EE454 Project 1 Report

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a Project Summary

b Procedural Approach

c Experimental Observations

c.1 Intermediate Output

Included in the appendix attached to this report. Each figure shows the concatenated output of each layer as a gray scale image.

d Performance Evaluation

e Further Exploration

e.1 Test Cases

To test the robustness/accuracy of the training outside of the given data set, additional test images were gathered and fed into the CNN. Images were rescaled to thumbnail size (32x32x3) with the Matlab command

```
thumbnail = imresize(img, [32 32]);
```

110 images total were collected; 100 fell into the preexisting image classes, 10 contained scenes not falling into any preexisting class. Running these new 10 images through the CNN yielded the following results:

Image #	Image Contents	CNN Classification
Image 1	Tree in Field	Horse (8)
Image 2	Winter Mountain Scene	Ship (9)
Image 3	Ryan and Zach	Bird (3)
Image 4	Steve	Frog (7)
Image 5	Sean	Cat (4)
Image 6	Desktop Computer	Automobile (2)
Image 7	Football on Field	Deer(5)
Image 8	Robert Collins	Truck (10)
Image 9	Old Main	Bird(3)
Image 10	Penn State Logo	Truck (10)

e.2 Reclassification

An attempt was made to distinguish these 10 images from the rest of the data set (i.e. reclassify these 10 images as unknown). Let V be the vector of output probabilities from the CNN for each image. Let C be the classification of the image producing probability vector V. Originally, we have

$p_i \in V$
$p_{max} = \max(p_1, p_2, ..., p_{10})$
$C = i$ given $p_i = p_{max}$

To reclassify the images we use
$p_{max} = \max(p_1, p_2, ..., p_{10})$
$P = \{p_1, p_2, ..., p_{10}\} \setminus \{p_{max}\}$
$p_{2max} = \max(P)$

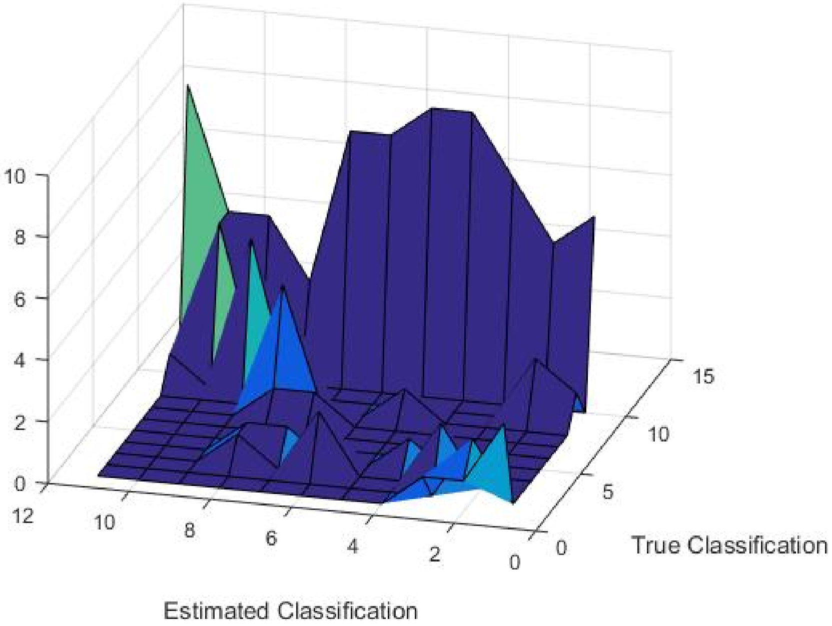
$$\begin{cases} C = i \text{ given } p_i = p_{max} & \text{for } p_{max} - p_{2max} > 0.25 \\ C = 11 & \text{otherwise} \end{cases}$$

Less precisely, the difference between the two peak responses was thresholded by .25; so, if there were two strong responses, the image is reclassified as unknown.

e.3 Results After Reclassification

In the confusion matrix below, classes 1 through 10 are the same classifications. Class 11 identifies an unknown image class.

	CNN Class	1	2	3	4	5	6	7	8	9	10	11
True Class												
1		3	0	0	0	0	0	0	0	1	0	6
2		1	2	0	0	0	0	0	0	2	0	5
3		1	0	2	0	0	0	0	0	0	0	7
4		0	0	0	1	0	0	0	0	0	0	9
5		0	0	0	0	0	0	0	1	0	0	9
6		0	0	2	0	0	0	0	0	0	0	8
7		0	0	0	1	0	0	1	0	0	0	8
8		0	0	1	1	0	0	1	4	0	0	3
9		0	0	0	0	0	0	0	0	5	0	5
10		0	0	0	0	0	0	0	0	0	5	5
11		0	0	0	0	0	0	0	0	1	0	9



Accuracy = 29.09%
The reclassification metric does well in replacing the 10 new images in the unknown category, but also places images that were previously correctly classified in the unknown category. Other metrics tested were

1. Thresholding on the number of classes that had a response above 0.1 (the mean value for random classification)

2. Taking the spatial derivative of the probability vector; this metric actually produces zero-mean Gaussian noise with a very small standard deviation.

f Member Contributions

Appendices

A Intermediate Output

Figure 1: Original Image

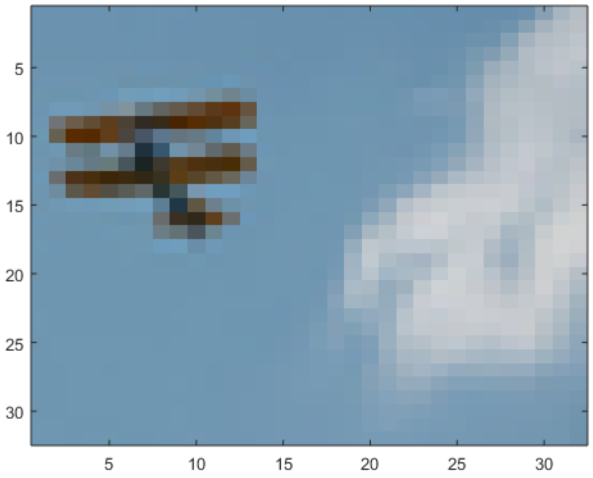


Figure 2: Layer 1 Output

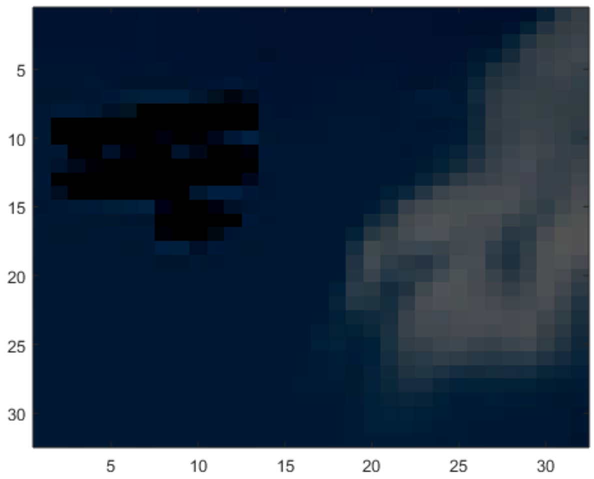


Figure 3: Layer 2 Output

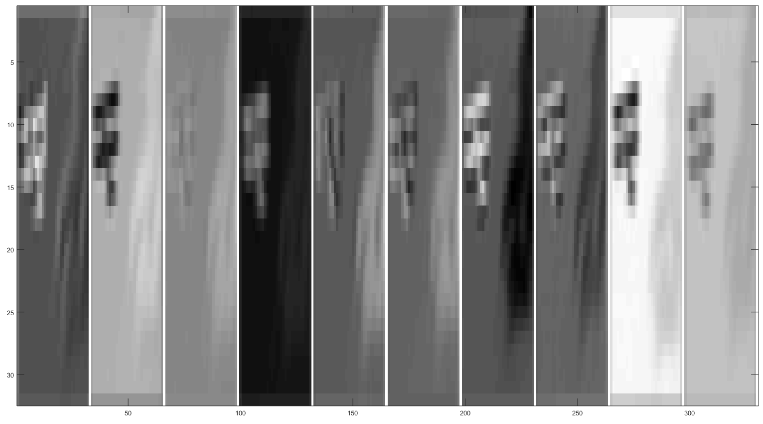


Figure 4: Layer 3 Output

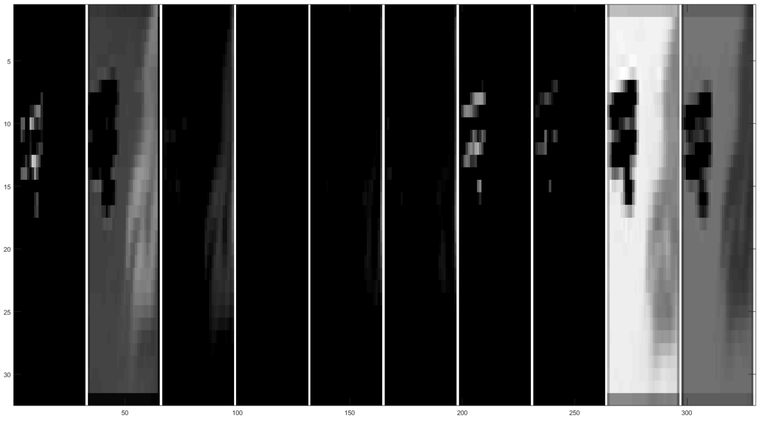


Figure 5: Layer 4 Output

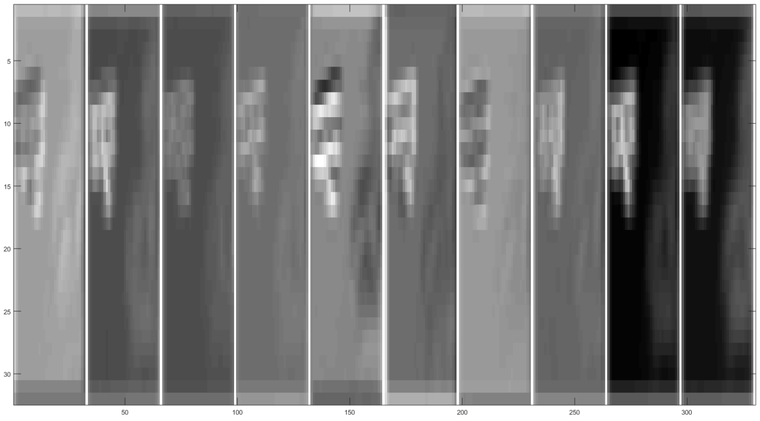


Figure 6: Layer 5 Output

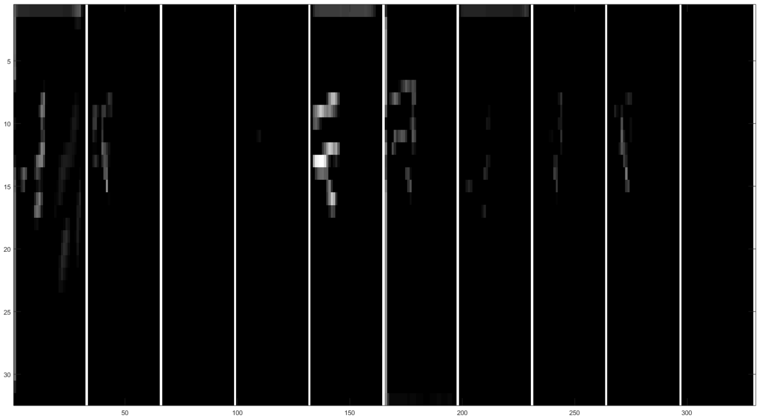


Figure 7: Layer 6 Output

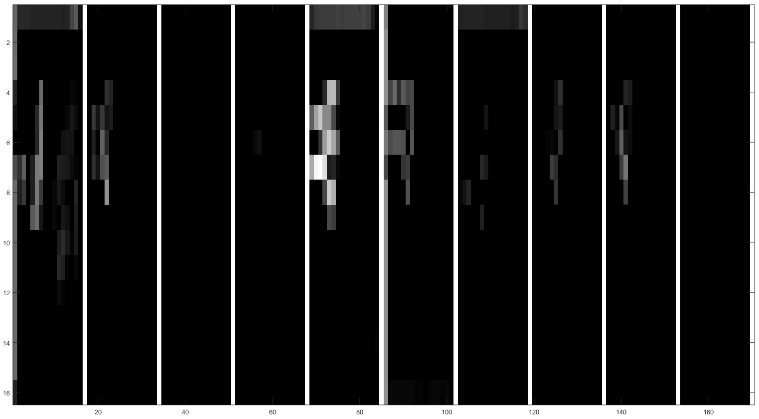


Figure 8: Layer 7 Output

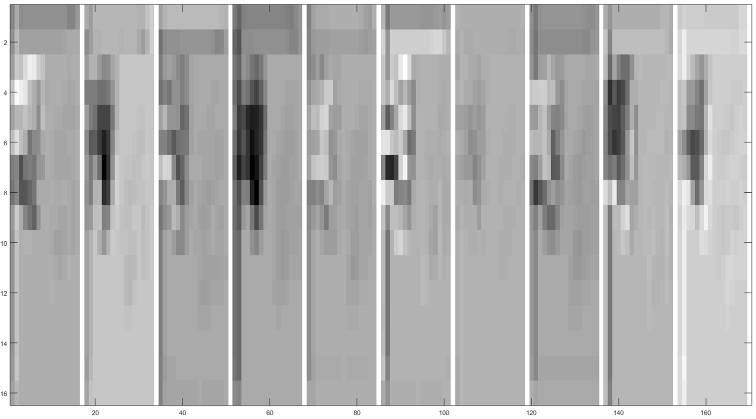


Figure 9: Layer 8 Output

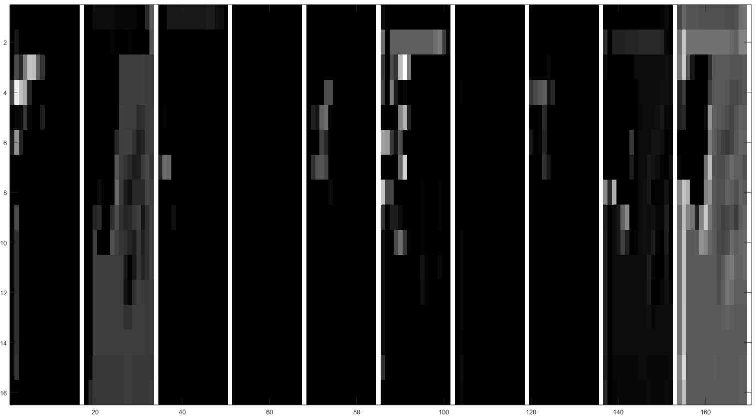


Figure 10: Layer 9 Output

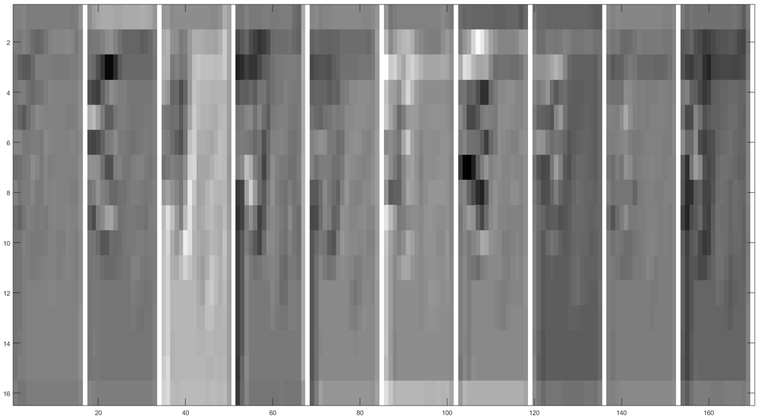


Figure 11: Layer 10 Output

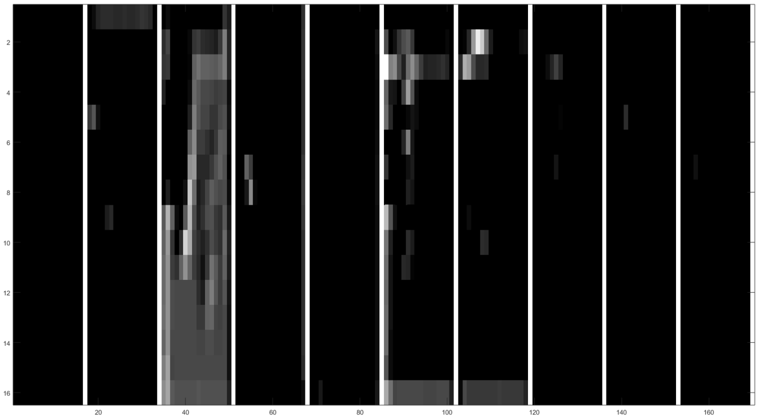


Figure 12: Layer 11 Output

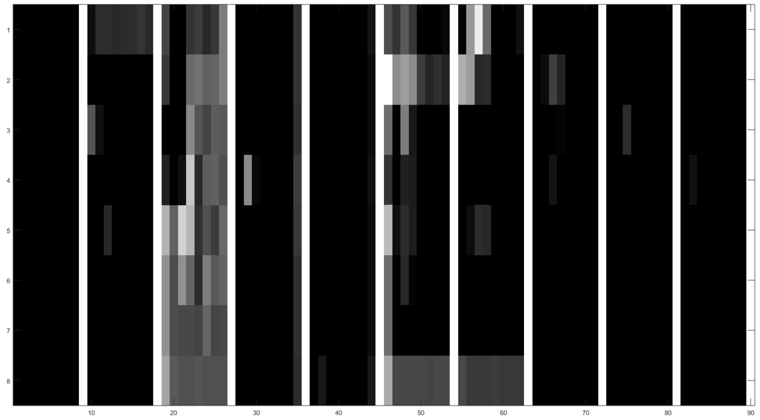


Figure 13: Layer 12 Output

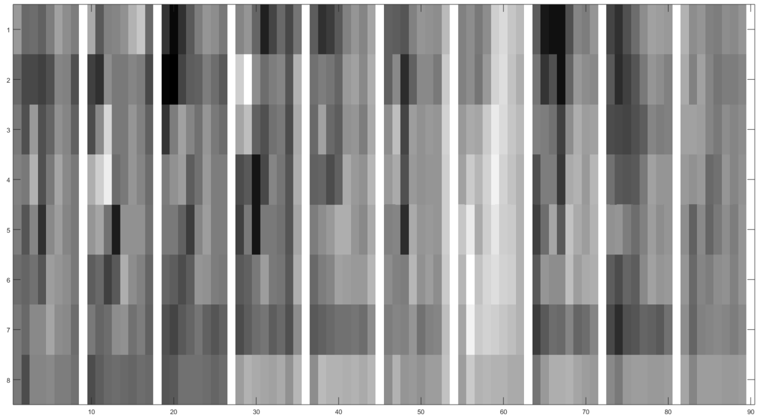


Figure 14: Layer 13 Output

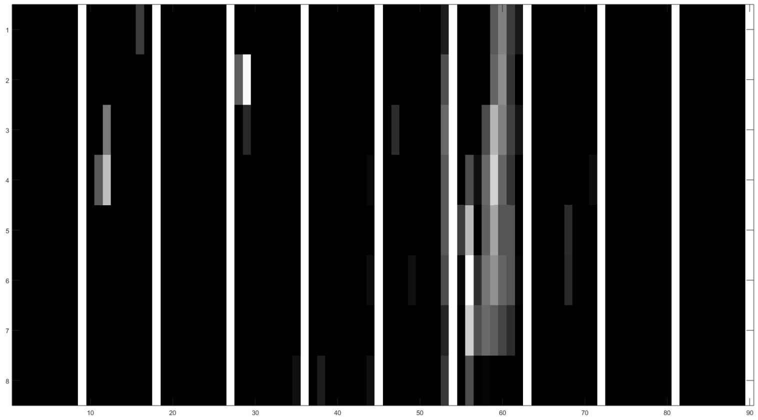


Figure 15: Layer 14 Output

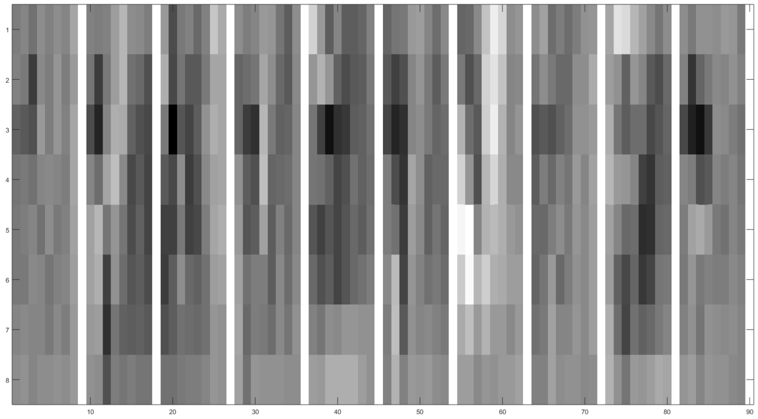


Figure 16: Layer 15 Output

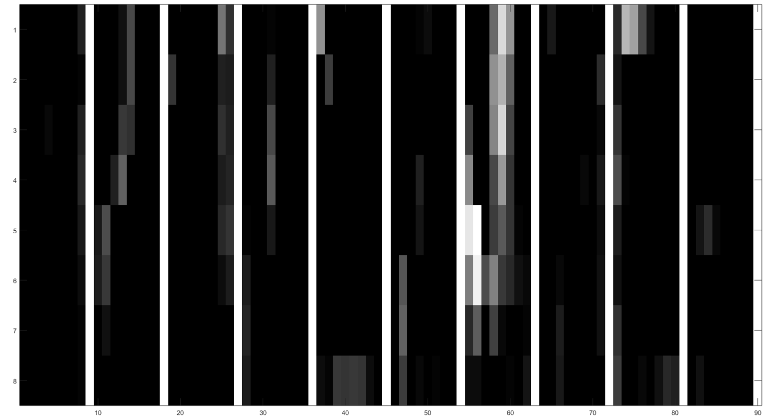


Figure 17: Layer 16 Output

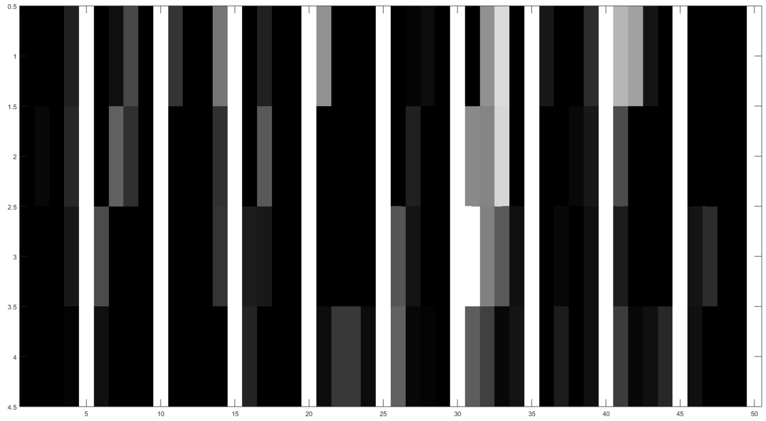


Figure 18: Layer 17 Output

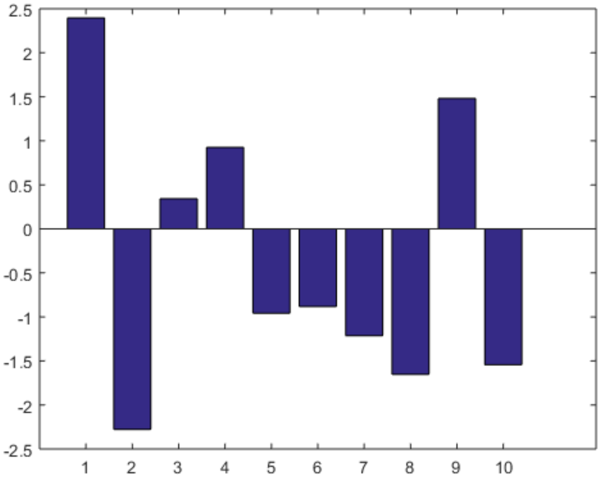
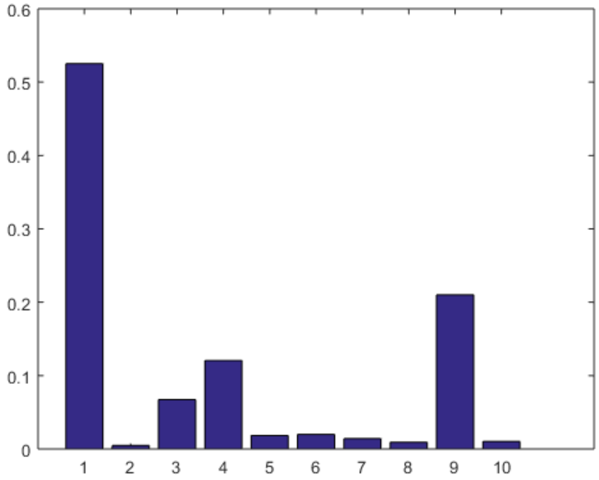


Figure 19: Layer 18 Output


0.6
0.5
0.4
0.3
0.2
0.1
0
1
2
3
4
5
6
7
8
9
10