



Autoencoders



Review of Unsupervised Learning



Deep Learning

- Let's quickly review what Unsupervised Learning is and the unique challenges it presents!
- Recall that Supervised Learning works with **labeled** data, giving us access to a direct check for errors for our models.



Deep Learning

- Most of the world's data is unlabeled!
- New articles, movie reviews, user Netflix ratings, images on the internet, etc...
- What approaches can we take to make use of this type of **unlabeled** data?



Deep Learning

- Two main approaches
 - Dimensionality Reduction
 - Clustering



Autoencoder Basics



Deep Learning

- The autoencoder is actually a very simple neural network and will feel similar to a multi-layer perceptron model.
- It is designed to reproduce its input at the output layer.

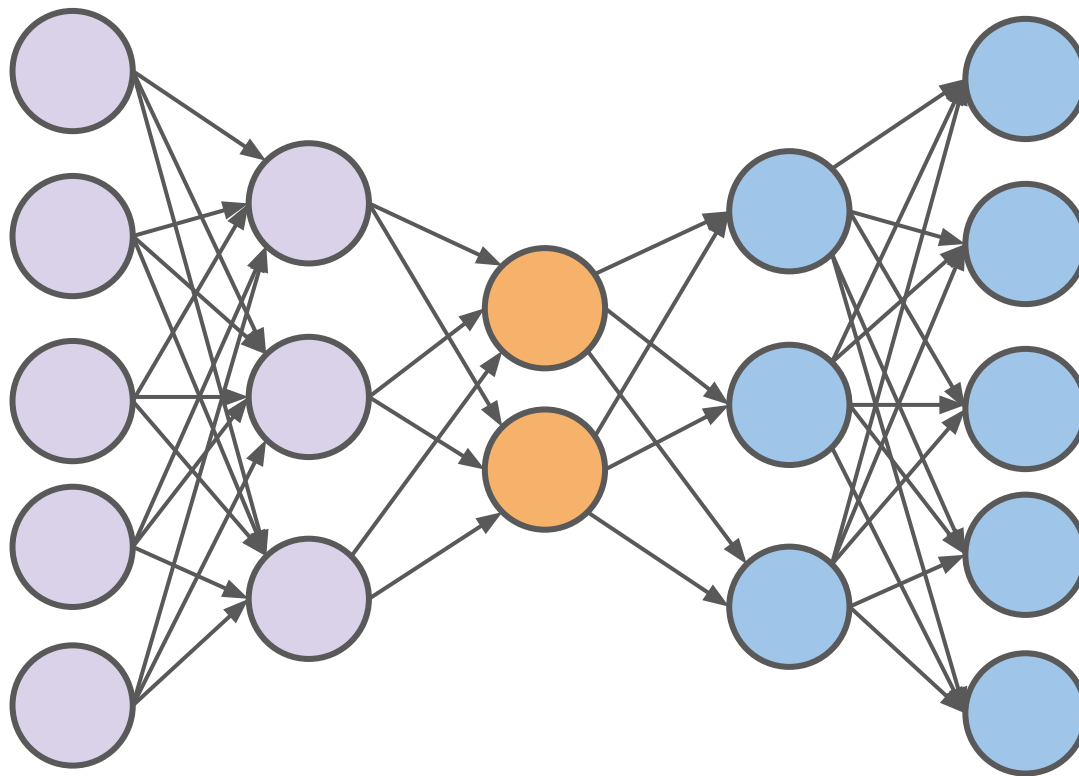


Deep Learning

- The key difference between an autoencoder and a typical MLP network is that the number of input neurons is equal to the number of output neurons.
- Let's explore what this looks like and why we would use it!



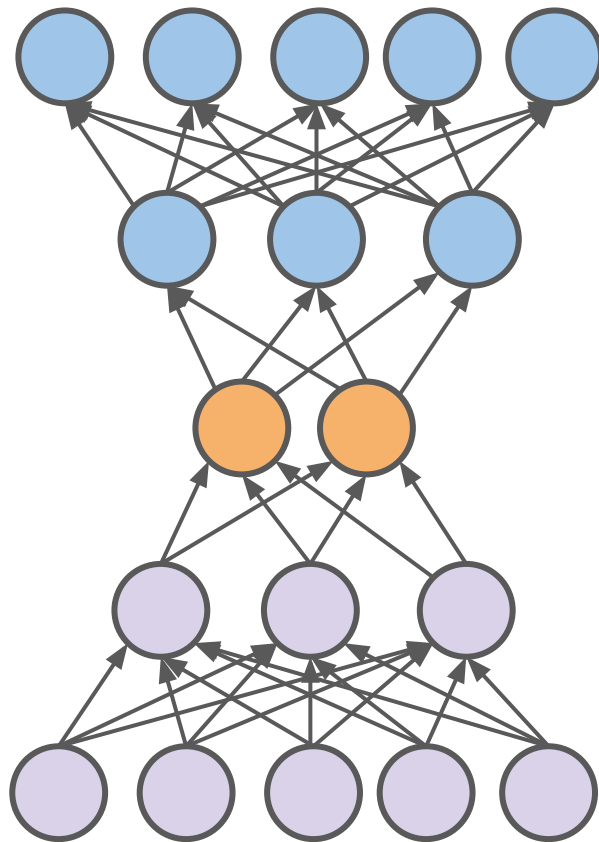
Example Autoencoder





Deep Learning

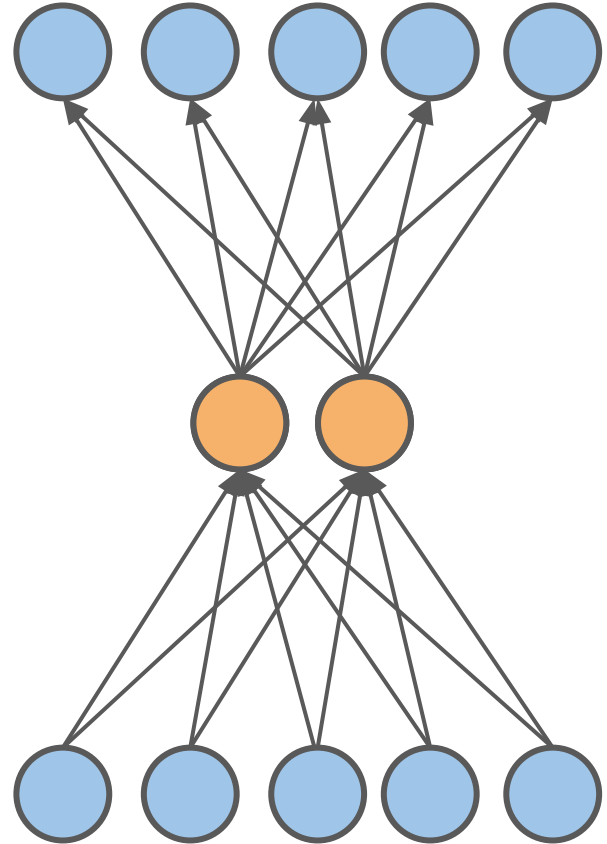
- Let's walk through the layers and explain the basic idea of an autoencoder.





Deep Learning

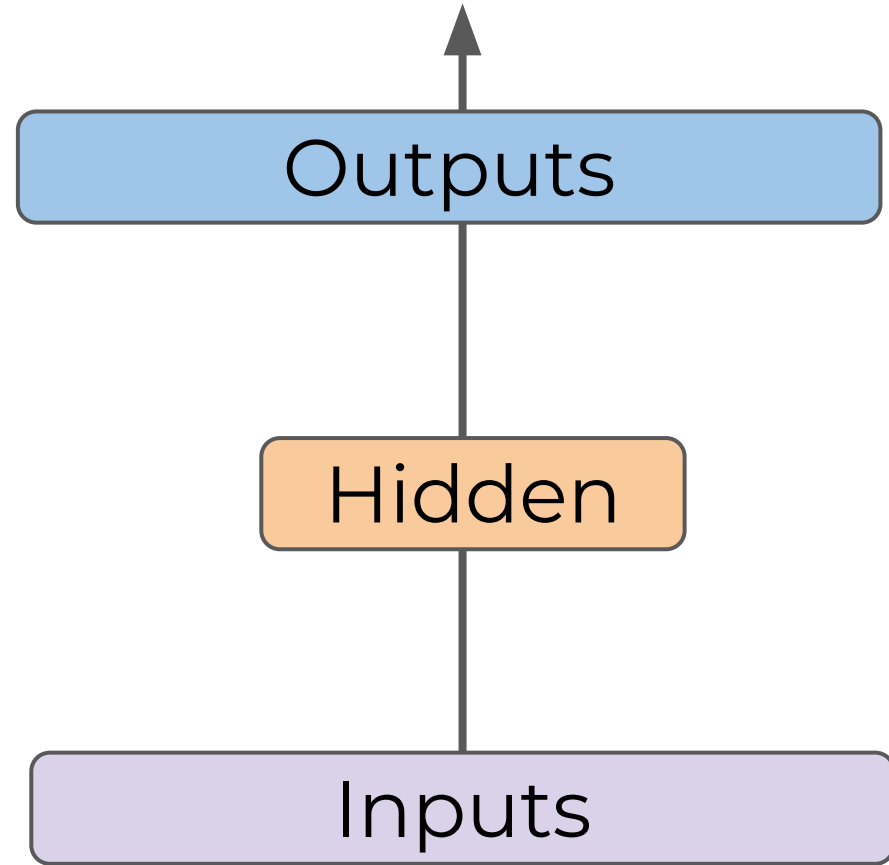
- Let's simplify this even further with just a single hidden layer.





Deep Learning

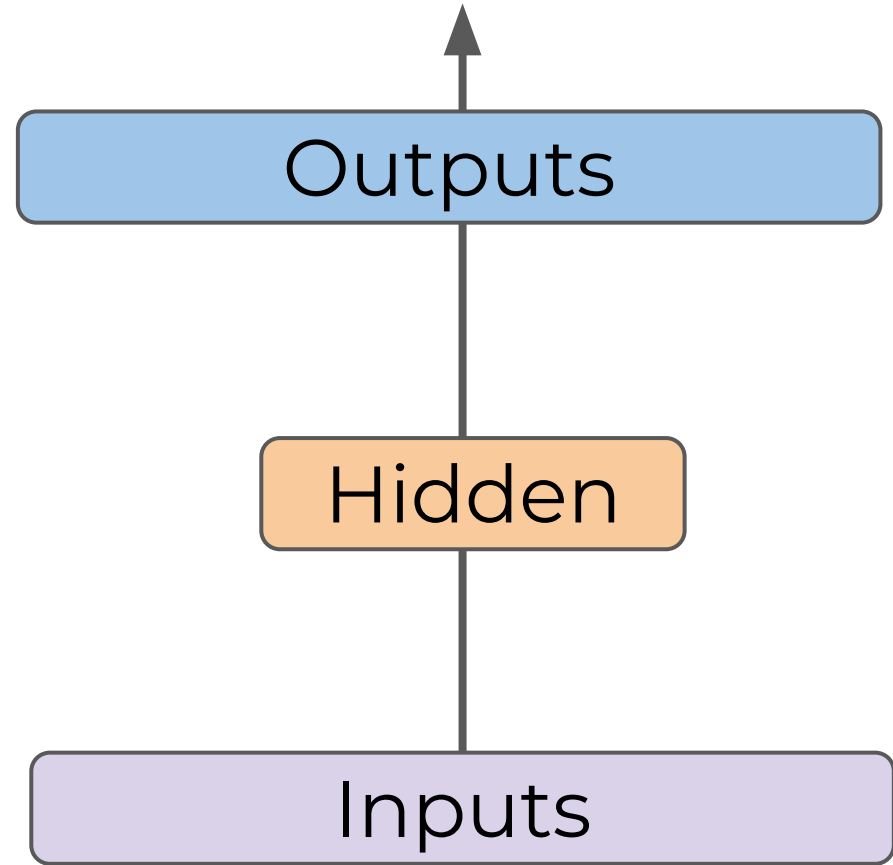
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Deep Learning

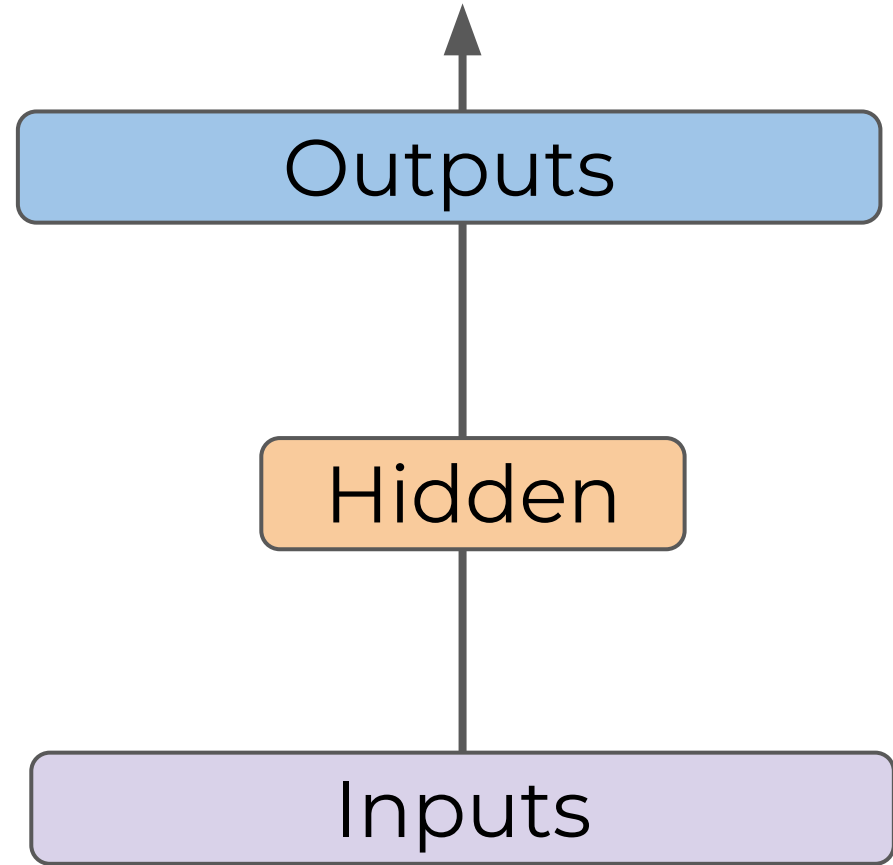
- Feed forward network trained to reproduce its input at the output layer.





Deep Learning

- Output size is the same as the input layer.





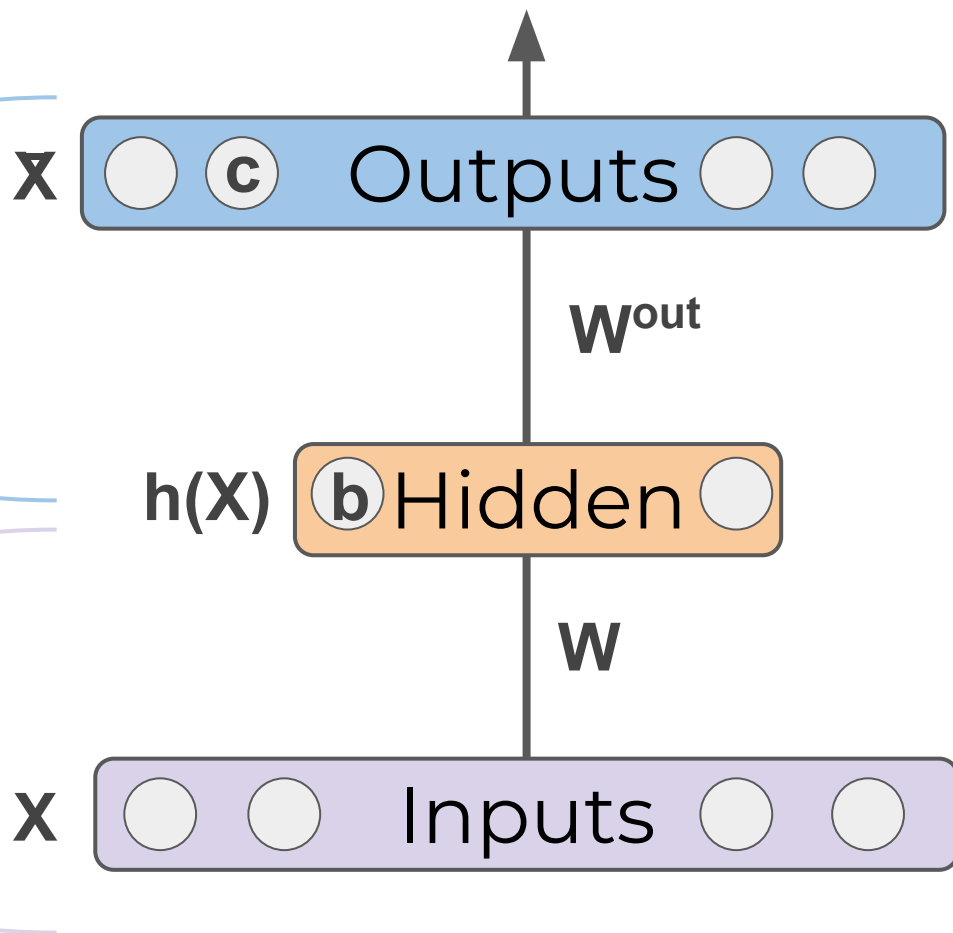
Deep Learning

Decoder

$$\hat{X} = \text{sigm}(c + W^{\text{out}} h(x))$$

Encoder

$$h(x) = \text{sigm}(b + Wx)$$





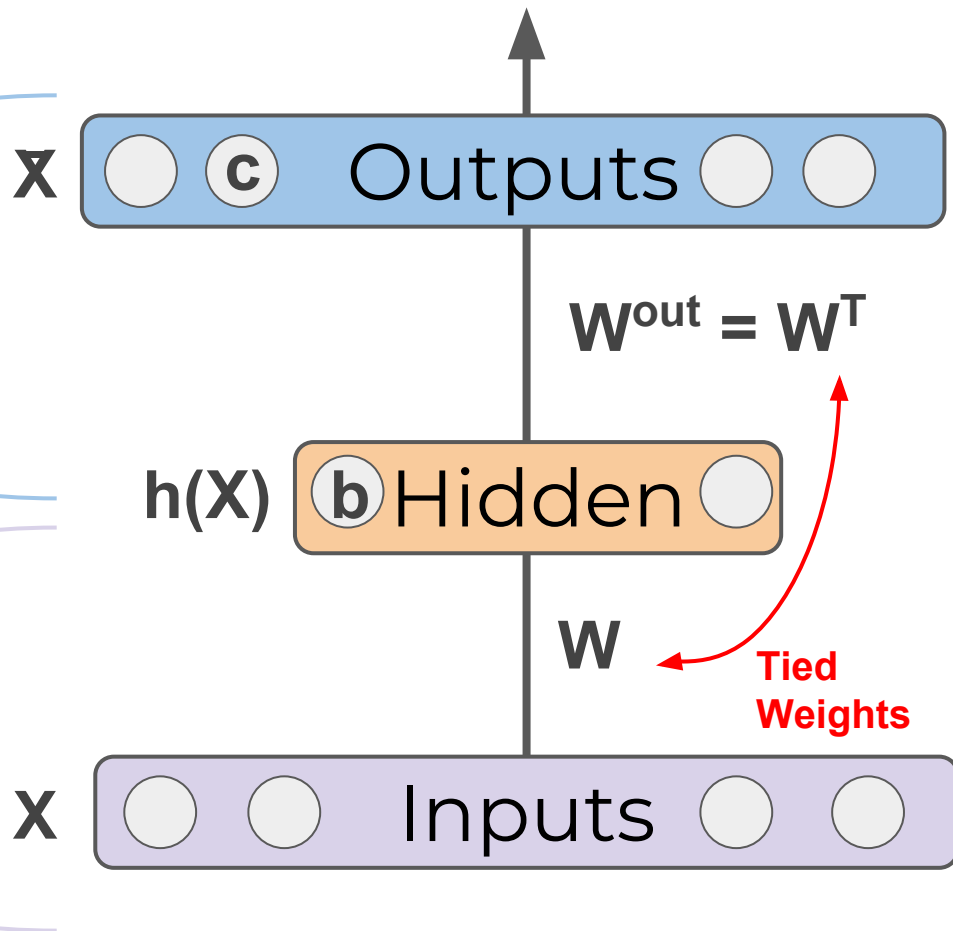
Deep Learning

Decoder

$$\hat{X} = \text{sigm}(c + W^{\text{out}} h(x))$$

Encoder

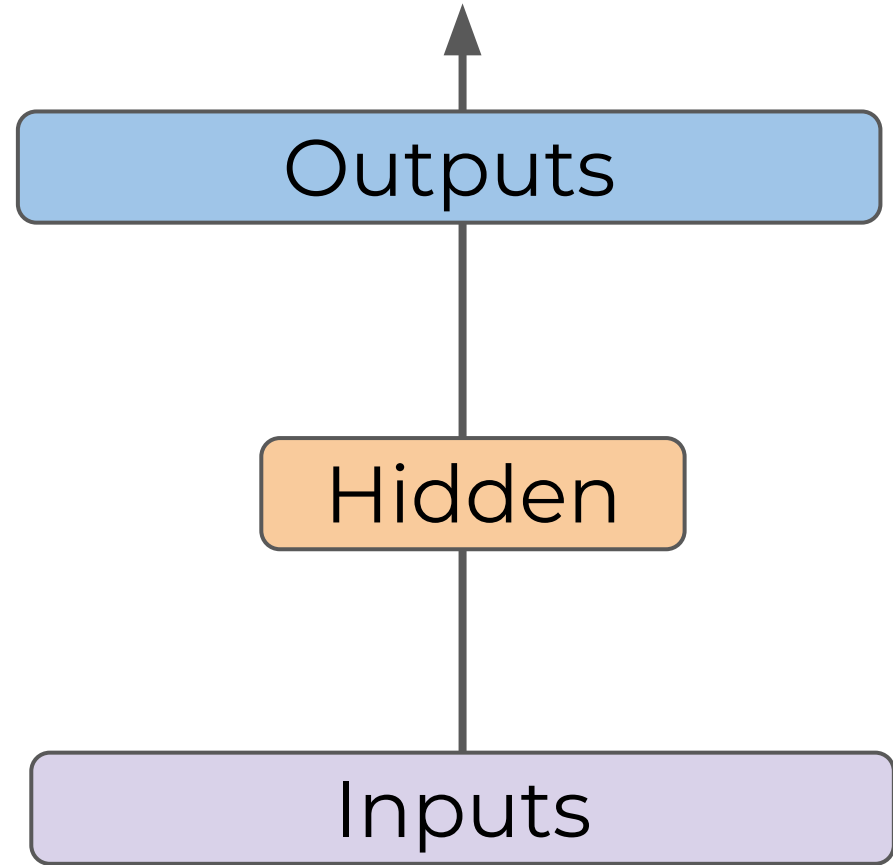
$$h(x) = \text{sigm}(b + Wx)$$





Deep Learning

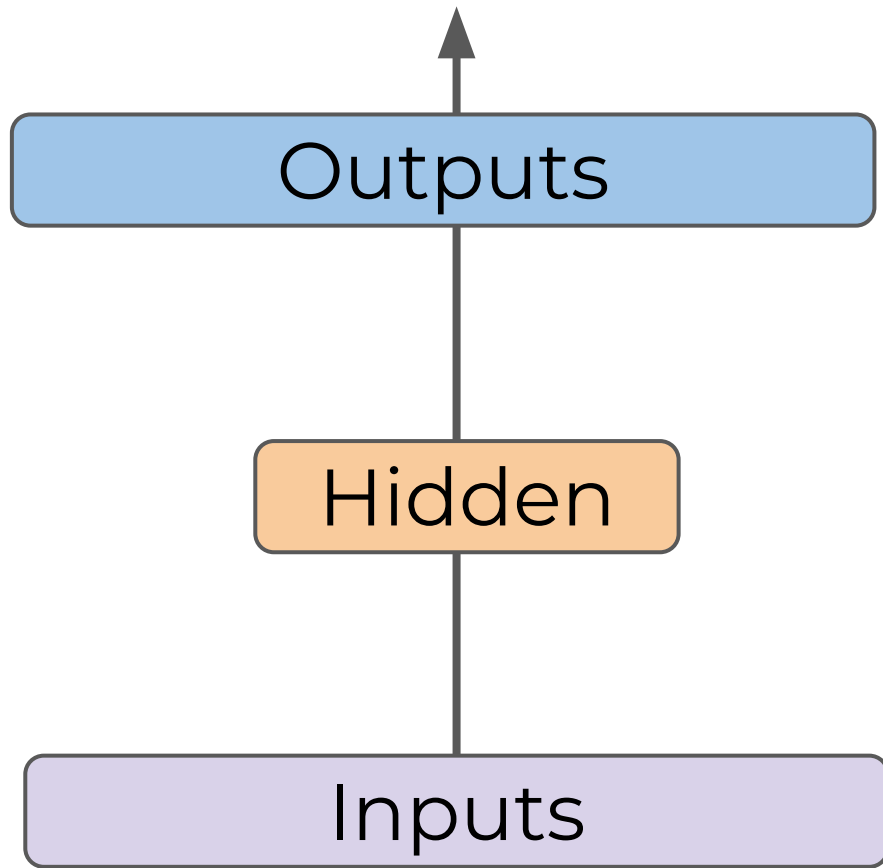
- The hidden/internal representation maintains all the information of the input.





Deep Learning

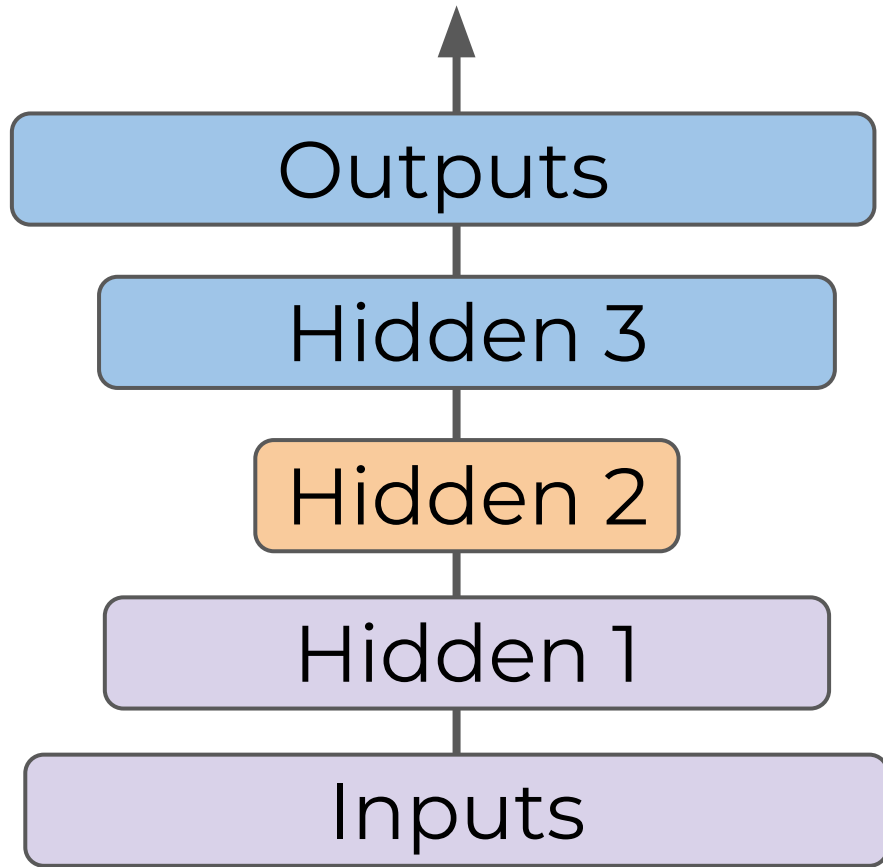
- We can use the hidden layer to extract meaningful features, we will also explore PCA with Autoencoders.





Deep Learning

- Later on we'll explore stacked autoencoders with more hidden layers.





Deep Learning

- You should know understand a very basic autoencoder.
- Up next we'll discuss how we can use an Autoencoder to perform dimensionality reduction.



Dimensionality Reduction with Linear Autoencoder



Deep Learning

- Linear Autoencoders can be used to perform a principal component analysis, which allows us to reduce the dimensionality of our data.



Deep Learning

- Dimensionality reduction allows us to get a lower dimension representation of our data.
- The encoder creates new (fewer) features from the input features.



Deep Learning

- For example we can input a 3 dimensional data set and output a 2 dimensional representation of it.
- Keep in mind, we are not simply choosing 2 of the previous 3, but instead constructing 2 new features from the 3.



Deep Learning

- We achieve this effect by using a linear autoencoder.
- Linear autoencoders perform the linear transformations by only using the weights and bias terms.



Linear Autoencoder

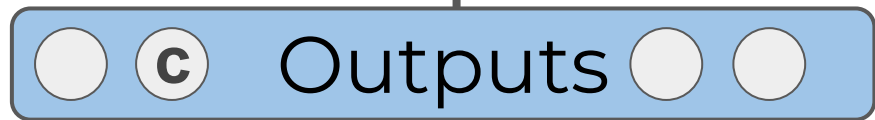
Decoder

$$\hat{X} = c + W^{\text{out}} h(x)$$

Encoder

$$h(x) = b + Wx$$

\hat{X}



Outputs

W^{out}

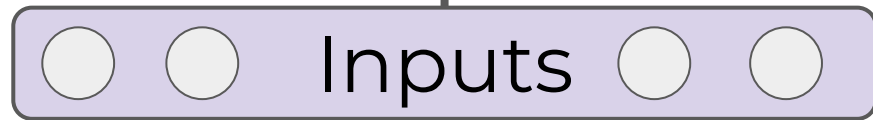
$h(X)$



Hidden

W

X



Inputs



Linear Autoencoder

After training we can use the hidden layer to obtain a reduced dimensionality

Encoder

$$h(x) = b + Wx$$

x

$h(X)$

b

Hidden

W

Inputs



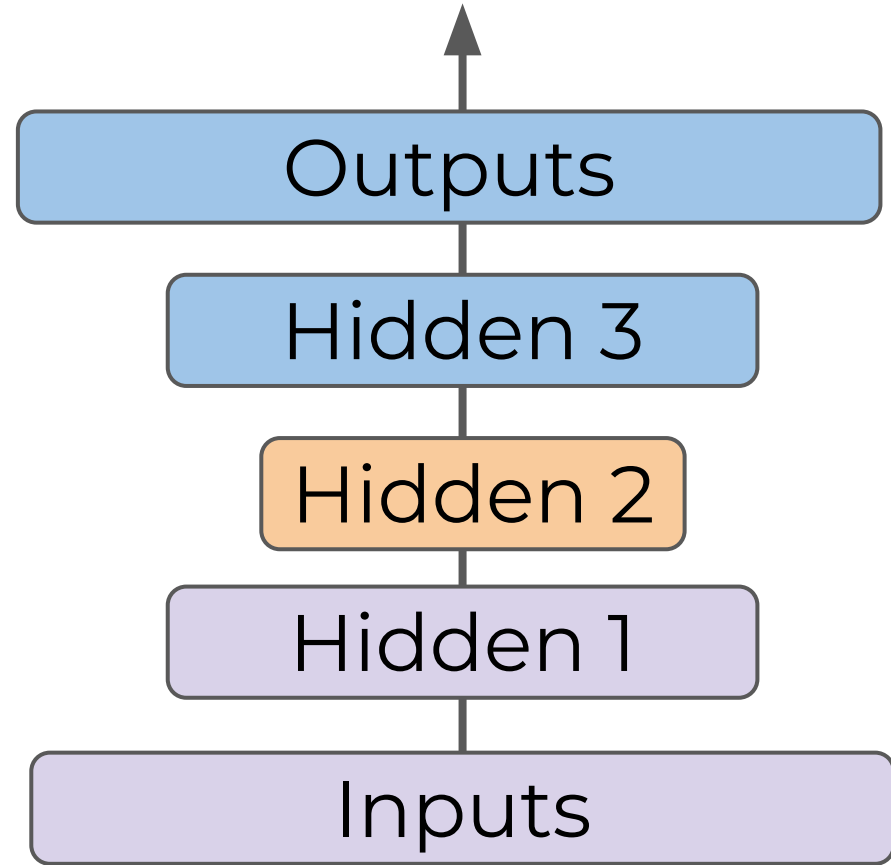
Deep Learning

- Let's code this out to see how it works!
- Also check out the resource links for the mathematical proof of this.
- Let's go to the jupyter notebook!



Deep Learning

- Let's walk through the layers and explain the basic idea of an autoencoder.





Stacked Autoencoder



Saving and Restoring Models



Tensorboard



Deep Learning

- Tensorflow has many abstractions!
 - TF Learn
 - Keras
 - TF-Slim
 - Layers
 - Estimator API
 - and more!



Deep Learning

- Many of these abstractions reside in TensorFlow's `tf.contrib` section.
- Typically libraries get developed and accepted into `contrib` and then “graduate” to being included as part of standard Tensorflow.



Deep Learning

- It is difficult to tell what abstractions are worth learning and which are not.
- The speed of development of TensorFlow has caused abstractions to come and go quickly!



Deep Learning

- This series of lectures will focus on presenting the most common abstractions used:
 - Estimator API
 - Keras
 - Layers



Deep Learning

- We will focus on understanding how to use these abstractions to build deep densely connected neural networks.
- Using these abstractions makes it easy to stack layers on top of each other for simpler tasks!



Deep Learning

- All the code is available in `Deep-Nets-with-TF-Abstractions.ipynb`
- Let's start by exploring the data set we will be using!



Dimensionality Reduction with Linear Autoencoder Exercise



TensorBoard



Stacked Autoencoder



Example Simple Autoencoder

