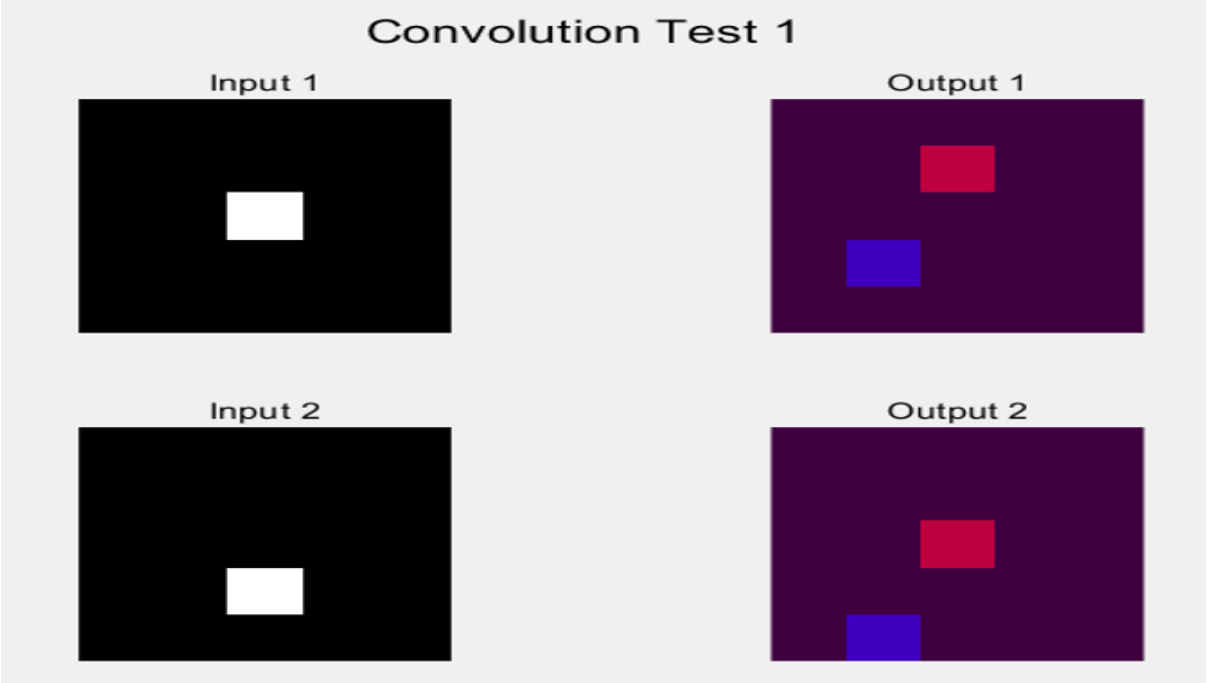
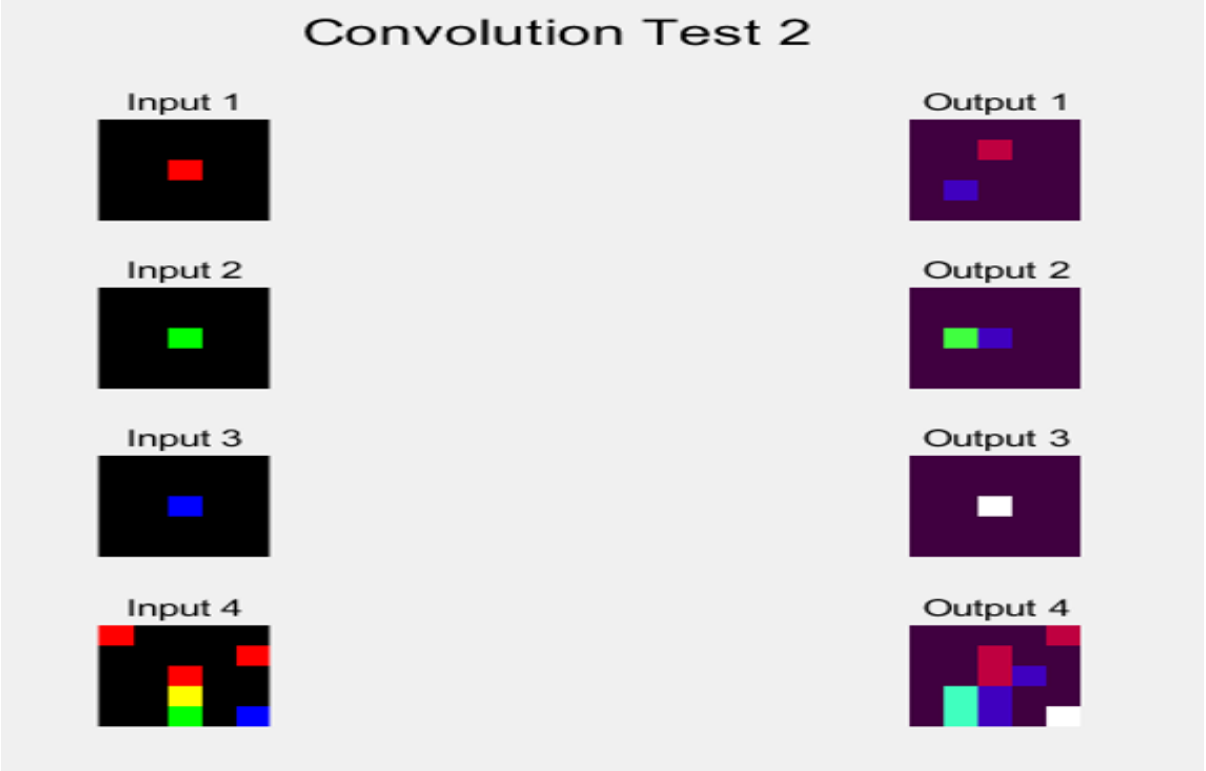
CMPT412 (Fall 2021): Project 1
Digit recognition with convolutional neural networks
Keenan Byun 301381767

1.Forward Passing Visualization





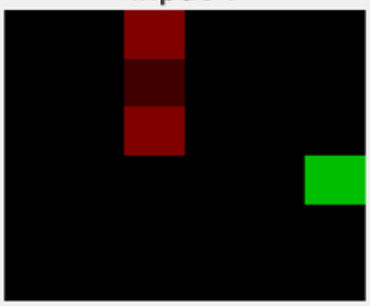
Inner Product Test

Batch 1

Batch 2

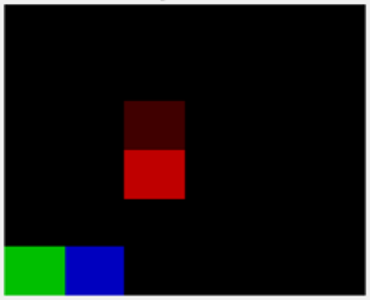
Pooling Test

Input 1



Output 1

Input 2



Output 2

3.1. Test Accuracy Report

cost = 0.163018 training_percent = 0.940000
cost = 0.183865 training_percent = 0.950000
cost = 0.114604 training_percent = 0.970000
cost = 0.123332 training_percent = 0.970000
cost = 0.172601 training_percent = 0.940000
test accuracy: 0.948000

cost = 0.165428 training_percent = 0.950000
cost = 0.150909 training_percent = 0.940000
cost = 0.132034 training_percent = 0.950000
cost = 0.114618 training_percent = 0.970000
cost = 0.154494 training_percent = 0.960000
test accuracy: 0.962000

cost = 0.141587 training_percent = 0.960000
cost = 0.159761 training_percent = 0.950000
cost = 0.170416 training_percent = 0.950000
cost = 0.129362 training_percent = 0.980000
cost = 0.128402 training_percent = 0.970000
test accuracy: 0.964000

cost = 0.142300 training_percent = 0.980000
cost = 0.153441 training_percent = 0.950000
cost = 0.074965 training_percent = 0.990000
cost = 0.135037 training_percent = 0.960000
cost = 0.112800 training_percent = 0.960000
test accuracy: 0.962000

cost = 0.201578 training_percent = 0.930000
cost = 0.133018 training_percent = 0.980000
cost = 0.149888 training_percent = 0.940000
cost = 0.180013 training_percent = 0.940000
cost = 0.148866 training_percent = 0.950000
test accuracy: 0.962000

cost = 0.152201 training_percent = 0.970000
cost = 0.121210 training_percent = 0.970000
cost = 0.126919 training_percent = 0.980000
cost = 0.138883 training_percent = 0.950000
cost = 0.224516 training_percent = 0.950000
test accuracy: 0.960000

3.2 Confusion Matrix

	1	2	3	4	5	6	7	8	9	10
1	39	0	0	0	0	0	0	0	1	0
2	0	49	0	0	0	0	1	0	0	1
3	0	0	58	2	0	0	0	1	1	0
4	0	0	2	49	0	0	0	1	1	1
5	0	1	0	0	47	0	0	0	0	5
6	0	0	0	1	0	45	0	1	0	0
7	0	0	0	0	0	0	38	0	0	0
8	0	0	0	0	0	0	0	49	0	1
9	1	0	1	2	0	0	0	1	44	1
10	0	0	0	0	1	0	0	1	0	53

Top two confused pairs:
class 10 & class 5(9&4): 9 and 4 have the most confused rate in the results. The reason is that the only difference between the two numbers is the property of the line. If the line of the number is straight, then it is number 4, and if the line of number is rounded, then it is number 9. They might be hard to distinguish.
class 10 & class 8(9&7): Except for the 9 and 4, other number pairs had similar confused rates. 9 and 7 is one of the pairs. 9 and 7 look similar too; for example, if the left top line is closed, then the number is 9; otherwise, it is 7. Actually, that is a big difference, but it depends on the habit of a person when the number is hand written; therefore, it could be confusing.

3.3 Real World Example

list of numbers:

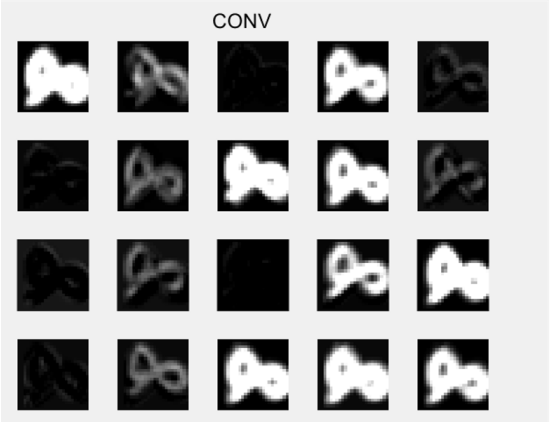
result:

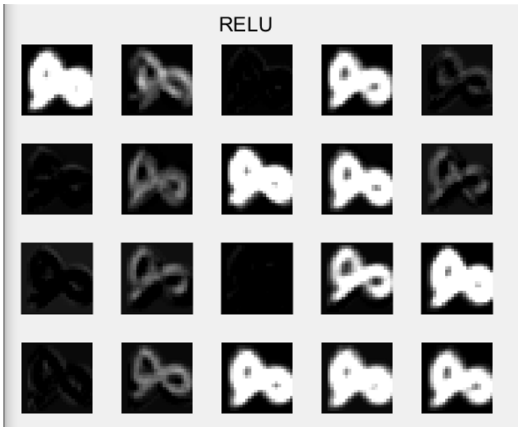
```
answer:       1     2     6     8     10

prediction:     10     2    10     8     5

Accuracy:     0.4000
```

4.1 Visualization





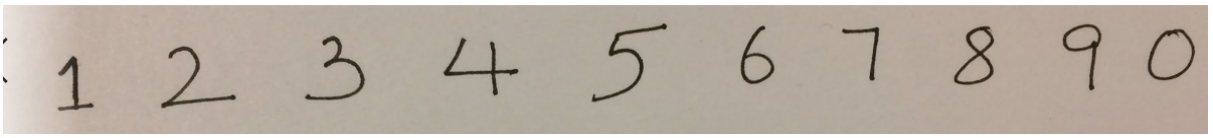
4.2 Comparison

original image:

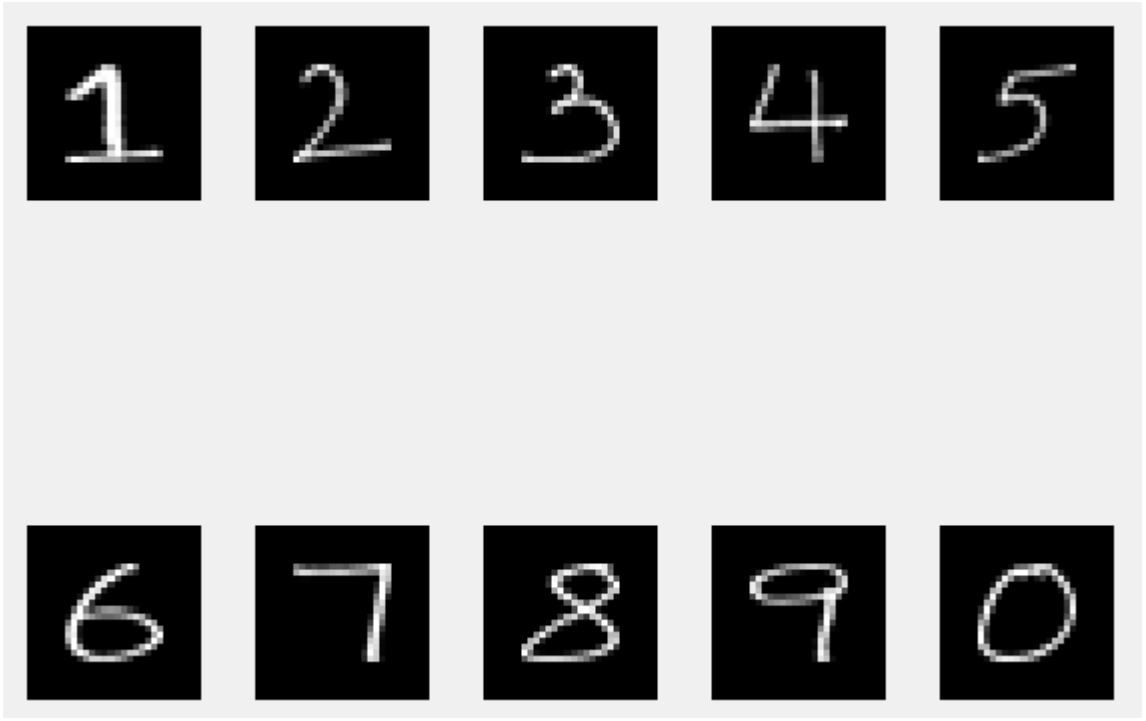
The result of the CONV layer and the ReLu layer looks similar. The filters make images expanding the border of objects with various sizes, blurring, darkening with various levels, and so on.

5 Image Classification

Image1:



Processed image1:

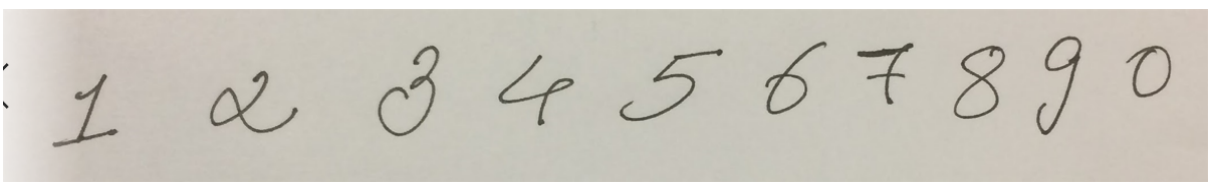


Output:

1 2 3 4 5 5 7 8 7 0

Rate:
8/10 = 80%

Image2:



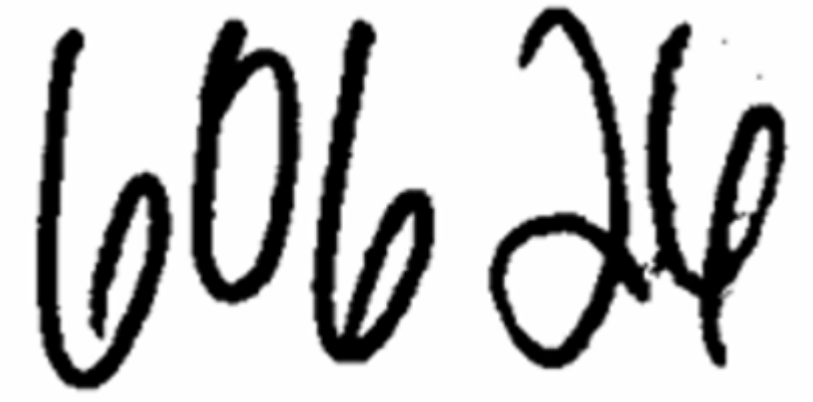
Processed image2:

Output:

1 6 3 9 5 5 7 8 7 0

Rate:
6/10 = 60%

Image3:



Processed image3:

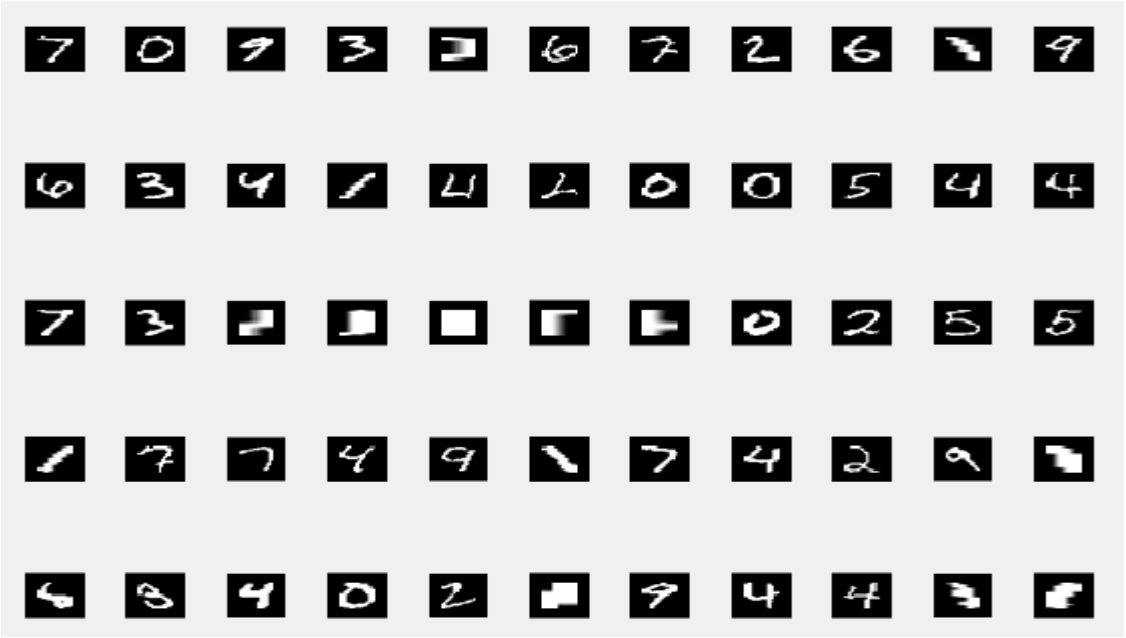
Output:

```
6     0     6     2     4
```

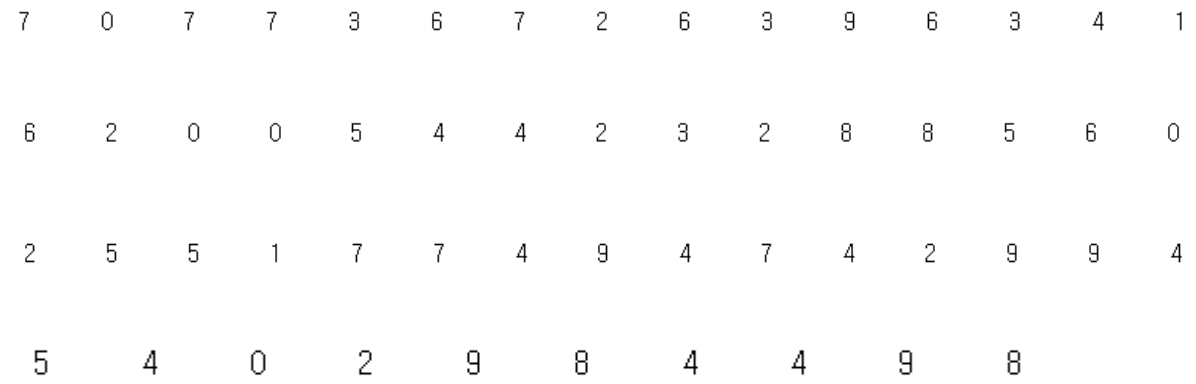
Rate:
4/5 = 80%

Image 4:

Processed image4 (recognition failed 50->55):



Output:



Rate:
37/ 47 = 88.1%

Total:
55/72 = 76.4%