More Neural Nets!

Wednesday, Lecture 2

FASE ML Bootcamp

Based on material from:

How do neural networks **train**?

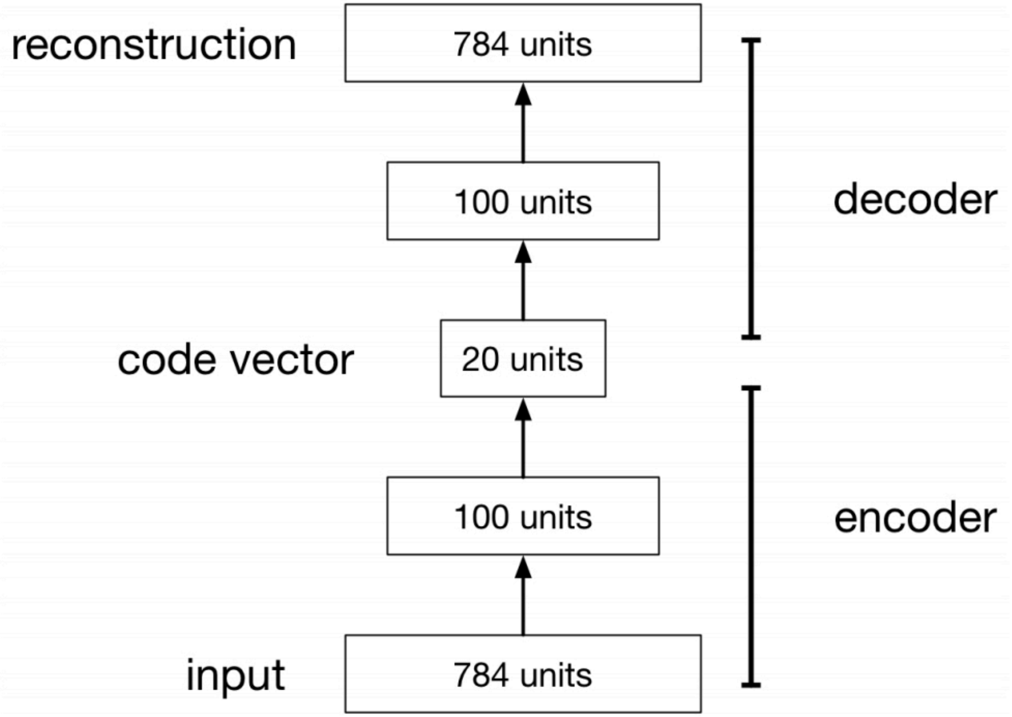
https://www.3blue1brown.com/neural-networks

2nd, 3rd and 4th videos

For written notes describing the content in the videos, this is a great resource
http://neuralnetworksanddeeplearning.com/index.html

Autoencoders

- An autoencoder is a feed-forward neural net whose job it is to take an input **x** and predict **x**.
- To make this non-trivial, we need to add a bottleneck layer whose dimension is much smaller than the input.



reconstruction

784 units

100 units

decoder

code vector

20 units

100 units

encoder

input

784 units

Autoencoders

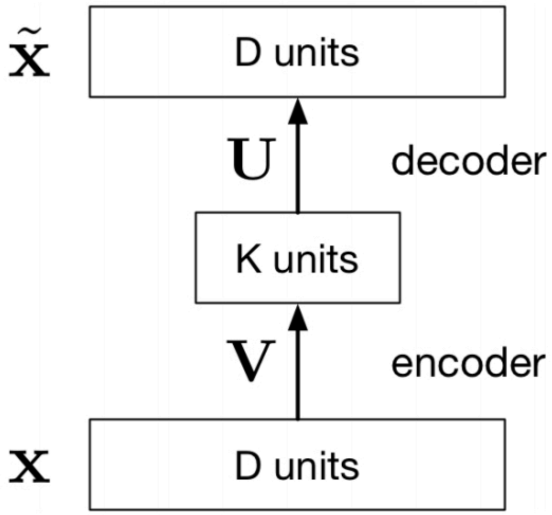
Why autoencoders?

- Map high-dimensional data to two dimensions for visualization
- Compression (i.e. reducing the file size)
  - Note: autoencoders don't do this for free — it requires other ideas as well.
- Learn abstract features in an unsupervised way so you can apply them to a supervised task
  - Unlabled data can be much more plentiful than labeled data

Principal Component Analysis

- The simplest kind of autoencoder has one hidden layer, linear activations, and squared error loss.

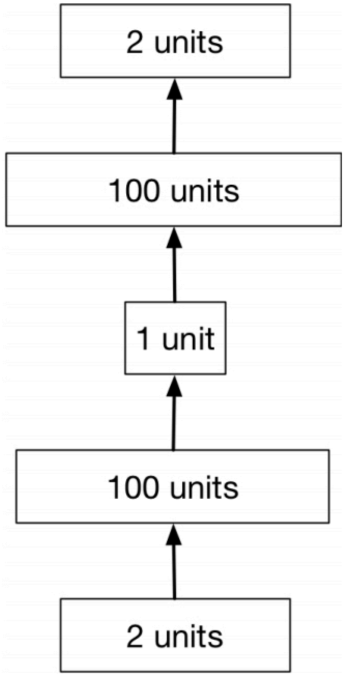
$$\mathcal{L}(\mathbf{x}, \tilde{\mathbf{x}}) = \|\mathbf{x} - \tilde{\mathbf{x}}\|^2$$

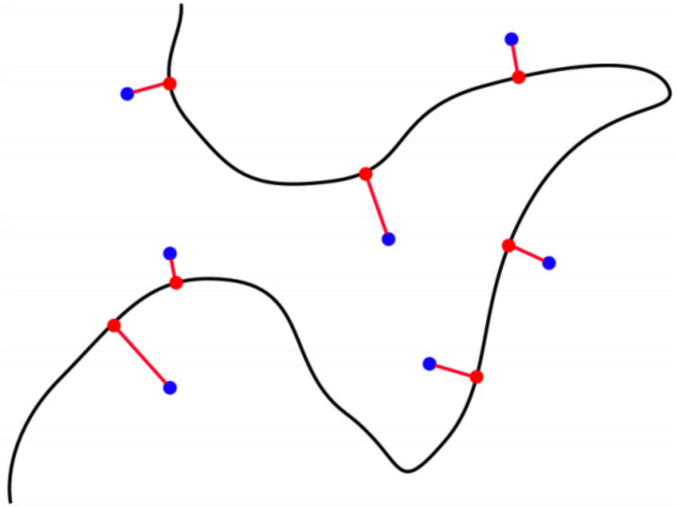


- This network computes $\tilde{\mathbf{x}} = \mathbf{U}\mathbf{V}\mathbf{x}$, which is a linear function.
- If $K \geq D$, we can choose $\mathbf{U}$ and $\mathbf{V}$ such that $\mathbf{U}\mathbf{V}$ is the identity. This isn't very interesting.
- But suppose $K < D$:
  - $\mathbf{V}$ maps $\mathbf{x}$ to a K-dimensional space, so it's doing dimensionality reduction.
  - The output must lie in a K-dimensional subspace, namely the column space of $\mathbf{U}$.

Deep Autoencoders

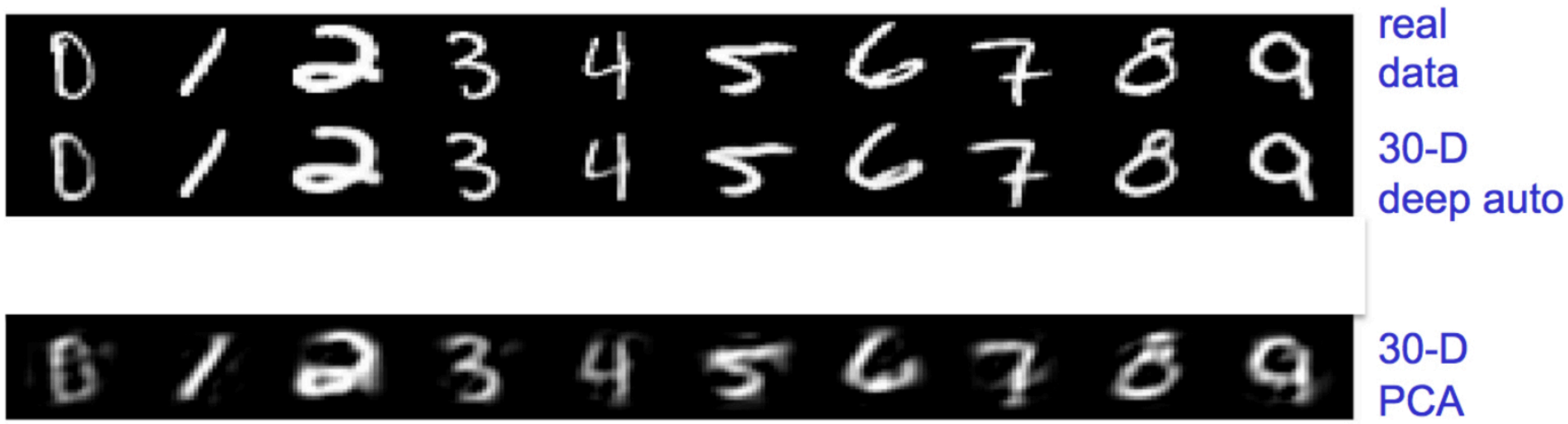
- Deep nonlinear autoencoders learn to project the data, not onto a subspace, but onto a nonlinear manifold
- This manifold is the image of the decoder.
- This is a kind of nonlinear dimensionality reduction.





Deep Autoencoders

- Nonlinear autoencoders can learn more powerful codes for a given dimensionality, compared with linear autoencoders (PCA)


real data
30-D deep auto
30-D PCA