CSE 573: Homework Assignment 3

Name: Sokhey, Harshdeep , UB#50247213

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1 Solution 1

1.1 Part 1

The ϵ in the equation refers to the Δchange in the input x of the function $f(.)$. It represents the smallest change in the function. In the context of a digital image a pixel is the smallest component. Thus, we can say that ϵ refers to a pixel in a digital image.

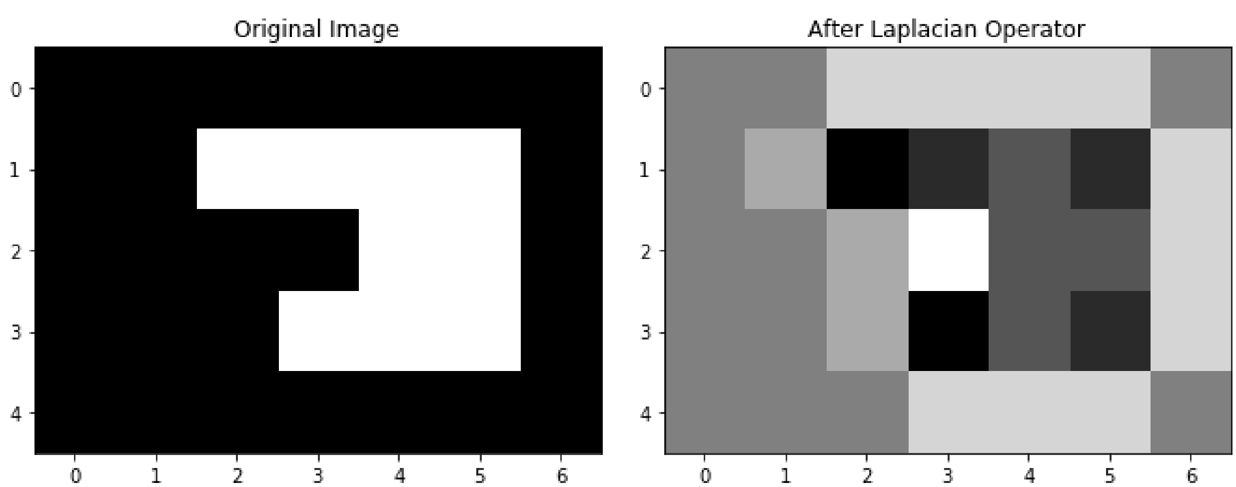
1.2 Part 2

$$\delta F = \frac{\partial^2 F}{\partial^2 x} + \frac{\partial^2 F}{\partial^2 y} = F(x+1) + F(x-1) - 2F(x) + F(y+1) + F(y-1) - 2F(y) \tag{1}$$

1.3 Part 3

The second order derivative can detect an edge if there is a significant spatial change in the derivative. Difference of Gaussian(DoG) and Laplacian of Gaussian(LoG) are examples of second order derivative edge detection.

1.4 Part 4



The resultant image matrix is as follows (negative values define the edge):

$$\begin{bmatrix} 0 & 0 & 2 & 2 & 2 & 2 & 0 \\ 0 & 1 & -3 & -2 & -1 & -2 & 2 \\ 0 & 0 & 1 & 3 & -1 & -1 & 2 \\ 0 & 0 & 1 & -3 & -1 & -2 & 2 \\ 0 & 0 & 0 & 2 & 2 & 2 & 0 \end{bmatrix}$$

1.5 Part 5

Nonlinear filters are filters where the output is not a linear function of the input of the filter. An example of non-linear filter would be a median filter. It is useful is removing outliers and noise which is independent of magnitude.

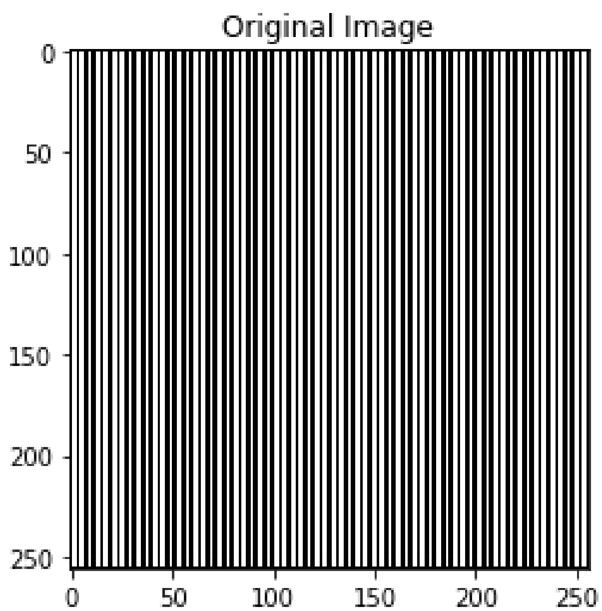
A **Linear** filter is one where the linearity hold. For example, a mean filter M applied on a signal defined as $X + \lambda Y$ can be written as $M(X + \lambda Y) = M(X) + \lambda M(Y)$. It is used for smoothing/blurring operations.

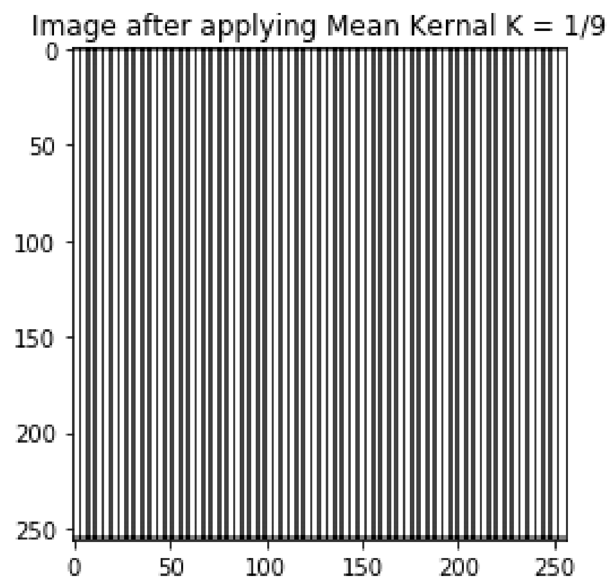
1.6 Part 6

Non-max suppression finds the pixel with the maximum value in an edge. We keep the pixel with the max-value and set the other neighboring pixels to zeros(black).

2 Solution 2

The mean filter has a **blurring** effect on the image. The results are as follows:





3 Solution 3

3.1 Part 1

The Scale-Invariant Feature Transform (**SIFT**) is used to detect and describe local features in an image. The key points are extracted from reference images and compared against features extracted from the new image based on the *Euclidean* distance of their feature vectors. As the name suggests, this algorithm is invariant to scale due to the following methods :

1. Utilizing Maxima and Minima of the **Difference of Gaussian**,for identifying key locations
2. **Scale-Space Pyramids**, which generate a stack of images of varying scales , provides scale invariance
3. **Orientation Assignment**, to achieve invariance to image rotation, by taking gradient around the neighborhood of the key point location

3.2 Part 2

The problem statement presents the following data:

- True Positives = 50
- True Negatives = 80
- False Positives = 20
- False Negatives = 30

	True	False
Positive	50	20
Negative	80	30

3.3 Part 3

The **ROC** curves are used for performance visualization for a classifier with 2 possible output classes. Graphically, it is a plot of the **True Positive** Rate (on the y-axis) versus the **False Positive** Rate (on the x-axis).

The classifier that accurately separates the classes will have an ROC curve that touches the upper left corner of the plot, while a poor classifier will be closer to the positive diagonal. The latter is the case where the classifier is randomly guessing the class results.

The **Area Under the Curve (AUC** is a way to quantify the performance of the classifier. It the percentange of the area under the curve to the overall area. A poor classifier will have an AUC of around 0.5 (random guessing) whereas a good classifier will have an AUC of 1.

3.4 Part 4

The process of panorama generation from image stitching can be divided into 3 main steps:

- **Image registration**, involves feature matching in set of images or alignment techniques that minimizes the sum of differences between overlapping pixels. RANSAC algorithm is a common way to achieve image registration.

- **Calibration**, removes or minimize differences between an ideal lens models and the existing camera-lens models. This also includes alignment and composting techniques.
- **Blending**, uses the adjustments done in the calibration stage along with remapping of the images to an output projection.

Bundle Adjustment is the optimization step where we minimize the re-projection error between the image locations of the observed and predicted points of the image. We refine the set of initial camera and structure parameter estimates to find the set of parameters that can accurately predict the locations of the observed points in the set of images. The following optimization techniques are commonly used :

- Gradient Descent Method
- Newton-Rhapson Method
- Gauss-Newton Method
- Levenberg-Marquardt Method (widely used)

4 Solution 4

4.1 Part 1

In the E-step, we estimate for the expected number of heads and tails for each coin across the trials . We use these counts to recompute an updated better guess for each coin bias in the M-step. We repeat these steps to update the estimates of the coin biases finally converging at the local maximum.

Assuming coin A has bias = 0.5 and coin B has bias = 0.6, after iteration 1 we get, bias for coin A = 0.31 and bias for coin B = 0.60.

4.2 Part 2

The **Watershed** algorithm is used for segmentation by considering pixel values as *elevation* in an image. The areas corresponding to the ground level is filled with different colors/markers till they meet. This form of watershedding is called *Watershed by Flooding.*