

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

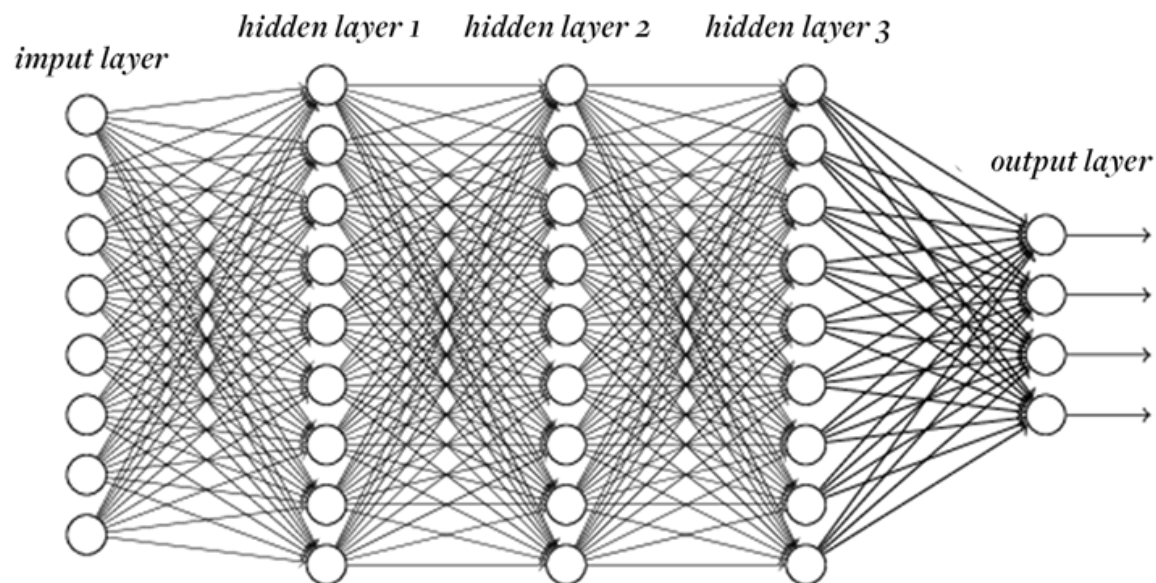
Motivation

- 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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 - Prof. at New York University
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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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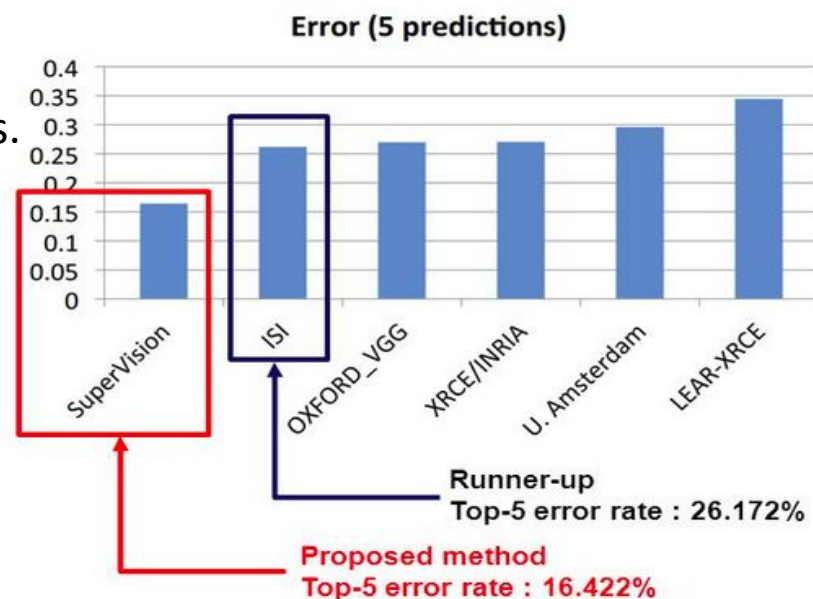
- It all began in 2012
- Image recognition challenge - ImageNet
 - 1000 classes of images
 - ~ 1 Million training images.



Recent wave in Artificial Neural Network

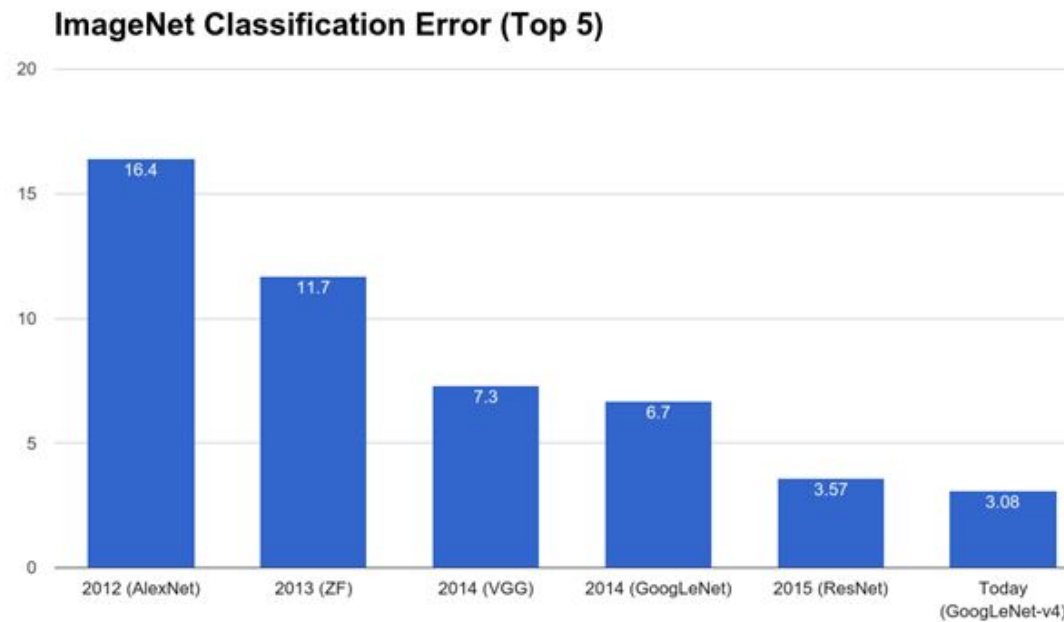
- **ImageNet Large Scale Visual Recognition Challenge (ILSVRC)**
- Winning team
 - **10%** better than other teams.
 - Team members:
 - Alex Krizhevsky
 - [Geoffrey Hinton](#)
 - [Ilya Sutskever](#) - Director at OpenAI
- This competition renewed interest in Neural Networks.

ILSVRC-2012 results



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.



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- The algorithm existed since 1990's, so why **Now**?
- Neural networks require a lot of data to train
- Require a lot of computations.
- 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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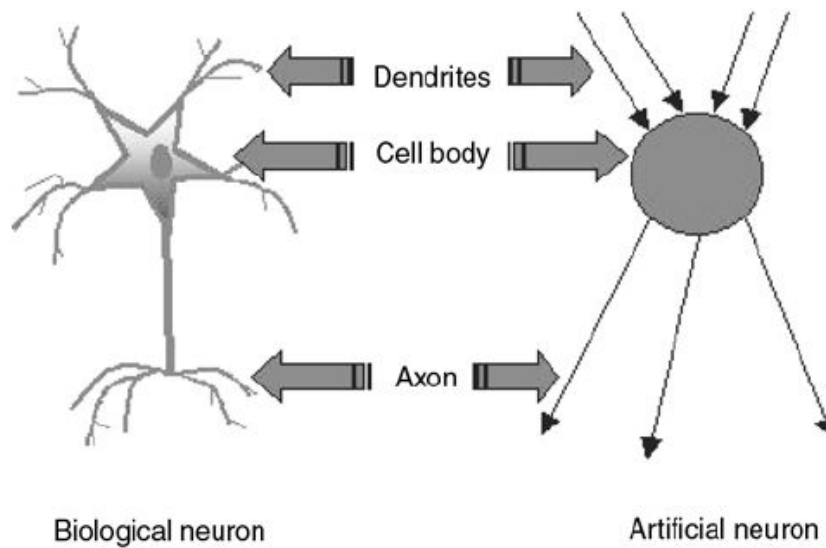
- Most common variations of neural networks architecture are:
 - Multilayer perceptron(MLP)
 - Convolutional Neural Network(CNN)
 - Recurrent Neural Network(RNN)
- **Multilayer Perceptron:**
 - We will build most of our fundamental understanding with **Multilayer Perceptron(MLP)**
- **Convolutional Neural Network:**
 - 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

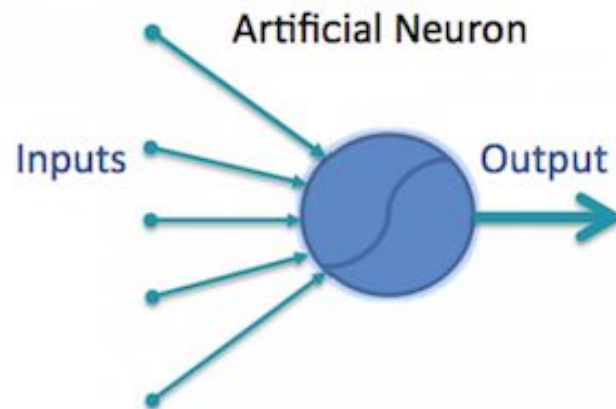
- We will talk only about intuition.
- We will study the mathematics later.



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
 - Fully connected layer
 - Dense layers

Multiple layer Perceptron

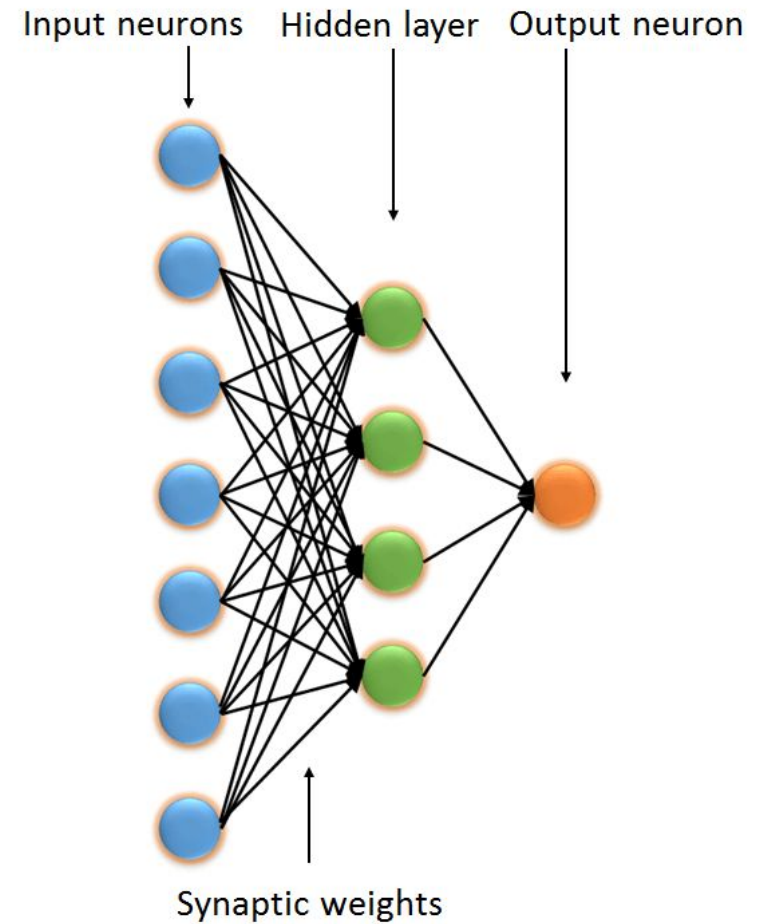
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Input layer -> Hidden layer -> Hidden Layer - > Output Layer

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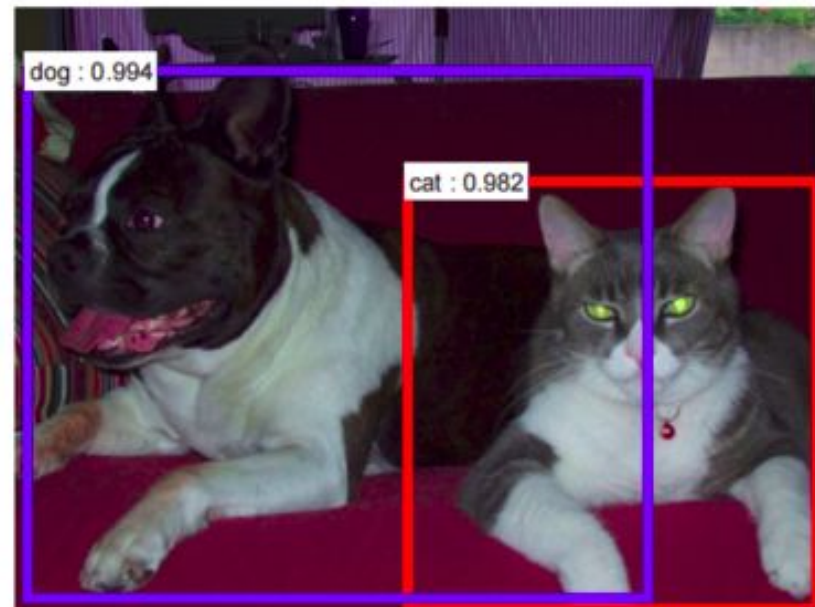
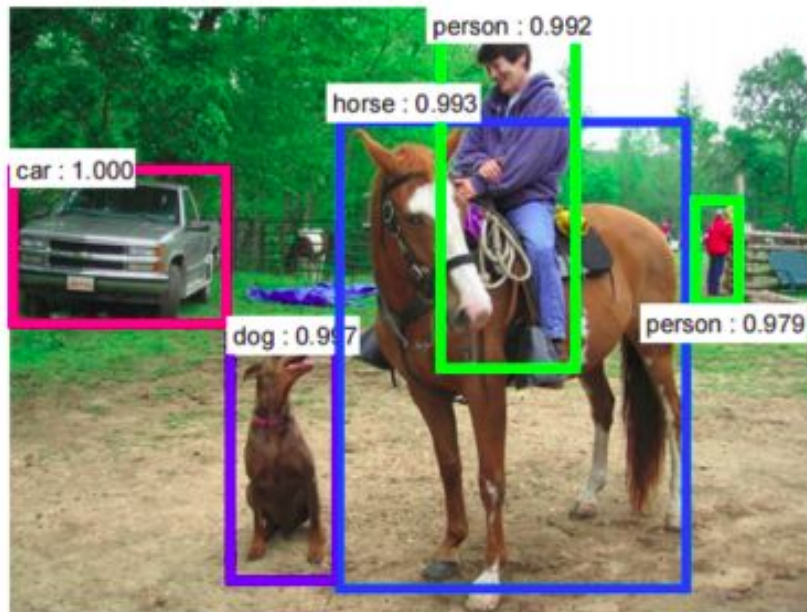
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Convolutional Neural Network

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



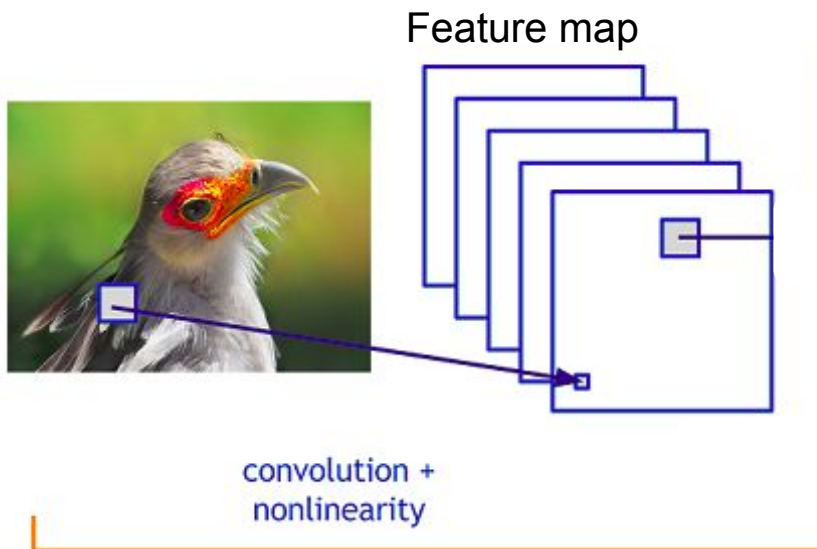
Convolutional Neural Network

- We will study about
 - Convolution
 - Pooling - max pooling



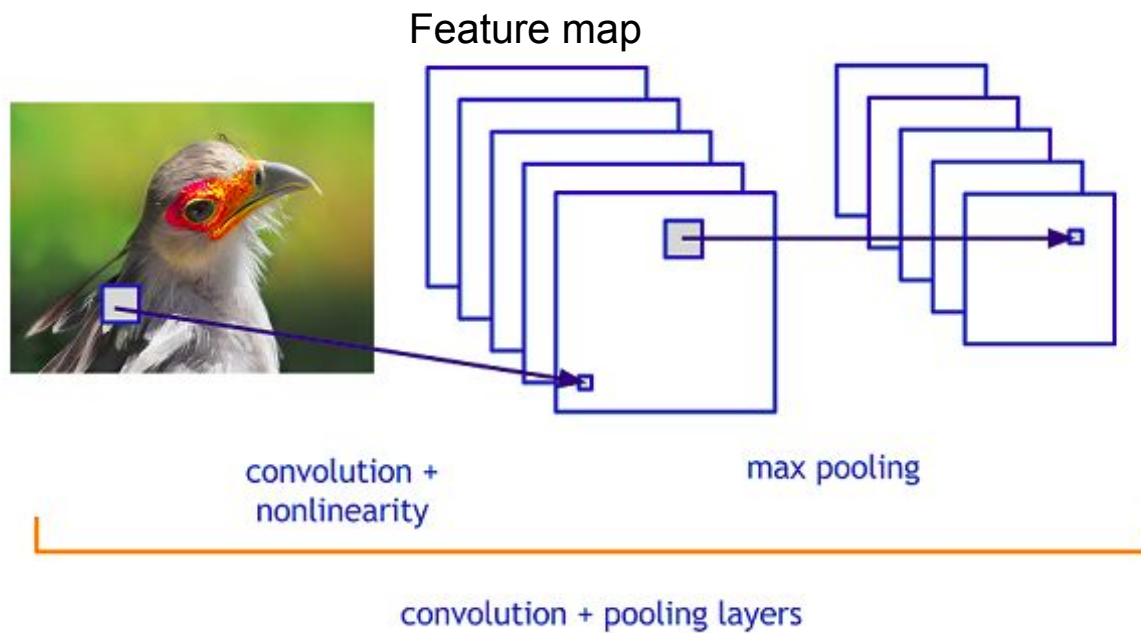
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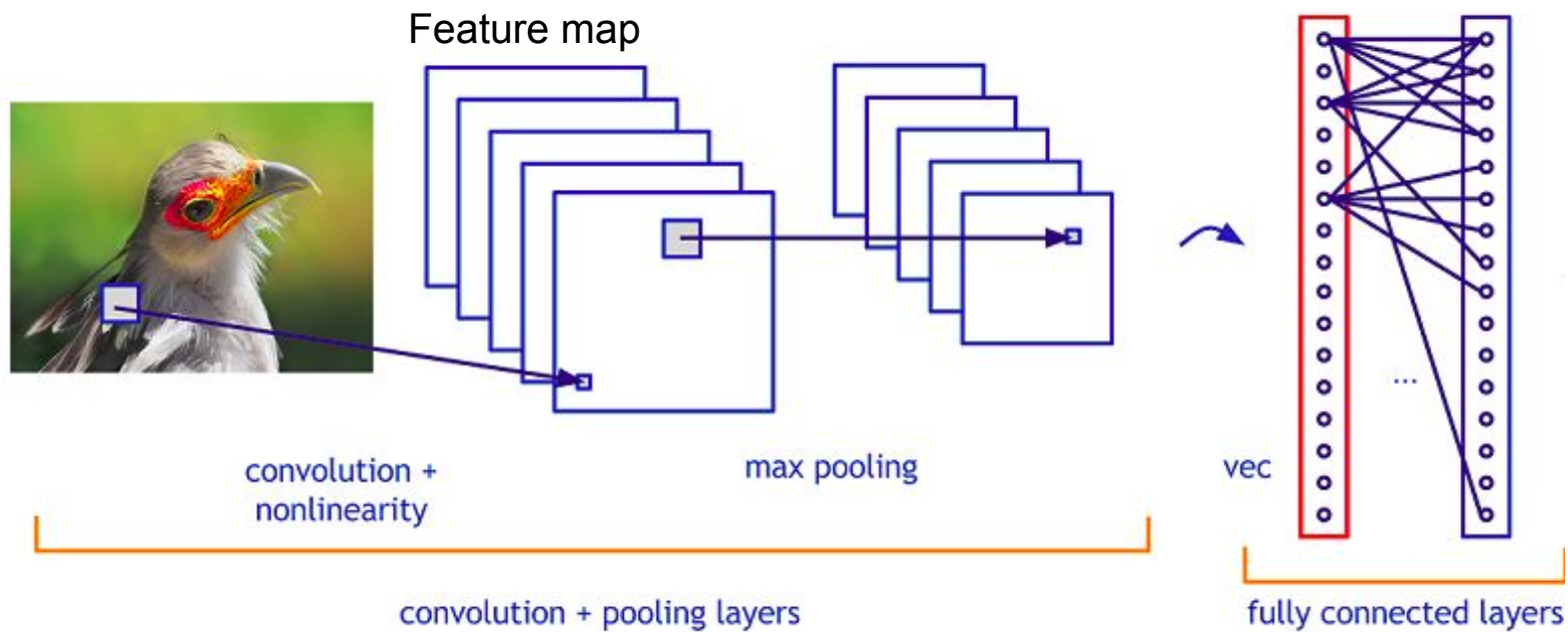
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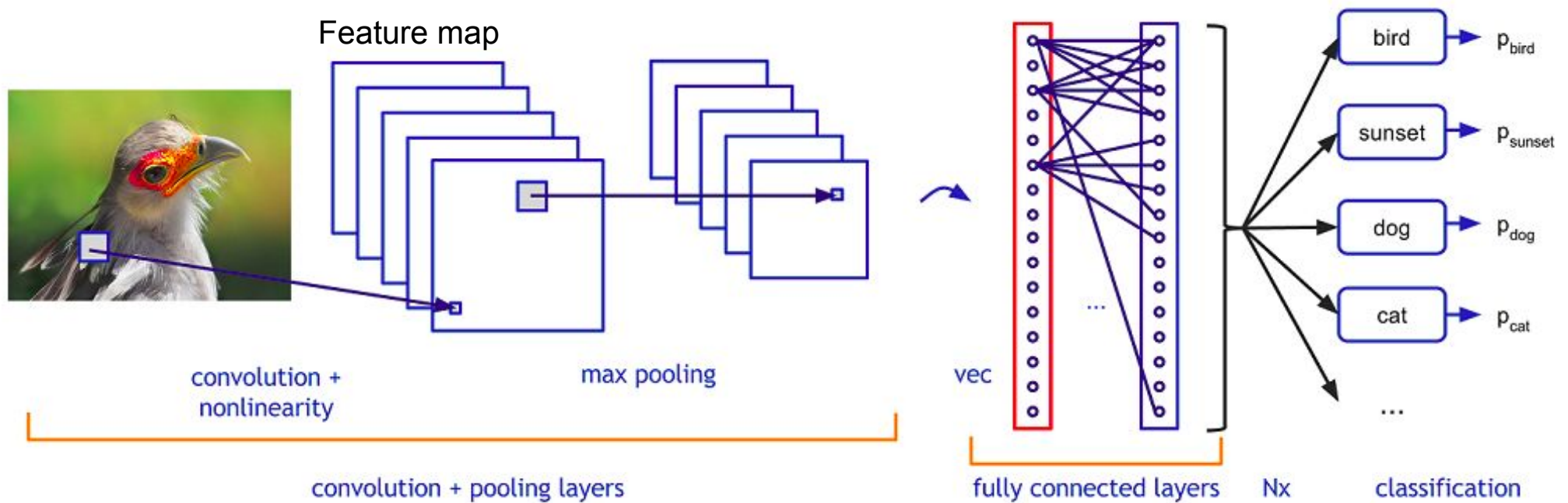
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Recurrent Neural Network

- Recurrent Neural Networks targets sequential/temporal information.

He is drinking Orange _____



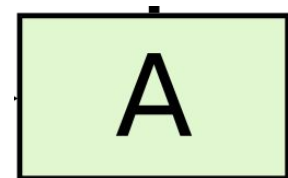
Juice can be inferred from previous words/context

Recurrent Neural Network

- Recurrent Neural Network targets sequential/temporal information.
- RNN Cell has memory/state which stores information/context from the past.

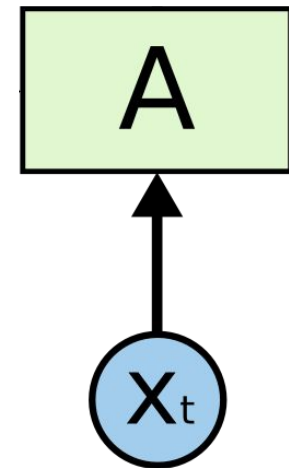
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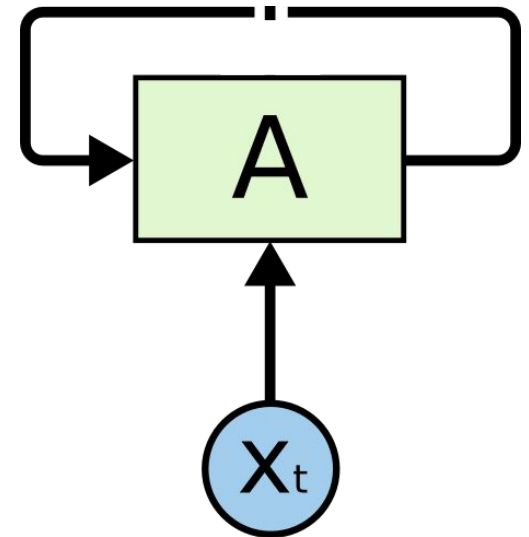
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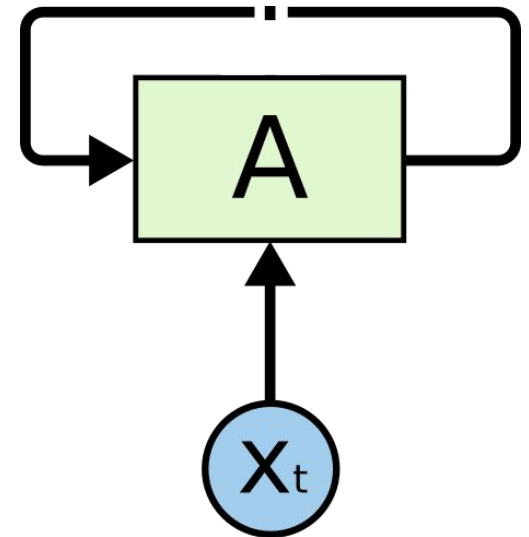
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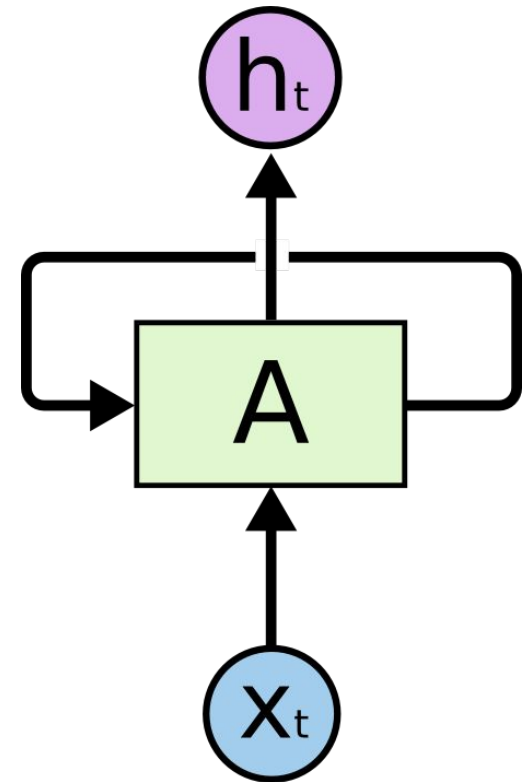
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 - accept
 - new input.
 - past context.
 - update their memory/state.

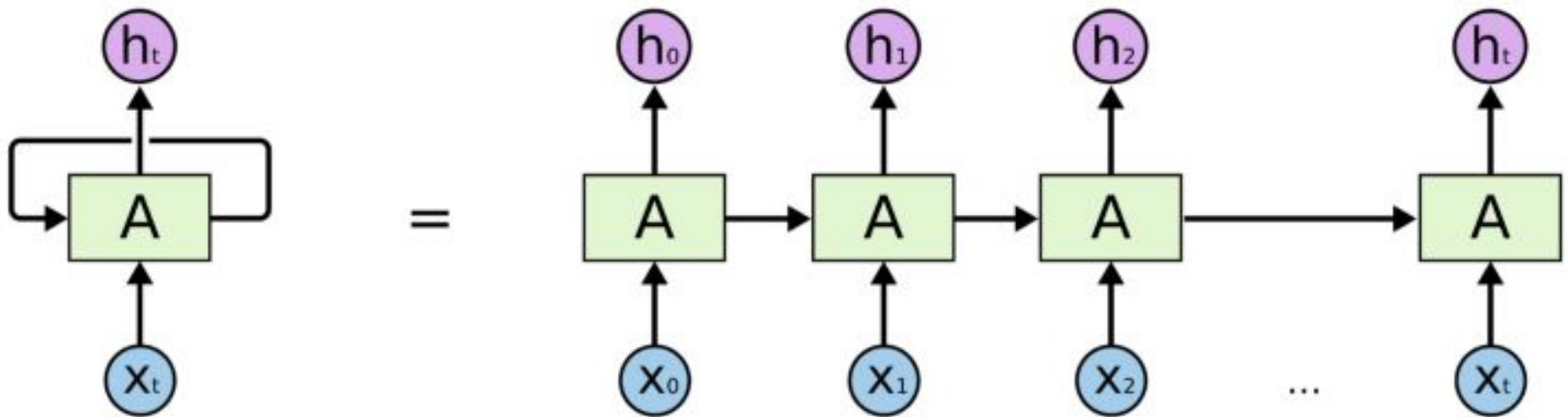


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 - accept
 - Generate an output.



Recurrent Neural Network: Unrolled in time



An unrolled recurrent neural network.

RNN and LSTM Cell

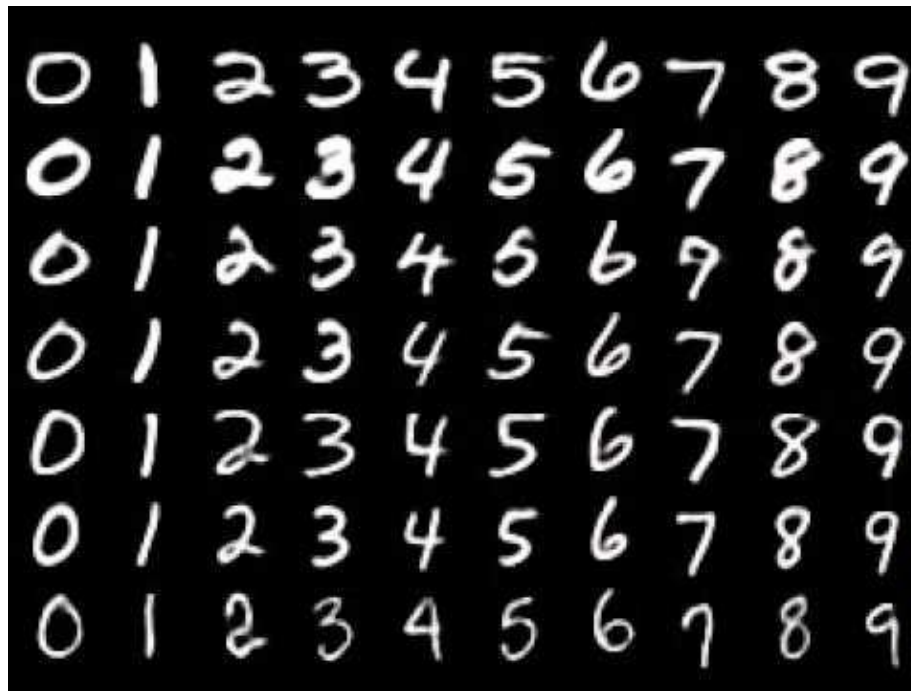
- LSTM: Long Short Term Memory
- RNN Cell specialized to remember past information/context.
 - LSTM Cell solves vanishing gradient problem seen in RNN Cell.(discussed later)
- Introduced in 1997
- Variants
 - Gated Recurrent Unit(GRU).

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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

Who is wearing glasses?

man



woman



Where is the child sitting?

fridge



arms



Is the umbrella upside down?

yes



no



How many children are in the bed?

2



1



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

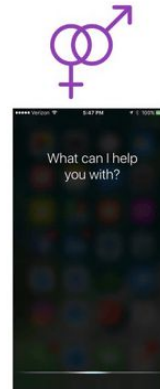
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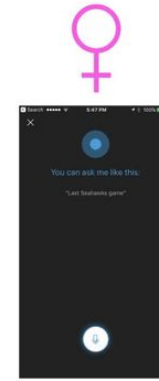
AMAZON'S ALEXA



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 parallel 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](#)