**Q1.1.1**

The features extracted by each of the filters are:

* **Gaussians**: This filters pickups the prominent features of the image by blurring out the less prominent ones, effectively extracting useful information and removing noise.
* **Laplacian of Gaussians**: This filter sharpens the gaussian blurred image, which extracts the significant edges in the image. If we directly used Laplacian, insignificant edges will also be extracted.
* **Gaussian Derivatives in x direction**: This filter will bring out the prominent contour changes along the x direction.
* **Gaussian Derivatives in y direction**: This filter will bring out the prominent contour changes along the y direction.

We need multiple scales of filters to control the amount of feature extraction from the images. For instance, a higher scale gaussian will blur out more features than a lower scale one. The more prominent ones will remain through all scales and thus, should be given more weightage.

**Q 1.1.2**

A collage of different colored squares

Description automatically generated

Filters = [Gaussian, Laplacian of Gaussian, Gaussian derivative in x direction, Gaussian derivative in y direction] {in x-direction}

Filter Scales = [1, 3, 5] {in y-direction}

**Q 1.3**

A kitchen with a heater

Description automatically generated with medium confidence

A green and blue background

Description automatically generated with medium confidence

A colorful image of a laundry machine

Description automatically generated

**Q 2.5**

**Confusion Matrix:**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Index** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** |
| **0** | 40 | 0 | 0 | 1 | 3 | 0 | 3 | 3 |
| **1** | 0 | 28 | 5 | 7 | 2 | 2 | 2 | 4 |
| **2** | 2 | 4 | 27 | 4 | 0 | 4 | 0 | 9 |
| **3** | 0 | 1 | 0 | 37 | 10 | 0 | 2 | 0 |
| **4** | 0 | 0 | 1 | 14 | 26 | 2 | 7 | 0 |
| **5** | 4 | 0 | 2 | 1 | 0 | 39 | 1 | 3 |
| **6** | 2 | 0 | 0 | 2 | 4 | 5 | 35 | 2 |
| **7** | 1 | 3 | 9 | 2 | 0 | 4 | 0 | 31 |

**Accuracy Value:**

0.6575

**Q2.6**

As seen in the confusion matrix, the kitchen (index 3) and the laundromat (index 4) have a high inaccuracy rate.

A kitchen with white cabinets and a refrigerator

Description automatically generated A multicolored image of a kitchen

Description automatically generated

A laundry room with a few washing machines

Description automatically generated A room with many objects

Description automatically generated with medium confidence

As shown above, both images have a very similar wordmap despite belonging to different classes. This is due to the similarities of the visual words such as the ‘rectangular white boxes. The boxes can be both kitchen cabinets and laundry machines.

**Q 3.1 Ablation Study**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S. No.** | **K** | **L** | **Alpha** | **Scales** | **Accuracy** | **Comment** |
| 1 | 10 | 1 | 25 | 2 | 0.4025 | Default Values |
| 2 | 10 | 3 | 25 | 2 | 0.5025 | Improved accuracy |
| 3 | 10 | 2 | 25 | 2 | 0.4475 | Reduced Accuracy |
| 4 | 50 | 2 | 25 | 2 | 0.605 | Improved Accuracy |
| 5 | 100 | 3 | 25 | 2 | 0.655 | Improved Accuracy |
| 6 | 100 | 2 | 35 | 2 | 0.6425 | Reduced Accuracy |
| 7 | 100 | 2 | 45 | 2 | 0.655 | Improved Accuracy |
| 8 | 100 | 2 | 35 | 3 | 0.6425 | Reduced Accuracy |
| 9 | 100 | 2 | 35 | 4 | 0.6425 | No effect |
| 10 | 100 | 2 | 25 | 2 | 0.6575 | Best result |

The given hyperparameters change the system accuracy by:

1. **K** – affects the number of visual words found. Directly improves accuracy with increasing value. Optimal value - 100
2. **L** – affects the number of layers done in spatial mapping. Causes better localization of visual words which improves accuracy. Optimal Value - 2
3. **Alpha** – affects the number of pixels sampled. Choosing a higher alpha will minutely improve accuracy while increasing compute exponentially. Optimal value - 25
4. **Scales** – affects the amount of feature extraction. As the images are being sampled randomly, the scale does not cause a huge difference. However, a high change in scale value does extract more features.