16-720 Computer Vision: Homework 1 (Fall 2024)

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September 13, 2024

Q1.1.1

- Gaussian: The Gaussian filter is a low-pass filter. It reduces high frequency noise by blurring the image and removing unnecessary details from the image.

- Laplacian of Gaussian (LoG): The LoG filter detects edges in the image by highlighting regions of rapid intensity change.

- Derivative of Gaussian in the x-direction: Detects rapid changes in the x-direction. Picks up vertical edges in the image.

- Derivative of Gaussian in the y-direction: Detects rapid changes in the y-direction. Picks up horizontal edges in the image.

- We need multiple scales of filter responses because different features come and go into focus at different scales, using a variety of filter scales allows us to extract informative features that may not be present at an individual scale alone.

Q1.1.2

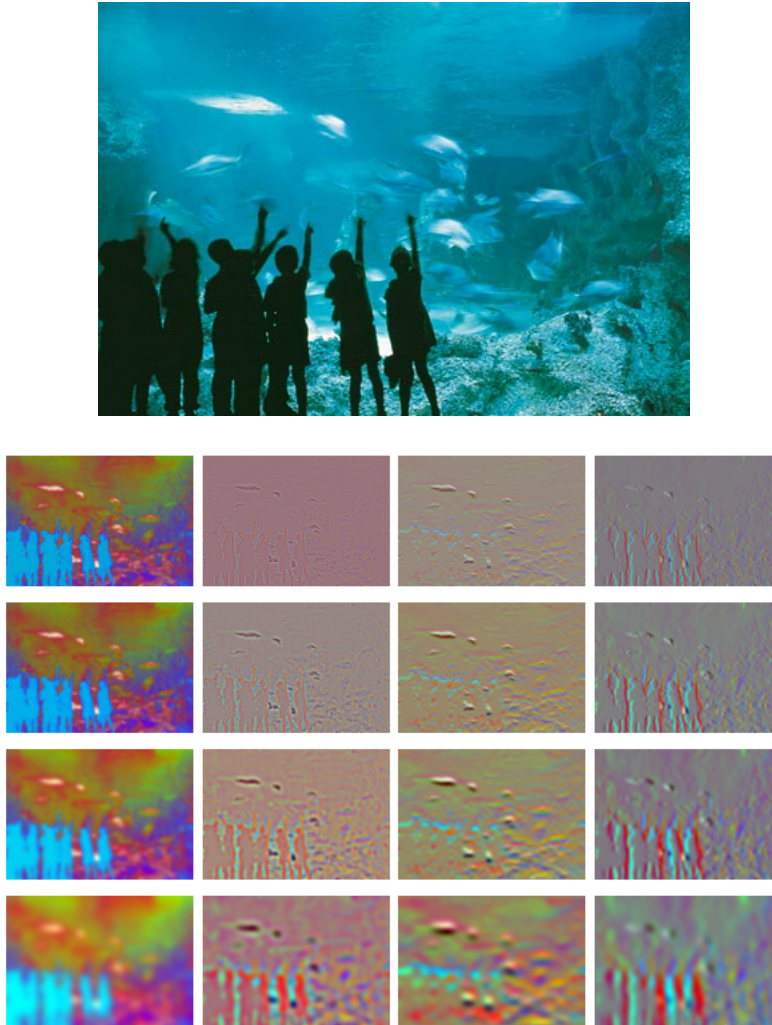The feature scales parameter is set as [1, 2, 4, 8].

Figure 1: Input image and filter responses in Lab colorization of the Gaussian, Laplacian of Gaussian, derivative of Gaussian in the x-direction, and derivative of Gaussian in the y-direction at [1, 2, 4, 8] scales

Q1.3

The parameters used for this section and for creating the dictionary are as follows (i.e. they are left on default):

- filter-scales = [1, 2]

- K = 10

- alpha = 25

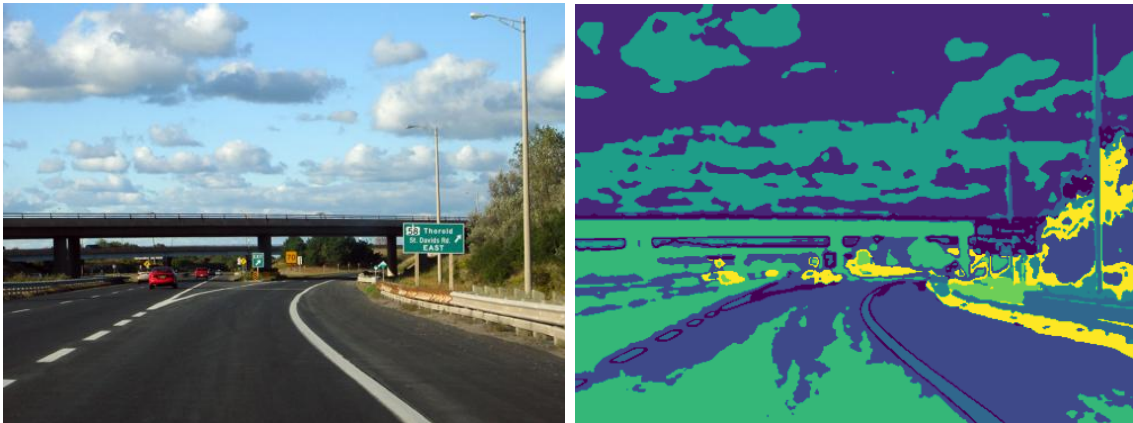Figure 2: RGB image and wordmap image for sun_aasmevtpkslccptd.jpg

Figure 3: RGB image and wordmap image for sun_bacfwopdcsewxkne.jpg

The "word" boundaries generally correspond to regions where the features vary drastically (texture, shading, color, tone, contours, etc). This makes sense intuitively as a visual word for asphalt would be very different than the visual word for clouds as they should belong to separate clusters in a well trained bag-of-words dictionary. As such, as we approach the boundary pixels between these two distinct features, we should see a color change in the corresponding wordmap, signifying a transition from one visual word to another.

Figure 4: RGB image and wordmap image for sun_bqpgzqwdglfssiyq.jpg

However, since we only set the visual words parameter (K) to 10, some features are not distinguished by the wordmap. An example would be the forward facing side of the background dune in Figure 4. Presumably due to the similar texture and color of the dune with its surrounding environment, the wordmap is not able to distinguish it with its background (i.e. sky). Such problems could potentially be solved by tuning hyper-parameters (such as increasing K) so that separate visual words are allocated to the notions of 'sky' and 'sand'.

Q2.5

The parameters used are as follows (i.e. they are left on default):

- filter-scales $= [1, 2]$

- $K = 10$

- alpha $= 25$

- $L = 1$

Confusion Matrix:

$$
\begin{bmatrix}
31 & 1 & 2 & 3 & 1 & 3 & 5 & 4 \\
0 & 29 & 4 & 6 & 4 & 0 & 3 & 4 \\
1 & 5 & 31 & 1 & 3 & 1 & 0 & 8 \\
3 & 2 & 3 & 30 & 9 & 1 & 1 & 1 \\
3 & 2 & 1 & 12 & 23 & 4 & 4 & 1 \\
2 & 1 & 5 & 1 & 2 & 31 & 4 & 4 \\
6 & 1 & 1 & 1 & 6 & 11 & 21 & 3 \\
4 & 6 & 4 & 0 & 2 & 7 & 6 & 21
\end{bmatrix}
$$

Accuracy: 0.5425 (54.25%)

Q2.6

From the confusion matrix, the classes that are most difficult to classify are the laundromat, waterfall, and windmill classes. They are only classified correctly 46%, 42%, and 42% of the time respectively. Some potential reasons are discussed below:

For the laundromat class, it is often (24% of the time) incorrectly classified as the kitchen class. This could be potentially due to the similar lighting and color textures of the two classes (i.e. indoor lighting, white or wooden walls). The similarity of the features is most likely the leading cause of the high number of incorrect classifications.

Figure 5: Similar color textures for laundromat and kitchen images could lead to incorrect classifications

For the waterfall class, 22% are incorrectly classified as being in the park class. One potential reason for this could be that both waterfalls and parks often have features related to water. The color and texture of these features are often very similar, thus resulting in incorrect classifications.

Figure 6: Similar water features for park and waterfall images could lead to incorrect classifications

For the windmill class, there is no class that is particularly prone to being misclassified as. A potential reason for this could be that different background features vary for each image in the image dataset. Some common examples includes grass backgrounds (which could be misclassified as a park class), water backgrounds (which could be misclassified as a waterfall class), road backgrounds (which could be misclassified as a highway class), etc. The variety of interesting features both in the background other than the windmill is mostly likely the reason for the high misclassification rate.

Figure 7: Variety of background features (such as grass, road, water, etc) could lead to incorrect classifications

Q3.1

The function `custom.tune_hyperparams(opts, n_worker)` is implemented that loops over a set of potential hyper-parameters and returns a combination of optimal parameters in the set that maximizes the overall accuracy on the test dataset. Using `filter_scales = [1, 2]`, `K = 160`, `alpha = 50`, and `L = 3`, we were able to achieve an accuracy of 0.695.

An ablation study of some major steps are described below. The results from running `custom.tune_hyperparams(opts, n_worker)` is included in the appendix.

Step	Parameter Changes	Expectation/Result	Accuracy
0	`filter_scales = [1, 2]`, `K = 10`, `alpha = 25`, `L = 1`	Default Parameters	0.5425
1	Increased alpha to 200	Increase accuracy	0.545
2	Increased K to 80	Increase accuracy	0.595
3	Increased L to 3	Increase accuracy	0.6575
4	Changed `filter_scales` to `[1, 2, 4]`	No change in accuracy	0.6575
n	Tuned parameters to be `filter_scales = [1, 2]`, `K = 160`, `alpha = 50`, `L = 3`	Optimal accuracy	0.695

Some observations while tuning the hyper-parameters were noted:

- Increasing `filter_scales` from `[1, 2]` to `[1, 2, 4]` tends to increase accuracy (albeit not by a lot), holding the other parameters constant. We expect this to be the case since increasing the number of filter scales allows us to focus on features at different scales. Some more coarse-grained features may not be apparent at fine-grained scales, and vice versa. However, increasing `filter_scales` to `[1, 2, 4, 8]` did not have a noticeable effect on the accuracy. One potential reason could be that the images tend to be of low resolution. Convoluting the images by such a coarse filter may just be too blurry and not give us additional information. In fact, the `filer_scales` parameter was not as effective in determining the accuracy, with the optimal parameters only using `filter_scales` of `[1, 2]`.

- Increasing `K` in general tends to increase accuracy, holding all else constant. The `K` hyper-parameter seems to be the most effective parameter in determining accuracy. This is to be expected since increasing the number of visual words means that a wordmap is more rich in information. As such, more distinct features may be segregated into different bins (e.g. water and sky might now have different visual words rather than being clumped into a "blue feature"), thus making the wordmap histograms more informative and increasing accuracy.

- Increasing `alpha` in general also tends to increase accuracy, holding all else constant. Although this increase is not as significant as increasing `K`. Again, this is to be expected

as increasing `alpha` increases the amount of data fed to generate the visual word dictionary. To save memory space, a low `alpha` essentially only uses a small randomly selected portion of each image to generate the dictionary. Information is lost during this process, thus rendering the dictionary less accurate. Dropping less pixels (increasing `alpha`) results in less information loss, thus resulting in a more accurate dictionary and increasing accuracy. There seems to be a cutoff at around `alpha = 100` where further increases in `alpha` did not increase accuracy. This is probably because a random subset of around 100 pixels is enough information regarding the features of an image.

- Increasing `L` from `1` to `3` in general tends to increase accuracy. This is to be expected as partitioning the image into finer sub-images can feed spatial information to the otherwise non-spatial bag-of-words histogram. This allows the model to better differentiate between spatial features, thus increasing accuracy.

Q3.2

Speed:

1. I noticed a significant bottleneck in the training time of the model was on building the recognition system. Therefore, I improved on the efficiency by parallelizing the function `visual_recog.build_recognition_system(opts, n_worker)` using `multiprocessing.Pool` and also creating `get_image_feature_parallel(args)` as a parallelized version of `get_image_feature(opts, img_path, dictionary)`.

2. Since my computer has 8 CPU cores, I expect that the parallelized version would increase the speed of building the recognition system and decrease the bottleneck for training the model.

3. I noticed around a 40% to 50% reduction in the time needed to train and build the recognition system. `visual_words.compute_dictionary(opts, n_worker)` was similarly parallelized, although its speedup effect is not very noticeable.

Accuracy:

1. I subtracted the mean color in each image channel during preprocessing before extracting its features.

2. I expect that the overall accuracy would increase as subtracting the mean color in each image channel would make objects stand out more compared to its background. In particular, I expect that this would decrease the misclassification rate for the windmill class as the various background features (such as grass, road, water, etc) would become less pronounced after subtracting the mean color, thus making the windmill feature more noticeable.

3. Using `filter_scales = [1, 2]`, `K = 160`, `alpha = 50`, and `L = 3`. What actually happened was that the accuracy actually decreased from 0.695 to 0.625. The misclassification rate for almost all classes increased instead of decreasing. This was contrary to what I expected. Perhaps an explanation for this could be that subtracting the mean color in each image channel in actuality may not cause features to stand out more compared to their background.

Appendix

Results from running `custom.tune_hyperparams(opts, n_worker)`:

```
Running on hyperparameters: filter-scale: [1, 2], K: 10, alpha: 25, L: 1 achieved
an accuracy of 0.545
Running on hyperparameters: filter-scale: [1, 2], K: 10, alpha: 25, L: 2 achieved
an accuracy of 0.53
Running on hyperparameters: filter-scale: [1, 2], K: 10, alpha: 25, L: 3 achieved
an accuracy of 0.605
Running on hyperparameters: filter-scale: [1, 2], K: 10, alpha: 50, L: 1 achieved
an accuracy of 0.5575
Running on hyperparameters: filter-scale: [1, 2], K: 10, alpha: 50, L: 2 achieved
an accuracy of 0.5525
Running on hyperparameters: filter-scale: [1, 2], K: 10, alpha: 50, L: 3 achieved
an accuracy of 0.55
Running on hyperparameters: filter-scale: [1, 2], K: 10, alpha: 100, L: 1 achieved
an accuracy of 0.535
Running on hyperparameters: filter-scale: [1, 2], K: 10, alpha: 100, L: 2 achieved
an accuracy of 0.5475
Running on hyperparameters: filter-scale: [1, 2], K: 10, alpha: 100, L: 3 achieved
an accuracy of 0.545
Running on hyperparameters: filter-scale: [1, 2], K: 10, alpha: 200, L: 1 achieved
an accuracy of 0.535
Running on hyperparameters: filter-scale: [1, 2], K: 10, alpha: 200, L: 2 achieved
an accuracy of 0.5625
Running on hyperparameters: filter-scale: [1, 2], K: 10, alpha: 200, L: 3 achieved
an accuracy of 0.595
Running on hyperparameters: filter-scale: [1, 2], K: 20, alpha: 25, L: 1 achieved
an accuracy of 0.62
Running on hyperparameters: filter-scale: [1, 2], K: 20, alpha: 25, L: 2 achieved
an accuracy of 0.6025
Running on hyperparameters: filter-scale: [1, 2], K: 20, alpha: 25, L: 3 achieved
an accuracy of 0.6075
Running on hyperparameters: filter-scale: [1, 2], K: 20, alpha: 50, L: 1 achieved
an accuracy of 0.59
Running on hyperparameters: filter-scale: [1, 2], K: 20, alpha: 50, L: 2 achieved
an accuracy of 0.5925
Running on hyperparameters: filter-scale: [1, 2], K: 20, alpha: 50, L: 3 achieved
an accuracy of 0.6125
Running on hyperparameters: filter-scale: [1, 2], K: 20, alpha: 100, L: 1 achieved
an accuracy of 0.555
Running on hyperparameters: filter-scale: [1, 2], K: 20, alpha: 100, L: 2 achieved
an accuracy of 0.62
Running on hyperparameters: filter-scale: [1, 2], K: 20, alpha: 100, L: 3 achieved
```

an accuracy of 0.64
Running on hyperparameters: filter-scale: [1, 2], K: 20, alpha: 200, L: 1 achieved
an accuracy of 0.5975
Running on hyperparameters: filter-scale: [1, 2], K: 20, alpha: 200, L: 2 achieved
an accuracy of 0.6325
Running on hyperparameters: filter-scale: [1, 2], K: 20, alpha: 200, L: 3 achieved
an accuracy of 0.6
Running on hyperparameters: filter-scale: [1, 2], K: 40, alpha: 25, L: 1 achieved
an accuracy of 0.625
Running on hyperparameters: filter-scale: [1, 2], K: 40, alpha: 25, L: 2 achieved
an accuracy of 0.6425
Running on hyperparameters: filter-scale: [1, 2], K: 40, alpha: 25, L: 3 achieved
an accuracy of 0.6425
Running on hyperparameters: filter-scale: [1, 2], K: 40, alpha: 50, L: 1 achieved
an accuracy of 0.63
Running on hyperparameters: filter-scale: [1, 2], K: 40, alpha: 50, L: 2 achieved
an accuracy of 0.67
Running on hyperparameters: filter-scale: [1, 2], K: 40, alpha: 50, L: 3 achieved
an accuracy of 0.6575
Running on hyperparameters: filter-scale: [1, 2], K: 40, alpha: 100, L: 1 achieved
an accuracy of 0.6325
Running on hyperparameters: filter-scale: [1, 2], K: 40, alpha: 100, L: 2 achieved
an accuracy of 0.65
Running on hyperparameters: filter-scale: [1, 2], K: 40, alpha: 100, L: 3 achieved
an accuracy of 0.6625
Running on hyperparameters: filter-scale: [1, 2], K: 40, alpha: 200, L: 1 achieved
an accuracy of 0.63
Running on hyperparameters: filter-scale: [1, 2], K: 40, alpha: 200, L: 2 achieved
an accuracy of 0.6375
Running on hyperparameters: filter-scale: [1, 2], K: 40, alpha: 200, L: 3 achieved
an accuracy of 0.6425
Running on hyperparameters: filter-scale: [1, 2], K: 80, alpha: 25, L: 1 achieved
an accuracy of 0.6175
Running on hyperparameters: filter-scale: [1, 2], K: 80, alpha: 25, L: 2 achieved
an accuracy of 0.6625
Running on hyperparameters: filter-scale: [1, 2], K: 80, alpha: 25, L: 3 achieved
an accuracy of 0.655
Running on hyperparameters: filter-scale: [1, 2], K: 80, alpha: 50, L: 1 achieved
an accuracy of 0.635
Running on hyperparameters: filter-scale: [1, 2], K: 80, alpha: 50, L: 2 achieved
an accuracy of 0.665
Running on hyperparameters: filter-scale: [1, 2], K: 80, alpha: 50, L: 3 achieved
an accuracy of 0.66
Running on hyperparameters: filter-scale: [1, 2], K: 80, alpha: 100, L: 1 achieved
an accuracy of 0.62

Running on hyperparameters: filter-scale: [1, 2], K: 80, alpha: 100, L: 2 achieved an accuracy of 0.6825
Running on hyperparameters: filter-scale: [1, 2], K: 80, alpha: 100, L: 3 achieved an accuracy of 0.6425
Running on hyperparameters: filter-scale: [1, 2], K: 80, alpha: 200, L: 1 achieved an accuracy of 0.61
Running on hyperparameters: filter-scale: [1, 2], K: 80, alpha: 200, L: 2 achieved an accuracy of 0.66
Running on hyperparameters: filter-scale: [1, 2], K: 80, alpha: 200, L: 3 achieved an accuracy of 0.6375
Running on hyperparameters: filter-scale: [1, 2], K: 160, alpha: 25, L: 1 achieved an accuracy of 0.6575
Running on hyperparameters: filter-scale: [1, 2], K: 160, alpha: 25, L: 2 achieved an accuracy of 0.69
Running on hyperparameters: filter-scale: [1, 2], K: 160, alpha: 25, L: 3 achieved an accuracy of 0.665
Running on hyperparameters: filter-scale: [1, 2], K: 160, alpha: 50, L: 1 achieved an accuracy of 0.6175
Running on hyperparameters: filter-scale: [1, 2], K: 160, alpha: 50, L: 2 achieved an accuracy of 0.6775
Running on hyperparameters: filter-scale: [1, 2], K: 160, alpha: 50, L: 3 achieved an accuracy of 0.695
Running on hyperparameters: filter-scale: [1, 2], K: 160, alpha: 100, L: 1 achieved an accuracy of 0.6325
Running on hyperparameters: filter-scale: [1, 2], K: 160, alpha: 100, L: 2 achieved an accuracy of 0.68
Running on hyperparameters: filter-scale: [1, 2], K: 160, alpha: 100, L: 3 achieved an accuracy of 0.665
Running on hyperparameters: filter-scale: [1, 2], K: 160, alpha: 200, L: 1 achieved an accuracy of 0.64
Running on hyperparameters: filter-scale: [1, 2], K: 160, alpha: 200, L: 2 achieved an accuracy of 0.65
Running on hyperparameters: filter-scale: [1, 2], K: 160, alpha: 200, L: 3 achieved an accuracy of 0.6675
Running on hyperparameters: filter-scale: [1, 2, 4], K: 10, alpha: 25, L: 1 achieved an accuracy of 0.5375
Running on hyperparameters: filter-scale: [1, 2, 4], K: 10, alpha: 25, L: 2 achieved an accuracy of 0.555
Running on hyperparameters: filter-scale: [1, 2, 4], K: 10, alpha: 25, L: 3 achieved an accuracy of 0.545
Running on hyperparameters: filter-scale: [1, 2, 4], K: 10, alpha: 50, L: 1 achieved an accuracy of 0.5225
Running on hyperparameters: filter-scale: [1, 2, 4], K: 10, alpha: 50, L: 2 achieved an accuracy of 0.5425
Running on hyperparameters: filter-scale: [1, 2, 4], K: 10, alpha: 50, L: 3 achieved

an accuracy of 0.585
Running on hyperparameters: filter-scale: [1, 2, 4], K: 10, alpha: 100, L: 1 achieved
an accuracy of 0.5425
Running on hyperparameters: filter-scale: [1, 2, 4], K: 10, alpha: 100, L: 2 achieved
an accuracy of 0.535
Running on hyperparameters: filter-scale: [1, 2, 4], K: 10, alpha: 100, L: 3 achieved
an accuracy of 0.54
Running on hyperparameters: filter-scale: [1, 2, 4], K: 10, alpha: 200, L: 1 achieved
an accuracy of 0.555
Running on hyperparameters: filter-scale: [1, 2, 4], K: 10, alpha: 200, L: 2 achieved
an accuracy of 0.5325
Running on hyperparameters: filter-scale: [1, 2, 4], K: 10, alpha: 200, L: 3 achieved
an accuracy of 0.54
Running on hyperparameters: filter-scale: [1, 2, 4], K: 20, alpha: 25, L: 1 achieved
an accuracy of 0.5825
Running on hyperparameters: filter-scale: [1, 2, 4], K: 20, alpha: 25, L: 2 achieved
an accuracy of 0.5975
Running on hyperparameters: filter-scale: [1, 2, 4], K: 20, alpha: 25, L: 3 achieved
an accuracy of 0.655
Running on hyperparameters: filter-scale: [1, 2, 4], K: 20, alpha: 50, L: 1 achieved
an accuracy of 0.55
Running on hyperparameters: filter-scale: [1, 2, 4], K: 20, alpha: 50, L: 2 achieved
an accuracy of 0.6075
Running on hyperparameters: filter-scale: [1, 2, 4], K: 20, alpha: 50, L: 3 achieved
an accuracy of 0.6475
Running on hyperparameters: filter-scale: [1, 2, 4], K: 20, alpha: 100, L: 1 achieved
an accuracy of 0.605
Running on hyperparameters: filter-scale: [1, 2, 4], K: 20, alpha: 100, L: 2 achieved
an accuracy of 0.605
Running on hyperparameters: filter-scale: [1, 2, 4], K: 20, alpha: 100, L: 3 achieved
an accuracy of 0.6225
Running on hyperparameters: filter-scale: [1, 2, 4], K: 20, alpha: 200, L: 1 achieved
an accuracy of 0.56
Running on hyperparameters: filter-scale: [1, 2, 4], K: 20, alpha: 200, L: 2 achieved
an accuracy of 0.6
Running on hyperparameters: filter-scale: [1, 2, 4], K: 20, alpha: 200, L: 3 achieved
an accuracy of 0.605
Running on hyperparameters: filter-scale: [1, 2, 4], K: 40, alpha: 25, L: 1 achieved
an accuracy of 0.62
Running on hyperparameters: filter-scale: [1, 2, 4], K: 40, alpha: 25, L: 2 achieved
an accuracy of 0.64
Running on hyperparameters: filter-scale: [1, 2, 4], K: 40, alpha: 25, L: 3 achieved
an accuracy of 0.6325
Running on hyperparameters: filter-scale: [1, 2, 4], K: 40, alpha: 50, L: 1 achieved
an accuracy of 0.63

Running on hyperparameters: filter-scale: [1, 2, 4], K: 40, alpha: 50, L: 2 achieved an accuracy of 0.6575
Running on hyperparameters: filter-scale: [1, 2, 4], K: 40, alpha: 50, L: 3 achieved an accuracy of 0.6625
Running on hyperparameters: filter-scale: [1, 2, 4], K: 40, alpha: 100, L: 1 achieved an accuracy of 0.6325
Running on hyperparameters: filter-scale: [1, 2, 4], K: 40, alpha: 100, L: 2 achieved an accuracy of 0.6675
Running on hyperparameters: filter-scale: [1, 2, 4], K: 40, alpha: 100, L: 3 achieved an accuracy of 0.6575
Running on hyperparameters: filter-scale: [1, 2, 4], K: 40, alpha: 200, L: 1 achieved an accuracy of 0.6075
Running on hyperparameters: filter-scale: [1, 2, 4], K: 40, alpha: 200, L: 2 achieved an accuracy of 0.6325
Running on hyperparameters: filter-scale: [1, 2, 4], K: 40, alpha: 200, L: 3 achieved an accuracy of 0.6425
Running on hyperparameters: filter-scale: [1, 2, 4], K: 80, alpha: 25, L: 1 achieved an accuracy of 0.6425
Running on hyperparameters: filter-scale: [1, 2, 4], K: 80, alpha: 25, L: 2 achieved an accuracy of 0.675
Running on hyperparameters: filter-scale: [1, 2, 4], K: 80, alpha: 25, L: 3 achieved an accuracy of 0.67
Running on hyperparameters: filter-scale: [1, 2, 4], K: 80, alpha: 50, L: 1 achieved an accuracy of 0.61
Running on hyperparameters: filter-scale: [1, 2, 4], K: 80, alpha: 50, L: 2 achieved an accuracy of 0.645
Running on hyperparameters: filter-scale: [1, 2, 4], K: 80, alpha: 50, L: 3 achieved an accuracy of 0.65
Running on hyperparameters: filter-scale: [1, 2, 4], K: 80, alpha: 100, L: 1 achieved an accuracy of 0.6325
Running on hyperparameters: filter-scale: [1, 2, 4], K: 80, alpha: 100, L: 2 achieved an accuracy of 0.6525
Running on hyperparameters: filter-scale: [1, 2, 4], K: 80, alpha: 100, L: 3 achieved an accuracy of 0.66
Running on hyperparameters: filter-scale: [1, 2, 4], K: 80, alpha: 200, L: 1 achieved an accuracy of 0.6225
Running on hyperparameters: filter-scale: [1, 2, 4], K: 80, alpha: 200, L: 2 achieved an accuracy of 0.6675
Running on hyperparameters: filter-scale: [1, 2, 4], K: 80, alpha: 200, L: 3 achieved an accuracy of 0.6575
Running on hyperparameters: filter-scale: [1, 2, 4], K: 160, alpha: 25, L: 1 achieved an accuracy of 0.595
Running on hyperparameters: filter-scale: [1, 2, 4], K: 160, alpha: 25, L: 2 achieved an accuracy of 0.645
Running on hyperparameters: filter-scale: [1, 2, 4], K: 160, alpha: 25, L: 3 achieved

an accuracy of 0.6525
Running on hyperparameters: filter-scale: [1, 2, 4], K: 160, alpha: 50, L: 1 achieved
an accuracy of 0.615
Running on hyperparameters: filter-scale: [1, 2, 4], K: 160, alpha: 50, L: 2 achieved
an accuracy of 0.65
Running on hyperparameters: filter-scale: [1, 2, 4], K: 160, alpha: 50, L: 3 achieved
an accuracy of 0.6325
Running on hyperparameters: filter-scale: [1, 2, 4], K: 160, alpha: 100, L: 1
achieved an accuracy of 0.62
Running on hyperparameters: filter-scale: [1, 2, 4], K: 160, alpha: 100, L: 2
achieved an accuracy of 0.6725
Running on hyperparameters: filter-scale: [1, 2, 4], K: 160, alpha: 100, L: 3
achieved an accuracy of 0.6525
Running on hyperparameters: filter-scale: [1, 2, 4], K: 160, alpha: 200, L: 1
achieved an accuracy of 0.63
Running on hyperparameters: filter-scale: [1, 2, 4], K: 160, alpha: 200, L: 2
achieved an accuracy of 0.65
Running on hyperparameters: filter-scale: [1, 2, 4], K: 160, alpha: 200, L: 3
achieved an accuracy of 0.69
Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 10, alpha: 25, L: 1
achieved an accuracy of 0.49
Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 10, alpha: 25, L: 2
achieved an accuracy of 0.5275
Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 10, alpha: 25, L: 3
achieved an accuracy of 0.5825
Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 10, alpha: 50, L: 1
achieved an accuracy of 0.465
Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 10, alpha: 50, L: 2
achieved an accuracy of 0.59
Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 10, alpha: 50, L: 3
achieved an accuracy of 0.5325
Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 10, alpha: 100, L:
1 achieved an accuracy of 0.5425
Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 10, alpha: 100, L:
2 achieved an accuracy of 0.5675
Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 10, alpha: 100, L:
3 achieved an accuracy of 0.5275
Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 10, alpha: 200, L:
1 achieved an accuracy of 0.54
Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 10, alpha: 200, L:
2 achieved an accuracy of 0.5875
Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 10, alpha: 200, L:
3 achieved an accuracy of 0.5575
Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 20, alpha: 25, L: 1
achieved an accuracy of 0.565

Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 20, alpha: 25, L: 2 achieved an accuracy of 0.5875

Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 20, alpha: 25, L: 3 achieved an accuracy of 0.5975

Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 20, alpha: 50, L: 1 achieved an accuracy of 0.5675

Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 20, alpha: 50, L: 2 achieved an accuracy of 0.5975

Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 20, alpha: 50, L: 3 achieved an accuracy of 0.595

Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 20, alpha: 100, L: 1 achieved an accuracy of 0.5975

Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 20, alpha: 100, L: 2 achieved an accuracy of 0.6125

Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 20, alpha: 100, L: 3 achieved an accuracy of 0.6075

Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 20, alpha: 200, L: 1 achieved an accuracy of 0.555

Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 20, alpha: 200, L: 2 achieved an accuracy of 0.5825

Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 20, alpha: 200, L: 3 achieved an accuracy of 0.6

Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 40, alpha: 25, L: 1 achieved an accuracy of 0.6375

Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 40, alpha: 25, L: 2 achieved an accuracy of 0.6675

Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 40, alpha: 25, L: 3 achieved an accuracy of 0.64

Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 40, alpha: 50, L: 1 achieved an accuracy of 0.6325

Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 40, alpha: 50, L: 2 achieved an accuracy of 0.615

Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 40, alpha: 50, L: 3 achieved an accuracy of 0.63

Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 40, alpha: 100, L: 1 achieved an accuracy of 0.6275

Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 40, alpha: 100, L: 2 achieved an accuracy of 0.6575

Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 40, alpha: 100, L: 3 achieved an accuracy of 0.65

Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 40, alpha: 200, L: 1 achieved an accuracy of 0.6175

Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 40, alpha: 200, L: 2 achieved an accuracy of 0.65

Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 40, alpha: 200, L:

3 achieved an accuracy of 0.6525
Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 80, alpha: 25, L: 1
achieved an accuracy of 0.6225
Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 80, alpha: 25, L: 2
achieved an accuracy of 0.6575
Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 80, alpha: 25, L: 3
achieved an accuracy of 0.625
Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 80, alpha: 50, L: 1
achieved an accuracy of 0.6075
Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 80, alpha: 50, L: 2
achieved an accuracy of 0.6375
Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 80, alpha: 50, L: 3
achieved an accuracy of 0.65
Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 80, alpha: 100, L:
1 achieved an accuracy of 0.61
Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 80, alpha: 100, L:
2 achieved an accuracy of 0.645
Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 80, alpha: 100, L:
3 achieved an accuracy of 0.665
Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 80, alpha: 200, L:
1 achieved an accuracy of 0.6025
Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 80, alpha: 200, L:
2 achieved an accuracy of 0.6625
Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 80, alpha: 200, L:
3 achieved an accuracy of 0.6475
Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 160, alpha: 25, L:
1 achieved an accuracy of 0.6
Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 160, alpha: 25, L:
2 achieved an accuracy of 0.6375
Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 160, alpha: 25, L:
3 achieved an accuracy of 0.685
Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 160, alpha: 50, L:
1 achieved an accuracy of 0.645
Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 160, alpha: 50, L:
2 achieved an accuracy of 0.6375
Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 160, alpha: 50, L:
3 achieved an accuracy of 0.6675
Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 160, alpha: 100, L:
1 achieved an accuracy of 0.6575
Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 160, alpha: 100, L:
2 achieved an accuracy of 0.6725
Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 160, alpha: 100, L:
3 achieved an accuracy of 0.665
Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 160, alpha: 200, L:
1 achieved an accuracy of 0.625

Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 160, alpha: 200, L: 2 achieved an accuracy of 0.655
Running on hyperparameters: filter-scale: [1, 2, 4, 8], K: 160, alpha: 200, L: 3 achieved an accuracy of 0.68