CIS 490 Machine Learning

A taste of (Artificial)Neural Network (NN) and Deep Learning

Instructor: (Julia) Hua Fang

Mar 27, 2019, "the Association for Computing Machinery (ACM), the world's largest society of computing professionals, announced that Drs. Hinton, LeCun and Bengio had won this year's Turing Award for their work on neural networks. The Turing Award, which was introduced in 1966, is often called the Nobel Prize of computing, and it includes a $1 million prize, which the three scientists will share".

https://www.nytimes.com/2019/03/27/technology/turing-award-ai.html

NN vs. Deep Learning

Traditional neural networks contain only 2 or 3 layers, while deep networks can have hundreds.

Deep learning is a type of machine learning in which a model learns to perform classification tasks directly from images, text, or sound. Deep learning is usually implemented using a neural network architecture.

The term "deep" refers to the number of layers in the network—the more layers, the deeper the network.

Adapted from MATLAB 2018

Typical Applications of Deep Learning

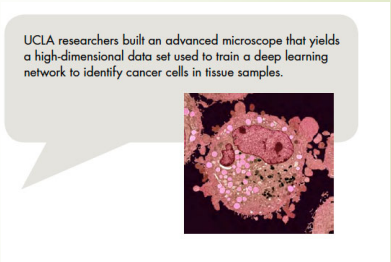
- Deep learning is especially well-suited to identification applications. E.g.,
  - face recognition,
  - text translation,
  - voice recognition,
  - advanced driver assistance systems, including, lane classification and traffic sign recognition.
  - Image analysis (ChexNet)
  - Video analysis

What makes Deep Learning State of the Art?

Accuracy!!!

Advanced tools and techniques have dramatically improved deep learning algorithms—to the point where they can outperform humans, e.g.,

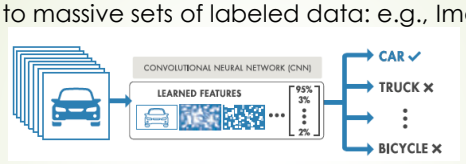
- at classifying images,
- win against the world's best GO player, or
- enable a voice-controlled assistant like Amazon Echo® and Google Home to find and download that new song you like.



Deep Learning: State of the Art

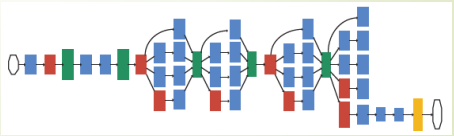
Three technology enablers make this degree of accuracy possible:

- Easy access to massive sets of labeled data: e.g., ImageNet; PASCAL VoC



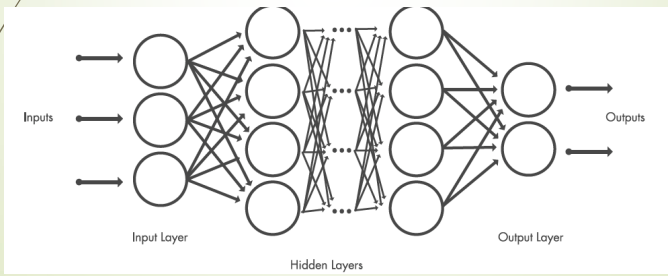
- Increased computing power: e.g. GPU

- Pretrained models built by experts: e.g., AlexNet



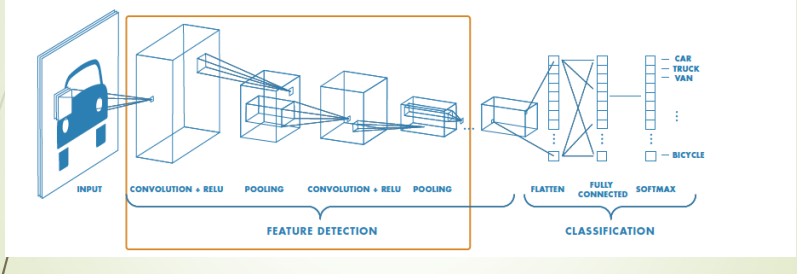
Deep NN Architecture

- Multiple nonlinear processing layers
- Inspired by biological nervous system
- Consist of an input, multiple hidden layers and an output layer
- Layers interconnected via nodes, or neurons
- each hidden layer using the output of the previous layer as its input



Deep Learning: CNN

A **convolutional neural network** (CNN, or ConvNet) is one of the most popular algorithms for deep learning with images and video.



Feature Detection Layers

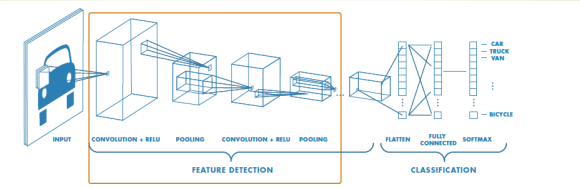
These layers perform one of three types of operations on the data: convolution, pooling, or rectified linear unit (ReLU).

Deep Learning: CNN

Feature Detection Layers

- **Convolution** puts the input images through a set of convolutional filters, each of which activates certain features from the images.
- **Pooling** simplifies the output by performing nonlinear downsampling, reducing the number of parameters that the network needs to learn about.
- **Rectified linear unit (ReLU)** allows for faster and more effective training by mapping negative values to zero and maintaining positive values.

These three operations are repeated over tens or hundreds of layers, with each layer learning to detect different features.

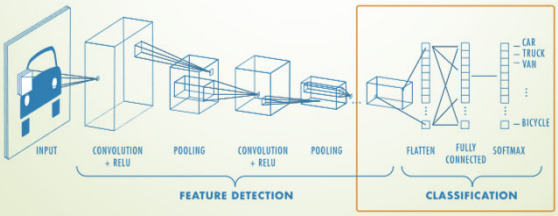


Deep Learning: CNN

Classification Layers

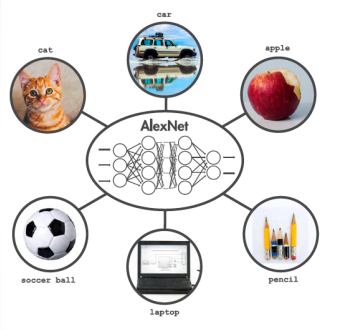
After learning features in many layers, ie, feature detection, the architecture of a CNN shifts to classification.

- The next-to-last layer is a **fully connected layer** (FC) that outputs a vector of K dimensions where K is the number of classes that the network will be able to predict. This vector contains the probabilities for each class of any image being classified.
- The final layer of the CNN architecture uses a **softmax** function to provide the classification output.



Getting start with Deep Learning: AlexNet

- use an existing network, such as AlexNet, most commonly used for image classification.
  - classify images into 1000 different categories, including keyboards, computer mice, pencils, and other office equipment, as well as various breeds of dogs, cats, horses, and other animals.



AlexNet was first published in 2012, and has become a well-known model in the research community.

Additional Deep Learning Resources: Matlab

- Deep Learning with MATLAB: Quick-Start Videos
- Start Deep Learning Faster Using Transfer Learning
- Transfer Learning Using AlexNet
- Introduction to Convolutional Neural Networks
- Create a Simple Deep Learning Network for Classification
- Deep Learning for Computer Vision with MATLAB