Reading Digits with Neural Networks

Todd Sierens[1,2]

[1]Perimeter Institute for Theoretical Physics
[2]University of Waterloo

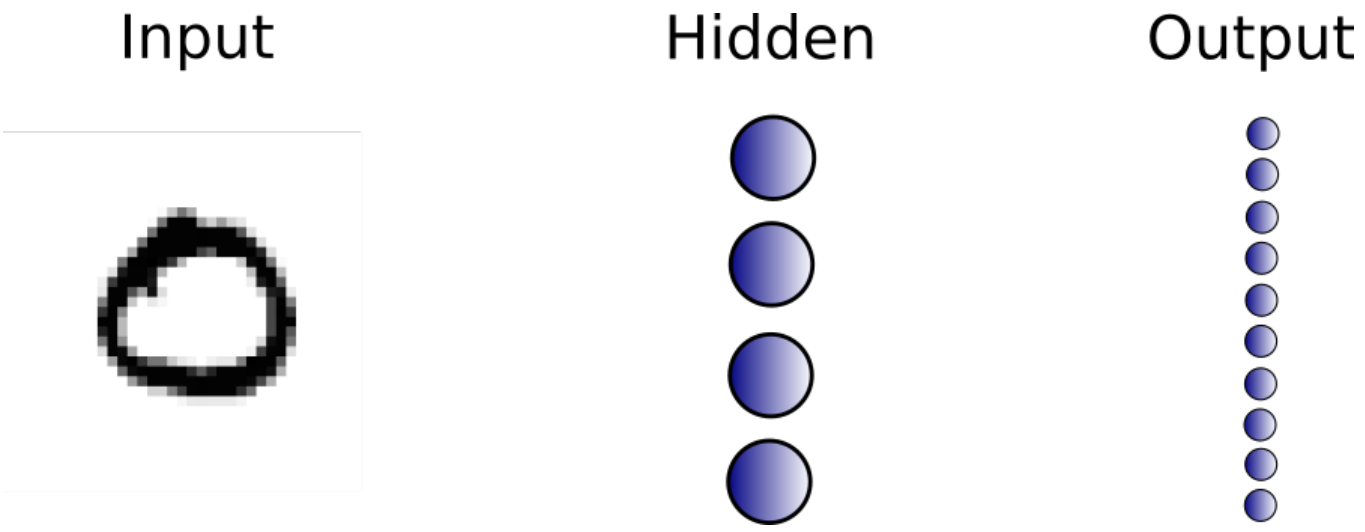
February 16, 2016

Outline

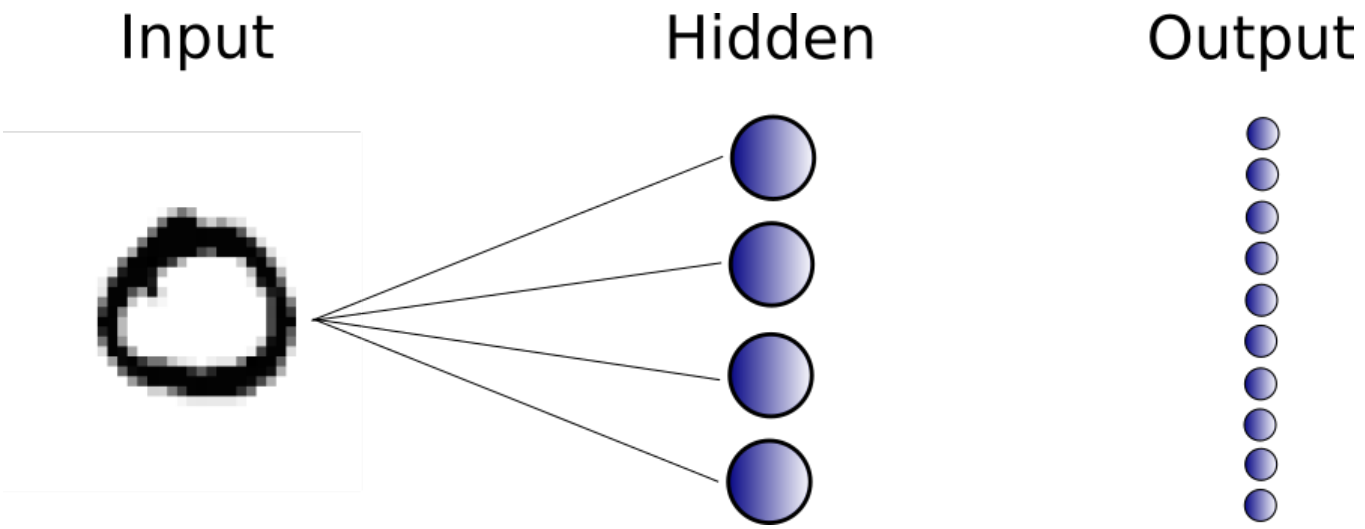
Handwritten digits

Figure: 100 handwritten digits from the MNIST database provided as a training set by kaggle.com.

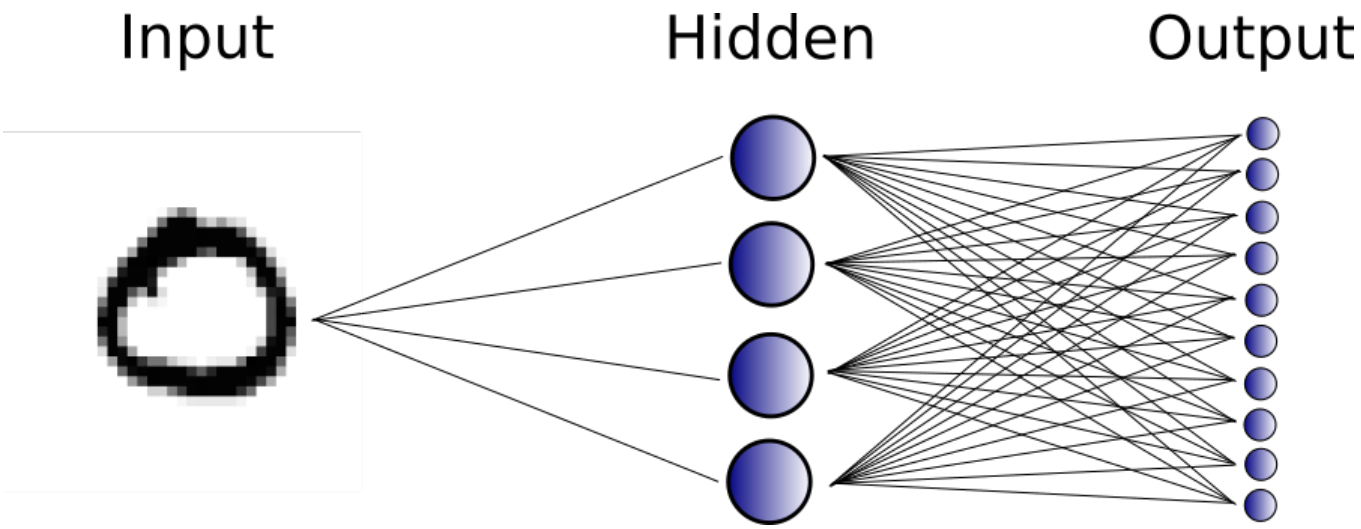
Neural Network

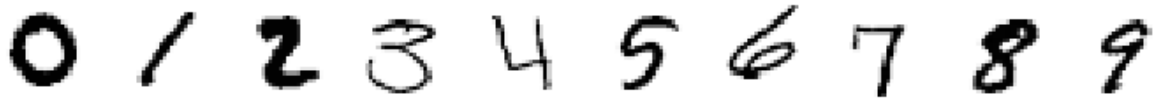


Neural Network

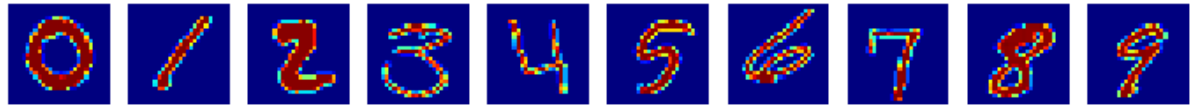


Neural Network

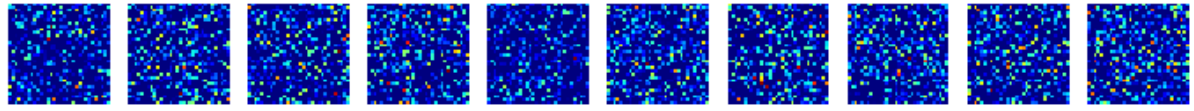




(a) Greyscale images of some of the training data.

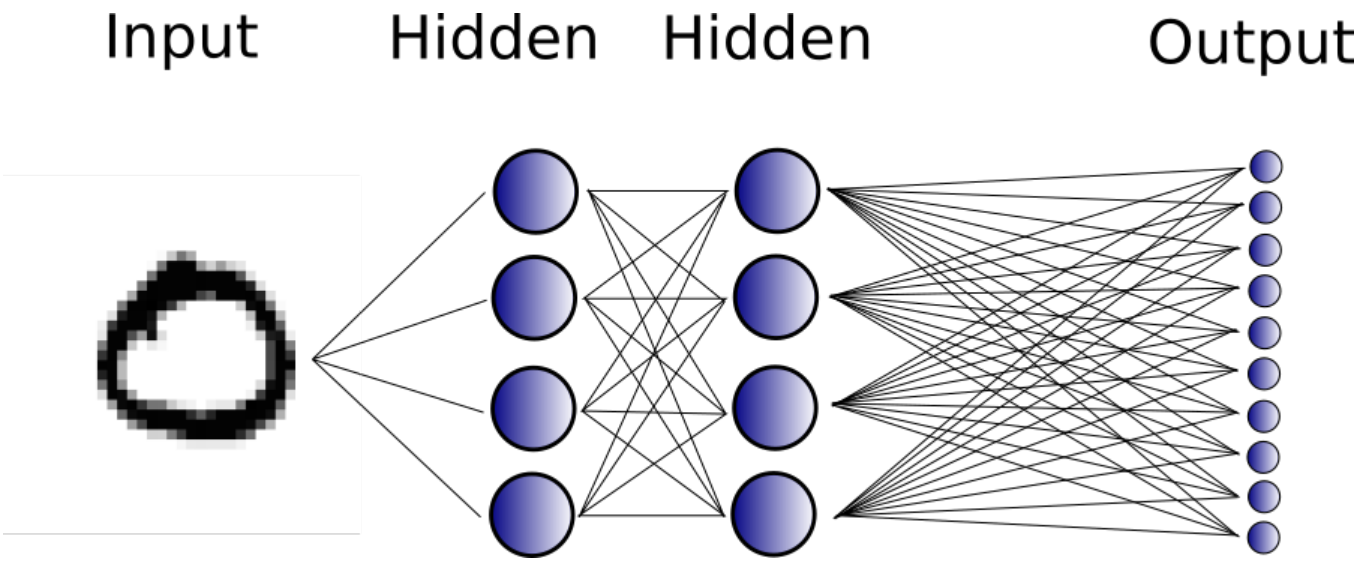


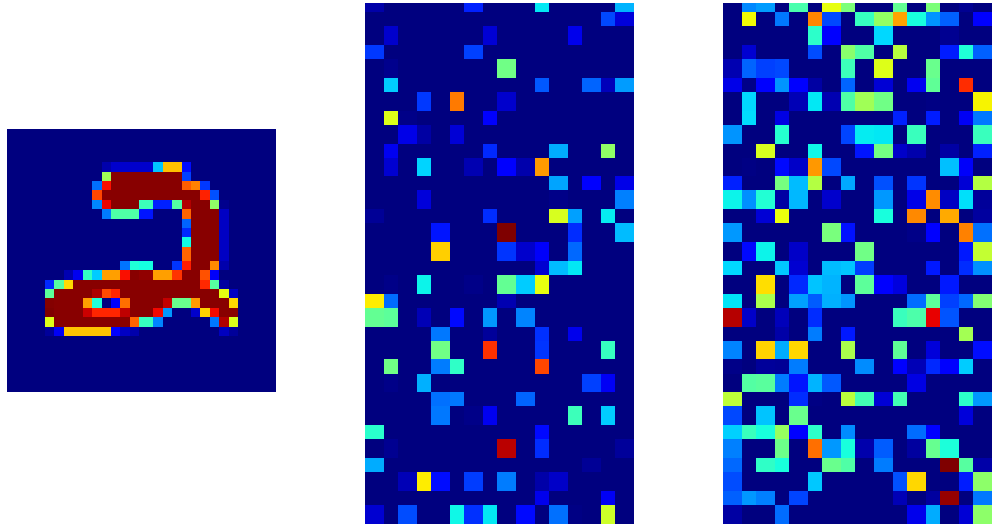
(b) Raw input layer of neural network.

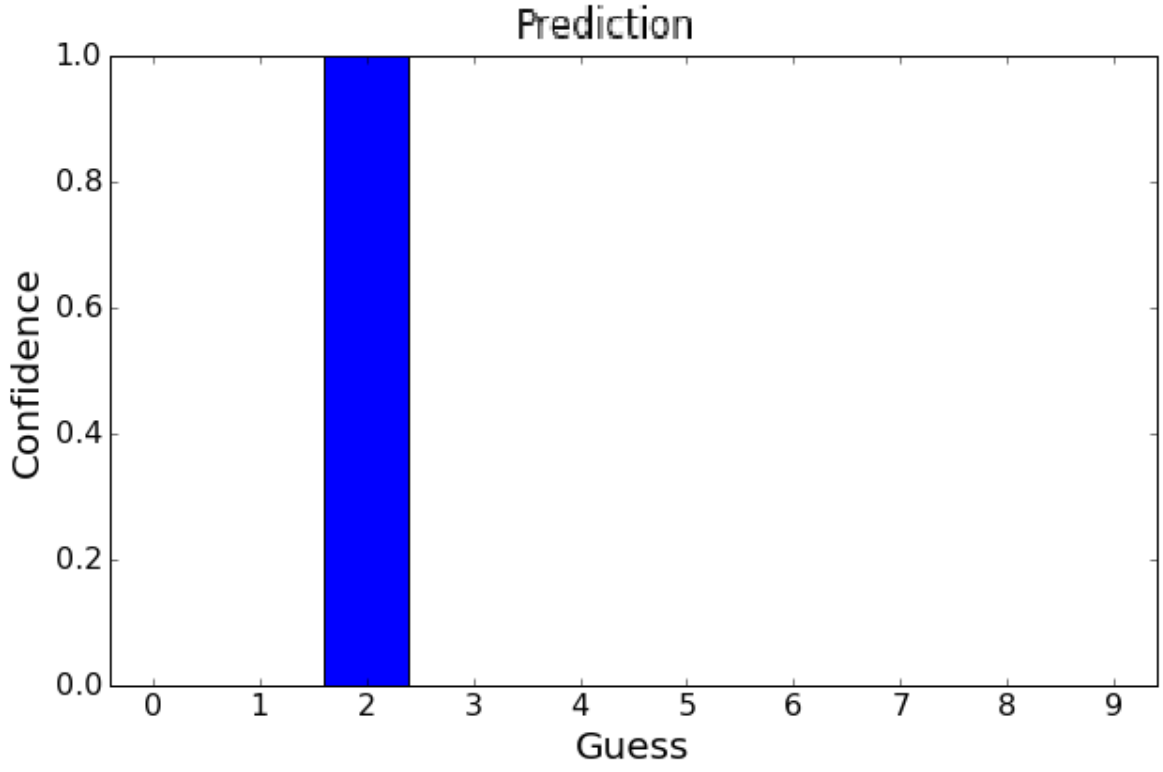


(c) Hidden layer of neural network.

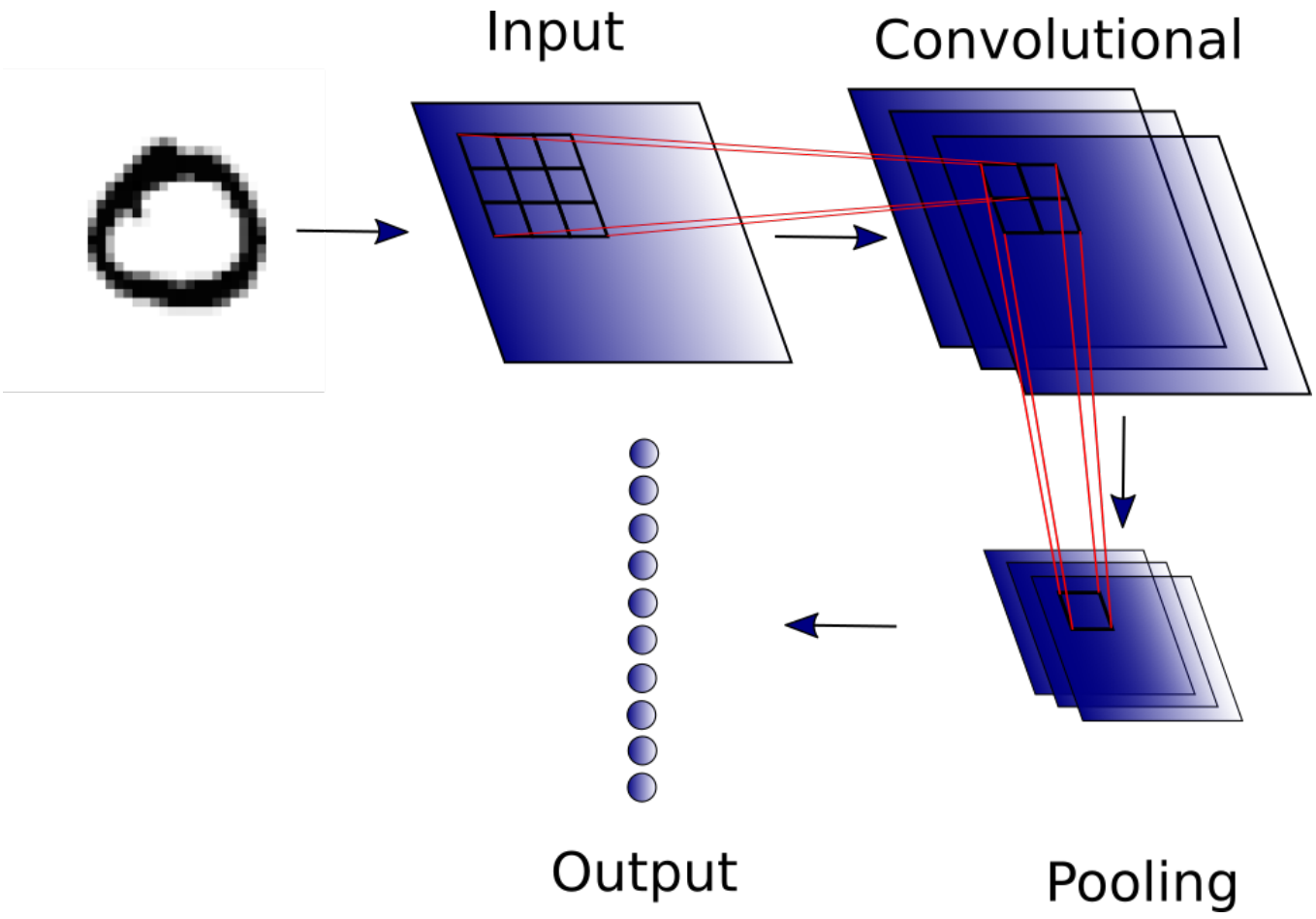
Multilayer Perceptron



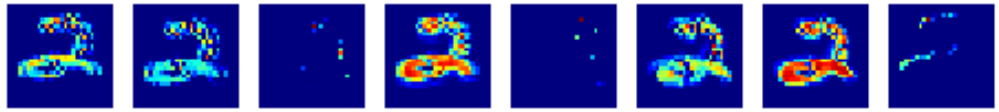



Prediction
1.0
0.8
0.6
0.4
0.2
0.0
Confidence
0
1
2
3
4
5
6
7
8
9
Guess

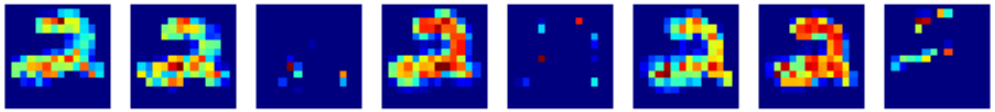
Convolutional Neural Network



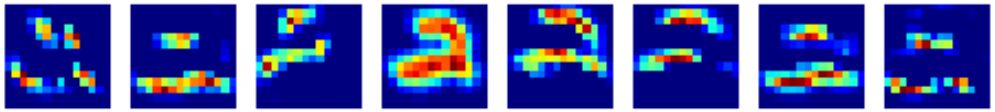
Input Layer



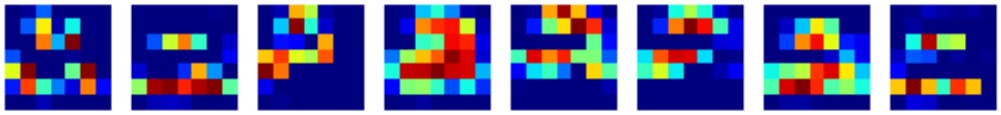
1st conv. layer



1st pooling layer

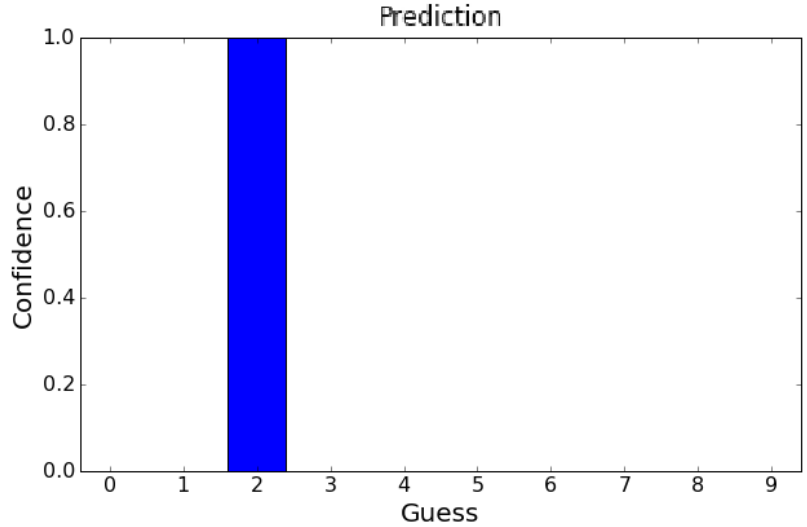


2nd conv. layer



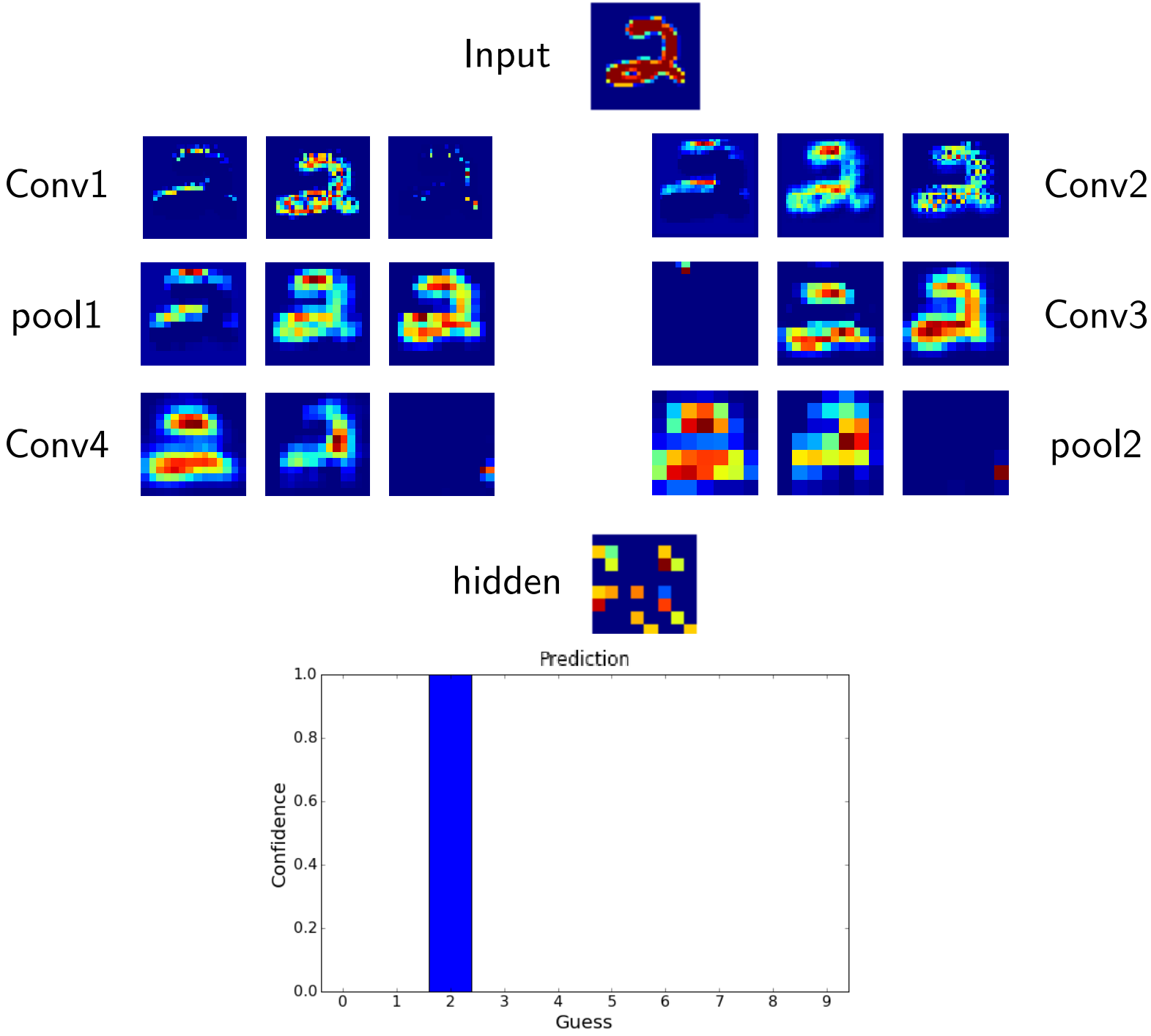
2nd pooling layer

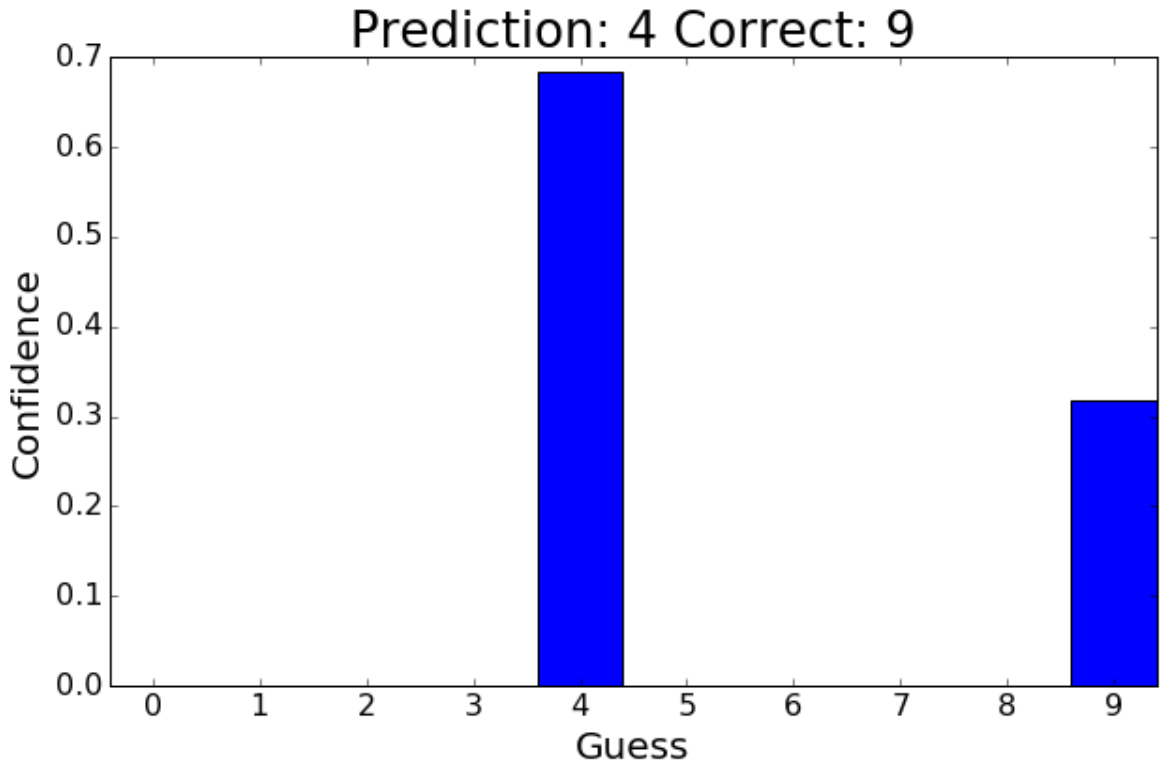
Hidden layer



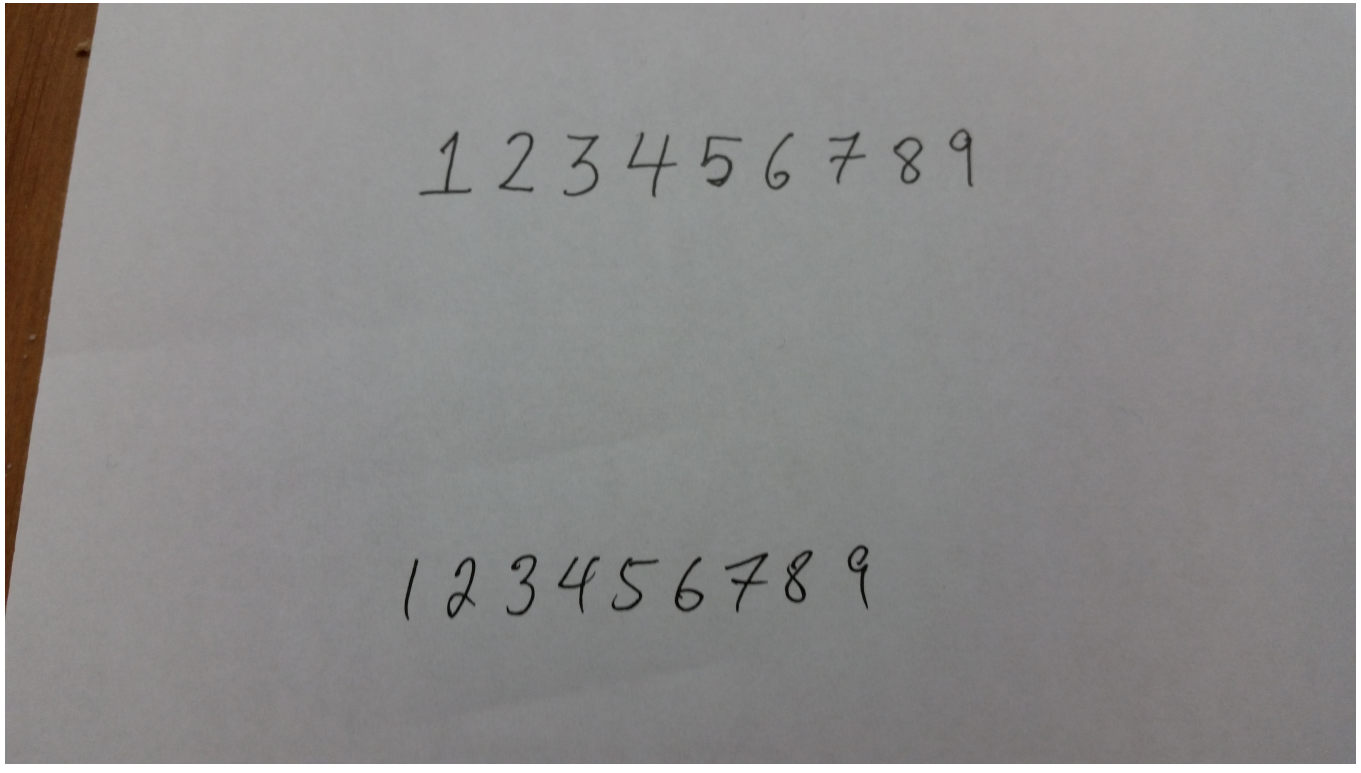
(a) prediction

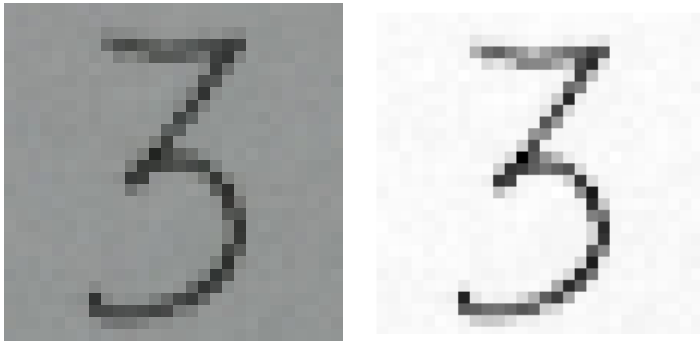
- A deeper convolutional neural network (CNN)

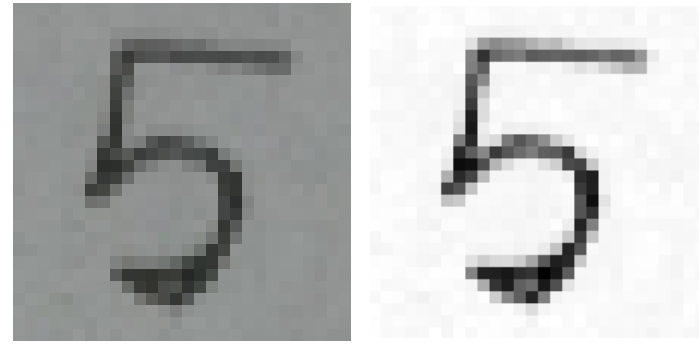

Input
Conv1
Conv2
pool1
Conv3
Conv4
pool2
hidden
Prediction
Confidence
1.0
0.8
0.6
0.4
0.2
0.0
0
1
2
3
4
5
6
7
8
9
Guess

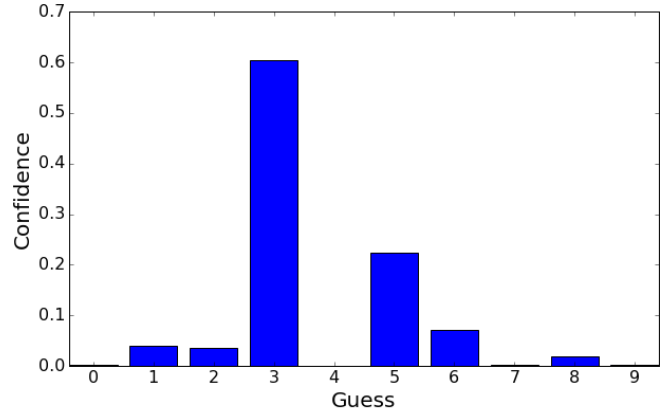

Prediction: 4 Correct: 9
Confidence
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0
1
2
3
4
5
6
7
8
9
Guess

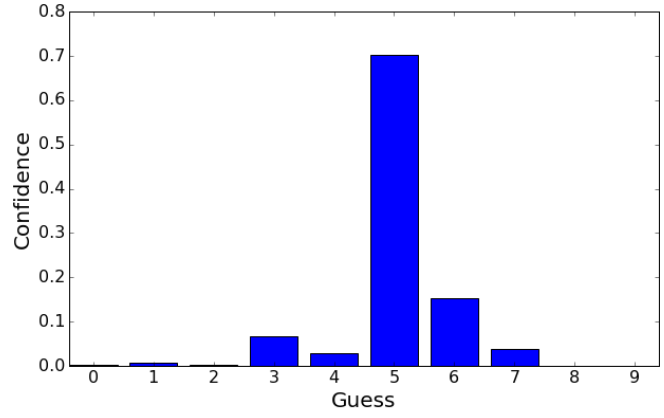
222	↓17	lalithkjain	0.98086	6	Mon, 18 Jan 2016 03:46:14 (-19.3h)
223	**↑180**	**ToddSierens**	**0.98086**	**16**	**Tue, 16 Feb 2016 09:07:07 (-1h)**
224	↓18	Jiaming Kong	0.98071	3	Sun, 20 Dec 2015 08:18:52


123456789
123456789






Confidence
Guess
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0 1 2 3 4 5 6 7 8 9


Confidence
Guess
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0 1 2 3 4 5 6 7 8 9

Performance Metrics

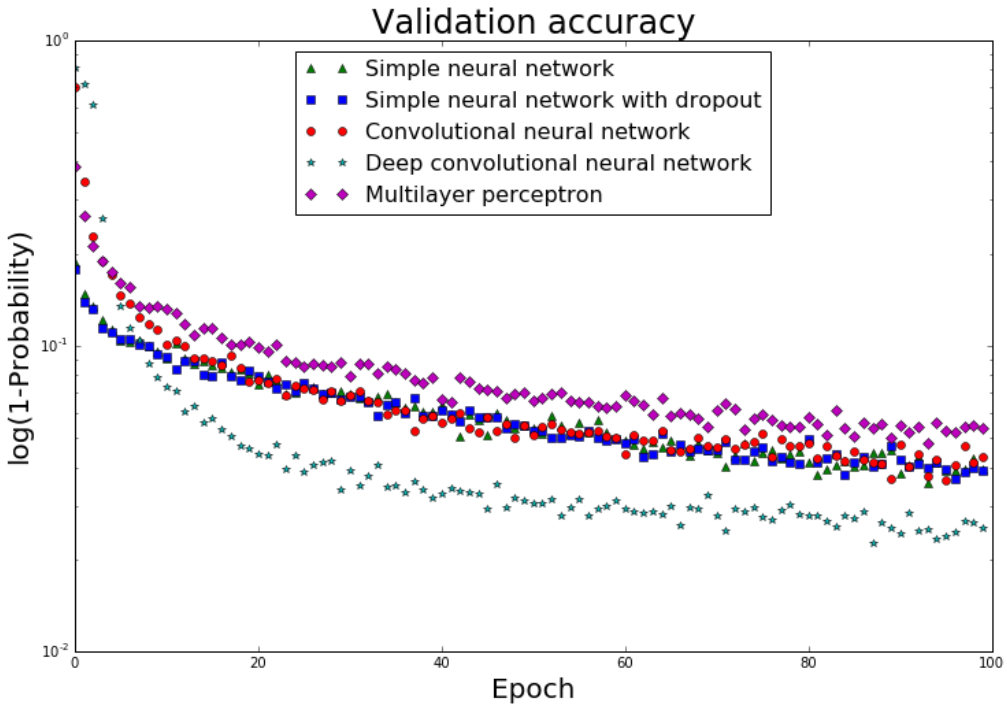


Figure: The validation accuracy of several models as a function of 'epoch'.

Performance Metrics

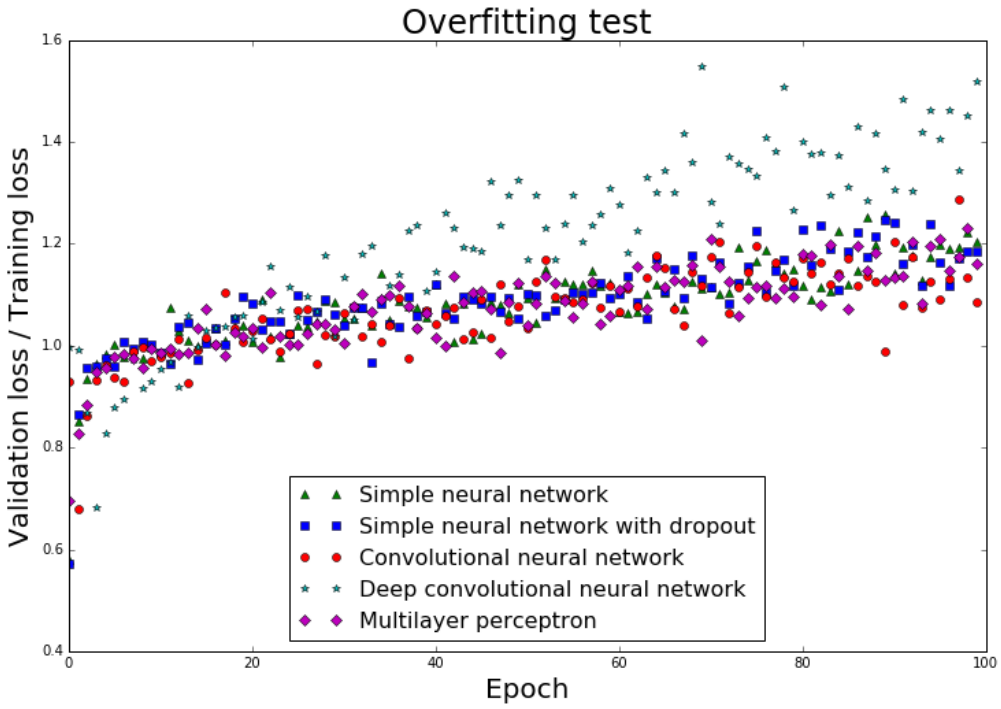


Figure: A measure of over-fitting. If this value is too far from 1 the model is over-fitting.

Performance Metrics

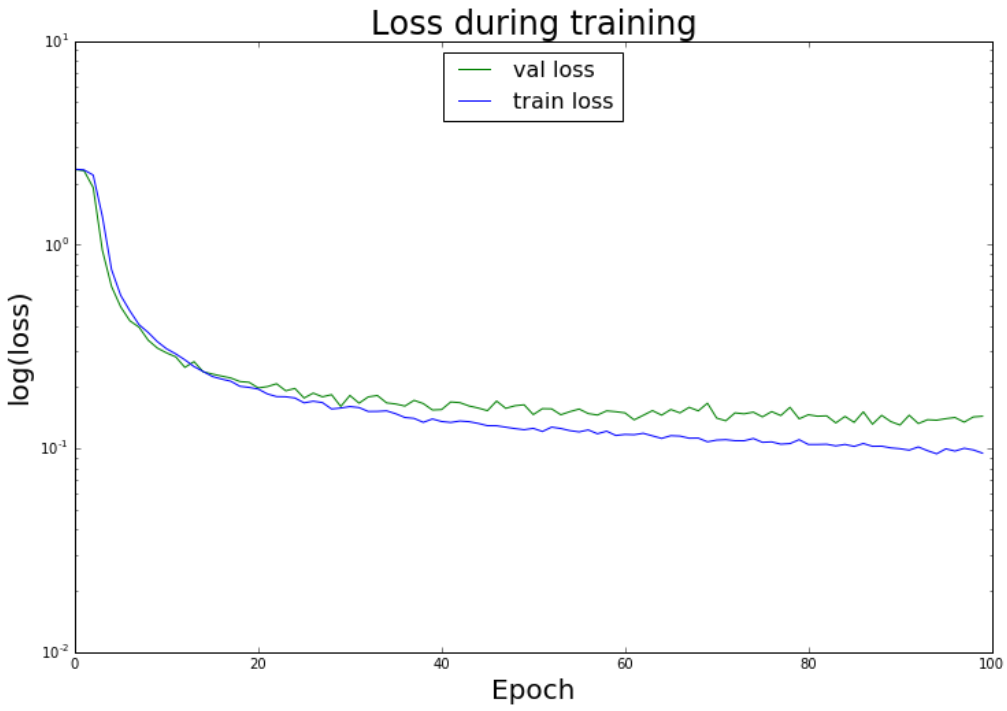


Figure: Validation loss and training loss for the deep CNN model.

Performance Metrics

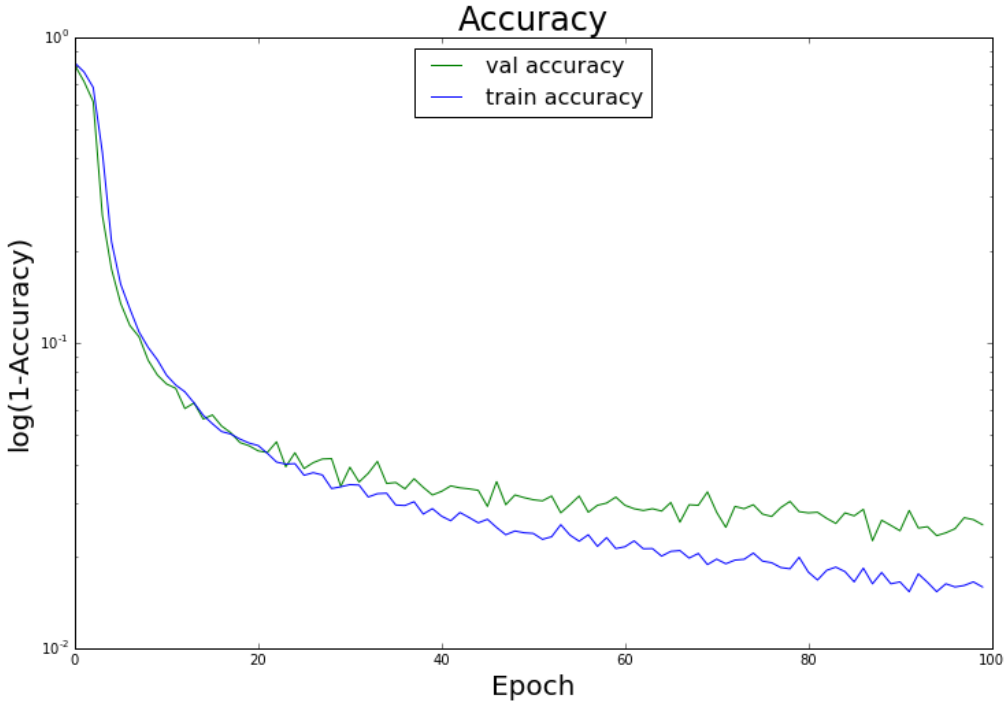


Figure: Validation accuracy and Training accuracy for the deep CNN model.

Performance Metrics

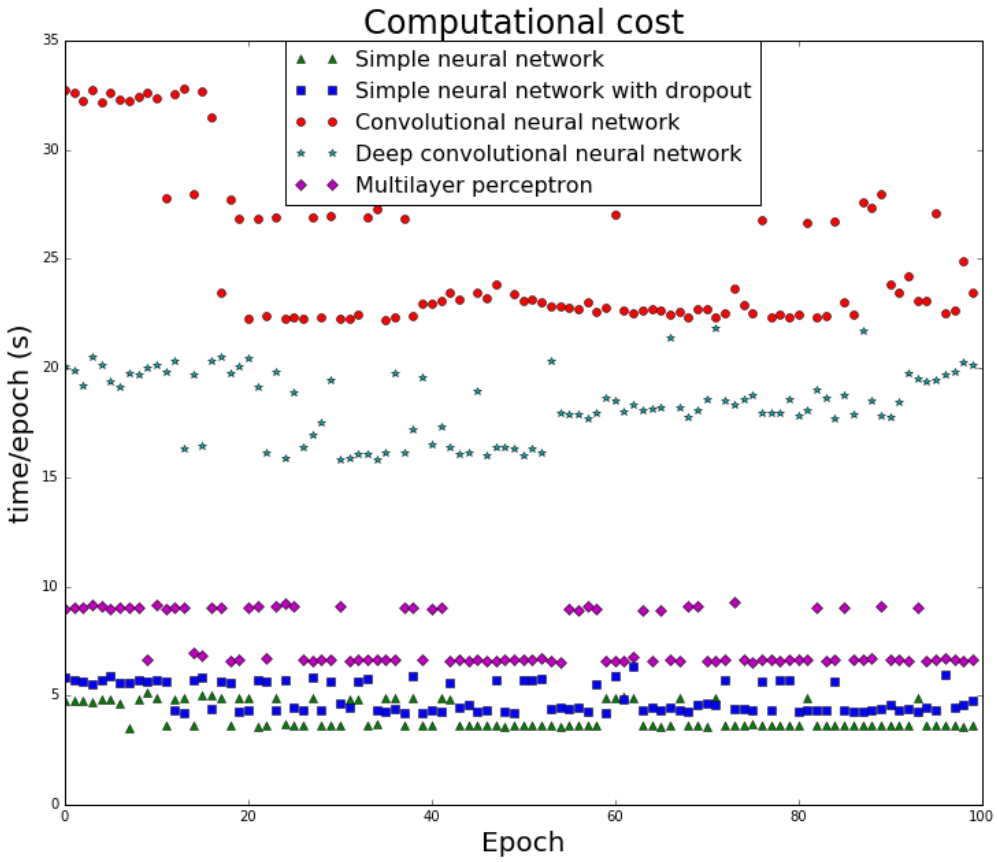


Figure: The amount of time each epoch required to execute. Since performance is dependent on many factors, only the relative time is meaningful.

The End

The End