

# Neural Networks and Deep Learning

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University of Colorado Boulder

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<https://home.cs.colorado.edu/~DrG/Courses/NeuralNetworksAndDeepLearning/AboutCourse.html>

# Today's Topics

- Applications
- History of neural networks and deep learning
- How does a machine learn?
- Course logistics

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# Key Motivation

Systems that support humans by either  
*improving upon existing human capabilities*  
*or providing new capabilities*

# Solutions – Spam Detection

A screenshot of a Gmail inbox interface. The search bar at the top contains the query "in:spam". The inbox list shows ten spam messages, each with a checkbox, star icon, and a small arrow icon. The messages are as follows:

- Congrats!! (12) Your request has been granted. 12:27 PM
- Mark Final Reminder- Hello , Last Hour Hire a Book Ghost Writer at 85% Off for Book Writin... 12:13 PM
- ⚠️ Unsubscribe Dannag, We need your confirmation please.. 11:09 AM
- WikiPedia Month End Offer! Get your Wikipedia page at 85% off 10:57 AM
- Private-Messag□ Hi\_I\_sent\_some\_private□\_Image□\_&\_Video□\_you\_will\_be\_surprised!!□\_□ 9:53 AM
- Paralegal Studies w. Study Online, Paralegal Studies 9:40 AM
- iM Horny 🍑🔥辣椒xxxRebeccaxxx has unlocked her private video for you🔥辣椒 9:03 AM
- utsafetyalert CAMPUS ALERT: All clear issued after threat to main building 8:57 AM

The left sidebar shows navigation links: Compose, Inbox (13), Snoozed, Important, Sent, Drafts (13), All Mail, Spam (58), Categories, [Imap]/Drafts, [Imap]/Outbox, [Imap]/Sent.

# Solutions – Information Retrieval

Baidu 新闻 machine learning 百度一下

网页 新闻 贴吧 知道 音乐 图片 视频 地图 文库 更多»

找到相关新闻92篇 新闻全文 新闻标题 | 按焦点排序 ▾

[...GWAS summary statistics for data mining and machine learning](#)  
中国矿业大学 2017年12月26日 16:58  
报告题目:Using GWAS summary statistics for data mining and machine learning 时间:12月29日上午9:00 地点:文昌校区逸夫楼邵206 主办单位:中国矿业大学信息与... 百度快照

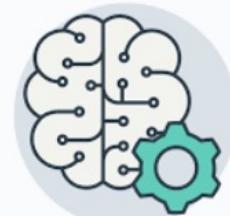
[\[Machine Learning\] 深度学习中消失的梯度](#)  
深圳热线 2017年12月07日 09:46  
原标题:[Machine Learning] 深度学习中消失的梯度 好久没有更新blog了,最近抽时间看了Nielsen的《Neural Net 百度快照

[Machine learning can help enhance drug trials: study](#)  
新华网 2017年11月16日 01:40  
15 (Xinhua) -- A team of researchers have demonstrated that machine learning could be an effective tool in determining whether a new drug works in the... 百度快照

Google machine learning

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artificial intelligence big data iot distributed robotic cyber s

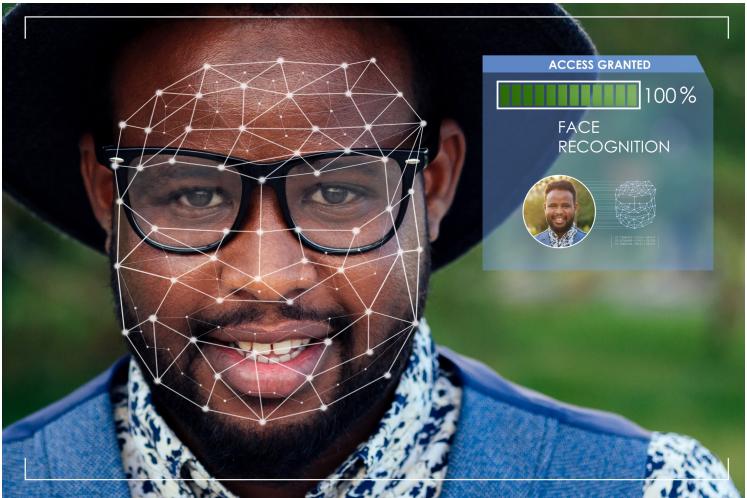


Machine learning & artificial intelligence  
ARTIFICIAL INTELLIGENCE  
Design an intelligent agent that perceives its environment and makes decisions to maximize chances of achieving its goal. Subfields: vision, robotics, machine learning, natural language processing, planning...

MACHINE LEARNING  
Gloss "computes the ability to learn without being explicitly programmed" (Arthur Samuel, 1959)  
SUPERVISED LEARNING Classification, regression  
UNSUPERVISED LEARNING Clustering, dimensionality reduction, recommendation  
REINFORCEMENT LEARNING Reward maximization



# Solutions – Recognition



(Face)



(Speech)



(Fraud)

# Solutions – Robotics



(Self-driving Vehicles)



(Medical Surgery)



(Manufacturing)

# Solutions – Recommendation Systems

The image displays four examples of recommendation systems:

- Netflix:** Shows a movie recommendation for "BUYERS GUIDE".
- Amazon Prime:** Shows a search result for "Books" with 1-12 of 14,024 results.
- Facebook:** Shows a "Recommended" section with posts from "Crafty Life" and "My neighbor".
- The New York Times:** Shows a "Recommendations" section featuring various books by Packt Publishing.

The New York Times section includes a call-to-action: "Get personalized recommendations, based on what you enjoy reading on NYTimes.com".

# Solutions – Advertising

Google search results for "machine learning".

Search bar: machine learning

Filter: All

Results: About 1,620,000,000 results (0.50 seconds)

**Ad · https://aws.amazon.com/free/machinelearning** ::

**AWS Machine Learning - Free Machine Learning Services**

Utilize 12 Months of Free **Machine Learning** Solutions When You Create an AWS Account.

**Transcribe**

Add Speech-to-Text Capability with Automatic Speech Recognition.

**Polly**

Turn Text Into Life-Like Speech Using Deep Learning Technologies.

**AWS AI Use Case Explorer**

Discover How Organizations Are Using AI to Drive Business Outcomes

**Translate**

Easily Translate Text Efficiently with Neural Machine Technologies.

**Ad · https://pg-p.ctme.caltech.edu/** ::

**AI & Machine Learning Bootcamp - in collaboration with IBM**

Become an AI & ML Expert in 7 months. Learn from the World's Best Instructors. Enroll Now!

# Solutions – Home Virtual Assistants



e.g., Amazon's Echo with Alexa



e.g., Google Home

# Today's Topics

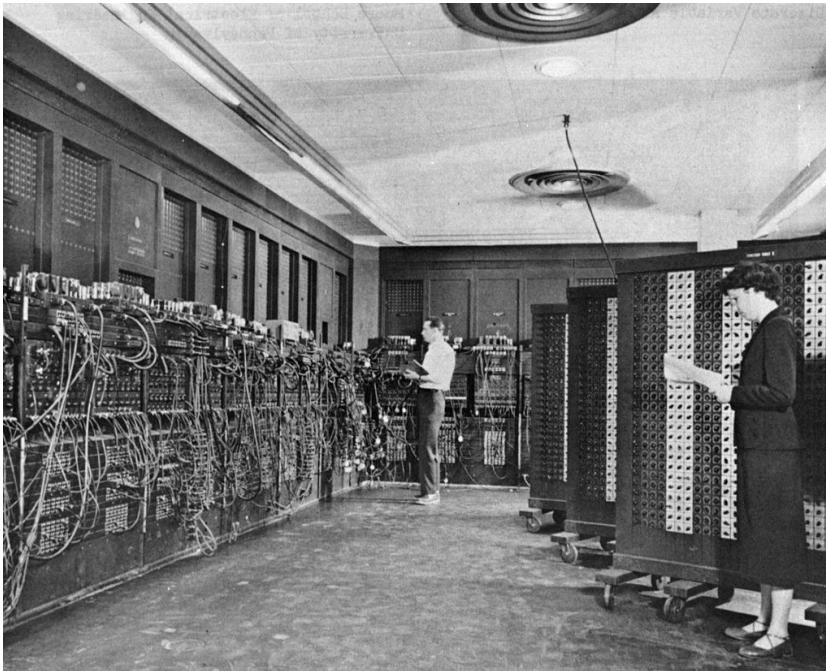
- Applications
- History of neural networks and deep learning
- How does a machine learn?
- Course logistics

# Origins: Computers

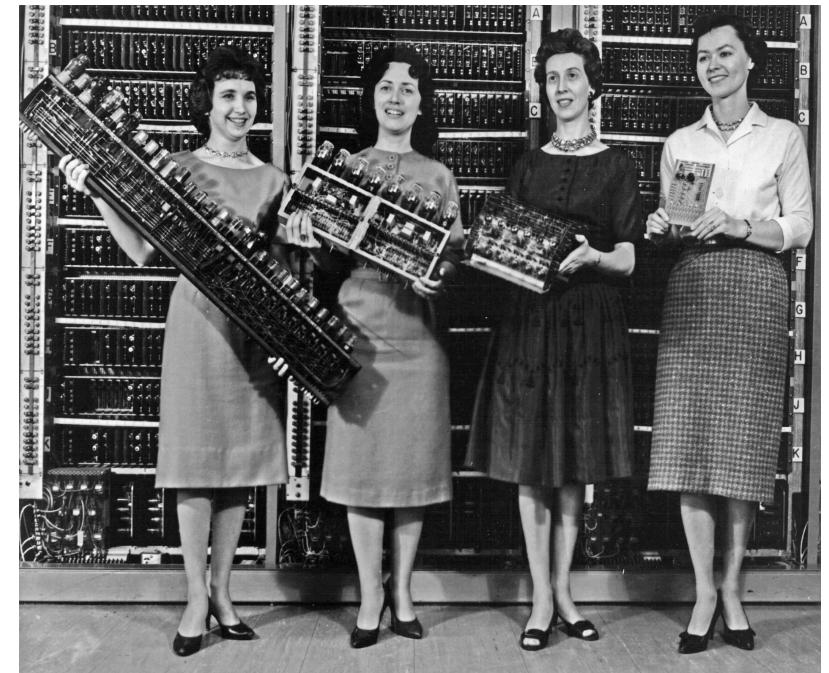
1945



First programmable machine



ENIAC (Electronic Numerical Integrator and Computer) created during World War II  
(could compute 5,000 additions in one second)



First programmers

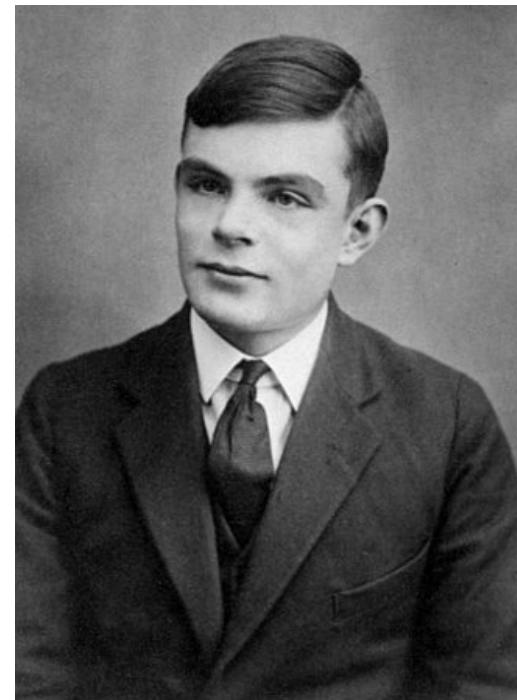
# Origins: Conceptual Framework

1945      1950

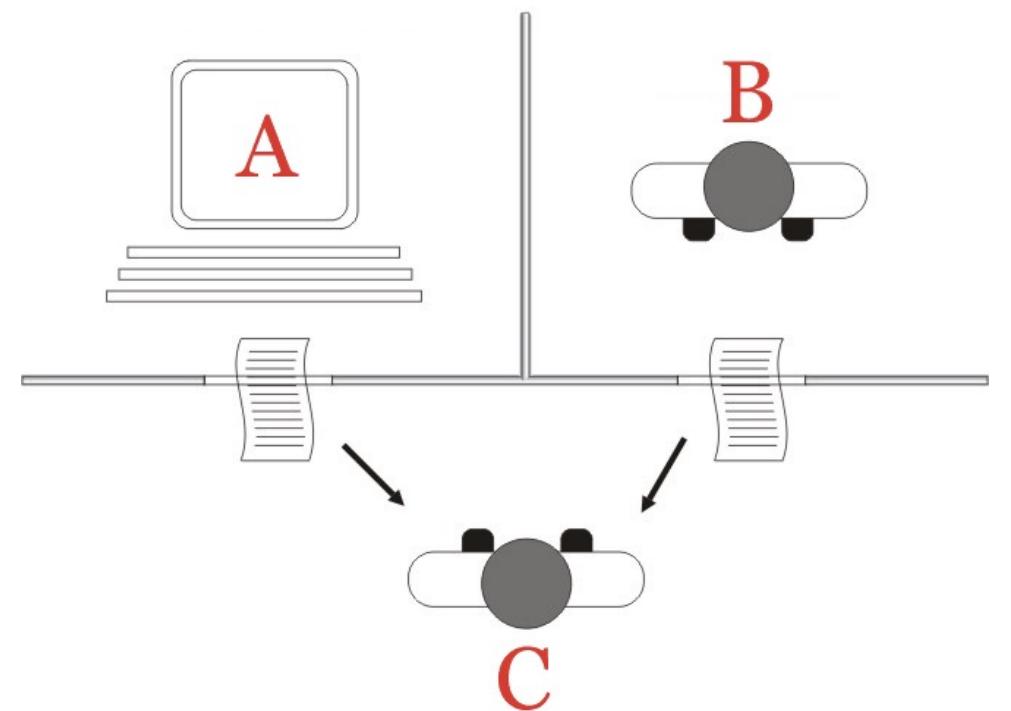


First programmable  
machine

Turing test



Alan Turing  
(1912-1954)



Turing Test: can "C" decide whether text  
responses come from a machine or human

# Origins: Conceptual Framework

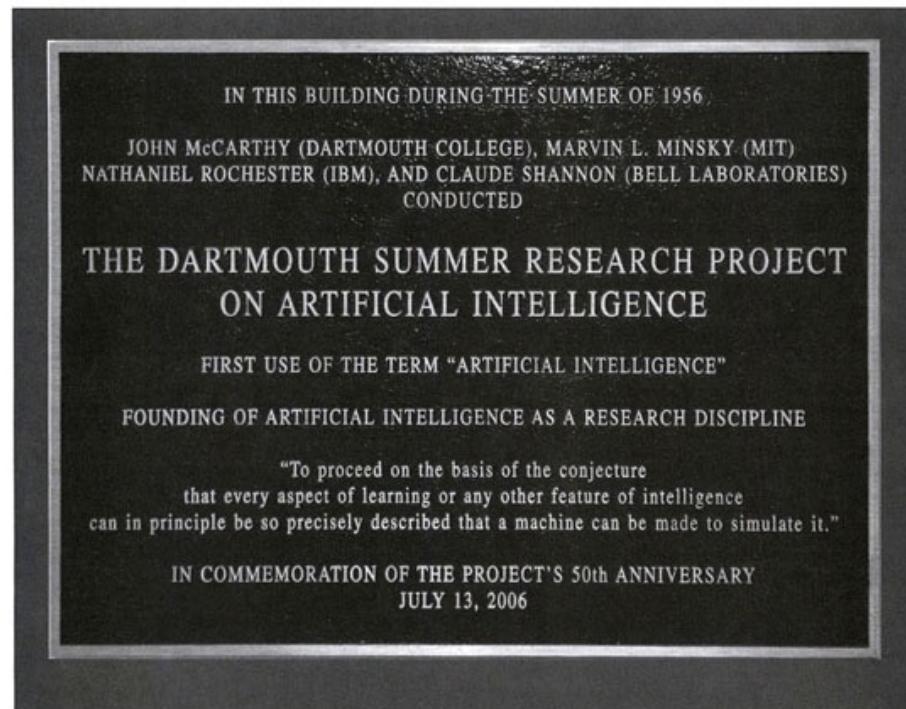
1945    1950    1956



First programmable  
machine

AI birth

Turing test



"Artificial intelligence" established as a field at a workshop

# Origins: Conceptual Framework

1945    1950    1956



First programmable  
machine

AI birth

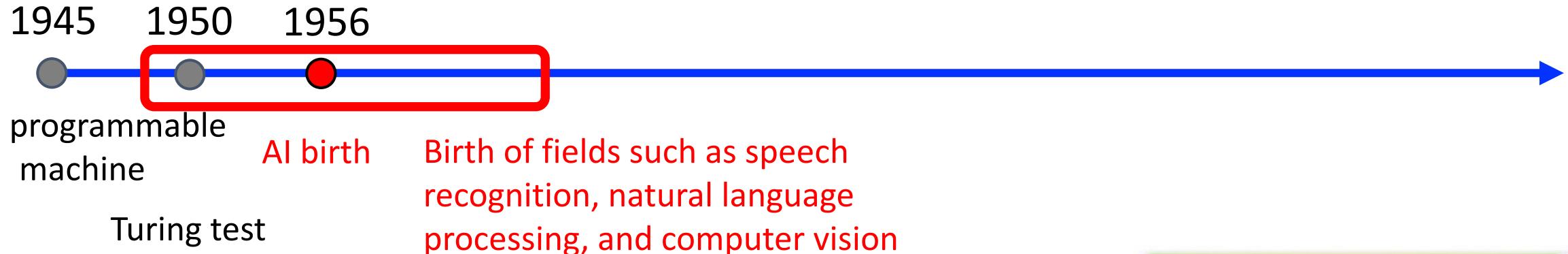
Turing test

IN THIS BUILDING DURING THE SUMMER OF 1956

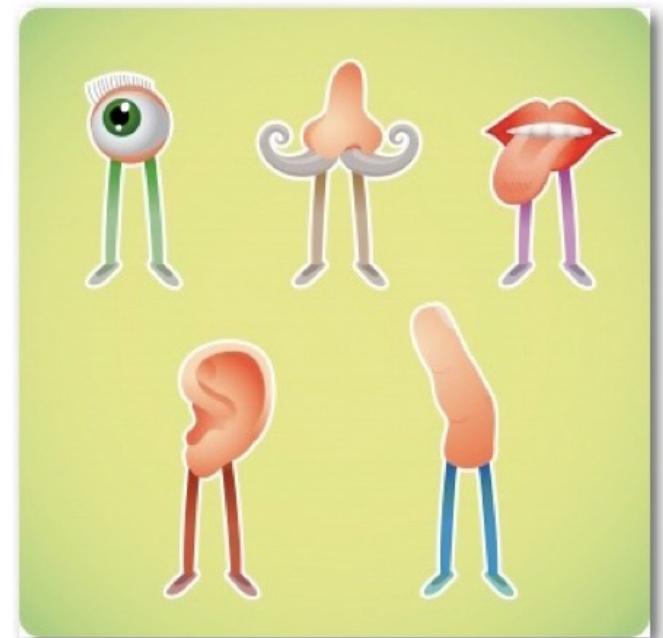
**Workshop Proposal:** "... We propose that a 2 month, 10 man study of artificial intelligence be carried out during the summer of 1956 at Dartmouth College in Hanover, New Hampshire. The study is to proceed on the basis of the conjecture that every aspect of learning or any other feature of **intelligence can in principle be so precisely described that a machine can be made to simulate it**. An attempt will be made to find how to **make machines use language, form abstractions and concepts, solve kinds of problems now reserved for humans**, and improve themselves. We think that a significant advance can be made in one or more of these problems **if a carefully selected group of scientists work on it together for a summer...**"

"Artificial intelligence" established as a field at a workshop

# Origins: Conceptual Framework



What human intelligence  
might computers imitate?



# Origins: Conceptual Framework

1945    1950    1956    1959



First programmable  
machine



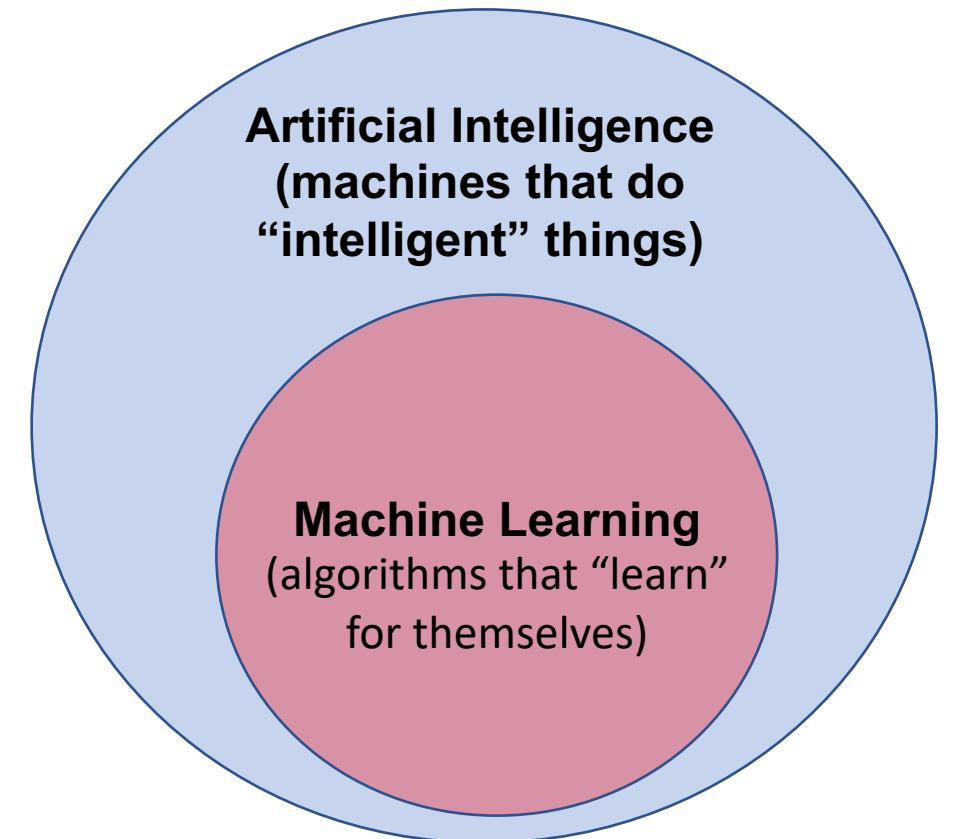
AI

Machine  
learning

Turing test

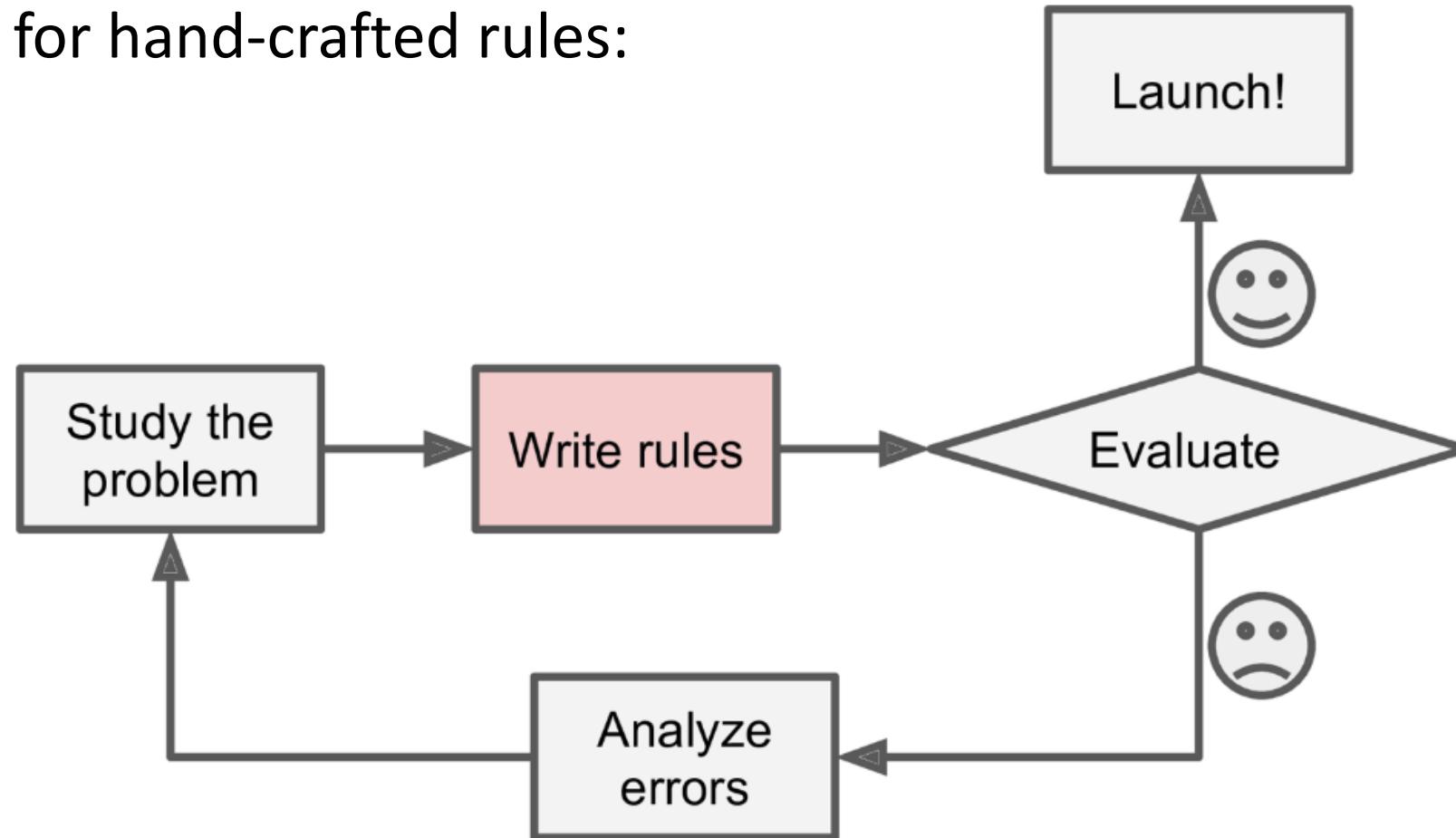
AI researcher Arthur Samuel coins the term  
“machine learning” as:

“Field of study that gives computers **the ability**  
**to learn without being explicitly programmed.**”



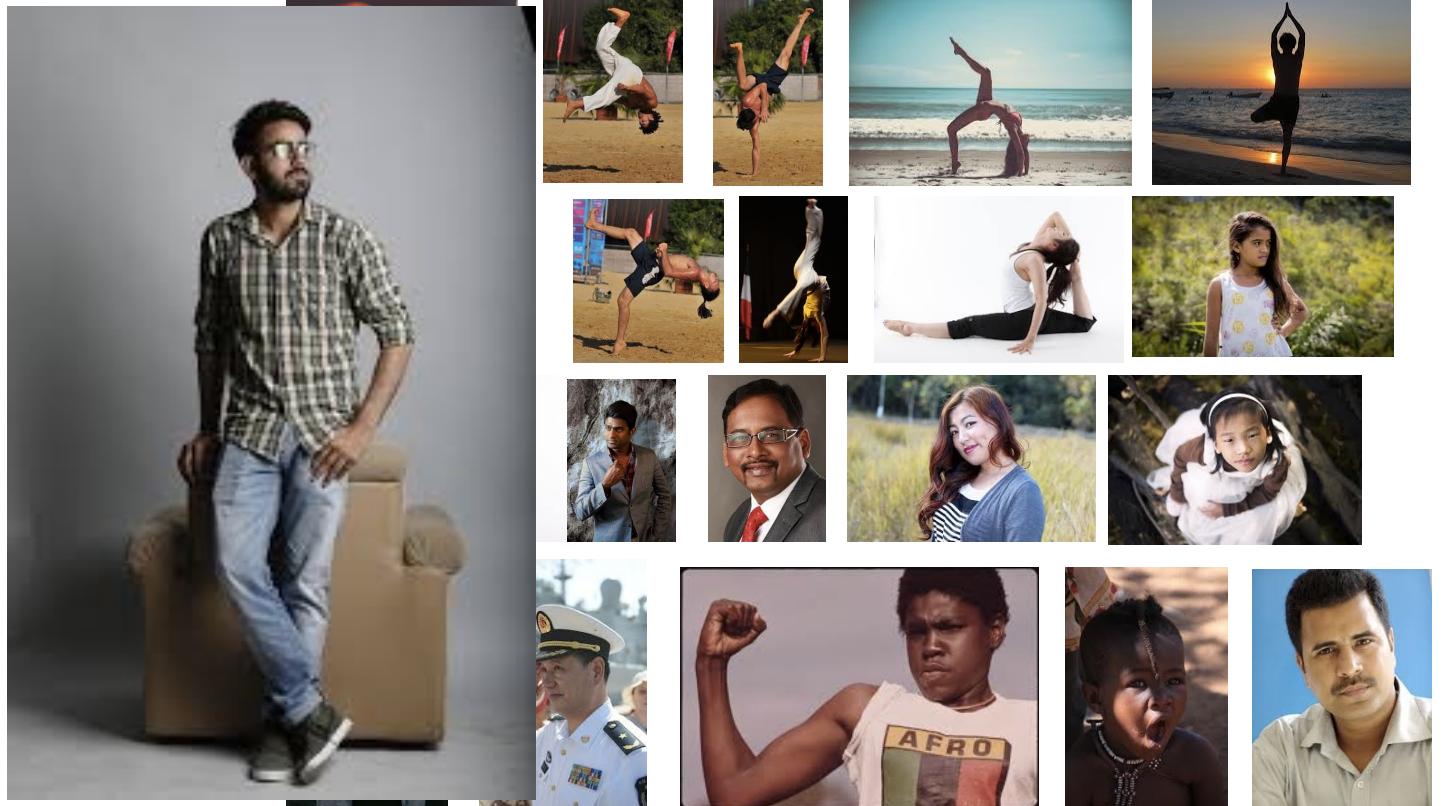
# Motivation for Machines that “Learn”

- Process for hand-crafted rules:



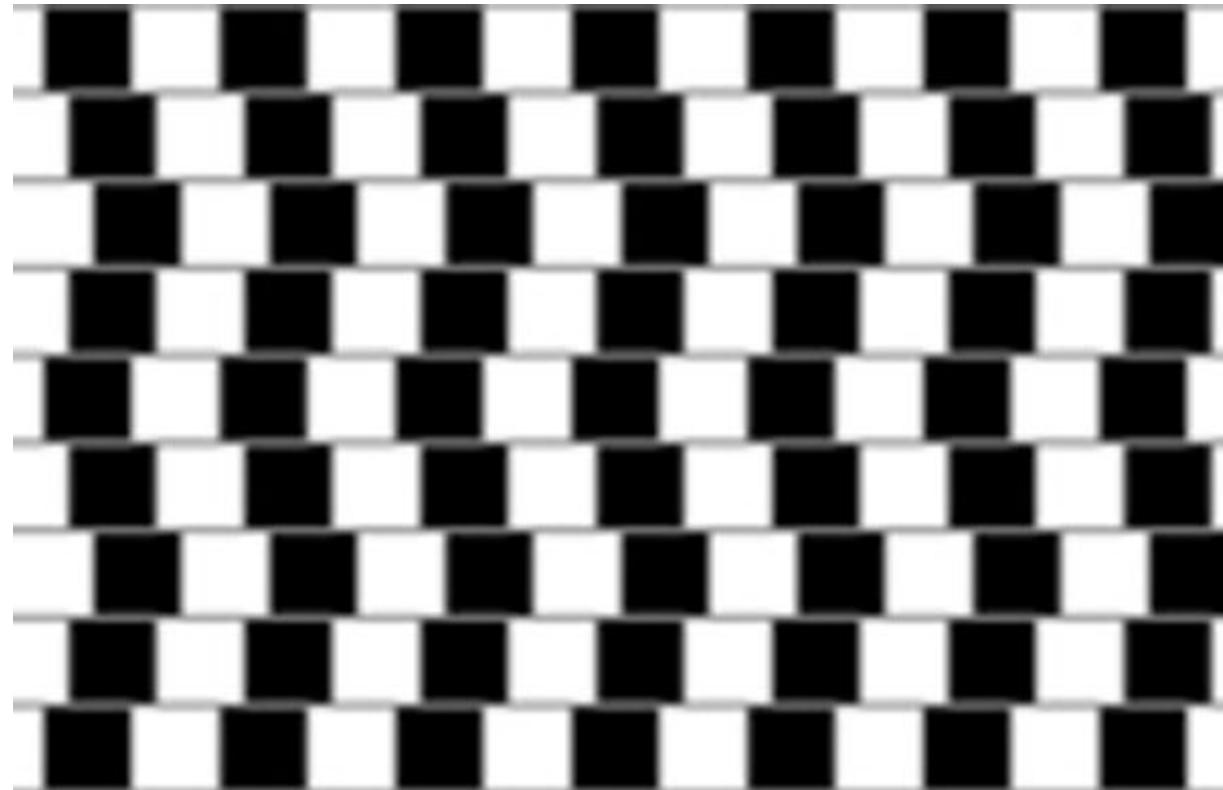
# Motivation for Machines that “Learn”: Class Task

e.g., What rules would you use to answer: “Is a person in the image?”



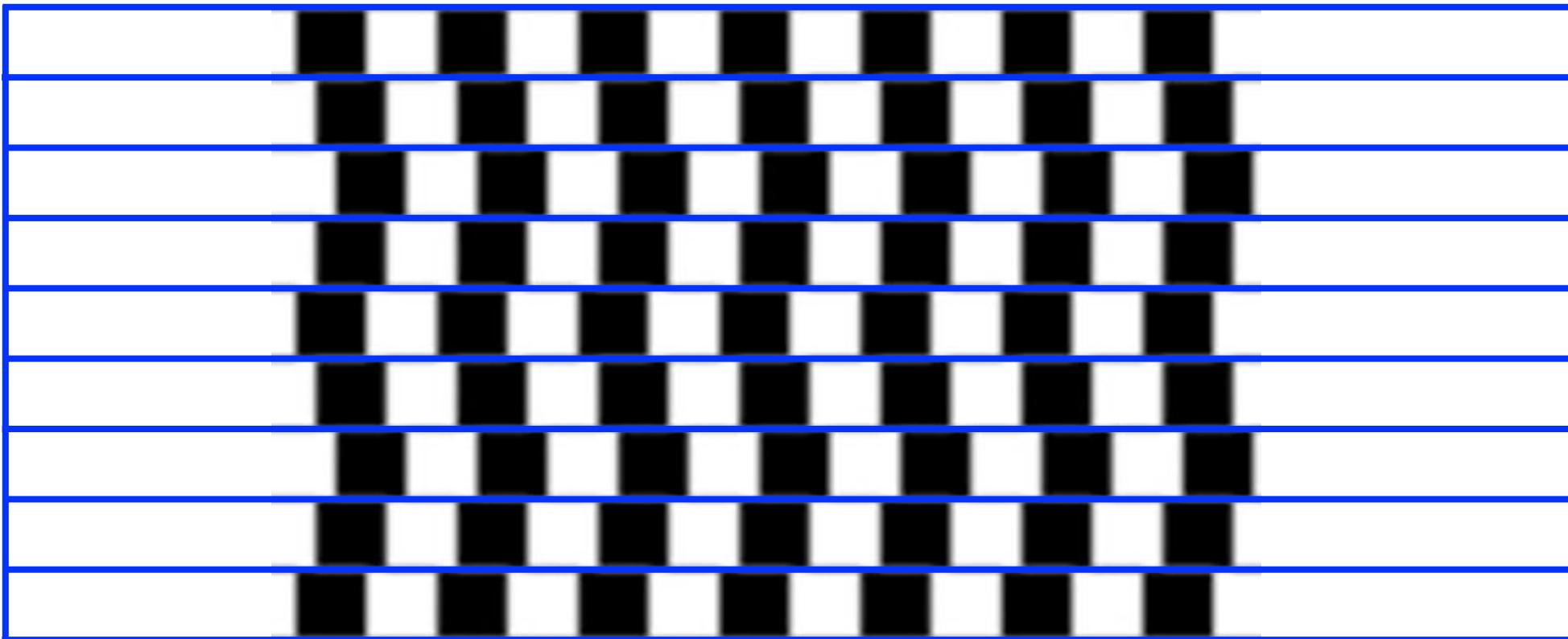
# Motivation for Machines that “Learn”

e.g., are these lines parallel?



# Motivation for Machines that “Learn”

e.g., are these lines parallel?

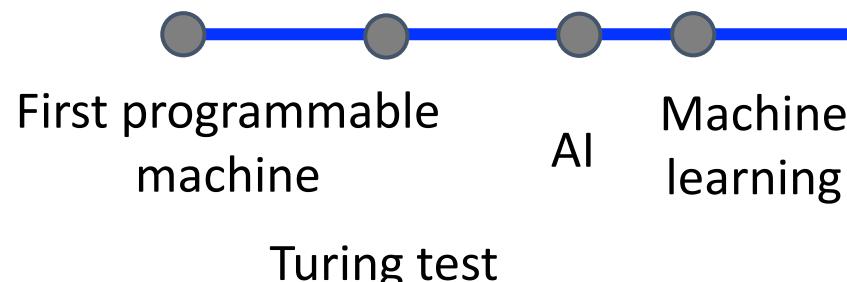


# Motivation for Machines that “Learn”

1. It is hard to hand-craft a complete set of rules
2. We, as humans, may not devise the best rules for a machine since our brains (unconsciously) pre-process the data we sense

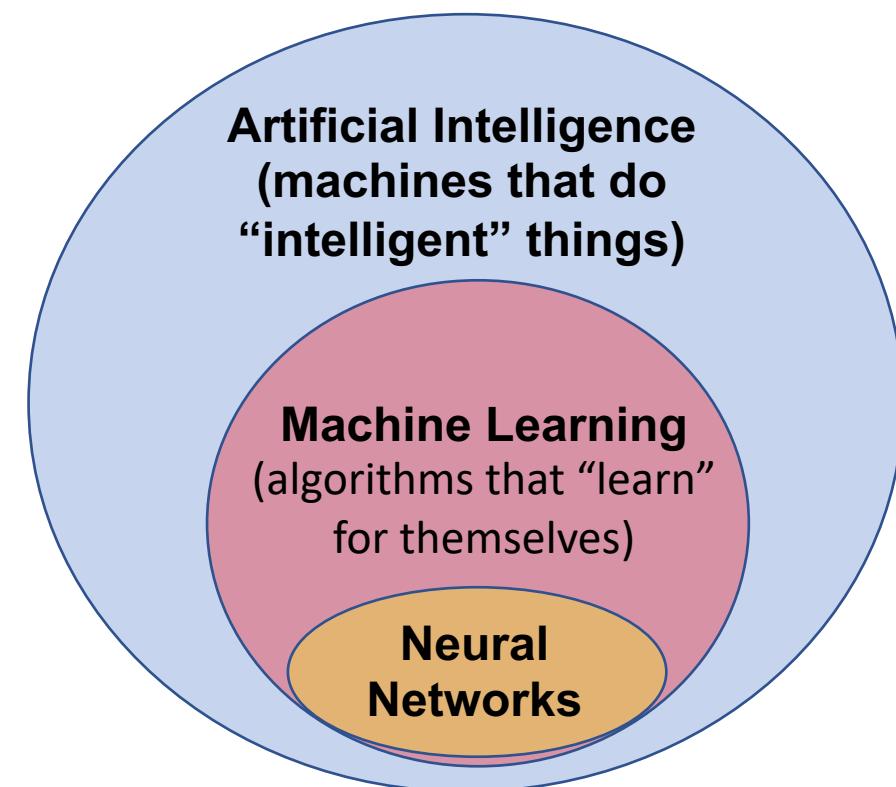
# Origins: Neural Networks with Deep Learning

1945 1950 1956 1959

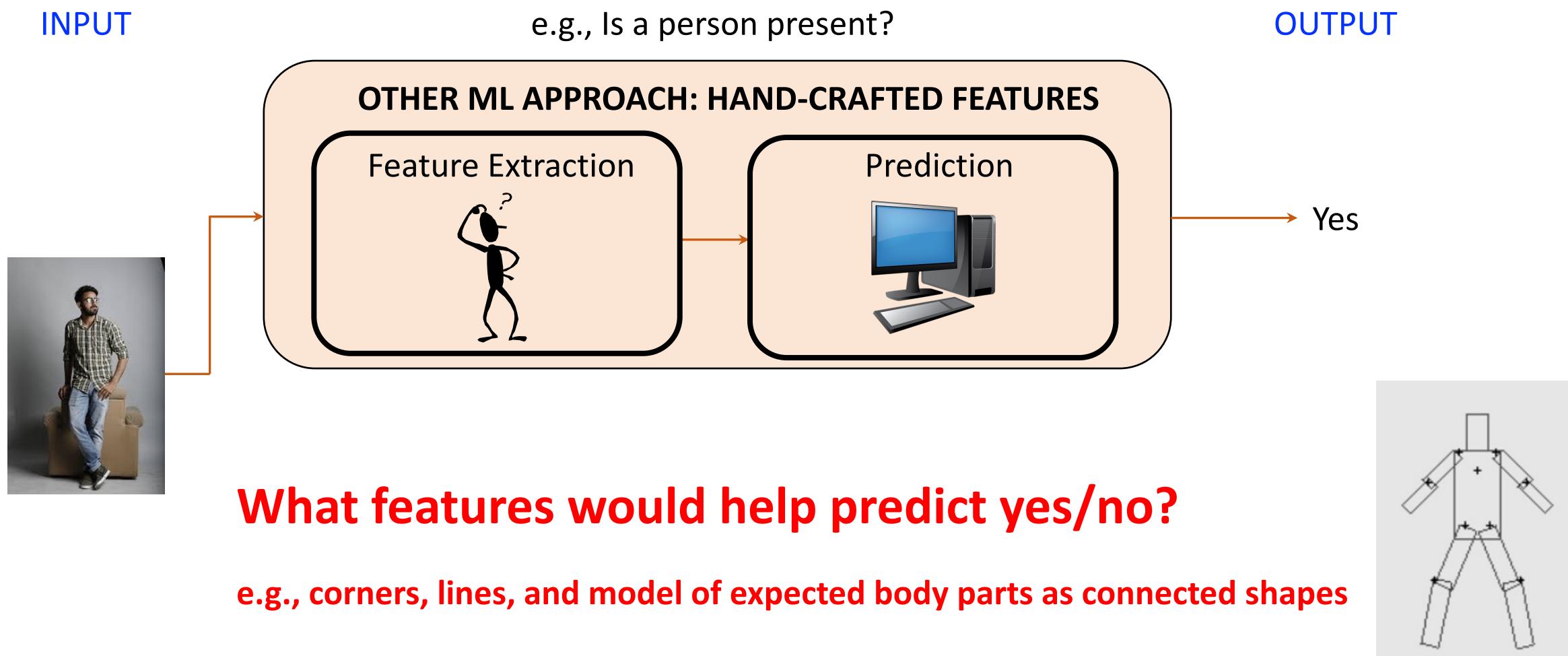


1986

Neural networks with effective  
“deep learning” strategy

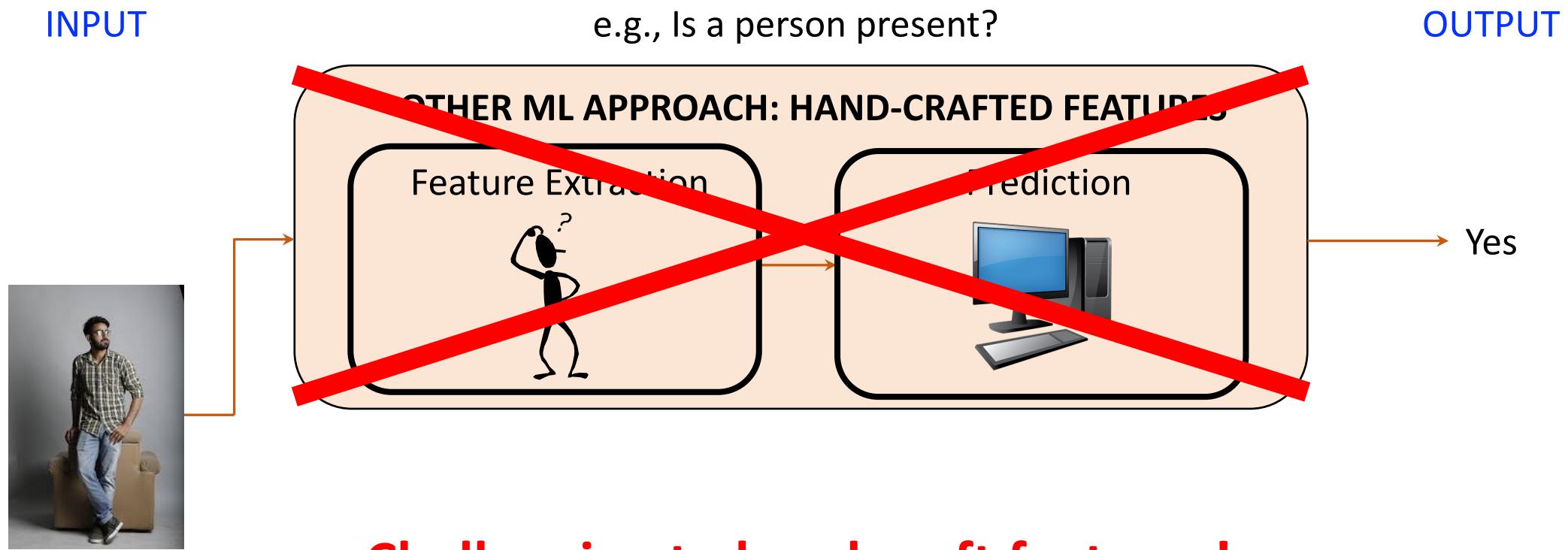


# Motivation for Neural Networks (NNs) Over Other Machine Learning (ML) Approaches

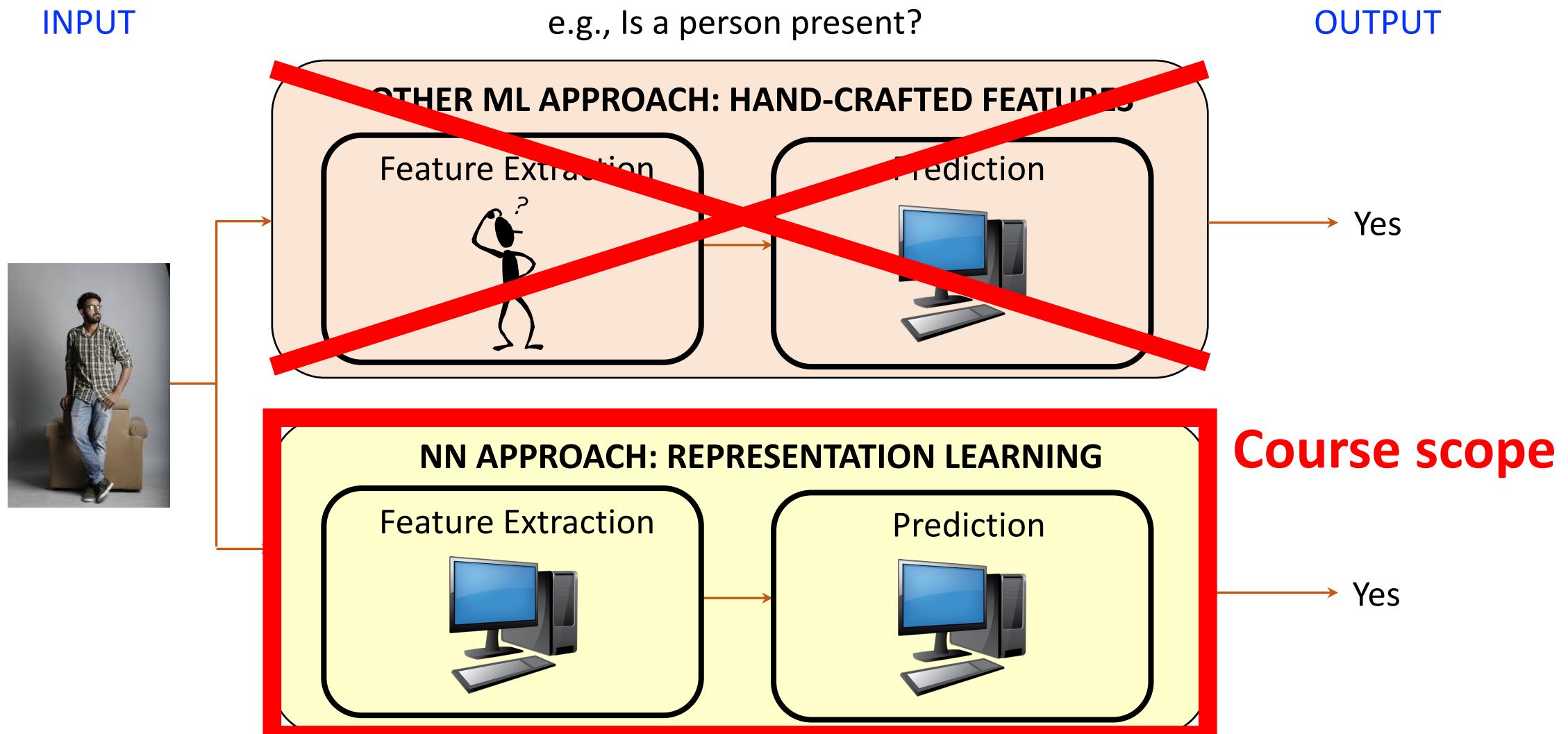


e.g., Pedro F Felzenszwalb and Daniel P Huttenlocher, IJCV 2004

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



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



# Origins: Rises/Falls of Neural Network Popularity

1945 1950 1956 1959

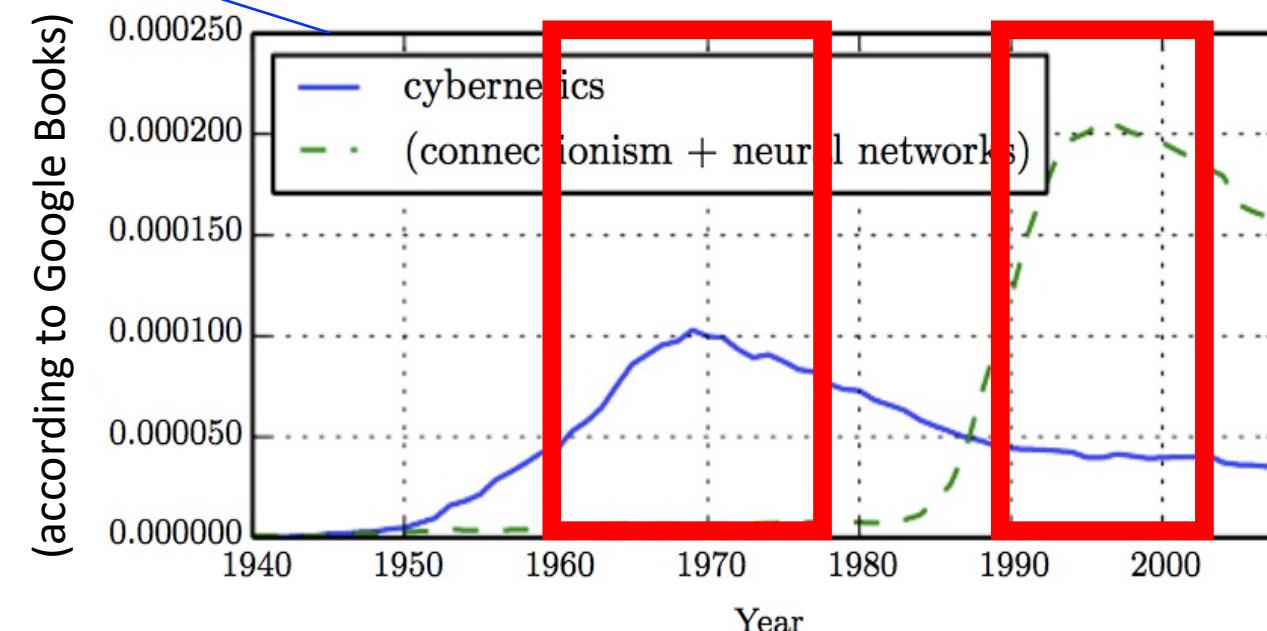
First programmable machine  
AI Machine learning

Turing test

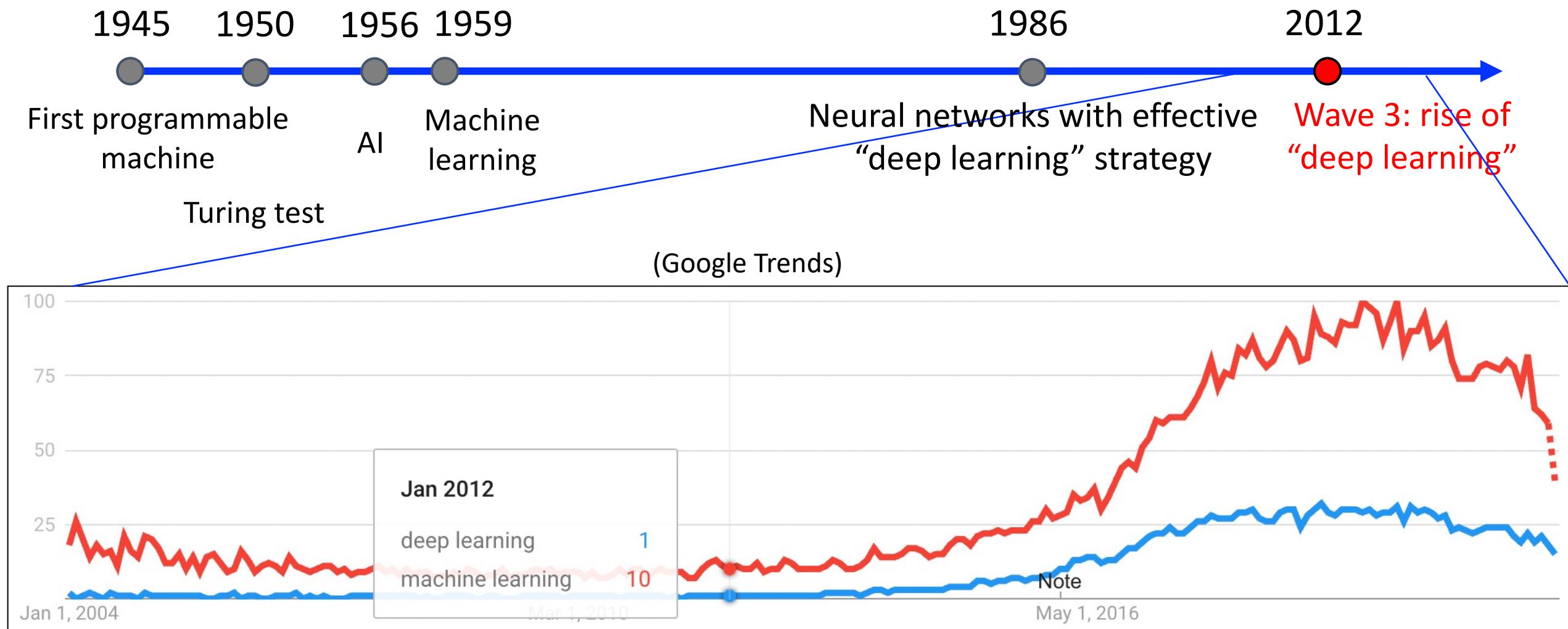
Neural networks are not new and have been called many names:

1986

Neural networks with effective “deep learning” strategy



# Origins: Rises/Falls of Neural Network Popularity



# Today's Topics

- Applications
- History of neural networks and deep learning
- How does a machine learn?
- Course logistics

# General Idea

An **algorithm** learns from **data**  
patterns that will be used to  
make a prediction

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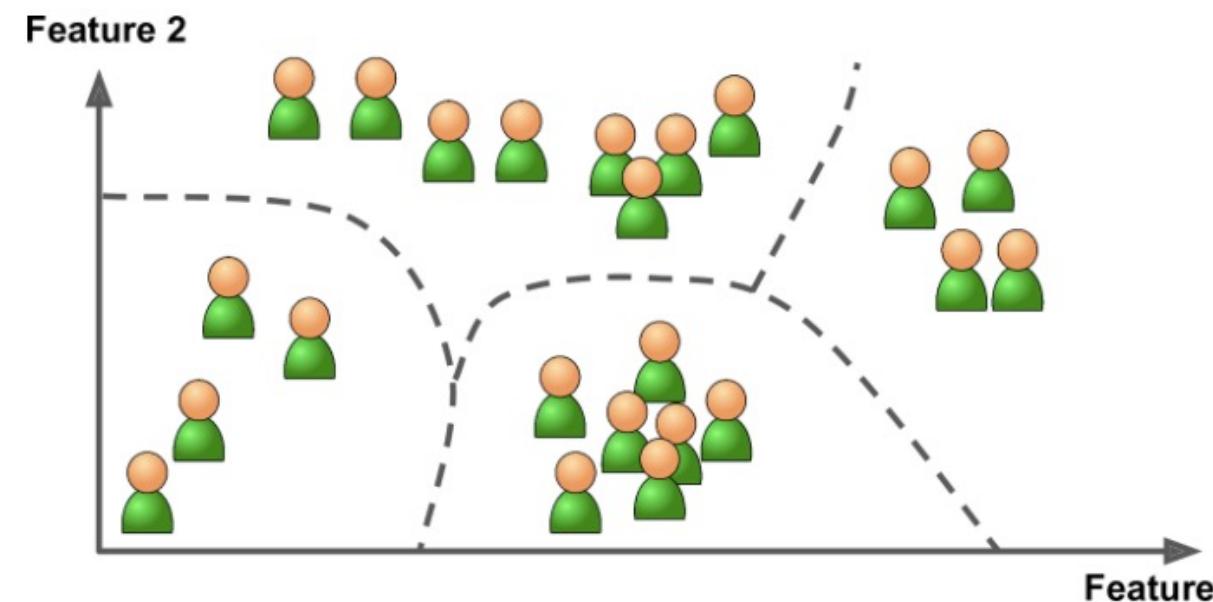
# Typical Algorithm Design

- Unsupervised Learning
  - Identify patterns by observing *unstructured* data
- Supervised Learning
  - Identify patterns by studying *structured* data with labels of expected outputs

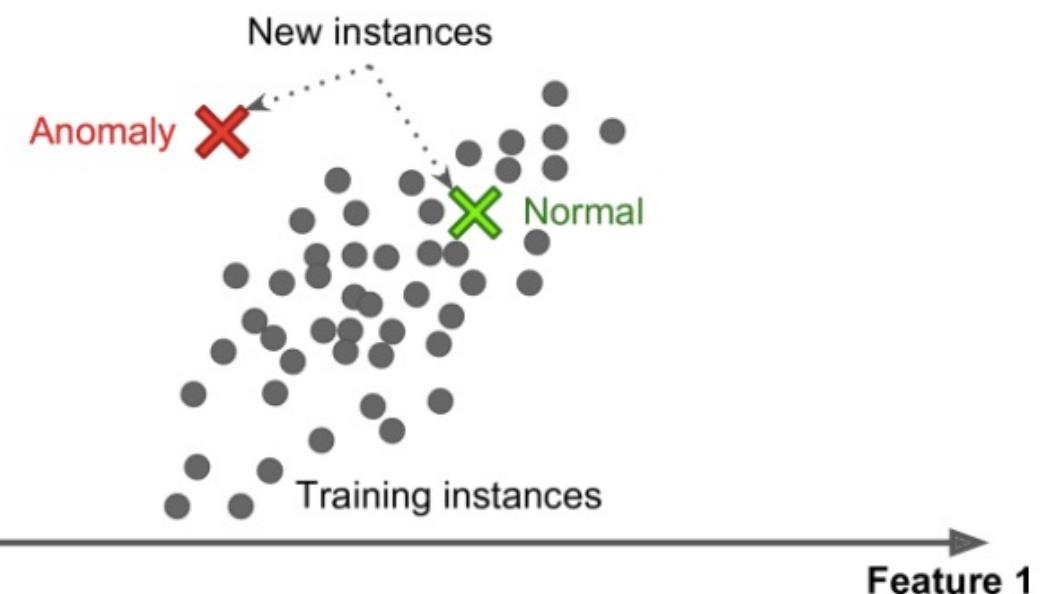


# Types of “Unsupervised” Learning Tasks

Clustering

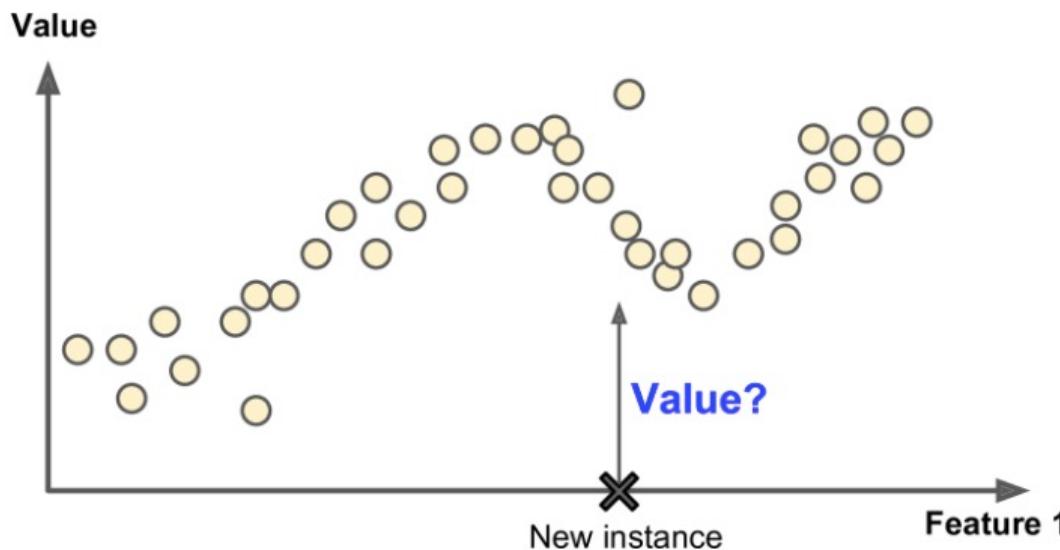


Anomaly Detection

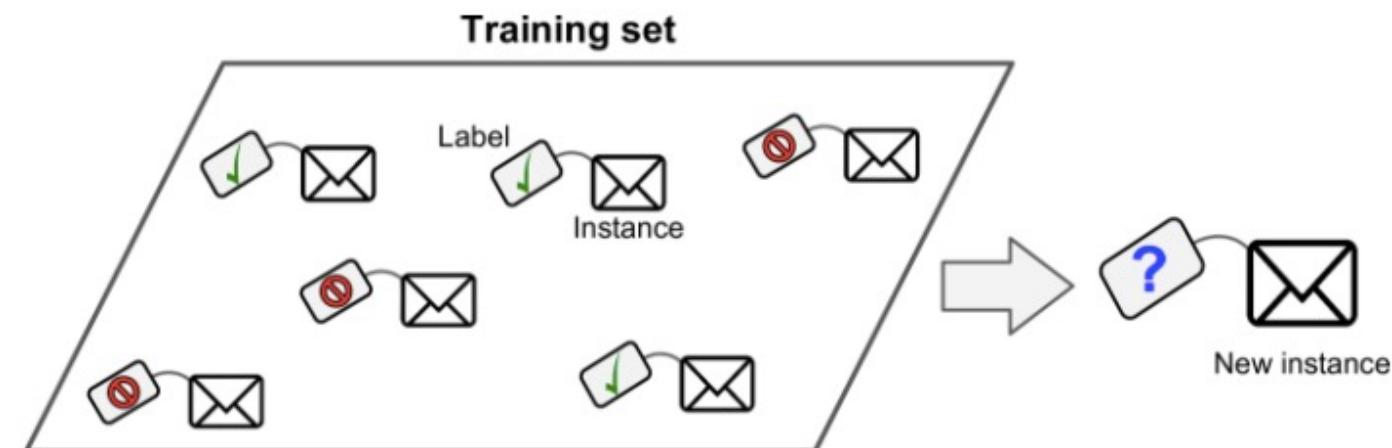


# Types of “Supervised” Learning Tasks

Regression  
(predict **continuous** value)

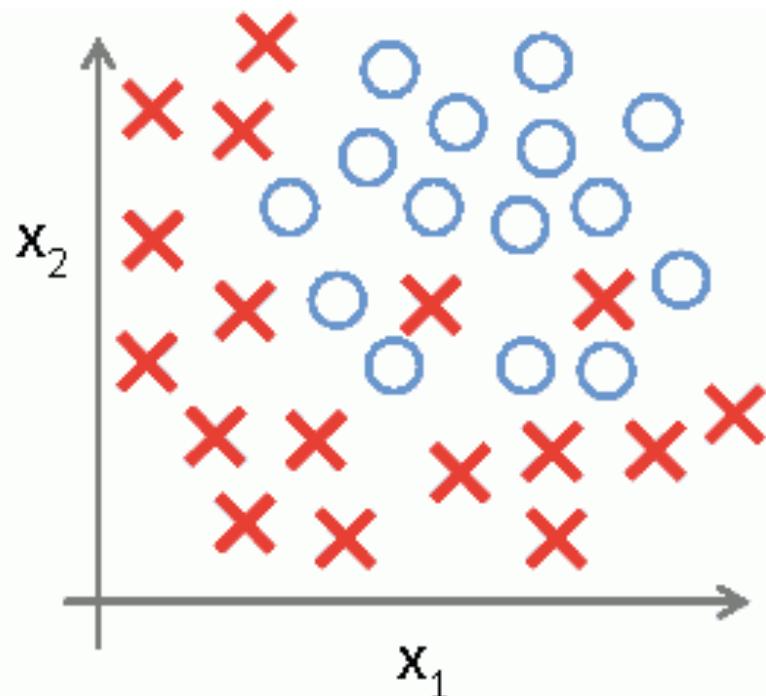


Classification  
(predict **discrete** value)



# Typical Supervised Learning Algorithm Design

- Model-based classification approach
  - e.g., create model to separate x from o

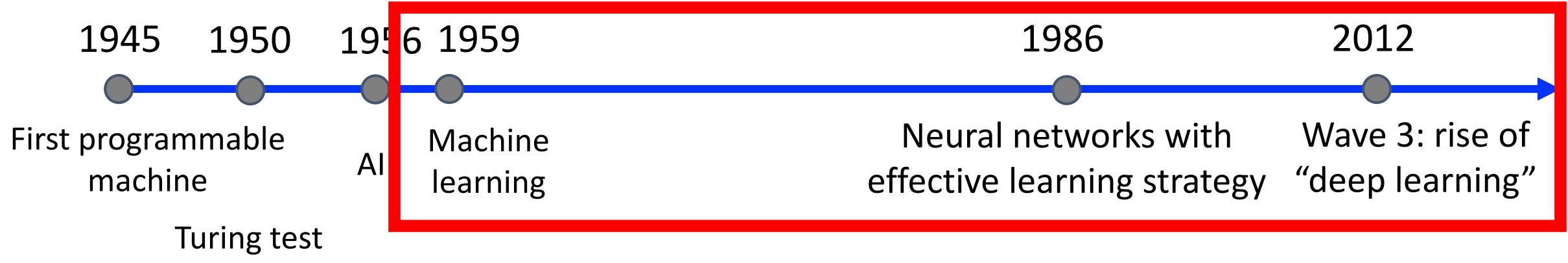


Class volunteer:  
1) Draw a straight line (linear equation)  
2) Draw a parabola (quadratic equation)  
3) Draw any curve

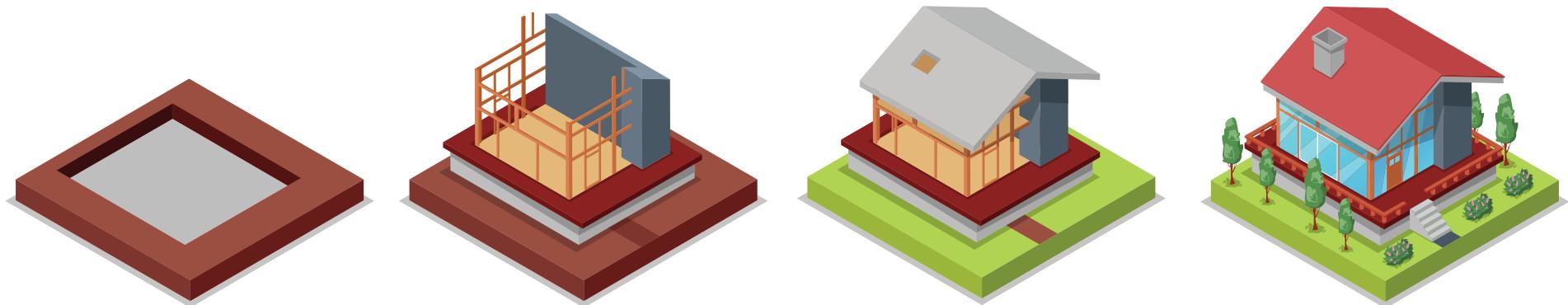
Models with increasing  
representational capacity

Figure source: <https://medium.com/greyatom/what-is-underfitting-and-overfitting-in-machine-learning-and-how-to-deal-with-it-6803a989c76>

# Algorithm Scope for Course: Last 65 Years

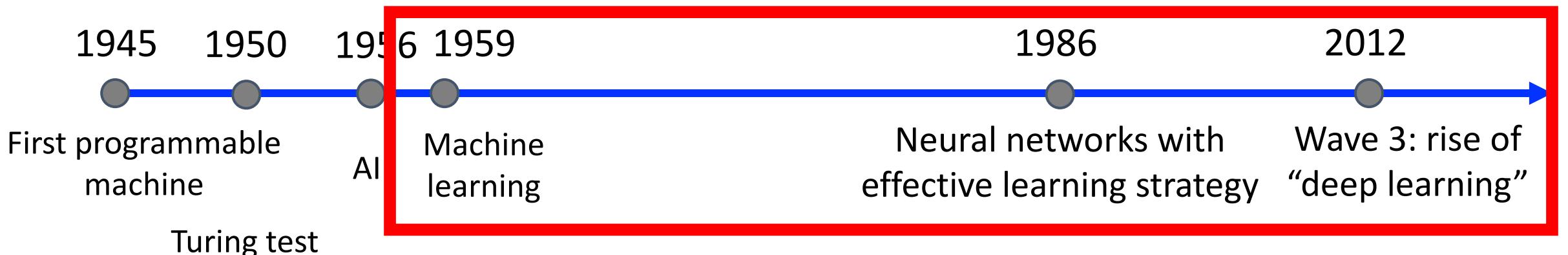


Analogous to understanding how houses we live-in work:



We study older algorithms because modern deep learning algorithms rely on techniques developed over the past 65 years.

# Algorithm Scope for Course: Last 65 Years



Week	Topic(s)	Week	Topic(s)
1	Introduction, Artificial neurons	9	Transformers
2	Feedforward neural networks (NN), NN training	10	Multimodal NN (vision + language)
3	NN training	11	Multimodal NN, Self-supervised learning, GANs
4	Convolutional neural networks (CNN), Introduction to CV	12	Few/zero-shot learning, Responsible/ethical learning
5	Training CNN algorithms	13	Deep learning in industry (guest speakers)
6	Regularization, Pretrained CNN features, Fine-tuning	14	Model compression, Efficient learning
7	Object detection, Semantic segmentation, Recurrent neural networks	15	NNs for speech processing & reinforcement learning
8	Introduction to natural language processing, Neural word embeddings, Attention	16	NN for information retrieval & course summary

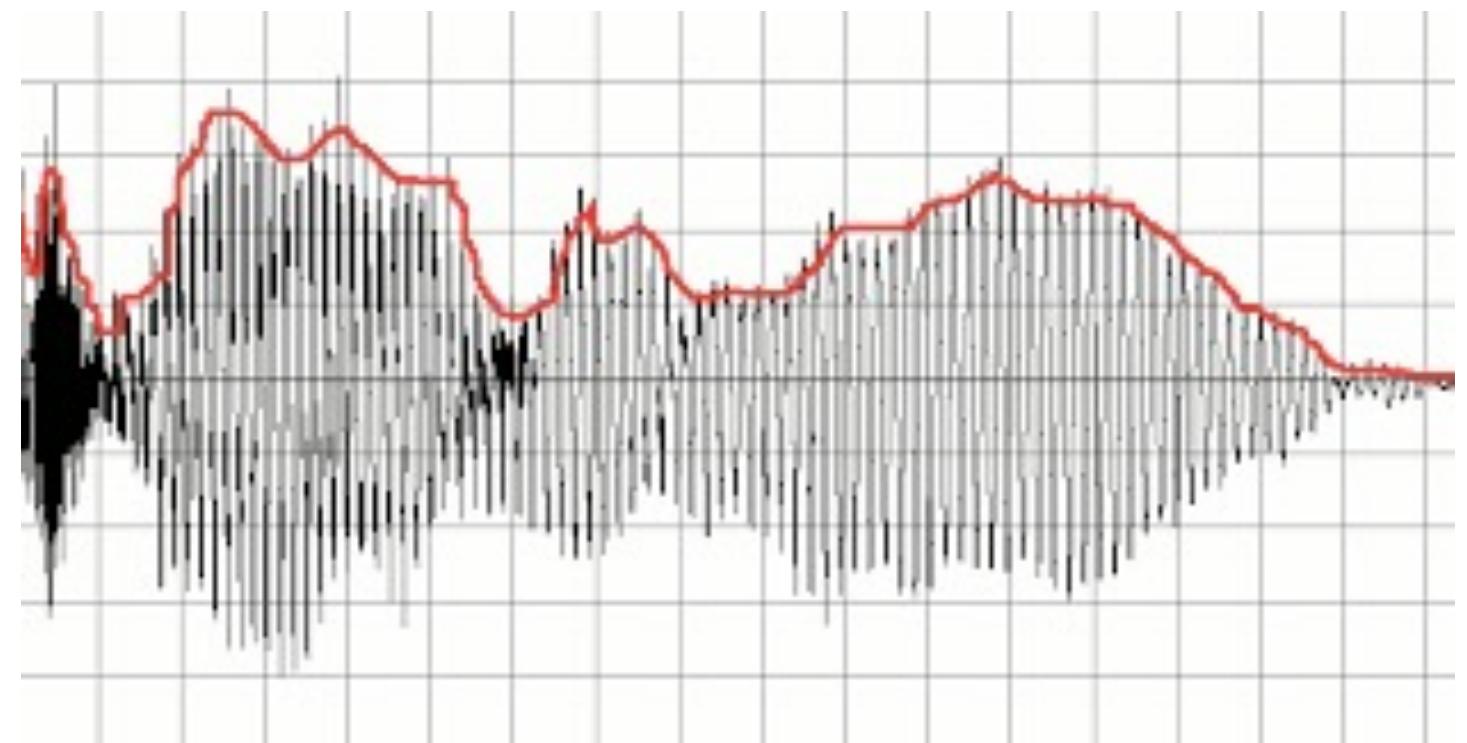
# General Idea

An algorithm learns from **data**  
patterns that will be used to  
make a prediction

# Data Types: What a Machine Learns From?



- Audio
  - Input?

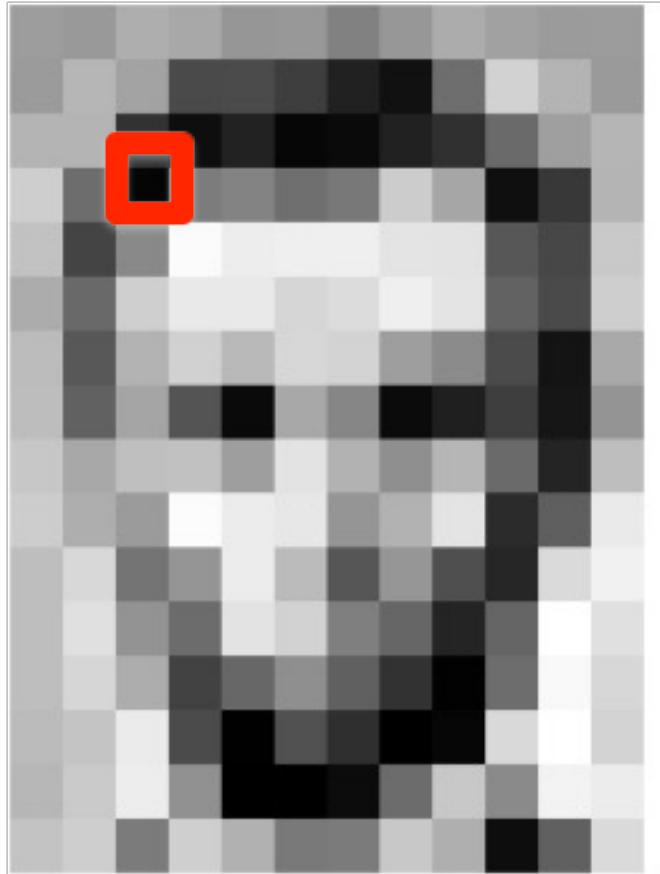


# Data Types: What a Machine Learns From?



- Audio
  - Input?
- Images
  - Input?

157	153	174	168	150	152	129	151	172	161	155	156
155	182	163	74	75	62	33	17	110	210	180	154
180	180	40	14	34	6	10	33	48	106	159	181
206	101	5	14	131	111	120	204	166	15	56	180
194	68	137	251	237	239	239	228	227	87	71	201
172	105	207	233	239	214	220	239	228	98	74	206
188	88	179	209	185	215	211	158	139	75	20	169
189	97	165	84	10	168	134	11	31	62	22	148
199	168	191	193	158	227	178	143	182	106	36	190
205	174	156	252	236	231	149	178	228	43	95	234
190	216	116	149	236	187	86	150	79	38	218	241
190	224	147	108	227	210	127	102	36	101	255	224
190	214	173	66	109	143	96	50	2	109	249	216
187	196	235	75	1	81	47	0	6	217	255	211
183	202	237	145	0	0	12	108	200	138	243	236
195	206	123	207	177	121	123	200	176	13	96	218



255

# Data Types: What a Machine Learns From?



- Audio
  - Input?
- Images
  - Input?
- Video
  - Input?

157	153	174	168	160	152	129	151	172	161	155	156
155	182	163	74	75	62	39	17	110	210	180	154
180	180	50	14	34	6	10	33	48	106	159	181
206	109	5	124	131	111	120	204	166	15	56	180
194	68	137	251	237	239	239	228	227	87	71	201
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188	88	179	209	185	215	211	158	139	75	20	169
189	97	166	84	10	168	134	11	31	62	22	148
199	168	191	193	158	227	178	143	182	106	36	190
205	174	195	252	236	231	149	178	228	43	95	234
190	216	116	149	236	187	86	150	79	38	218	241
190	224	147	108	227	210	127	102	36	101	255	224
190	214	173	66	103	143	96	50	2	109	249	215
187	196	235	75	1	81	47	0	6	217	255	211
183	202	237	145	0	0	12	108	200	138	243	236
195	206	123	207	177	121	123	200	175	13	96	218

Time 1

167	153	174	168	150	152	129	161	172	161	155	156
155	182	163	74	75	62	39	17	110	210	180	154
180	180	50	14	34	6	10	33	48	106	159	181
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183	202	237	145	0	0	12	108	200	138	243	236
195	206	123	207	177	121	123	200	175	13	96	218

1 hour

Analogous to:



# Data Types: What a Machine Learns From?



- Audio
  - Input?
- Images
  - Input?
- Video
  - Input?
- Text
  - Input?

e.g.,

Confidential letter sh

---

David-Khoza@mmoscacsv.com  
to ▾

.

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**2 Attachments**

I would like to share this confidential deal and opportunity with you, with the hope that we can work closely together for its success and mutual benefit. Our government account is currently struggling and pressuring payments from their contractors with whom they have contracts in the current year. My proposition is you to present your services for managing the backlog of a contractor and to guarantee a beneficiary of continued access to the value of that backlog.

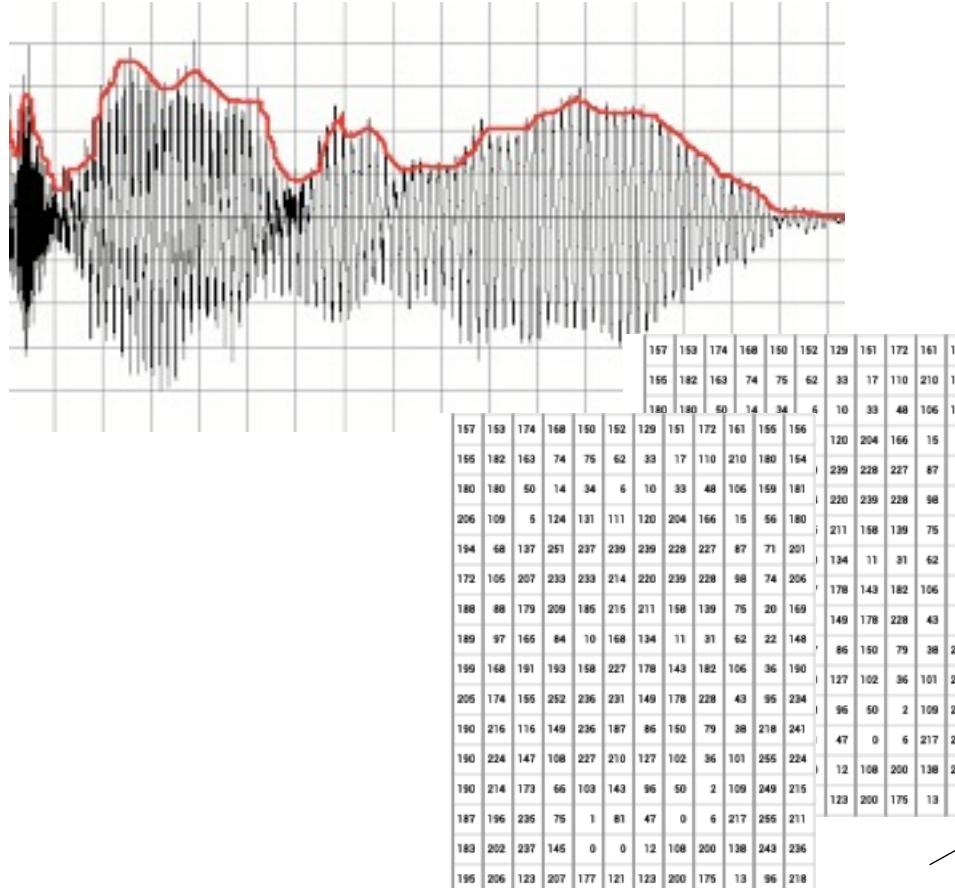
It is within my authority as the Director General in the ministry to sign off your proposal for profiling as one of our contractors and beneficiaries of payment, regardless until payment that particular debt that will be investigated, assessed and approved by the ministry and be appointed using tenders. This will officially place you as the contractor payment beneficiary. Once the contract payment is approved on your name, via ministry's appointed bank will pay you the annual UNDISBURSED. This opportunity will be beneficial to both of us and I have received over all modality to achieve a successful completion of the transaction.

Note that you do not require to possess one and have valid or professional license. This transaction is being made free and there are no legal obligation for any consequential profiling. I guarantee that it will be measured under a legitimate arrangement without any breach of the law either here in South Africa or elsewhere. Once your contract payment is approved and the transfer is concluded to your account, with funds to be held with you and not with those the South Africa rates of 5% for me, and 10% for you as your benefit. I urge for you full cooperation in this deal, and always maintain an amicable level of communication and confidentiality, respecting your position in this government agency. The transaction will be done officially in the most secure manner using electronic signature and standard banking procedures.

# Data Types: What a Machine Learns From?



- Audio
  - Input?
- Images
  - Input?
- Video
  - Input?
- Text
  - Input?
- Multi-modal
  - Input? - combination of the above



157	153	174	168	160	152	129	151	172	161	155	156
155	182	163	74	75	62	38	17	110	210	180	154
180	180	50	14	34	6	10	33	48	106	159	181
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194	68	137	251	237	239	239	228	227	87	71	201
172	105	207	233	233	214	220	239	228	98	74	206
188	88	179	209	185	215	211	158	139	75	20	169
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190	214	173	66	103	143	96	50	2	109	249	215
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195	206	123	207	177	121	123	200	175	13	96	218

Confidential letter sh

David-Khoza@mmoscacsv.com  
to

# Data Types: Many Public Datasets Available

- Dataset creation is beyond the scope of this class
- We will benefit from other people's efforts:
  - [Google Dataset Search](#)
  - [Amazon's AWS datasets](#)
  - [Kaggle datasets](#)
  - [Wikipedia's list](#)
  - [UC Irvine Machine Learning Repository](#)
  - Quora.com
  - Reddit
  - Dataportals.org
  - Opendatamonitor.eu
  - Quandl.com

# General Idea

An **algorithm** learns from **data**  
patterns that will be used to  
make a prediction

# Why Are Neural Networks and Deep Learning So Popular? – Its Success in Practice!

Its success was realized with the relatively recent onset of:

1. **Big data**: originally, often from the Internet
2. **Better hardware**: faster hardware and more storage enabled practically fast “deep learning”

# Neural Networks: Key Ingredients for Success

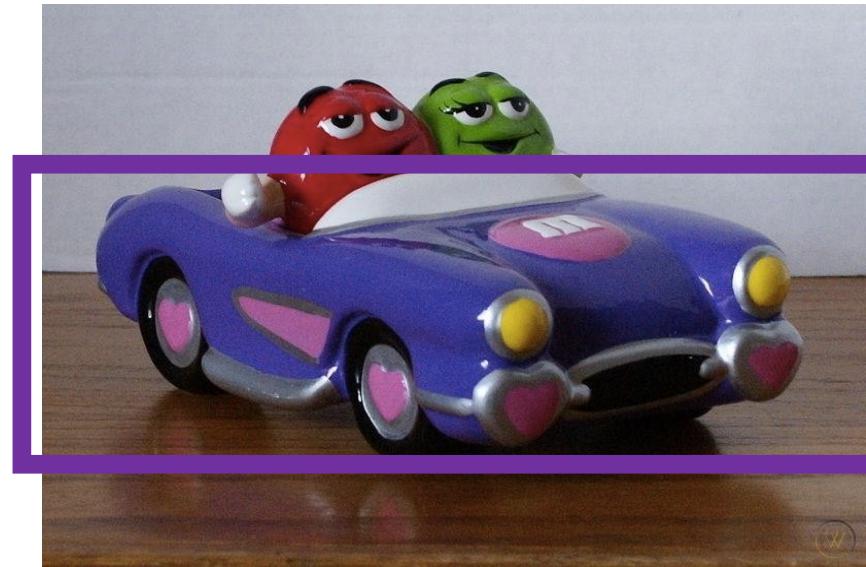
An **algorithm** learns from **data**  
on a **processor** the patterns that  
will be used to make a prediction



Analogous to a Love Story of Partnering Up and Road Tripping Somewhere

# Key Challenge 1: How Long Does Learning Take?

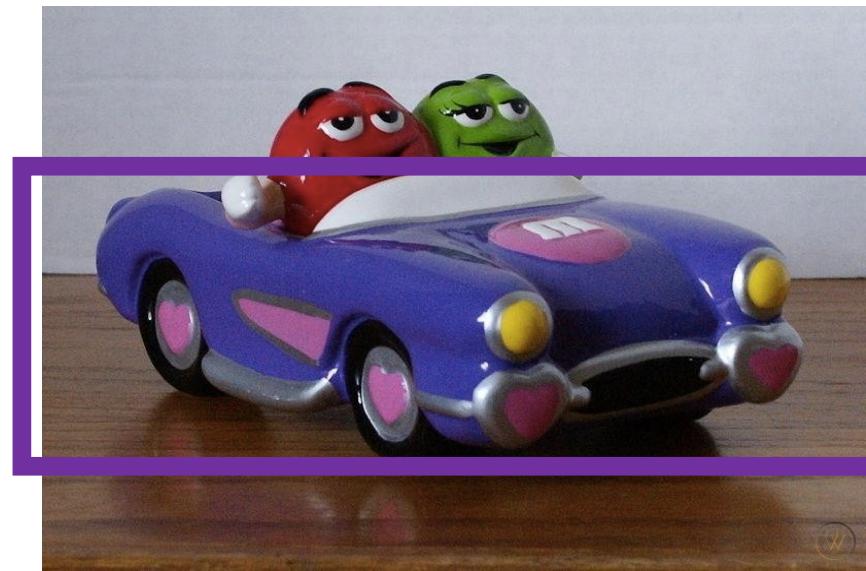
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# Key Challenge 1: How Long Does Learning Take?

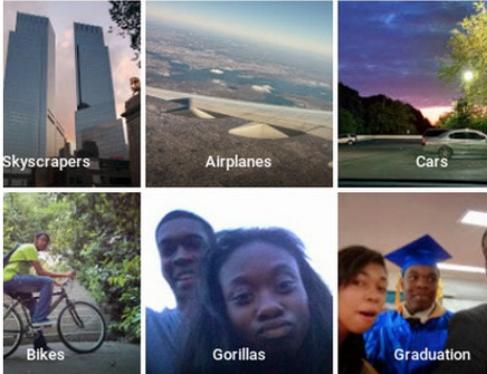
e.g., Train Algorithms Using  
**GPUs (think Porsche) Instead of CPUs (think Golf Cart)**



# Key Challenge 2: Where Will You Go?

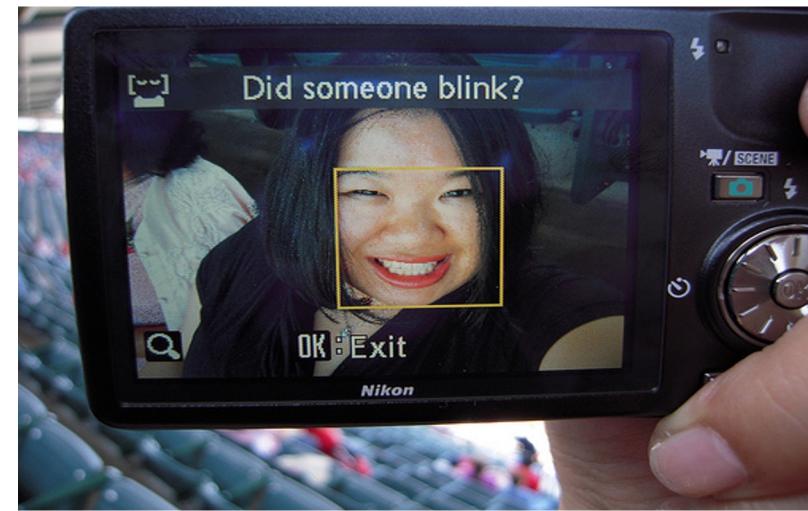
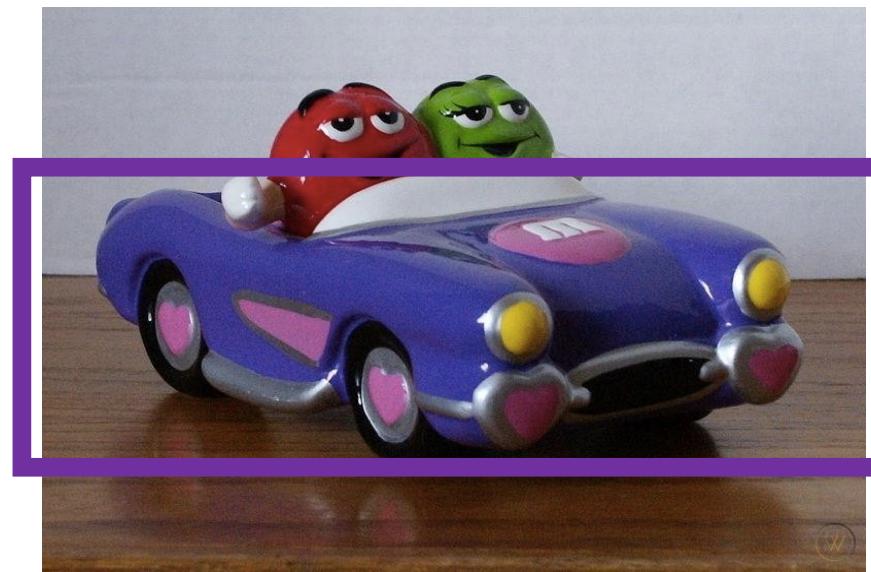
 **diri noir avec banan**  
@jackyalcine

Google Photos, y'all fucked up. My friend's not a gorilla.



Using Twitter to call out Google's algorithmic bias

<https://www.theverge.com/2015/7/1/8880363/google-apologizes-photos-app-tags-two-black-people-gorillas>



Two kids bought their mom a camera for Mother's Day... when they took portrait pictures of each other, a message flashed across the screen asking, "Did someone blink?"

<http://content.time.com/time/business/article/0,8599,1954643,00.html>

# Today's Topics

- Applications
- History of neural networks and deep learning
- How does a machine learn?
- Course logistics

# Introductions

**Instructor:** Danna Gurari; aka, Dr. G  
(preferred pronouns: she/her)



**Teaching assistant:** Samreen Anjum  
(preferred pronouns: she/her)



**Teaching assistant:** Lucas Hayne  
(preferred pronouns: he/him)



# Introductions

NameCoach: share your name pronunciation in Canvas

To record your name:

1. Find NameCoach in Canvas courses page
2. Click on record button to start
3. Review recording by clicking on play button

BigBlueButton  
Collaborations  
Chat  
Attendance  
My Media  
Web Grading Sync  
New Analytics  
**NameCoach** 1.  
CU Boulder Libraries  
Studio  
Zoom  
Piazza  
Course Materials  
Files   
Settings

## NameCoach info for CSCI 5922: Neural Nets and Deep Learning

### Your recording for CSCI 5922: Neural Nets and Deep Learning



### Recordings for CSCI 5922: Neural Nets and Deep Learning

Recorded Names	Unrecorded Names
1 person have recorded their name	
Show entries per page	
10	
Name/email	Last Name 
Name Pronunciation Invited At 	
Danna Gurari	 Danna Gurari
	Invited At: 08.09.2022
	Recorded At: 01.05.2022

# Course Objectives

- Understand the key concepts for designing deep learning models:
  1. Characterize the process to train and test deep learning algorithms
  2. Identify the challenges for designing modern deep learning algorithms that can harness today's 'big' data
  3. Recognize strengths and weaknesses of different deep learning algorithms
- Apply deep learning models to perform various AI tasks:
  1. Experiment with deep learning libraries, including scikit-learn and Keras
  2. Evaluate deep learning algorithms for tasks in various application domains, including for analyzing text and images

# Course Objectives

- Conduct and communicate a novel project:
  1. Propose a novel project idea (this will be an iterative process)
  2. Design and execute experiments to support the proposed idea
  3. Create a presentation about the project
  4. Write a report about the project

# Course Overview

- Website
  - [https://home.cs.colorado.edu/~DrG/Courses/NeuralNetworksAndDeepLearning/  
AboutCourse.html](https://home.cs.colorado.edu/~DrG/Courses/NeuralNetworksAndDeepLearning/AboutCourse.html)
- Syllabus on website

<b>% of Final Class Grade</b>	
• Grading :	Problem Sets 25%
	Lab Assignments 35%
	Final Project 40%

# Q&A: “What are the assignments?”

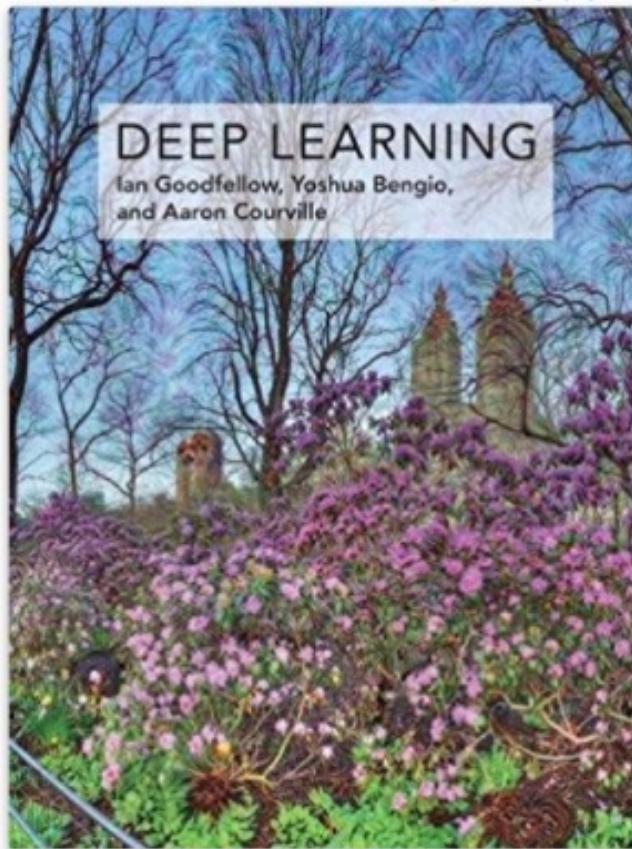
- 3 problem sets ([first assignment due next week](#))
- 4 lab assignments
- Final project
  - Proposal
  - Outline
  - Presentation
  - Final report
- Grading policies:
  - Late policy: Penalized 1% per hour for up to 2 hours and no credit afterwards
  - Regrade requests: Must be submitted within 2 weeks of receiving the grade to the TA, Samreen Anjum. After the allotted time frame, regrade requests will not be considered.
- Grading timeline
  - Due to many students (100+) and 2 graders, expect to receive grades ~1 week after submission

# Q&A: “Do I have the appropriate pre-requisites/background?”

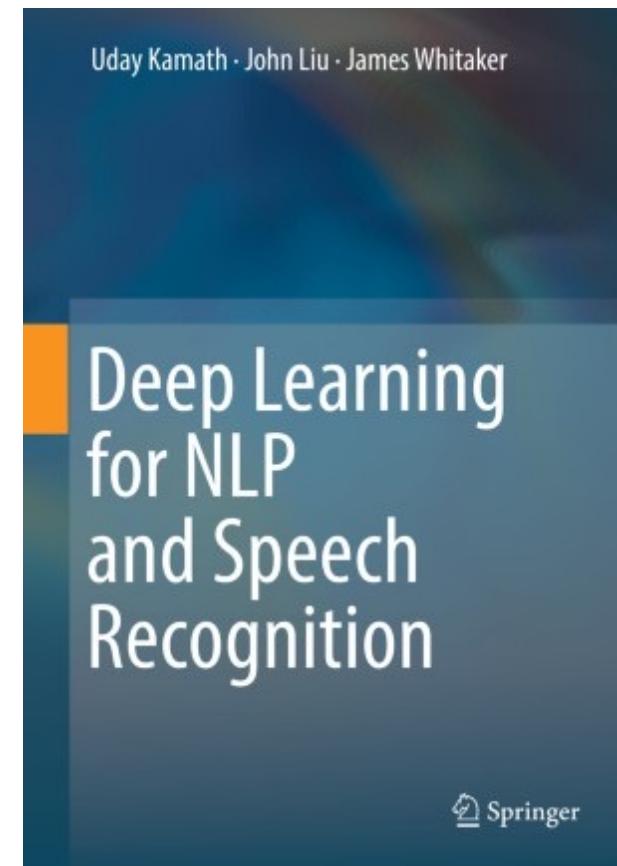
- You are expected to have programming competency as well as experience with probability/statistics and linear algebra.

# Q&A: “What are required textbooks?”

(available online for free)



(available online for free when connected  
to CU Boulder’s network or VPN)



# Q&A: “How Do I Contact You for Questions?”

- **Questions for Instructor:** I will stay after each class lecture to answer questions.
- **Piazza:** We encourage you to first post any questions to Piazza. This can benefit other students, who may have similar questions, to see the answers posted on Piazza and it also allows peers to answer your questions. You can post questions to Piazza from Canvas.
- **Office Hours:** The TAs will host office hours every day from Monday to Friday. To attend, please enter your name on the office hours spreadsheet shared in Canvas and Piazza and then join the video meeting link shared on Canvas.
- **Appointments:** Email the TA to make an appointment or solicit an answer. Please note that at least 24 hours notice will typically be needed before the TA will be able to meet. The TA will involve the instructor for any items she is unable to address.
- **Regrade requests:** All requests must be emailed to the TA, Samreen Anjum, within 2 weeks of receiving the grade to be considered.

# My Experience Related to Deep Learning

2007-2010

2010-2015

2015-2017

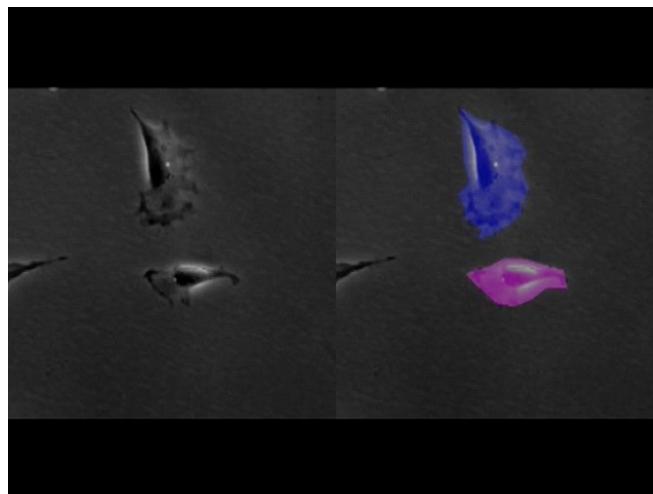
2017-Present

Software developer and project manager helping to record and analyze visible and infrared video



Source: Boulder Imaging

PhD student designing computer vision methods to segment and track cells in images and videos



Postdoctoral fellow conducting research projects related to vision and language problems



Is it edible or  
poisonous?

Assistant professor overseeing research projects related to many vision and language problems

e.g., image classification, object detection, semantic segmentation, object tracking, image captioning, visual question answering, style transfer, image inpainting, and image search

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2007-2010

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2015-2017

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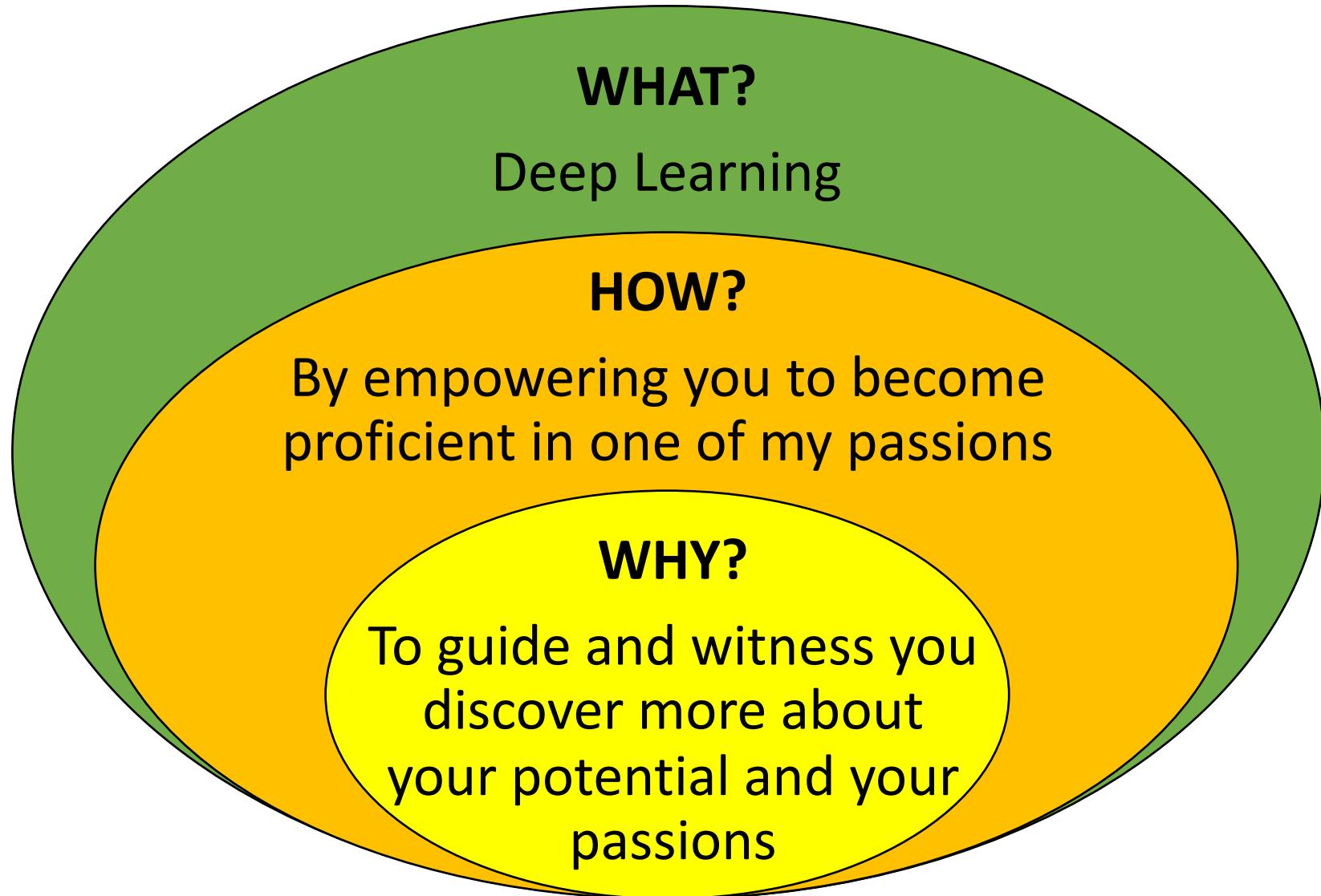
20 publications involving deep learning



Is it edible or poisonous?

style transfer, image inpainting, and image search

# What is My “Why” for Teaching You...



# Today's Topics

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- History of neural networks and deep learning
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*The End*