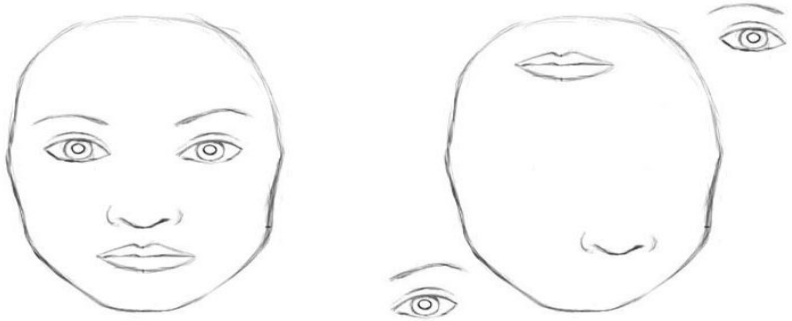
Capsule Networks

COMPUTER VISION
PROJECT 03

Ojas Barve (200213803)
Sharvari Deshpande (200206230)
Anushka Gupta (200206727)

Motivation

CNNs are Translational invariant, means they are unable to identify the position of one object relative to another. For example, CNN’s predicts a face to a bunch of randomly assembled face parts because all the key features are there. But Capsule Networks have the ability to identify that the face parts are not in correct position relative to another.

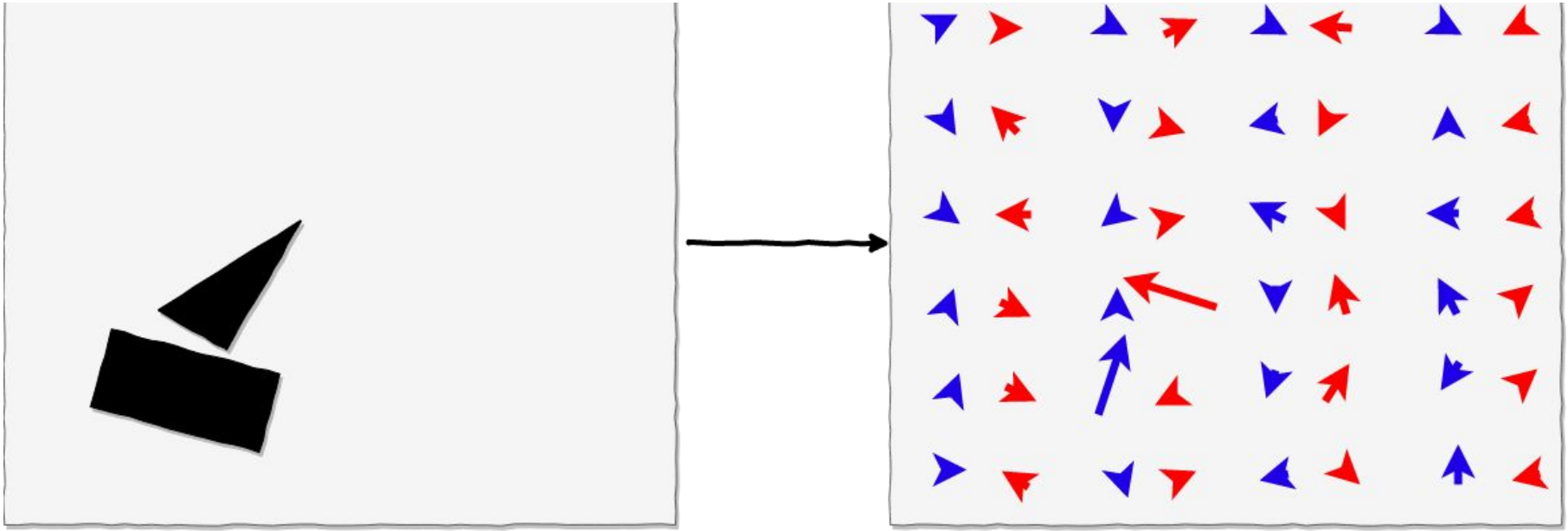


Objective

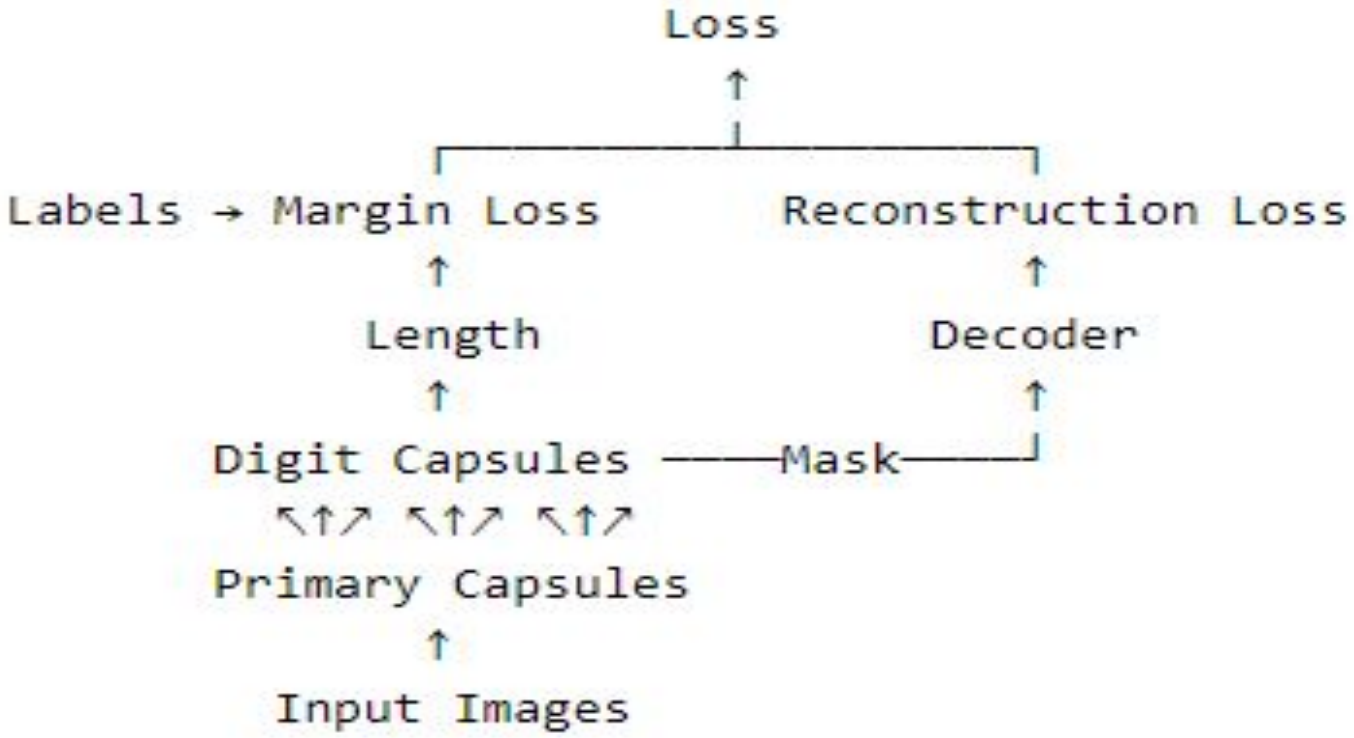
The key idea behind the project is to explore the capsule network space on the Street View Housing Numbers (SVHN) dataset using the TensorFlow framework based on the paper.

http://ufldl.stanford.edu/housenumbers/

Overview of CapsNet - Inverse graphics Approach



CapsNet Flowchart



Squashing Function Used:

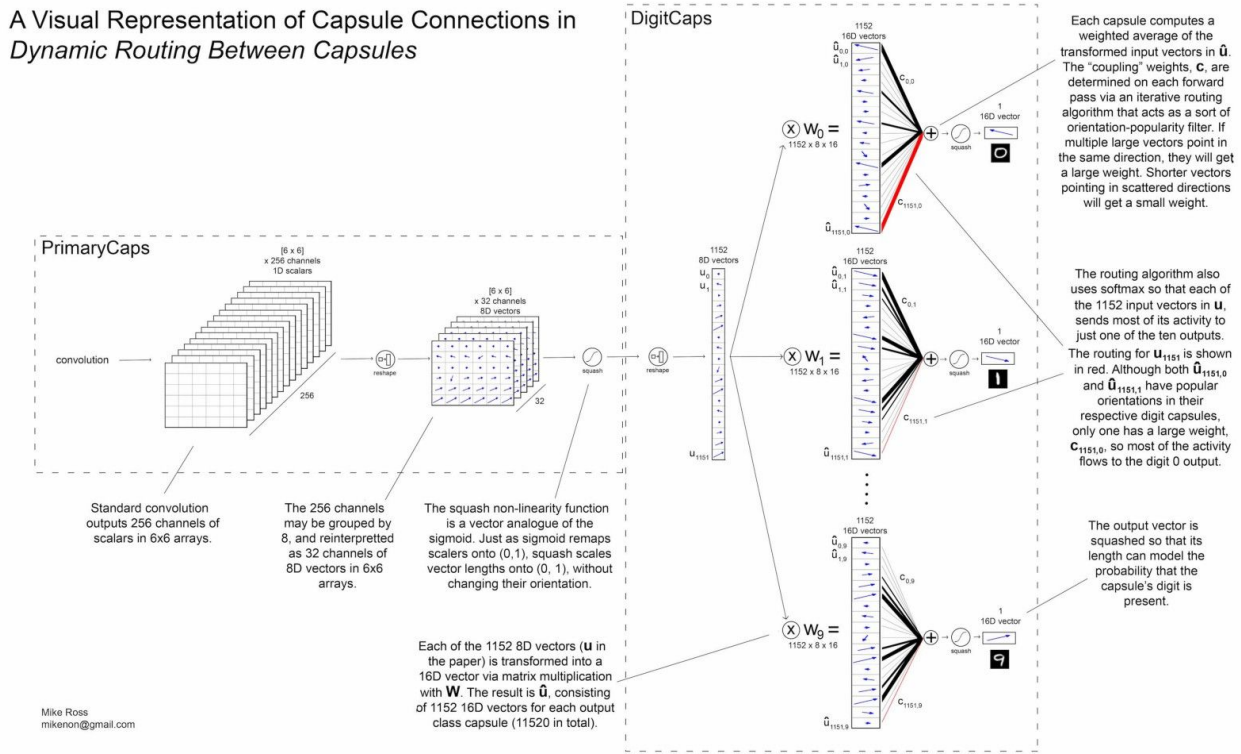
$$(\mathbf{s}) = \frac{\| \mathbf{s} \|^2}{1 + \| \mathbf{s} \|^2} \frac{\mathbf{s}}{\| \mathbf{s} \|}$$

Margin Loss:

$$L_k = T_k \max(0,\ m^+ - \| \mathbf{v}_k \|)^2 + \lambda(1 - T_k)\max(0,\ \| \mathbf{v}_k \| - m^-)^2$$

- T_k is equal to 1 if the digit of class k is present, or 0 otherwise.
- In the paper, $m^+ = 0.9$, $m^- = 0.1$ and $\lambda = 0.5$.

Method overview



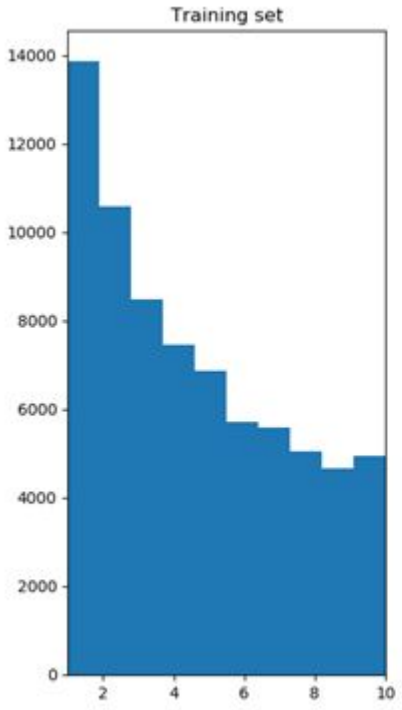
Experimental results

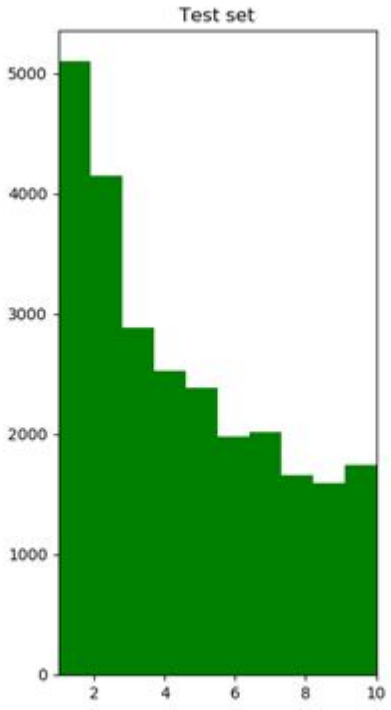
Dataset creation:

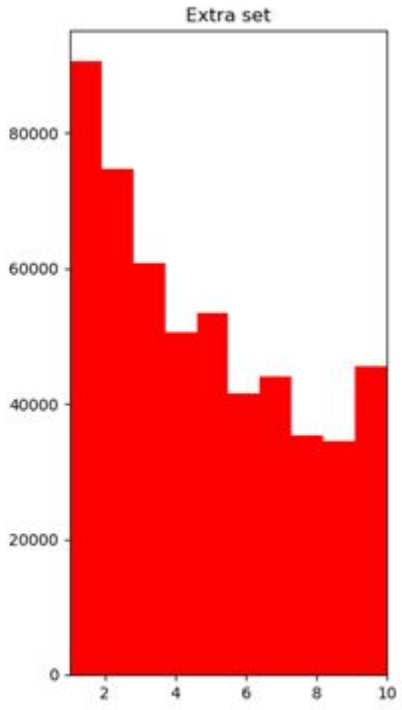
- We used the Street View Housing Numbers (SVHN) Dataset for experimentation.
- They are divided as 73, 257 for training, 26, 032 for testing and it has an additional 531, 131 as extra images
- We decided to create a balanced validation set to ensure, the model has an ability to recognize digits with each number having an equal importance.

```
Training set (69257, 32, 32, 1) (69257, 10)
Validation set (6000, 32, 32, 1) (6000, 10)
Test set (26032, 32, 32, 1) (26032, 10)
```

Data View


Training set
14000
12000
10000
8000
6000
4000
2000
0
2
4
6
8
10


Test set
5000
4000
3000
2000
1000
0
2
4
6
8
10


Extra set
80000
60000
40000
20000
0
2
4
6
8
10

Experimental results

At each epoch:

Epoch: 1 Val accuracy: 75.0167% Loss: 7.686755
Epoch: 2 Val accuracy: 81.3167% Loss: 7.841952
Epoch: 3 Val accuracy: 85.7500% Loss: 7.548036
Epoch: 4 Val accuracy: 87.6500% Loss: 7.603930
Epoch: 5 Val accuracy: 87.8167% Loss: 7.626252
Epoch: 6 Val accuracy: 88.8333% Loss: 7.597592
Epoch: 7 Val accuracy: 88.5000% Loss: 7.485849
Epoch: 8 Val accuracy: 88.6500% Loss: 7.567253
Epoch: 9 Val accuracy: 87.6333% Loss: 7.603738
Epoch: 10 Val accuracy: 90.8500% Loss: 7.582572

Accuracy:

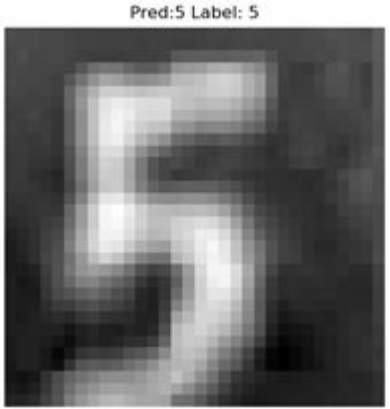
The final averaged out accuracy and loss for the model are:

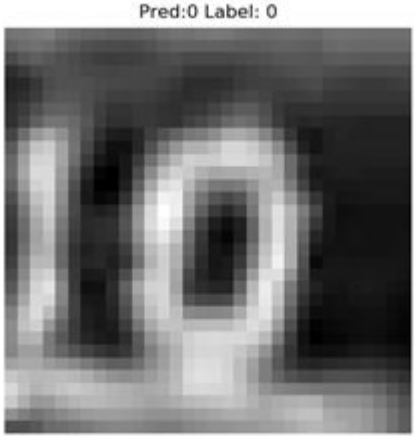
Final test accuracy: 88.4385% Loss: 8.275824

Experimental Results

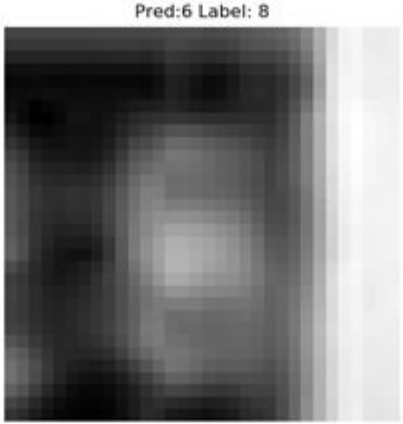
The model correctly predicts for the following:

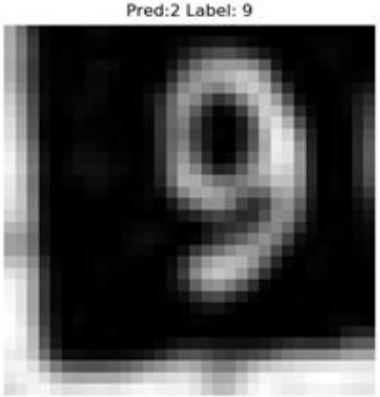
- Numbers from images on the downloaded dataset

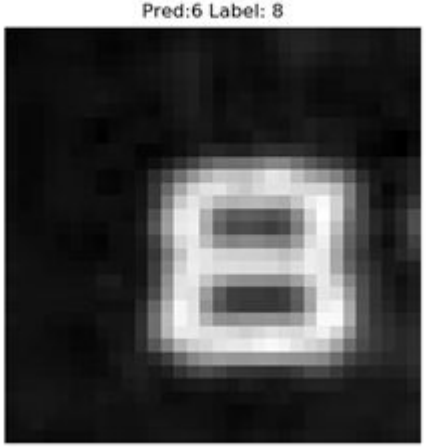




Misclassifications







Experimental results

- Predictions on images

Figure : Image Captures

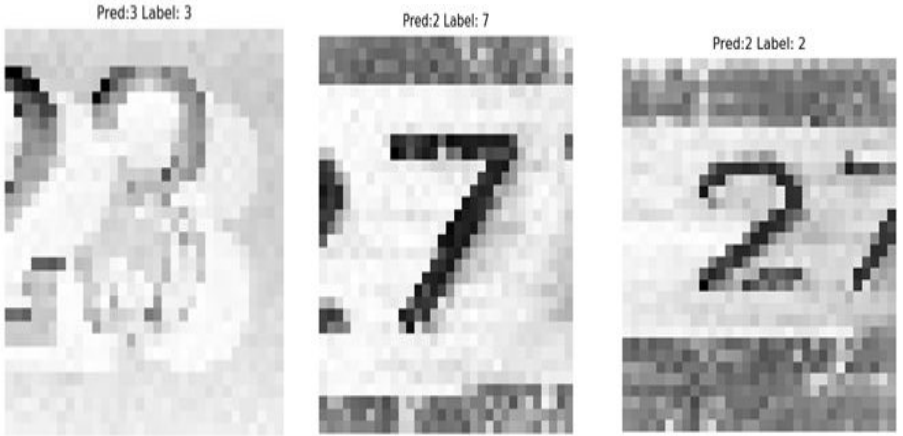
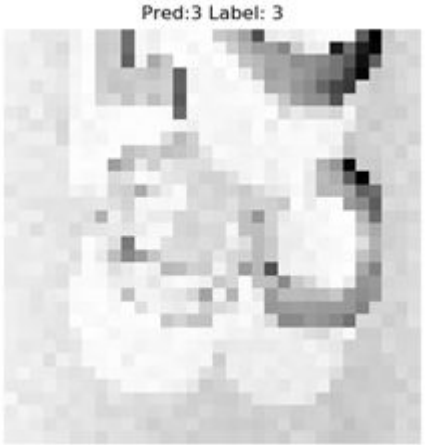
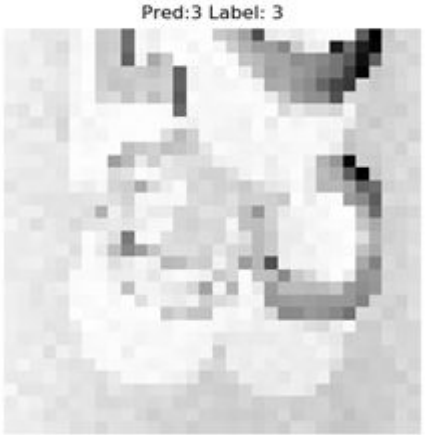


Figure : Image Predictions

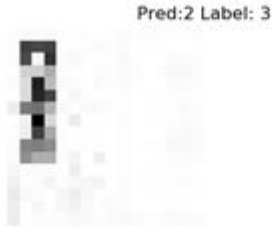
Experimental results

- Predictions at different angles, for example 90 degrees.





Translated Images



Conclusion

From the results obtained above the capsule network did not perform as well as it performed on the MNIST data set as described in the paper.

MNIST Results:
INFO:tensorflow:Restoring parameters from ./my_capsule_network
Epoch: 1 Val accuracy: 99.4400% Loss: 0.007998 (improved)
Epoch: 2 Val accuracy: 99.3400% Loss: 0.007959 (improved)
Epoch: 3 Val accuracy: 99.4000% Loss: 0.007436 (improved)
Epoch: 4 Val accuracy: 99.4000% Loss: 0.007568
Epoch: 5 Val accuracy: 99.2600% Loss: 0.007464
Epoch: 6 Val accuracy: 99.4800% Loss: 0.006631 (improved)
Epoch: 7 Val accuracy: 99.4000% Loss: 0.006915
Epoch: 8 Val accuracy: 99.4200% Loss: 0.006735
Epoch: 9 Val accuracy: 99.2200% Loss: 0.007709
Epoch: 10 Val accuracy: 99.4000% Loss: 0.007083

Future Work

- We intend to experiment with different face datasets which we used in the previous projects and try inference on translated, skewed, disfigured and rotated images .

References

https://arxiv.org/abs/1710.09829

https://github.com/ageron/handson-ml/blob/master/extra_capsnets.ipynb

https://www.youtube.com/watch?v=pPN8d0E3900&feature=youtu.be