CS 419 - Assignment 2

Berkay Barış Turan - 28132

December 18, 2023

Question 4

The objects of interest are sometimes brighter and sometimes darker with respect to their surrounding. Is using opening going to be sufficient?

The gravel images provided are having different brightness levels compared to their surroundings. When implementing Granulometry, family of openings with varying kernel sizes are being utilized. When using opening, brighter objects from a darker background are gathered, and dark background is mostly being removed. In most of the applications, just using openings might not be sufficient since the brightness levels may vary. However, in this example, when just openings are being utilized, the desired outcomes are being achieved.

What shape/range of sizes of structuring elements should you use?

We should use disk shaped structuring element owing to common shapes of gravels can be approximated into disks. Since Granulometry is a family of opening with varying SE sizes, I have utilizes several disks with increasing radius values as follows: 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29, 31. Disks with smaller radius where used to determine smaller gravels while disks with higher radius values are used for identifying the larger gravels. The kernel sizes are odd.

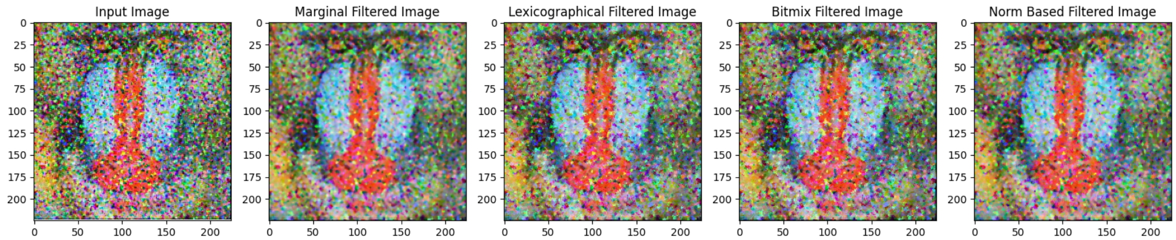
Should you use openings/closings or openings/closings by reconstruction?

Opening by reconstruction is a widely used approach for pattern spectrum analysis of objects, granulometric analysis. However, for this specific example, using opening was alone successful on identifying gravel types.

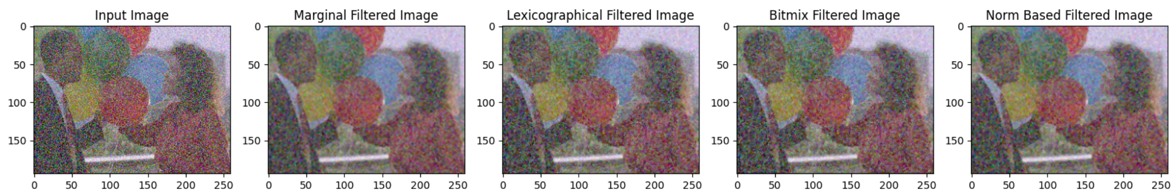
As if that was not enough, say you calculate the granulometry of an unlabeled image, how are you supposed to compare the resulting numerical series against the granulometry of a labeled image? Should you rely on the Euclidean distance ? Or their Manhattan distance? Or Chebyshev distance? Or something entirely different?

In this example, for labeling the unlabeled gravels, I have utilized a different approach. For each type of gravels, I have calculated their pattern spectrum showing for a given radius, it shows the size distribution of the gravel. Afterwards, when an unlabeled gravel is being provided to the algorithms, firstly its pattern spectrum is being calculated; thereafter, for each of the intervals ther difference of the distributed is calculated. Then, all of the differences for each radius is summed by taking their absolute values. Finally, the unlabeled gravel is being label with respect to the the labeled spactrum having the lowest difference value. The reason why I implemented this kind of approach is that inputs having the same gravel with a labeled data should have a closer pattern spectrum in comparison to different types. As it can be observed from the corresponding outputs, this approach worked for identification of the gravels.

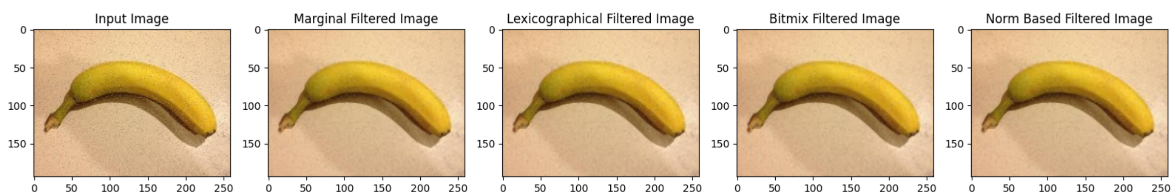
Question 5



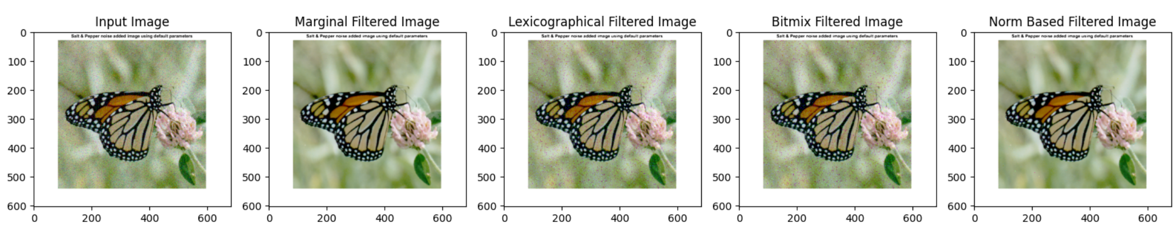
MSE for Marginal Median Filter: 3315.980892857143
MSE for Lexicographical Median Filter: 5568.578412698413
MSE for Bitmix Median Filter: 5662.819186507936
MSE for Norm Median Filter: 5031.84748015873



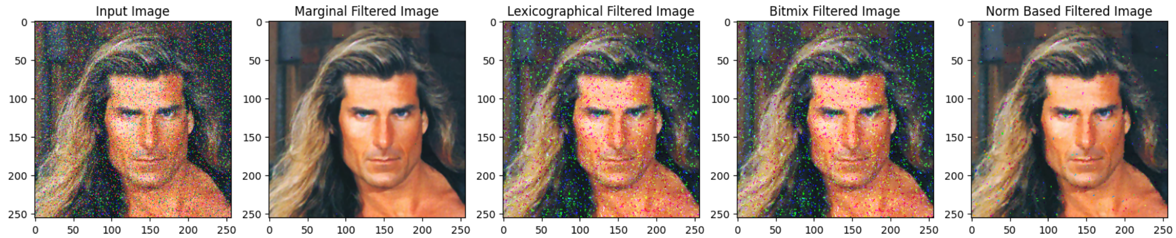
MSE for Marginal Median Filter: 2513.778251005055
MSE for Lexicographical Median Filter: 3355.4406519921986
MSE for Bitmix Median Filter: 3367.2773952155394
MSE for Norm Median Filter: 3038.0281216415237



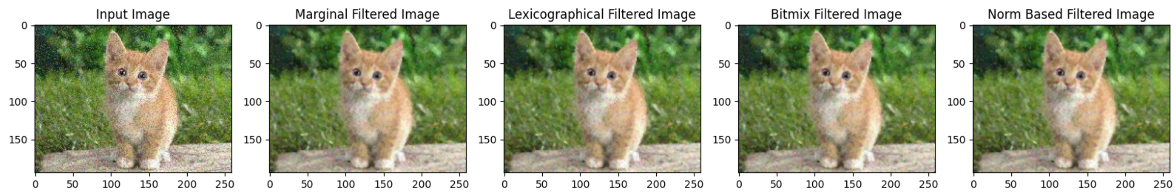
MSE for Marginal Median Filter: 211.19165704732714
MSE for Lexicographical Median Filter: 219.39270787724396
MSE for Bitmix Median Filter: 228.07138876726506
MSE for Norm Median Filter: 216.69380647215698



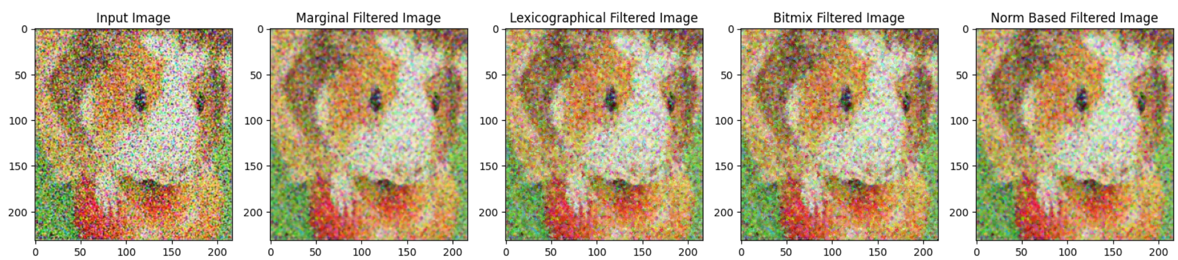
MSE for Marginal Median Filter: 2295.9167286733486
MSE for Lexicographical Median Filter: 3048.5236987107473
MSE for Bitmix Median Filter: 3050.4211031839823
MSE for Norm Median Filter: 2385.389017765522



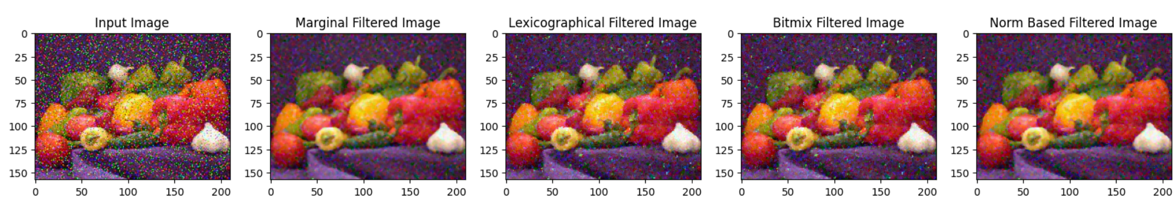
MSE for Marginal Median Filter: 6040.466354370117
MSE for Lexicographical Median Filter: 8314.848907470703
MSE for Bitmix Median Filter: 8297.738189697266
MSE for Norm Median Filter: 6600.698348999023



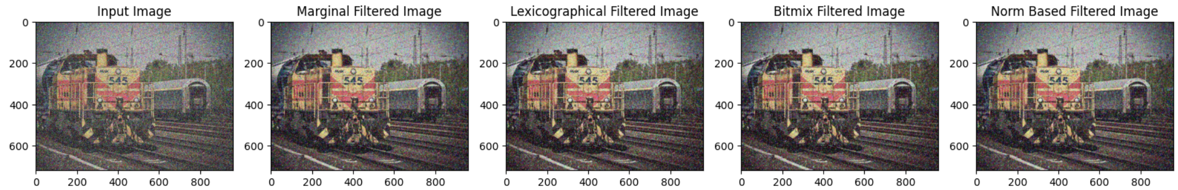
MSE for Marginal Median Filter: 1159.0214146399715
MSE for Lexicographical Median Filter: 1188.7344266210246
MSE for Bitmix Median Filter: 1199.6052820124985
MSE for Norm Median Filter: 1177.3475500537356



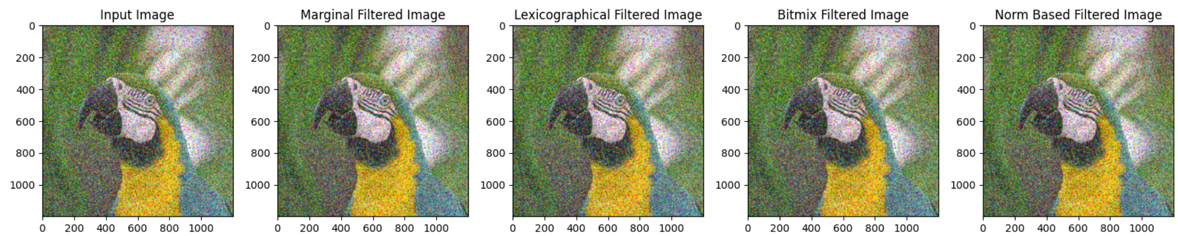
MSE for Marginal Median Filter: 2834.2797354203085
MSE for Lexicographical Median Filter: 4301.378138407755
MSE for Bitmix Median Filter: 4415.560285237566
MSE for Norm Median Filter: 3839.544831558875



MSE for Marginal Median Filter: 3824.9357142857143
MSE for Lexicographical Median Filter: 5301.158890898131
MSE for Bitmix Median Filter: 5326.150723327306
MSE for Norm Median Filter: 4859.883845690175



MSE for Marginal Median Filter: 11683.789814814814
MSE for Lexicographical Median Filter: 13289.15882667824
MSE for Bitmix Median Filter: 13301.252954282407
MSE for Norm Median Filter: 12618.242651909723



MSE for Marginal Median Filter: 293.4547263888889
MSE for Lexicographical Median Filter: 1353.1093659722221
MSE for Bitmix Median Filter: 1358.0157027777777
MSE for Norm Median Filter: 1193.9983486111112

Which one filters the image best, and by how much?

By analyzing the filtered images, and the corresponding MSE values, it can be observed that marginal median filtering gives the best results. It is not surprising since for salt and paper noise, it is known that the median filtering is performing well. The amount of difference of the performance is depending on the image and the noise. For some of the images, there exists a relatively high difference of MSE values showing marginal median filtering outperforms the other filters; for some of the images this difference is relatively low, but still outperforming the others. The second best filtering that has MSE values higher than marginal median, lower than the others is the norm based filtering. The lexicographical and bitmix filtering are interchanging among each other depending on the image by their MSE values. However, when we inspect the filtered images, it is obvious the observe that marginal median filtering, and norm based filtering removes the most of the noise pretty wel; however, images after being filtered by lexicographical and bitmix filtering are still having a high amount of noise that is not being removed. Although marginal median filtering performs the best, we should bare in mind that while it removes the noises, some artifacts might be created, and images become little bit blurry (losing some details).

Does their relative performance depend on the image?

The relative performance of the filters are depending on the images. With the images having low noise, all of the filters are displaying a relatively low MSE values while for the images having high noise, their MSE values are increasing. For instance for the images having low noise such as Cat and Banana, MSE values are relatively low, while in the images having high noise such as Hamster and Man corresponding MSE values are higher. Briefly, for the images having low noise, MSE values of the filters does not have significant differences, while in the images with high noise, the differences among the MSE values of filters changing drastically.

Or on the level/correlation of noise?

The difference is highly dependent on with the noise among on the images. In the images with low noise, marginal median and norm based filtering are performing very well on removing noises. However, in the images with high noise, their performance is decreasing. Although they remove some of the noise, they are not successful on removing the most of it (such as Hamster and Parrot).

What about the effect of the filter size?

For the images provided in this report, the kernel size of 3 has been utilized. When the kernel size is increased, we observe images with distorted looks (blurry), higher chance of artifacts. Additionally, MSE values of the filters with larger kernels are worse than the smaller ones. (The filtered images shown in this report are filtered with a kernel with size 3. The filtering of the same images with a kernel size of 5 is shown in the notebook)

What about the effect of the color space?

It is observed that when the color space of the noise has an effect on filtering. For black and white noise, the filtering operations is performed better (Cat, Butterfly, Banana). When the noise is consisting of a wider range of color space (RGB), filter are not being that much successful on filtering these noises (Vegetable, Hamster).