

Artificial Neural Networks/Deep learning

DSE 220

Overview

- Motivation
- History & Phases in Research of Artificial Neural Networks
- Recent wave in Artificial Neural Network
- Types of Neural Network
 - Perceptron.
 - Multilayer Perceptron.
 - Convolutional Neural Network.
 - Recurrent Neural Network.
- Examples/Applications of Artificial Neural Networks
- Basics/Fundamentals of Neural Networks
 - Artificial Neuron
 - Multilayer Perceptron
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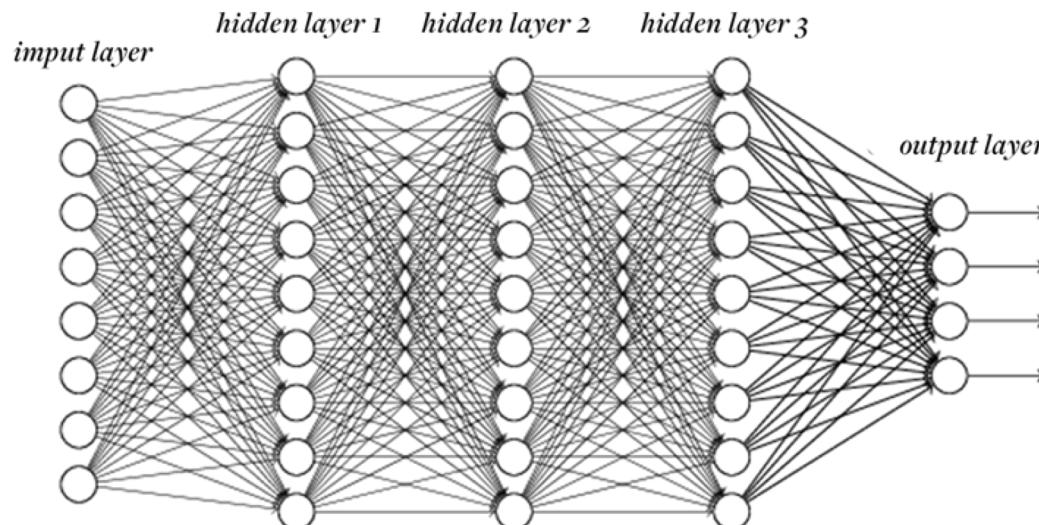
Motivation

- 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.



History & Phases in Research of Artificial Neural Network

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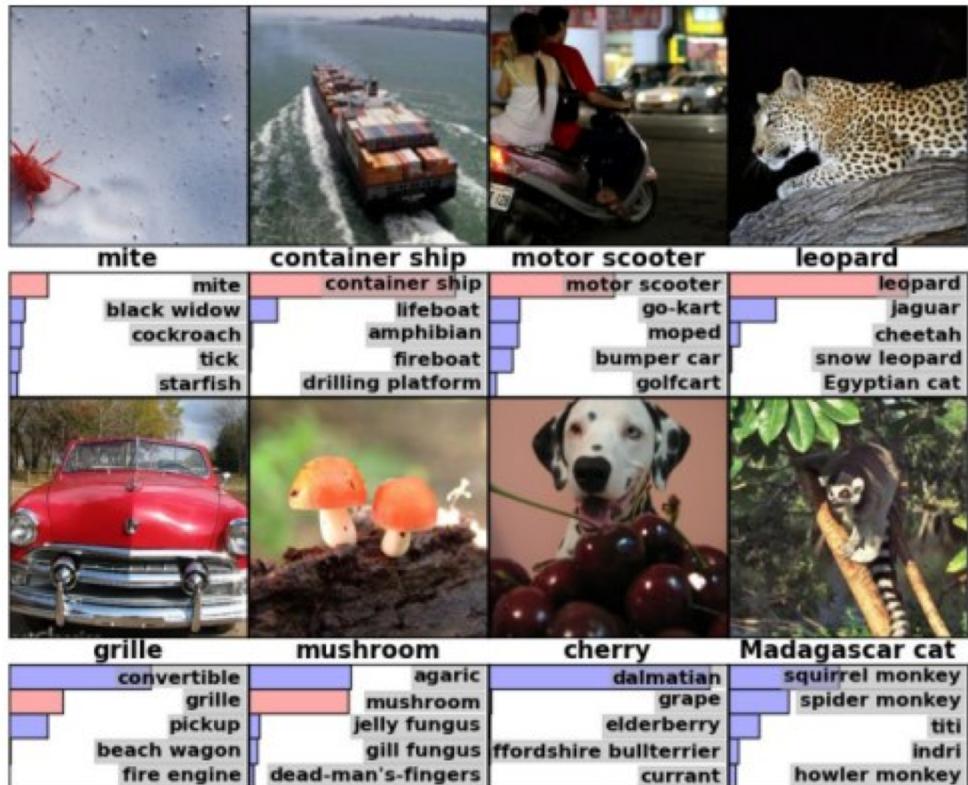
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 - Independently discovered backpropagation Algorithm.
- Research in Neural Networks died because
 - Required a lot of data.
 - Computation Intensive.

Recent wave in Artificial Neural Network

- It all began in 2012.

Recent wave in Artificial Neural Network

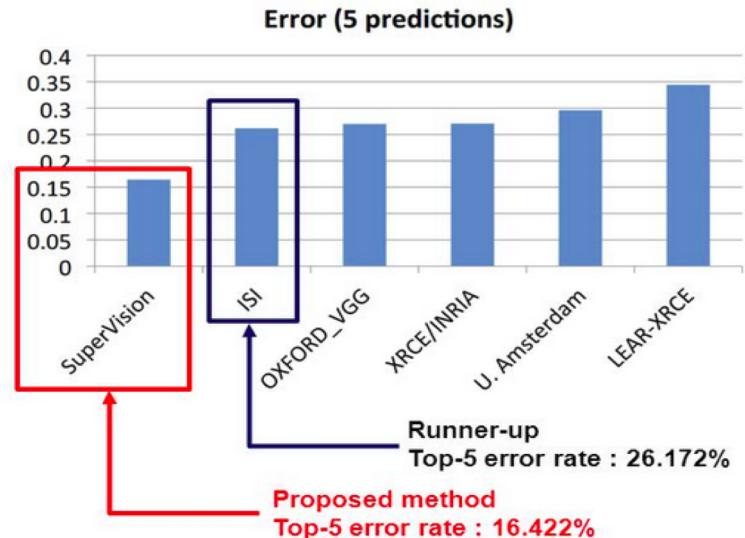
- It all began in 2012
- Image recognition challenge - ImageNet
 - 1000 classes of images
 - ~ 1 Million training images.



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.

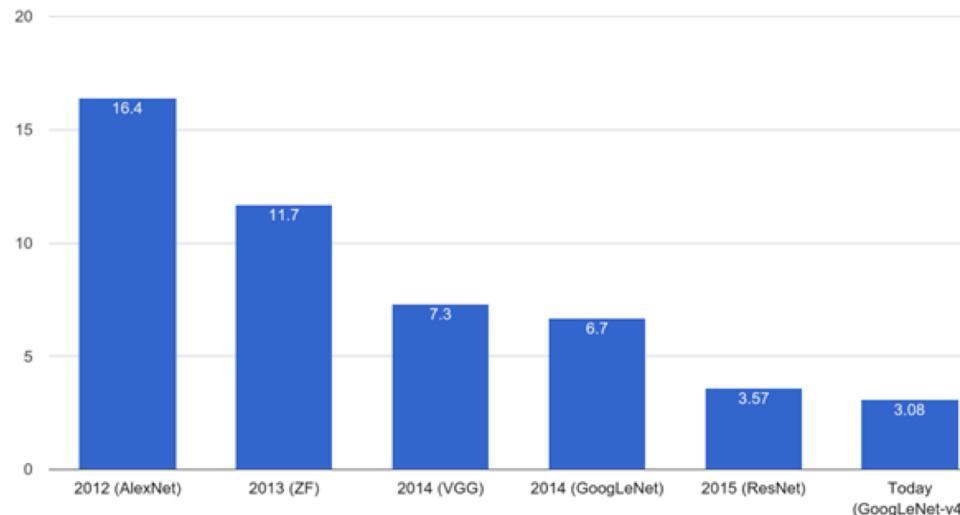
ILSVRC-2012 results



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.

ImageNet Classification Error (Top 5)



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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

Types of Neural Networks

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

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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

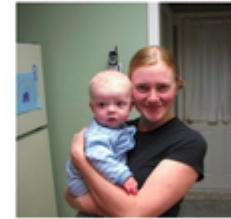
woman



Where is the child sitting?

fridge

arms



Is the umbrella upside down?

yes

no



How many children are in the bed?

2

1

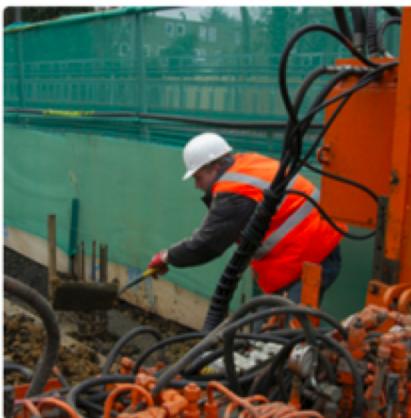


Applications of Convolutional Neural Networks

- 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

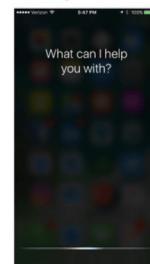
Applications of Recurrent Neural Networks



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 parallelly 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

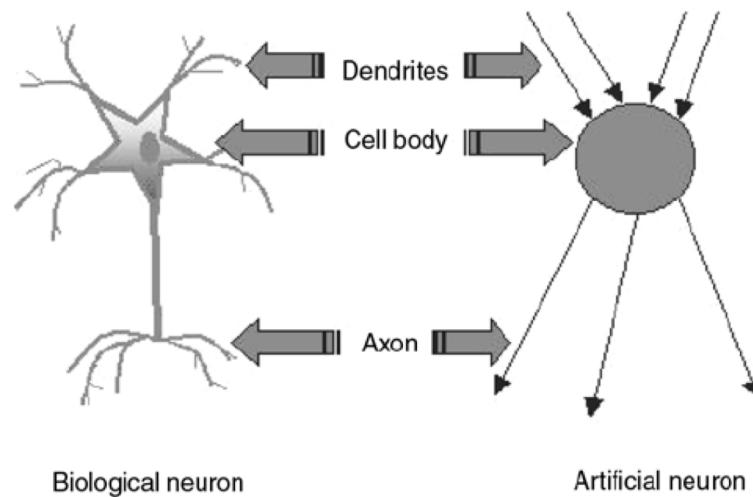
- [Object Detection](#)
- [Object Segmentation](#)
- [Generative Networks](#)

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Artificial Neuron

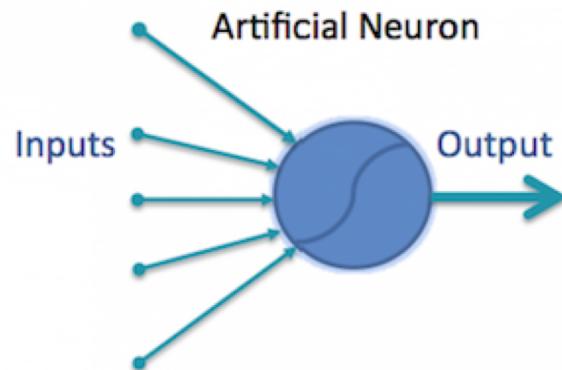
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- We will study the mathematics later.



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

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Multiple layer Perceptron

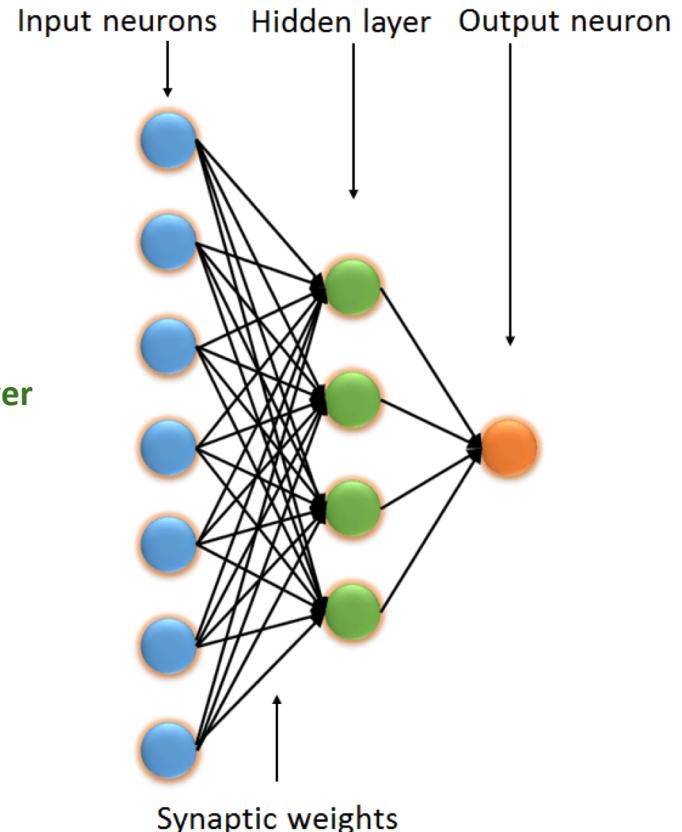
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Input layer -> Hidden layer -> Hidden Layer - > Output Layer

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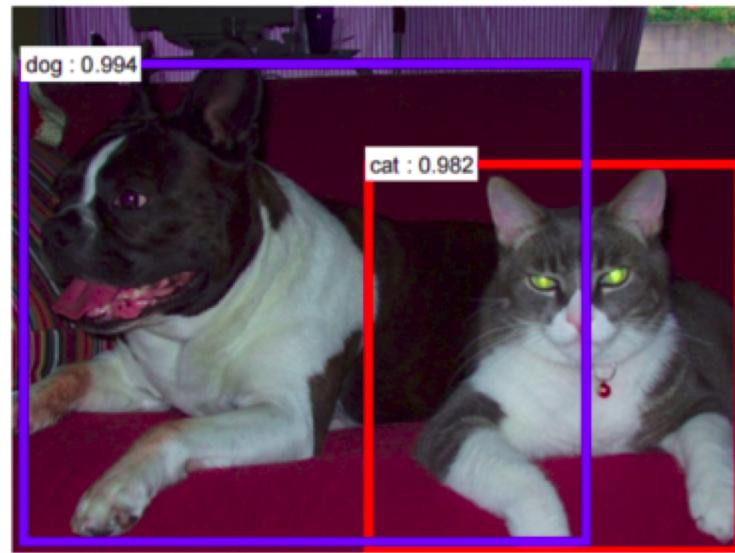
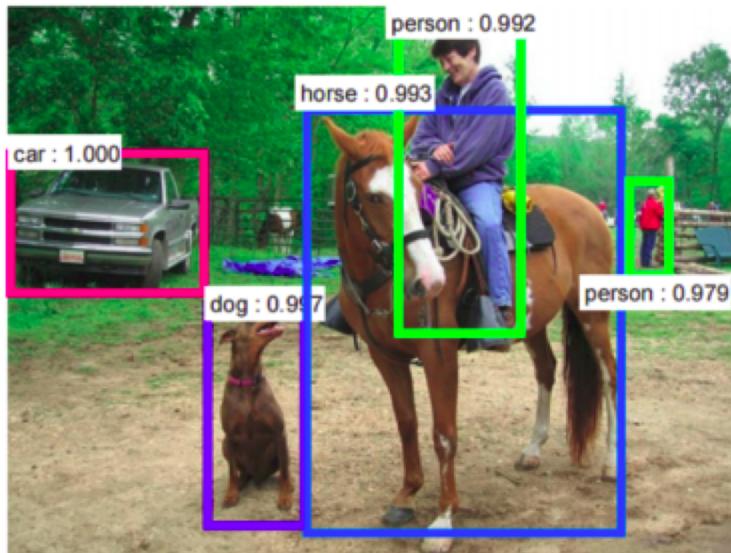


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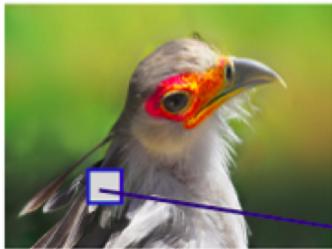
Convolutional Neural Network

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



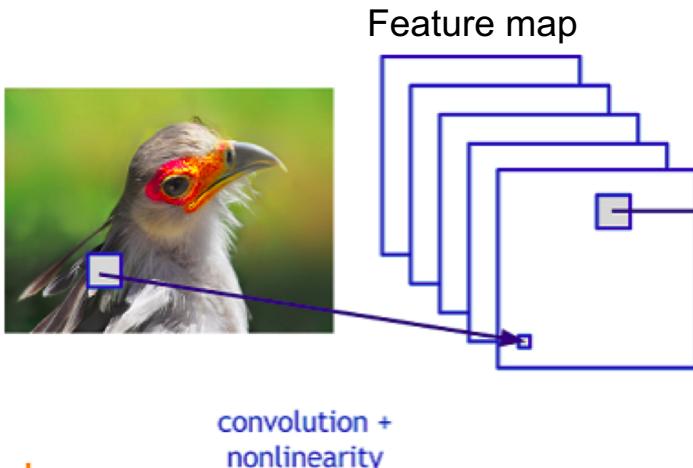
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 - Convolution
 - Pooling - max pooling



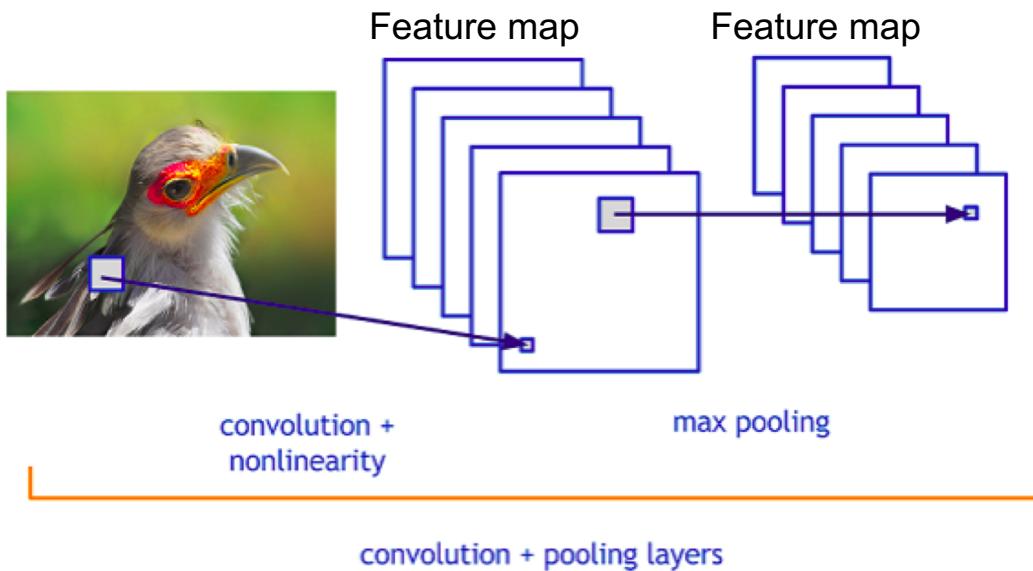
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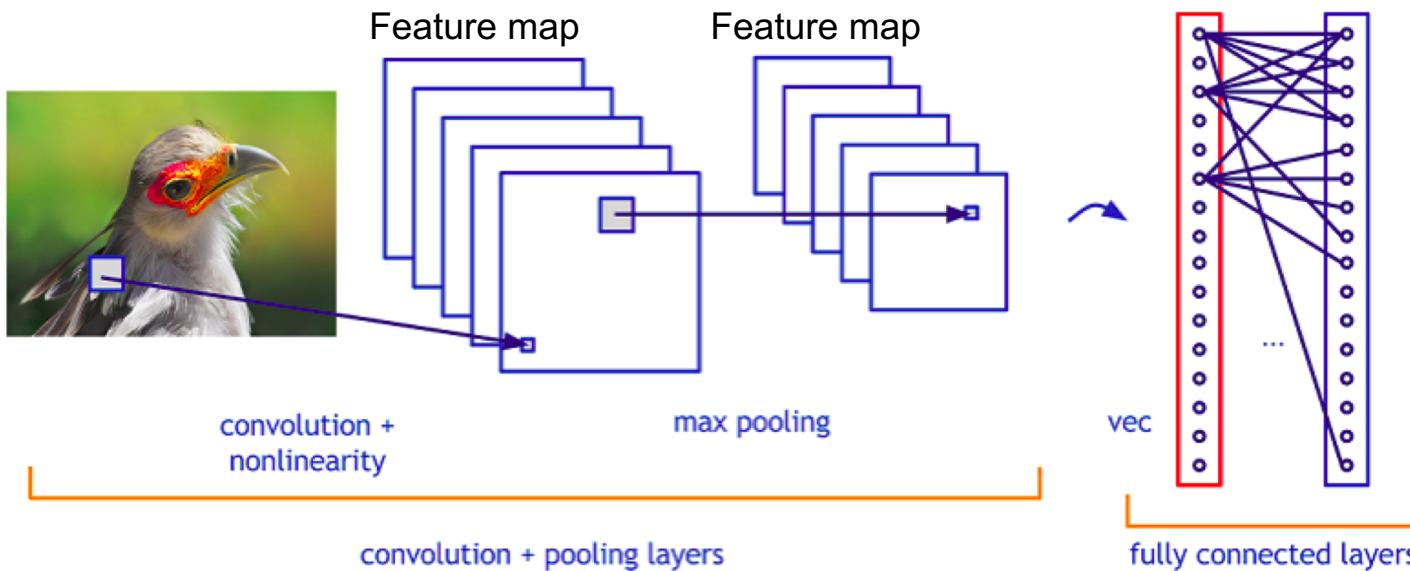
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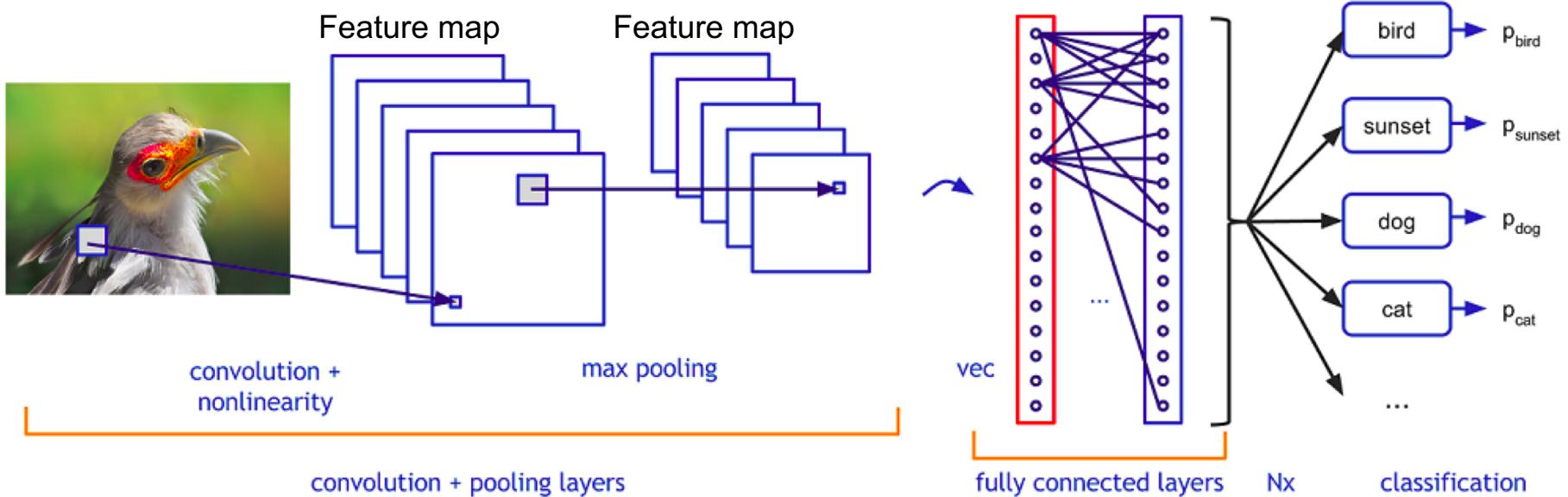
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Recurrent Neural Network

- Recurrent Neural Networks targets sequential/temporal information.

He is drinking Orange _____



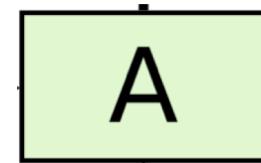
Juice can be inferred from previous words/context

Recurrent Neural Network

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

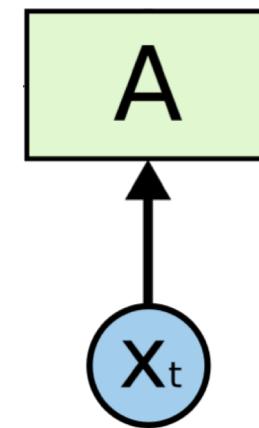
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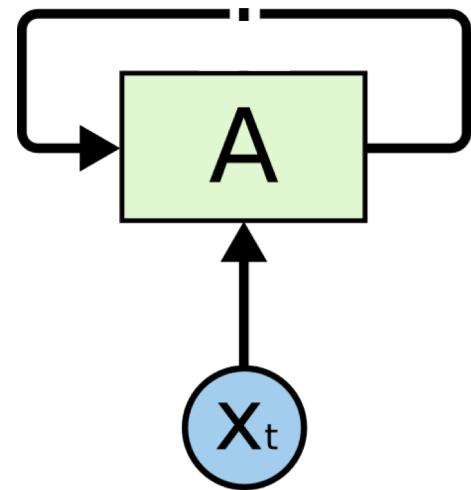
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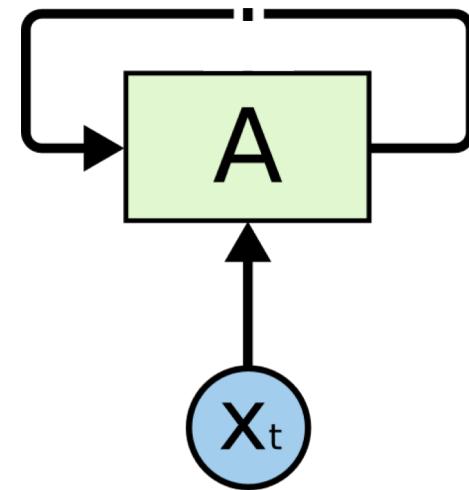
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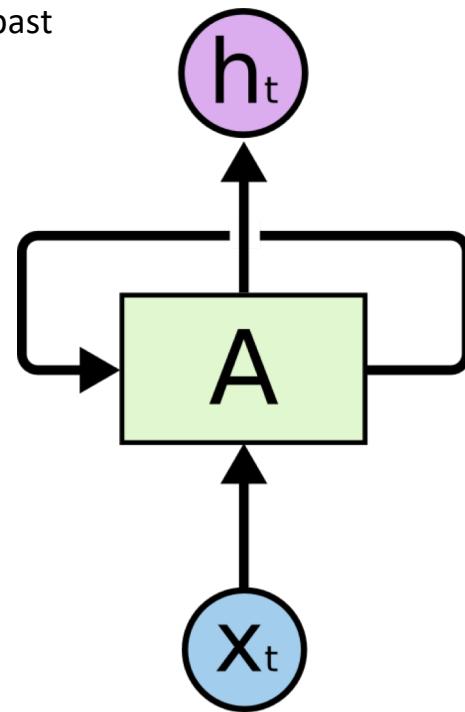
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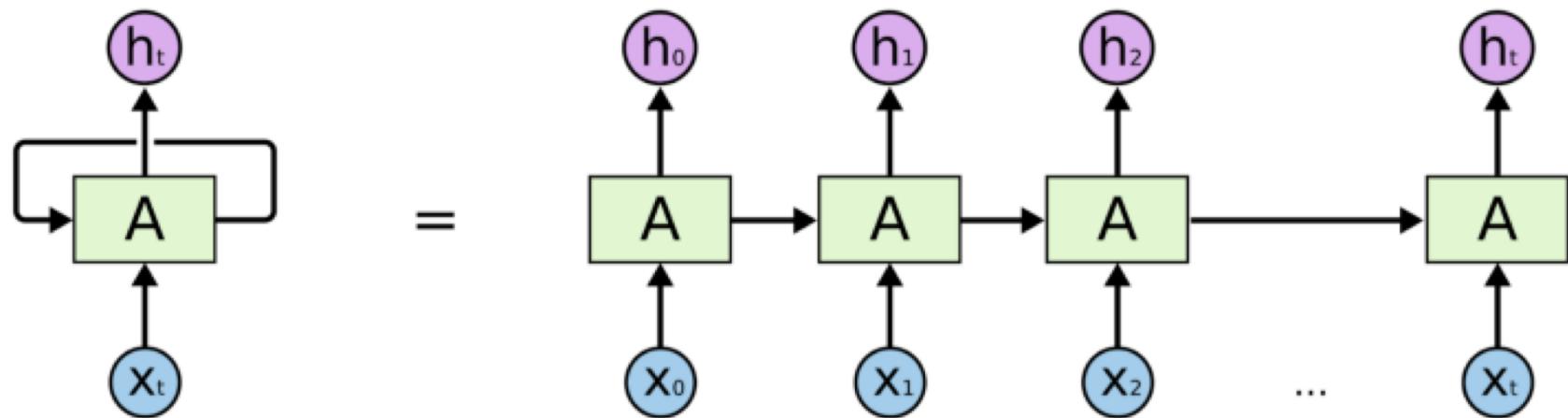


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 - past context.
 - update their memory/state.
 - Generate an output.



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).