Visualizing Neural Networks

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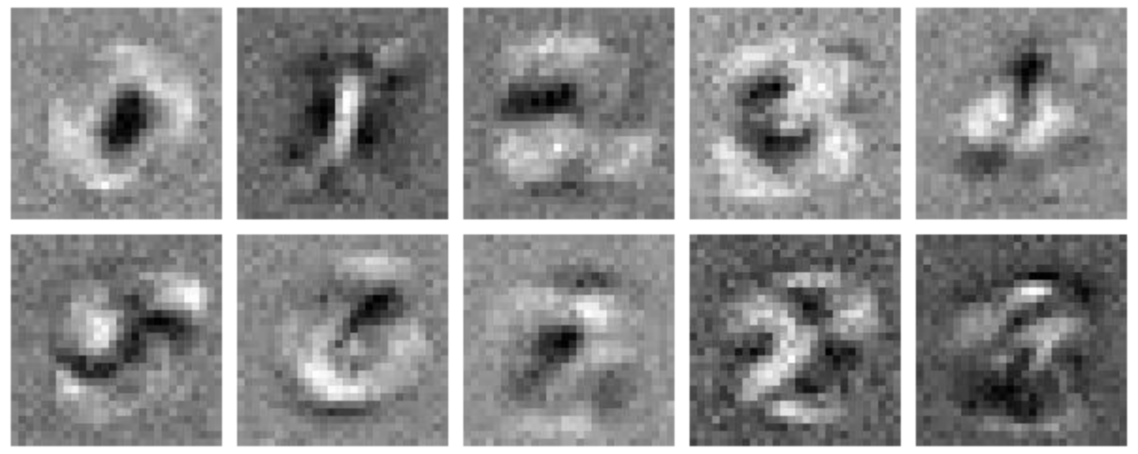
Motivation

- Neural Networks have a lot of magic numbers called the hyperparamters, most of which have no set heuristics.
- Most deep learning frameworks hide the details of the network and there are a lot of things that happen under the hood.



MNIST digits seen by the deep neural network (from m4la.github.io)

Aims and Objectives

- Understand the heuristics of various hyperparameters such as the learning rate, batch size, regularization rate and how they affect the performance of neural networks.
- Extend these ideas to deep neural networks and their application in Computer Vision problems.
- Understand the working of tensorflow and use it for our computation.
- Implement the class visualization technique to understand how and what the neural network learns.

Methodology

Backpropagation Learning

Given a cost function,

$$C = \frac{1}{2n}\sum_x \|y - a^L\|^2 + \frac{\lambda}{2n}\sum_w w^2$$

the network learns using the backpropagation algorithm:

The error in the last layer: $\delta^L = \nabla_a C \odot \sigma'(z^L)$

The error in the subsequent layers: $\delta^l = \left((w^{l+1})^T \delta^{l+1}\right) \odot \sigma'(z^l)$

The gradients: $\frac{\partial C}{\partial w^l_{jk}} = a^{l-1}_k \delta^l_j$ and $\frac{\partial C}{\partial b^l_j} = \delta^l_j$

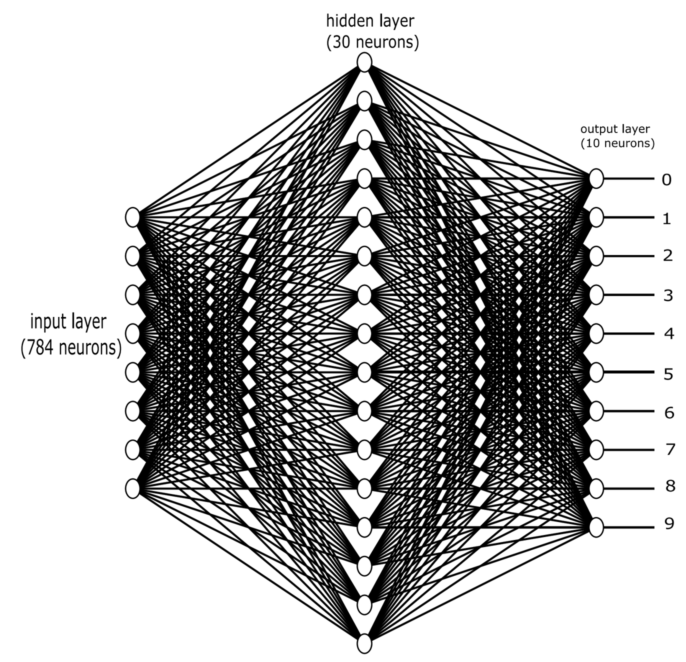
Class Visualization -- Deconvolution

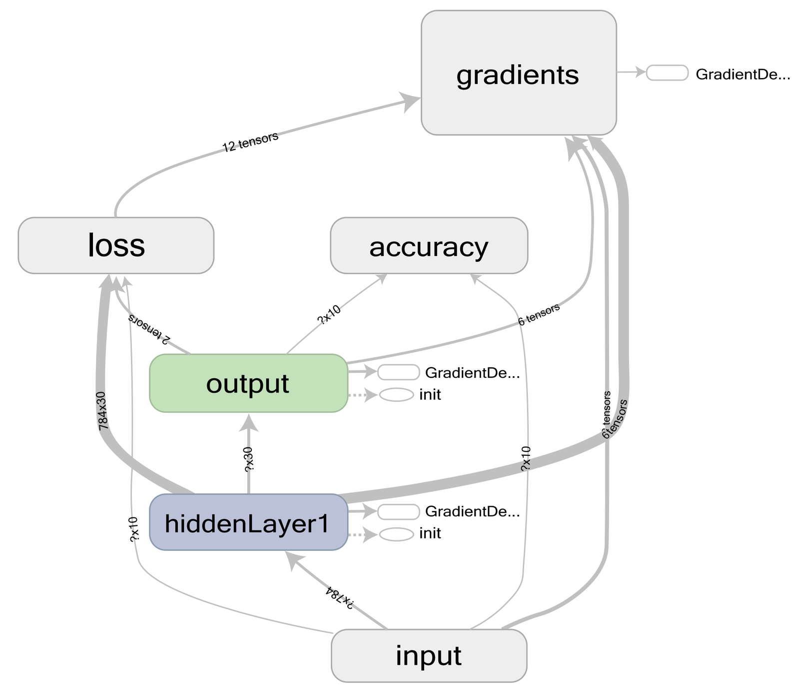
Applied deconvolution operation on pre-trained AlexNet.

$$I^* = argmax_I(S_c(I)) - \lambda||I||^2$$

Computational Graph – Tensorboard

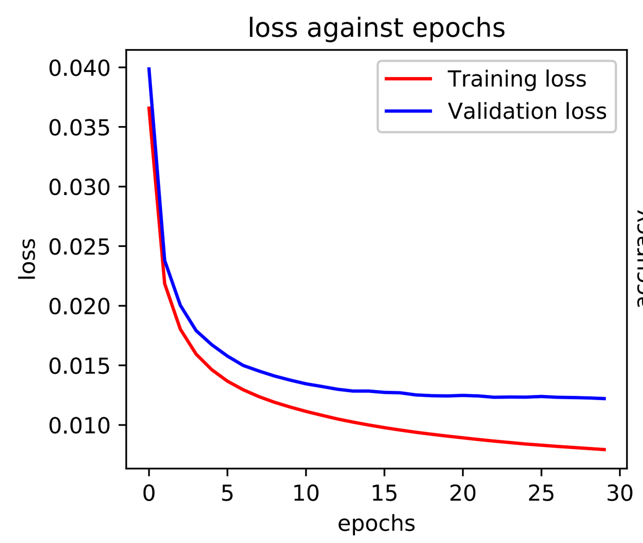
- Computational graph of a sample neural network produced using tensorboard.
- Input layer: 784 neurons; Hidden layer: 30 neurons; Output: 10 neurons

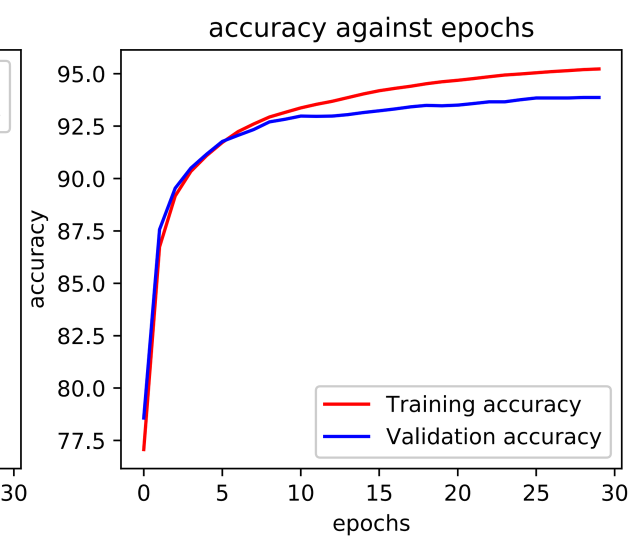




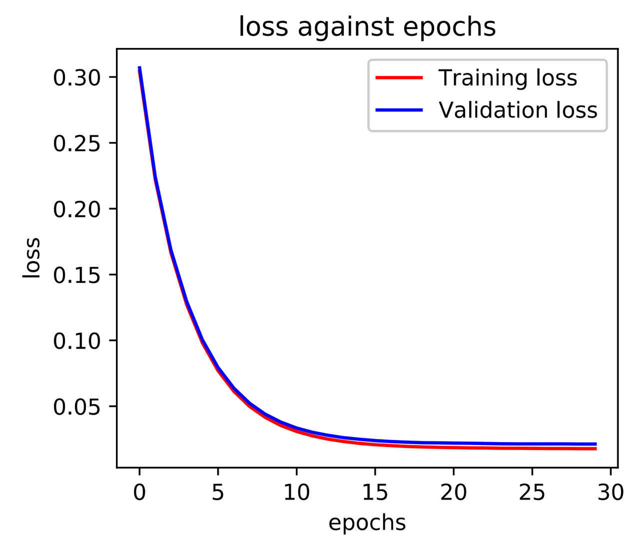
Results – Vanilla Network

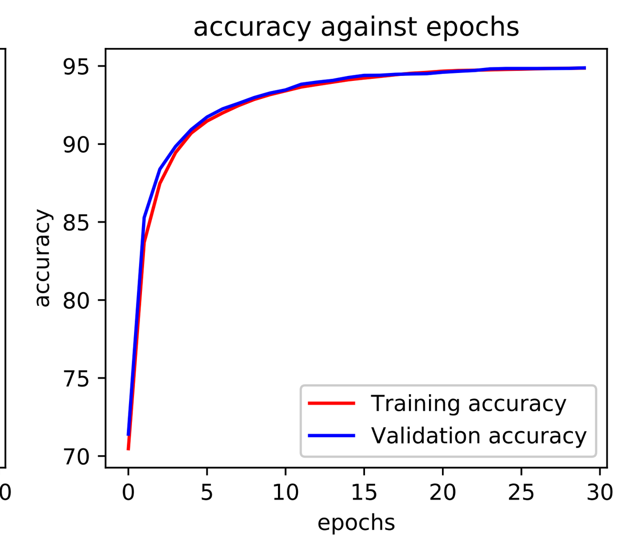
- Tested the network with following hyperparameters:
  learningRate(α): 2.5; batchSize: 50; iterations: 30



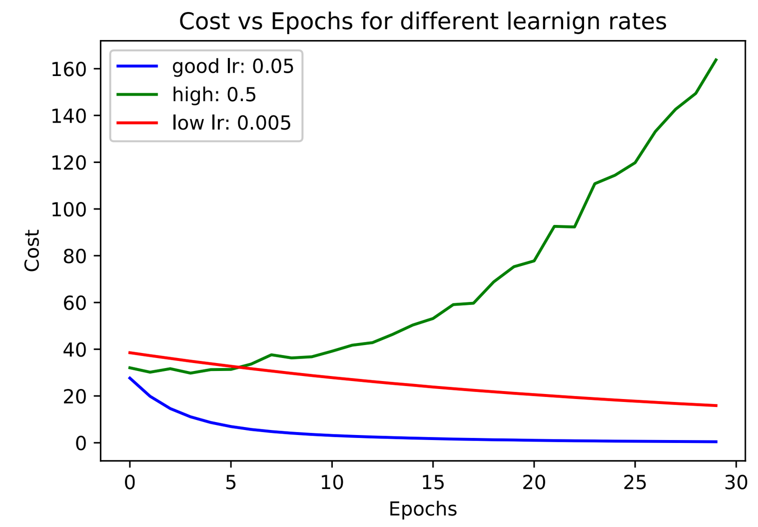


- In just 30 iterations, our simple model achieved a test accuracy of 94% on the MNIST digits dataset.
- Adding an L2-regularizor with λ = 0.001 reduced the gap between train and validation loss and raised the test accuracy by about 1% to 95%.



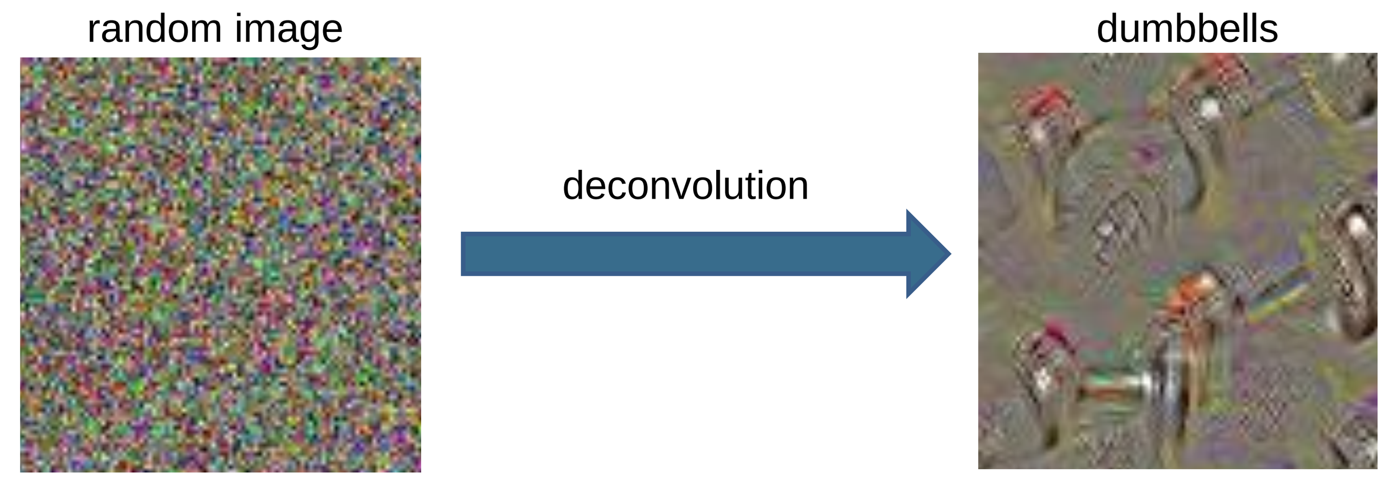


- The choice of hyperparameters (such as the learning rate(α)) is crucial to the performance of a network.
- A high learning rate may miss the minimum.
- A low learning rate takes a lot of time to converge.
- A good learning rate, however, converges fast.



Results – Class Visualization

- We start with a random image and perform gradient ascent with:
  learningRate:25; iterations: 5000; regularizationRate: 0.0001



Future Work

- Explore other visualization techniques to better understand what individual neurons learn.
- Build a tool that automates the visualization of the kernels, filters, and different layers of a network.
- Extend these ideas to sequential models such as RNNs and their application in language modeling.
- Build on these ideas to develop a debugging tool for neural networks which would help visualize the model to address machine learning issues such as exploding and vanishing gradients during training.

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