

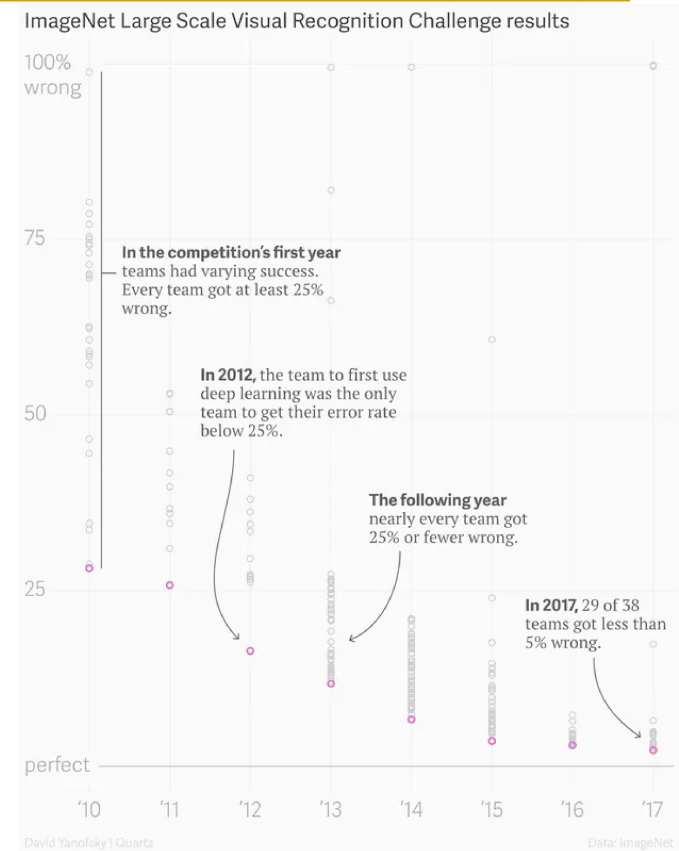
University of Illinois at Urbana-Champaign
Dept. of Electrical and Computer Engineering

ECE 101: Exploring Digital Information Technologies for Non-Engineers

Machine Learning (part 2 of 2)

Neural Nets through the Years

- **1942**—First computational model for neural networks
- **1965**—First functional networks of many layers
- **1975**—Backpropagation algorithms for training multilayer networks
- **1990s**—Datasets quite small; computers not that fast; other methods doing better
- **2005-2007**—Unsupervised learning with deep nets; use of GPUs
- **2009**—ImageNet: Image database of 14 million images for more than 21000 concepts
- **2012**—AlexNet: Winner of ImageNet Large Scale Visual Recognition Challenge 2012



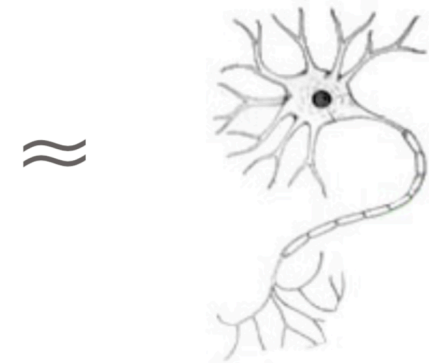
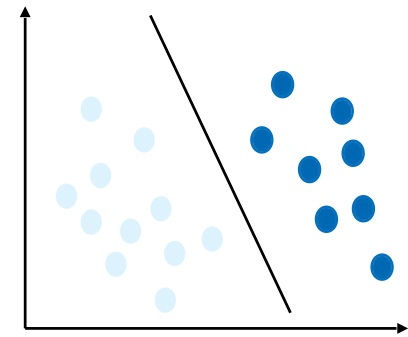
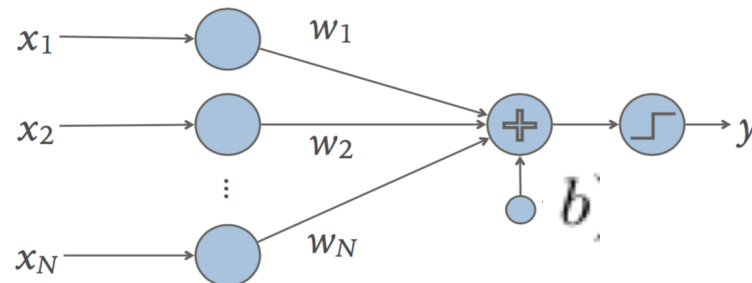
Perceptron

An early version of a **perceptron**, which **mimics a human neuron**.

Inputs (on the left) are multiplied by weights, then summed together with a bias.

The sum is then converted to +1 or -1.

It's a linear classifier!

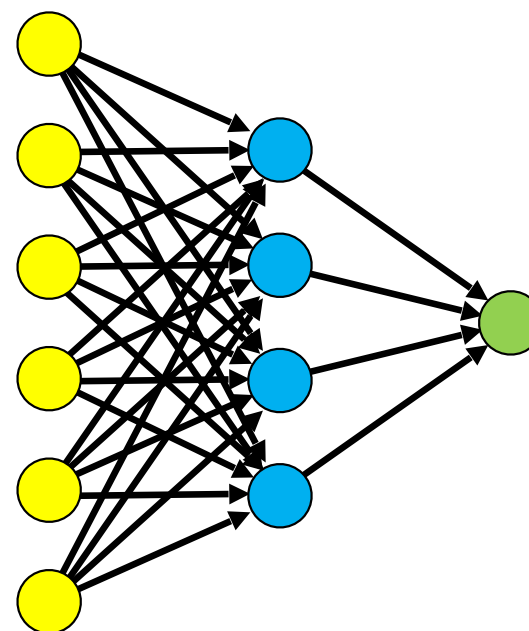


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Neural Networks Consist of Many Artificial Neurons

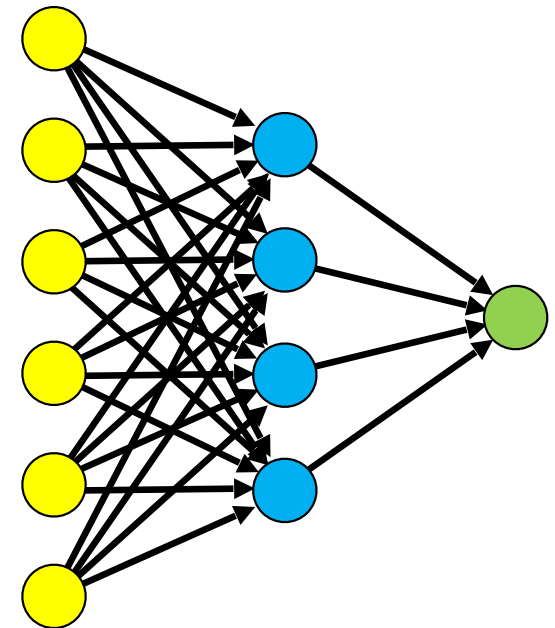
To **perform more complex**
(non-linear) **tasks**,

- perceptrons can be **connected in a network**
- by using the output of one perceptron
- as the input to a second,
- then a third, and so forth.



Input, Output and Hidden Layers

- **Input layer** (in yellow)
- Every input is connected to every node in the **hidden layer** (in blue)
- **Output layer** (in green) consists of a single output perceptron
- Every node in hidden layer is connected to the output node



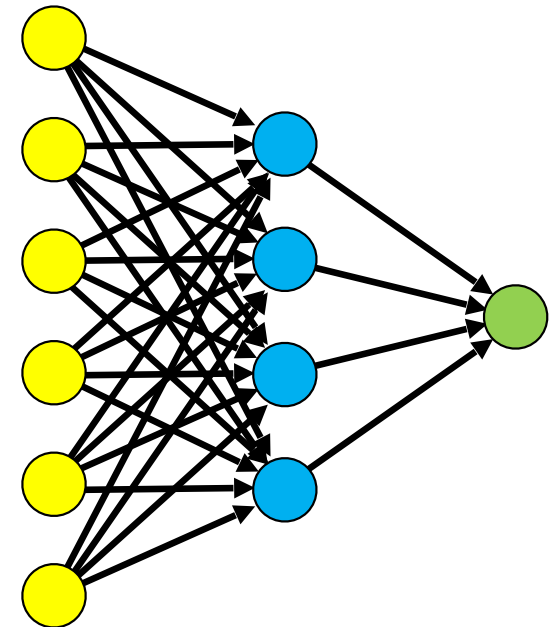
Advancement: Deeper Networks that Leverage Input Relationships

In theory, a small number of fully connected hidden layers can learn anything.

In practice, three things happened before neural networks enjoyed major success.

By the late 1990s, researchers had built

- **new architectures** that **leveraged relationships between the inputs**, and
- **deeper networks** to **capture more complex functions more quickly**.



Advancement: Ubiquitous Availability of Fast Computation

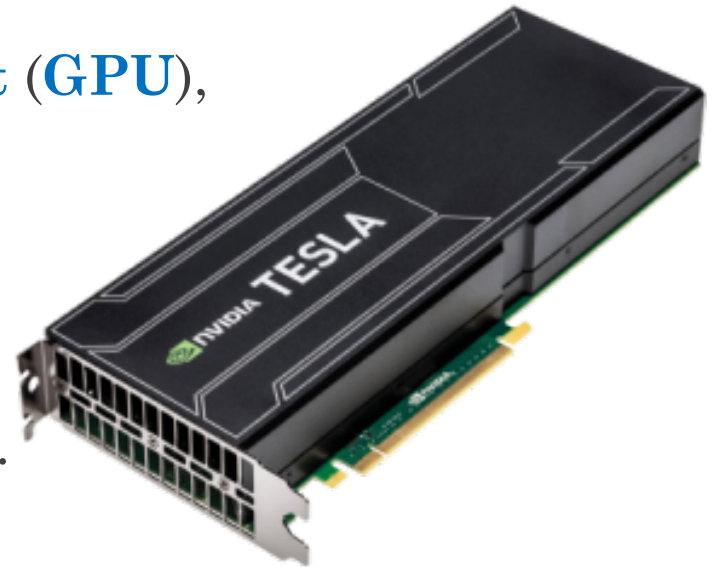
The last change came in early 2007

- with the release of the first easily programmable **graphics processing unit (GPU)**,
- NVIDIA's GTX80 (not the one shown).

GPUs had developed

- to meet the entertainment market demand for high-resolution graphics,
- and by 2007 offered much **more raw computational power than processors.**

They are **well-suited to training and applying neural networks.**



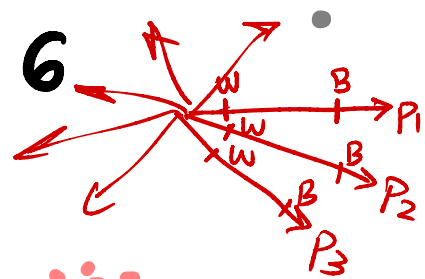
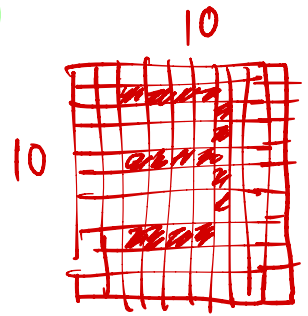
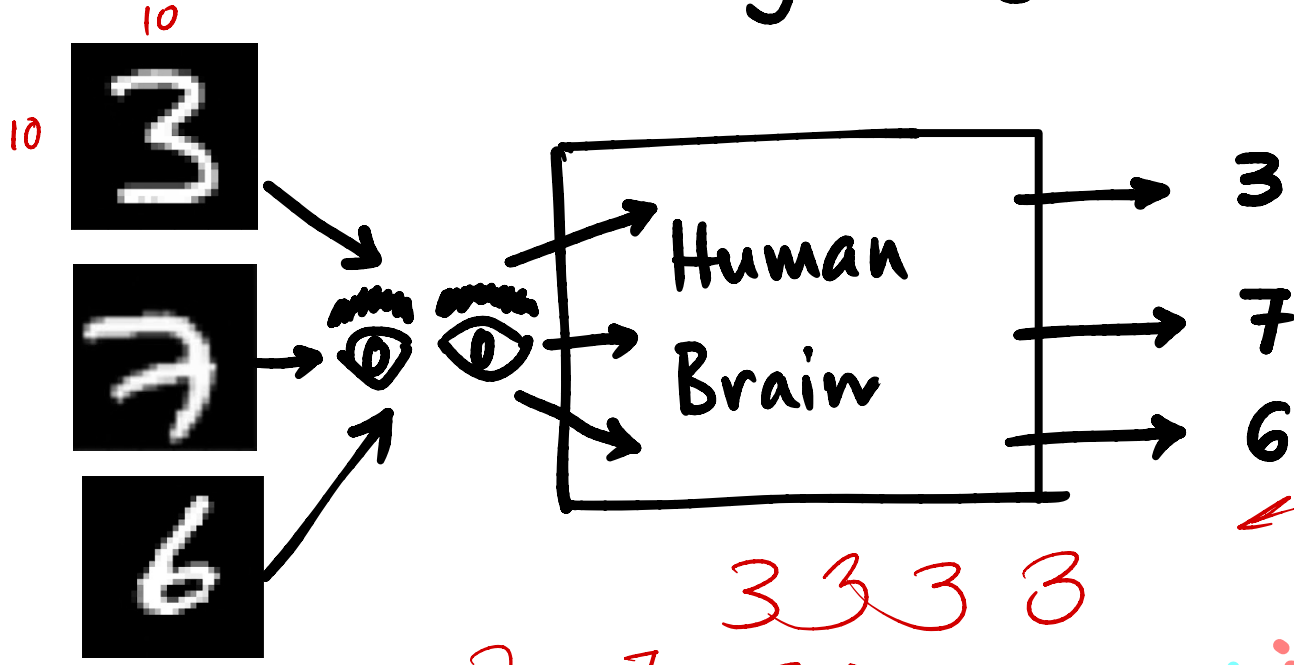
UIUC Offered First Class on GPGPU Programming

The **first class on** general-purpose GPU
(**GPGPU**) **programming**

- was offered at UIUC in Spring 2007
- by David Kirk, chief architect from NVIDIA,
- and Wen-mei Hwu, ECE professor.



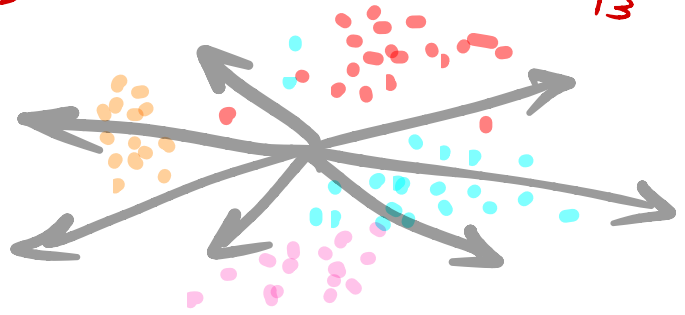
Consider handwriting recognition



3 3 3 3

7 7 7 7 7

How would you do this with feature space?



But wait !!!

What features should we
use ??

often called an "art"



Enter neural networks.

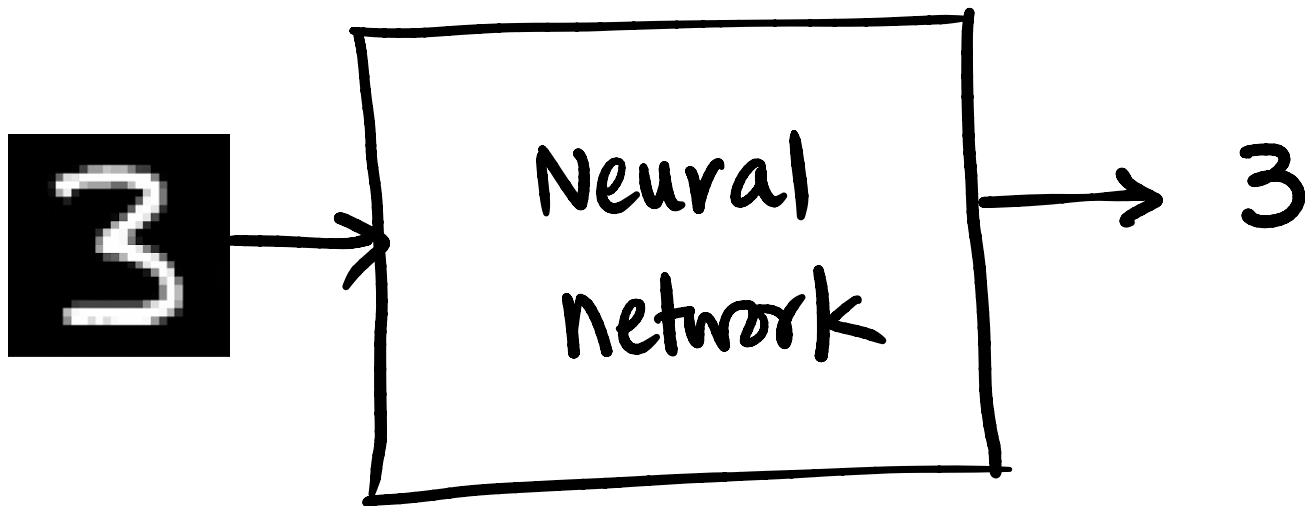
Deep Learning Derives Features from Data

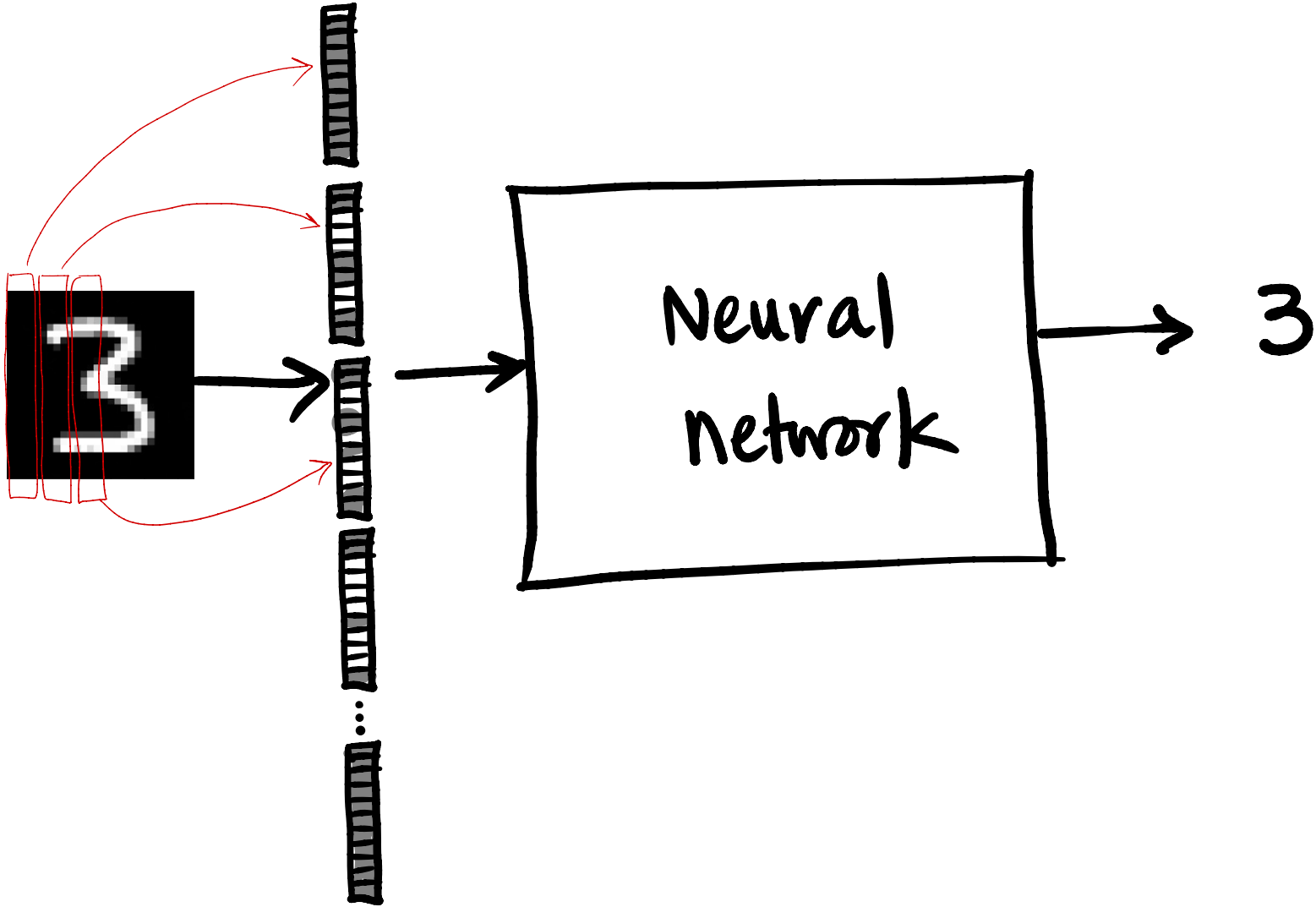
More recent designs

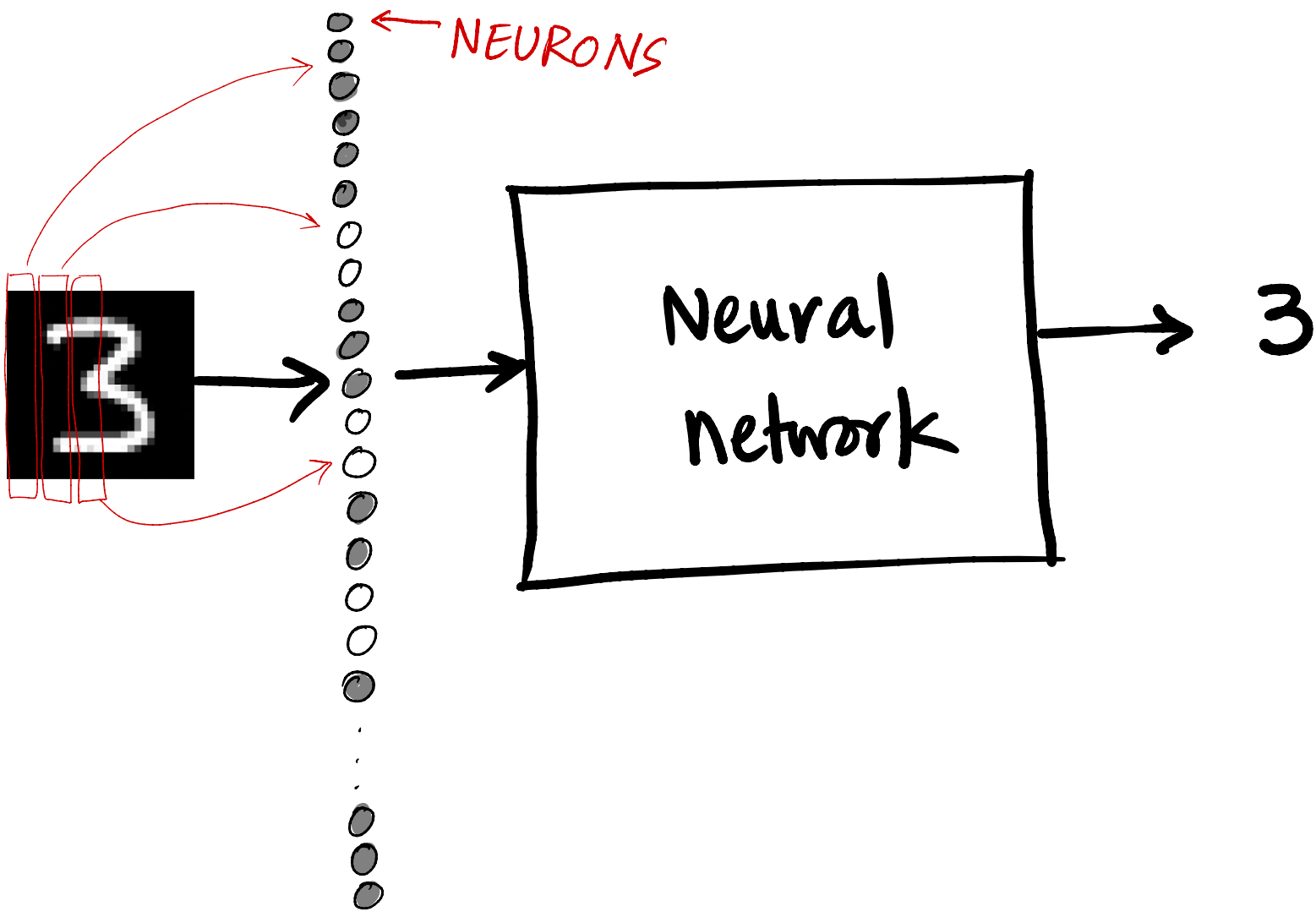
- have stopped using human-modeled features, and
- instead **allow training** of the neural network
- **to derive the features of importance** from the data.

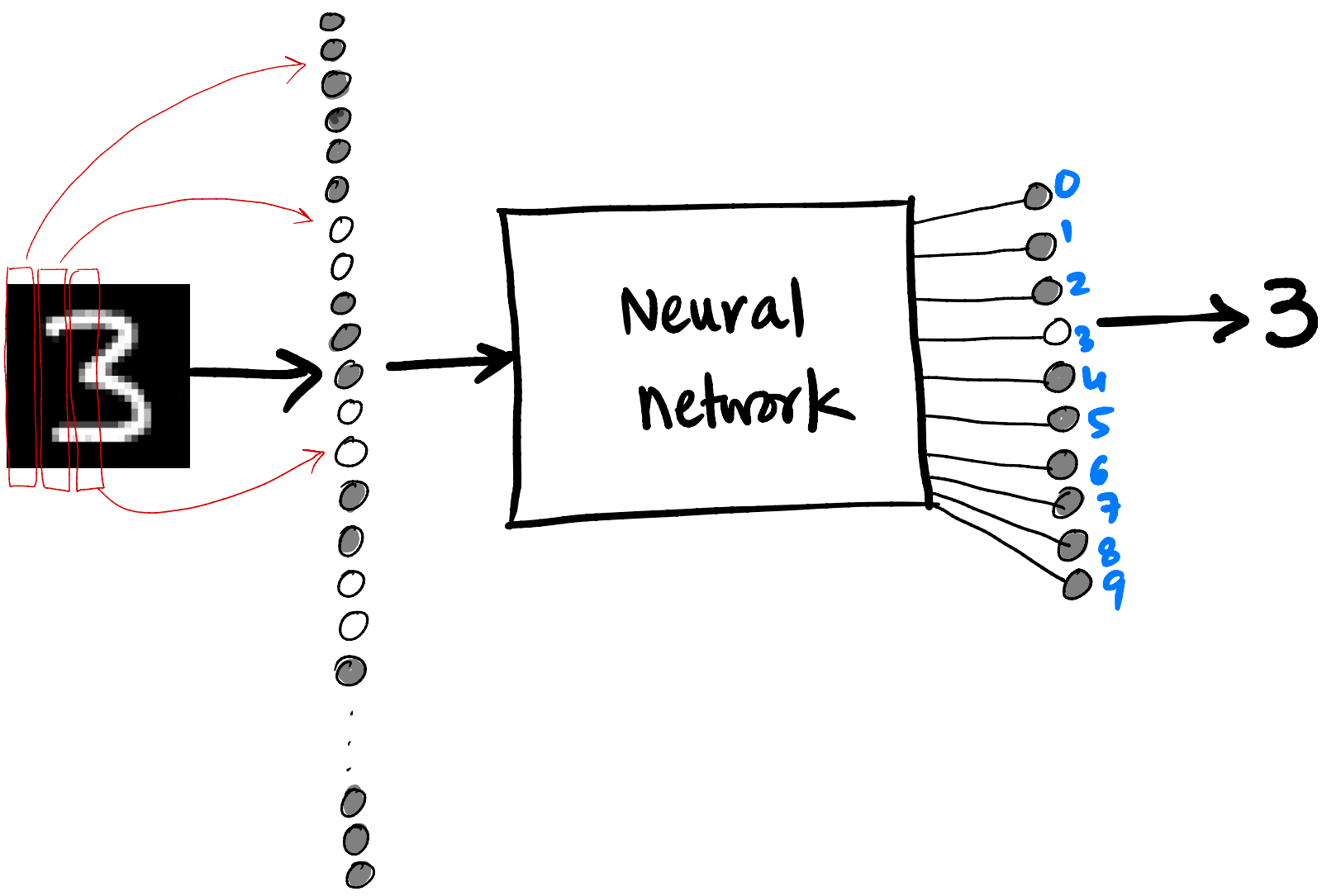
This approach is called **deep learning**.

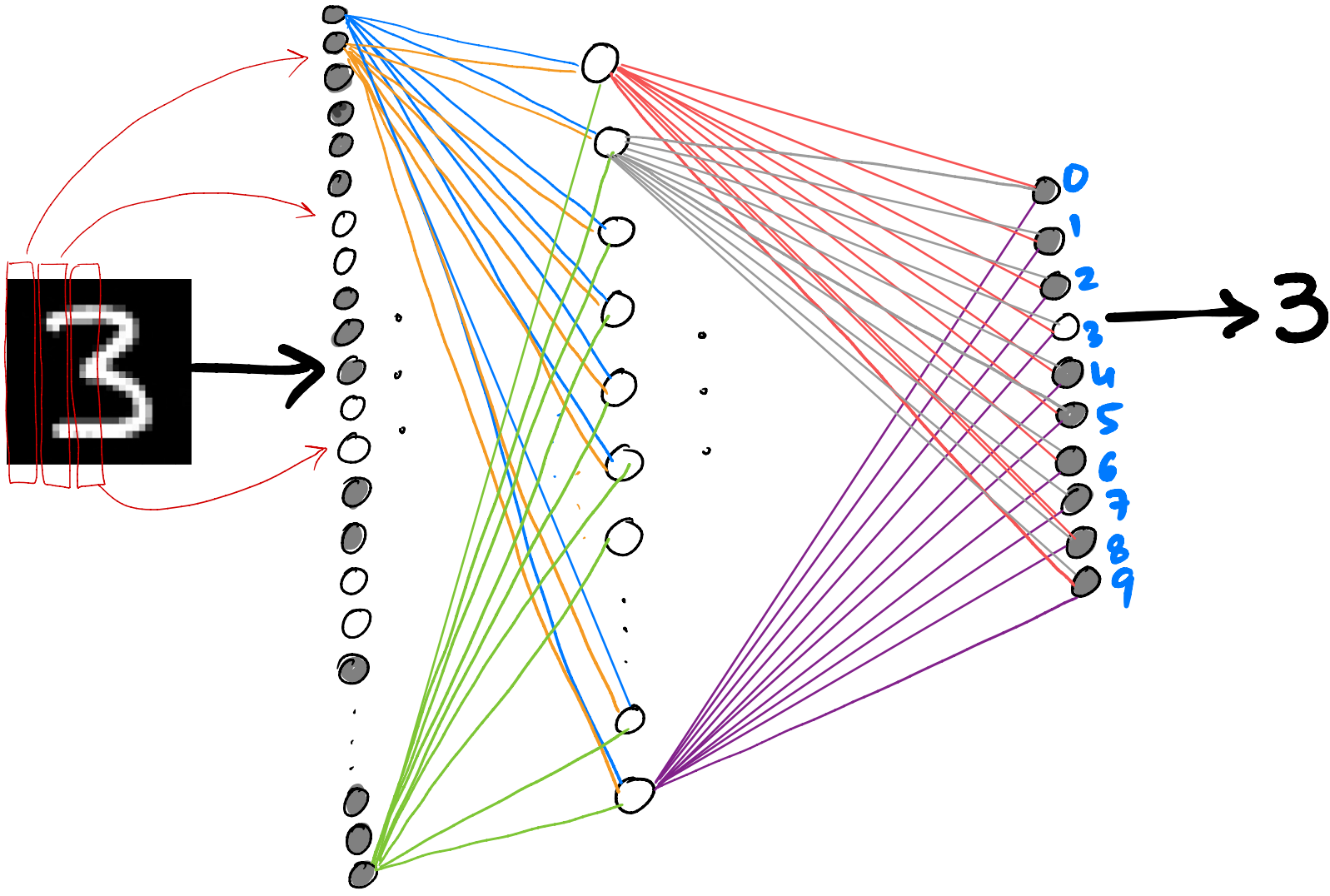
Deep learning is **possible due to** the sheer **volume of data** now **available** in many problems.

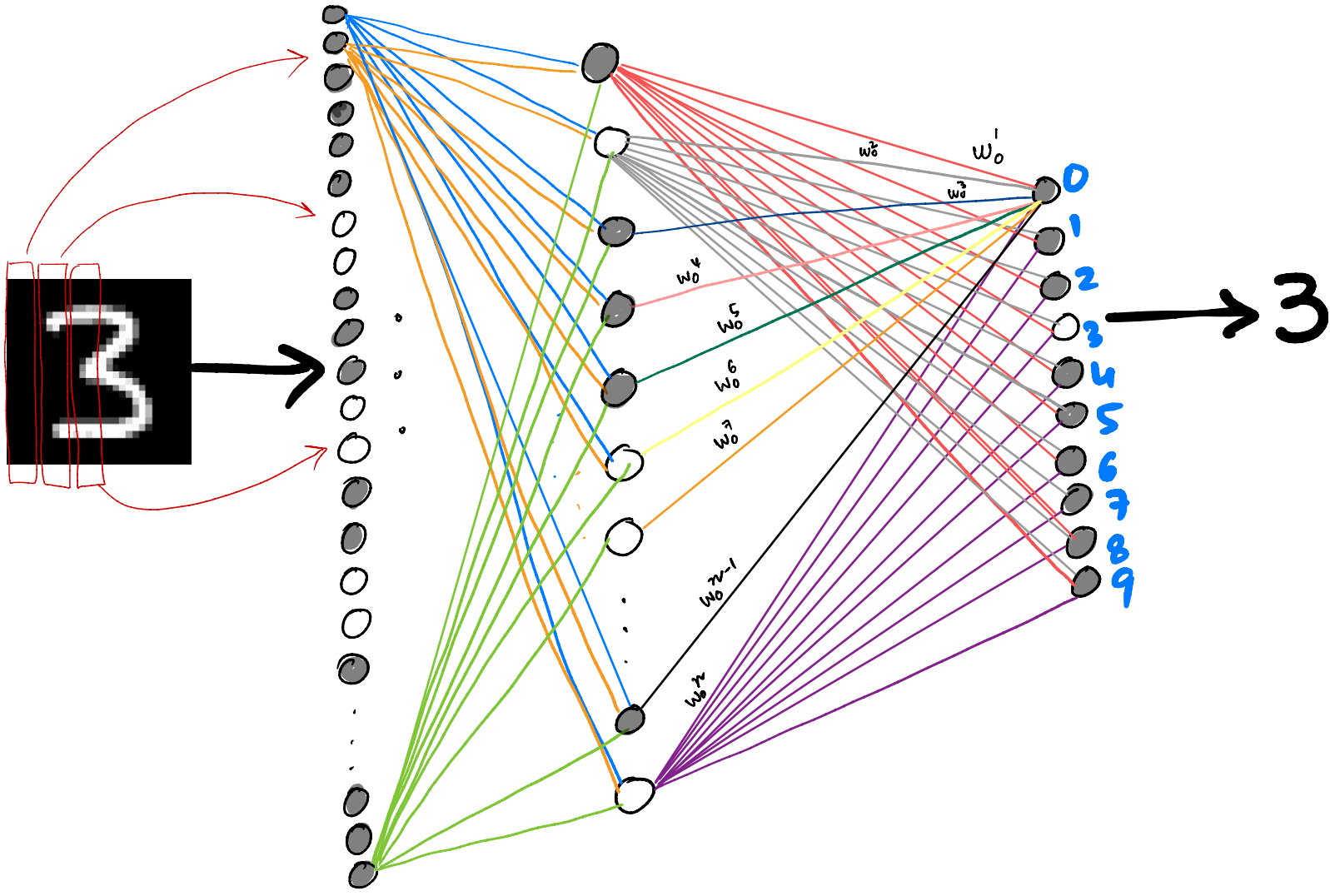


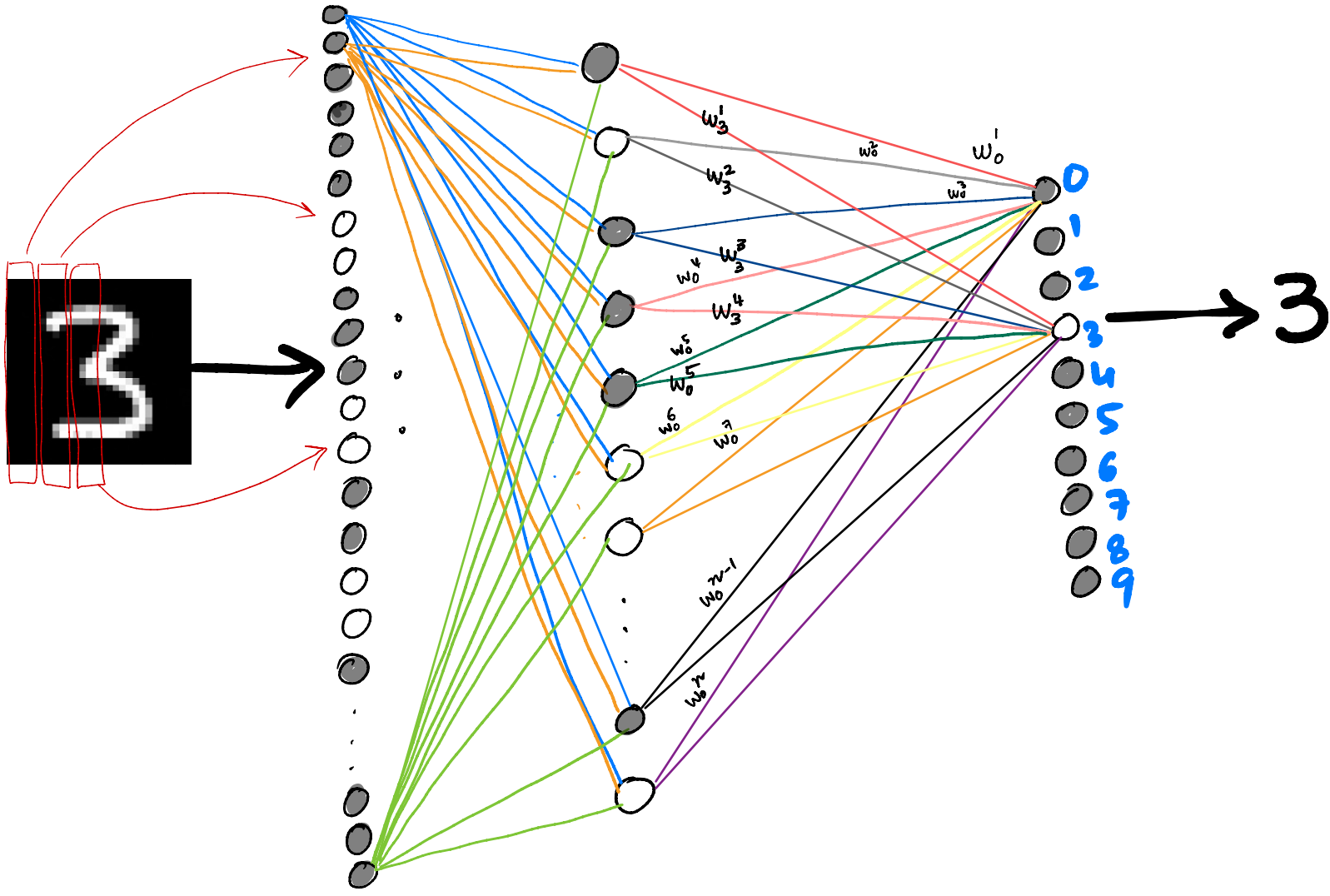












Terminology You Should Know from These Slides

- Deep Neural Networks (DNNs)
- perceptron
- fully connected layer
- Input layer, hidden layer, output layer
- Graphics Processing Unit (GPU)
- Deep learning