Introduction to Machine Learning

Prof. Dr. M. Elif Karslıgil

elif@yildiz.edu.tr

Course Information

- Instructor:
  - Prof. Dr. M. Elif Karslıgil
  - elif@yildiz.edu.tr

- Lectures:
  - Monday 14.00-17.00

Course Information

- Grading:
  - 2 mini projects (%15 each)
  - 1 final project (%20)
  - 1 midterm exam (%20)
  - Final exam (%30)

Course Information

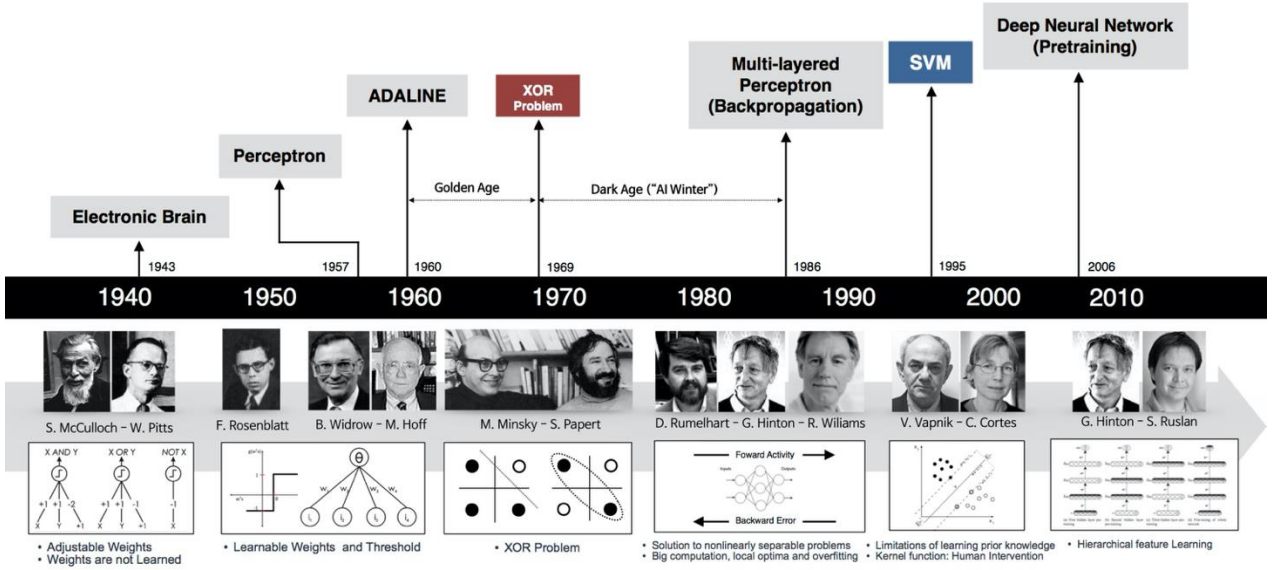
- Text Books: Not required, but for students who want to read more
  - Introduction to Machine Learning - 2nd Edition by Ethem Alpaydın, 2010
  - Pattern Recognition and Machine Learning by Christopher Bishop, 2006
  - Deep Learning by Ian Goodfellow, Yoshua Bengio, and Aaron Courville, 2016
  - Machine Learning Yearning by Andrew Ng, 2019

Prerequisites

- Basic familiarity with statistics
- Basic knowledge about algorithm design, data structures, algorithm complexity
- Coding in **Python**

History of AI

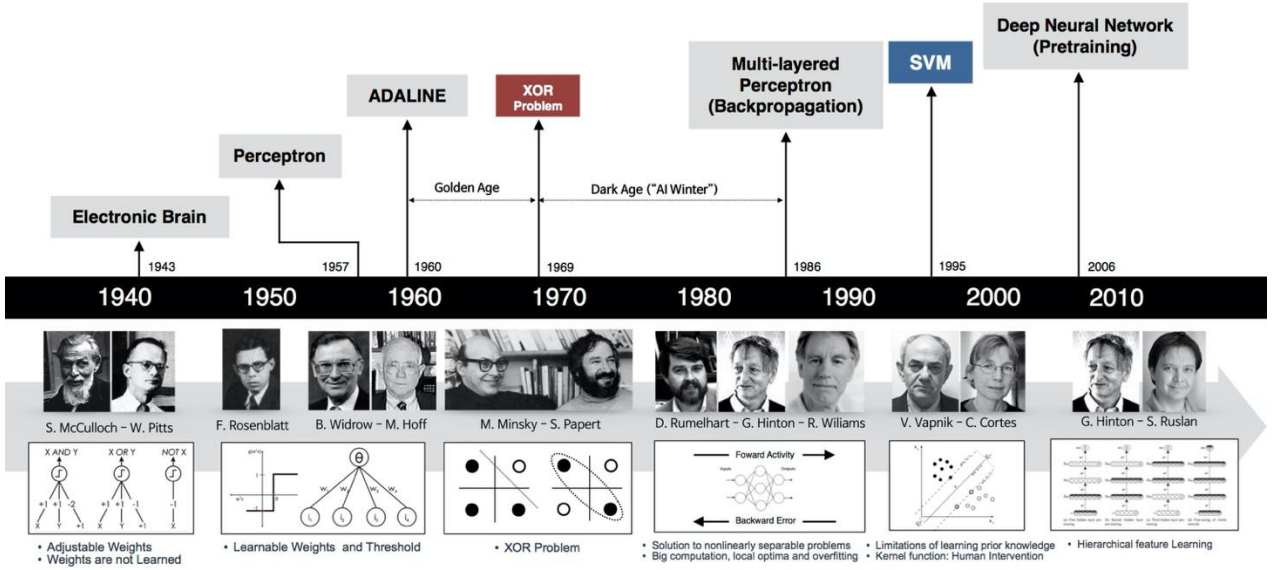
- 1943: Mc Culloch & Pitts: Boolean Circuit model of the brain
- 1950: Alan Turing: Computing Machinery and Intelligence (Can machines think?)
- 1956: Dartmouth meeting: The term Artificial Intelligence was coined by John McCarthy
- 1957: Frank Resenblatt: perceptron, first NN model



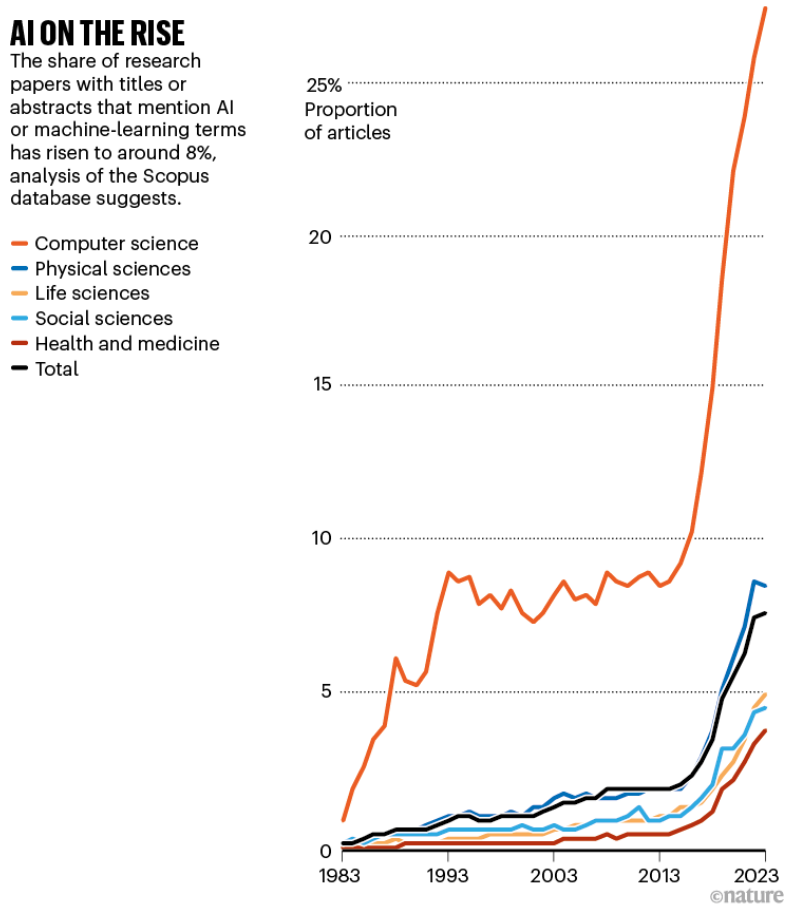
History of AI

- 1966-1973: Realization that many AI problems are intractable
- 1989: Rumelhart, Hinton and Williams: popularized multilayered perceptron
- 2000: Vladimir Vapnik et.al.:

  Support Vector Machine
- **2006:** Hinton et.al Deep Neural Network

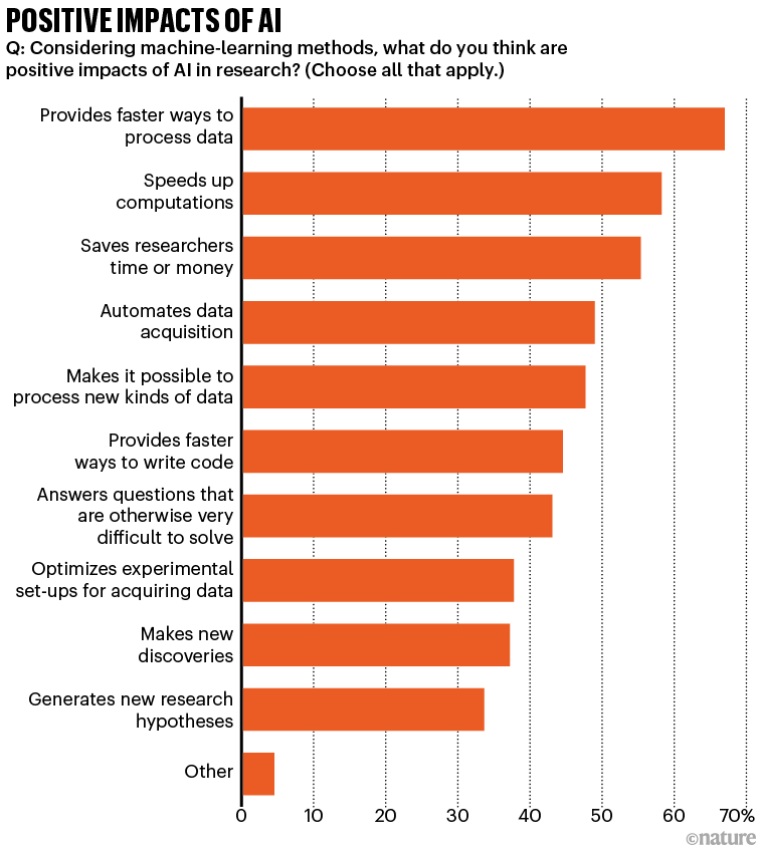


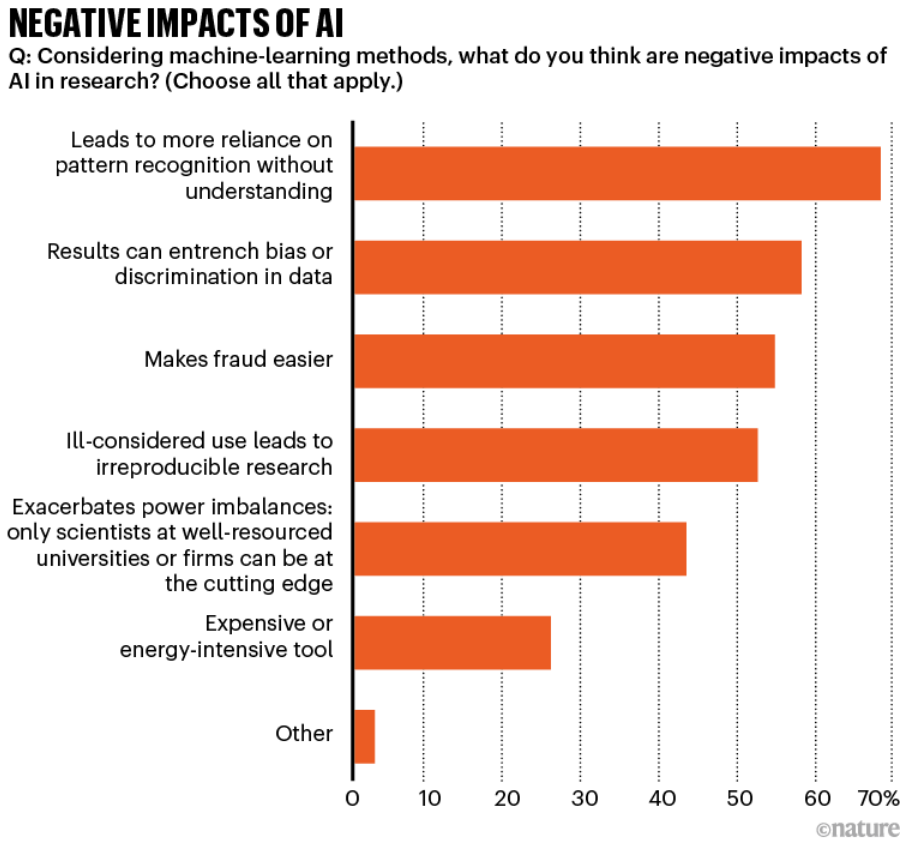
What 1,600 researchers think about AI?



The share of research papers that mention AI terms has risen in every field over the past decade, according to an analysis for this article by *Nature*.

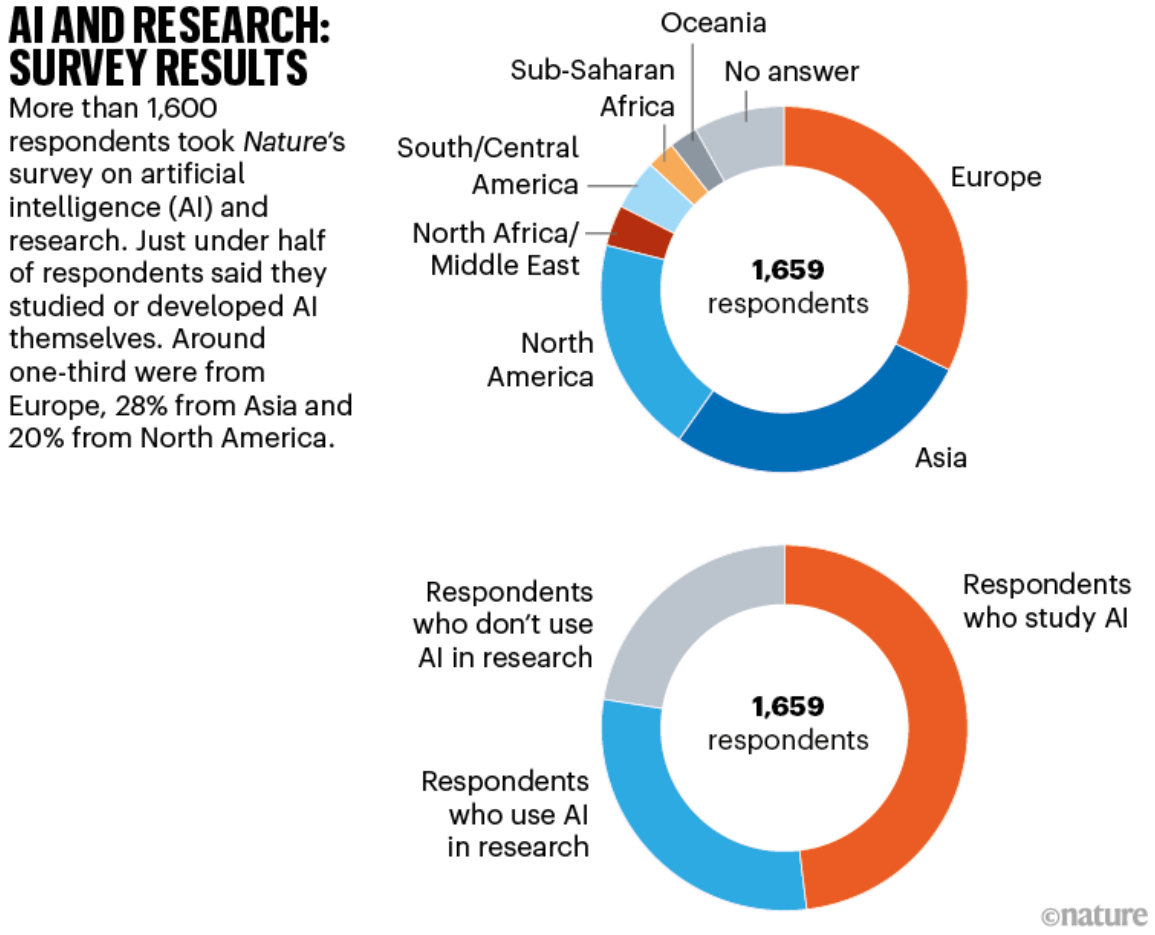
What 1,600 researchers think?



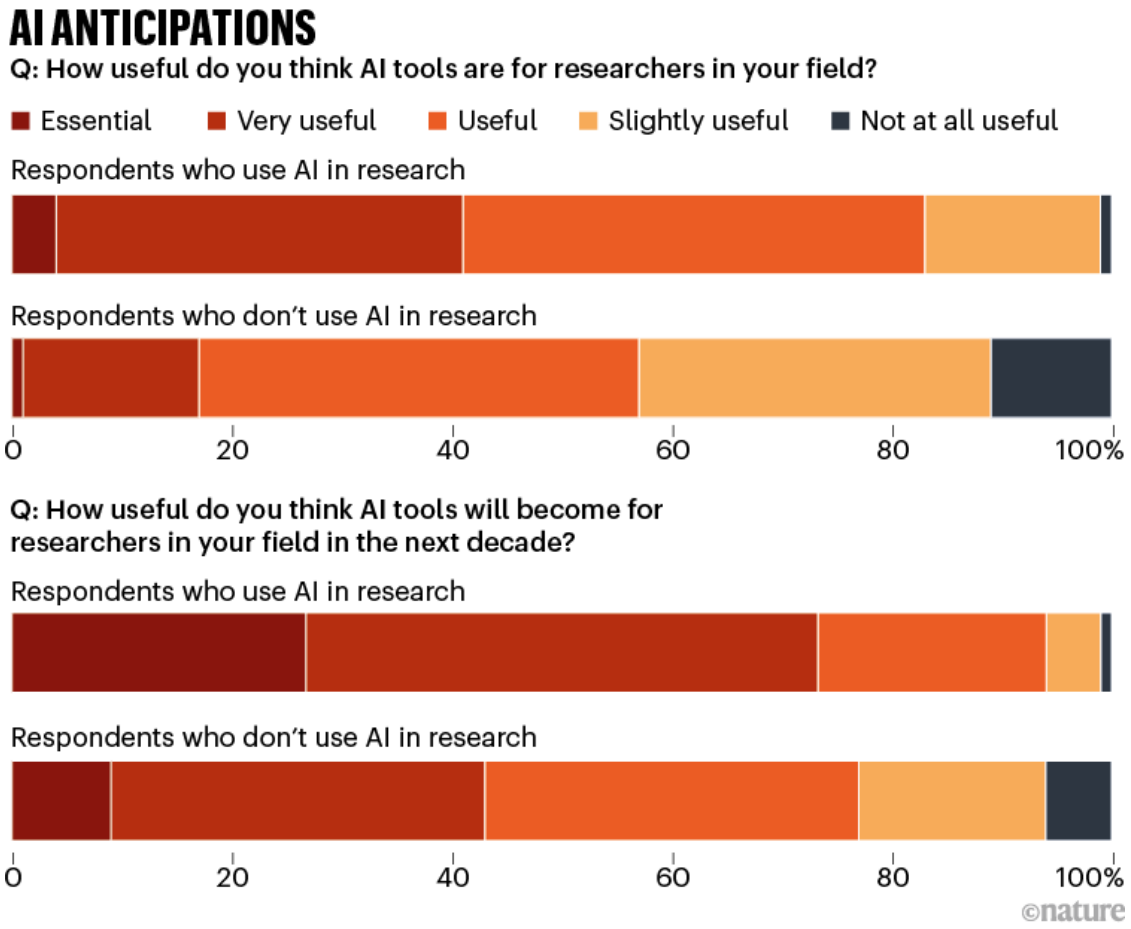


Richard Van Noorden & Jeffrey M. Perkel, Nature, 2023
https://www.nature.com/articles/d41586-023-02980-0

AI and Research Survey Results



AI Anticipations



What is Artificial Intelligence

- John McCarthy coined the phrase Artificial Intelligence in 1956
- The main goal of AI is to develop intelligent machines, that think, learn and act like humans.
- Some Subgoals
  - Perception
  - Reasoning
  - Search
  - Communication
  - Learning

What is Artificial Intelligence

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- Some Subgoals
  - Perception : interpreting vision, sound, smell and touch
  - Reasoning
  - Search
  - Communication
  - Learning

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  - Perception
  - Reasoning: getting logical conclusion and making predictions from available knowledge, facts, and beliefs
  - Search
  - Communication
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  - Search: the process of navigating from a starting state to a goal state by transitioning through intermediate states
  - Communication
  - Learning

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  - Perception
  - Reasoning
  - Search
  - Communication: providing human-computer interaction. Technologies such as machine translation of human languages, spoken dialogue systems like Siri
  - Learning

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- Some Subgoals
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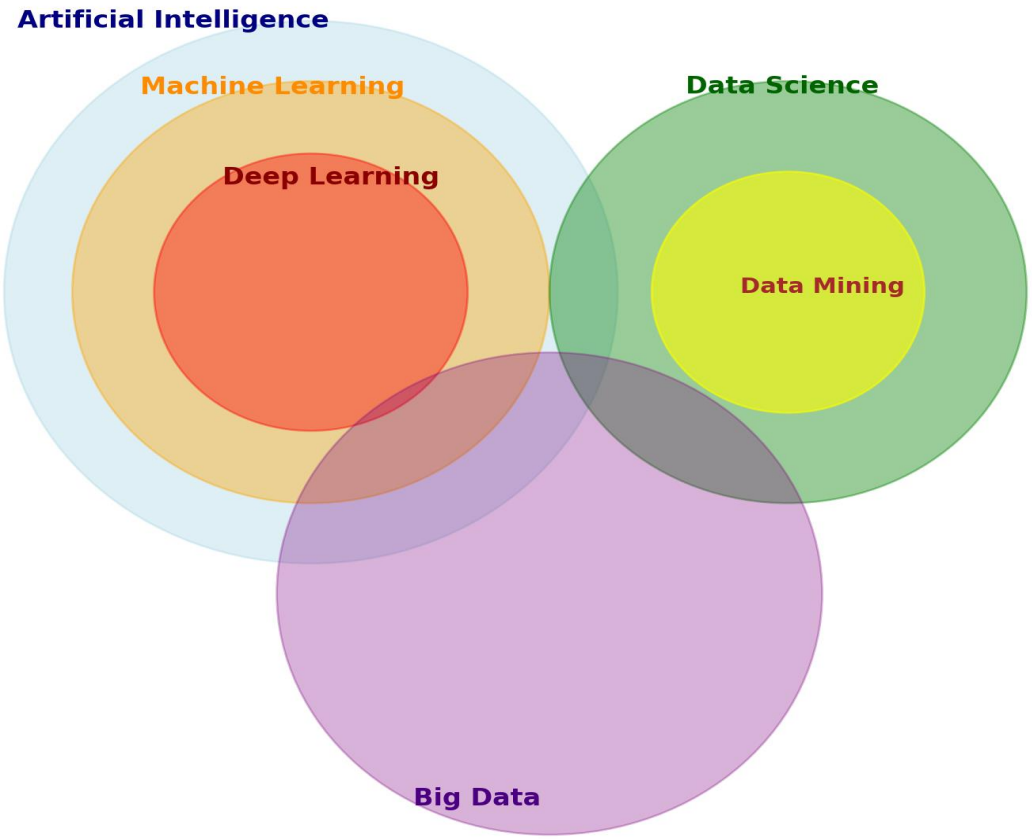
  - Search
  - Communication
  - Learning: by MACHINE LEARNING

Artificial Intelligence and Related Fields



What is Machine Learning ?

- Machine Learning is the field of study that gives the computer the ability to learn without being explicitly programmed (Arthur Samuel -1959) .
- ML systems improve their learning over time, by feeding them data and information in the form of observations and real-world interactions

Traditional Programming

- Applications
  - Web Page coding
  - Bank ATM software
  - Tetris game
  - Stock control software

Traditional Programming

- How can we write a computer program?
  - we design an algorithm that encodes a set of rules that are useful to solve the problem
  - For some problems it is very difficult to specify those rules
  - Is there a cat in the image ?

What is Machine Learning ?

- Traditional Programming

- Machine Learning Programming

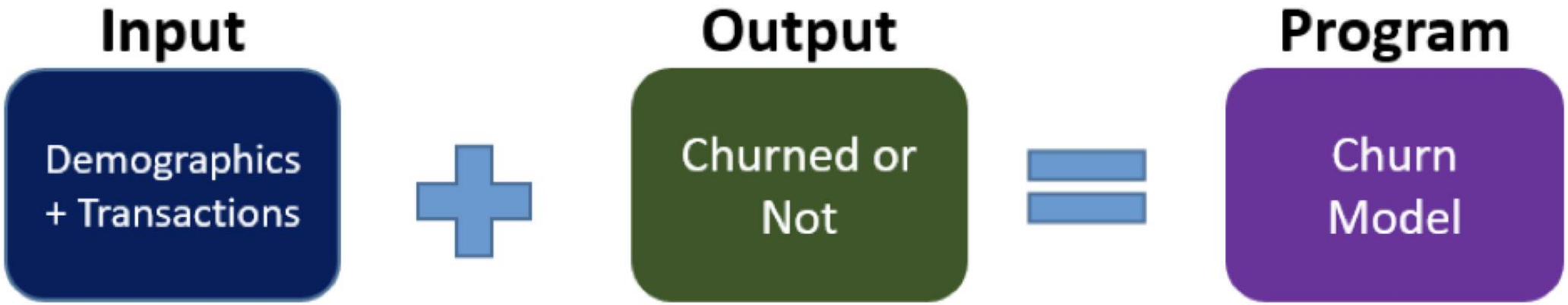
What is Machine Learning ?

- Machine Learning Programming:

  - Instead of writing a program, we collect examples that specify the correct output for a given input
  - A machine learning algorithm then takes these examples and produces program that does the job
  - If we do it right, the program works for new cases as well as the ones we trained it on.

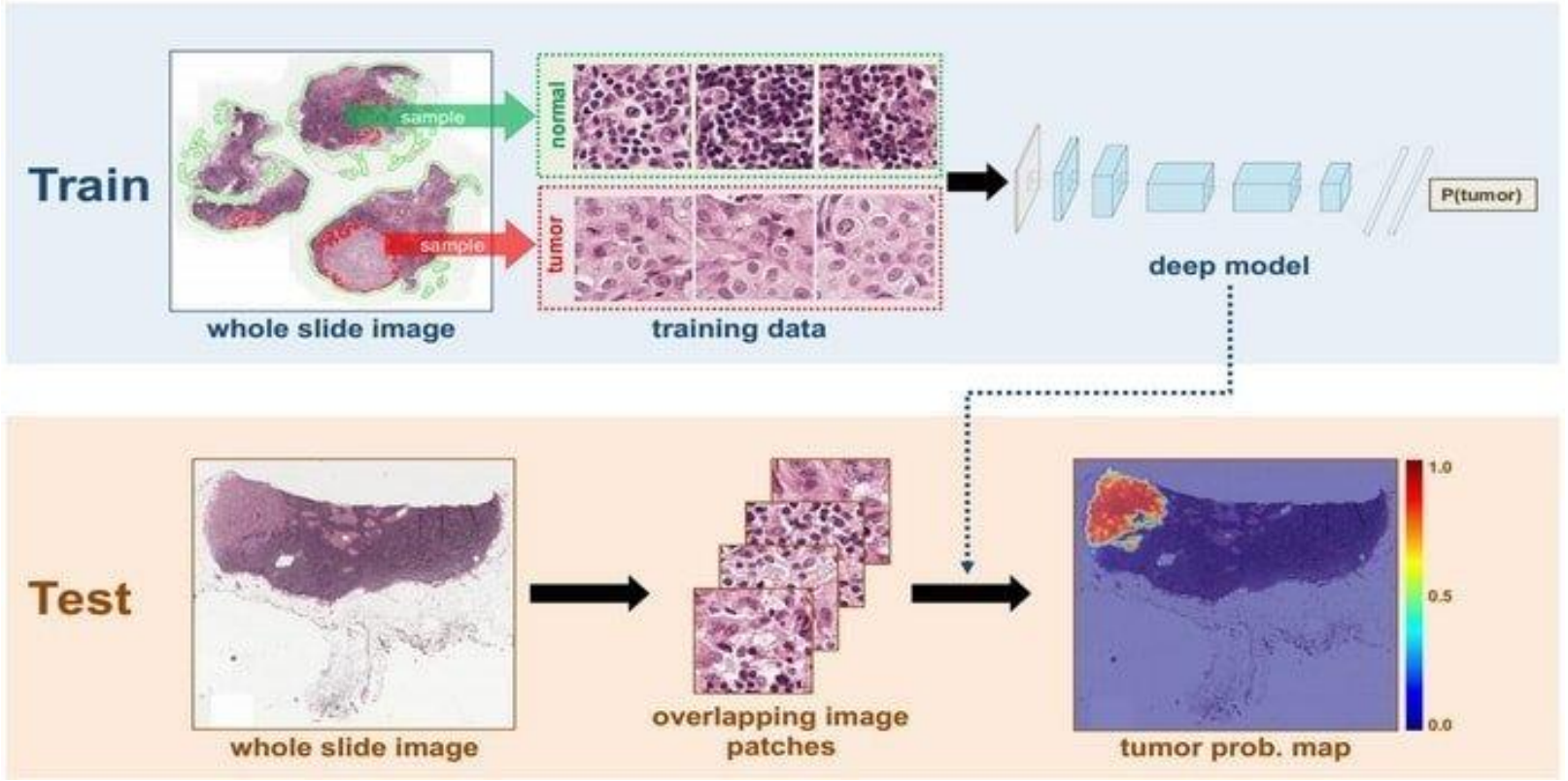
What is Machine Learning ?

- Example : Predict if a customer will churn or not



Machine Learning Applications

- Cancer Detection and Prediction



Machine Learning Applications

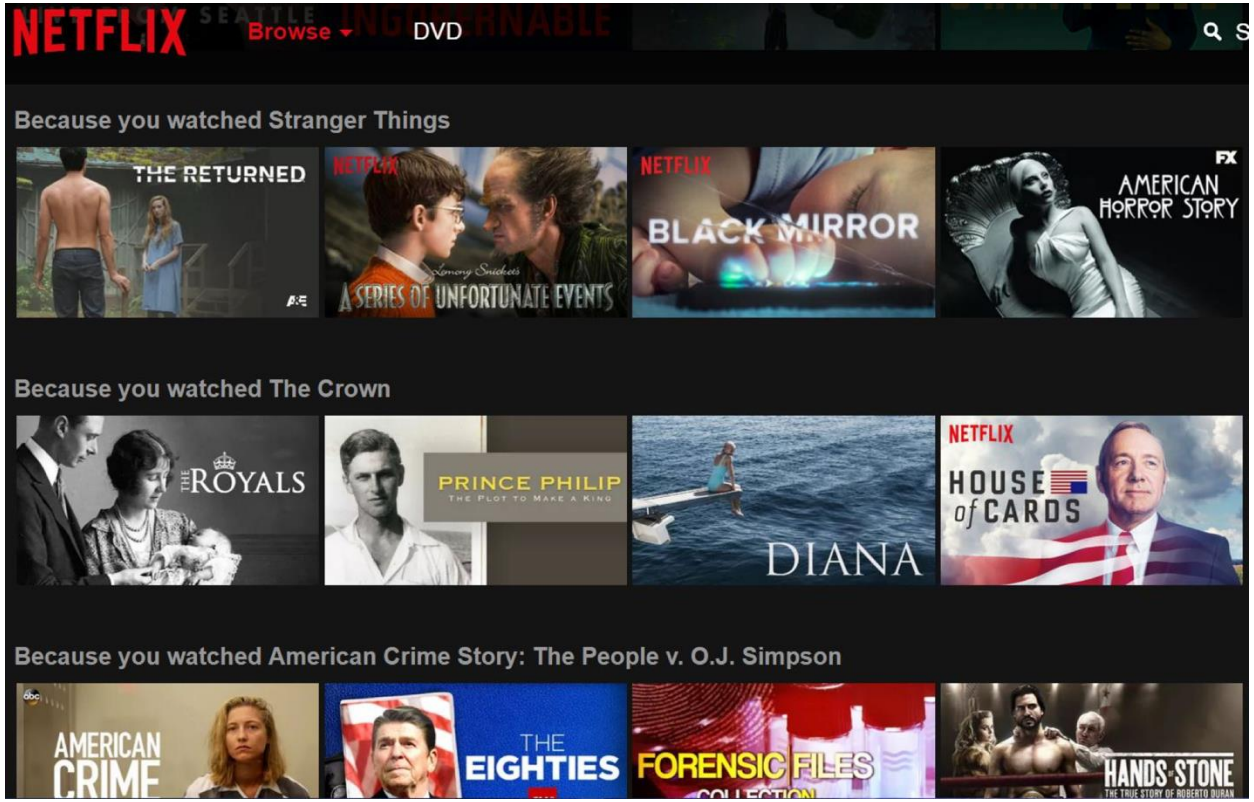
- Robotic Surgery

Machine Learning Applications

- Virtual Personal Assistants

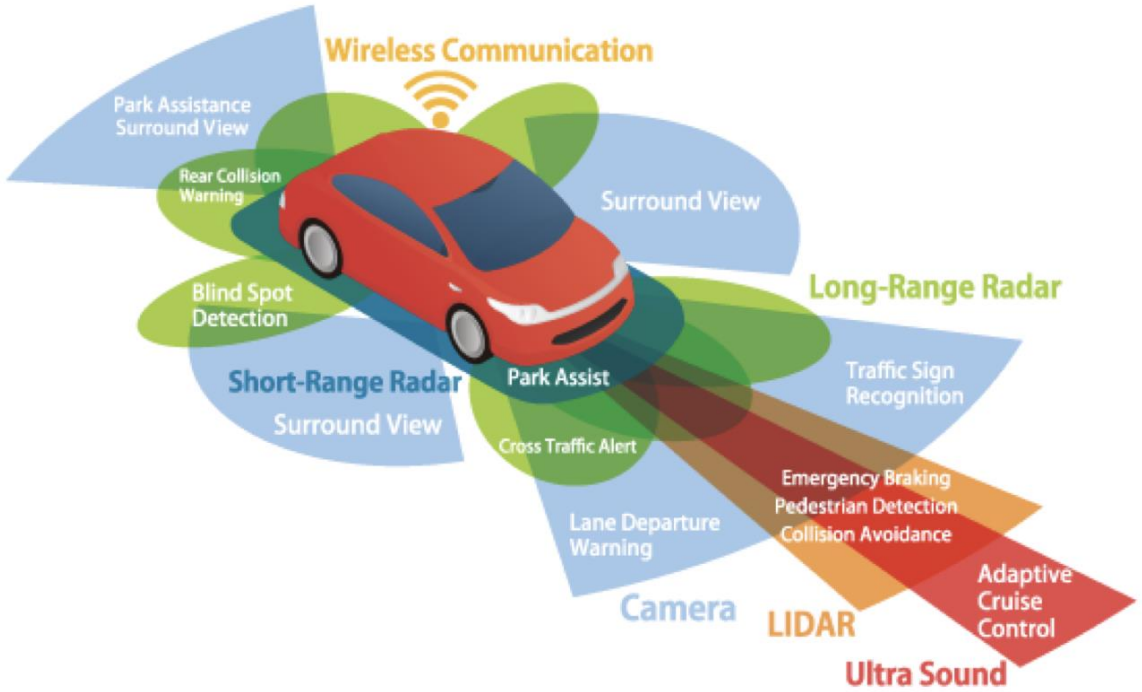
Machine Learning Applications

- Recommendation Systems



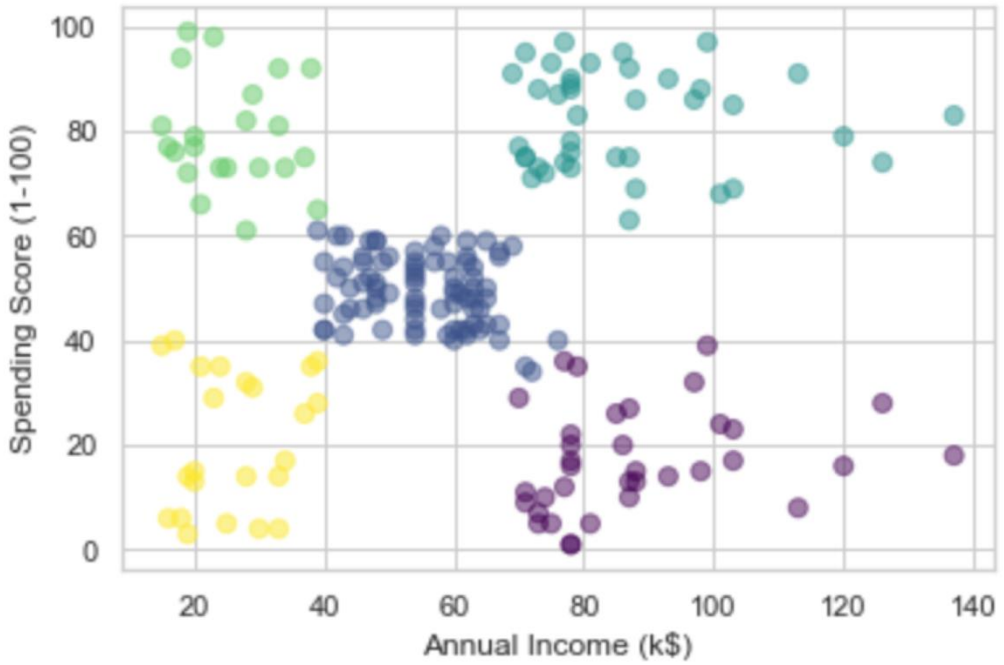
Machine Learning Applications

- Self Driving Vehicle



Machine Learning Applications

- Customer Segmentation

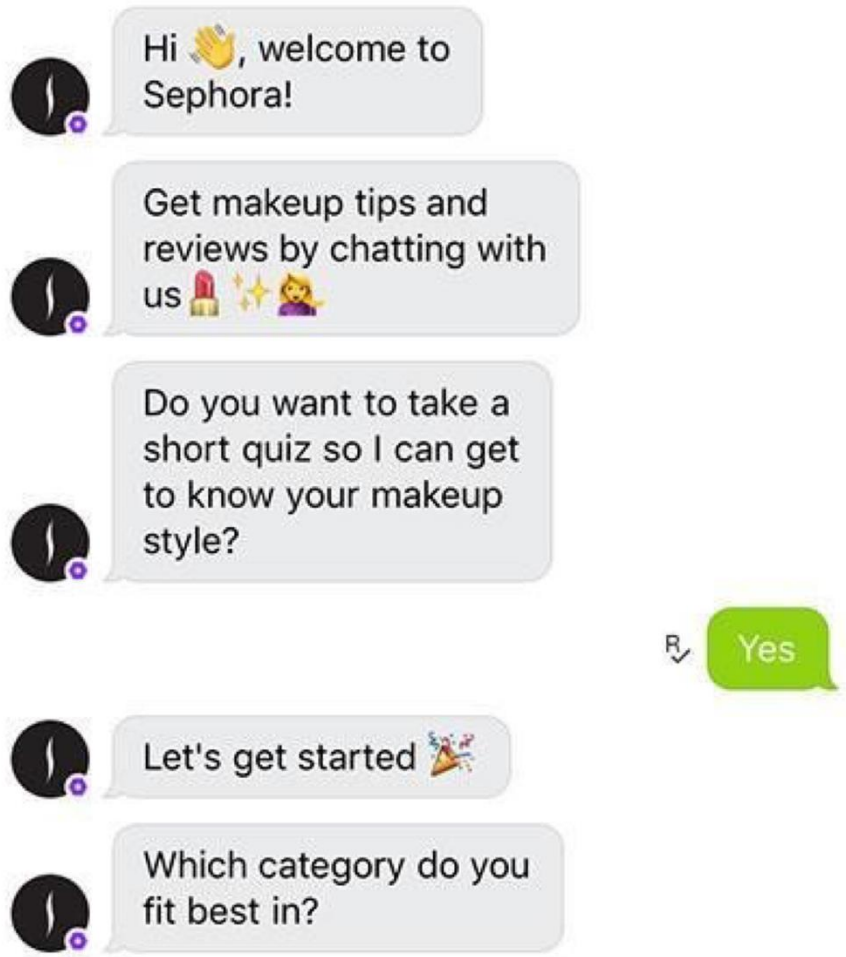


Machine Learning Applications

- Game Playing

Machine Learning Applications

- Automatic Chatbot



Machine Learning Applications

ChatGPT

Developer(s)	OpenAI
Initial release	November 30, 2022; 10 months ago
Stable release	August 3, 2023; 59 days ago[1]
Written in	Python
Engine	GPT-3.5 GPT-4
Platform	Cloud computing platforms
Type	Chatbot Large language model Generative pre-trained transformer
License	Proprietary
Website	chat.openai.com/chat

- **ChatGPT** : **Chat Generative Pre-trained Transformer**, is a large language model-based chatbot developed by OpenAI and launched on November 30, 2022,
- which enables users to refine and steer a conversation towards a desired length, format, style, level of detail, and language.

Why is Machine Learning Important?

- **Data in many domain is huge**
  - Thousands to billions of data samples
  - Impossible for human analysts to see patterns across so much data
- In some domains discovery and use of patterns must happen in real time, e.g. in streaming data

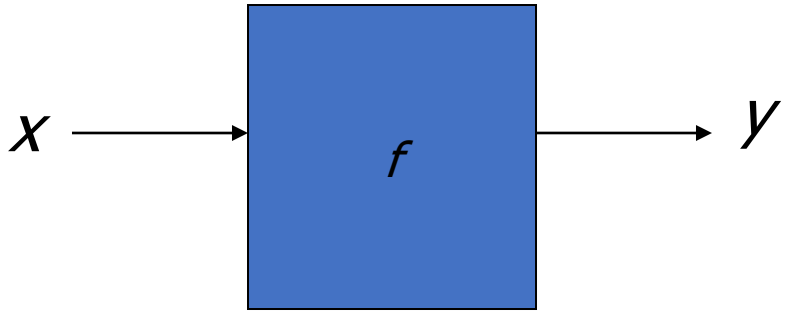
Types of Machine Learning

- Supervised Learning (predictive-predict the feature)
  - Build a predictive model from examples of data with known outcomes
  - Learn to **predict output** for a given input vector
- Unsupervised Learning (descriptive-understand the past)
  - Discover structure in data for which outcomes are not known

Supervised Learning

- Learn to predict output when given an input vector

- Samples : $D = \{d_1, d_2, .. d_n\}$

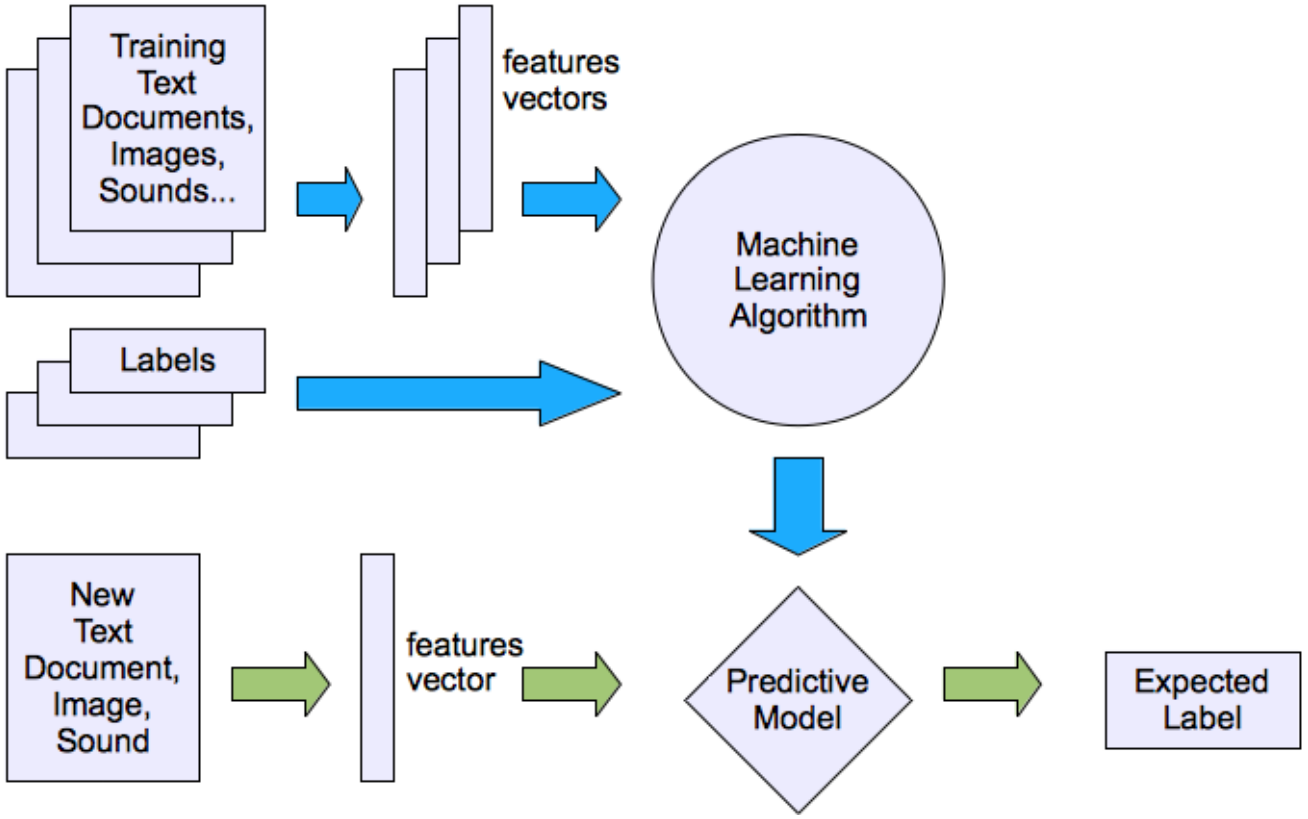


$d_i = <x_i, y_i>$

x_i : Input vector

y_i : Desired Output

Supervised Learning

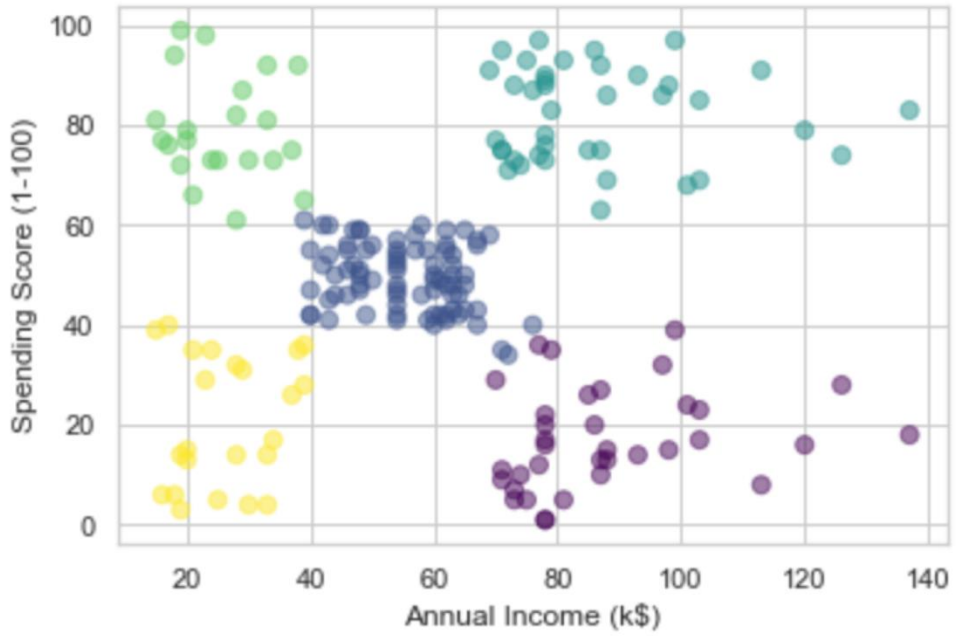


Unsupervised Learning

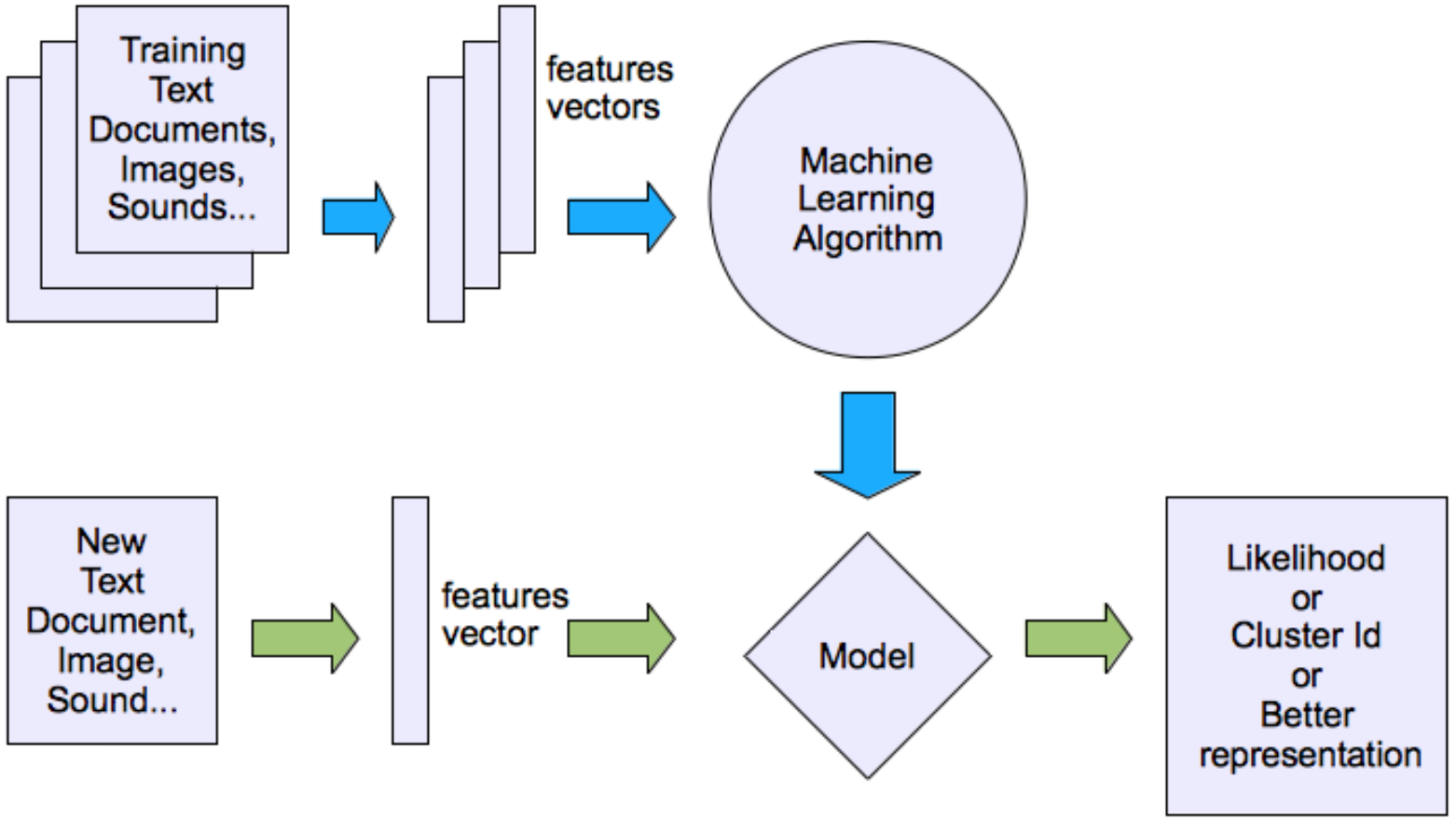
- Models are not supervised using training dataset
- Samples : $D = \{d_1, d_2, .. d_n\}$

$d_i = \langle x_i \rangle$

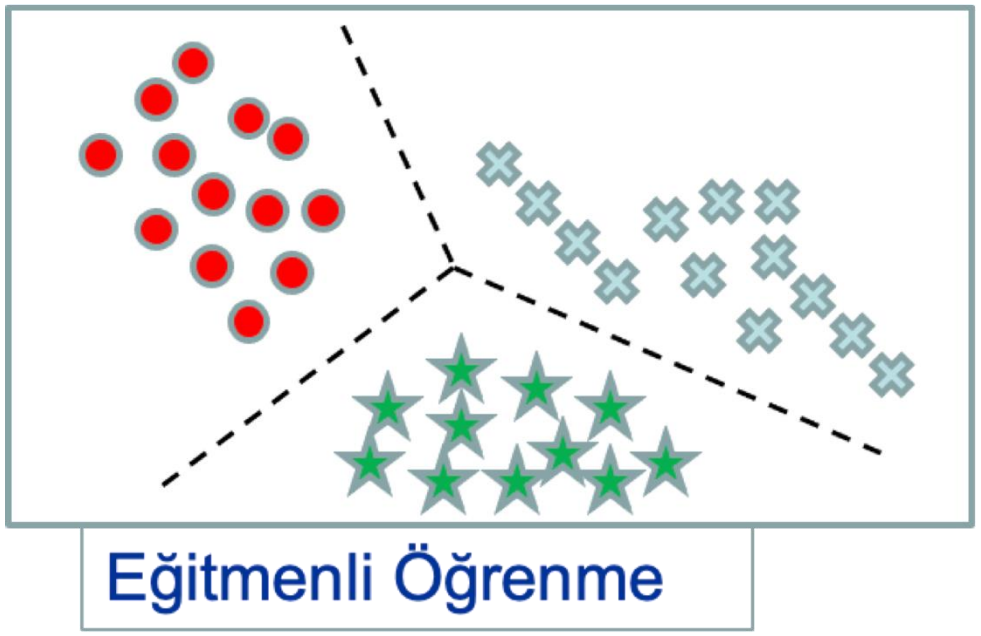
x_i : Input vector

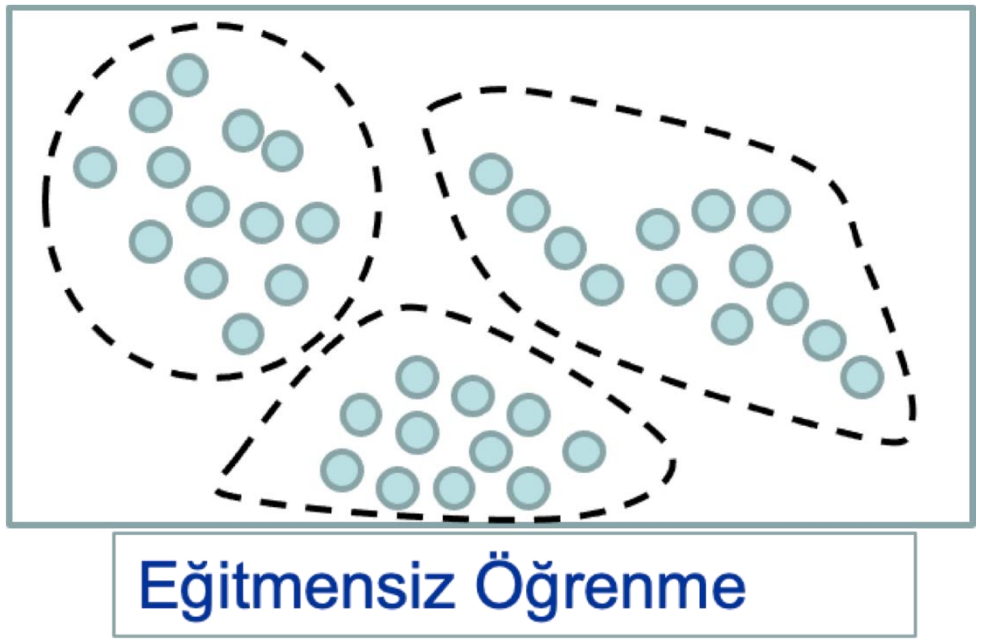


Unsupervised Learning



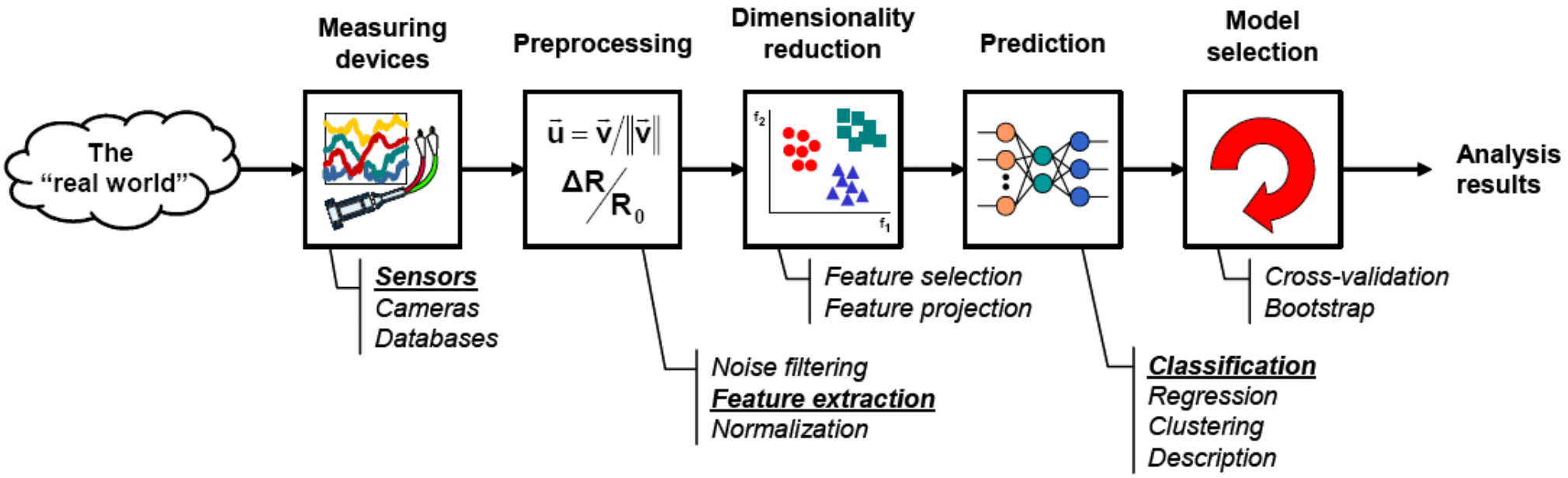
Types of Machine Learning





Reinforcement Learning

Stages of a supervised machine learning system



Example Problem:
Credit Card Fraud Detection

Steps:

1. Determining Learning Approach
2. Data Set Preperation
3. Assumptions
4. Feature Selection-Extraction
5. Model Selection
6. Evaluation

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Example Problem:
Credit Card Fraud Detection

- Determining Learning Approach:
  - Can the data be labeled?
    - YES (Fraud, Normal)
  - Is data labeling hard? Is it time consuming?
    - NO

Example Problem:
Credit Card Fraud Detection

Steps:

1. Determining Learning Approach
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Example Problem:
Credit Card Fraud Detection

- Data Set Preperation
  - Establish data collection mechanism
  - Acquire and integrate data
  - Check your data quality
  - Handle missing data
  - Preprocess (Format, Clean, Normalize etc.)
  - Transform the data if necessary
  - Split into training and evaluation sets

Example Problem:
Credit Card Fraud Detection

- Data Set Preperation
  - How much data is enough?
  - From which sources should i collect data?
  - Who could label the data?
  - How common are label errors?
  - Do we need to create new features ?
  - Can synthetic data be used?
  - How could outliers be handled ?

Example Problem:
Credit Card Fraud Detection

Steps:

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Example Problem:
Credit Card Fraud Detection

- Assumptions
  - Only make prediction for online shopping
  - Do not profile a new customer
  - Make prediction for above 200 TL

Example Problem:
Credit Card Fraud Detection

Steps:

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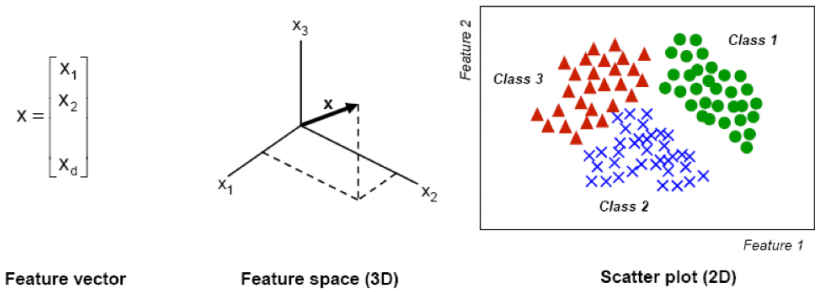
Example Problem:
Credit Card Fraud Detection

- Feature Selection-Extraction
  - Features are input to the ML system
  - Reducing features improves performence of the model
  - Reducing features reduce computational cost



Feature vector | Feature space (3D) | Scatter plot (2D)

Good features | Bad features

Example Problem:
Credit Card Fraud Detection

Steps:

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Example Problem:
Credit Card Fraud Detection

- Model Selection: We have a set of models M={M1, M2..Md}
  - Which model generalizes the best?
    - Model selection
    - Hyperparameter selection
  - Evaluate complexity, maintainability, and available resources of a model .

Example Problem:
Credit Card Fraud Detection

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Example Problem:
Credit Card Fraud Detection

- Evaluation:
- How to evaluate the performance of a model?
  - Training and validation sets are used to simulate unseen data
  - First the common problems should be identified, then test scenarios are prepared
  - It is important that the test data is not used *in any way* to create the classifier