KAZAKH BRITISH TECHNICAL UNIVERSITY

Introduction to Machine Learning

Seminar 1

Introduction to machine learning concepts

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How to convert hours to minutes?

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- X - watch
- $F(X) = 60X$ - conversion to minutes, function

What force is applied to the body?

- Known body weight m and its acceleration a
- What is the force F?

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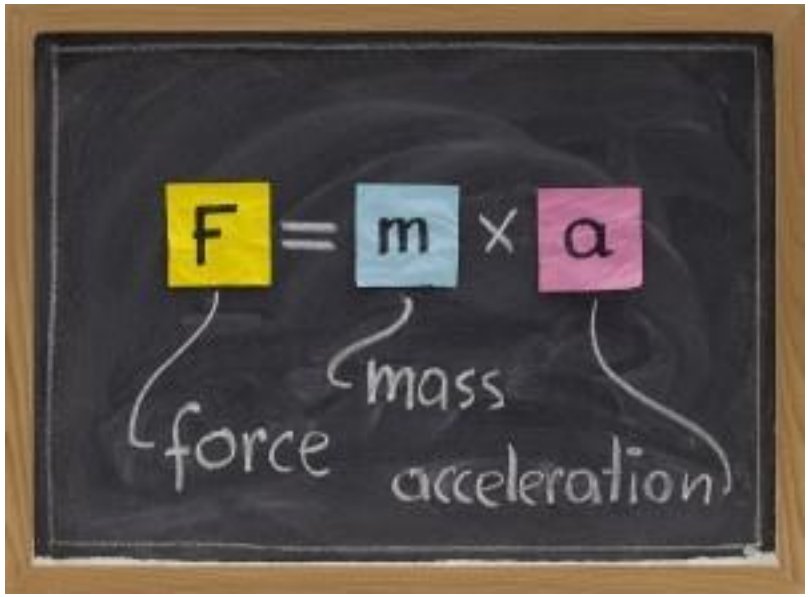
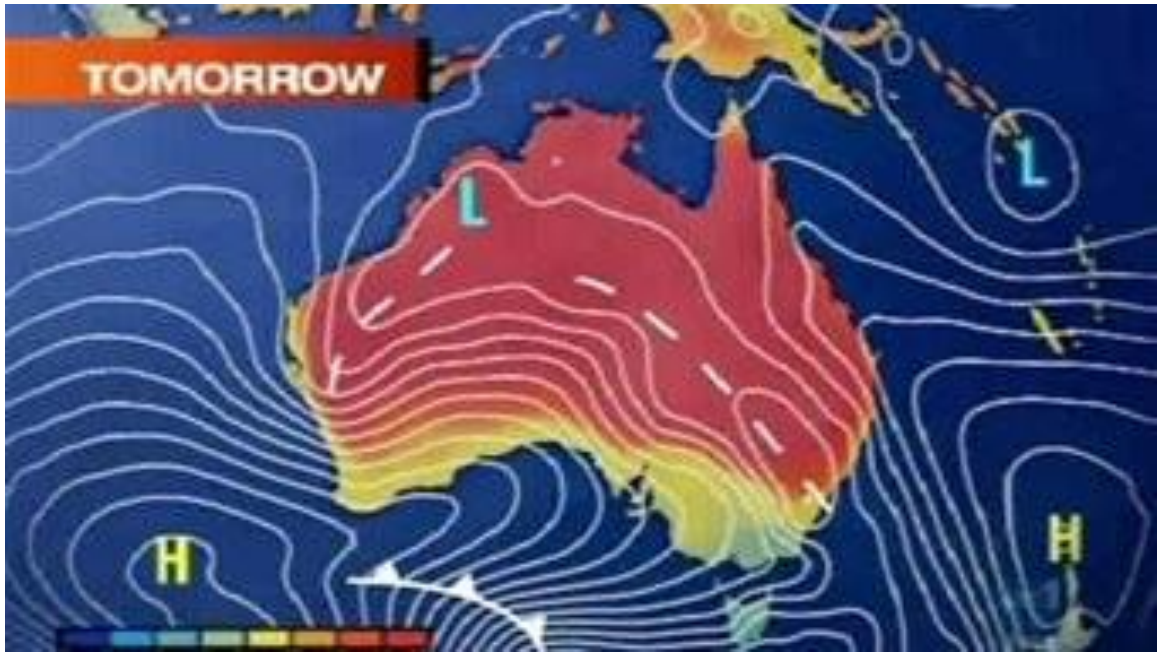


How to predict the weather?



Navier-Stokes equations

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} + w\frac{\partial u}{\partial z} = -\frac{\partial P}{\partial x} + Re\left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} + \frac{\partial^2 u}{\partial z^2}\right),$$

$$\frac{\partial v}{\partial t} + u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} + w\frac{\partial v}{\partial z} = -\frac{\partial P}{\partial y} + Re\left(\frac{\partial^2 v}{\partial x^2} + \frac{\partial^2 v}{\partial y^2} + \frac{\partial^2 v}{\partial z^2}\right),$$

$$\frac{\partial w}{\partial t} + u\frac{\partial w}{\partial x} + v\frac{\partial w}{\partial y} + w\frac{\partial w}{\partial z} = -\frac{\partial P}{\partial z} + Re\left(\frac{\partial^2 w}{\partial x^2} + \frac{\partial^2 w}{\partial y^2} + \frac{\partial^2 w}{\partial z^2}\right),$$

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0.$$

Navier-Stokes equations

Differential Equations

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} + w\frac{\partial u}{\partial z} = -\frac{\partial p}{\partial x} + Re\left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} + \frac{\partial^2 u}{\partial z^2}\right),$$

Allows you to find the air speed and pressure at any point

$$\frac{\partial v}{\partial t} + u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} +$$

Very hard to decide

$$\frac{\partial w}{\partial t} + u\frac{\partial w}{\partial x} + v\frac{\partial w}{\partial y} +$$

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0.$$

Text Sentiment Analysis

- What is the emotional color of the text?
- Options: positive, neutral, negative
- Application: automatic analysis of user reviews

Text Sentiment Analysis

"Thank you very much! Apparently, this is exactly what all foreign courses on Machine Learning and Knowledge Discovery lack. It's a theory, a math, an explanation of what how it is arranged "in the guts".»

What color?

Text Sentiment Analysis

"I see a very big minus that the course will be on the finished sci-kit library. The course from Andrew is better because the student himself writes an algorithm and sees from the inside how it works.»

What color?

Text Sentiment Analysis

- x - text in Kazakh language
- f(x) — its color (takes the values -1, 0, 1)
- Is it possible to write out a formula for f(x) ?

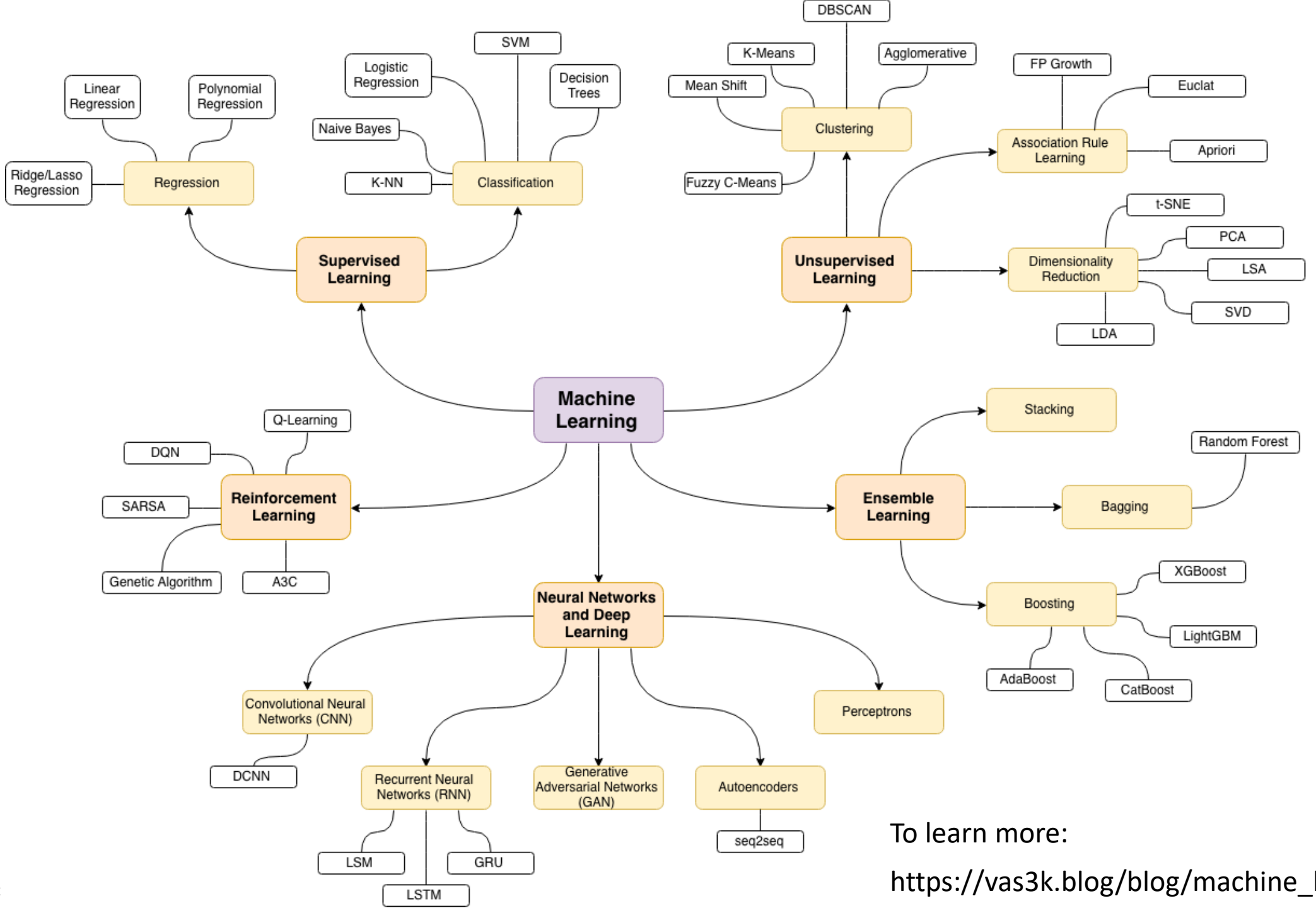
- The input is not numbers at all
- Exact dependency may not exist

More challenging tasks!

- What will be the demand for the product next month?
- How much money will the store make in a year?
- Will the client return the loan?
- Will the patient get cancer?
- Will the student pass the next session?
- Is there a humanist or a techie in the photo?
- Who will win the battle in an online game?

More challenging tasks!

- Everywhere - very complex implicit dependencies
- Cannot be expressed by formula
- But there are a number of examples
  - Texts with known colors
- We will approximate dependencies using examples



To learn more:

https://vas3k.blog/blog/machine_learning/

Basic terms

Task example

- Chain of restaurants
- We want to open another
- Multiple accommodation options
- Which of the options will bring the maximum profit?

* see kaggle.com, TFI Restaurant Revenue Prediction

Notation

- X - an object, sample - what we want to make predictions for
  - Specific restaurant location
- $\mathbb{X}$ - is the space of all possible objects
  - All possible restaurant locations
- y - response, target variable,target - what we predict
  - Profit during the first year of operation
- $\mathbb{Y}$ - response space - all possible response values
  - All real numbers

Training sample

- We don't understand anything about economics
- But we have many objects with known answers
- $X = (x_i, y_i)_1^\ell$ — training sample
- ℓ - sample size

Features

- Objects - abstract entities
- Computers only work with numbers
- Special characters, factors,features - numerical characteristics of objects
- d - number of signs
- $X = (x^1, \ldots, x^d)$— indicative description

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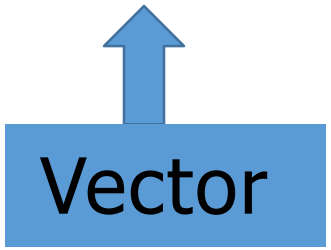

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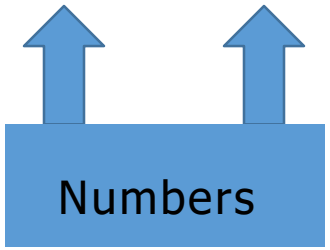


Features

- About demographics:
  - Average age of residents of the nearest quarters
  - Dynamics of the number of inhabitants
- About real estate:
  - Average cost per square meter of housing nearby
  - Number of schools, banks, shops, gas stations
  - Distance to the nearest competitor
- About roads:
  - Average number of cars passing by per day

Algorithm

- $a(x)$ - algorithm, model - a function that predicts the answer for any object
- Displays XX in YY
- Linear model: $a(x) = w_1x^1 + \ldots + w_dx^d$

Loss function

- Not all algorithms are useful
- $a(x) = 0$ - will not bring any benefit
- Loss function - a measure of the correctness of the algorithm's answer
- Predicted $10,000 profits, actually $5,000 - good or bad?

- Standard deviation: $(a(x) - y)^2$
- $E = (10\ 000 - 5000)^2 = y$

Quality functional

- Quality functional, quality metric - measure of the quality of work sample algorithm
- Root mean square error (Mean Squared Error, MSE):

$$\frac{1}{\ell}\sum_{i=1}^{\ell}(a(x_i)-y_i)^2$$

- Less is better

Quality functional

- Must meet business requirements
- One of the most important components of data analysis

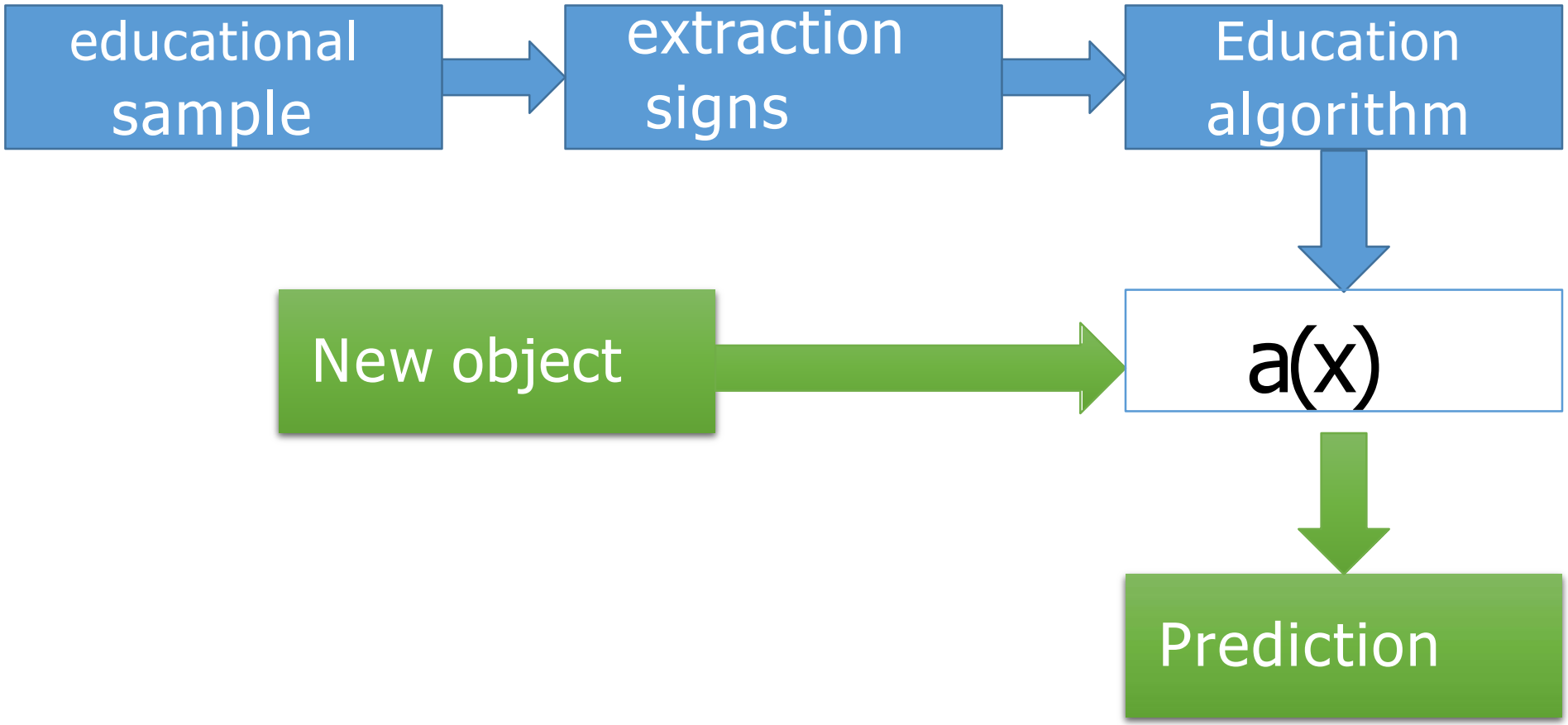
Algorithm training

- There is a training sample and a quality functional
- Family of algorithms - $\mathcal{A}$
  - From what we choose an algorithm
  - Example: all linear models

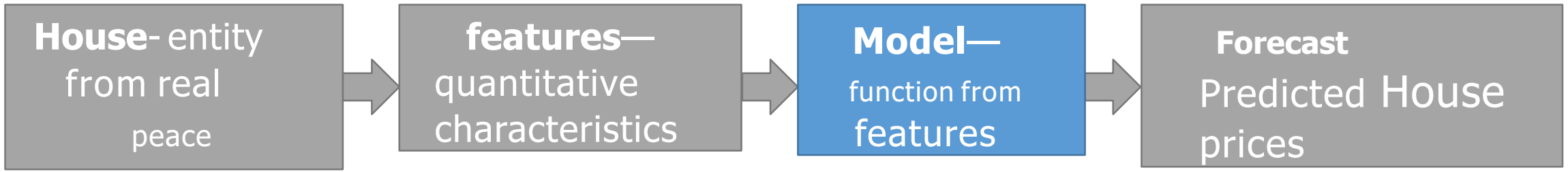
$$\mathcal{A} = \{w_1 x^1 + \cdots + w_d x^d \mid w_1, \ldots, w_d \in \mathbb{R}\}$$

- Training: search for the optimal algorithm in terms of quality functional

Machine learning



House value prediction



House value prediction

Training sample:

Square	Price
50	250
60	340
10	20
90	800
10	1000
120	?

Possible signs:

- square
- $square^2$
- $Square^3$
- $\sin(square)$
- $\sqrt{square}$
- and so on

Possible models:

- $w_1 * square$
- $w_1 * square$
- $w_1 * square + w_1 * square$
- and so on

Model view- Job expert or full search.

Scale selection $w_1 w_2$— automatic process (based on data)

House value prediction

Model $a(x) = 5 * \text{square}$

Square	Forecast	Price	$(a - y)^2$
50	250	250	0
60	300	340	1600
10	50	20	900
90	450	800	122500

MSE: 31250

RMSE: 176.78

Model $a(x) = 0.1 * \text{square}^2$

Square	Forecast	Price	$(a - y^2)$
50	250	250	0
60	360	340	400
10	10	20	100
90	810	800	100

MSE: 150

RMSE: 12.25

House value prediction

Signs may be more:

- Square
- Year of construction
- Availability of a swimming pool
- Number of rooms
- Distance from the center
- Cop Rating

  site
- And so on

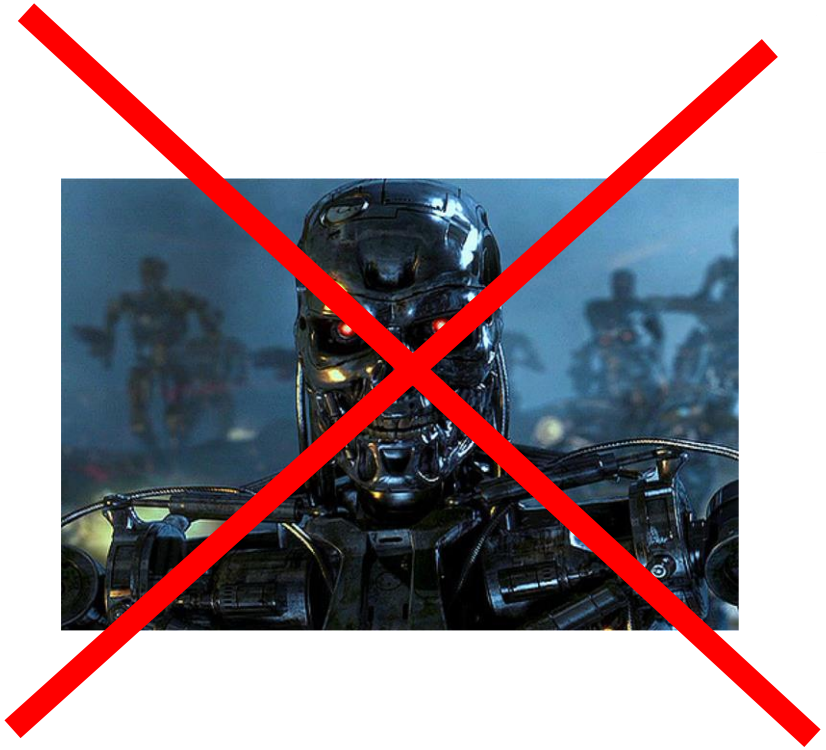
Possible models:

- Linear: $w_{1\ 50} * \text{area} + w_{2\ 50} * \text{year} + w_3 * 10\ \text{pool} + w_4 * \text{room} + w_5 * \text{remoteness} + w_6 * \text{Police}$
- Decision Trees
- Neural networks
- Method k nearest neighbors
- And so on

What you need to know

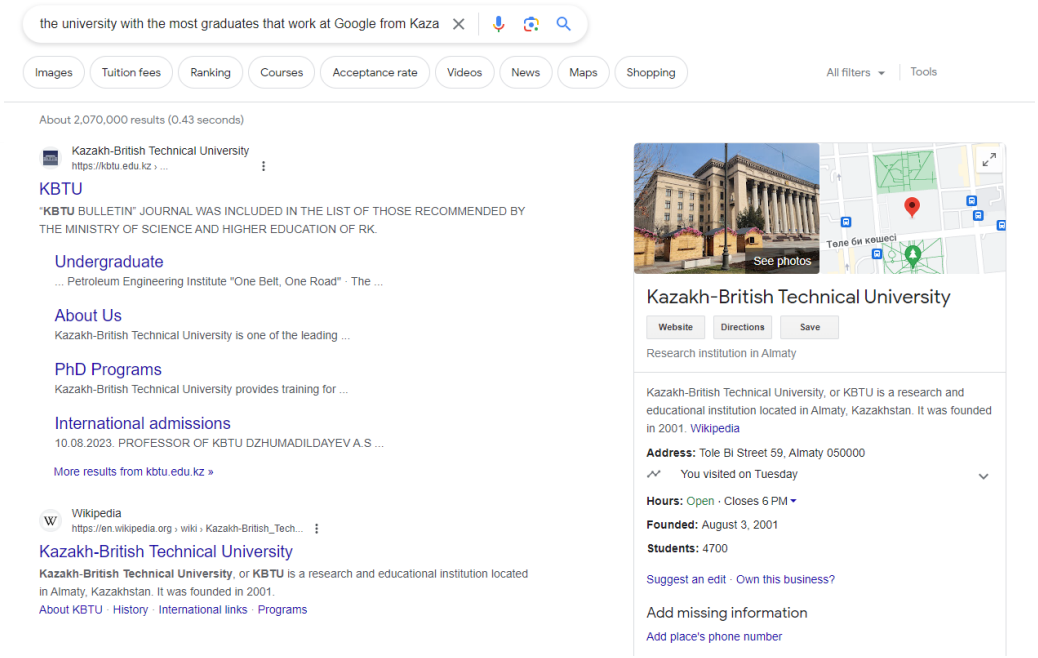
1. How to formulate the problem?
2. What signs to use?
3. Where to get the training sample?
4. How to choose a quality metric?
5. How to train the algorithm?
6. How to evaluate the quality of an algorithm?

Artificial intelligence



Strong AI

in 20-100 years



Specialized AI

now

Machine learning in HR

- Searching for candidates and predicting the outcome of the interview
- Help with rotation
- Employee departure prediction
- Analysis of internal forums, highlighting complaints

Recommender systems

- Shelves of recommendations onAmazon generate 35% of all purchases
- Recommendations based on machine learning and analysis big data