

Assignment-1 (CS-699)

Report

Group-1

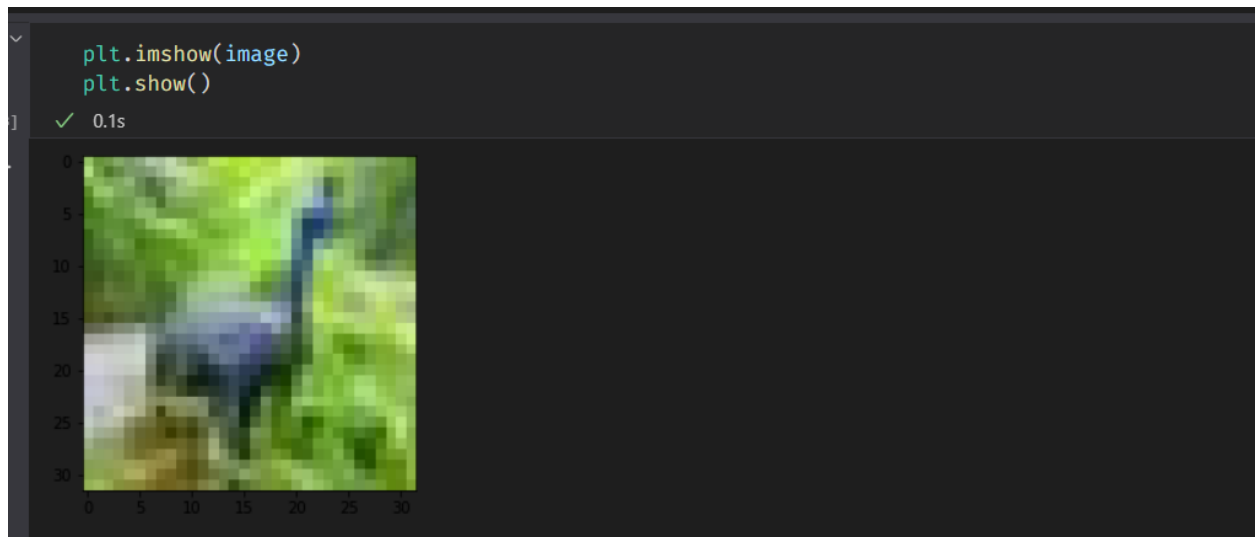
Saatvik Chugh (b18084)

Ishaan Dahiya (b18059)

Task 1

Test Image: 0000.jpg

Image dimensions = (32 x 32 x 3)



Conversion to grayscale:

Image dimensions = (32 x 32)



Filter:

```
● print(kernel)
✓ 0.5s
```

```
[[ 0.06088911  0.09298086  0.08877179]
 [ 0.48708511 -0.27624761  0.02461258]
 [-0.53545182  0.3994453   -0.11256535]]
```

Image obtained from the convolution operation:

```
plt.imshow(convulated_image, cmap=plt.get_cmap('gray'))
plt.show()
✓ 0.1s
```



Convolved image dimensions:

```
print(convulated_image.shape)
✓ 0.3s
```

```
(30, 30)
```

Using the formula:

$$H1 = 32, W1 = 32, F = 3, S = 1, P = 0$$

$$H2 = \frac{H1 - F + 2P}{S} + 1$$

$$W2 = \frac{W1 - F + 2P}{S} + 1$$

$$H2 = 30, W2 = 30$$

Same as the calculated output.

Task 2

Image selected is same as task-1

Using the formula:

$$H2 = \frac{H1 - F + 2P}{S} + 1$$

$$W2 = \frac{W1 - F + 2P}{S} + 1$$

$$D2 = D1$$

```
conv_layer1 = ConvolutionLayer(3, 3, 3, 32)
conv_layer2 = ConvolutionLayer(3, 3, 32, 64)
```

[52] ✓ 0.3s

```
out1 = conv_layer1.forward(image)
a_out1 = relu(out1)
out2 = conv_layer2.forward(a_out1)
a_out2 = relu(out2)
```

[53] ✓ 0.7s

Layer-1

$H_1 = 32, W_1 = 32, D_1 = 3, S = 1, F = 3, P = 0$

$H_2 = 30, W_2 = 30, D_2 = 32$

```
print(a_out1.shape)
```

[56] ✓ 0.4s

... (30, 30, 32)

Layer-2

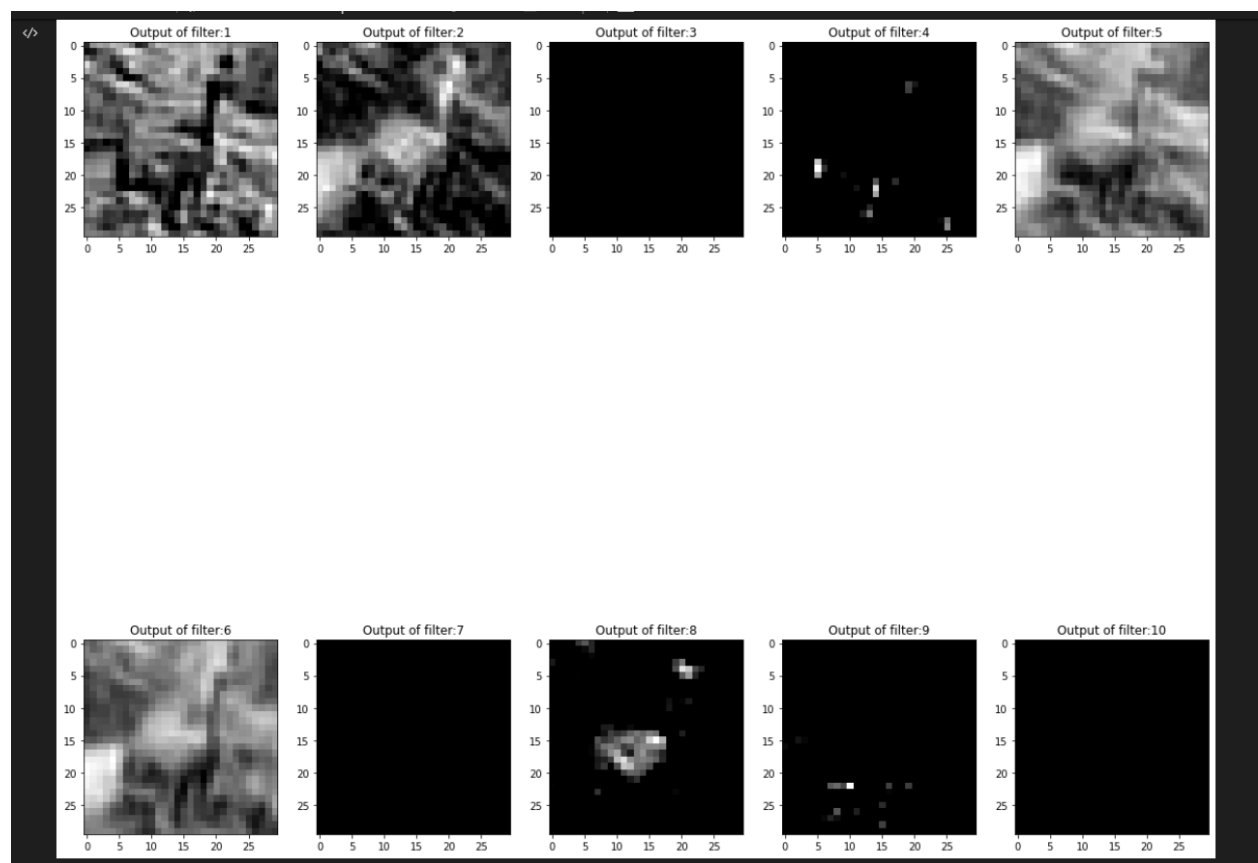
$H_1 = 30, W_1 = 30, D_1 = 32, S = 1, F = 3, P = 0$

$H_2 = 28, W_2 = 28, D_2 = 64$

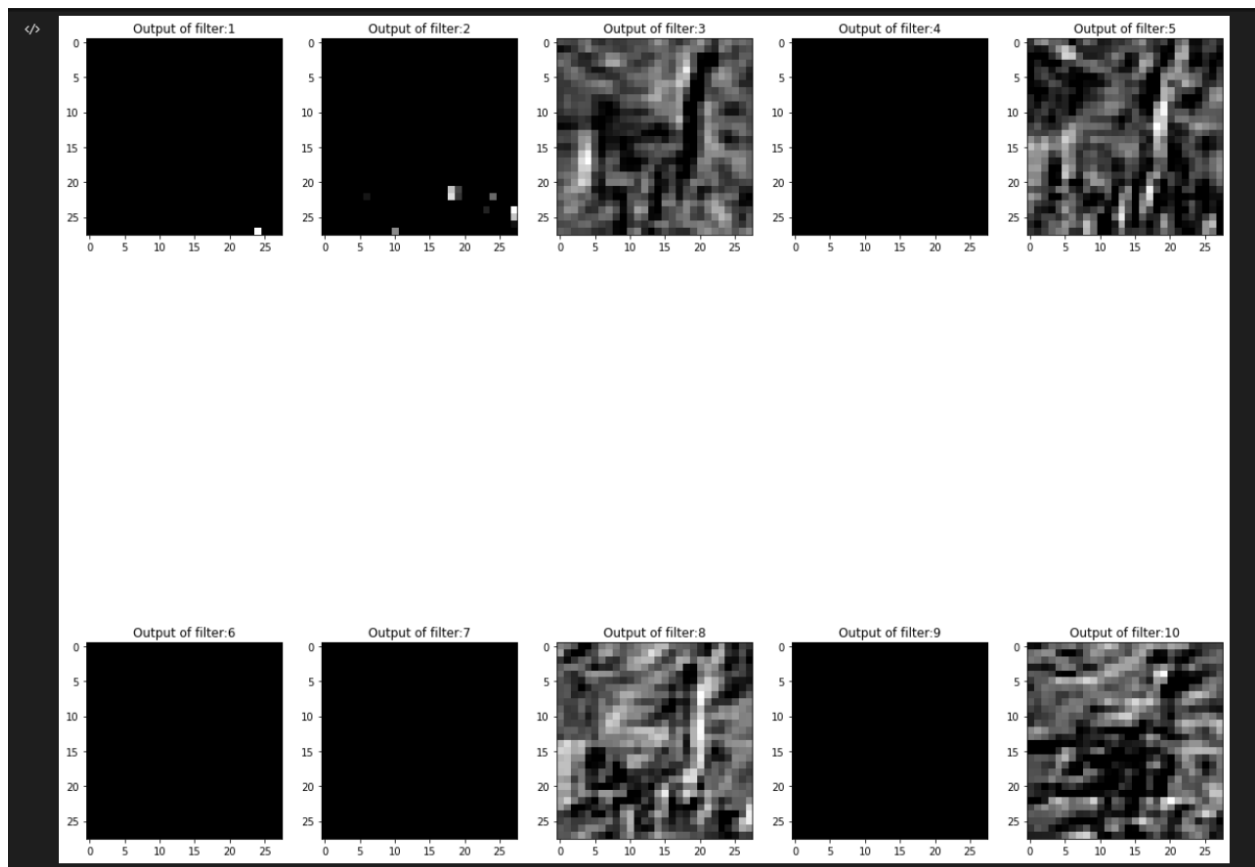
```
print(a_out2.shape)
[57] ✓ 0.6s
... (28, 28, 64)
```

Feature Maps of 10 selected filters

Layer-1



Layer-2



Observations

The filters of the CNN are used to extract useful information using the convolution operation on the inputs with the filters like edges etc.

Our initialised weights serve the same purpose but since they haven't been trained, they don't really seem to be extracting any useful information at this stage except for some filters like filters - 3, 5, 8, 10.

Wrt. dimensions The formula for calculating the dimensions of the output is verified.

Task 3

Training set: 600 images (200 images of each class)

Test set: 10 images (30 images of each class)

Model

Gradient Descent Used: **SGD**

Conv Layer 1 (K = 32, Activation fn = ReLu) →

Conv Layer 2 (K = 64, Activation fn = ReLu) → Max Pooling Layer →

Input Flatten → FCC Layer (with Softmax activation)

Epochs = 10

Activation function for convolution layer: **ReLu**

$$f(x) = x \text{ if } x \geq 0 \text{ else } 0$$

Activation function for dense layer: **Softmax**

$$f(x_c) = \frac{e^{x_c}}{\sum_{k=0}^3 e^{x_k}}$$

Loss function used: **Cross Entropy Loss**

$$L = -\log(p_c)$$

Weight Initialization:

Taken from normal distribution with standard deviation inversely proportional to the square root of the number of units.

Accuracy obtained:

[Step 1]: Average Loss 0.267	Accuracy: 100%
[Step 2]: Average Loss 0.778	Accuracy: 50%
[Step 3]: Average Loss 1.160	Accuracy: 33%
[Step 4]: Average Loss 1.208	Accuracy: 25%
[Step 5]: Average Loss 1.090	Accuracy: 40%
[Step 6]: Average Loss 1.150	Accuracy: 33%
[Step 7]: Average Loss 1.226	Accuracy: 28%
[Step 8]: Average Loss 1.195	Accuracy: 25%
[Step 9]: Average Loss 1.212	Accuracy: 22%
[Step 10]: Average Loss 1.159	Accuracy: 30%
[Step 11]: Average Loss 1.189	Accuracy: 27%
[Step 12]: Average Loss 1.156	Accuracy: 33%
[Step 13]: Average Loss 1.182	Accuracy: 30%
[Step 14]: Average Loss 1.218	Accuracy: 28%
[Step 15]: Average Loss 1.216	Accuracy: 26%
[Step 16]: Average Loss 1.185	Accuracy: 31%
[Step 17]: Average Loss 1.210	Accuracy: 29%
[Step 18]: Average Loss 1.178	Accuracy: 33%
[Step 19]: Average Loss 1.139	Accuracy: 36%
[Step 20]: Average Loss 1.152	Accuracy: 35%
[Step 21]: Average Loss 1.128	Accuracy: 38%
[Step 22]: Average Loss 1.092	Accuracy: 40%
[Step 23]: Average Loss 1.074	Accuracy: 43%
[Step 24]: Average Loss 1.044	Accuracy: 45%
[Step 25]: Average Loss 1.033	Accuracy: 48%
...	
[Step 26]: Average Loss 1.003	Accuracy: 50%
[Step 27]: Average Loss 0.991	Accuracy: 51%
[Step 28]: Average Loss 1.009	Accuracy: 50%
[Step 29]: Average Loss 0.984	Accuracy: 51%
[Step 30]: Average Loss 0.967	Accuracy: 53%

10 Filter outputs (feature maps) from the first convolution layer:

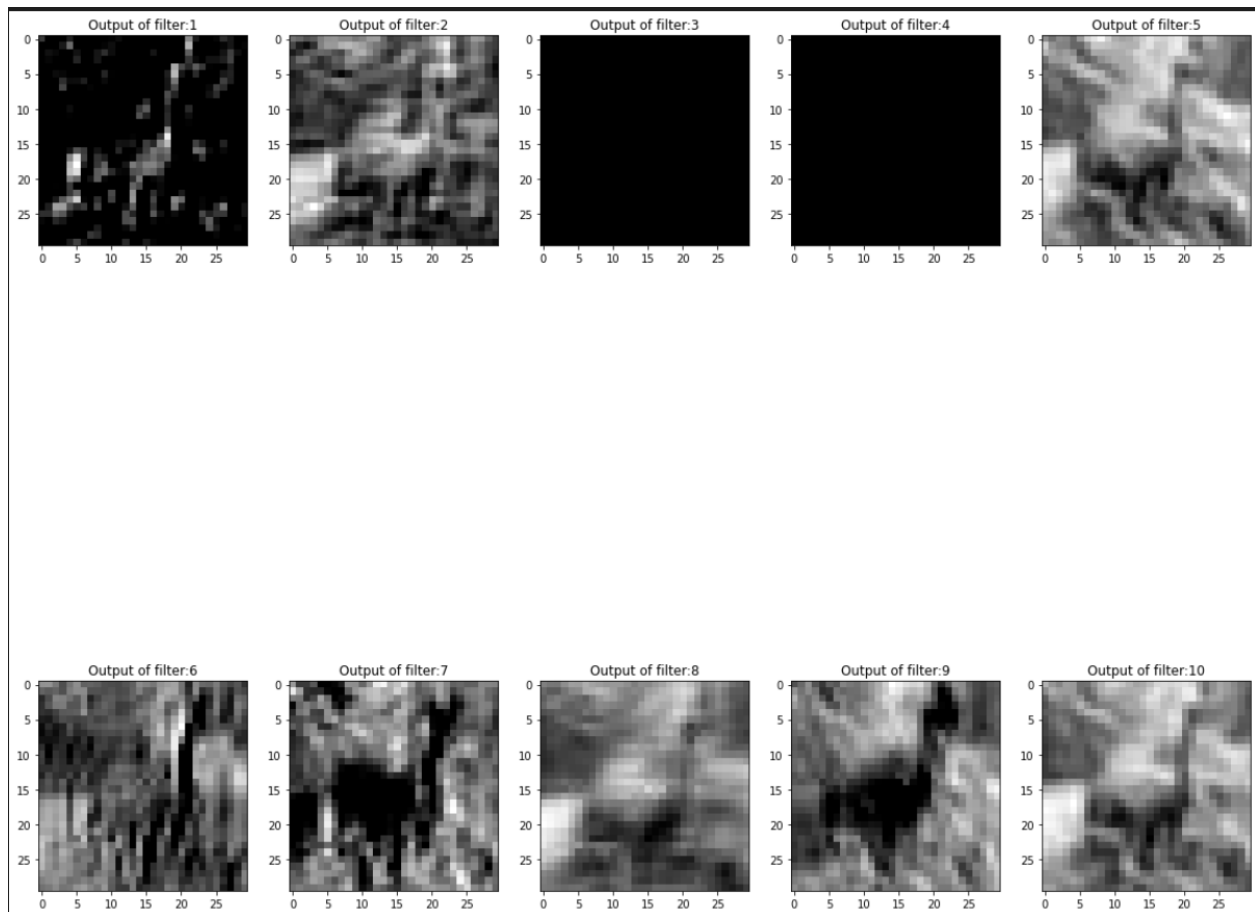


Image used: Same as task-2 to compare the feature maps of untrained and trained weights. The feature maps suggest the convolution layer is learning some features of the image when compared to feature maps of the untrained convolution layer

10 Filter outputs (feature maps) from the second convolution layer:

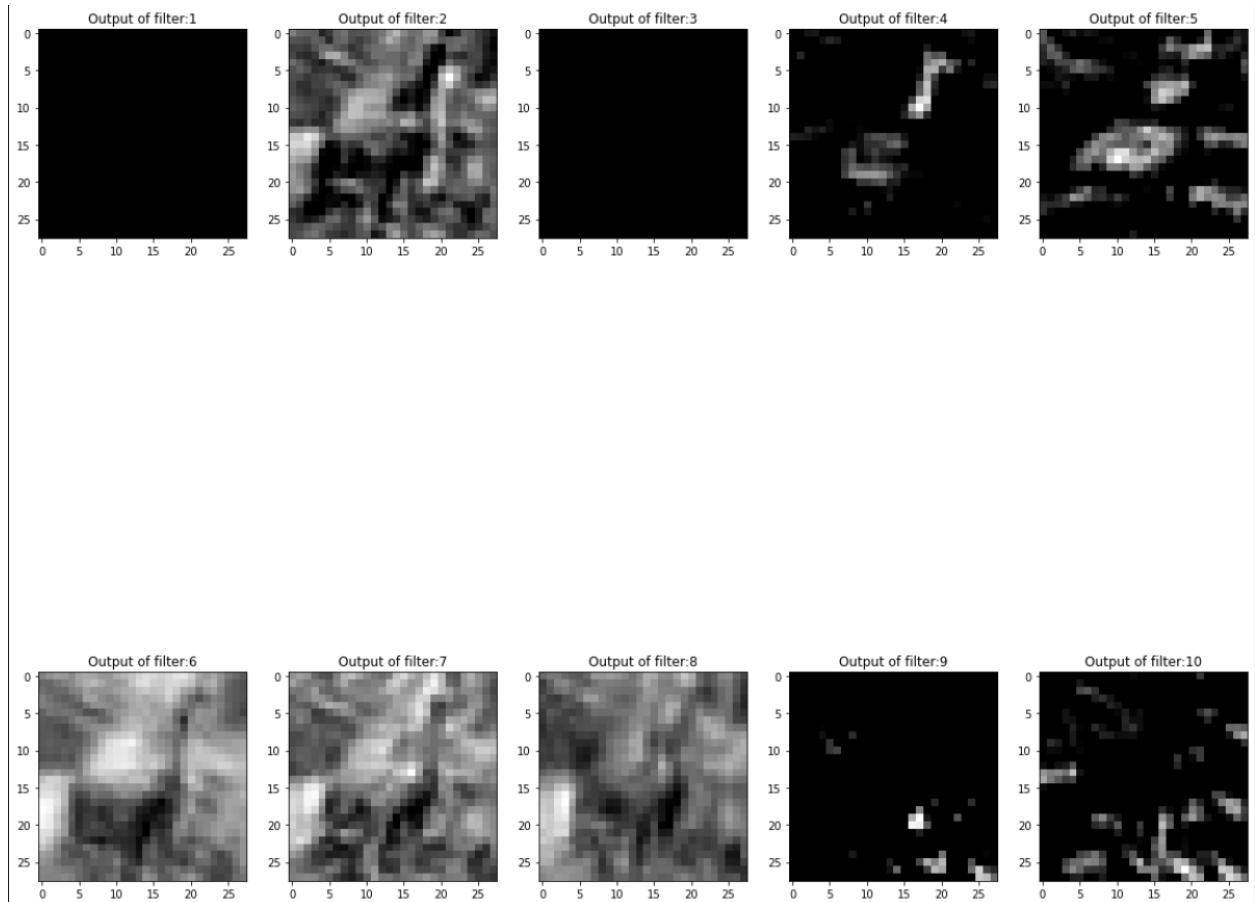
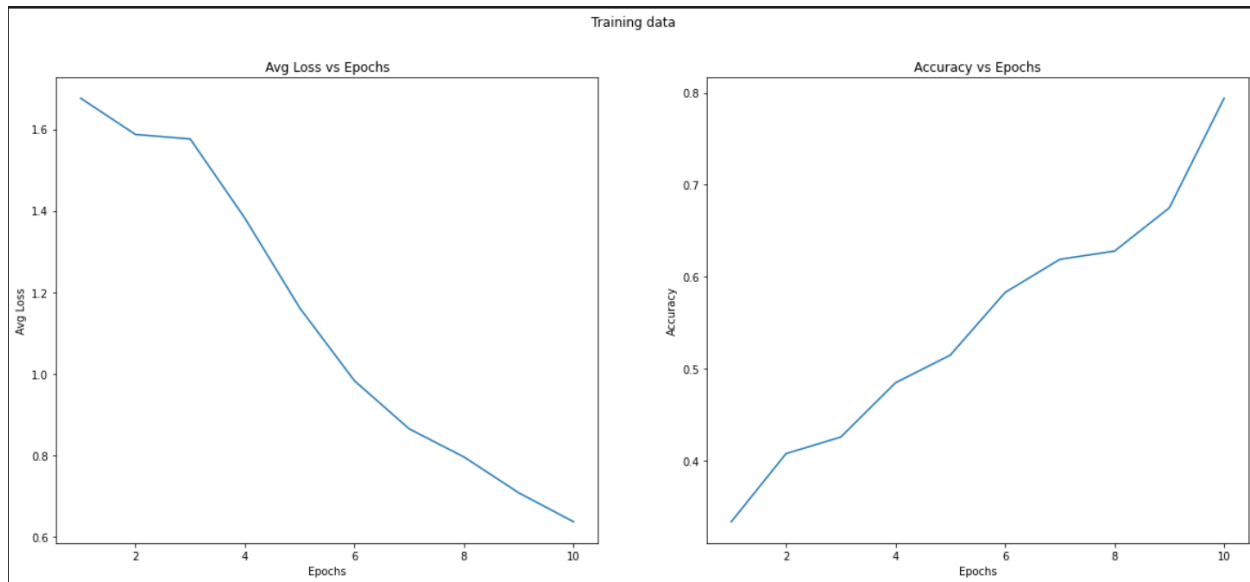
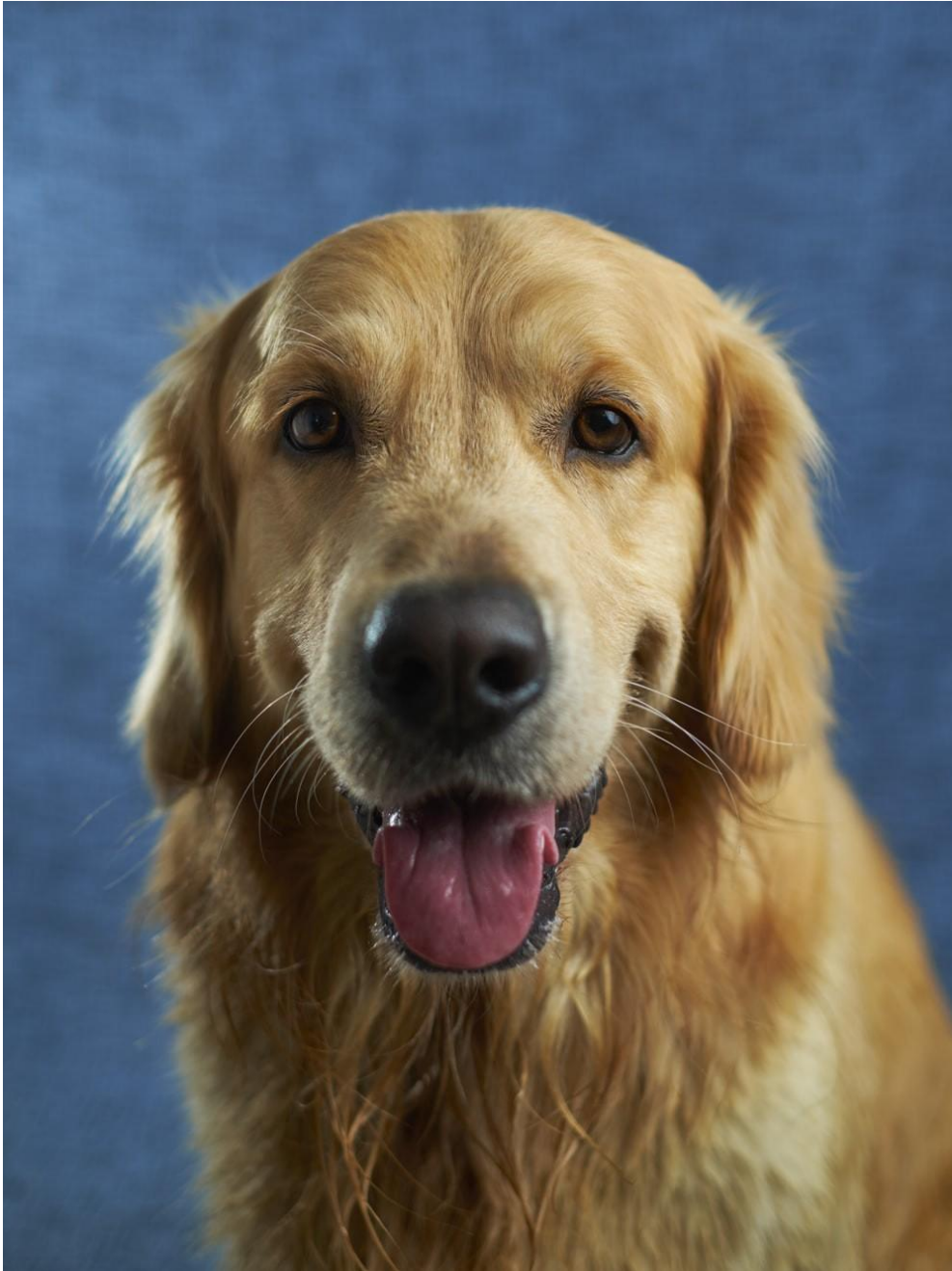


Image used: Same as task-2 to compare the feature maps of untrained and trained weights. The feature maps suggest the convolution layer is learning some features of the image when compared to feature maps of the untrained convolution layer

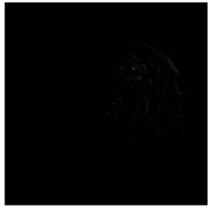
Metrics vs Epochs



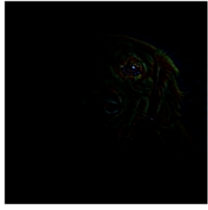
Task4



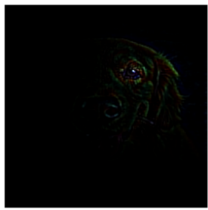
```
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers).
```



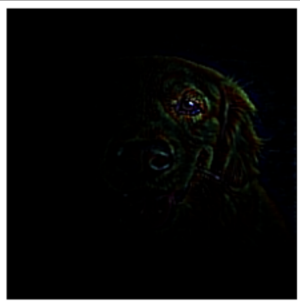
```
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers).
```



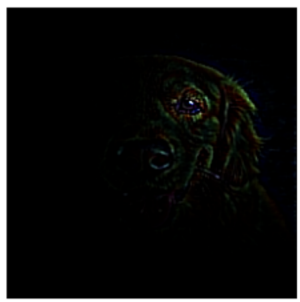
```
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers).
```



```
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers).
```



```
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers).
```



As can be seen with the images from 5 neurons, each gradient image has different pixel intensity. Each neuron caters to different aspects of the image and pixels.

Outputs

Task 1

Feature maps:

```
[[ 5.90924408e+01  2.98470739e+01  1.81805370e+01  3.11787466e+01
  2.40702468e+01  3.17099238e+01  5.93489410e+01  4.76906702e+01
  5.88862156e+01  5.04357547e+01  4.26709556e+01  4.40573138e+01
  4.45691409e+01  4.23509647e+01  4.09419816e+01  5.98893497e+01
  4.27335248e+01  3.91282674e+01  4.36145551e+01  5.30447035e+01
  5.45554905e+01  4.79698813e+01  3.61042604e+01  5.73815704e+01
  5.53064955e+01  4.13744626e+01  3.39544888e+01  3.61578977e+01
  2.89862263e+01  2.59284013e+01]
[ 5.57150122e+01  3.10175076e+01  1.03921064e+01  2.59462344e+01
  4.33614177e+01  3.46283221e+01  2.85663635e+01  6.12514352e+01
  4.03450295e+01  4.26566707e+01  4.69804112e+01  4.92243420e+01
  4.80457955e+01  4.61024188e+01  4.34002905e+01  4.29434559e+01
  3.92302466e+01  4.42306099e+01  5.44028714e+01  5.70322623e+01
  5.25157235e+01  4.31763558e+01  2.98261725e+01  4.03725991e+01
  3.86434869e+01  3.27256789e+01  2.99581064e+01  3.08584154e+01
  2.36537276e+01  2.55517919e+01]
[ 3.58085361e+01  4.60183885e+01  4.28740727e+01  3.75592257e+01
  4.23483175e+01  2.55890137e+01  2.76123785e+00  3.75119066e+01
  4.44622681e+01  5.03629160e+01  5.20486181e+01  4.52451379e+01
  3.99122344e+01  4.18930491e+01  4.78903350e+01  3.27122671e+01
  4.94398198e+01  5.21874838e+01  5.55397921e+01  4.60341343e+01
  4.05243715e+01  4.23134495e+01  3.06725256e+01  2.08424748e+01
  2.53310615e+01  2.90818753e+01  3.44289335e+01  3.32578836e+01
  2.73046167e+01  2.80200936e+01]
[ 2.67312564e+01  4.85182803e+01  4.90099384e+01  3.00114489e+01
  2.83585572e+01  2.95238513e+01  2.28552059e+01  1.40733597e+01
  3.97970611e+01  4.15793562e+01  4.36799363e+01  4.25307430e+01
  3.58785019e+01  3.39040537e+01  4.46831136e+01  6.07839254e+01
  5.12738872e+01  4.76042654e+01  4.46332210e+01  3.67231303e+01
  3.81590521e+01  5.24889828e+01  5.00461313e+01  3.18959600e+01
  3.92275707e+01  4.18987012e+01  3.99283085e+01  3.14779578e+01
  2.50206574e+01  2.19962348e+01]
[ 2.59470231e+01  2.84815670e+01  3.06521295e+01  3.02437940e+01
  3.35803450e+01  4.41329724e+01  3.96752951e+01  2.36197070e+01
  1.66840346e+01  1.62706845e+01  2.12584516e+01  3.57647225e+01
```

4.66330896e+01 4.77579904e+01 4.63726180e+01 5.70206571e+01
4.24455608e+01 4.06416658e+01 4.16537060e+01 3.90429561e+01
3.88025003e+01 4.88100137e+01 5.02642359e+01 3.62999041e+01
4.26498877e+01 3.96485740e+01 3.02880086e+01 2.24739938e+01
2.30966828e+01 2.26161560e+01]
[3.77166172e+01 3.04869667e+01 2.85534160e+01 3.26896740e+01
3.02206515e+01 3.29059392e+01 4.31441322e+01 3.66276604e+01
4.96276105e+01 4.08802482e+01 2.82298342e+01 3.15265362e+01
4.31701497e+01 4.79574918e+01 4.49014928e+01 4.06897417e+01
4.10430286e+01 4.16041314e+01 4.62970921e+01 3.79151819e+01
2.44896842e+01 2.38615552e+01 2.46679945e+01 1.93783713e+01
2.48396128e+01 2.39417997e+01 2.06027913e+01 2.09682757e+01
2.82319629e+01 2.91921200e+01]
[2.44579664e+01 2.25779764e+01 3.92121929e+01 2.65626473e+01
1.93932934e+01 4.22698318e+01 4.30519312e+01 4.65478683e+01
4.44101895e+01 5.10225093e+01 4.72596812e+01 3.36290939e+01
2.78600087e+01 3.34375158e+01 3.83074679e+01 3.34947579e+01
4.75892847e+01 3.86342900e+01 5.43305981e+01 2.85148478e+01
1.54124247e+01 3.39994347e+01 -1.55682109e+01 2.33832292e+01
9.82271915e+00 1.89309338e+01 2.36210091e+01 2.92255824e+01
2.53768375e+01 2.11980704e+01]
[2.16632427e+01 2.94879603e+01 2.76364344e+01 3.28287069e+01
3.12529062e+01 2.46247621e+01 3.03717368e+01 3.56884113e+01
3.29838825e+01 3.72000143e+01 4.17116550e+01 3.71459038e+01
3.10854828e+01 3.32392238e+01 4.11266747e+01 3.73806757e+01
4.50698375e+01 4.78229659e+01 4.06179551e+01 2.63056086e+01
1.80874771e+01 2.16401798e+01 2.49946307e+01 1.56471376e+00
2.49135378e+01 2.49851131e+01 2.43361567e+01 2.84269963e+01
2.96740937e+01 2.10608713e+01]
[1.91832540e+01 3.24327838e+01 2.70569308e+01 3.32266262e+01
3.29015222e+01 1.78712117e+01 2.35052203e+01 3.68714801e+01
2.22537755e+01 2.82654530e+01 3.75746588e+01 3.86259393e+01
3.63867114e+01 3.95656250e+01 4.54082507e+01 5.93954146e+01
3.70545765e+01 4.99638144e+01 4.84221353e+01 3.81200453e+01
3.65381864e+01 2.14583524e+01 3.71837511e+01 3.31302657e+01
4.11344545e+01 3.30080384e+01 1.98847745e+01 1.26918364e+01
1.21164074e+01 1.25508575e+01]
[1.86639839e+01 2.92477257e+01 2.24124151e+01 2.60718048e+01
3.21809177e+01 2.07538484e+01 2.64055975e+01 3.19266215e+01
3.27725397e+01 3.02983344e+01 2.97601341e+01 3.30051121e+01
3.71063455e+01 3.77300690e+01 4.07447098e+01 4.08671382e+01
4.52130989e+01 5.50431458e+01 4.87104963e+01 3.36482922e+01
3.91513178e+01 2.68625909e+01 4.11906598e+01 5.12749716e+01
4.11727061e+01 3.35020019e+01 1.76807144e+01 2.71487354e+00

1.99073427e+00 1.11643379e+01]
 [1.73252259e+01 2.13120200e+01 1.79741936e+01 1.93137339e+01
 2.56774169e+01 2.37080836e+01 2.81238466e+01 2.49918154e+01
 4.12183086e+01 3.39381957e+01 2.69340130e+01 3.27520606e+01
 3.89722867e+01 3.94028798e+01 4.37718710e+01 3.82589438e+01
 5.30740050e+01 4.75116107e+01 3.71233675e+01 1.96781662e+01
 3.65092737e+01 3.61634442e+01 4.07299028e+01 4.60046835e+01
 3.33366431e+01 3.59683532e+01 3.53918619e+01 2.60809002e+01
 1.89125041e+01 2.20348975e+01]
 [1.70241671e+01 1.56343351e+01 2.14033282e+01 1.92591136e+01
 1.99285426e+01 2.67216119e+01 2.32733917e+01 2.30153793e+01
 3.54323942e+01 3.64601064e+01 3.50262865e+01 3.93808664e+01
 4.70397689e+01 4.75696921e+01 4.55493609e+01 5.11683445e+01
 3.38097199e+01 2.48365966e+01 2.77500952e+01 1.52812774e+01
 3.19429329e+01 3.60123368e+01 3.28611638e+01 4.27154035e+01
 4.09674252e+01 4.76171129e+01 5.59084774e+01 5.20398179e+01
 4.13787163e+01 3.72972372e+01]
 [2.12887071e+01 1.72017961e+01 3.05459369e+01 2.66517927e+01
 2.05569138e+01 2.93451978e+01 1.79791007e+01 2.62686408e+01
 2.54395959e+01 3.70766492e+01 4.32079811e+01 4.46786016e+01
 4.33429152e+01 4.28813811e+01 3.62574977e+01 2.99082835e+01
 2.52939285e+01 1.06456988e+01 1.67005412e+01 3.47833970e+00
 2.55467550e+01 3.89945863e+01 3.39803772e+01 3.79786514e+01
 4.43098811e+01 4.50359903e+01 4.86246686e+01 5.26585617e+01
 5.14571293e+01 4.76424222e+01]
 [2.54373419e+01 2.04300269e+01 3.28679128e+01 3.04406647e+01
 2.29212910e+01 2.94794510e+01 1.54378363e+01 3.30300220e+01
 2.02680173e+01 3.22413410e+01 4.34695057e+01 4.38757372e+01
 4.27106946e+01 4.40121796e+01 4.31528127e+01 3.43152956e+01
 4.41106889e+01 2.63909210e+01 1.91336372e+01 1.95267710e+00
 2.89176086e+01 5.33774248e+01 4.48315310e+01 3.97399723e+01
 3.48657172e+01 3.11511570e+01 3.35328096e+01 4.36676594e+01
 4.96178329e+01 4.90015302e+01]
 [1.14472632e+01 2.11517051e+01 1.12031387e+01 8.35728167e+00
 2.37629575e+01 -8.77570100e+00 1.36013205e+01 1.47775184e+01
 3.12119605e+01 3.08359134e+01 4.36125914e+01 4.65372126e+01
 4.23169975e+01 4.65692003e+01 3.93464518e+01 5.51851705e+01
 2.99545178e+01 6.60975078e+01 3.03293579e+01 4.10703996e+01
 2.50967320e+01 3.90405200e+01 5.65104160e+01 3.64816456e+01
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 4.61278621e+01 4.38609426e+01]
 [6.17351187e-02 -3.20709829e-01 3.74469620e+00 5.35707549e+00
 1.16893121e+01 6.02860464e+00 1.35688132e+01 1.34171772e+01
 4.13577687e+01 4.09510590e+01 4.38515883e+01 4.09249939e+01

3.75994278e+01 4.79500426e+01 5.46964594e+01 3.35372294e+01
4.62666145e+01 4.14164615e+01 5.12740680e+01 3.41991505e+01
3.09979283e+01 5.27927327e+01 4.38526118e+01 4.40055029e+01
4.99575184e+01 5.55538953e+01 6.12079357e+01 5.32651981e+01
4.68374267e+01 5.10013132e+01]
[1.50547122e+01 1.62000780e+01 2.09673320e+01 2.56662407e+01
3.13099386e+01 2.14952463e+01 2.08393566e+01 3.95382465e+01
3.87003396e+01 3.24743017e+01 3.80909788e+01 4.76646186e+01
3.66965071e+01 2.44806066e+01 2.72893449e+01 2.29986640e+01
3.88131206e+01 2.78771212e+01 3.61165140e+01 2.21411307e+01
2.21553076e+01 5.14103878e+01 4.23830156e+01 4.40911460e+01
3.36131584e+01 4.32342335e+01 5.52602332e+01 5.30730287e+01
4.70240818e+01 5.19820577e+01]
[3.42437814e+01 3.47838962e+01 3.70340814e+01 4.09164633e+01
4.51527450e+01 3.23512224e+01 2.28433366e+01 3.28523733e+01
3.49406049e+01 2.45795218e+01 2.31538300e+01 3.79829271e+01
3.86193084e+01 2.51270778e+01 1.84636259e+01 3.56837269e+01
2.43348526e+01 2.63715821e+01 2.32155829e+01 2.48923011e+01
2.60000102e+01 3.38907398e+01 3.79863080e+01 5.04715153e+01
1.80021567e+01 2.23854827e+01 3.17349423e+01 3.77902517e+01
3.83887717e+01 4.19389026e+01]
[4.47500182e+01 4.49177919e+01 4.58934929e+01 4.66770664e+01
5.07772224e+01 3.56265598e+01 2.01256565e+01 2.46716780e+01
2.32111056e+01 2.14820774e+01 2.04420680e+01 2.60686987e+01
3.97527341e+01 4.30636371e+01 3.35999268e+01 3.33874682e+01
1.74672163e+01 2.67179393e+01 1.89244707e+01 3.10499376e+01
2.78087768e+01 9.62382446e+00 3.31113876e+01 3.09646576e+01
2.99661518e+01 2.15519930e+01 1.88469565e+01 2.37061386e+01
3.30999375e+01 3.77003925e+01]
[5.11311130e+01 5.00704814e+01 4.96571395e+01 4.88689394e+01
5.20595012e+01 3.76127441e+01 2.02931969e+01 1.92191590e+01
7.17742758e+00 2.16462943e+01 2.91550212e+01 2.35196347e+01
2.57886925e+01 3.44858326e+01 2.64520044e+01 1.08665943e+01
2.50522557e+01 1.52238447e+01 2.06841442e+00 1.78254922e+01
2.13377614e+01 1.33548465e+01 4.07900677e+01 1.74469646e+01
3.90085136e+01 3.02126657e+01 2.00583754e+01 2.05215667e+01
2.94001766e+01 3.44046191e+01]
[4.65865236e+01 4.70082415e+01 4.53983290e+01 4.24312250e+01
4.30931297e+01 3.02579441e+01 1.70777736e+01 3.82952168e+00
9.07992269e+00 1.29623277e+01 1.08027681e+01 1.95205057e+00
9.98947756e+00 1.65205638e+01 9.60449182e+00 8.79517279e+00
2.75179231e+01 -4.44564652e+00 -1.51417746e+00 1.75231649e+01
2.00849535e+01 3.17233869e+01 3.88710108e+01 3.03038688e+01
3.16638981e+01 3.42392441e+01 3.46043425e+01 3.08832207e+01

2.92060664e+01 3.21277537e+01]
[4.56003326e+01 4.53677317e+01 4.33446163e+01 3.82937611e+01
3.82619137e+01 2.66090447e+01 1.60626871e+01 1.05654895e+01
7.15723630e+00 -2.43431493e+00 -1.91435689e+01 -2.14425567e+01
-2.12212552e-01 1.39280864e+01 7.53420235e-01 1.39250984e+01
1.62319980e+01 -1.19837603e+01 5.93350156e+00 2.64319852e+01
2.06665006e+01 2.84102362e+01 2.45087195e+01 3.35821848e+01
3.06107850e+01 4.00336728e+01 4.79833108e+01 4.31341336e+01
3.43756082e+01 3.24611563e+01]
[3.85011855e+01 5.19048723e+01 5.20442468e+01 3.96903478e+01
2.74339829e+01 3.38360391e+01 4.55995931e+00 4.69377158e+01
2.61043104e+01 8.68404882e+00 2.63967140e+01 1.11116389e+00
1.78062026e+01 1.93174598e+01 -9.74078320e+00 1.52480950e+01
6.43926976e+00 1.63434161e+01 2.45161037e+01 1.54253914e+01
2.51680767e+01 5.33434679e+01 4.78664543e+01 4.99474615e+01
3.68672808e+01 4.54224089e+01 5.25112359e+01 5.22989222e+01
4.73691599e+01 3.80786701e+01]
[4.37447670e+01 4.15894152e+01 3.89413843e+01 4.01510370e+01
4.71261064e+01 5.40455567e+01 4.70923818e+01 1.03697367e+01
4.42498595e+01 3.51350767e+01 4.21288194e+01 4.30768711e+01
3.52903227e+00 3.88096156e+00 1.00675998e+01 1.89509143e+01
1.19442589e+01 1.84008378e+01 2.42128377e+01 2.99759279e+01
3.80090714e+01 5.19753312e+01 5.54050477e+01 4.22016130e+01
4.55829447e+01 4.78098473e+01 3.65843120e+01 3.73480103e+01
5.88692709e+01 5.14122905e+01]
[4.35759227e+01 4.68943199e+01 5.36720633e+01 5.09266223e+01
4.16634845e+01 3.33220340e+01 3.09646598e+01 1.75583801e+01
3.87772902e+01 3.01394903e+01 2.49389457e+01 4.00579962e+01
3.12284340e+00 9.02694612e+00 1.90554814e+01 1.54005125e+01
5.79234923e+00 1.51186239e+01 2.25515154e+01 2.78114499e+01
3.16084436e+01 2.87839600e+01 2.87858717e+01 2.46541144e+01
3.25145490e+01 4.22365783e+01 4.60951175e+01 4.35647035e+01
5.52125522e+01 5.58801920e+01]
[4.87712928e+01 4.77696806e+01 4.68348724e+01 3.97889267e+01
2.86898422e+01 2.31727406e+01 1.96716744e+01 2.36535509e+01
7.89452974e+00 1.32226080e+01 1.01065442e+01 2.72253763e+01
1.13580392e+01 7.03110620e+00 8.96413945e+00 2.02184101e+01
2.82938196e+01 2.83908403e+01 1.84754158e+01 2.19970494e+01
2.88937909e+01 2.22665553e+01 1.44982374e+01 4.15364759e+01
1.86855216e+01 2.29630243e+01 4.20688606e+01 4.29002709e+01
3.14179873e+01 4.05621807e+01]
[4.55277805e+01 3.80205548e+01 3.16423195e+01 2.64398334e+01
2.14538319e+01 1.98349370e+01 1.58487509e+01 1.13785194e+01
-5.60096632e+00 1.05161517e+01 1.62398660e+01 2.82929809e+01

```

2.66393341e+01 9.56435026e+00 -1.02650338e+00 2.53983731e+01
3.35454924e+01 3.23661334e+01 1.67653078e+01 7.80717837e+00
1.64426664e+01 2.63197091e+01 2.74497831e+01 3.75544673e+01
2.46028411e+01 7.47597255e+00 1.76855350e+01 3.62675648e+01
2.57720916e+01 3.50183626e+01]
[ 3.87014119e+01 3.31067500e+01 3.19318325e+01 3.07420086e+01
1.75628703e+01 6.77913483e+00 1.03399007e+01 1.78998156e+01
2.01223346e+01 2.38734197e+01 2.80328846e+01 2.97860973e+01
4.21998556e+01 2.51236891e+01 1.29360847e+01 -3.96414545e-01
1.07069395e+01 1.91916178e+01 2.00680245e+01 1.20336543e+01
3.69503929e+00 9.08081251e+00 2.68404690e+01 1.97232133e+01
3.74136046e+01 9.92082429e+00 2.88661429e+00 2.52237106e+01
3.42840032e+01 3.69005945e+01]
[ 3.54158720e+01 3.10684708e+01 3.11516057e+01 3.21465643e+01
2.63443898e+01 1.85902600e+01 2.35443032e+01 3.38496315e+01
3.76631541e+01 2.33721017e+01 2.89520026e+01 2.67881050e+01
3.57220693e+01 2.26683458e+01 3.47950555e+01 5.24667282e+00
2.03158614e+01 2.46023411e+01 2.83326752e+01 3.16294682e+01
2.17096576e+01 9.71327795e+00 2.13972411e+01 2.30278929e+01
2.98487070e+01 1.87940833e+01 5.93464029e+00 9.81348195e+00
2.28895611e+01 2.92158954e+01]
[ 3.30115917e+01 2.89035172e+01 2.47207067e+01 3.31009652e+01
4.18051239e+01 4.36480073e+01 3.87077803e+01 3.12646348e+01
2.70527521e+01 1.17113700e+01 2.20130593e+01 2.36750097e+01
2.06074540e+01 1.26479991e+01 4.20564980e+01 4.72964983e+01
4.39475541e+01 3.65630207e+01 2.89845840e+01 4.00485288e+01
4.44008945e+01 3.08369752e+01 2.70565704e+01 2.15471716e+01
2.44189208e+01 2.89391004e+01 2.27112015e+01 1.04658880e+01
1.62353744e+01 2.57560800e+01]]

```

Task 2

Layer-1

```

[[[0.1325947 0.32236858 0.    ... 0.    0.    0.    ]
[0.45791948 0.11517275 0.    ... 0.    0.    0.    ]
[0.51143107 0.12602697 0.    ... 0.    0.    0.    ]
...
[0.32339342 0.16176369 0.    ... 0.    0.    0.    ]
[0.31266935 0.11692491 0.    ... 0.    0.    0.    ]

```

[0.26003953 0.09164783 0. ... 0. 0. 0.]]

[[0.0349905 0.36862636 0. ... 0. 0. 0.]

[0.07288442 0.15624409 0. ... 0. 0. 0.]

[0.23884979 0.06257572 0. ... 0. 0. 0.]

...

[0.23206461 0.11720041 0. ... 0. 0. 0.]

[0.29939349 0.0636008 0. ... 0. 0. 0.]

[0.28594107 0.09364872 0. ... 0. 0. 0.]]

[[0.33741902 0.12108213 0. ... 0. 0. 0.]

[0.20443171 0.20703303 0. ... 0. 0. 0.]

[0.31455536 0.20567645 0. ... 0. 0. 0.]

...

[0.22818197 0.11410624 0. ... 0. 0. 0.]

[0.23499558 0.11239383 0. ... 0. 0. 0.]

[0.22780691 0.15033541 0. ... 0. 0. 0.]]

...

[[0.25999321 0.28308572 0. ... 0. 0. 0.]

[0.27741383 0.23672633 0. ... 0. 0. 0.]

[0.22014624 0.24312089 0. ... 0. 0. 0.]

...

[0.45317364 0. 0. ... 0. 0. 0.]

[0.59731481 0. 0. ... 0. 0. 0.]

[0.47285149 0.05765636 0. ... 0. 0. 0.]]

[[0.36550842 0.16715601 0. ... 0. 0. 0.]

[0.32231395 0.16279358 0. ... 0. 0. 0.]

[0.18048194 0.20983212 0. ... 0. 0. 0.]

...

[0.51325877 0. 0. ... 0. 0. 0.]

[0.47596456 0. 0. ... 0. 0. 0.]

[0.46657986 0. 0. ... 0. 0. 0.]]

[[0.39008246 0.12151199 0. ... 0. 0. 0.]

[0.39735945 0.0577591 0. ... 0. 0. 0.]

[0.37104218 0.03826526 0. ... 0. 0. 0.]

...

[0.27159968 0. 0. ... 0. 0. 0.]

[0.24668278 0. 0. ... 0. 0. 0.]

[0.36739214 0. 0. ... 0. 0. 0.]]]

Layer-2

```
[[[0.00000000e+00 0.00000000e+00 1.32794909e-04 ... 1.56689389e-04
  0.00000000e+00 1.31907559e-05]
 [0.00000000e+00 0.00000000e+00 1.20922433e-04 ... 1.37875669e-04
  0.00000000e+00 7.41024330e-06]
 [0.00000000e+00 0.00000000e+00 1.12860494e-04 ... 9.83239567e-05
  0.00000000e+00 6.44310147e-05]
 ...
 [0.00000000e+00 0.00000000e+00 1.68520284e-04 ... 7.70119834e-06
  0.00000000e+00 6.16719869e-05]
 [0.00000000e+00 0.00000000e+00 1.89734593e-04 ... 7.75410257e-05
  0.00000000e+00 6.72482871e-05]
 [0.00000000e+00 0.00000000e+00 1.68095750e-04 ... 6.04872527e-05
  0.00000000e+00 7.17518107e-05]]]

[[[0.00000000e+00 0.00000000e+00 1.88116304e-05 ... 1.94841492e-04
  0.00000000e+00 1.13121502e-04]
 [0.00000000e+00 0.00000000e+00 4.15929605e-05 ... 3.98386136e-05
  0.00000000e+00 1.30072010e-04]
 [0.00000000e+00 0.00000000e+00 8.77242711e-05 ... 0.00000000e+00
  0.00000000e+00 1.48888512e-04]
 ...
 [0.00000000e+00 0.00000000e+00 9.27818505e-05 ... 3.67631457e-05
  0.00000000e+00 6.74980158e-05]
 [0.00000000e+00 0.00000000e+00 1.29682123e-04 ... 9.57978474e-05
  0.00000000e+00 9.13967549e-05]
 [0.00000000e+00 0.00000000e+00 1.40870641e-04 ... 2.32809791e-05
  0.00000000e+00 1.13263777e-04]]]

[[[0.00000000e+00 0.00000000e+00 1.42956738e-04 ... 6.39472223e-05
  0.00000000e+00 1.24579021e-04]
 [0.00000000e+00 0.00000000e+00 1.61312818e-04 ... 1.14441513e-05
  0.00000000e+00 1.16200481e-04]
 [0.00000000e+00 0.00000000e+00 1.19167266e-04 ... 6.05963754e-05
  0.00000000e+00 8.20137666e-05]
 ...
 [0.00000000e+00 0.00000000e+00 9.17109001e-05 ... 1.48254512e-05
  0.00000000e+00 1.07643526e-04]
 [0.00000000e+00 0.00000000e+00 1.60637755e-04 ... 6.95452602e-05
  0.00000000e+00 1.17078809e-04]
 [0.00000000e+00 0.00000000e+00 1.60490901e-04 ... 0.00000000e+00
```

0.00000000e+00 1.09625659e-04]]

...

[[0.00000000e+00 0.00000000e+00 1.65956907e-04 ... 7.71707178e-05
0.00000000e+00 7.67490459e-05]

[0.00000000e+00 0.00000000e+00 1.82991149e-04 ... 9.75785797e-05
0.00000000e+00 7.67662522e-05]

[0.00000000e+00 0.00000000e+00 1.58440101e-04 ... 6.64369841e-05
0.00000000e+00 7.84153014e-05]

...

[0.00000000e+00 0.00000000e+00 1.27843472e-04 ... 8.88897373e-05
0.00000000e+00 7.34263475e-05]

[0.00000000e+00 0.00000000e+00 4.72095464e-05 ... 2.26662406e-04
0.00000000e+00 4.93259407e-05]

[0.00000000e+00 4.79654127e-05 1.53578682e-04 ... 2.83438103e-04
0.00000000e+00 0.00000000e+00]]

[[0.00000000e+00 0.00000000e+00 1.24236682e-04 ... 1.08888755e-04
0.00000000e+00 5.50988263e-05]

[0.00000000e+00 0.00000000e+00 1.29950246e-04 ... 9.48693098e-05
0.00000000e+00 9.01895824e-05]

[0.00000000e+00 0.00000000e+00 1.47225419e-04 ... 7.14871887e-05
0.00000000e+00 7.55437450e-05]

...

[0.00000000e+00 0.00000000e+00 1.22537687e-04 ... 1.04179999e-04
0.00000000e+00 1.02530484e-04]

[0.00000000e+00 0.00000000e+00 8.62530385e-05 ... 1.99629913e-04
0.00000000e+00 4.95054036e-05]

[0.00000000e+00 4.60439710e-06 1.52755623e-04 ... 1.77799648e-04
0.00000000e+00 2.72145471e-05]]

[[0.00000000e+00 0.00000000e+00 1.65014167e-04 ... 1.05284207e-04
0.00000000e+00 3.07964091e-05]

[0.00000000e+00 0.00000000e+00 1.53179621e-04 ... 1.02092259e-04
0.00000000e+00 3.18949140e-05]

[0.00000000e+00 0.00000000e+00 1.16573378e-04 ... 1.37172372e-04
0.00000000e+00 3.28566409e-05]

...

[0.00000000e+00 0.00000000e+00 1.47374462e-04 ... 2.16385873e-05
0.00000000e+00 9.67739014e-05]

[0.00000000e+00 0.00000000e+00 1.90825810e-04 ... 7.50490035e-05
0.00000000e+00 1.34844270e-05]

[0.00000000e+00 0.00000000e+00 2.34984811e-04 ... 6.84871365e-05

0.00000000e+00 3.45593208e-05]]]