22AIE304 Deep Learning

What, Why, How?

Outline

- Course Structure
- What, Why, How?
- Applications
- Brief History

Course Info

Course:

22AIE304 DEEP LEARNING L – T – P – C 2 – 0 – 3 – 3

Evaluation Pattern 70: 30

Team:

Dr Simi Surendran

Ms Gargi S

Ms Radhu Krishna

Course Objectives

CO#	Outcome
CO1	Apply the fundamentals of deep learning.
CO2	Apply deep learning algorithms using Matlab/Python.
CO3	Apply deep learning models for signal analysis.
CO4	Implement deep learning models for image analysis.

Syllabus and Textbooks

Syllabus

- Unit 1 Deep Neural Networks (DNN) –Convolutional Neural Network (CNN) – Recurrent Neural Network (RNN): Long-Short- Term-Memory (LSTM) - Graph based Neural Network (GNN)
- Unit 2 Pre-processing: Noise Removal using deep learning algorithms - Feature Extraction - Signal Analysis: Time Series Analysis, CNNs, Auto encoders.
- Unit 3 Image Analysis: Transfer Learning, Attention models- Ensemble Methods for Signal and Image Analysis.

Textbook/References

- Bishop C.M, “Pattern Recognition and Machine Learning”, Springer, 1st Edition, 2006.
- Goodfellow I, Bengio Y, Courville A, & Bengio Y, “Deep learning”, Cambridge: MIT Press, 1st Edition, 2016.
- Soman K.P, Ramanathan. R, “Digital Signal and Image Processing – The Sparse Way”, Elsevier, 1st Edition, 2012.

Course Structure

- Lectures
- Programming assignments -10 m
- Quizzes – (2 graded quizzes) -20 m
- Midterm written examination -20 m
- Course project (teams of 2-4)-20 m
  - Proposal – Week 4
  - Report 1 – Week 9
  - Presentations – Week 14
- End Semester written examination – 30 m

What is Deep Learning?

Artificial Intelligence

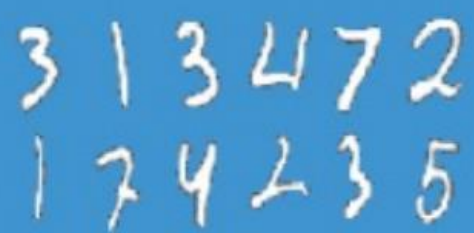
Any technique that enables computers to mimic human behavior

Machine Learning

Ability to learn without explicitly being programmed

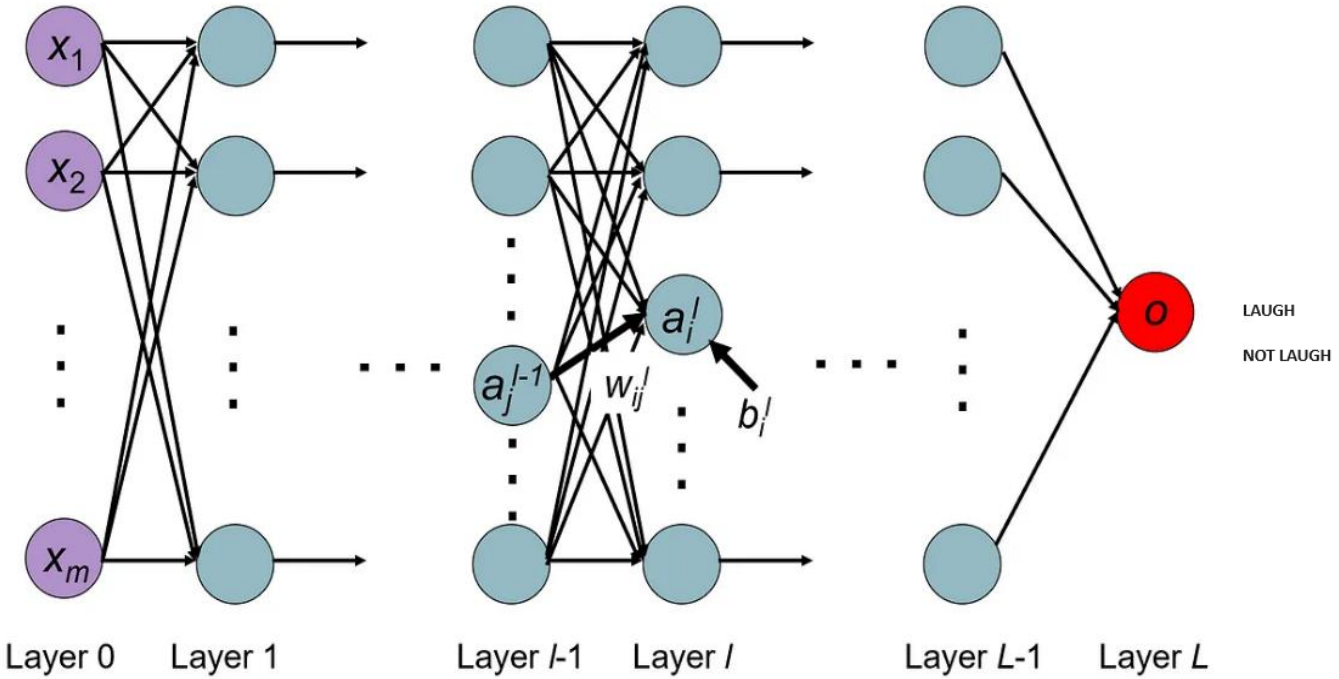
Deep Learning

Extract patterns from data using neural networks



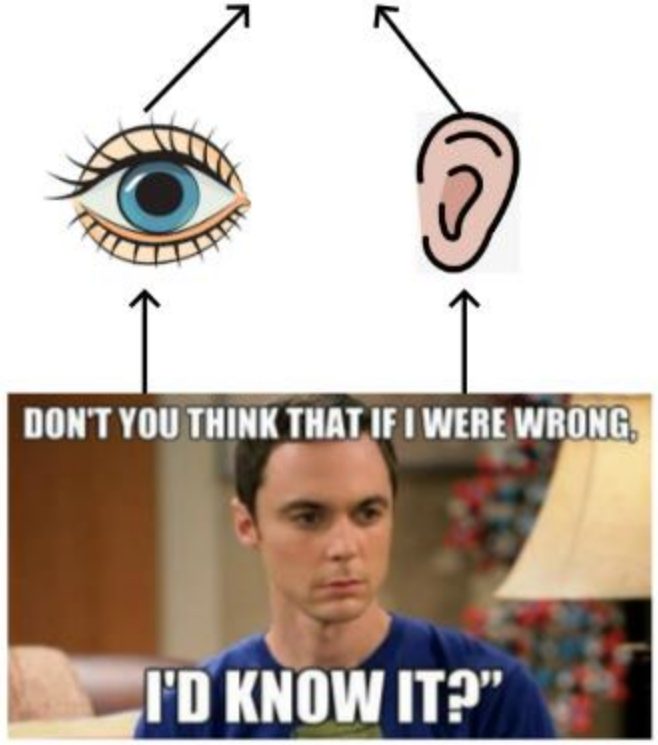
How DL works?

- DL relies on artificial neural networks, inspired by the human brain, consisting of layers of interconnected nodes (or neurons)



LAUGH

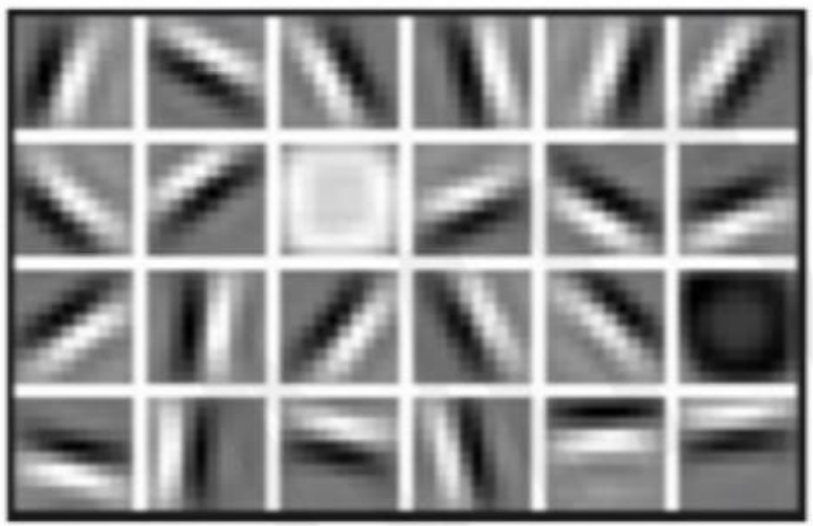
NOT LAUGH



Hand engineered features are time consuming, brittle, and not scalable in practice

Can we learn the **underlying features** directly from data?

Low Level Features



Lines & Edges

Mid Level Features

Eyes & Nose & Ears

High Level Features

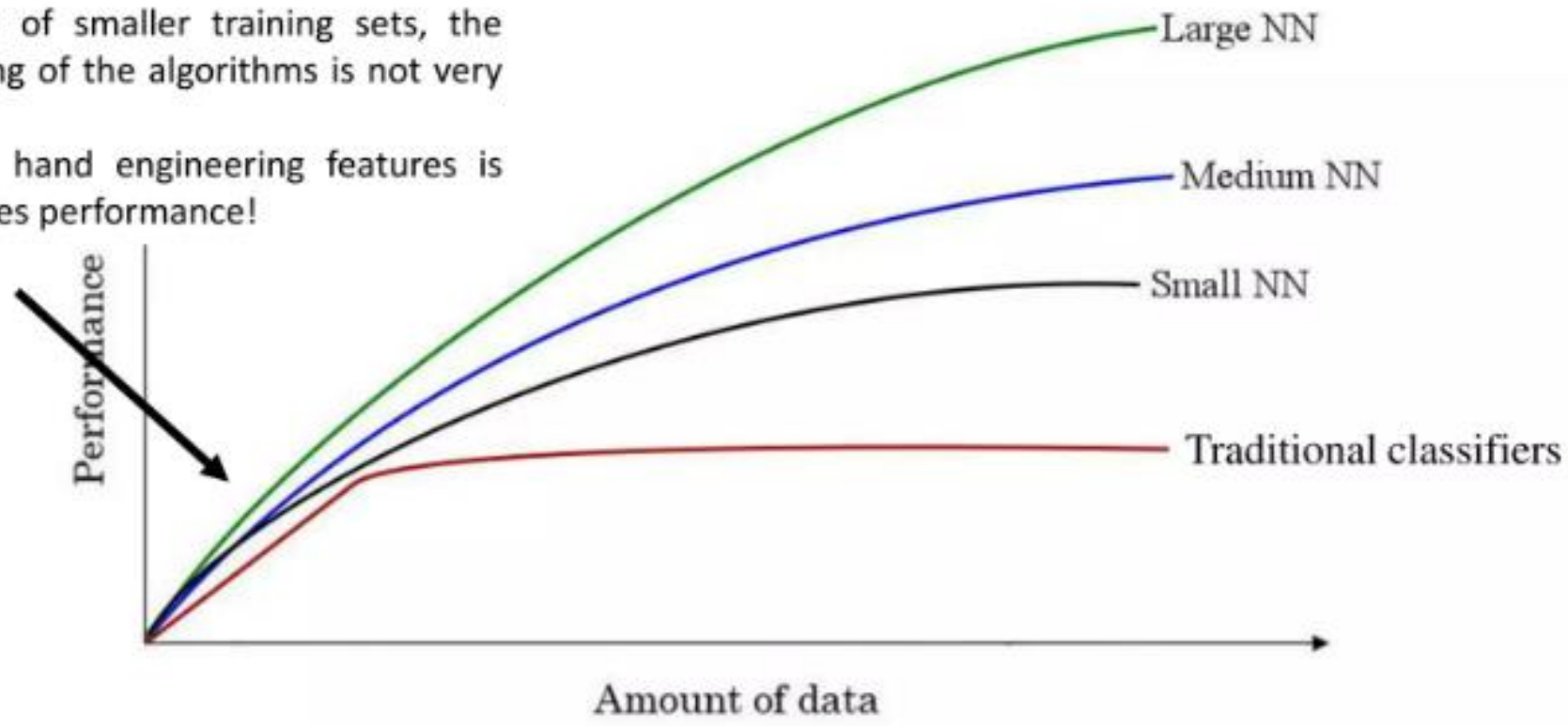
Facial Structure

Deep learning requires less human intervention, as features of a dataset are extracted automatically, versus simpler machine learning techniques that often require an engineer to manually identify features and classifiers of the data and adjust the algorithm accordingly.

The Rise of Deep Learning

- How to overcome performance plateau problem?

In this regime of smaller training sets, the relative ordering of the algorithms is not very well defined.
Often, skill at hand engineering features is what determines performance!



Why Now?

Neural Networks date back decades, so why the dominance?

1952 Stochastic Gradient Descent

1958 Perceptron
- Learnable Weights

1986 Backpropagation
- Multi-Layer Perceptron

1995 Deep Convolutional NN
- Digit Recognition

1. Big Data

- Larger Datasets
- Easier Collection & Storage

IMAGENET

2. Hardware

- Graphics Processing Units (GPUs)
- Massively Parallelizable

3. Software

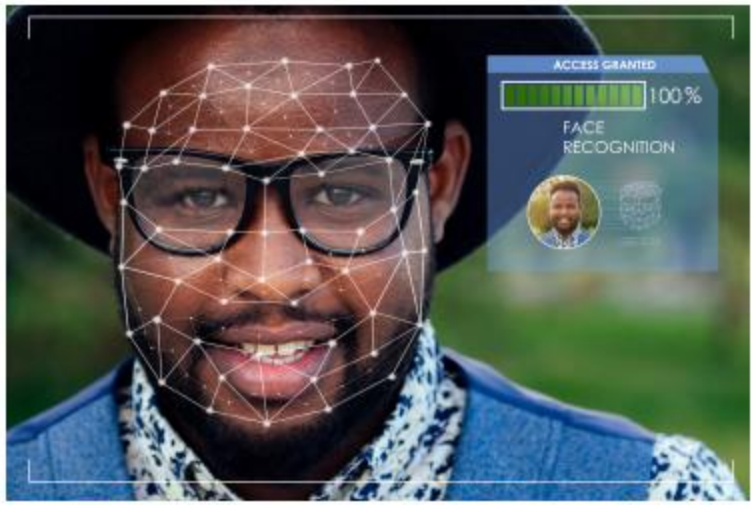
- Improved Techniques
- New Models
- Toolboxes

TensorFlow

Applications

Neural Network and Deep Learning Solutions

Recognition



(Face)

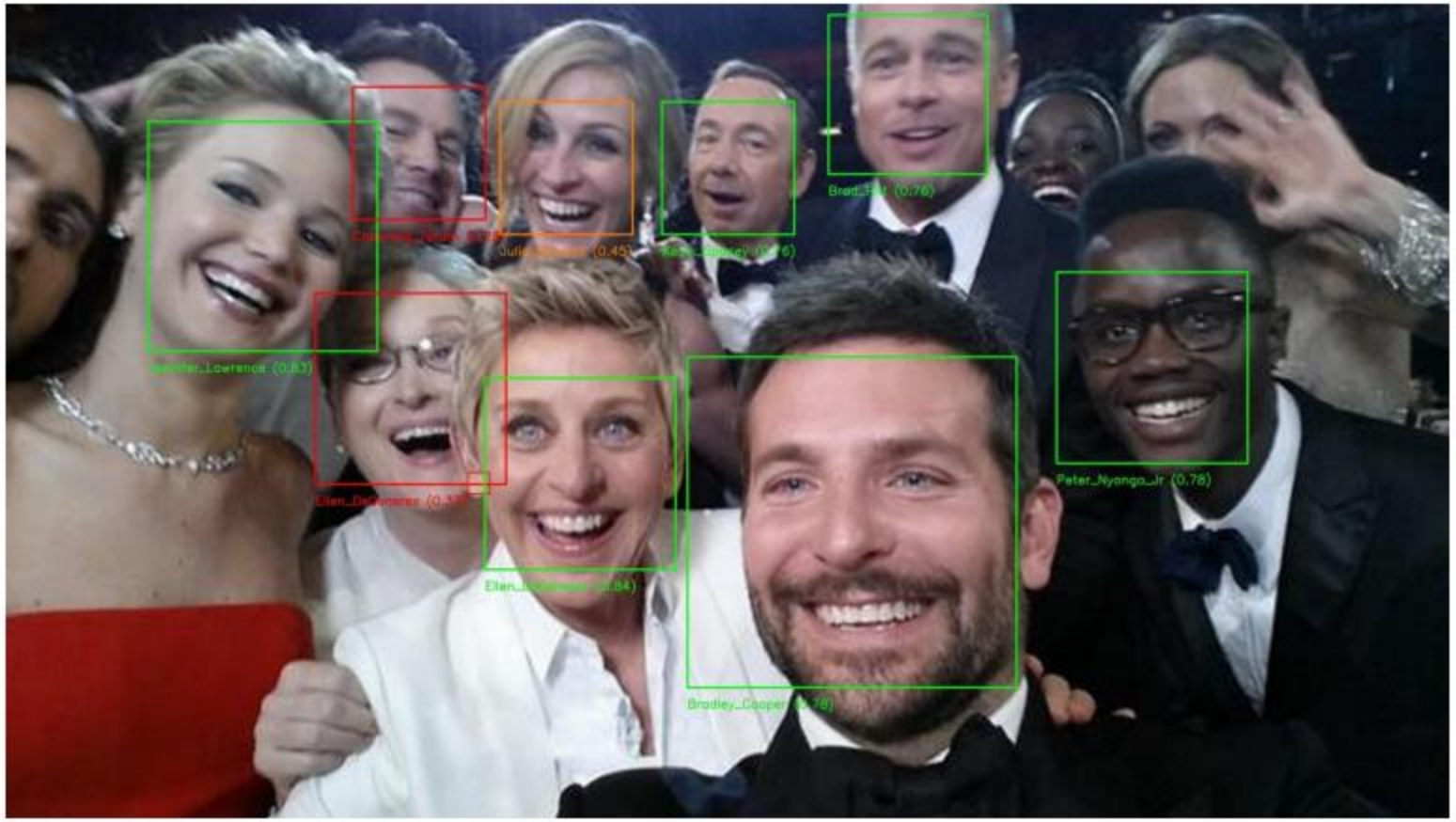
FaceNet

(Speech)

WaveNet and **DeepSpeech**

(Fraud)

- Face recognition



https://towardsdatascience.com/an-intro-to-deep-learning-for-face-recognition-aa8dfbbc51fb

DeepFace is a deep learning-based face recognition system developed by Facebook's AI research team

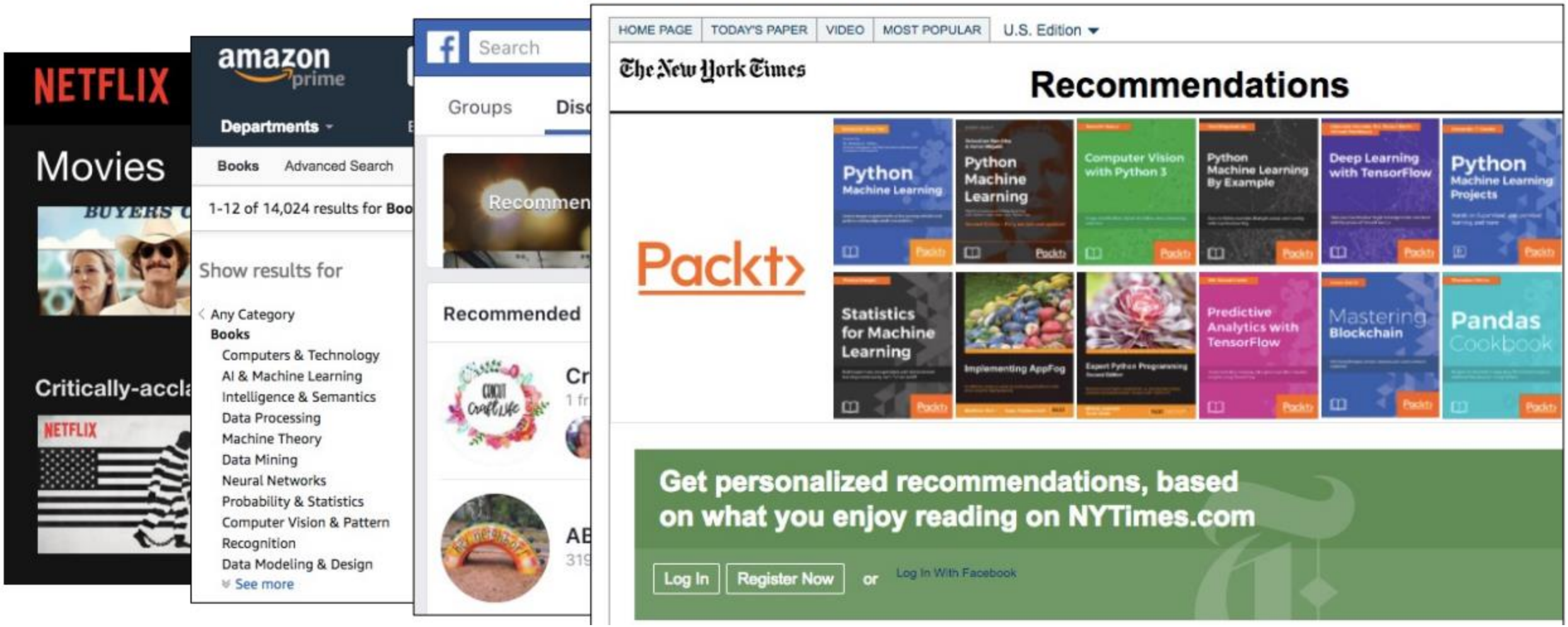
Robotics

(Self-driving Vehicles)

(Medical Surgery)

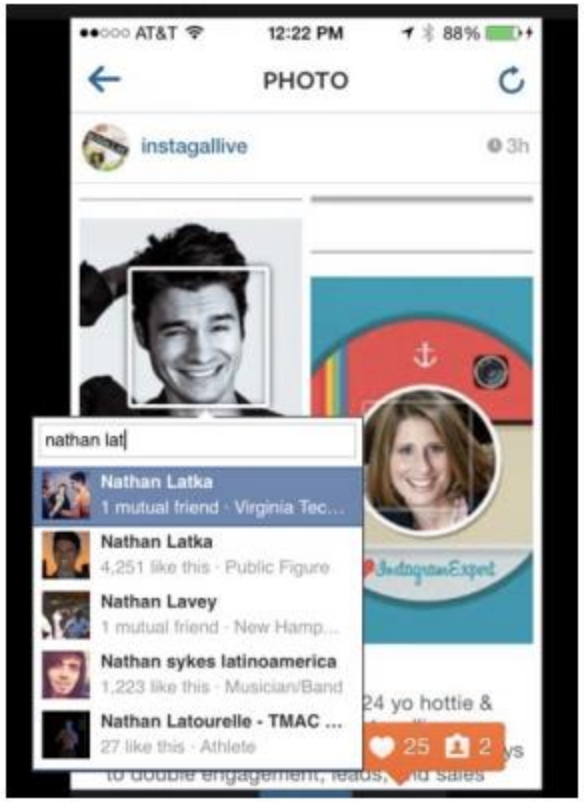
(Manufacturing)

Recommendation Systems



Computer Vision Systems

e.g., self-driving vehicle on Mars



e.g., recognizing people

e.g., shopping without a cashier

DeepFace is a deep learning-based face recognition system developed by Facebook's AI research team

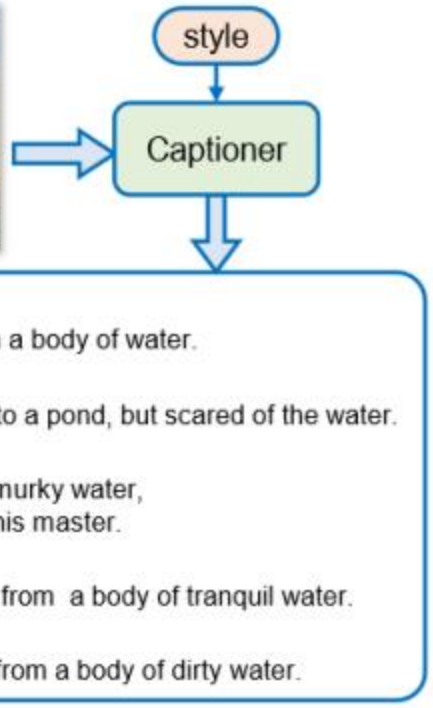
Amazon Go

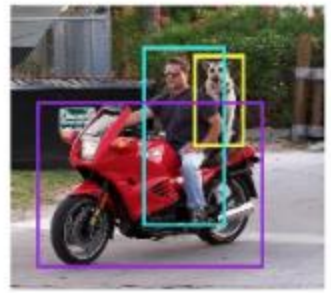
Home Virtual Assistants

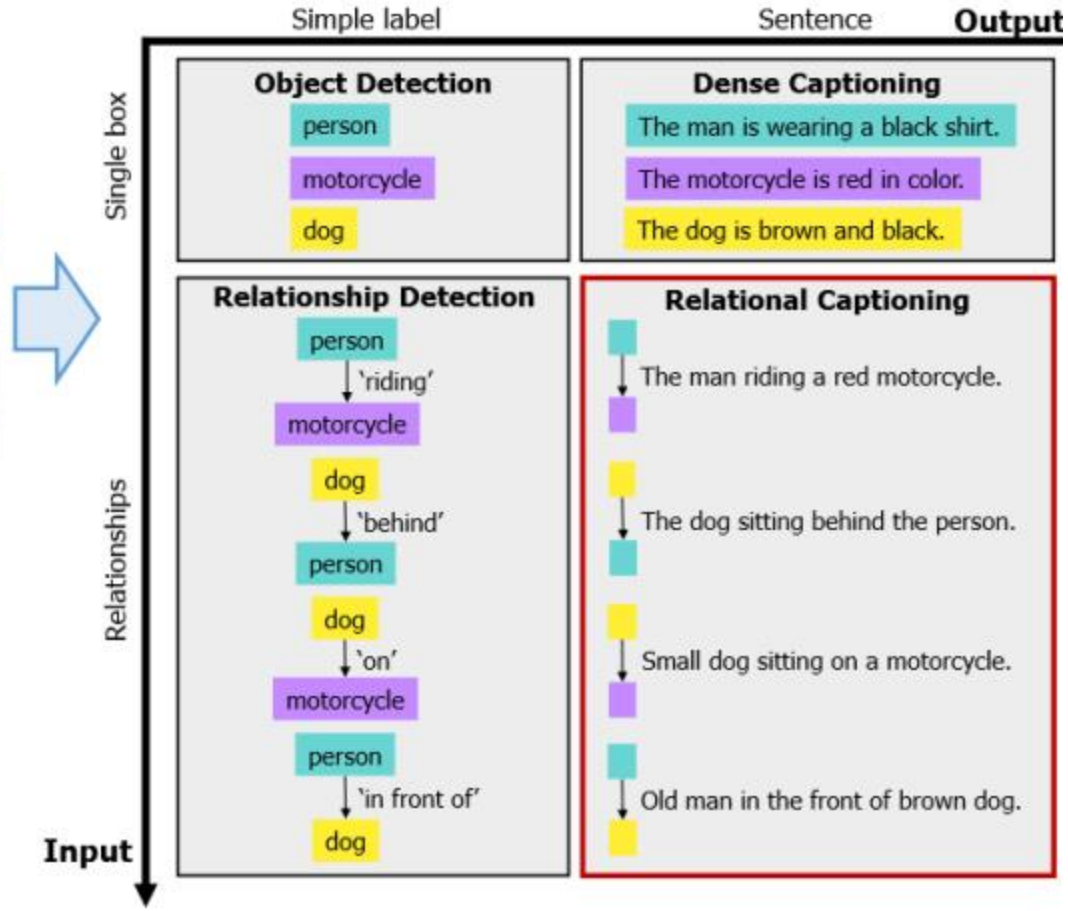
e.g., Amazon's Echo with Alexa

e.g., Google Home

• Image captioning







http://openaccess.thecvf.com/content_CVPR_2019/papers/Guo_MSCap_Multi-Style_Image_Captioning_With_Unpaired_Stylized_Text_CVPR_2019_paper.pdf
http://openaccess.thecvf.com/content_CVPR_2019/papers/Kim_Dense_Relational_Captioning_Triple-Stream_Networks_for_Relationship-Based_Captioning_CVPR_2019_paper.pdf

- Image captioning

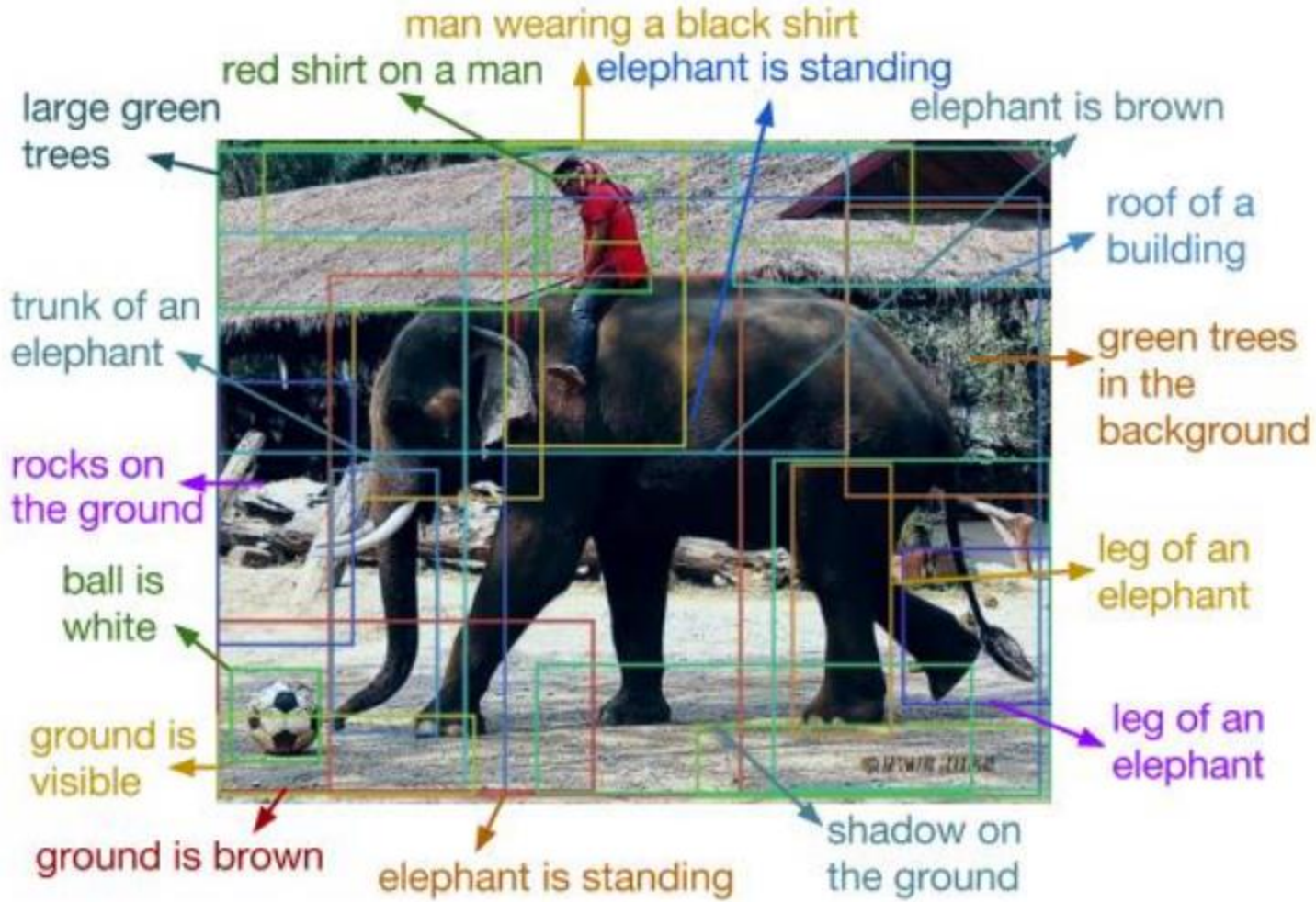
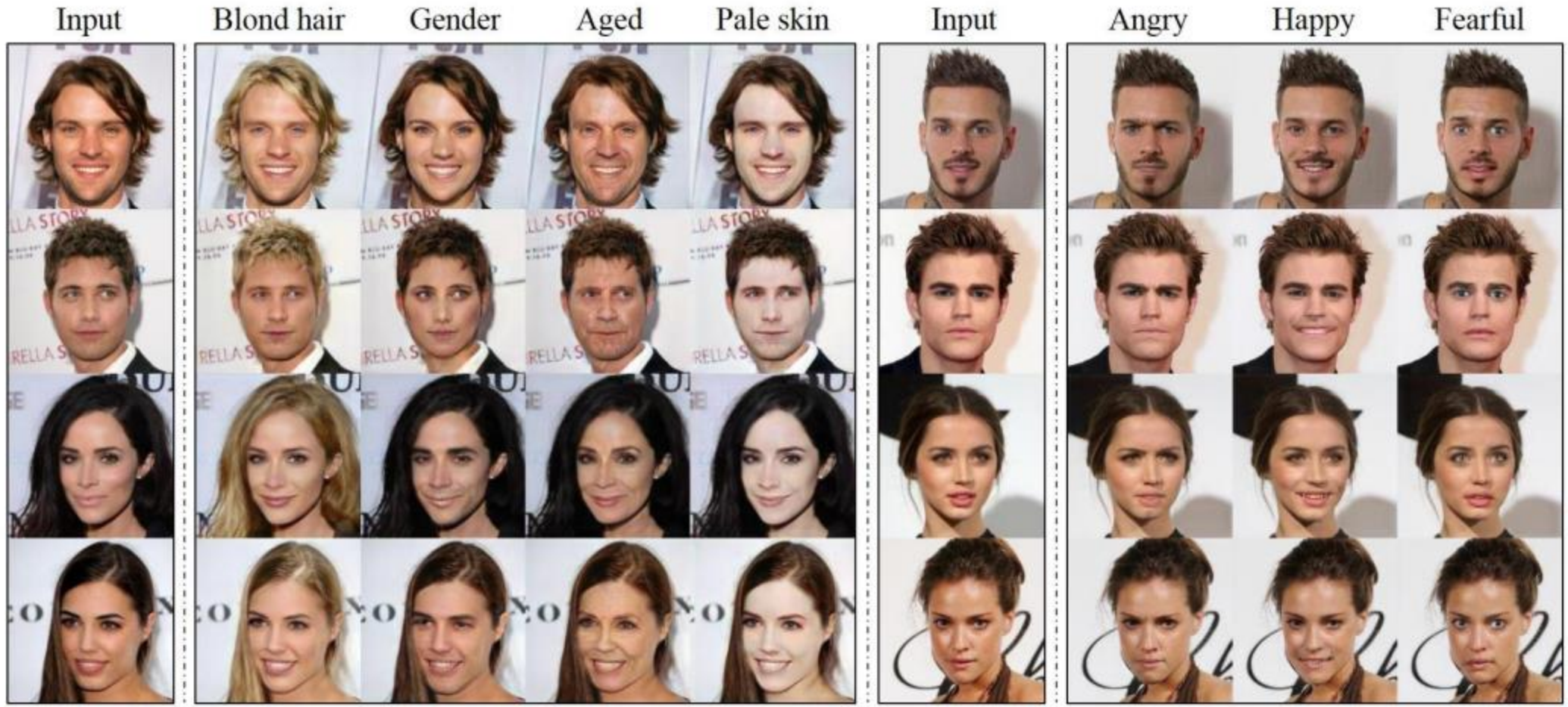


Figure from the paper "DenseCap: Fully Convolutional Localization Networks for Dense Captioning", by Justin Johnson, Andrej Karpathy, Li Fei-Fei

- Image generation

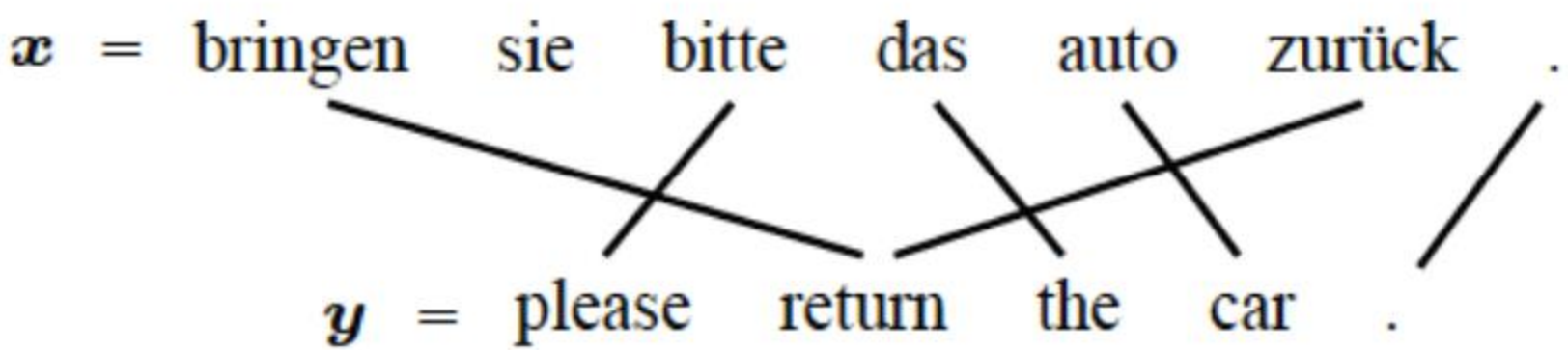


Choi et al., "StarGAN: Unified Generative Adversarial Networks for Multi-Domain Image-to-Image Translation", CVPR 2018

- Fake news generation

https://www.youtube.com/watch?v=-QvIX3cY4Ic

- Machine translation



Google Translate, Microsoft Translator

- Robotic pets

https://www.youtube.com/watch?v=wE3fmFTtP9g

• Artificial general intelligence???

AI refers to systems designed to perform specific tasks or solve particular problems. These systems are often termed "narrow AI"

lack generalization beyond those areas

AGI would have the capacity to understand, learn, and apply knowledge across a wide range of tasks,

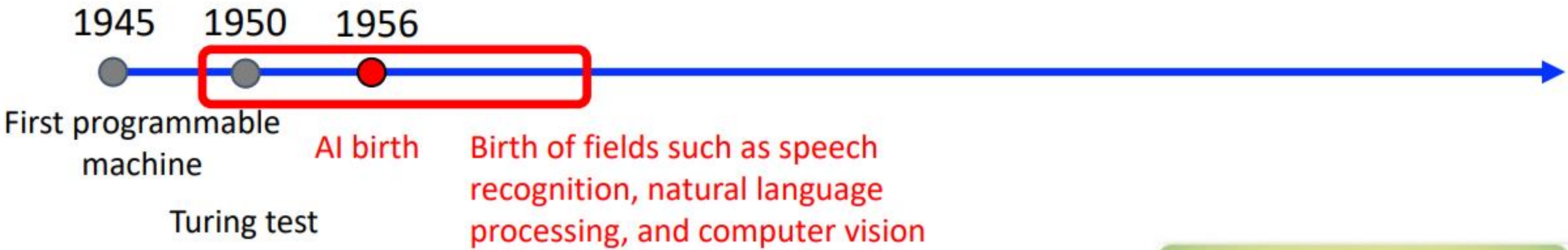
AI Example: Virtual Assistant

AGI Example: Advanced Cognitive Agent
planning a vacation, managing your schedule

https://www.dailymail.co.uk/sciencetech/article-5287647/Humans-robot-second-self.html

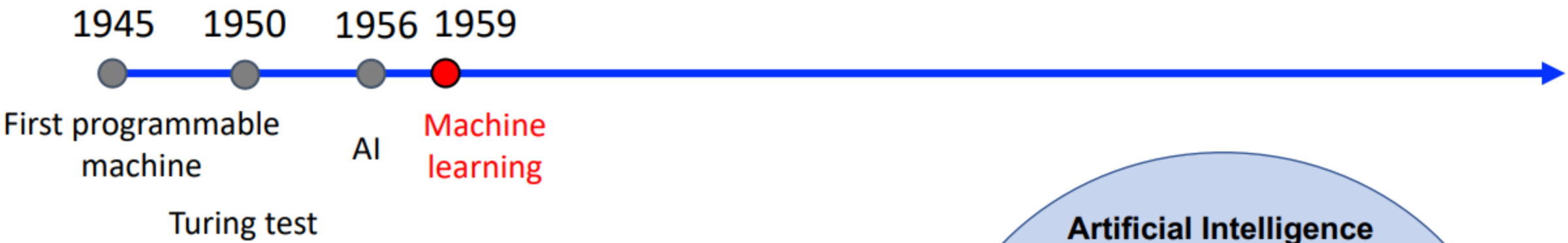
Brief History

Origins: Conceptual Framework



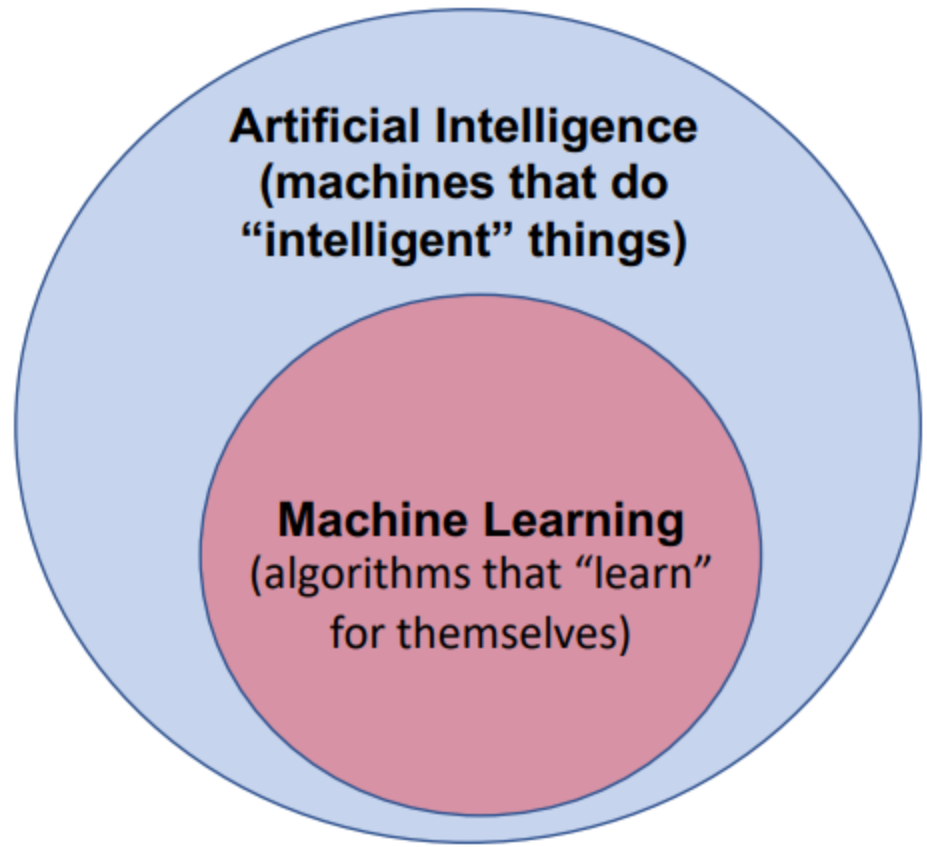
What human intelligence might computers imitate?

Origins: Conceptual Framework

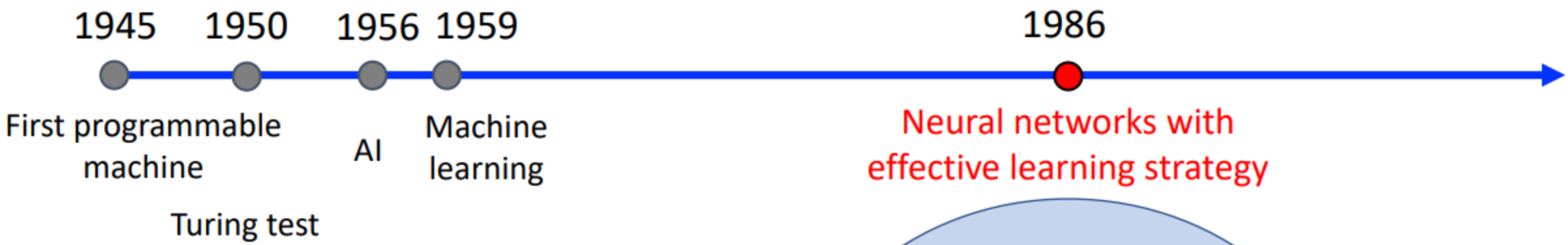


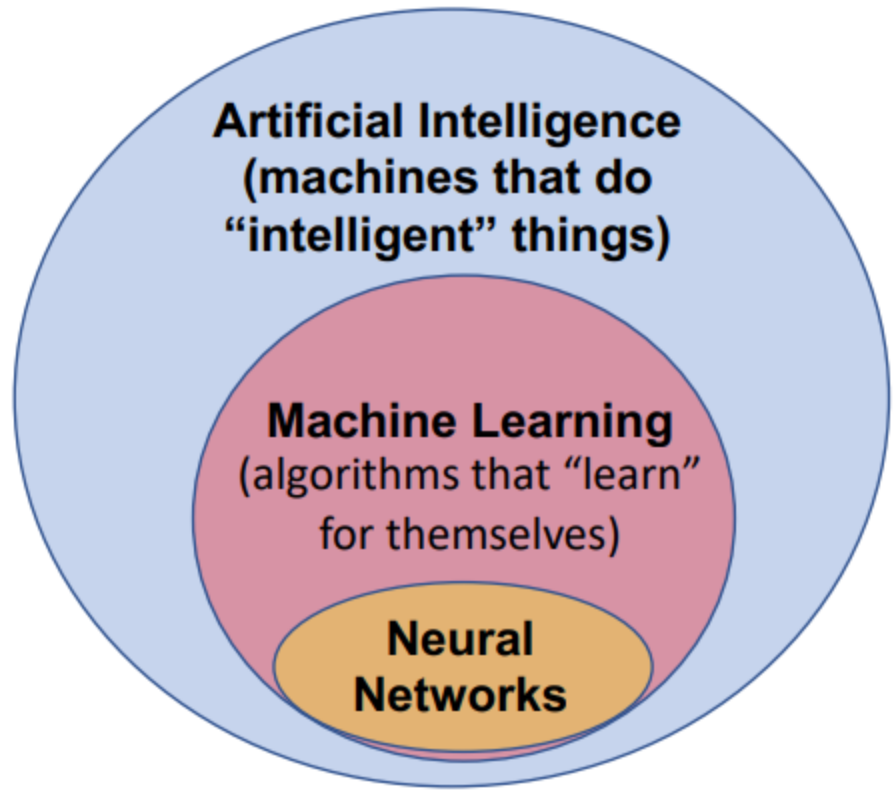
AI researcher Arthur Samuel coins the term "machine learning" as:

"Field of study that gives computers the ability to learn without being explicitly programmed."



Origins: Modern Neural Networks



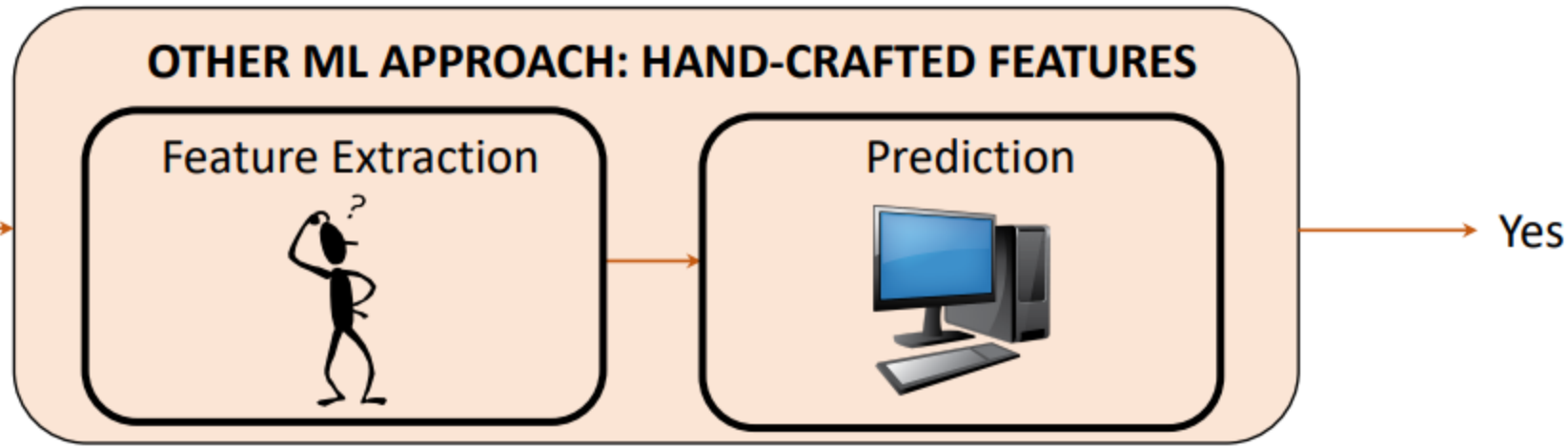


Motivation for Neural Networks (NNs) Over Other Machine Learning (ML) Approaches

INPUT

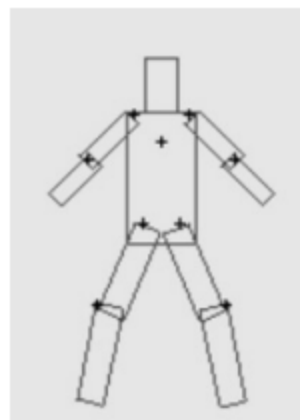
e.g., Is a person present?

OUTPUT



What features would help predict yes/no?

e.g., corners, lines, and model of expected body parts as connected shapes



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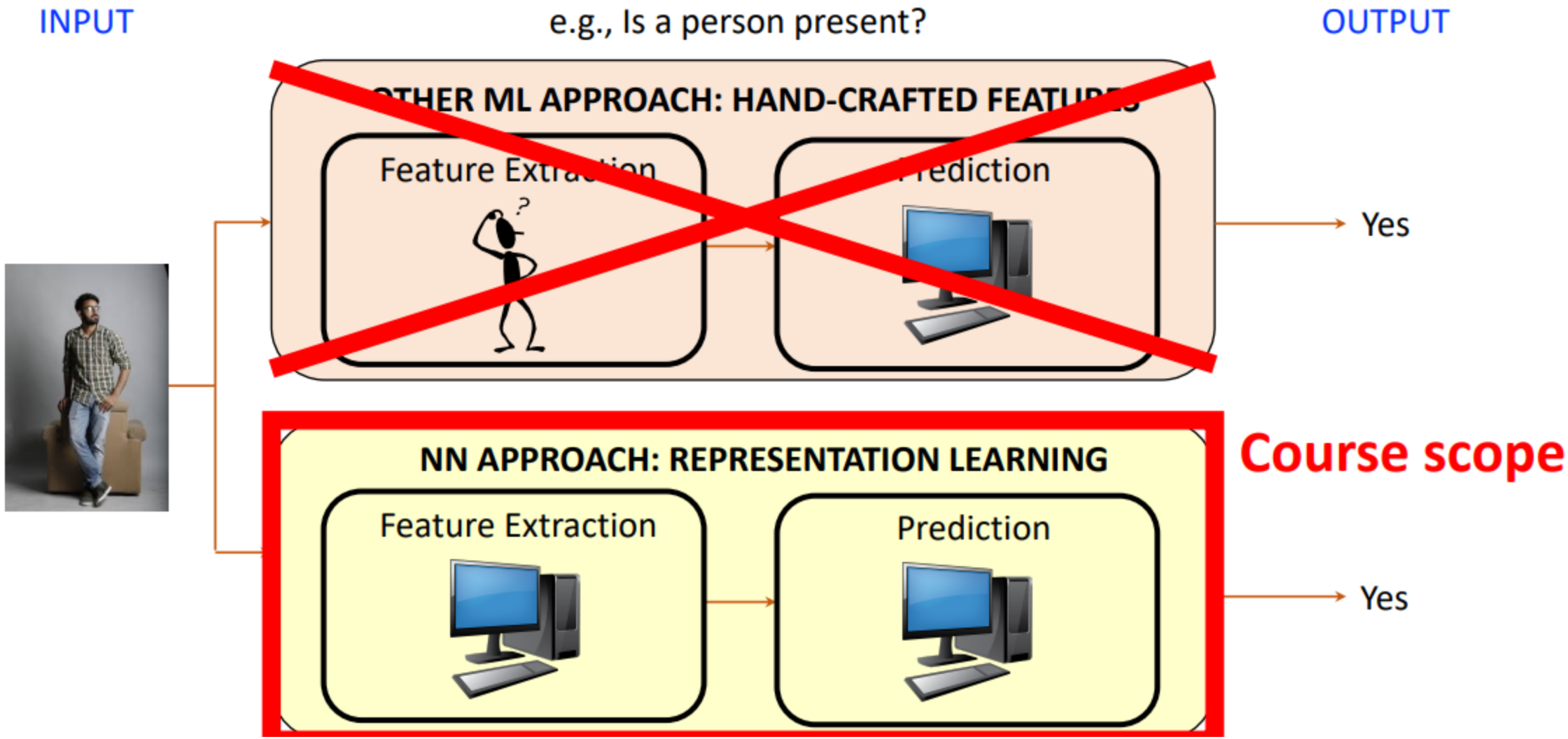
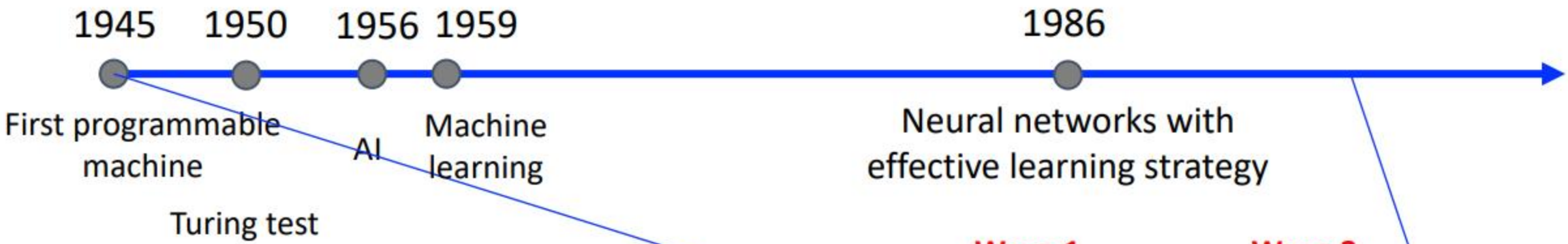
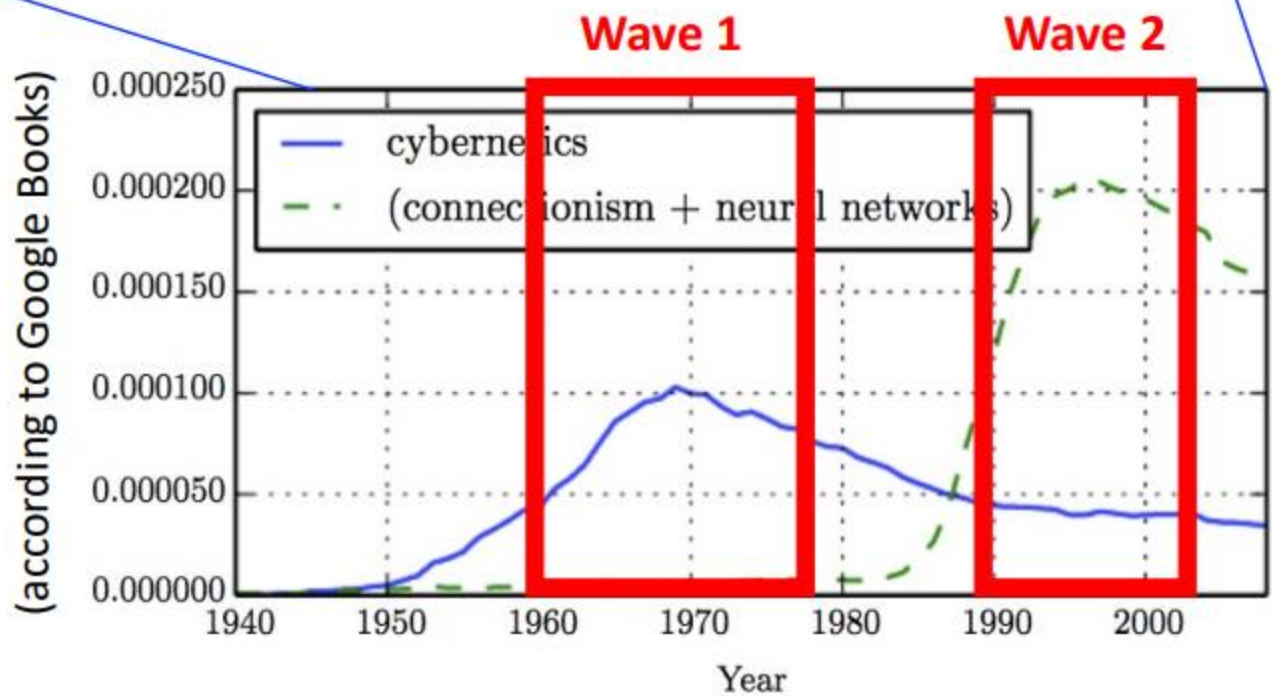


Origins: Rises/Falls of Neural Network Popularity



Neural networks are not new and have been called many names:



Ian Goodfellow, Yoshua Bengio, and Aaron Courville; Deep Learning, 2016

Origins: Rises/Falls of Neural Network Popularity

1945 First programmable machine

1950 Turing test

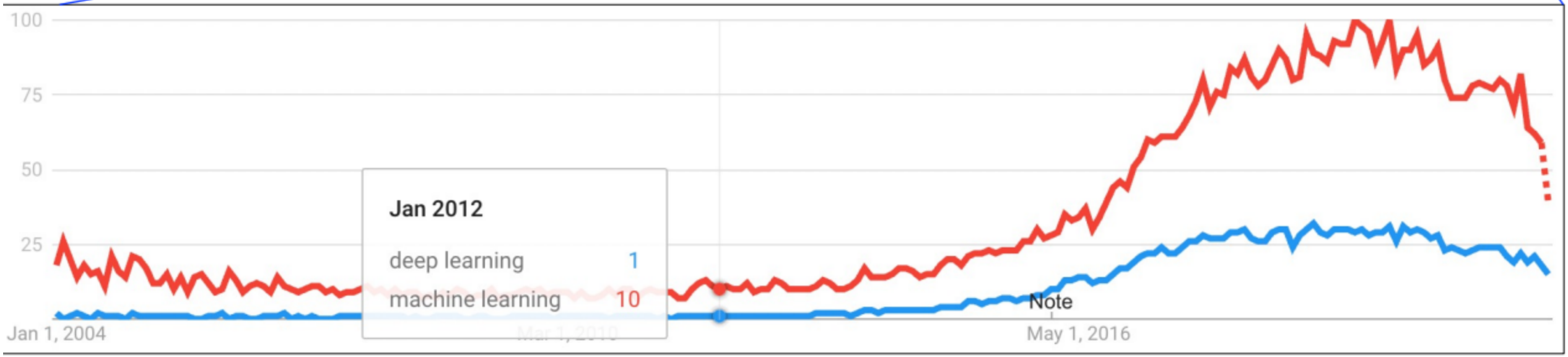
1956 AI

1959 Machine learning

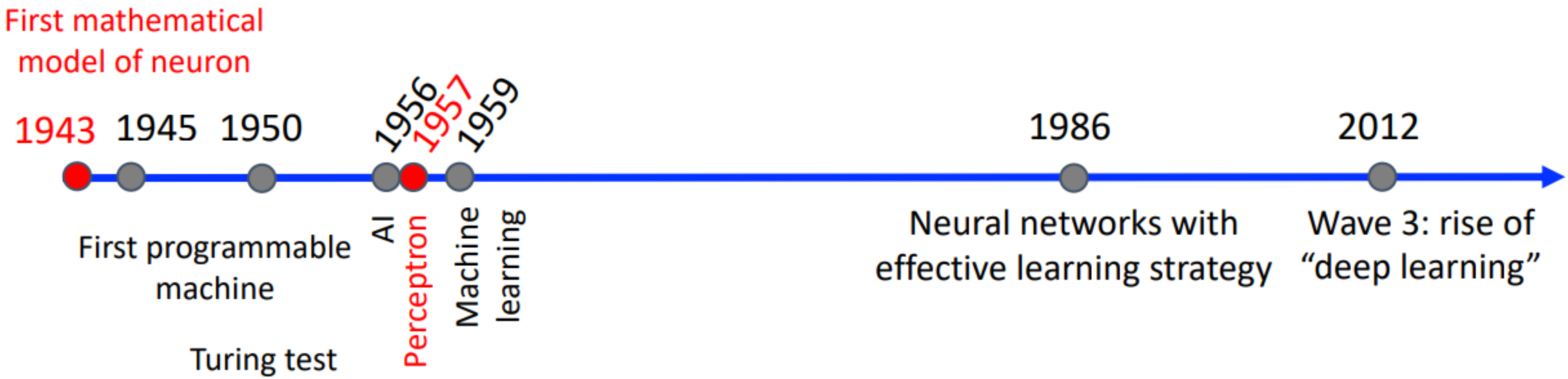
1986 Neural networks with effective learning strategy

2012 Wave 3: rise of "deep learning"

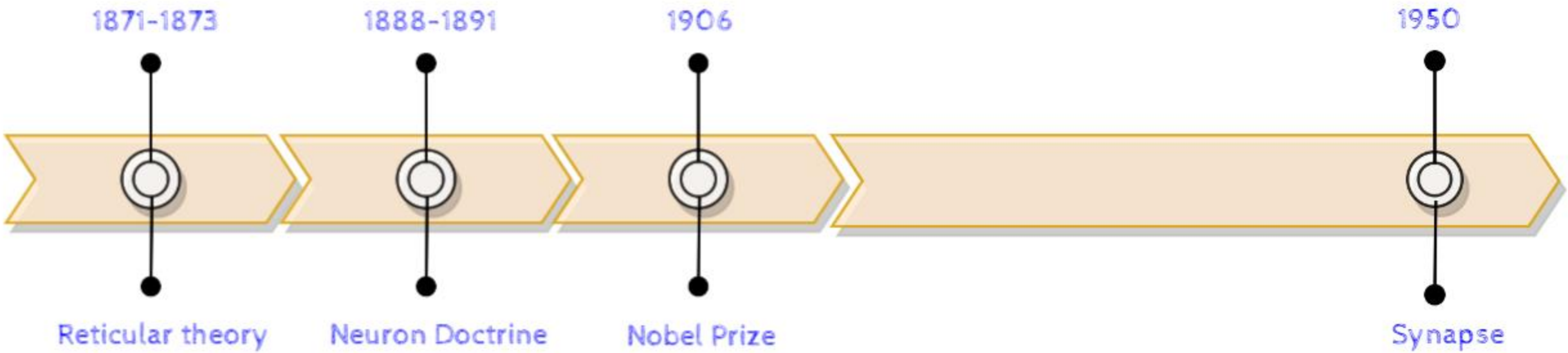
(Google Trends)

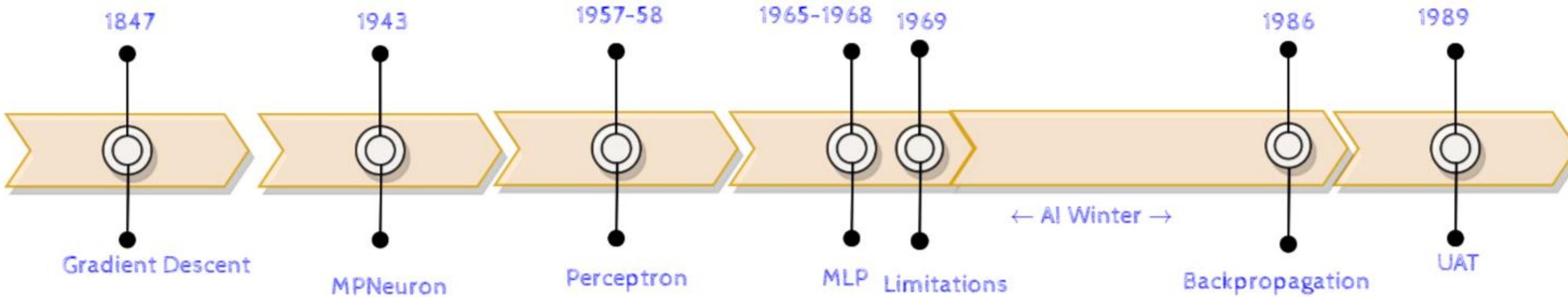


Historical Context: Artificial Neurons

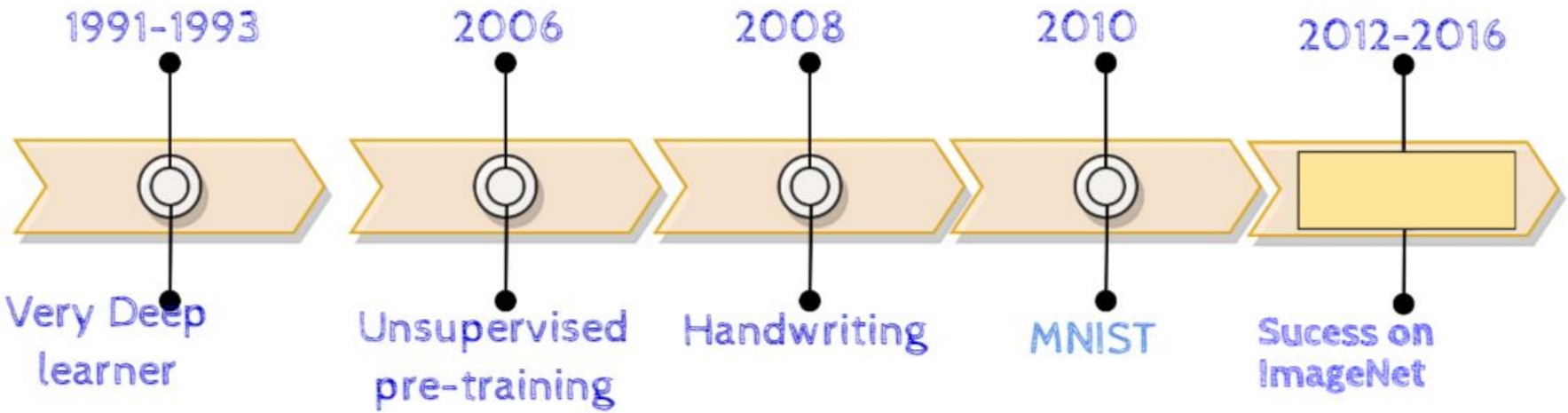


Recall: modern deep learning algorithms rely on techniques developed over the past 65 years.

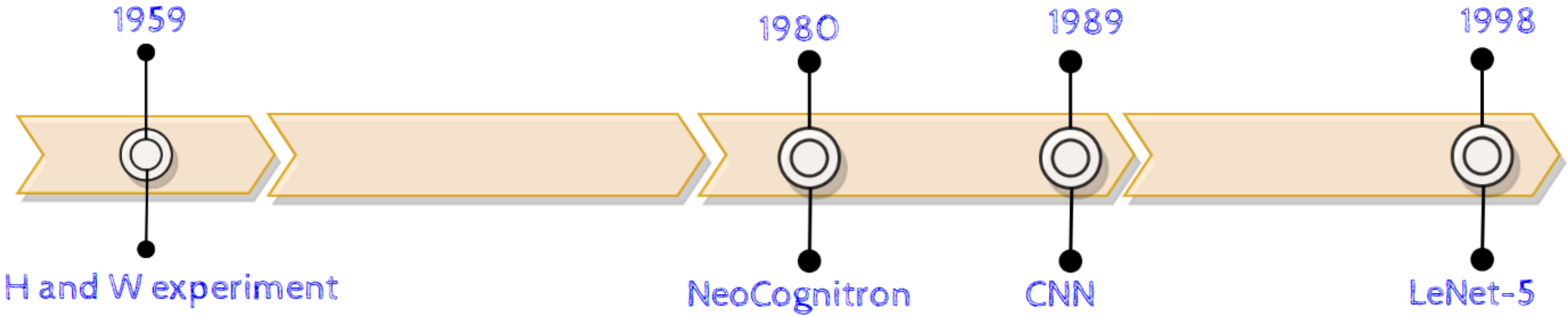

1871-1873
1888-1891
1906
1950
Reticular theory
Neuron Doctrine
Nobel Prize
Synapse


1847
Gradient Descent
1943
MPNeuron
1957-58
Perceptron
1965-1968
MLP
1969
Limitations
← AI Winter →
1986
Backpropagation
1989
UAT

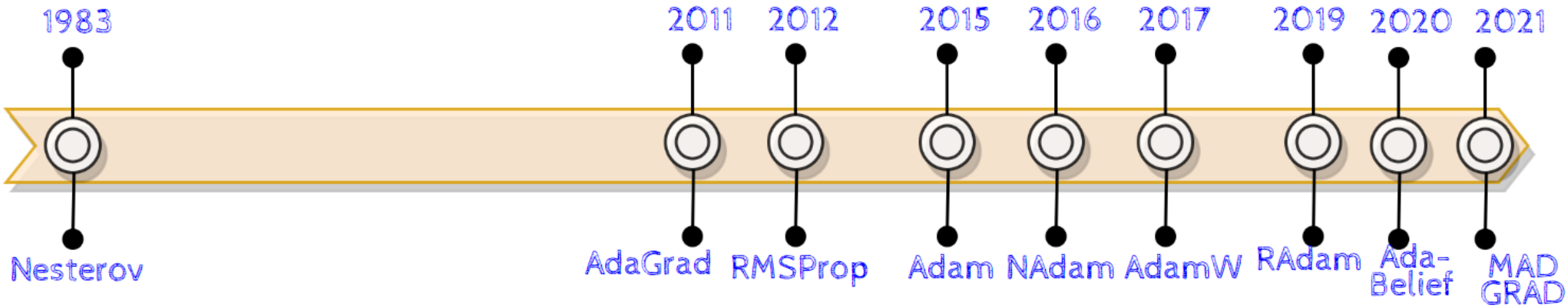
Network	Error	Layers
AlexNet	16.0 %	8
ZFNet	11.2%	8
VGGNet	7.3%	19
GoogLeNet	6.7%	22
MS ResNet	3.6%	152



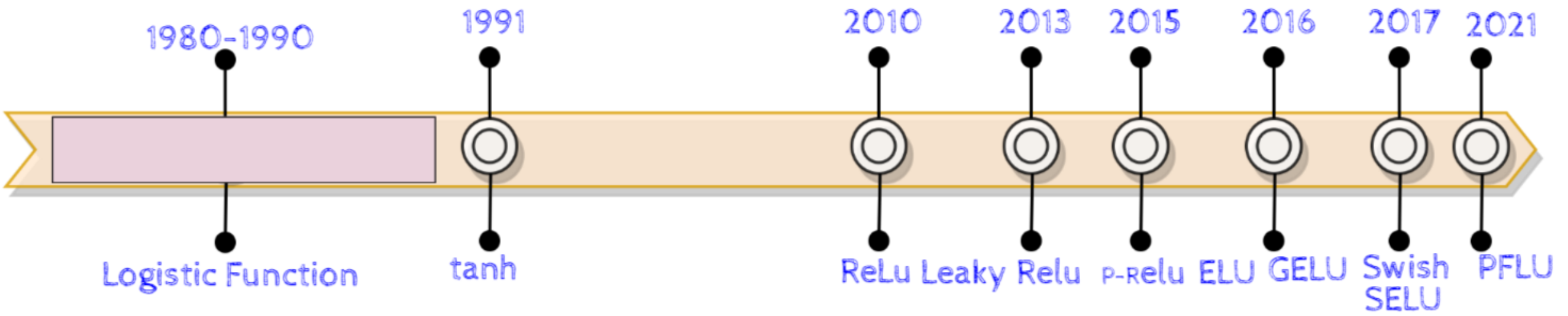
Source: Prof. Mithesh Khapra Deep Learning Course

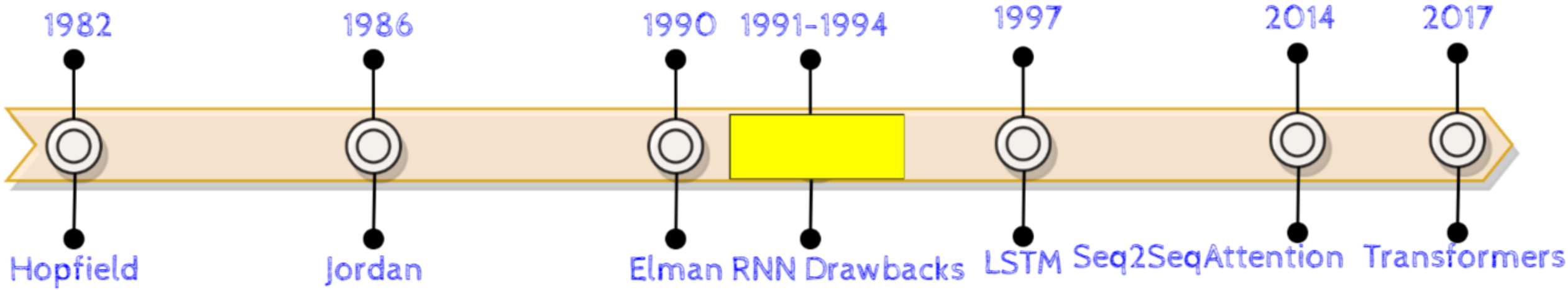

1959
H and W experiment
1980
NeoCognitron
1989
CNN
1998
LeNet-5

Better Optimization Methods

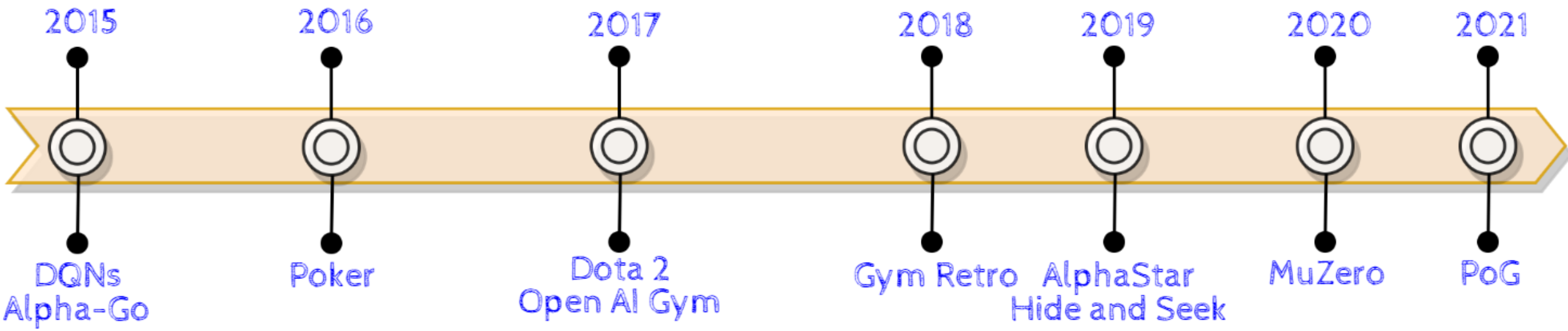


Better Activation Functions

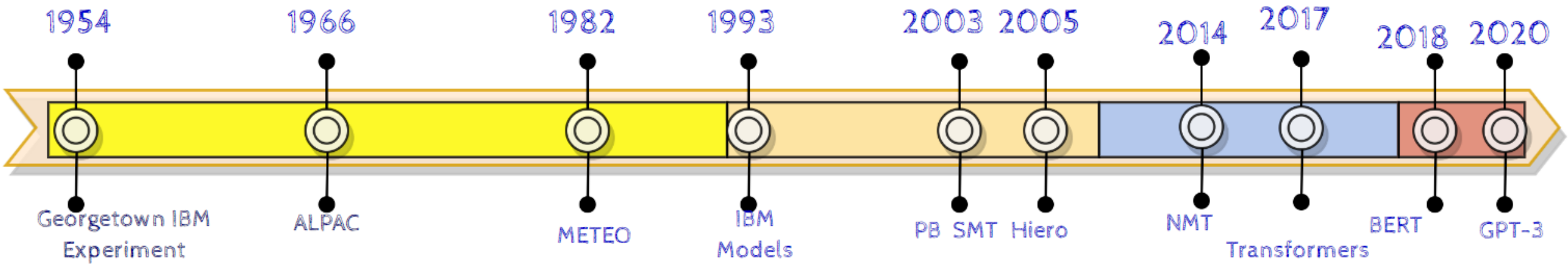



1982
1986
1990
1991-1994
1997
2014
2017
Hopfield
Jordan
Elman
RNN Drawbacks
LSTM
Seq2SeqAttention
Transformers

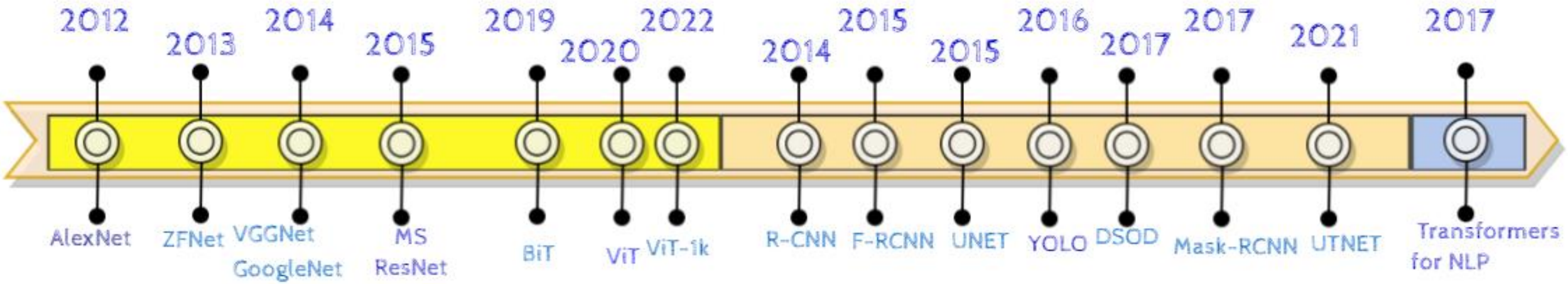
Games


2015
DQNs
Alpha-Go
2016
Poker
2017
Dota 2
Open AI Gym
2018
Gym Retro
2019
AlphaStar
Hide and Seek
2020
MuZero
2021
PoG

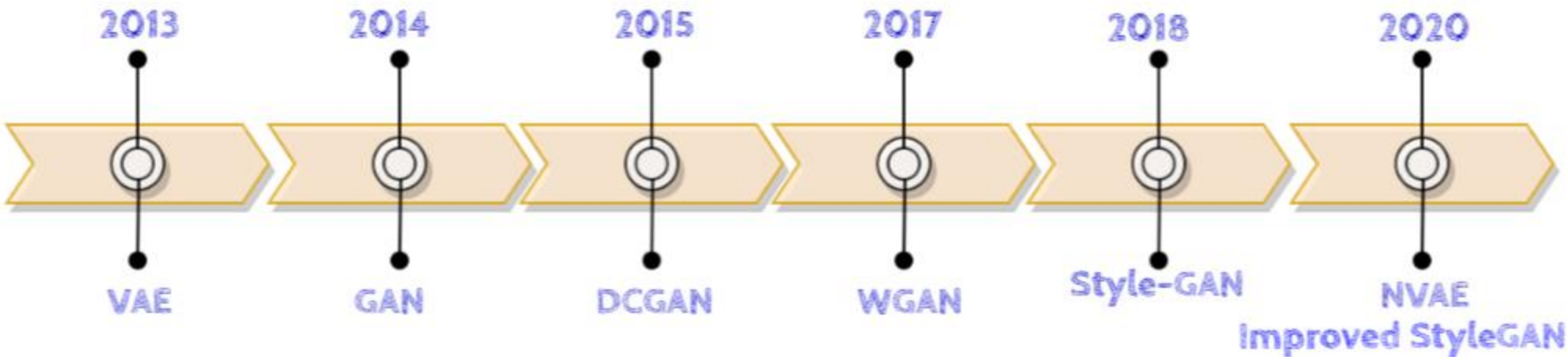
Transformer Revolution



From Language To Vision



From Discrimination to Generation



Green AI

Summary of Developements

- **Early Foundations (1950s-1980s)**
- Introduction of the Perceptron and early neural network models.
- Development of the backpropagation algorithm for training multi-layer networks.
- **Rise of Modern Deep Learning (1990s-2000s)**
- Emergence of deep learning as interest shifted back to neural networks.
- **Breakthroughs and Rapid Development (2010s-Present)**
- **2012 ImageNet**: AlexNet revolutionizes image classification with deep convolutional networks.
- **Deep Learning Frameworks**: Introduction of TensorFlow and PyTorch enhances model development and experimentation.
- **NLP Advances**: Introduction of transformers and models like BERT and GPT transform natural language processing.
- **Current Trends and Future Directions**
- Focus on **Efficiency and Green AI**: Reducing computational and environmental impact.
- Emphasis on **Ethics and Fairness**: Addressing bias and transparency in AI systems.
- Rise of **Multi-Modal Models**: Integrating text, images, and other data types for comprehensive AI solutions.

References

- CS7015: Deep Learning http://www.cse.iitm.ac.in/~miteshk/CS7015_2018.html
- **Deep Learning in Neural Networks: An Overview** Juergen Schmidhuber