

# Image Retrieval with Deeplearning

Jeffrey Tang

# Who am I ?

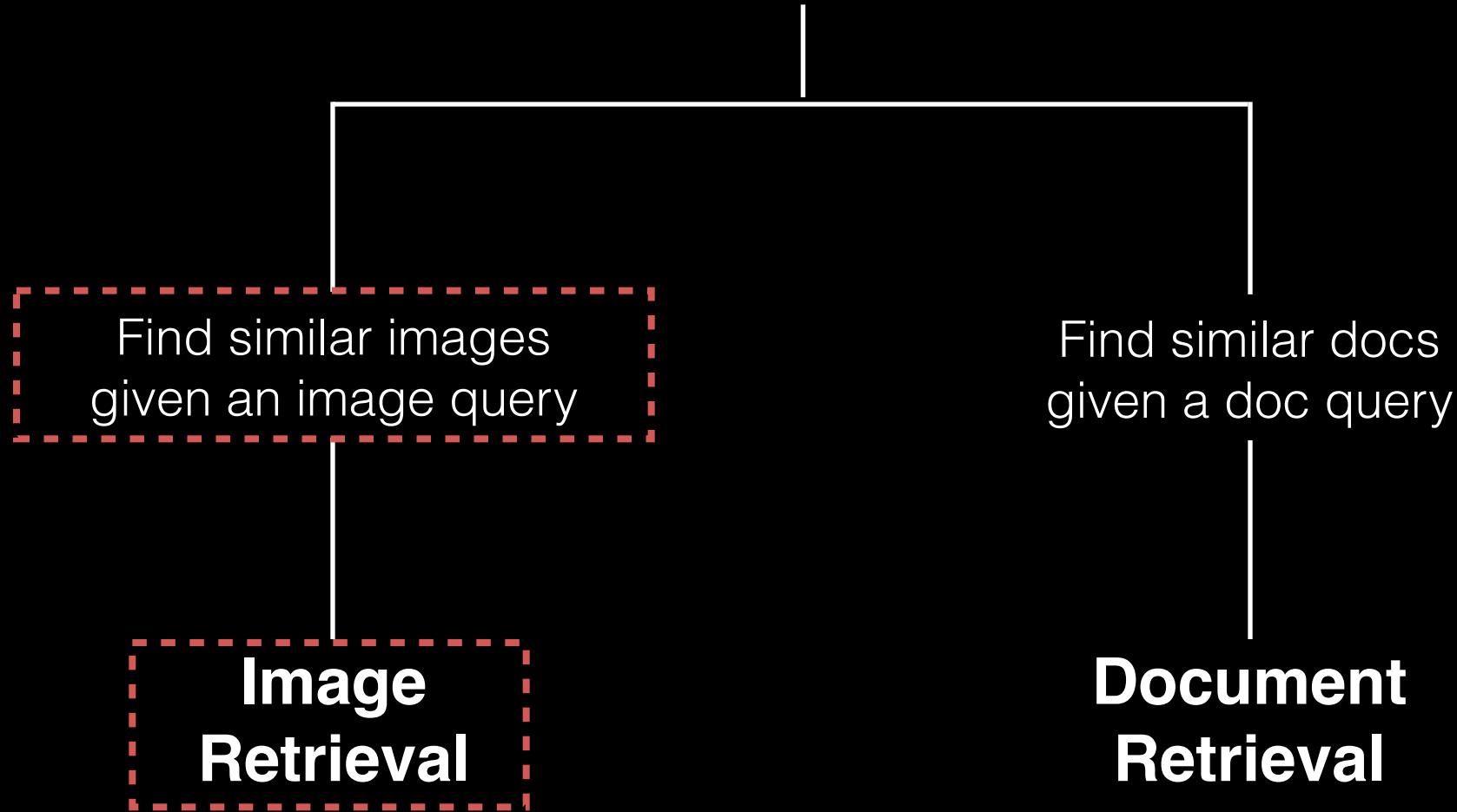
- **Software Engineer at Skymind.io**
  - Python Interface to deeplearning4j (Java)
  - Optimization of deep learning on Spark
- **(Ex-)Data Science Instructor at Galvanize**

# Goals

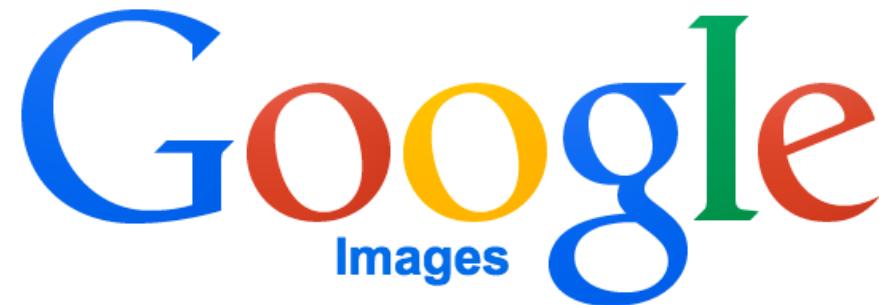
- **Image Retrieval**
  - ★ Application & Overview
- **Deep Learning**
  - ★ Image Retrieval using Auto-Encoders
  - ★ Code Example
- **Deep Learning Ecosystem**

# Image Retrieval Overview

# Information Retrieval



# Google Images



## Search by image

X

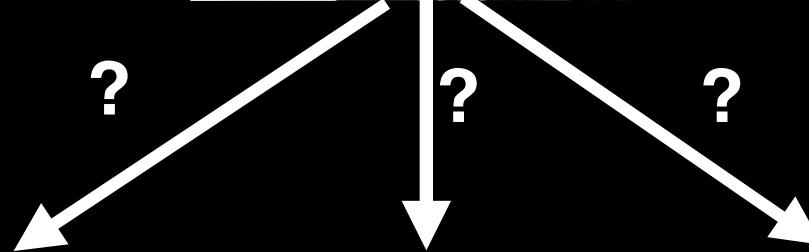
Search Google with an image instead of text. Try dragging an image here.

Paste image URL

Upload an image

No file chosen

# Applications: Real Estate



# Applications: Place Matching



?

?

?



# Applications: Product Matching



# High Level

- Image Retrieval == Image Recommenders
- Find similar images based on a query image
- Compare query to every stored image

## Images



...

|  
Resize/  
Vectorize/  
Scale



[ 0.92, 0.01, 0.64, 0.51, 0.47, 0.71 ... ],  
[ 0.84, 0.44, 0.88, 0.82, 0.35, 0.74 ... ],  
[ 0.09, 0.20, 0.59, 0.52, 0.78, 0.59 ... ]

...

|  
Dimensionality  
Reduction  
(PCA, SVD, AutoEncoder)



[ 0.25, 0.62, 0.18 ... ], [ 0.36, 0.81, 0.87 ... ]  
[ 0.16, 0.3 , 0.07 ... ],  
[ 0.65, 0.53, 0.59 ... ]

...

## Query Image



|  
Resize/  
Vectorize/  
Scale



[ 0.83, 0.42, 0.98, 0.13, 0.43, 0.88 ... ]

|  
Trained  
Model



Cosine  
Similarity

[ 0.25, 0.62, 0.18 ... ], [ 0.36, 0.81, 0.87 ... ]  
[ 0.16, 0.3 , 0.07 ... ],  
[ 0.65, 0.53, 0.59 ... ]

# Why Reduce Dimension ?

- Yields a more **generalized (and better)** representation of the image
- More robust to noisy images
- **Faster computations**  
(Comparing fewer dimensions)

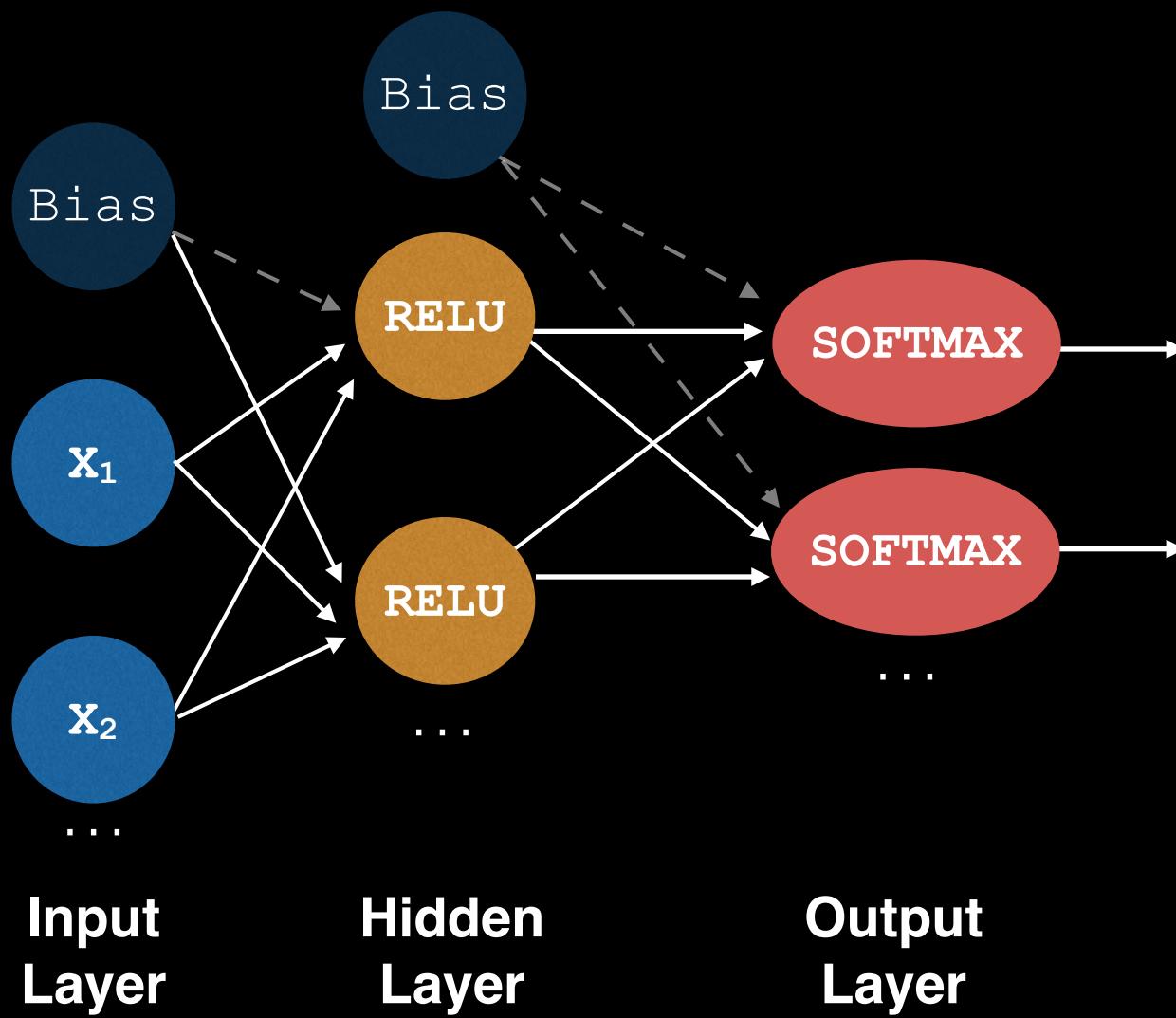
# Why Deep Learning ?

- **PCA / SVD** reduces dimension assuming **linear manifold** of the original feature space
- **AutoEncoders** is capable of reconstructing a **non-linear manifold**
- AutoEncoders yield better representation

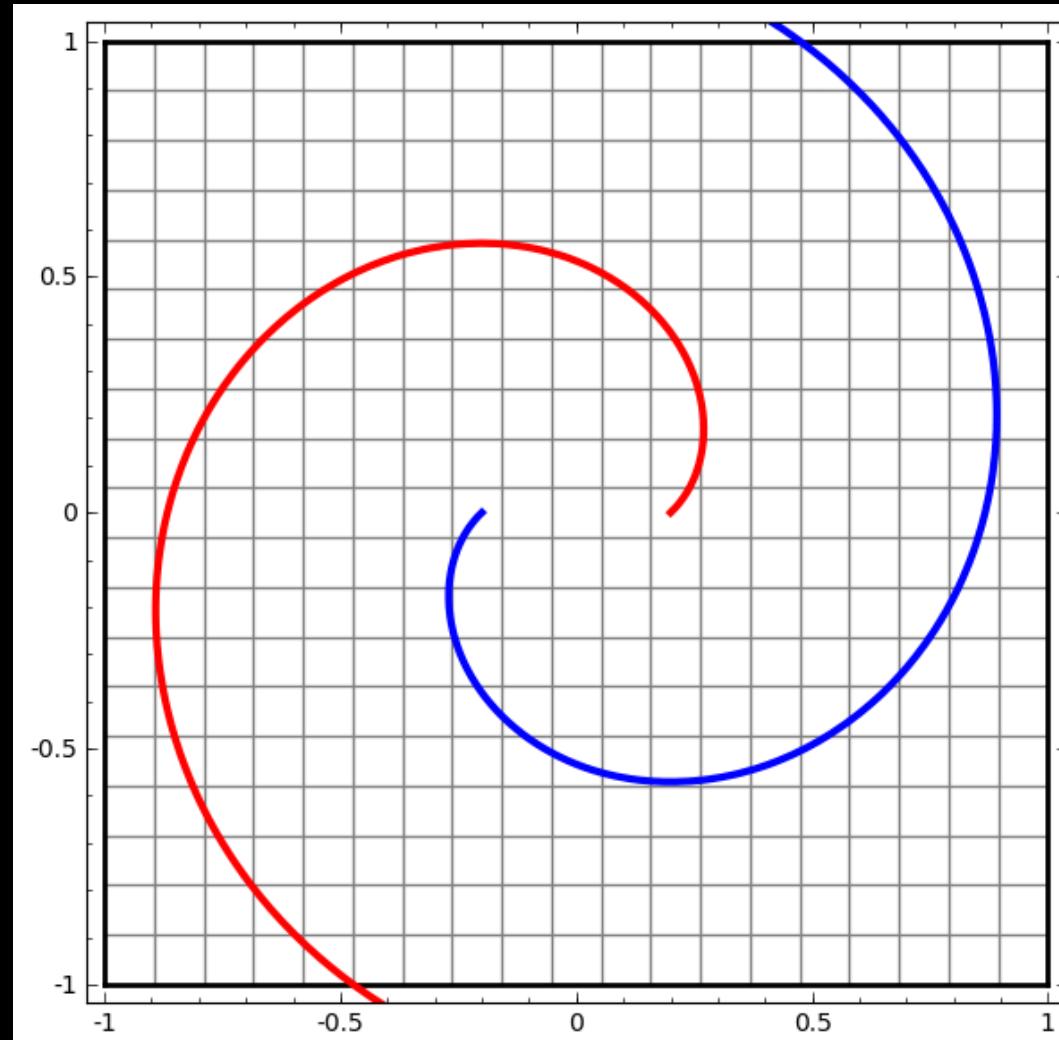
# Deep Learning

# Introduction

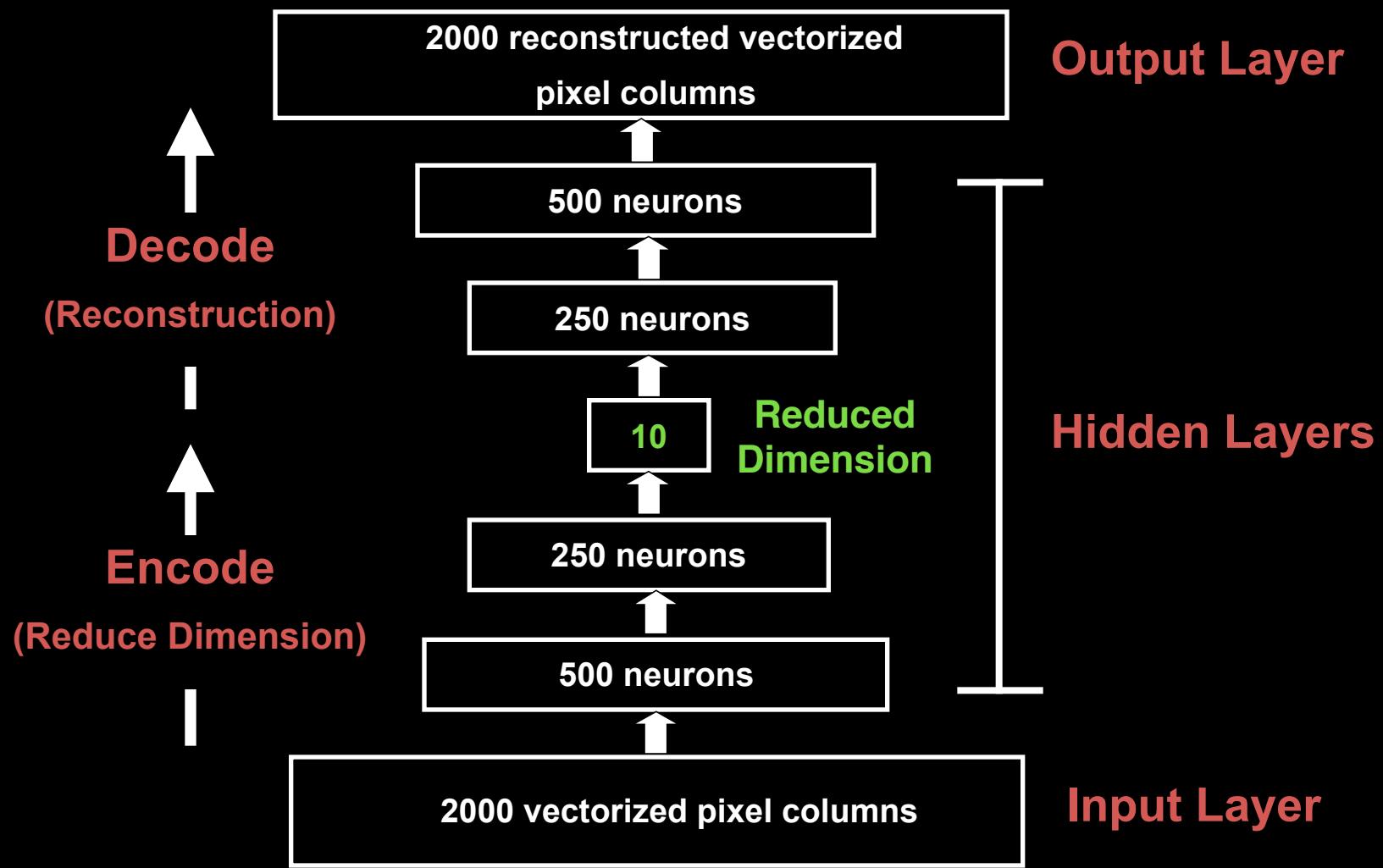
# FeedForward Neural Network



# Hidden Layer Transformation



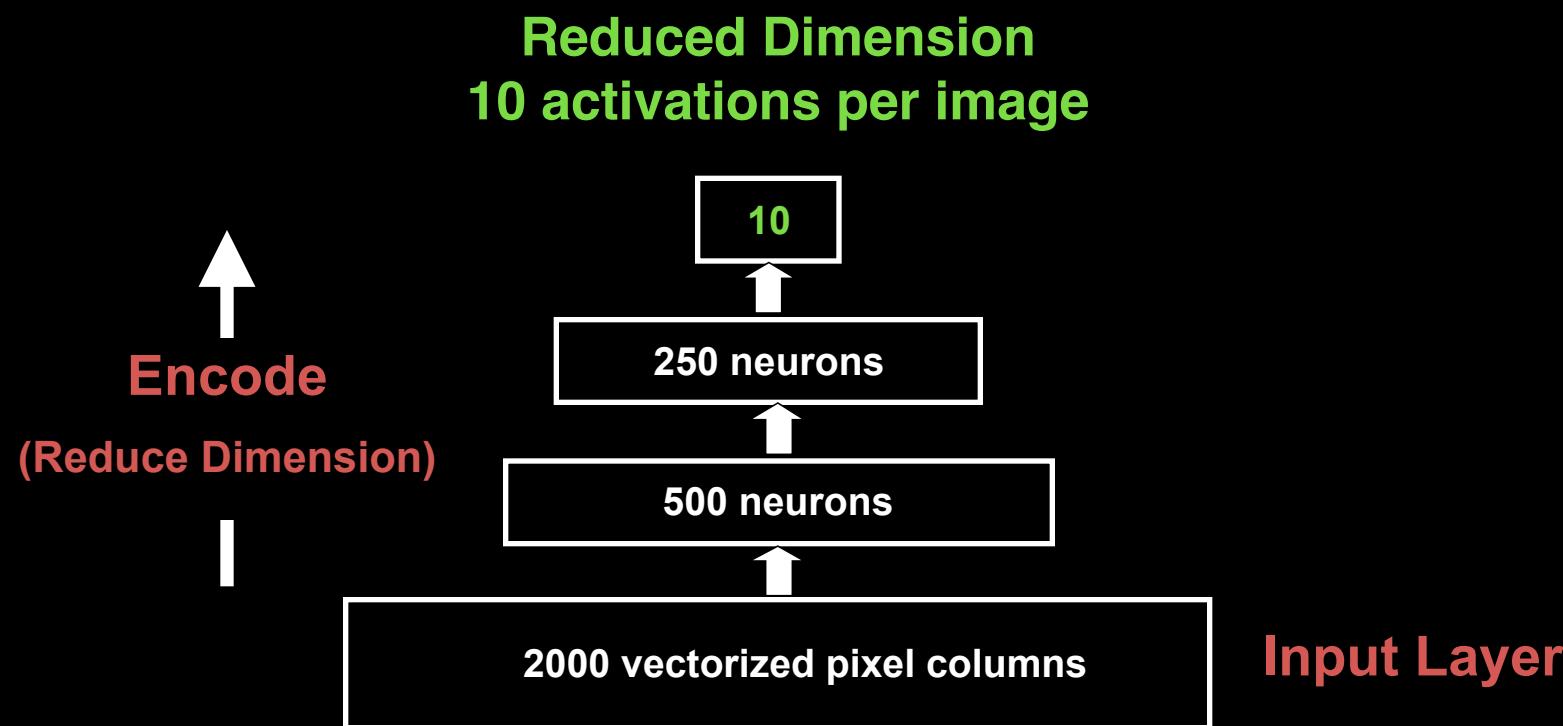
# AutoEncoder



# Training AutoEncoder

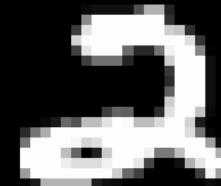
- **Output Layer reconstructs Input Layer**
- **Error** from reconstruction is **back-propagated through hidden layer** to update the weights
- Tricks for training deep AutoEncoders  
(Geoffrey Hinton et al 2006 Science)

# Using AutoEncoder

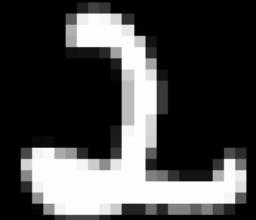
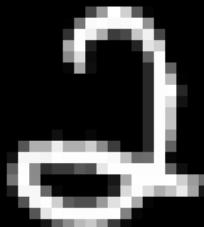
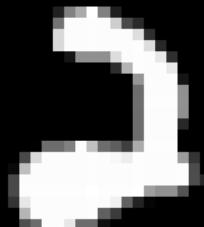
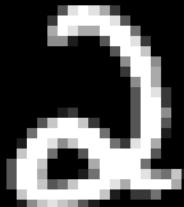


# MNIST Example

Query Image

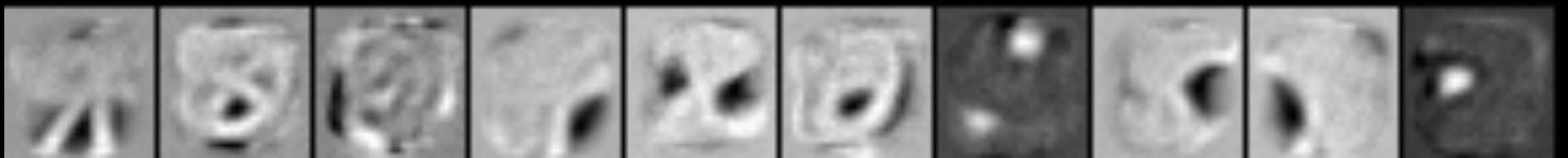


5 most similar images



[Link to code](#)

# Visualizing Weights

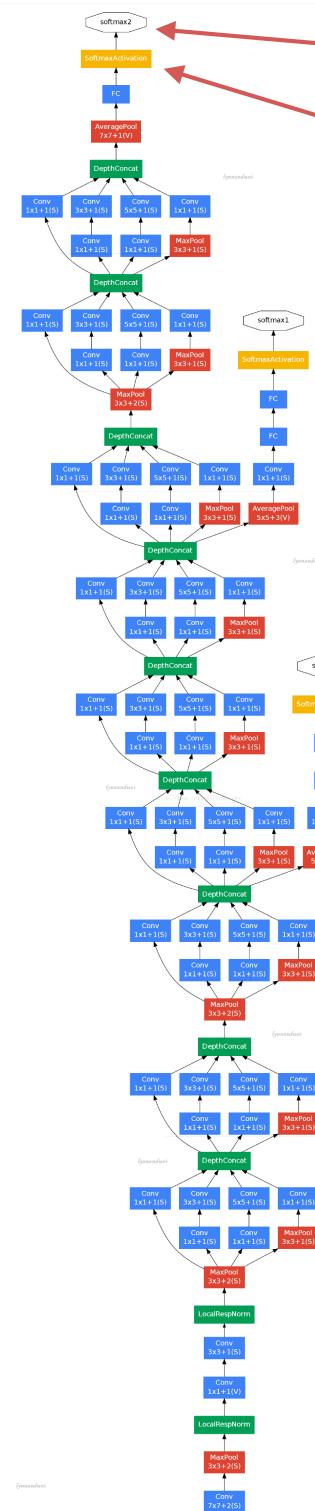


# Alternative Approach

- Supervised learning
- With convolutional neural network
- Use activations before the output layer as reduced dimensions
- **GoogleNet with ImageNet data:**  
A pre-trained convolutional network (1k labels)

# ImageNet Data





# Output Layer

## Activations before Output Layer

## Input Layer

# Dato / GraphLab Pre-trained Convolutional Net

```
graphlab.neuralnet_classifier.NeuralNetClassifier.extract_feature
```

# Convolution

35	40	41	45	50
40	40	42	46	52
42	46	50	55	55
48	52	56	58	60
56	60	65	70	75



0	1	0		
0	0	0		
0	0	0		



		42		

Input

Kernel

Output

# Deep Learning Ecosystem

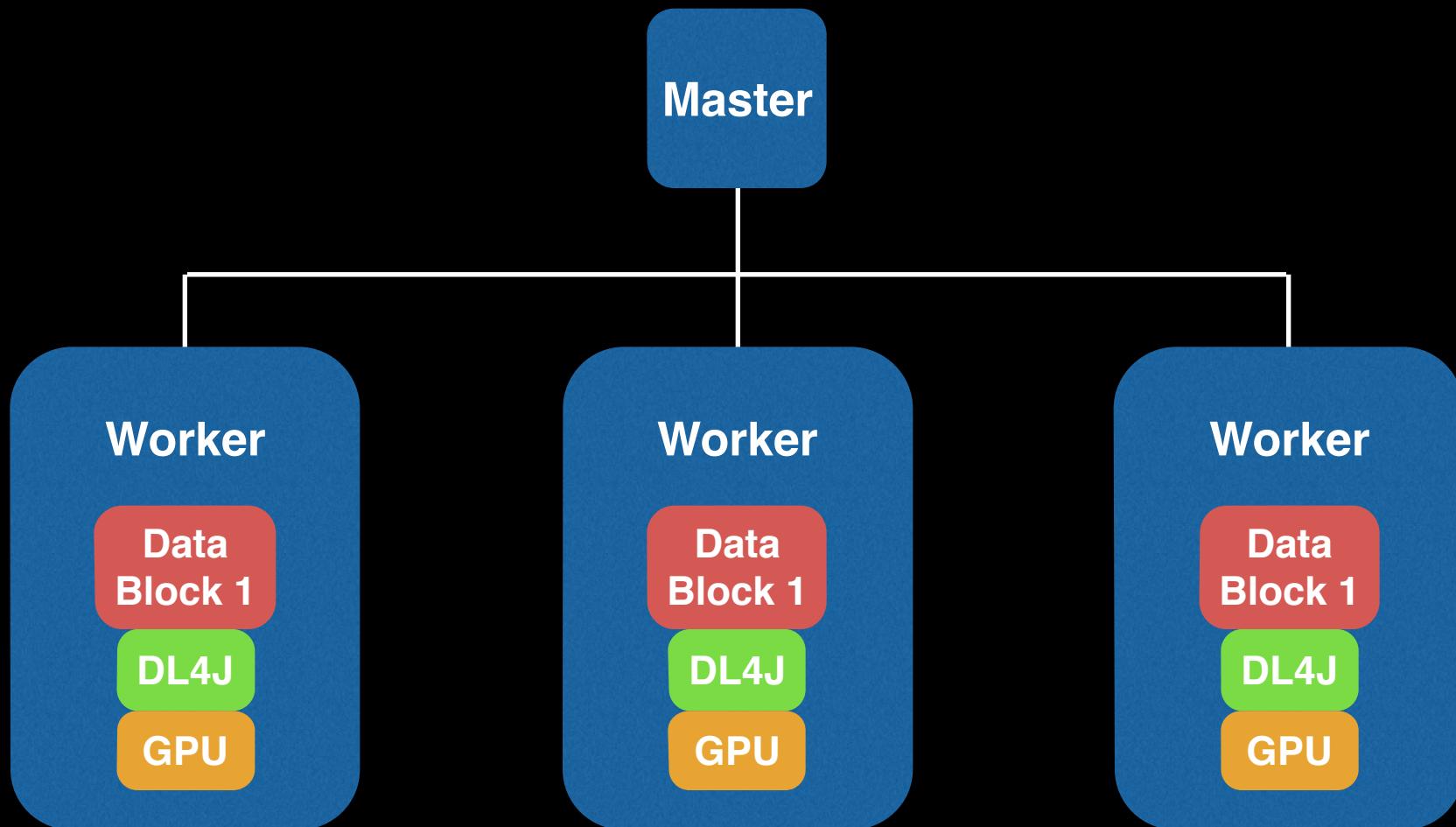
# Deep Learning Libraries

Python	Java	C
Lasagne	Deeplearning4j	Theano
Sknn	Neuralnetworks	Caffe
Dato (GraphLab)		SINGA
OpenDeep		
Theano		
Caffe		

# Why DeepLearning4j

- **Java:**  
Better integration with production systems
- **NN Features:**  
AutoEncoder, RBM and Recurrent (LSTM)
- **Distributed:**  
Training on distributed GPU (Spark)

# Distributed Deep Learning



# Road Map

- **Stable Release:** Aug / Sep, 2015
- **Optimized Release:** Oct / Nov, 2015
- **Python Interface:** Oct / Nov, 2015

# DL4J Github Repo

 [deeplearning4j / deeplearning4j](#) Watch ▾ 188 Star 1,244 Fork 390

Deep Learning for Java, Scala & Clojure on Hadoop, Spark & GPUs <http://deeplearning4j.org> — Edit

 2,651 commits  53 branches  22 releases  36 contributors

 Branch: **master** 

Merge pull request #523 from deeplearning4j/ablayerfixes 

 nyghtowl authored 12 hours ago	latest commit 5157070aff 	
 <a href="#">deeplearning4j-cli</a>	Changed name for remainder to max on numlinsearchiterations.	13 days ago
 <a href="#">deeplearning4j-core</a>	Remove incorrect deprecated annotation	a day ago
 <a href="#">deeplearning4j-scaleout</a>	fixed TextPipeline in Spark. Tests passed. Build Success	22 hours ago
 <a href="#">deeplearning4j-ui</a>	fix compilation error on update filters	10 days ago
 <a href="#">dl4j-caffe</a>	Fix straggler on descent name. Removed caffe stuff that is in progres...	14 days ago
 <a href="#">dl4j-test-resources</a>	done lookupcache	2 days ago
 <a href="#">.gitignore</a>	Minor cleanup	14 days ago

**Code**

-  Issues 31
-  Pull requests 4
-  Wiki
-  Pulse
-  Graphs
-  Settings

HTTPS clone URL <https://github.com> 

You can clone with **HTTPS, SSH,**

# Toady's Github Repo

[https://github.com/jyt109/autoencoder\\_image\\_search](https://github.com/jyt109/autoencoder_image_search)