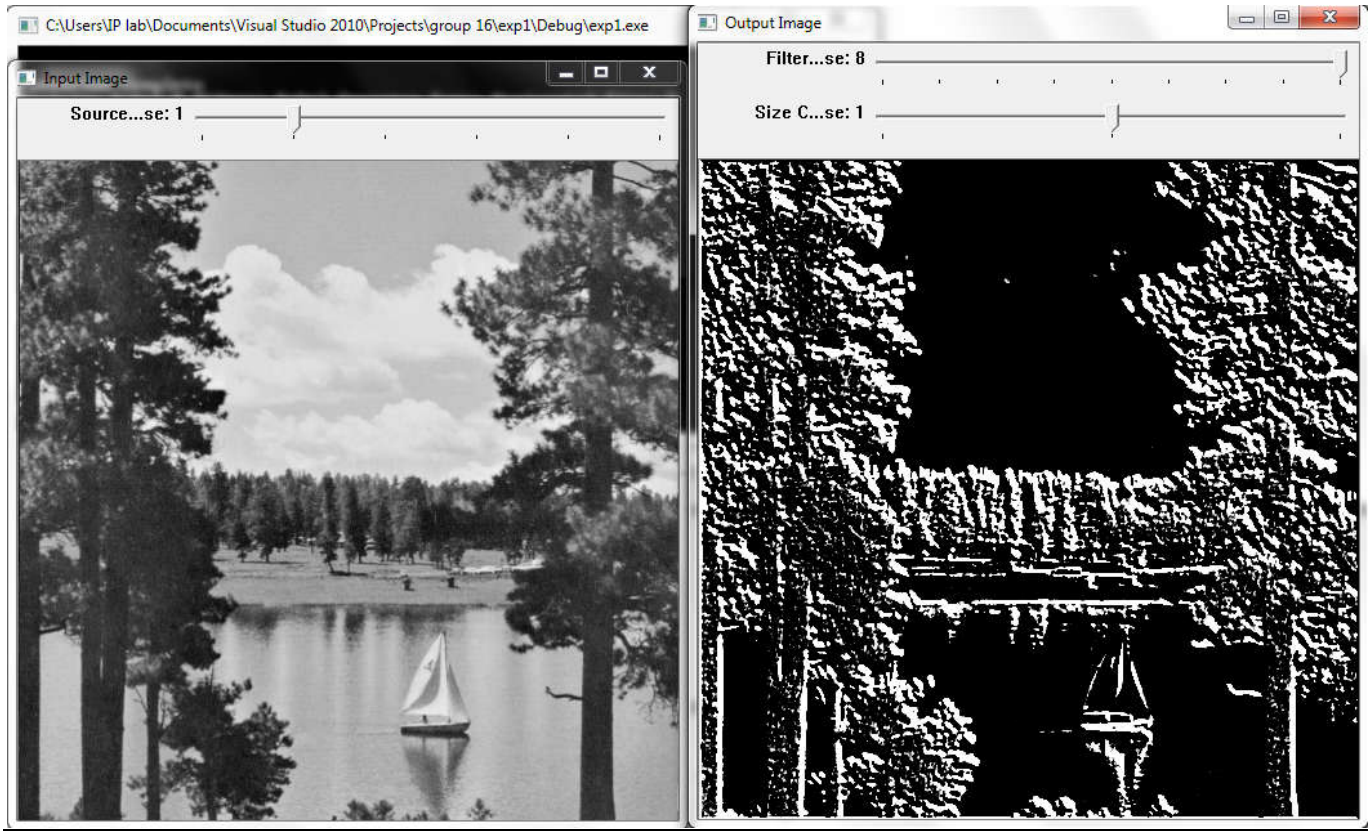
Sobel Horizontal



Sobel Vertical



Sobel Diagonal



DISCUSSIONS

- Averaging filter acts like a low-pass filter. It helps in reduction of irrelevant details in the image. It creates a smoothing effect.
- Median filter uses statistical properties of the image. It is very effective in removing impulse noise also called salt and pepper noise. It also preserves the edges in the image and thus preserves the details while reducing the noise.
- Gradient operator detects the edges in the image. It uses a first-order derivative and thus at the edges, it produces thick lines as the value goes from zero to negative to zero again at the edges. It has stronger response to gray level step than second-order derivative.
- Laplacian operator uses second-order derivative and thus provides stronger response to thin lines and isolated points. This way it also becomes prone to noise. Laplacian is isotropic in nature and thus is rotation-invarient.
- Sobel operator is a weighted first-order derivative. It differentiates in one direction and smoothes edges in other direction. The edge-detected output will be smoothed in this case.

SOURCES

[1] https://en.wikipedia.org/wiki/Median_filter

[2] https://en.wikipedia.org/wiki/Discrete_Laplace_operator

[3] https://en.wikipedia.org/wiki/Sobel_operator

[4] https://en.wikipedia.org/wiki/Image_gradient