

Assignment 2 Report

CZ4042 Neural Networks

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**Experiments and Results**

**Part A:** **Object Recognition**

1. After configuring the convolutional neural network (CNN) properly, with mini-batch gradient descent learning with batch size of 128, the 10000 training samples are used to train the CNN.

a. The training cost and test accuracy against learning epochs is plotted, as shown in Figure 1 and Figure 2 respectively.

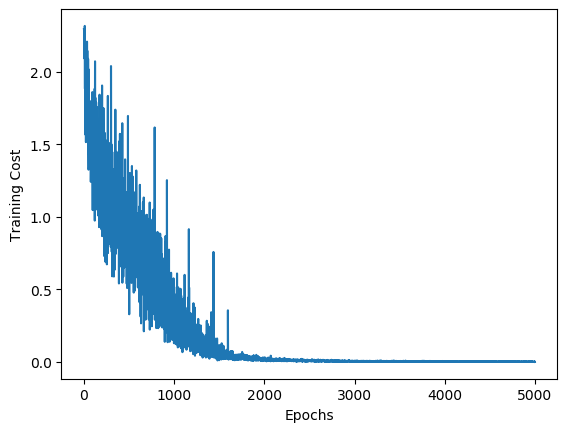
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Figure 1: Training cost Figure 2: Test accuracy

b. Two test images are randomly selected, the two images and their feature maps at both convolution layers and pooling layers are shown in Figure 3, 4, 5, 6, 7, 8, 9, 10, 11,12. Figure 3 is the first image, Figure 4, 5, 6, 7 are the first image’s feature maps at the first convolution layer, the first pooling layer, the second convolution layer and the second pooling layer respectively. Figure 8 is the second image, Figure 9, 10, 11, 12 are the second image’s feature maps at the first convolution layer, the first pooling layer, the second convolution layer and the second pooling layer respectively.

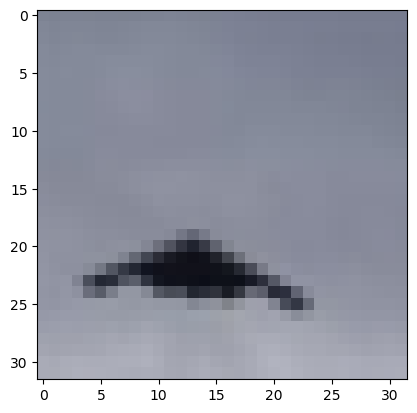


Figure 3: The first image

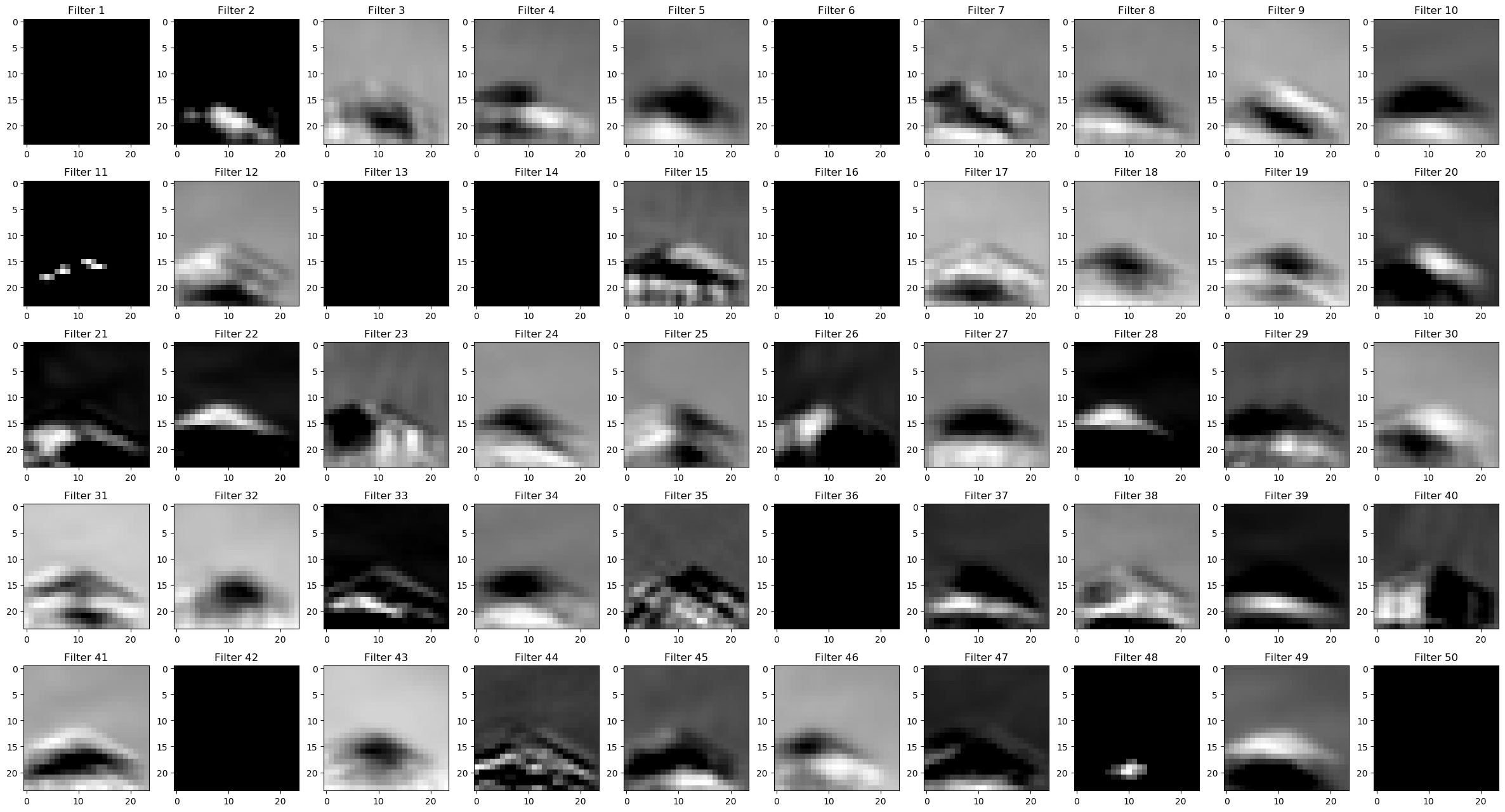


Figure 4: The first image’s feature maps at the first convolution layer

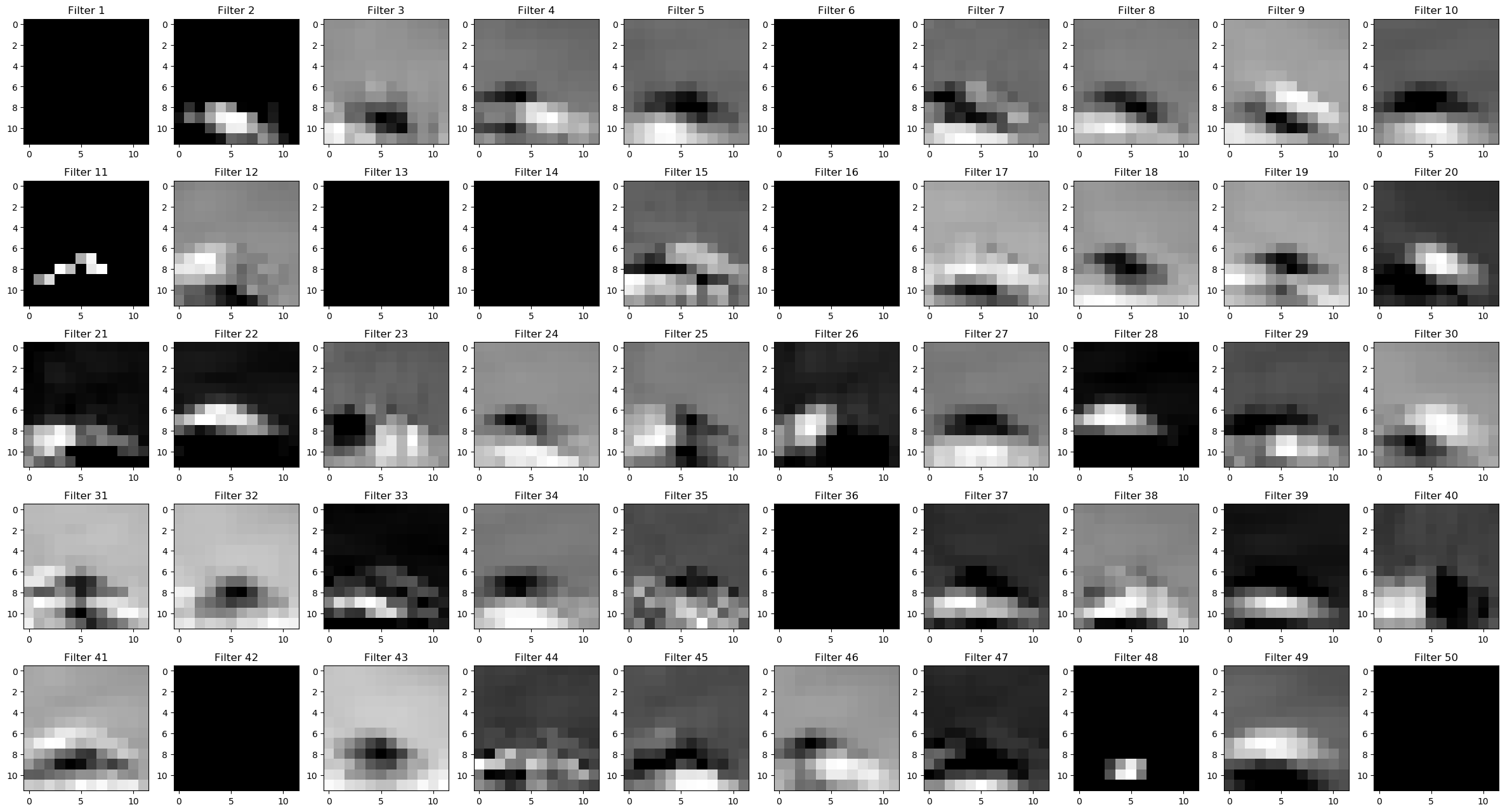


Figure 5: The first image’s feature maps at the first pooling layer

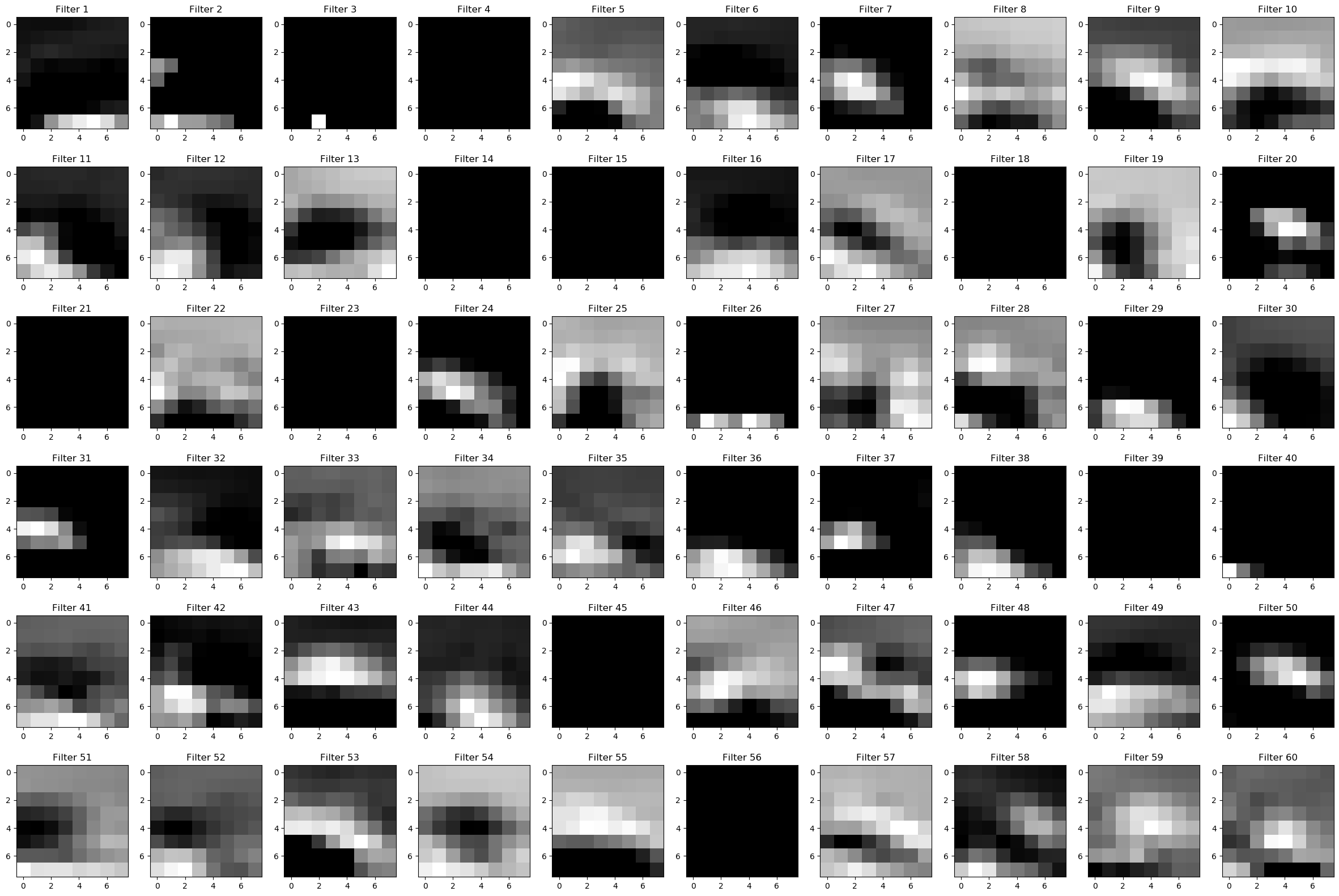


Figure 6: The first image’s feature maps at the second convolution layer

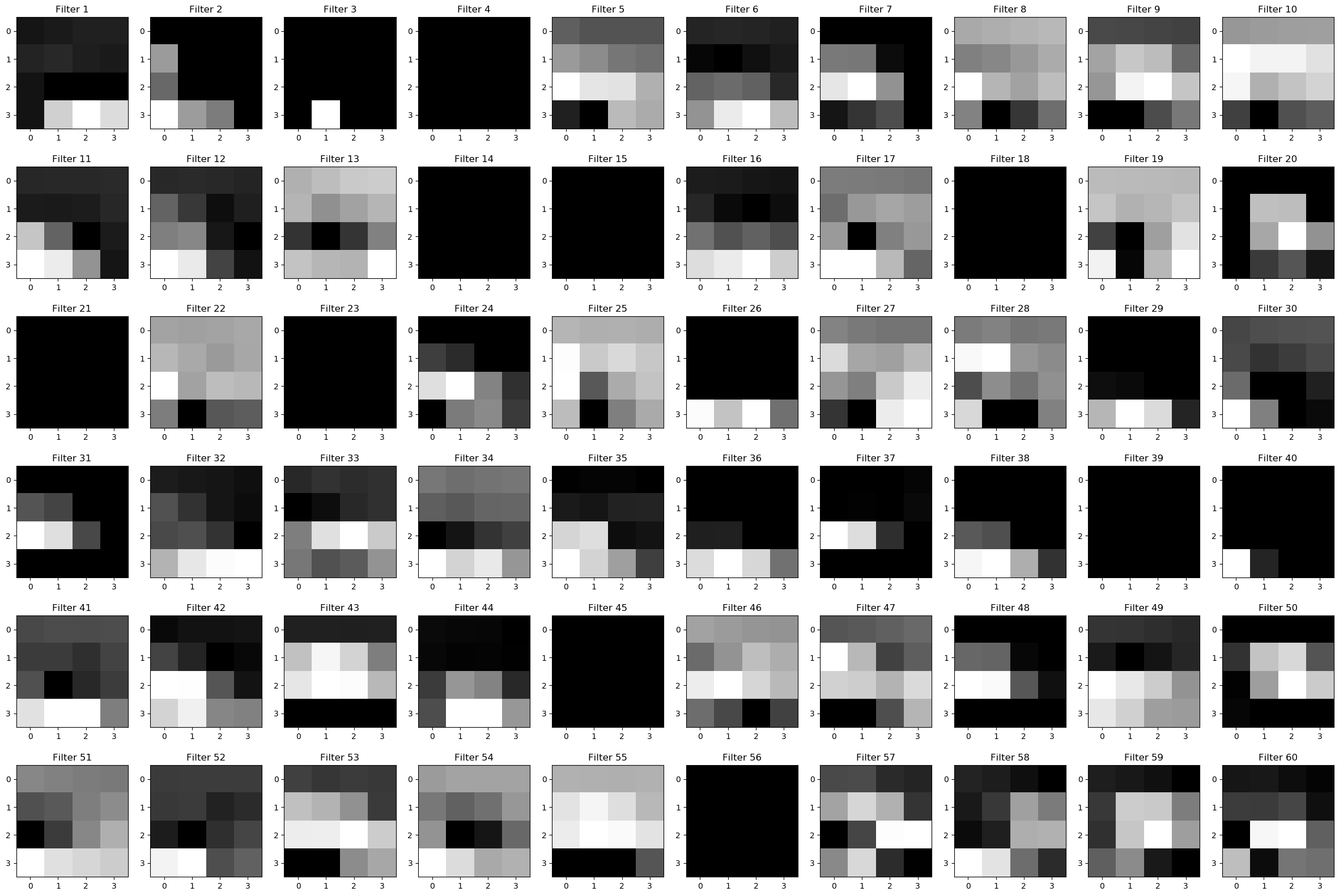


Figure 7: The first image’s feature maps at the second pooling layer

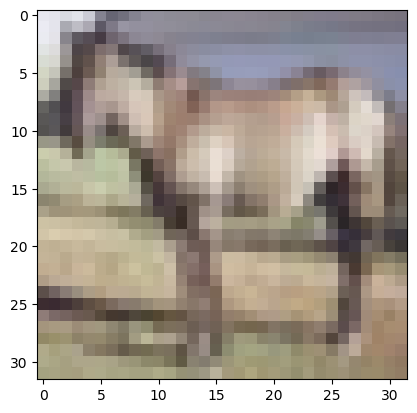


Figure 8: The second image

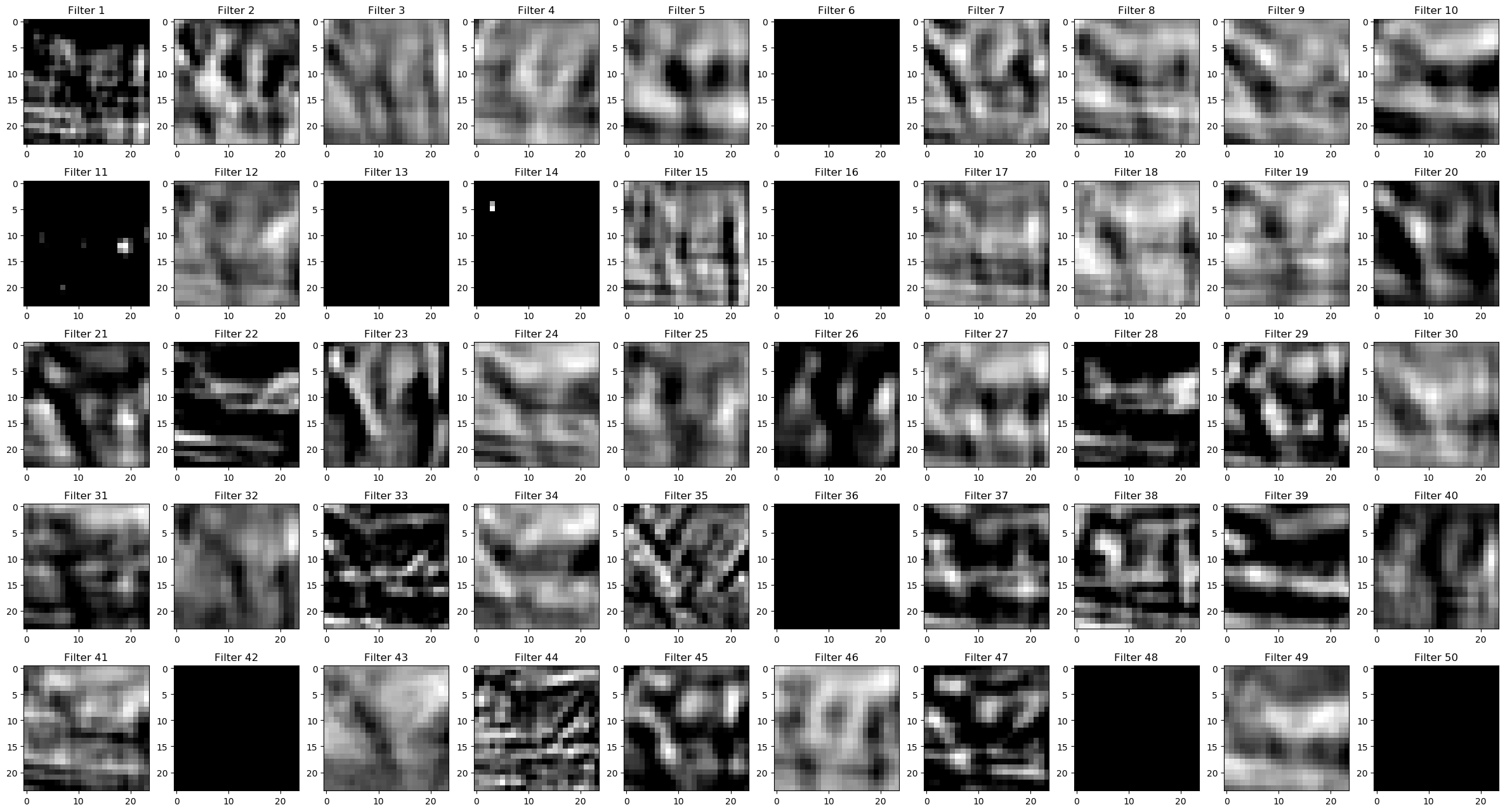


Figure 9: The second image’s feature maps at the first convolution layer

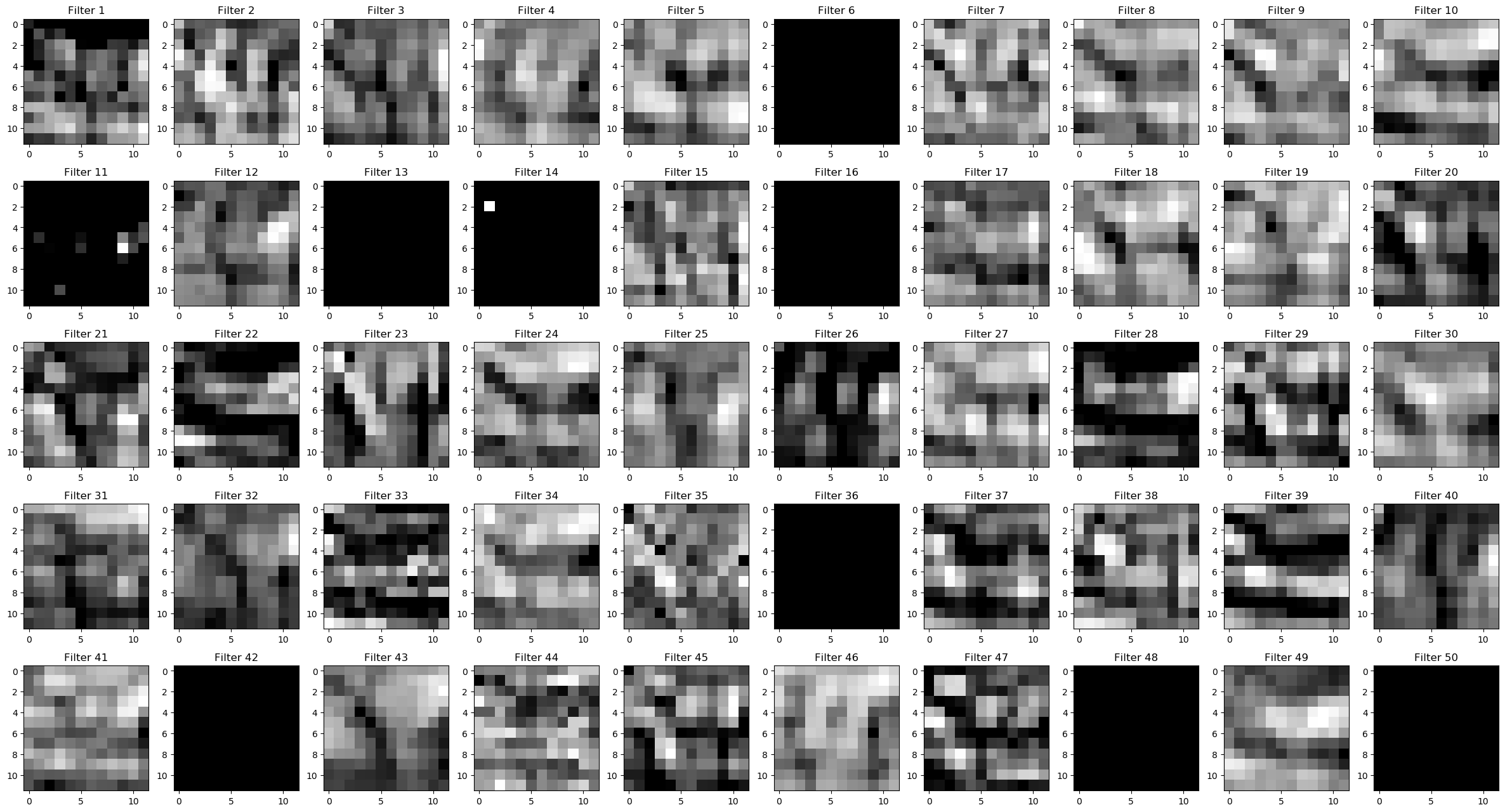


Figure 10: The second image’s feature maps at the first pooling layer

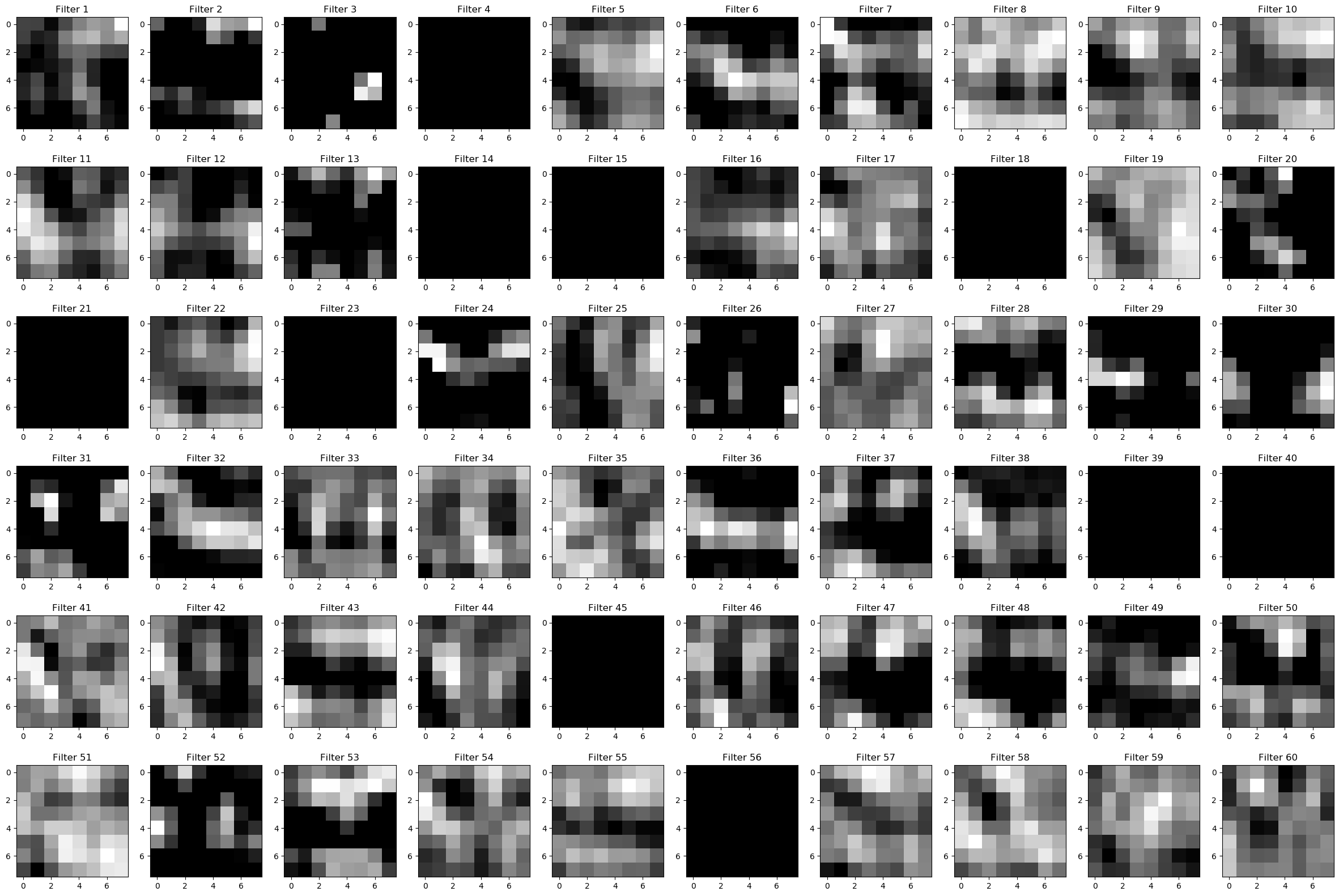


Figure 11: The second image’s feature maps at the second convolution layer

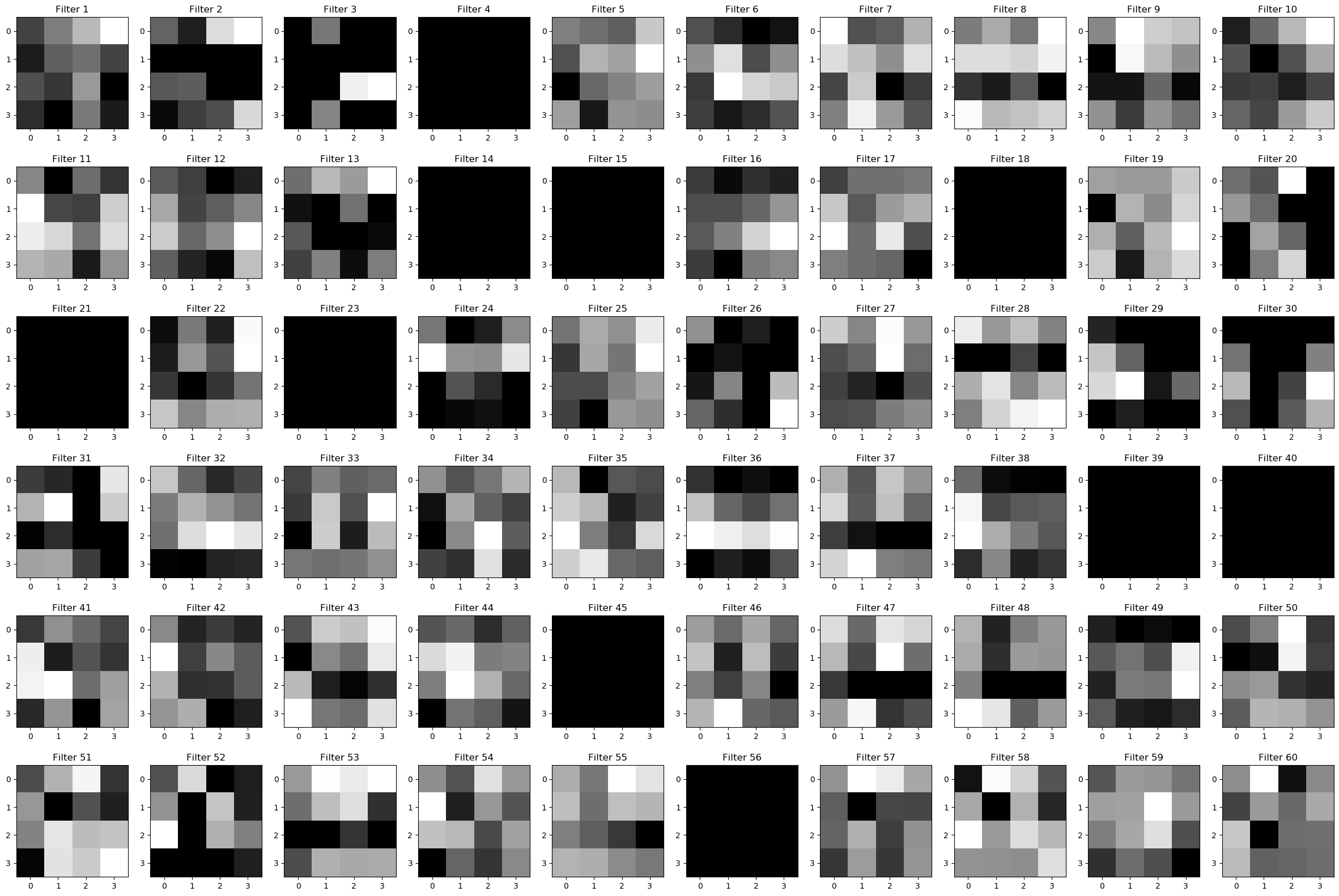


Figure 12: The second image’s feature maps at the second pooling layer

2. With a grid search, the [number of feature maps in first convolution layer, number of feature maps in second convolution layer] combinations of [40, 40], [40,50], [40, 60], [40, 70], [50, 40], [50,50], [50, 60], [50, 70], [60, 40], [60,50], [60, 60], [60, 70], [70, 40], [70,50], [70, 60], [70, 70] are examined one by one. The test accuracy against training epoch diagram for each of the combinations is shown in Figure 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28 respectively.

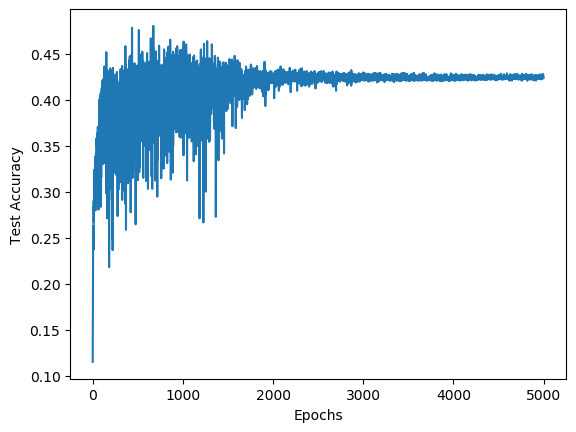
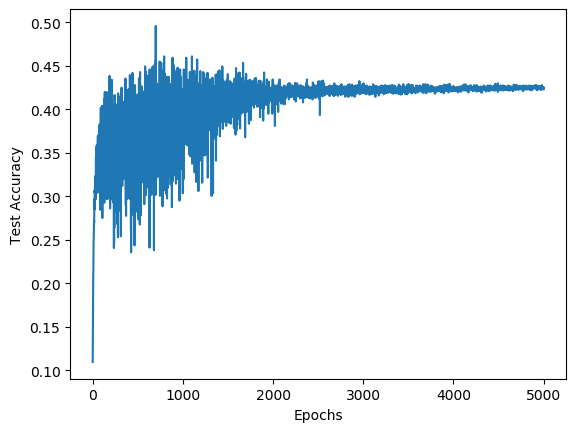
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Figure 13: Test accuracy for [40, 40] Figure 14: Test accuracy for [40, 50]

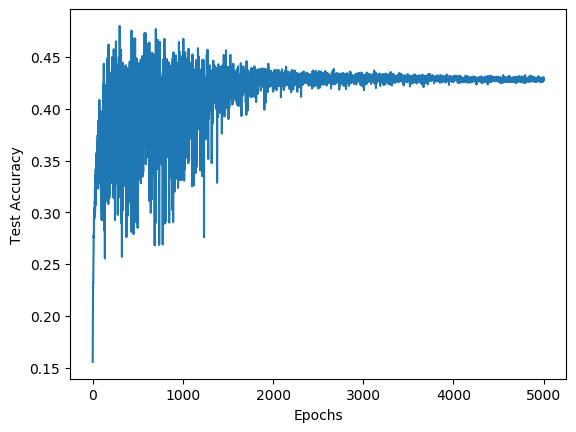
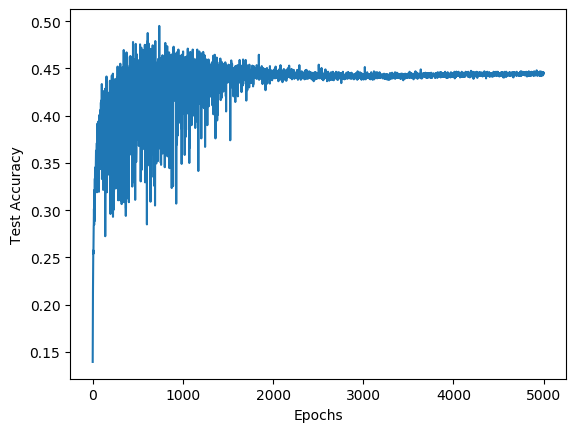
 

Figure 15: Test accuracy for [40, 60] Figure 16: Test accuracy for [40, 70]

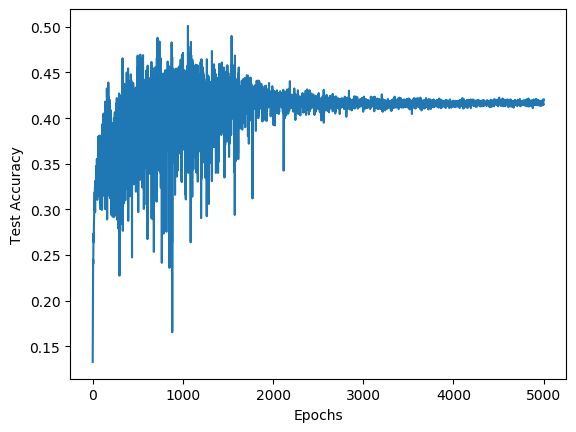
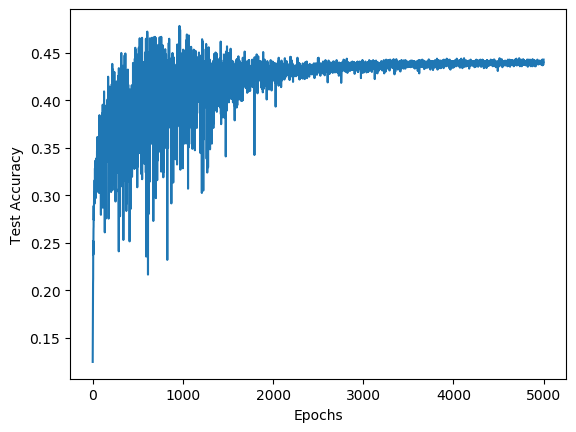
 

Figure 17: Test accuracy for [50, 40] Figure 18: Test accuracy for [50, 50]

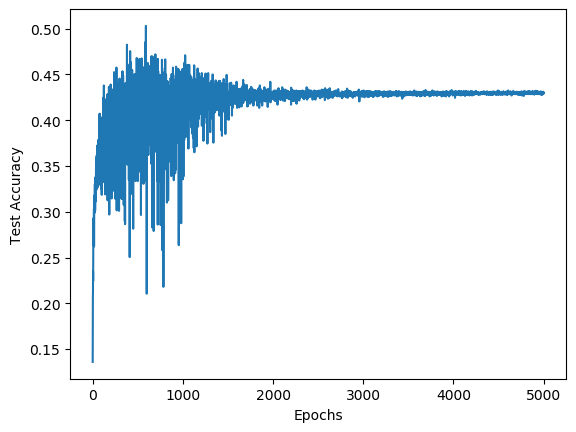
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Figure 19: Test accuracy for [50, 60] Figure 20: Test accuracy for [50, 70]

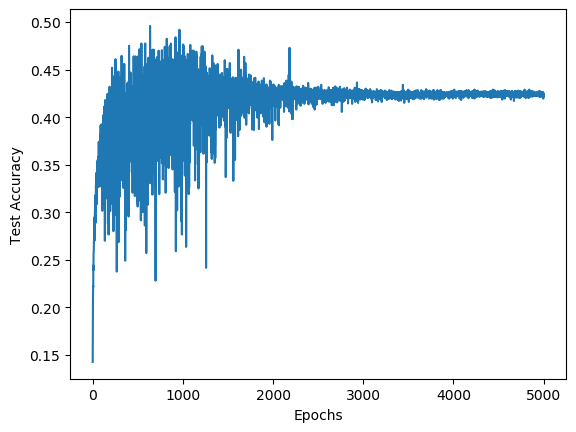
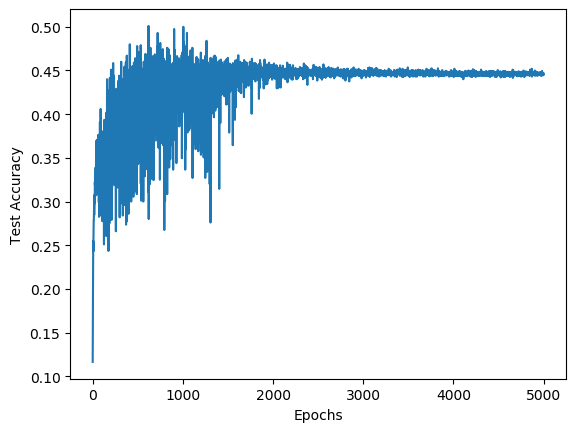
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Figure 21: Test accuracy for [60, 40] Figure 22: Test accuracy for [60, 50]

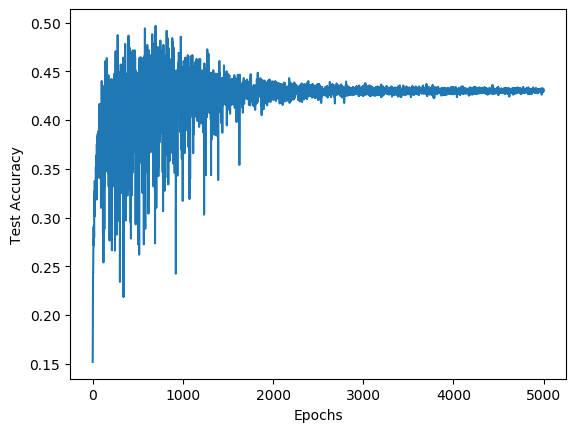
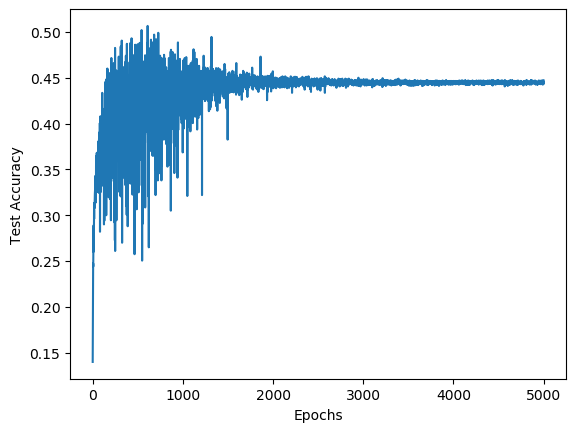
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Figure 23: Test accuracy for [60, 60] Figure 24: Test accuracy for [60, 70]

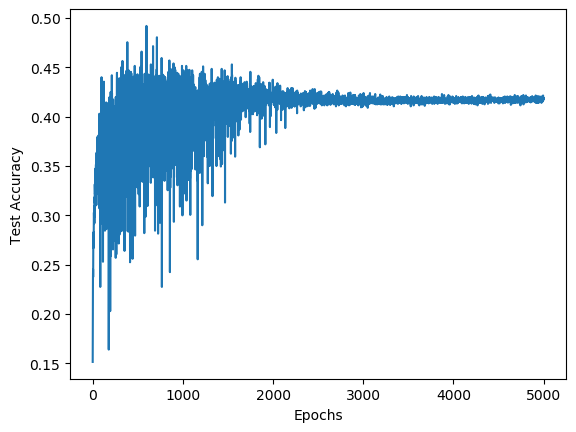
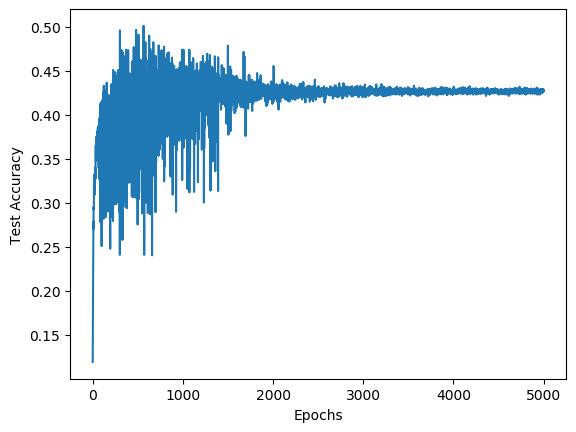
 

Figure 25: Test accuracy for [70, 40] Figure 26: Test accuracy for [70, 50]

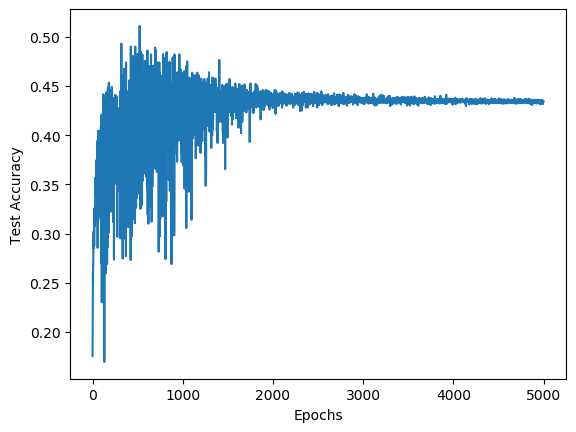
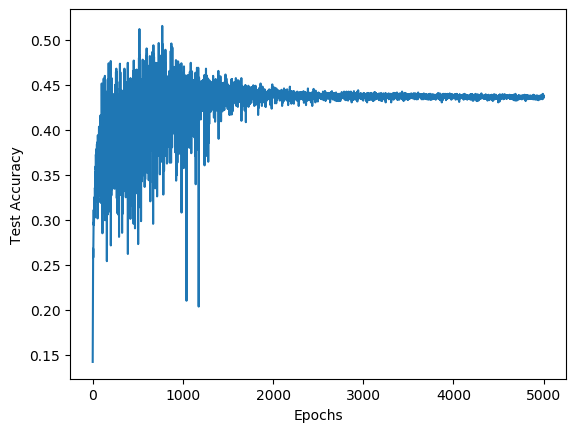
 

Figure 27: Test accuracy for [70, 60] Figure 28: Test accuracy for [70, 70]

From the figures above, and the data obtained by the grid search, it can be found that the combinations [40, 70], [60, 50] and [60, 70] can achieve the highest test accuracy, their test accuracies approximately converge to 0.445.

Since a smaller number of convolution layer feature maps will lead to a smaller usage of computational resources, the combination [40, 70] is selected to be the optimal number of feature maps. In other words, the optimal number of feature maps in the first convolution layer is 40, and the optimal number of feature maps in the second convolution layer is 70.

3. Using the optimal number of filters [40, 70], the CNN is trained by four different methods one at a time.

a. A momentum term 𝛾 = 0.1 is added to the network, with the momentum term, the training costs and test accuracies against epochs is plotted, as shown in Figure 29 and Figure 30.

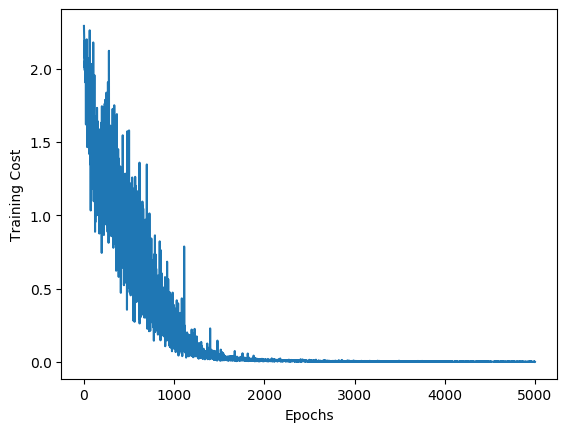
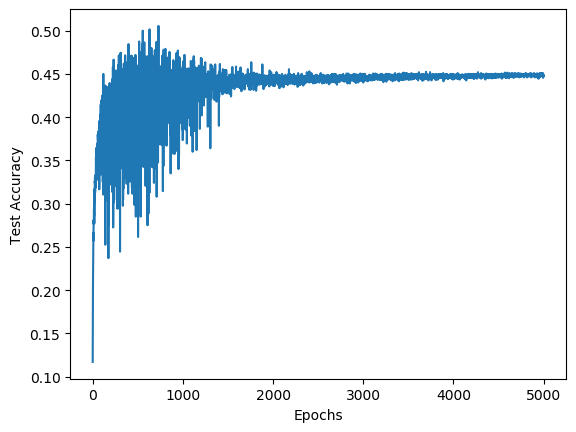
 

Figure 29: Training cost for momentum Figure 30: Test accuracy for momentum

b. When RMSProp algorithm is utilized for learning, the training costs and test accuracies against epochs is plotted, as shown in Figure 31 and Figure 32.

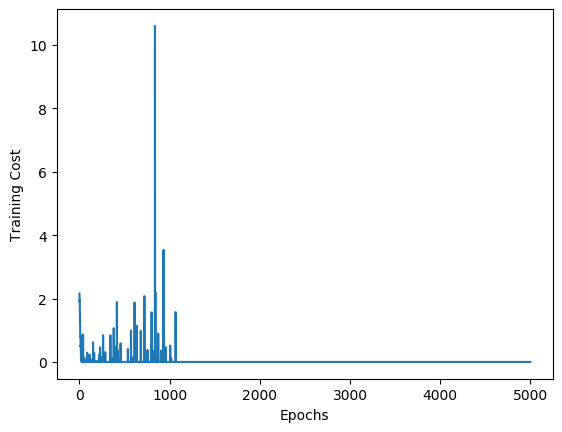
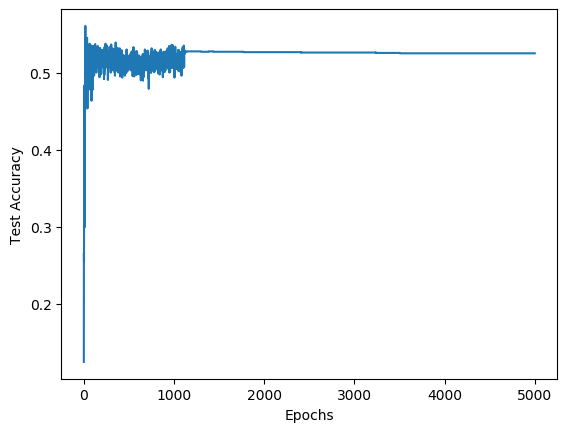
 

Figure 31: Training cost for RMSProp Figure 32: Test accuracy for RMSProp

c. When Adam optimizer is used for learning, the training costs and test accuracies against epochs is plotted, as shown in Figure 33 and Figure 34.

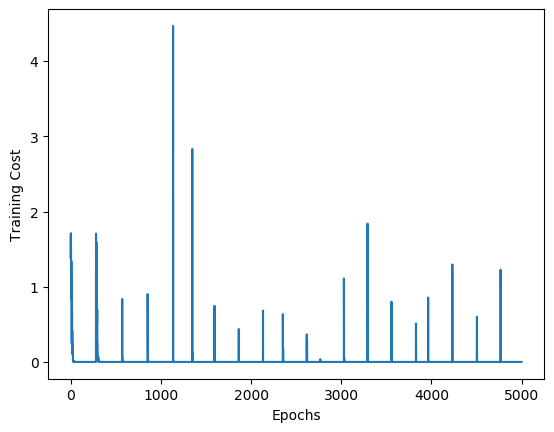
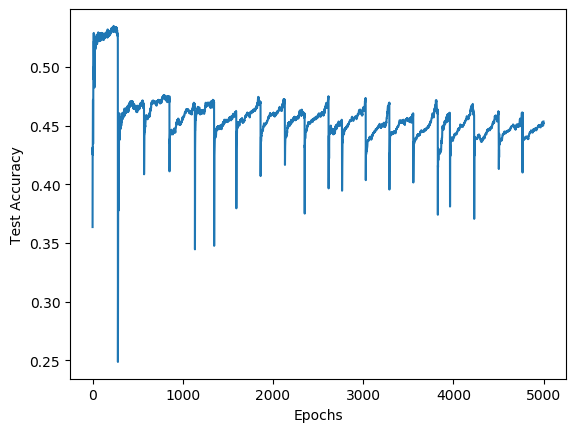
 

Figure 33: Training cost for Adam Figure 34: Test accuracy for Adam

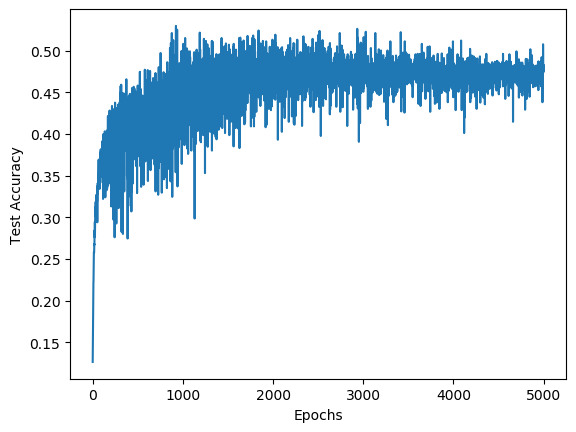
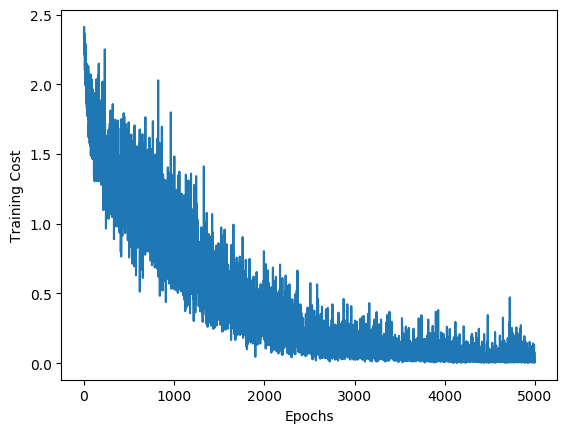
d. When dropout with a rate of 0.5 is applied to the fully connected layer, the training costs and test accuracies against epochs is plotted, as shown in Figure 35 and Figure 36. 

Figure 35: Training cost for dropout Figure 36: Test accuracy for dropout

4.