Introduction to Machine Learning

Spring 2018

Today’s Topics

- Class logistics
- Why machine learning?
- What does a machine learn?
- Designing a “supervised” machine learning algorithm
- Lab

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Introductions

Instructor: Danna Gurari

Danna: pronounced like “Donna”

Gurari: rhymes with Ferrari

Interdisciplinary class: introduce yourself & share about your

- career aspirations
- experience with machine learning and programming

Class Overview and Logistics

- Typical class format:
  - First half = lecture + discussion
  - Break = snacks provided
  - Second half = hands-on lab session

- Class website
  - Assignments
  - Schedule
  - Final Project

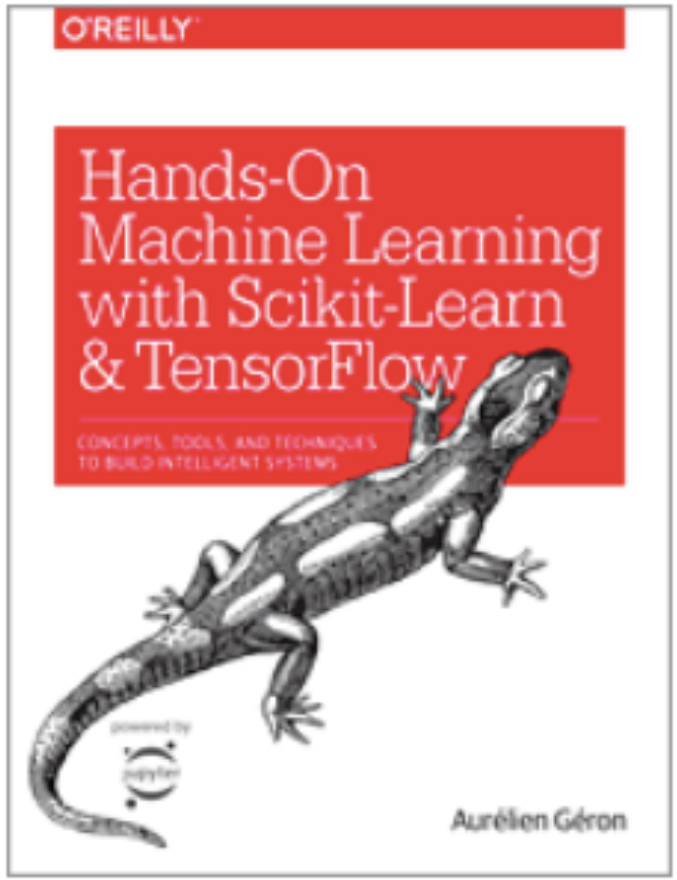
- Syllabus

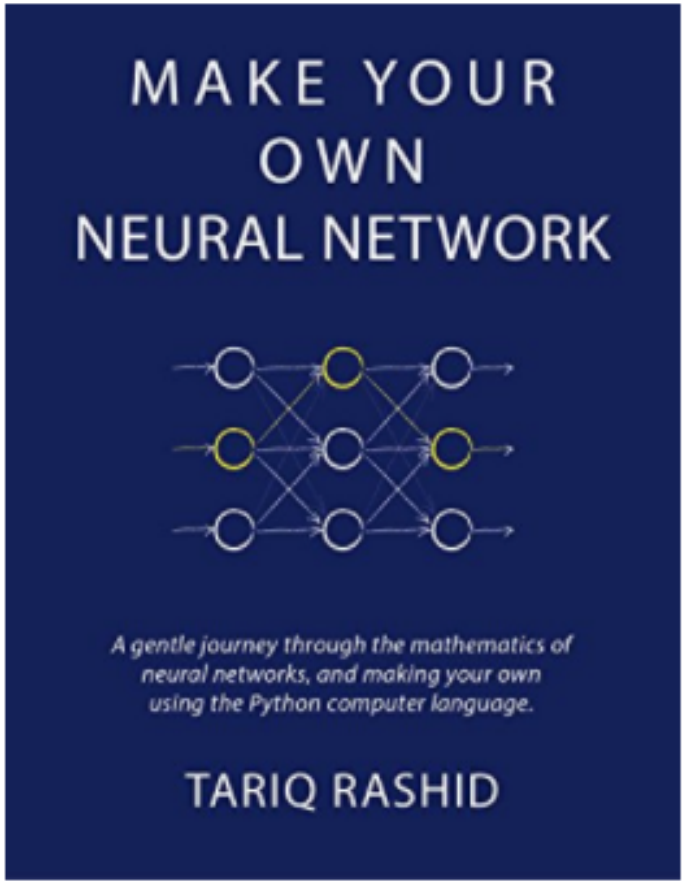
Q&A: “Do I have the appropriate pre-requisites/background?”

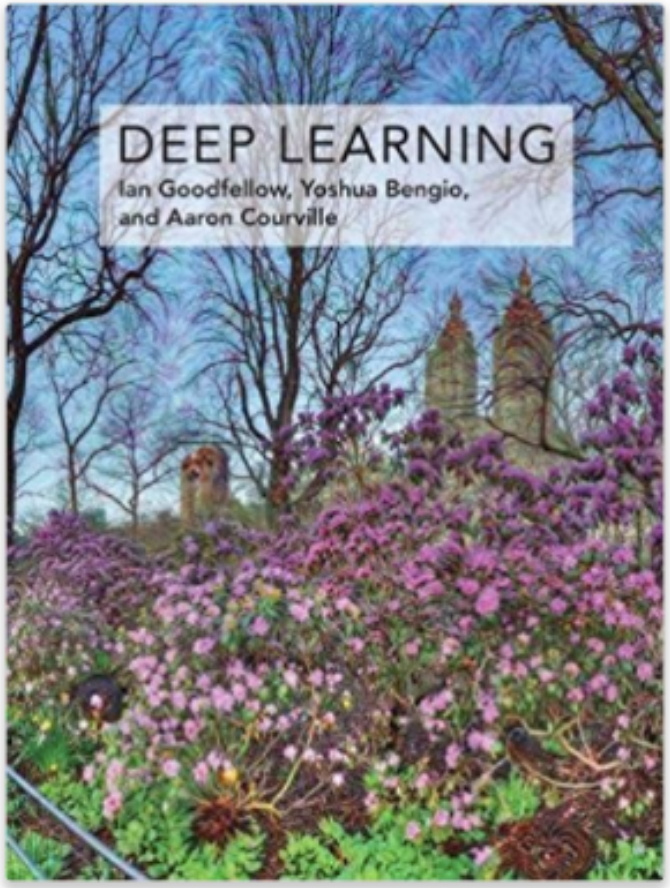
- Yes. There are no pre-requisites.
- You will be expected to further develop skills we cover in class on your own; e.g.,
  - Programming; e.g., Python
  - Linear algebra; e.g., vector/matrix manipulations
  - Calculus; e.g. partial derivatives
  - Probability; Bayes rule
  - Statistics; mean/median/maximum likelihood

Q&A: ““What are required textbooks?”

- None. The following are strongly recommended:







Congratulations!

- By taking this class, you receive a gift of:

- Thanks to: Microsoft Azure

Today’s Topics

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Origin of Machine Learning: Human “Computer”

- 1613-Present: https://en.wikipedia.org/wiki/Human_computer
  - i.e., a person performs calculations towards solving complex problems
  - e.g., astronomy, fluid dynamics, nuclear fission
  - e.g.,

:

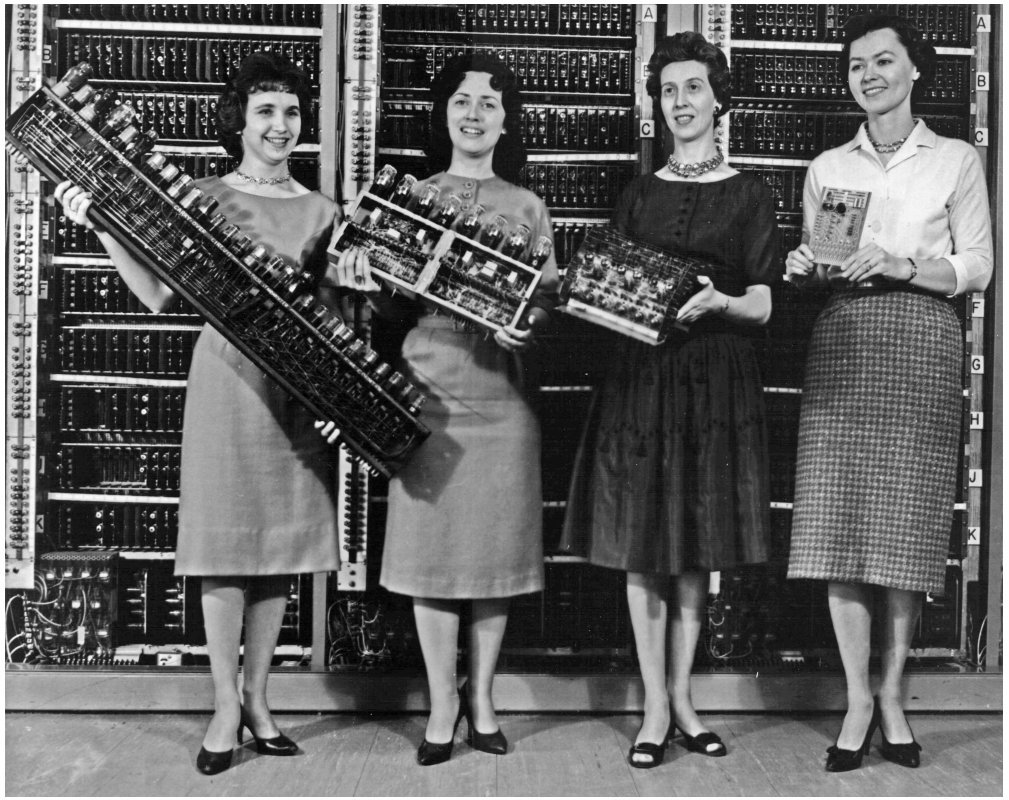
Dorothy Vaughn

Mary Jackson

Miriam Mann

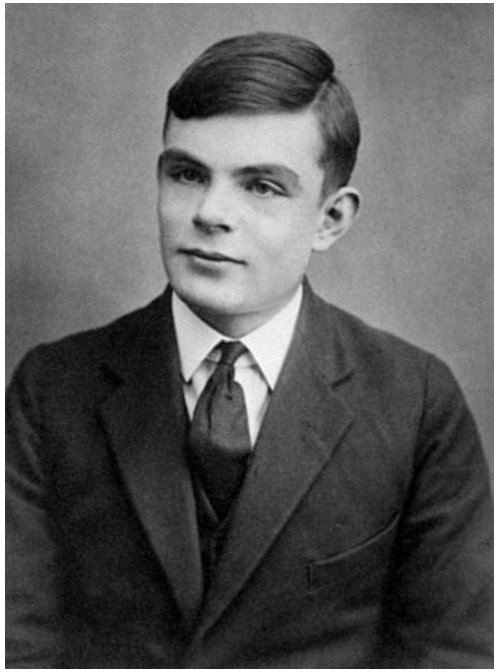
Origin of Machine Learning

- Timeline
  - Early 1940s: first computing machines created; e.g., ENIAC in World War II



Origin of Machine Learning

- Timeline
  - Early 1940s: first computing machines created; e.g., ENIAC in World War II
  - 1950: Alan Turing devises a test to decide if a machine's behavior is indistinguishable from that of a human



Turing Test:

Origin of Machine Learning

- Timeline
  - Early 194
  - 1950: Ala
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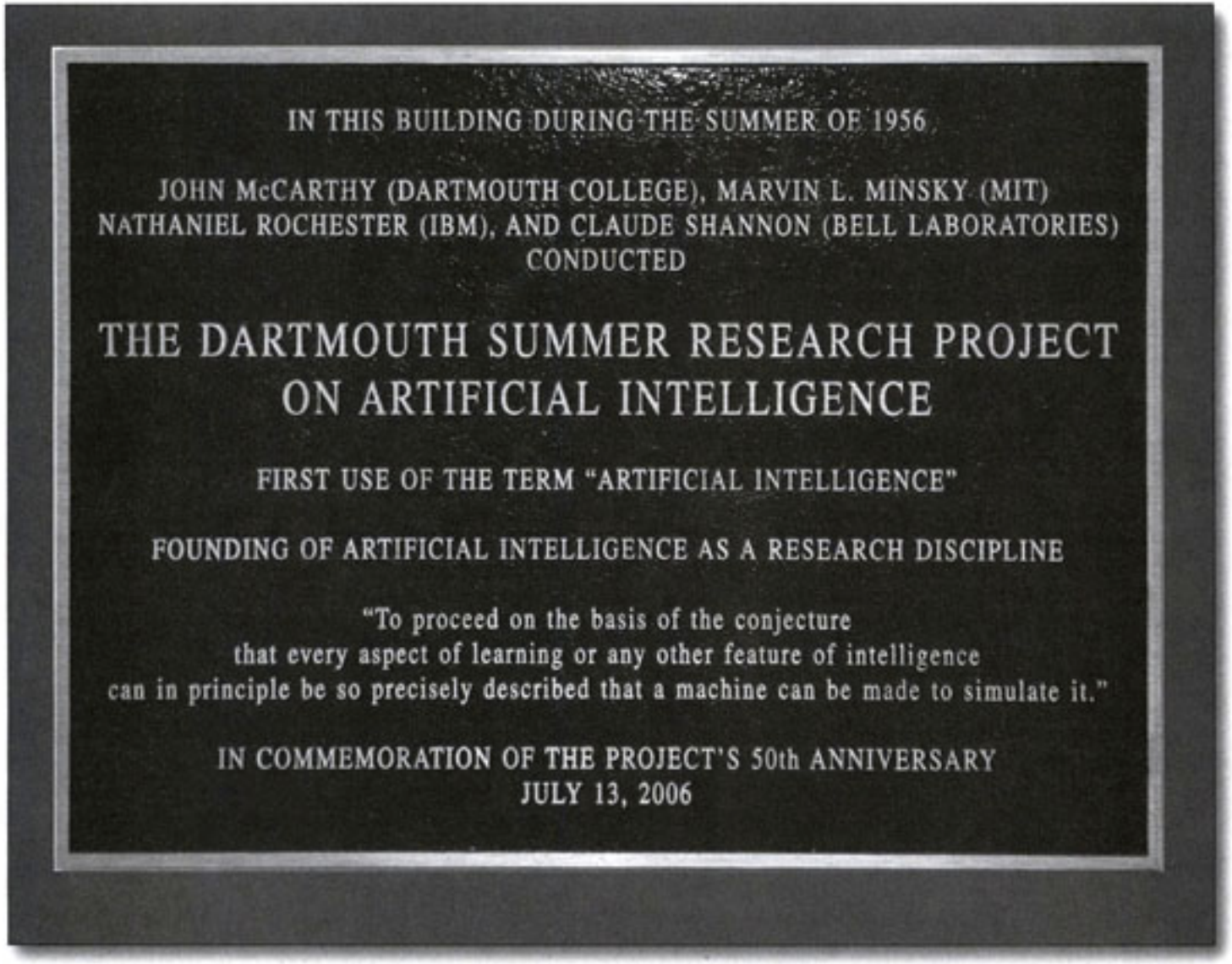

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Proposal Exc
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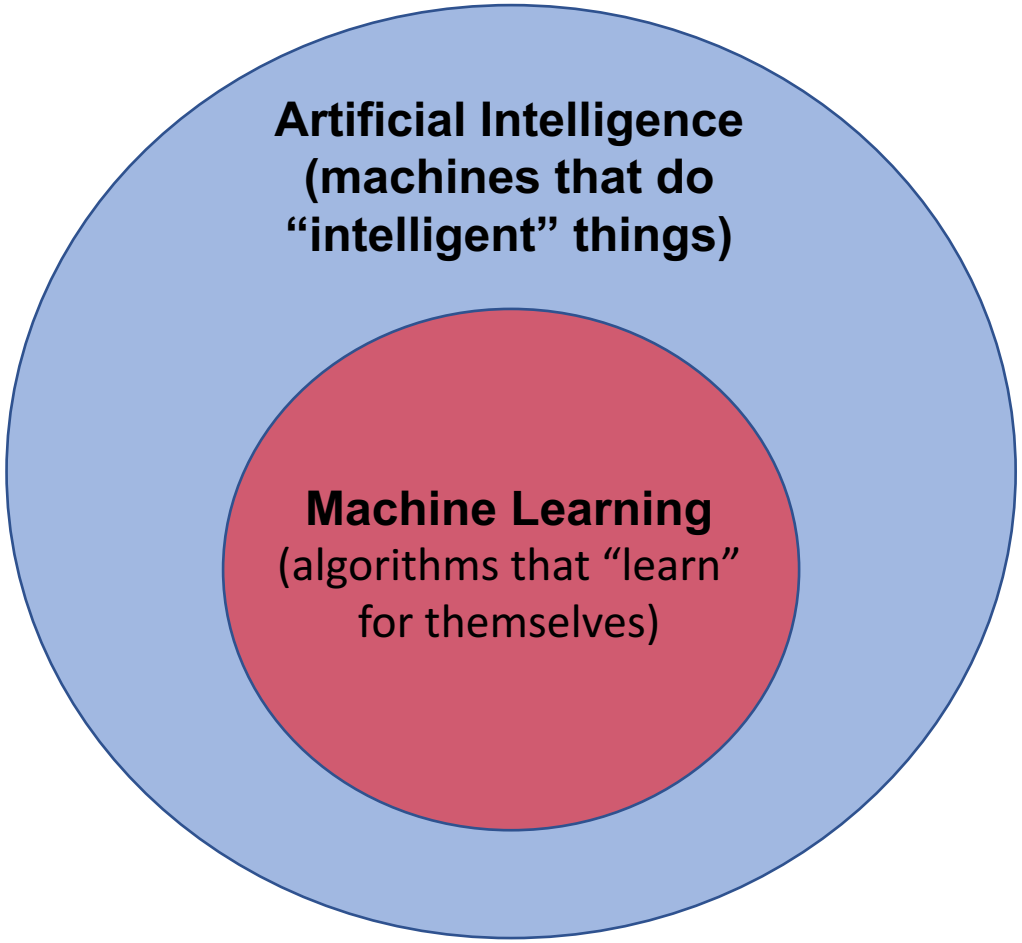
Origin of Machine Learning

- Timeline
  - Early 1940s: first computing machines created; e.g., ENIAC in World War II
  - 1950: Alan Turing devises a test to decide if a machine's behavior is indistinguishable from that of a human
  - 1956: birth of "artificial intelligence" (AI) as a field at a workshop called "Dartmouth Summer Research Project on Artificial Intelligence"
  - 1959: AI researcher coins the term "machine learning"

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

What is Machine Learning?

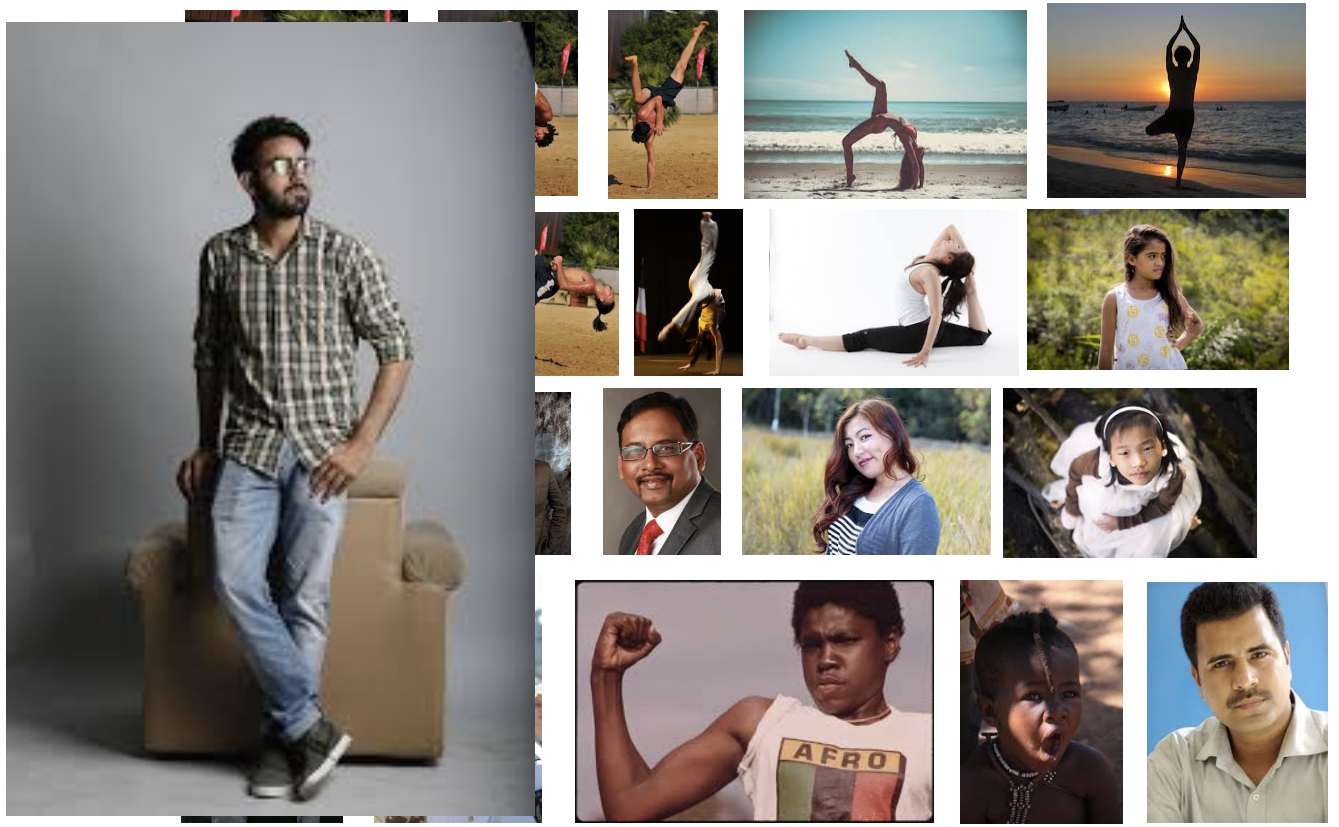


Why Have Machines “Learn”?

- It is hard to hand-craft a complete set of rules

Why Have Machines “Learn”?

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

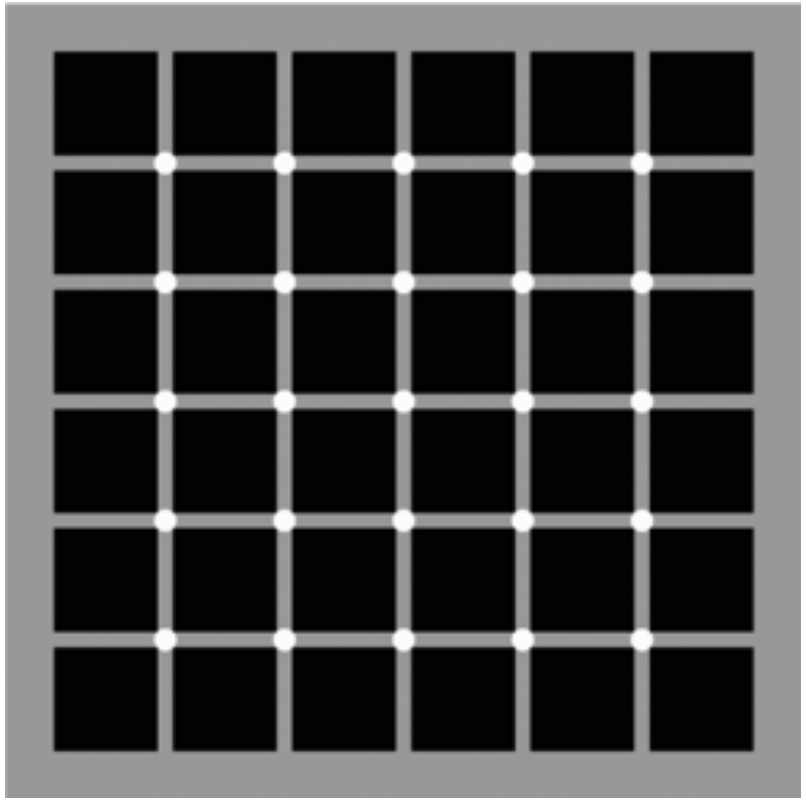


Why Have Machines “Learn”?

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

Why Have Machines “Learn”?

e.g., how many black dots do you see in the image?



Origin of Machine Learning

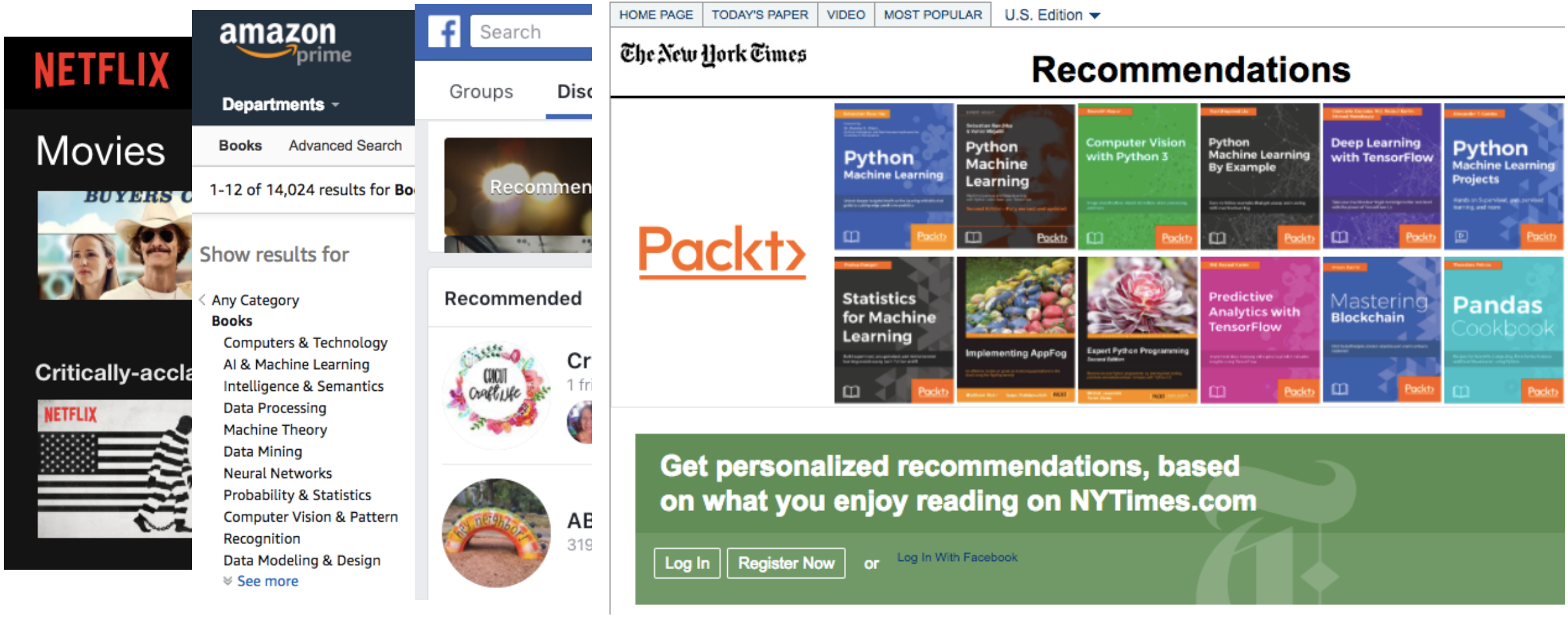
- Recall Timeline
  - Early 1940s: first computing machine created for U.S. Army during World War II
  - 1950: Alan Turing devises a test to decide if a machine's behavior is indistinguishable from that of a human
  - 1956: birth of "artificial intelligence" (AI) as official workshop called "Dartmouth Summer Research Project on Artificial Intelligence"
  - 1959: AI researcher coins the term "machine learning"

What has happened in the past 59 years?

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

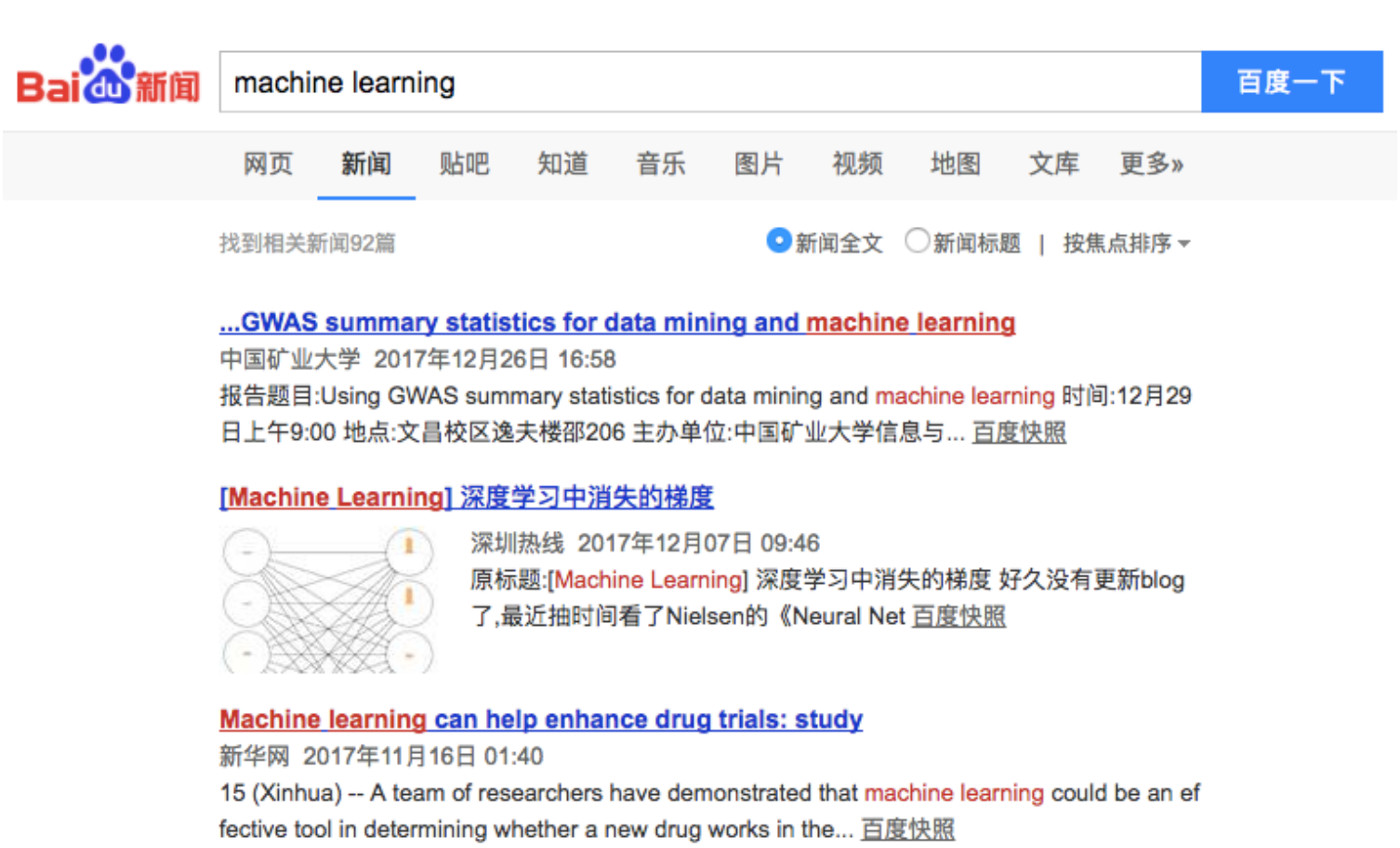
AI Problems Solved by Machine Learning Today

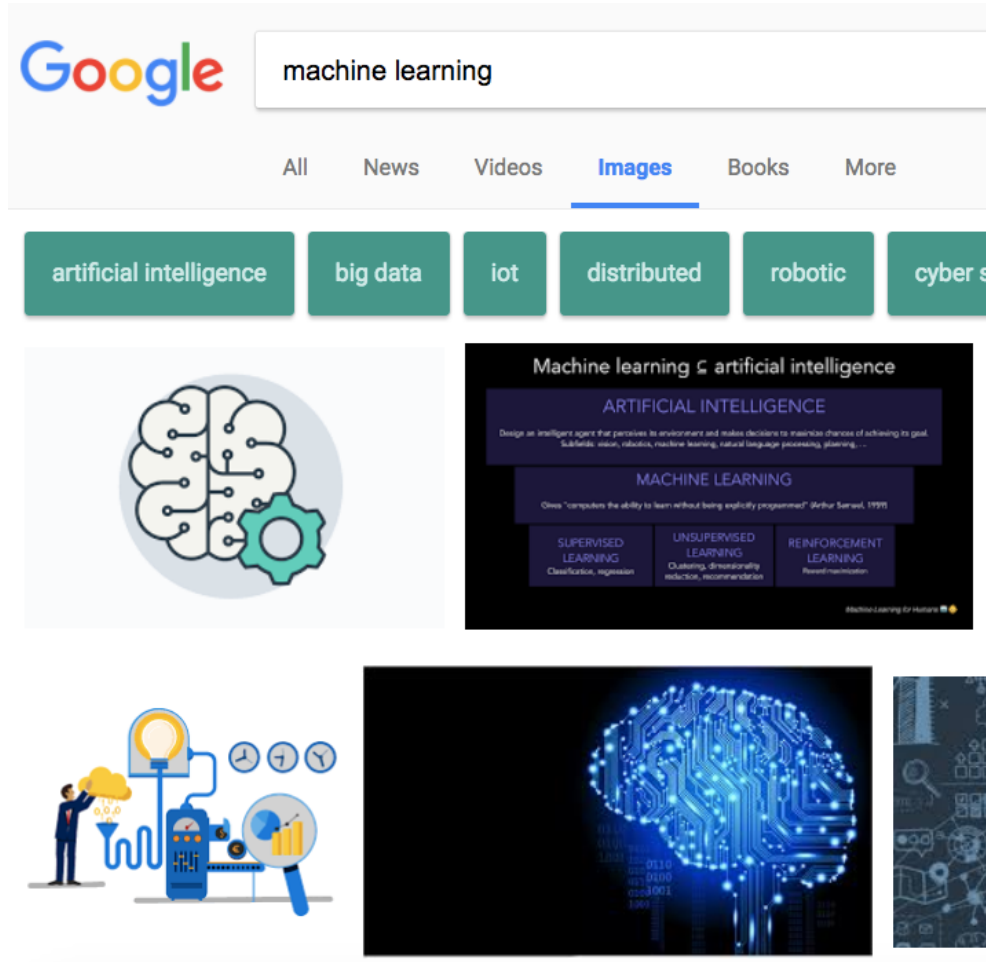
Recommendation Systems



AI Problems Solved by Machine Learning Today

Information Retrieval

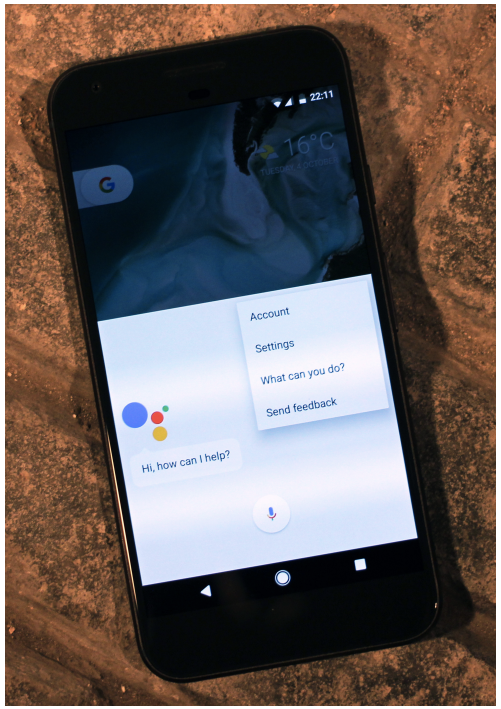




AI Problems Solved by Machine Learning Today

Recognition

(Face)



(Speech)

(Fraud)

AI Problems Solved by Machine Learning Today

Robotics

(Self-driving Vehicles)

(Medical Surgery)

(Manufacturing)

Today’s Topics

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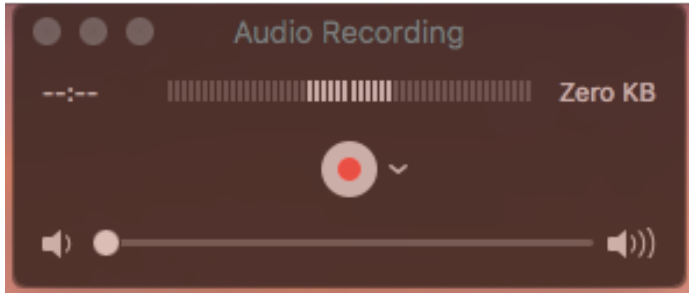
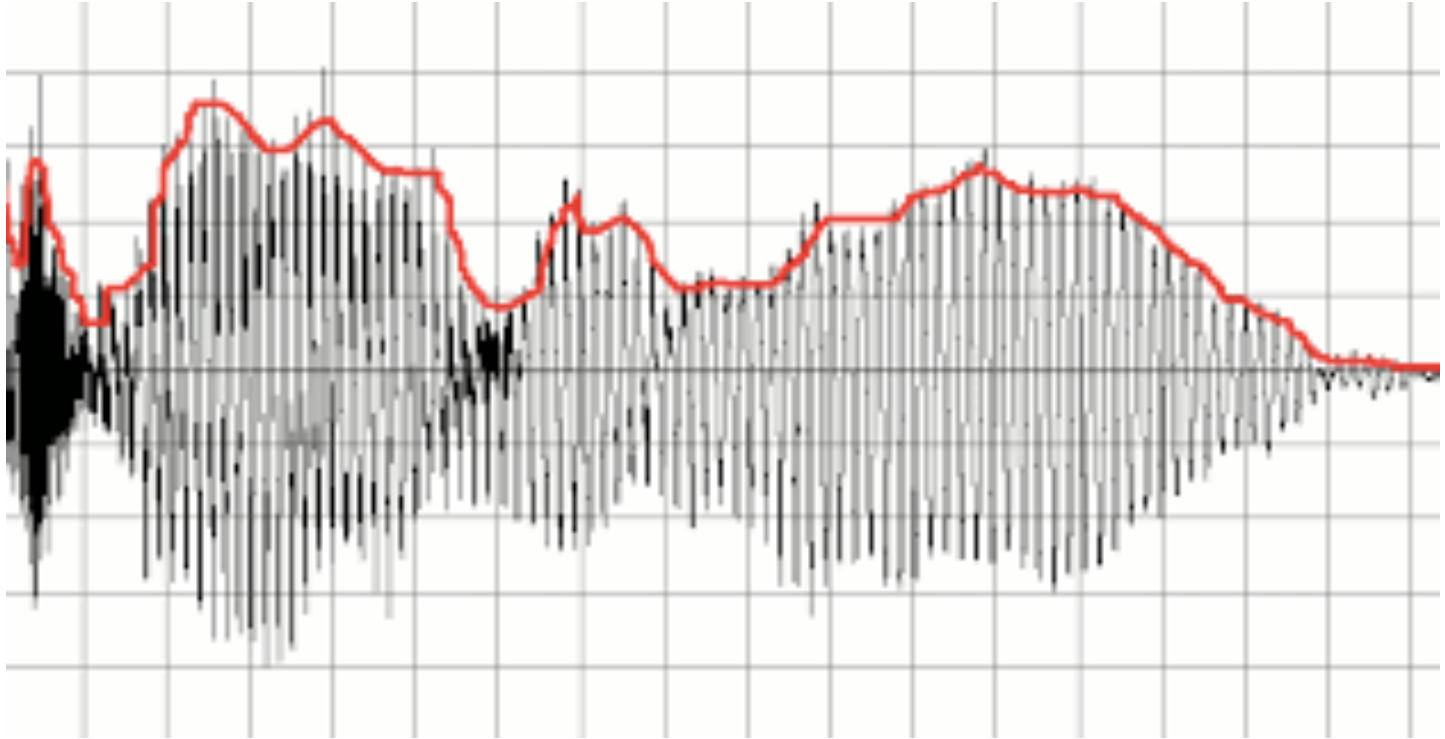
First: What Does a Machine Get?

- Audio
  - Input?



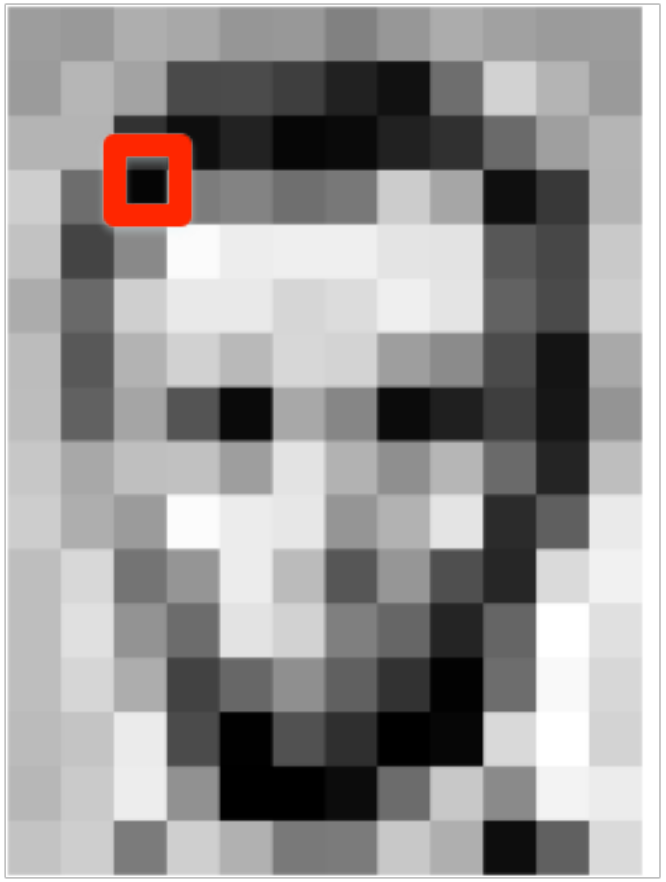
e.g.,



First: What Does a Machine Get?

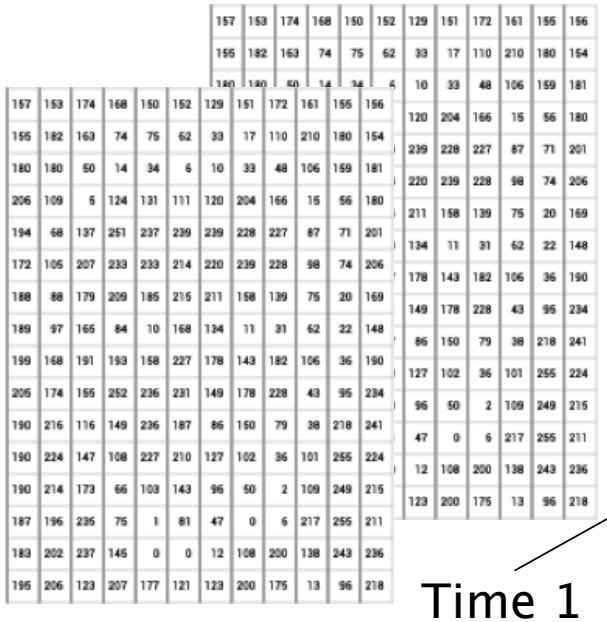
- Audio
  - Input?
- Images
  - Input?

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	50	14	34	6	10	33	48	106	159	181
206	109	5	24	131	111	120	204	166	15	56	180
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
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	155	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

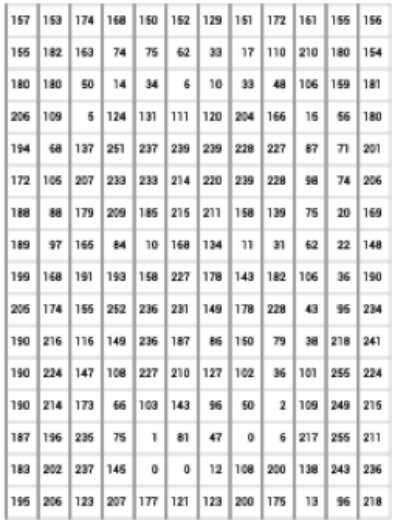


First: What Does a Machine Get?

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

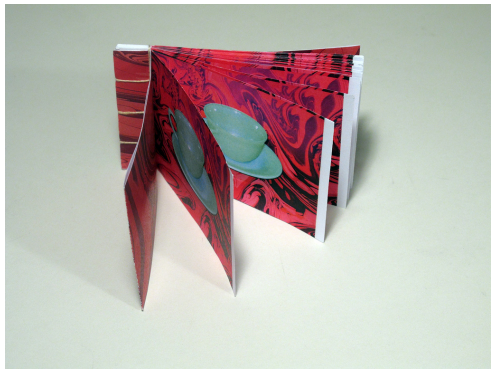


Time 1



1 hour

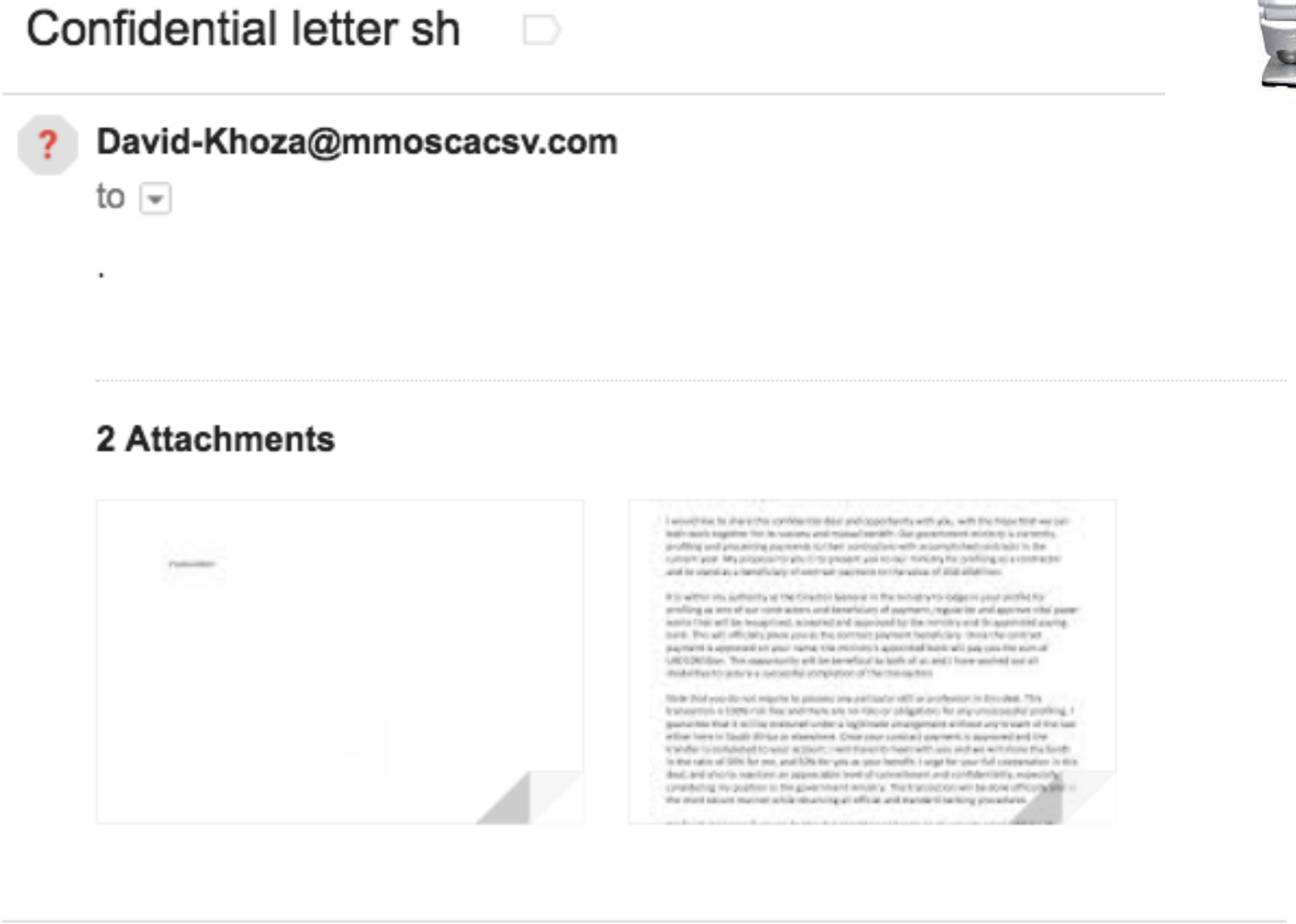
Analogous to:



First: What Does a Machine Get?

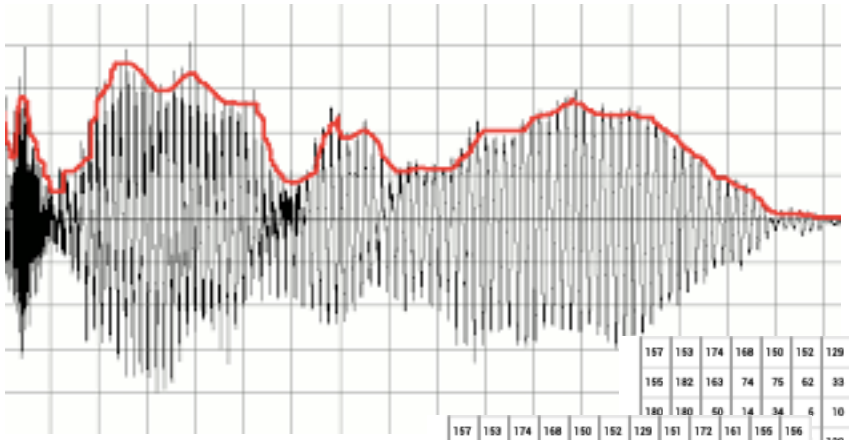
- Audio
  - Input?
- Images
  - Input?
- Video
  - Input?
- Text
  - Input?

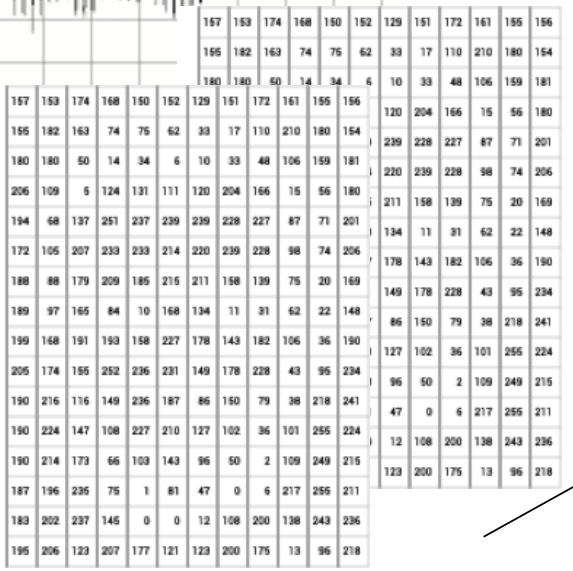
e.g.,

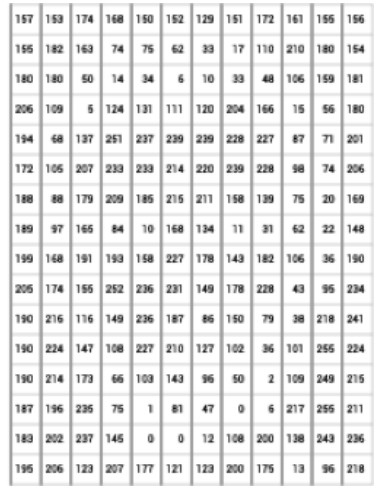


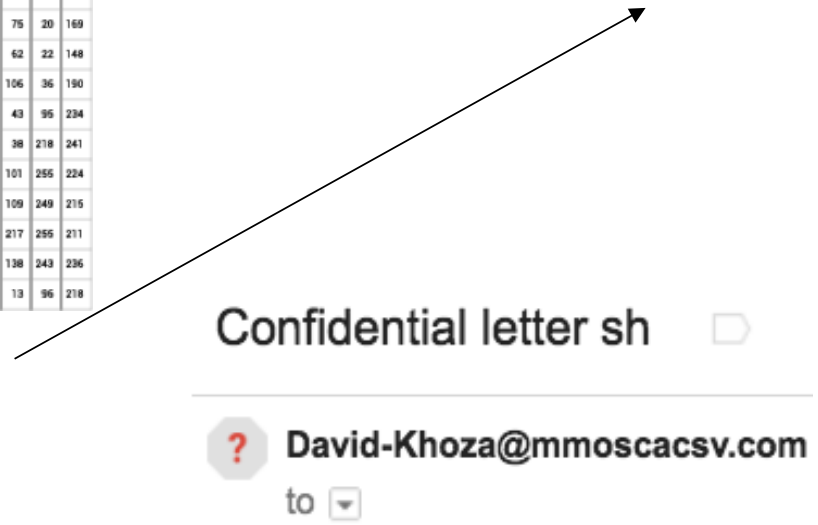
First: What Does a Machine Get?

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

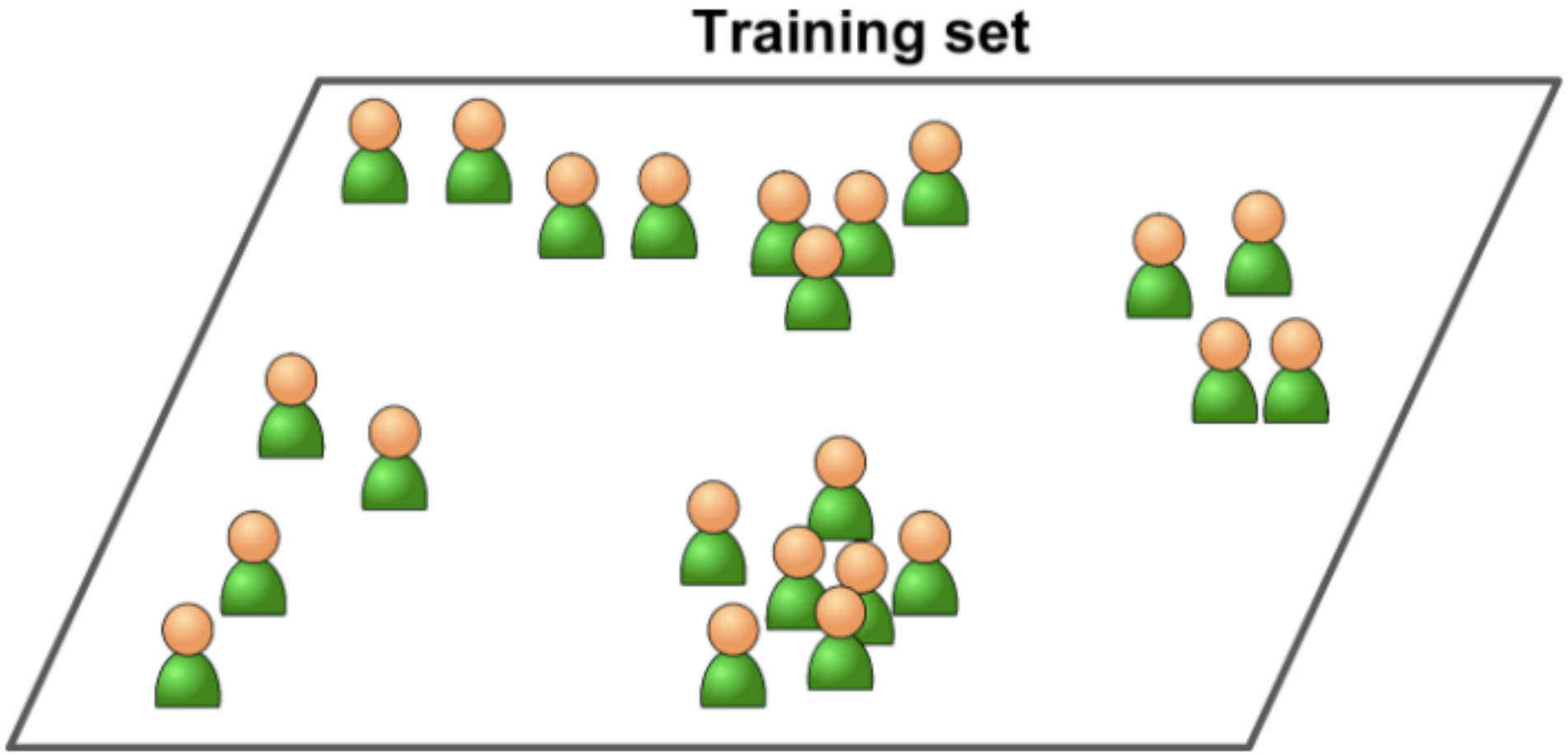








First: What Does a Machine Get?



Hands-on Machine Learning with Scikit-Learn & TensorFlow, Aurelien Geron

Types of Learning Tasks

- Unsupervised
  - No label given for training data

- Supervised
  - Label given for training data: e.g., “cat”

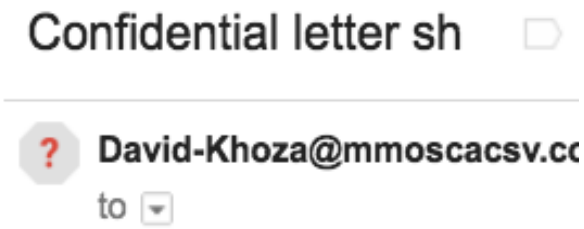
Types of Learning Tasks

- Unsupervised
  - No label given for training data

- Supervised
  - Label given for training data: e.g., “berimbau”

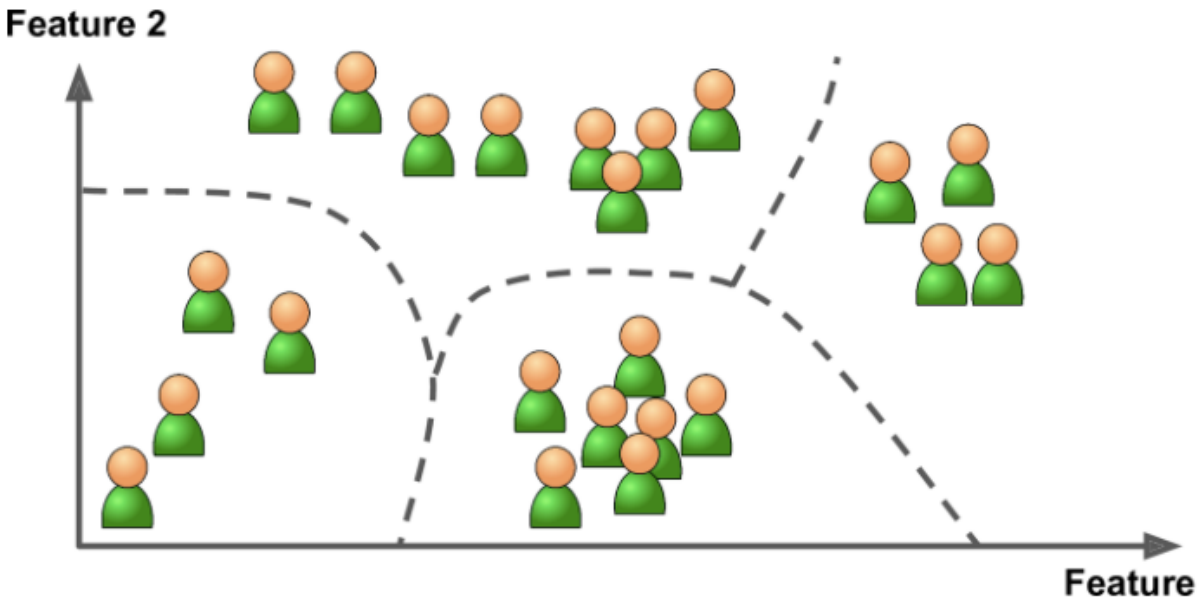
Types of Learning Tasks

- Unsupervised
  - No label given for training data
- Supervised
  - Label given for training data: e.g., “yes”



Types of “Unsupervised” Learning

Clustering



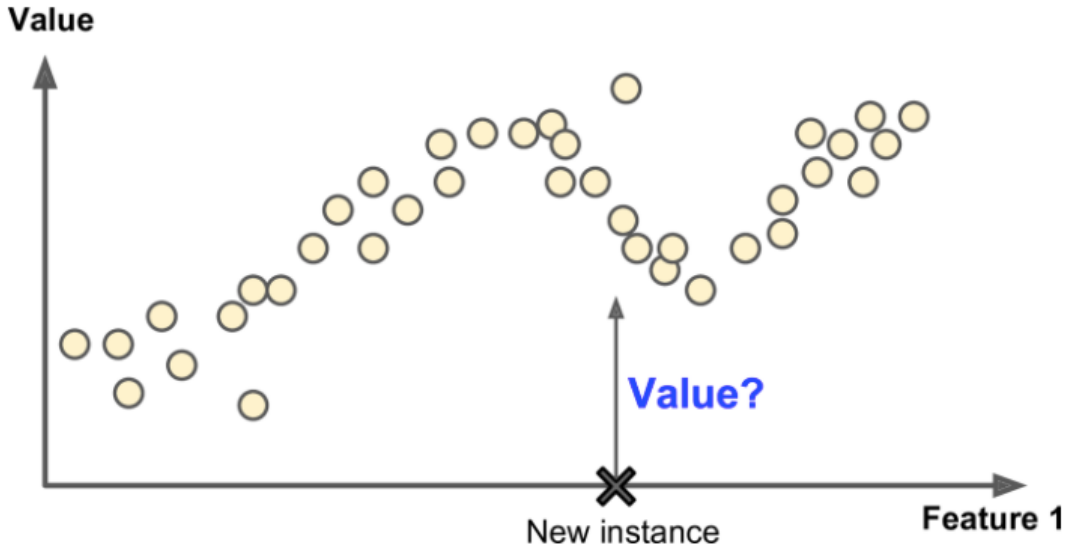
Anomaly Detection

What are real world applications for these types?

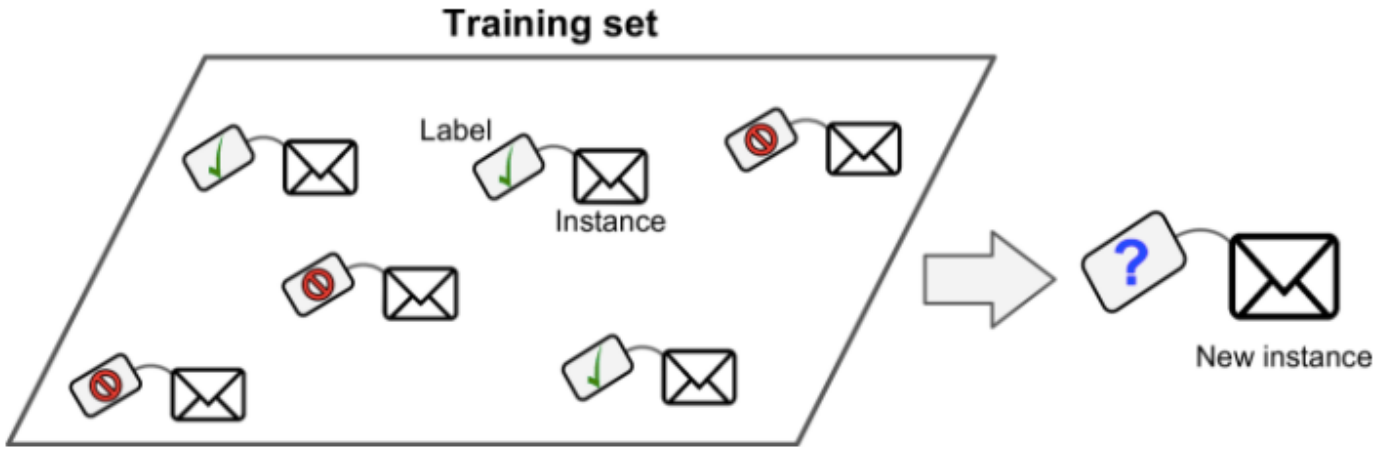
Hands-on Machine Learning with Scikit-Learn & TensorFlow, Aurelien Geron

Types of “Supervised” Learning

Regression
(predict **continuous** value)



Classification
(predict **discrete** value)



What are real world applications for these types?

Hands-on Machine Learning with Scikit-Learn & TensorFlow, Aurelien Geron

Learning Challenge: Sufficient Training

Little Training ⟷ Highly Trained

Learning Challenge: Sufficient Training

e.g., images

images on basic hard drive: 10^5
(500 GB/2 MB = 250,000)

images seen during my first 10 years: 10^9
(24 images/sec * 60 sec * 60 min * 16 hr * 365 days * 10 yrs = 5,045,760,000)

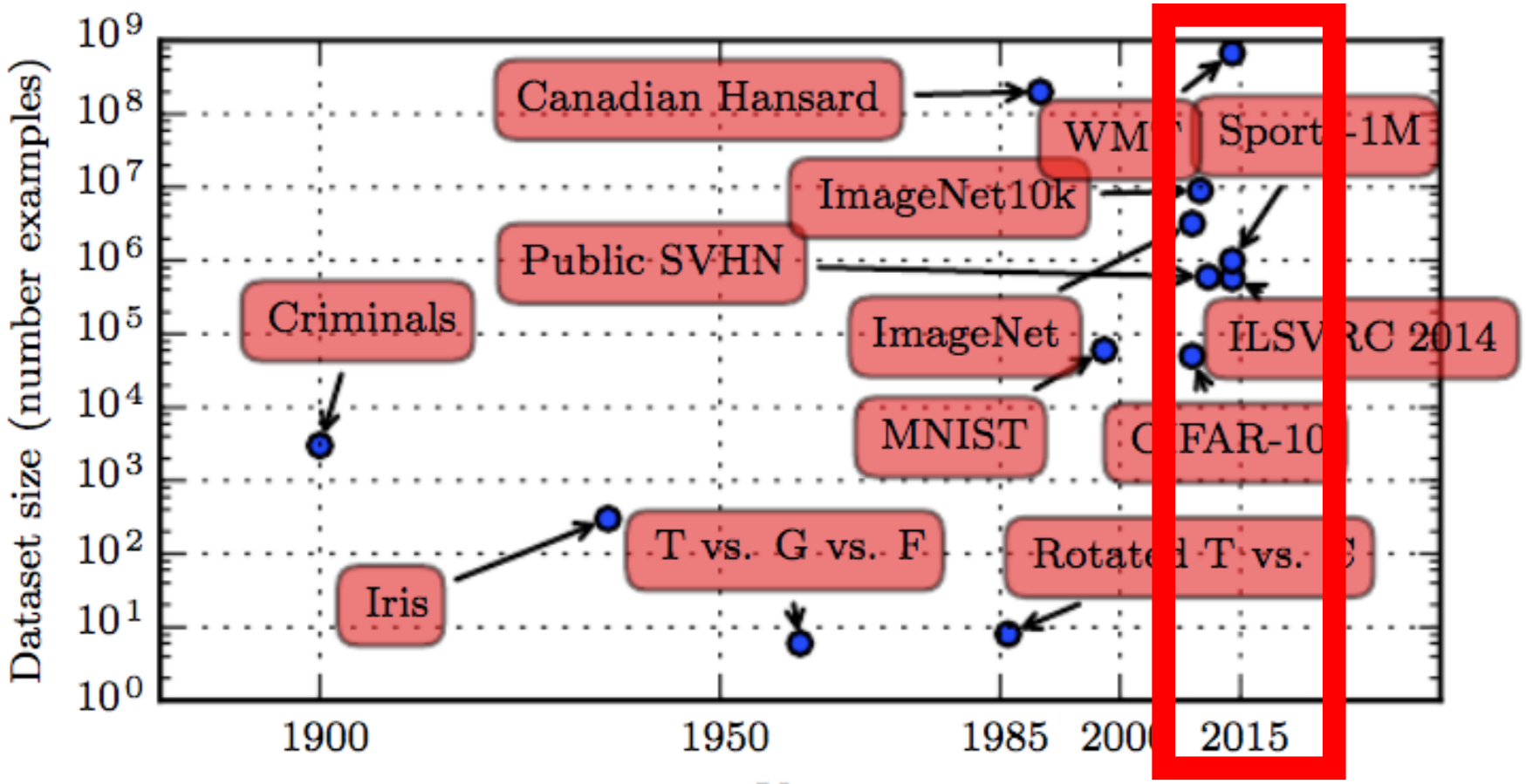
images seen by all humanity: 10^{20}
(7.5 billion humans[1] * 24 images/sec * 60 * 60 * 16 * 365 * 60 yrs = $2.23 * 10^{20}$)

[1] http://www.worldometers.info/world-population/

Adapted from slides by Antonio Torralba

Learning: Where Machine Learning is Today

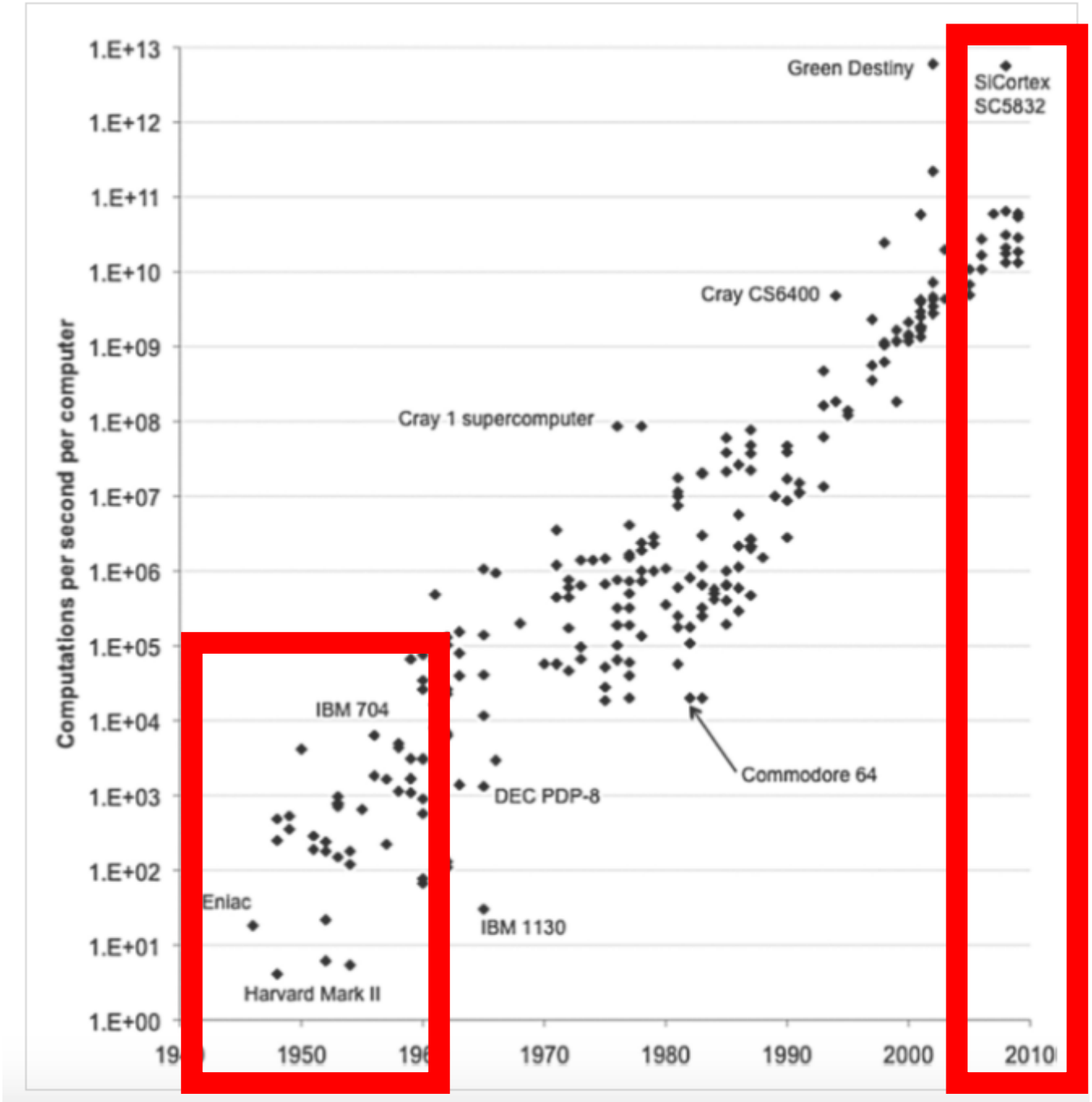
- "Big"-ger Data
  - e.g., internet



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

Learning: Where Mac

- "Big"-ger Data
  - e.g., internet
- Better Hardware
  - e.g., faster processing -- GPUs



https://ourworldindata.org/technological-progress

Learning: Where Machine Learning is Today

- "Big"-ger Data
  - e.g., internet
- Better Hardware
  - e.g., faster processing -- GPUs
  - e.g., more memory

The IBM Model 350 disk file with a storage space of 5MB fro[m] 1956 [a]nd a Micro SD Card

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Learning: Where Machine Learning is Today

- "Big"-ger Data
  - e.g., internet
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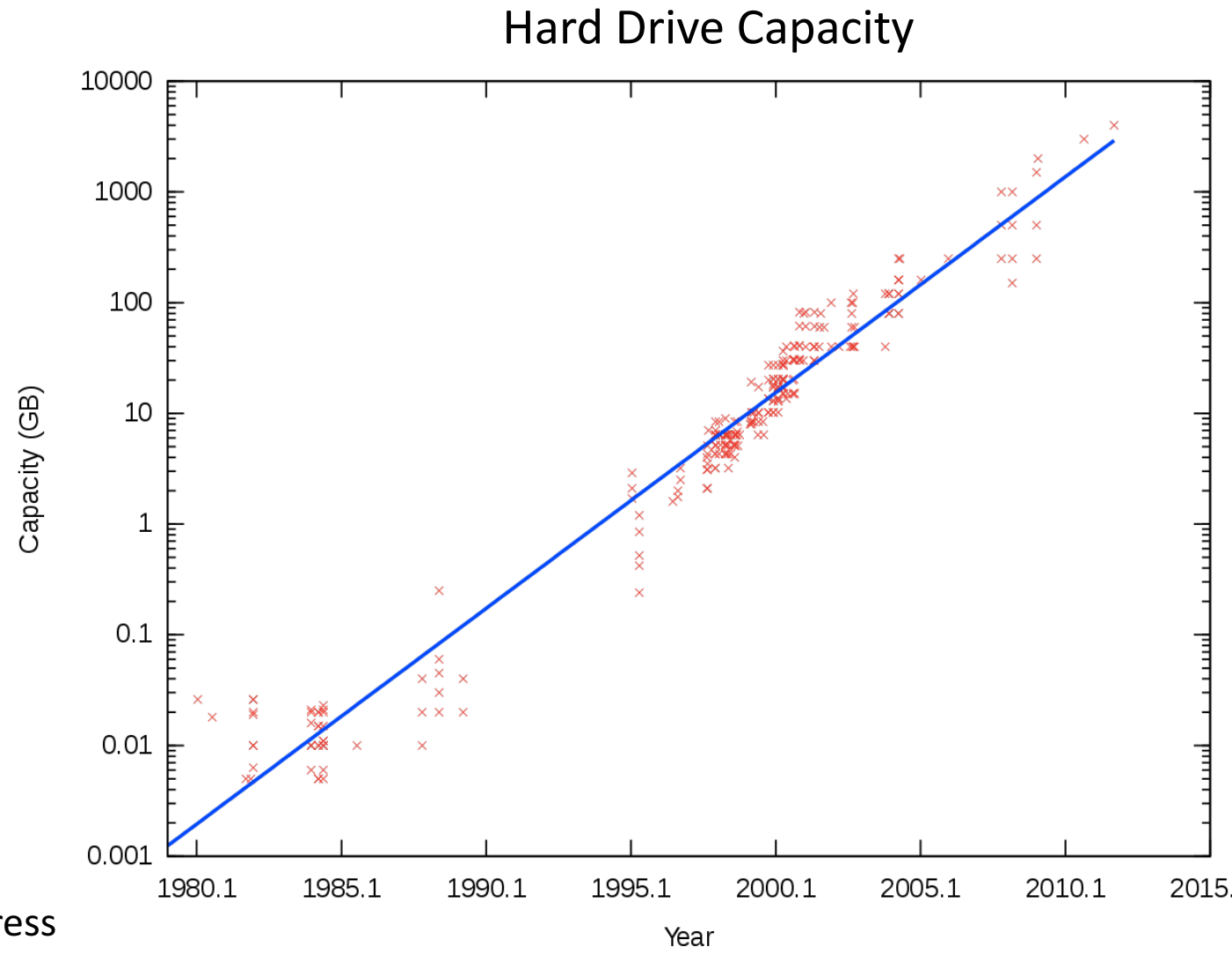

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Learning: Where Machine Learning is Today

- "Big"-ger Data
  - e.g., internet
- Better Hardware
  - e.g., faster processing -- GPUs
  - e.g., more memory

In the past 59 years, machines were:

(1) given **more training data,**

(2) built to **think faster,** and

(3) built to **remember more**!

What does your money in this class buy you?

- State-of-Art Hardware
  - e.g., faster processing -- GPUs
  - e.g., more memory

- Thanks to: Microsoft Azure

Today’s Topics

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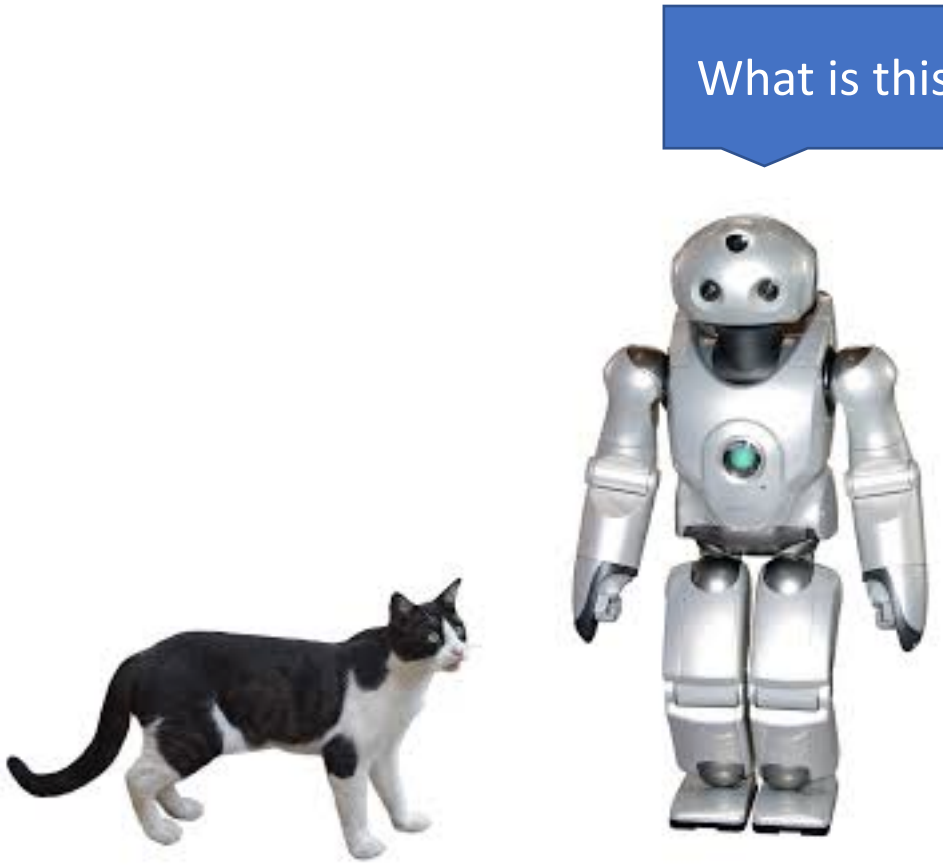
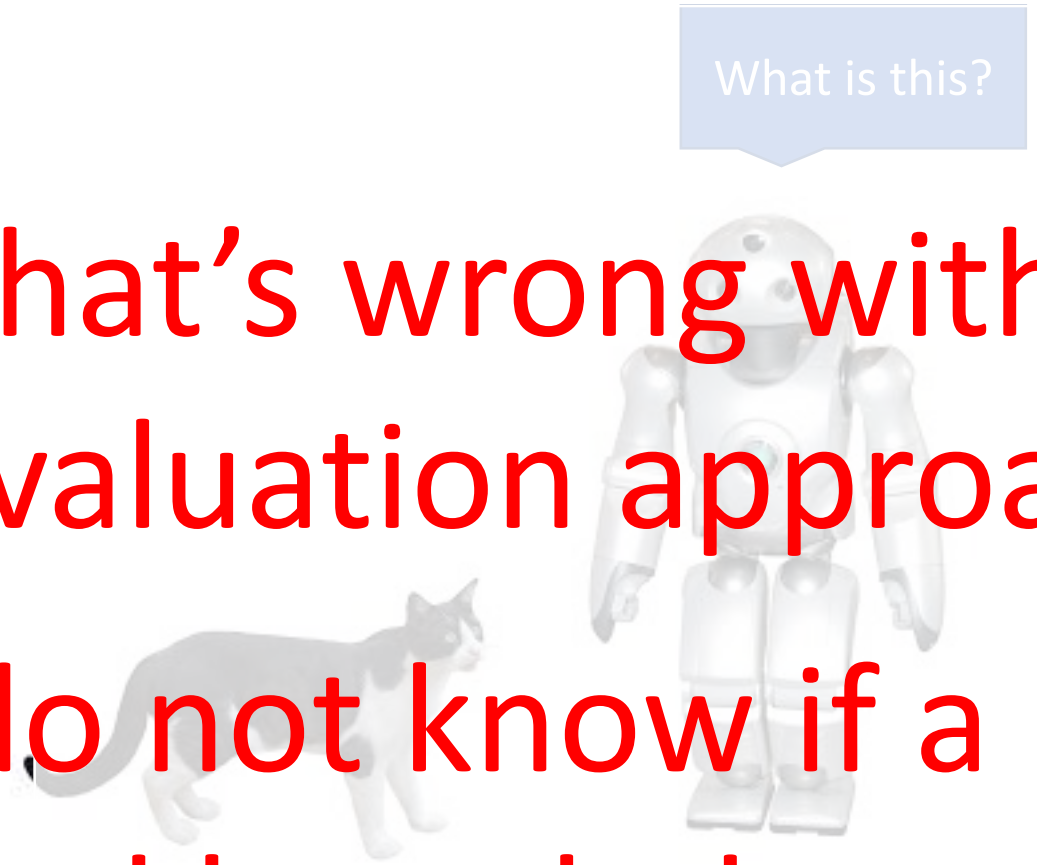
How to Evaluate a Machine's "Learning"?

- Training Data:



How to Evaluate a Machine's "Learning"?

- Testing Data:

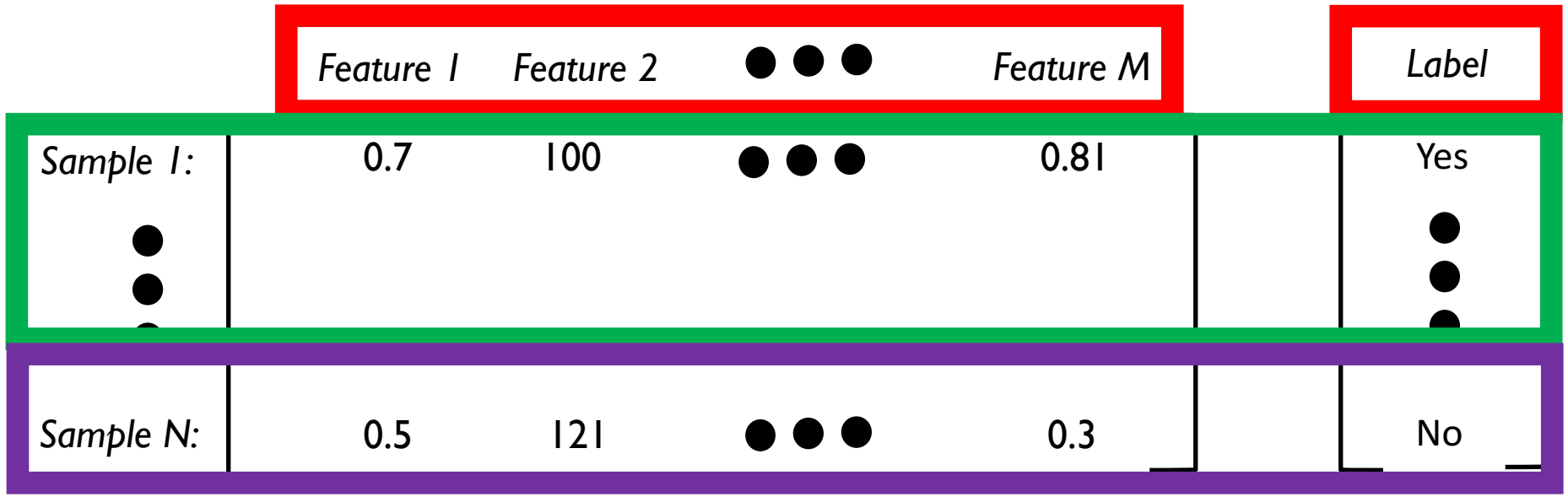


What's wrong with this evaluation approach?

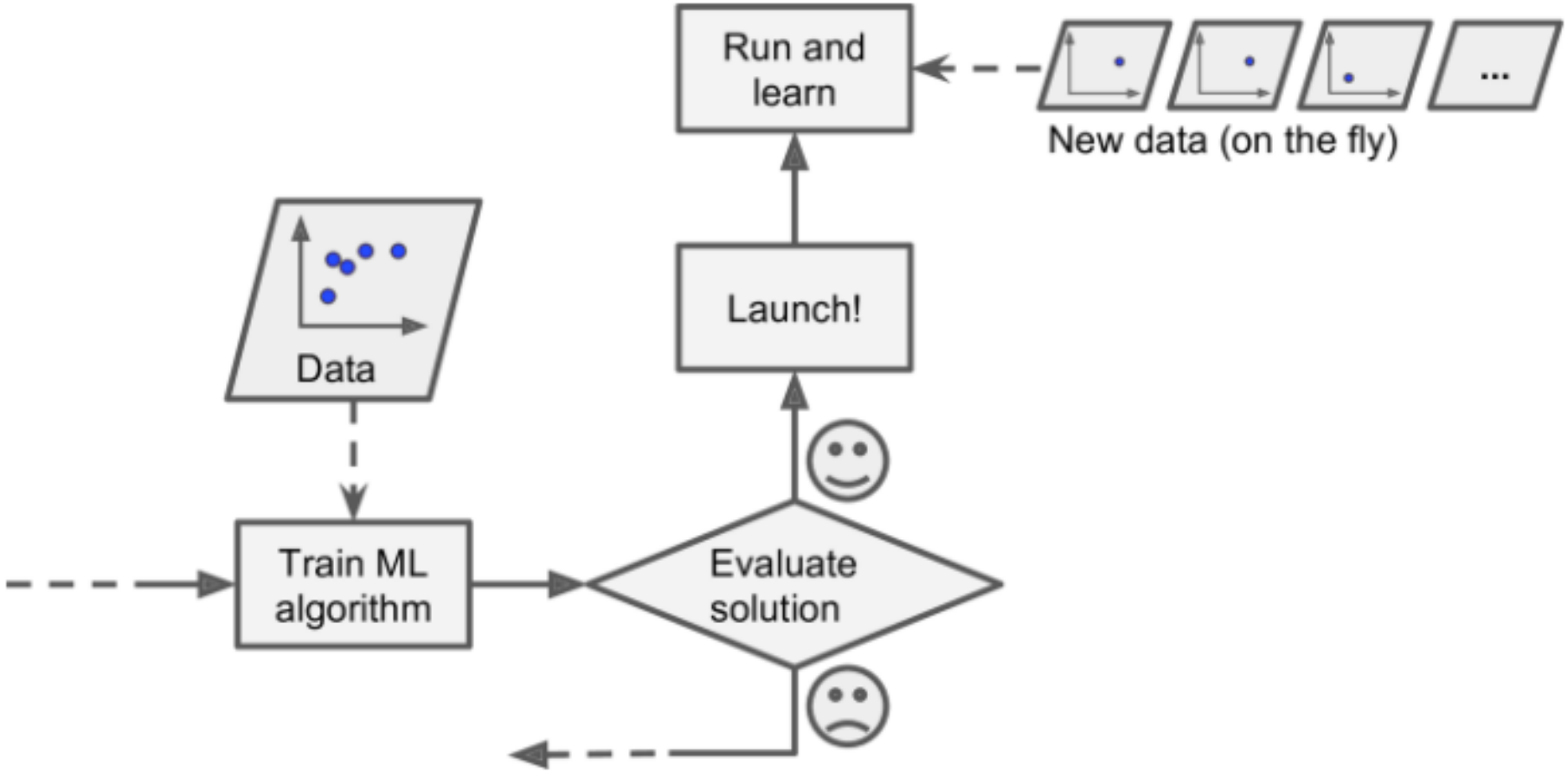
We do not know if a machine's learned knowledge generalizes.

How to Evaluate a Machine's "Learning"?

- Split data into a "training set" and "testing set"



How to Teach a Machine?
Online Learning vs Offline Learning



Hands-on Machine Learning with Scikit-Learn & TensorFlow, Aurelien Geron

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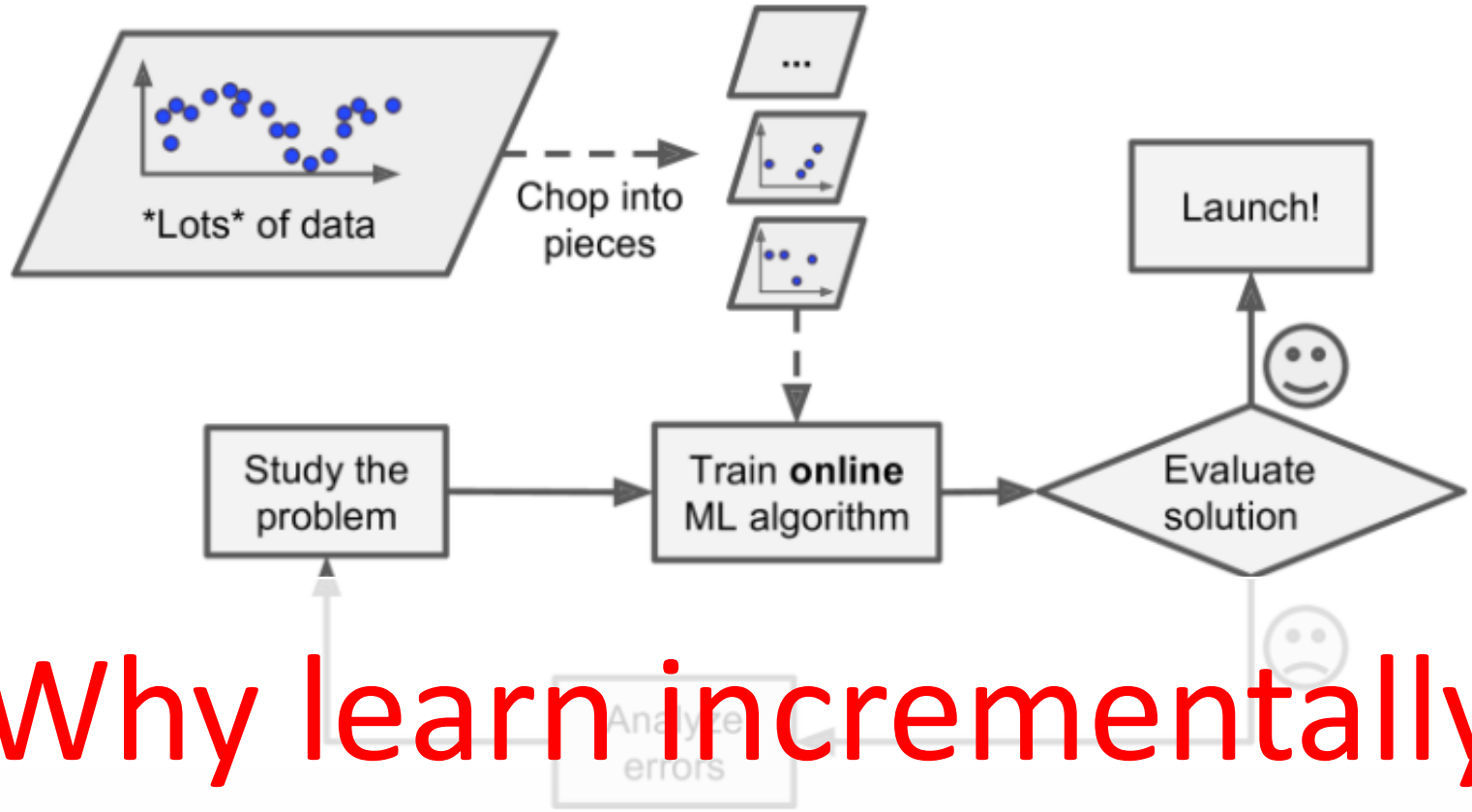
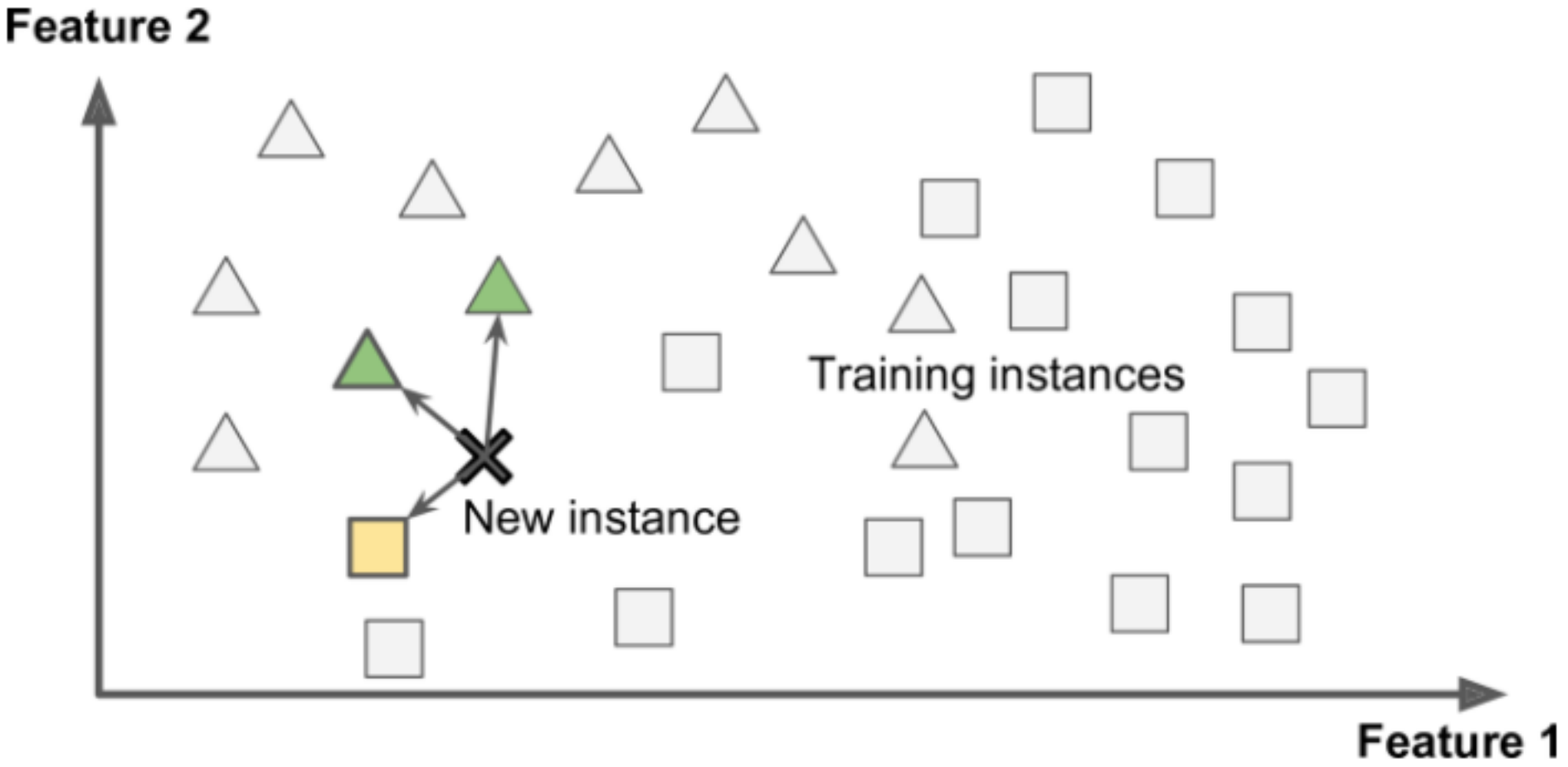
Online Learning vs Offline Learning



Why learn incrementally?

Hands-on Machine Learning with Scikit-Learn & TensorFlow, Aurelien Geron

How to Teach a Machine?
Instance-Based Learning



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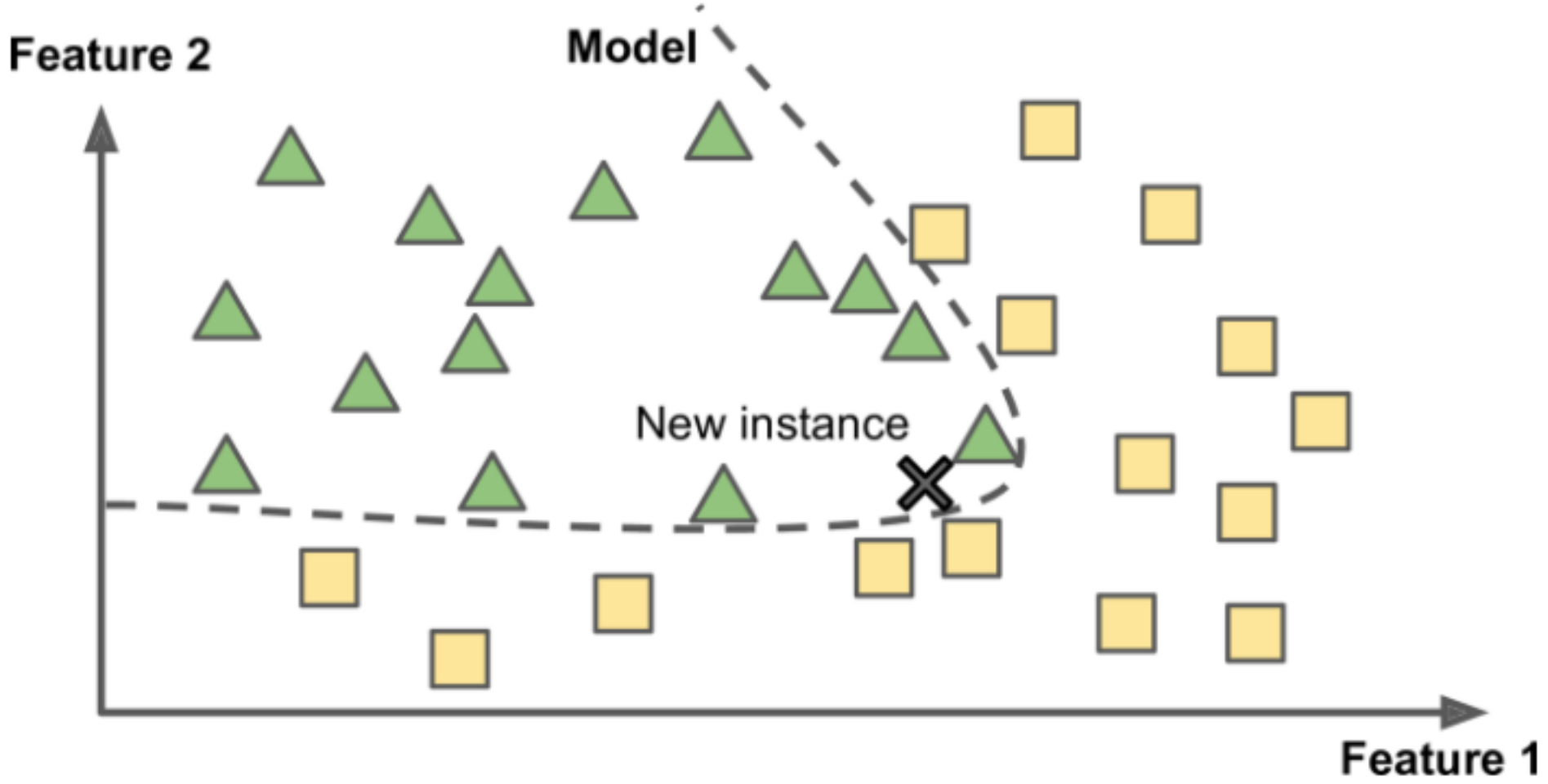
How to Teach a Machine?
Model-Based Learning



Hands-on Machine Learning with Scikit-Learn & TensorFlow, Aurelien Geron

Machine Learning Model

- Goal: learn data distribution in the “real world”
- Modeling:
  - Can **increase** model’s representational capacity
    - e.g,. linear versus quadratic?
  - Can **decrease** model’s representational capacity
    - e.g,. linear versus quadratic?

Machine Learning Model

- Underfitting
  - Model is too simple
- Overfitting
  - Model is too complex
- Regularization
  - Simplifies a complex model

Today’s Topics

- Class logistics
- Why machine learning?
- What does a machine learn?
- Designing a “supervised” machine learning algorithm
- Lab

Account Set-up

- Log into a machine: EID and UT password
- Request iSchool account (if you do not yet have an account)
  - https://www.ischool.utexas.edu/accounts/request_account.php
- Reset iSchool password (if you do not yet have an account)
  - Instructions included in email approving the account