Deep Learning

MGTF 495

Class Outline

- **Deep Learning**
  - Motivation

  - History & Phases in Research of Artificial Neural Networks

  - Recent wave in Artificial Neural Network

  - Types of Neural Networks

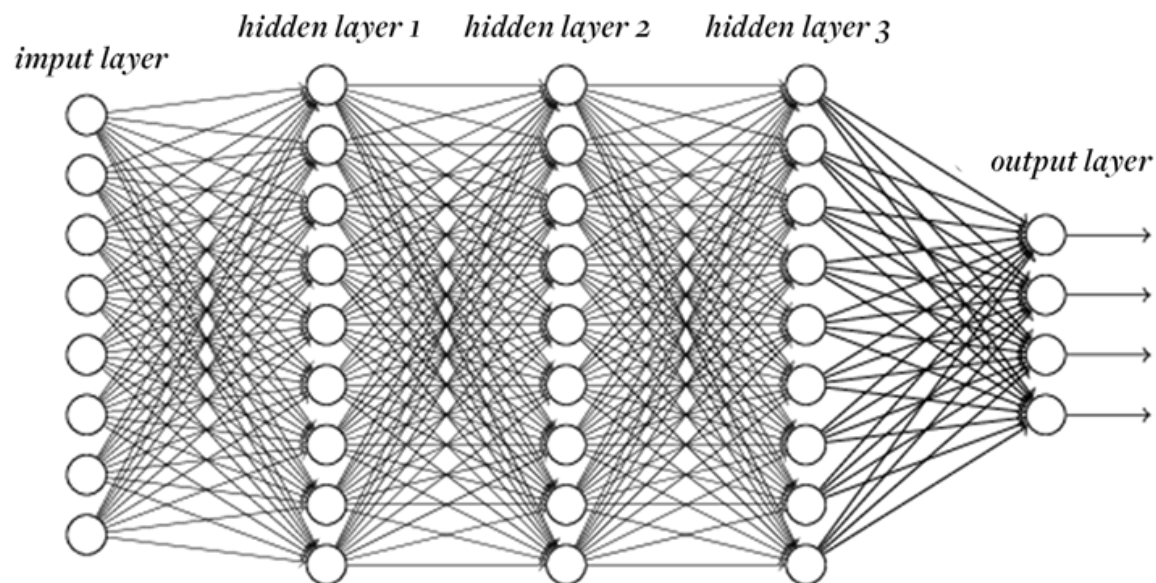 - Examples/Applications of Artificial Neural Networks

Motivation

- In human brain, billions of neurons interact with each other.

Motivation

- Idea is to replicate neurons in brain through Artificial Neuron.
- These artificial neurons interact with each other.

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pro and cons

   pros: powerful

cons: data required.
         computation

History & Phases in Research of Artificial Neural Network

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  - Prof. at New York University
  - Director of FAIR: Facebook AI Research.
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    - Independently discovered backpropagation Algorithm.
- Research in Neural Networks died because
    - Required a lot of data.
    - Computation Intensive.

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Recent wave in Artificial Neural Network

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Recent wave in Artificial Neural Network

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- Image recognition challenge - ImageNet
  - 1000 classes of images
  - ~ 1 Million training images.

Recent wave in Artificial Neural Network

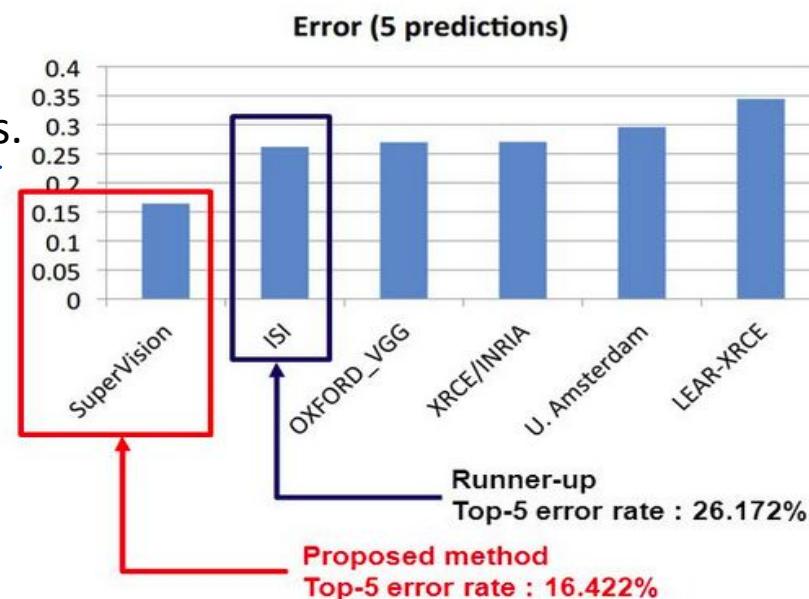- **ImageNet** Large Scale Visual Recognition Challenge (ILSVRC)

- Winning team
  - **10%** better than other teams.

  - Team members:
    - Alex Krizhevsky
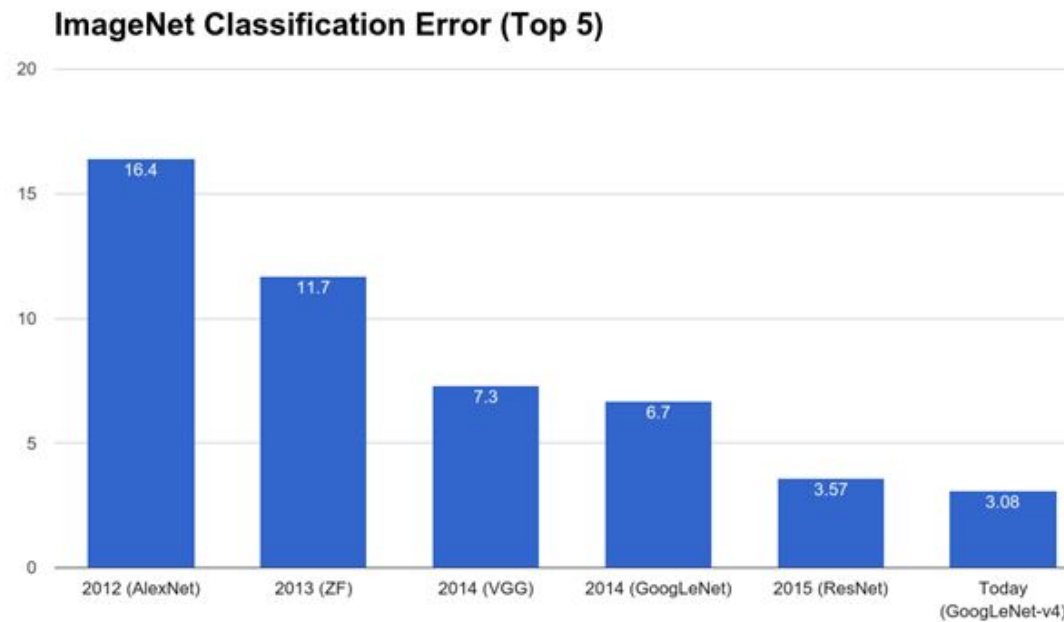   - Geoffrey Hinton
    - Ilya Sutskever - Director at OpenAI

- This competition renewed interest in Neural Networks.

ILSVRC-2012 results

Error (5 predictions)

Runner-up
Top-5 error rate : 26.172%

Proposed method
Top-5 error rate : 16.422%

ImageNet Results

- Over the years, accuracy on ImageNet has significantly improved.

- Today, the Deep learning models have better accuracy than humans.

- Later, we will see the trend in this area of research.

ImageNet Classification Error (Top 5)

Year (Model)	Error
2012 (AlexNet)	16.4
2013 (ZF)	11.7
2014 (VGG)	7.3
2014 (GoogLeNet)	6.7
2015 (ResNet)	3.57
Today (GoogLeNet-v4)	3.08

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- These problems are now solved.

  - Lots of Data - with the help of Internet/Mobile Devices

    - Amazon Mechanical Turk - label data.

  - Lots of computational power - GPU

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Types of Neural Networks

- Most common variations of neural network architectures are:
    - Multilayer perceptron 多层感知机
    - Convolutional Neural Network 卷积
    - Recurrent Neural Network 差回视经网络

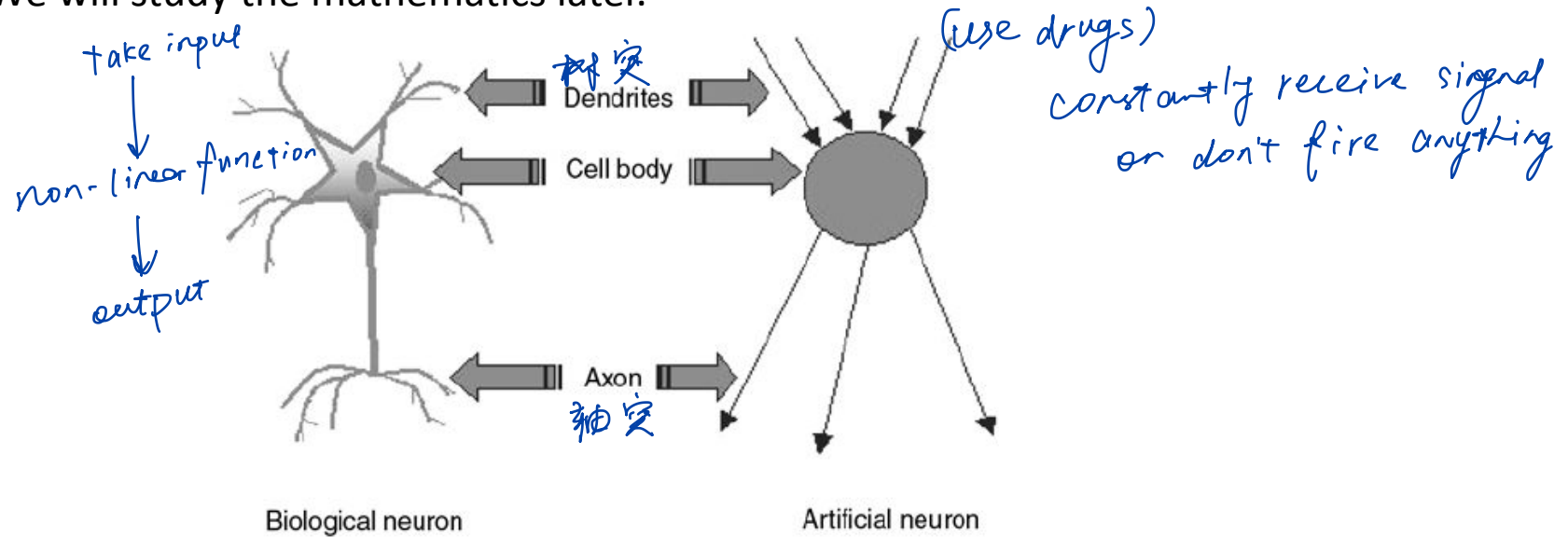# Types of Neural Networks

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    - We will build most of our fundamental understanding with **Multilayer Perceptron**(MLP)

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    - Convolutional Neural Network(CNN)
    - Recurrent Neural Network(RNN)

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    - We will extend understanding of MLP into CNN**.**
    - CNN's are typically used in Images/Videos related problems.
    - Can be used to generate/draw images as well.

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- **Recurrent Neural Network:**
  - Typically used to understand sequences, eg speech, text, etc.
  - It can even be used to generate music.

Artificial Neuron

- We will talk only about intuition.
- We will study the mathematics later.

take input

non-linear function

output

阿突
Dendrites

Cell body

Axon
轴突

(use drugs)
constantly receive signal
or don't fire anything

Biological neuron

Artificial neuron

One neuron is connected to many other neurons

Artificial Neuron
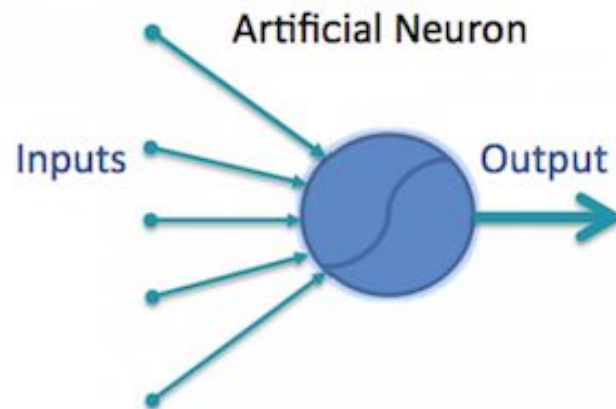
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Multiple layer Perceptron

- Multiple Neurons interact with each other.
- We introduce the concept of layer.
- Also called
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Input layer -> Hidden layer ……….. -> Hidden Layer - > Output Layer

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Input neurons Hidden layer Output neuron

Synaptic weights
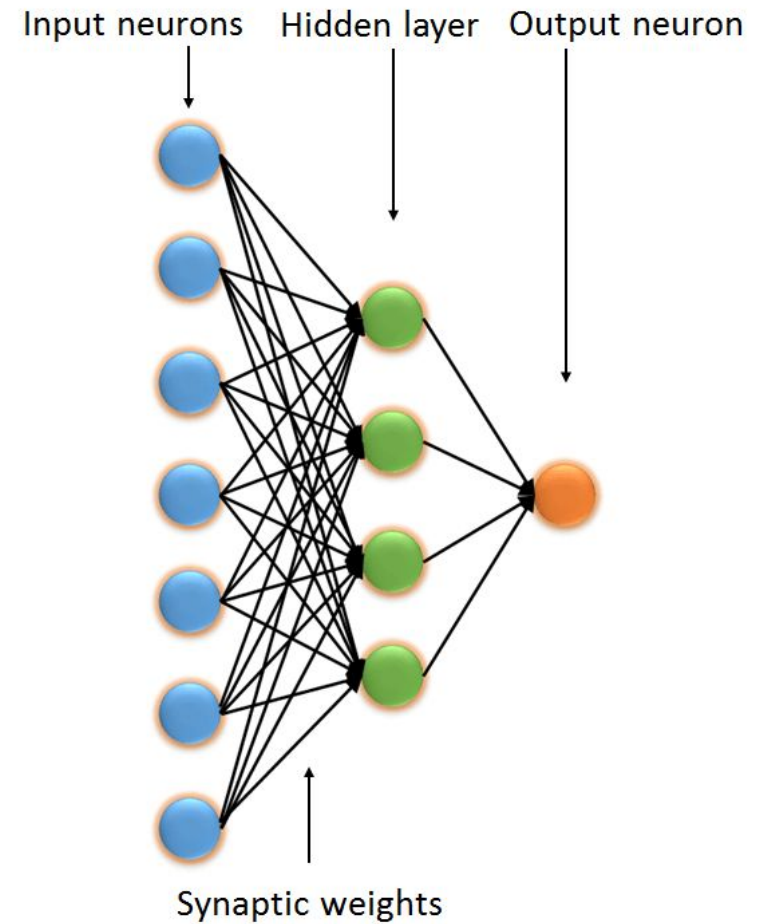
Convolutional Neural Network

- Most fundamental application of CNN:
  - Identify the objects.
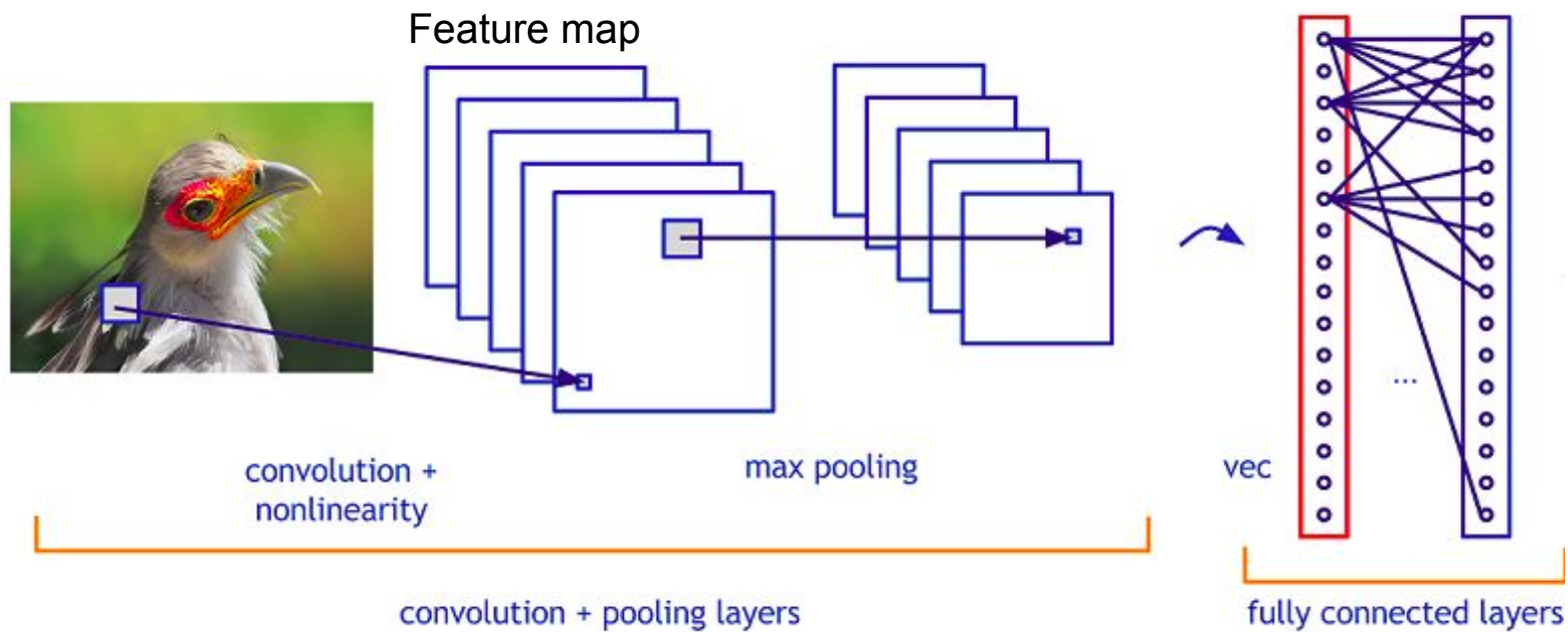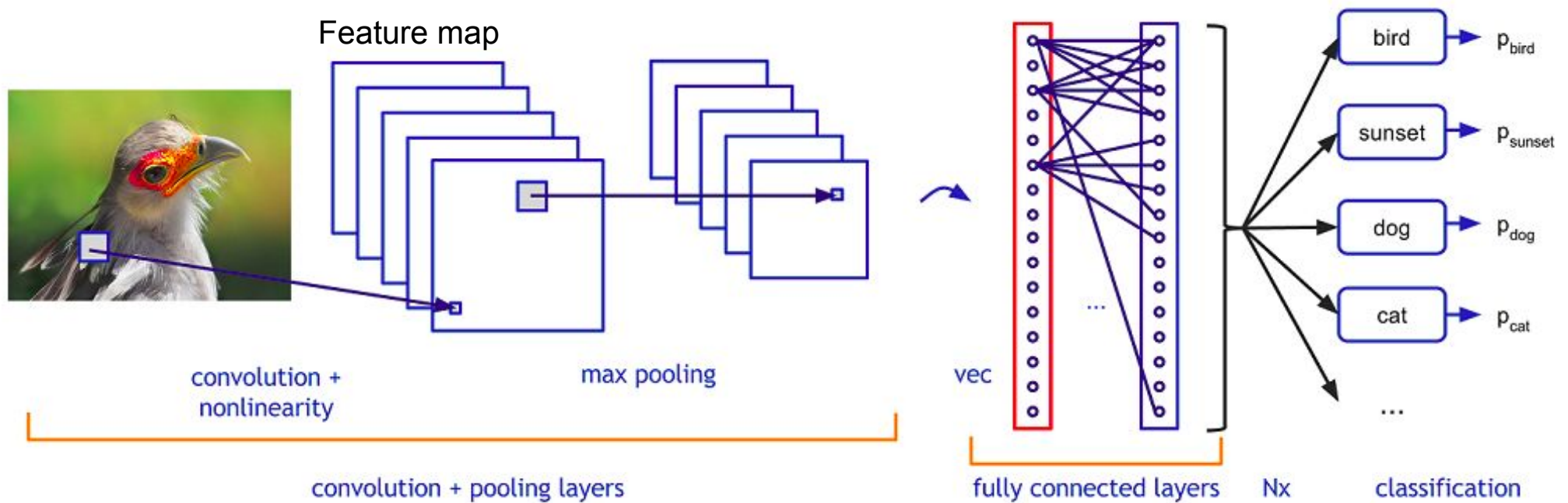 - Locate these objects in image.
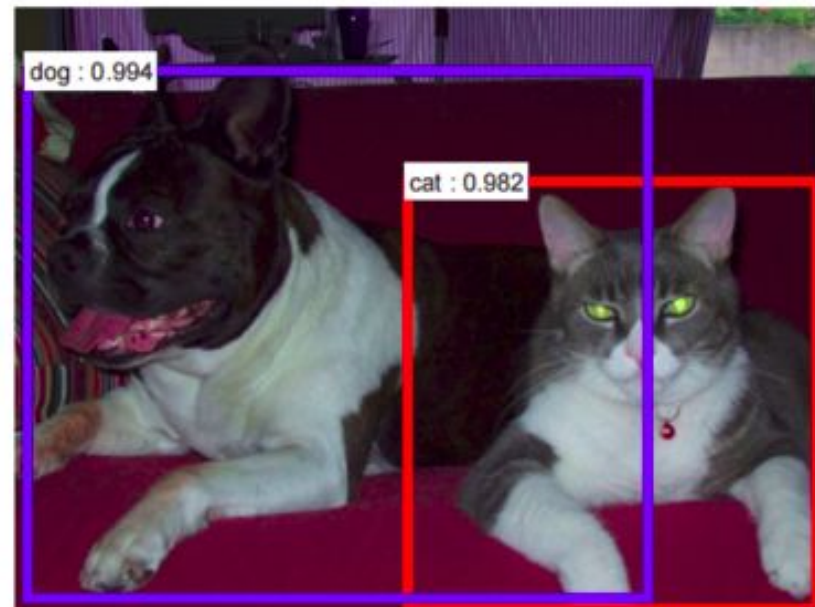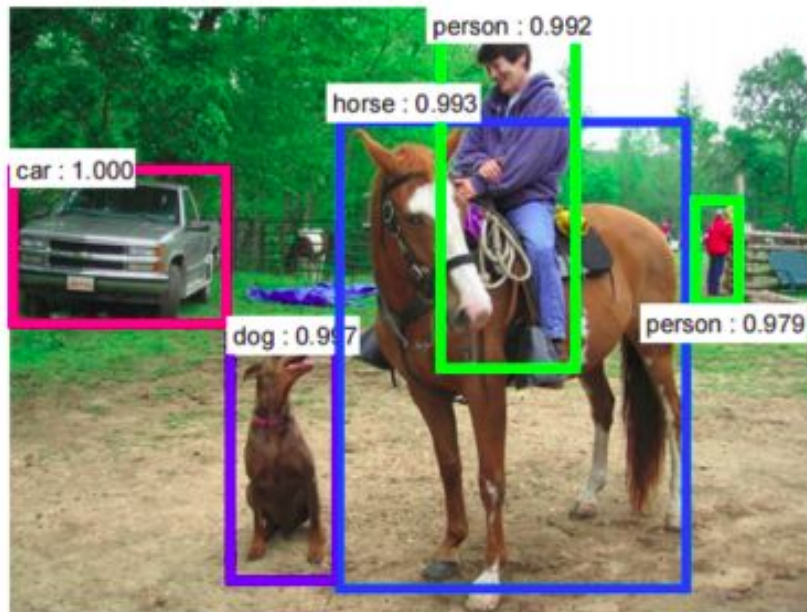
Convolutional Neural Network

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  - Convolution
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Feature map

convolution +
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fully connected layers

Convolutional Neural Network

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max pooling

vec

bird → p_{bird}

sunset → p_{sunset}

dog → p_{dog}

cat → p_{cat}

...

convolution + pooling layers

fully connected layers   Nx   classification

Recurrent Neural Network

- Recurrent Neural Networks targets sequential/temporal information.

He is drinking Orange _____

↑

Juice can be inferred from previous words/context

Recurrent Neural Network

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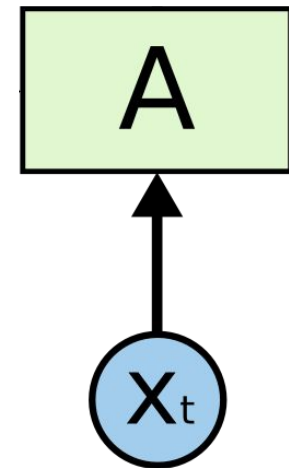- RNN Cell has memory/state which stores information/context from the past.

Recurrent Neural Network: RNN Cell

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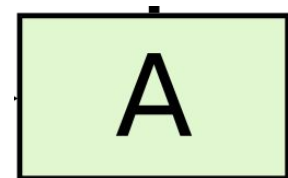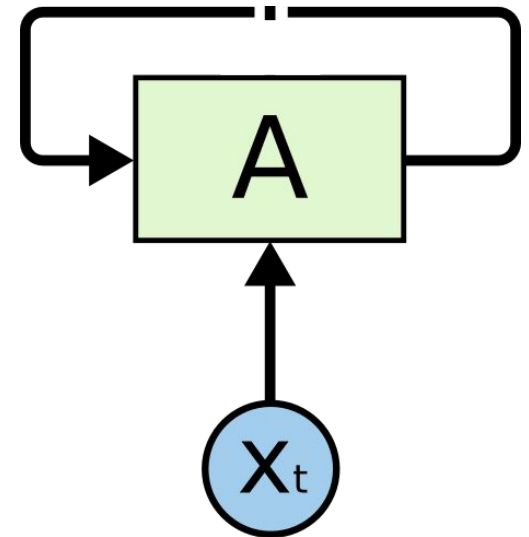
    - They have a state
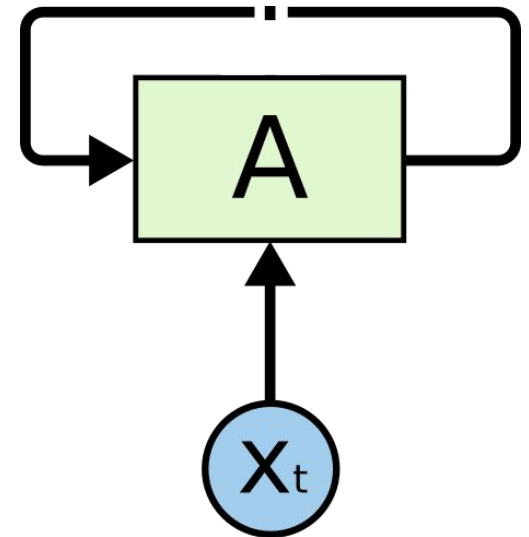
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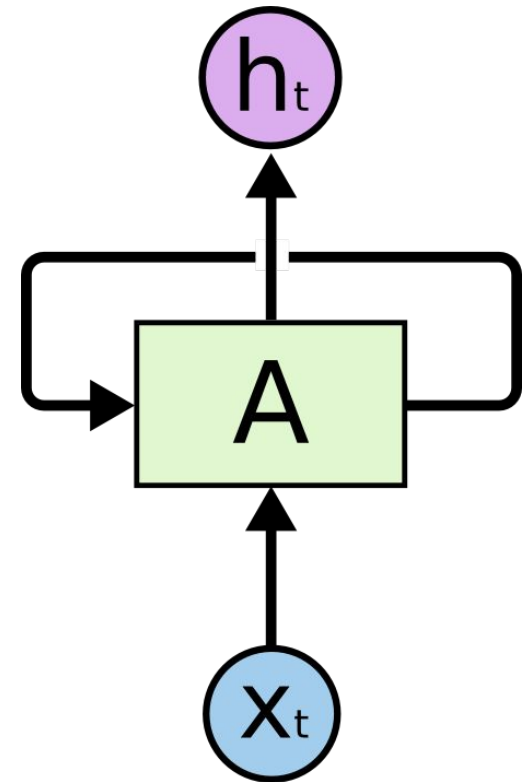
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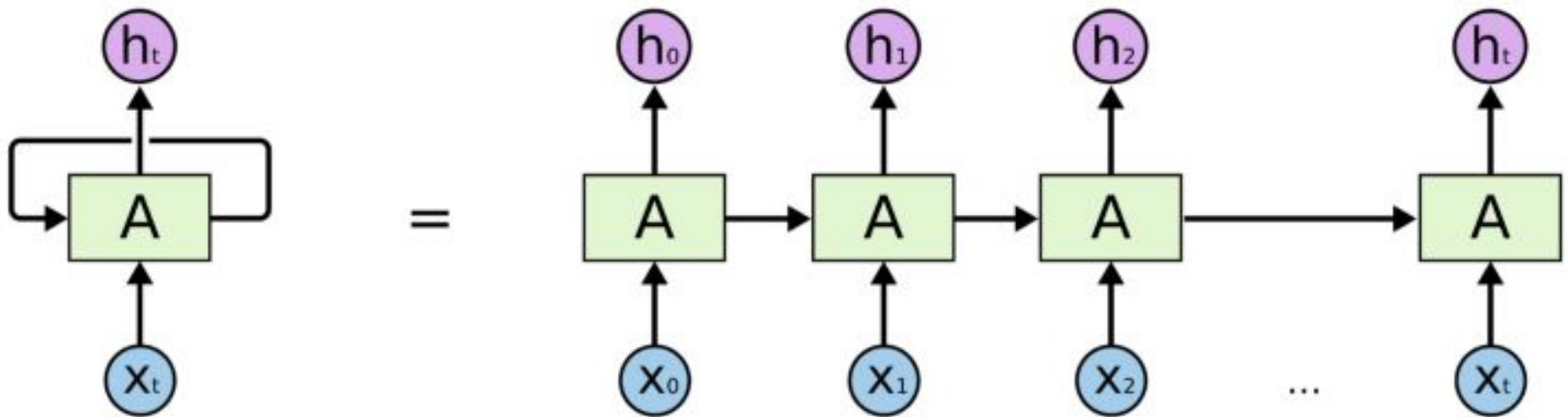
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        - new input.

        - past context.

    - update their memory/state.

        - Generate an output.

Recurrent Neural Network: Unrolled in time

An unrolled recurrent neural network.

RNN and LSTM Cell

- LSTM: Long Short Term Memory
- RNN Cell specialized to remember past information/context.
  - LSTM Cell solves vanishing gradient problem seen in RNN Cell.(discussed later)
- Introduced in 1997
- Variants
  - Gated Recurrent Unit(GRU).

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Applications of Artificial Neural Networks

- Recognize digits.
- Widely used in Cheque deposit machines.

Applications of Convolutional Neural Networks

- Visual Question Answering

Applications of Convolutional Neural Networks

- Image captioning

"man in black shirt is playing guitar."

"construction worker in orange safety vest is working on road."

"two young girls are playing with lego toy."
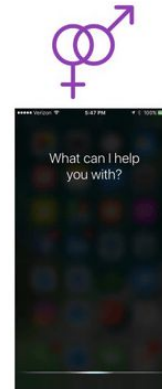
Image Captioning
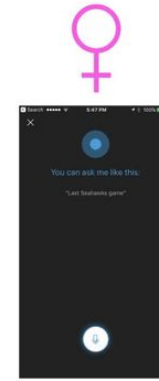
Applications of Recurrent Neural Networks

AMAZON'S ALEXA   GOOGLE'S ASSISTANT   APPLE'S SIRI   MICROSOFT'S CORTANA

Applications of Recurrent Neural Networks

- Train on Wikipedia, and they can summarize the articles.

- They can write software codes.

- Generate Music.

- Video classification.

Frameworks

- Neural networks are difficult to write from the scratch.

- There are standard libraries/frameworks, which can run parallely code on GPU
  - Theano - University of Montreal.
  - Caffe - Berkeley
  - TensorFlow - Google
  - PyTorch - Facebook
  - **Keras** - A wrapper on top of TensorFlow/Theano

- In this course, we will use **Keras** framework with tensorflow backend.

State of the art network/applications

- Object Detection

- Object Segmentation

- Generative Networks