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Introduction to Artificial Intelligence: Methods, Models, Algorithms

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How to translate hours in minutes?

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x - hours

$f(x) = 60x$ - conversion in minutes, function

What force is applied to the body?

We know the mass of the body m and its acceleration a

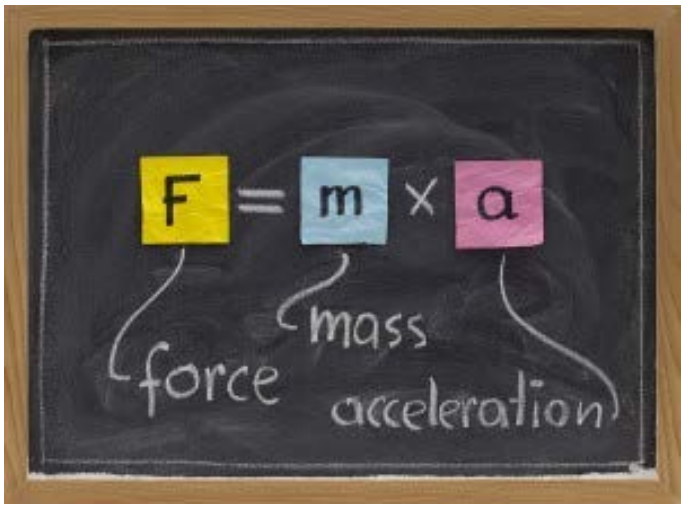
What is the force F?

What force is applied to the body?

We know the mass of the body m and its acceleration a

What is the force F?

Newton's second law: $F = ma$



How to predict the weather?

The Navier-Stokes equations

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} + w\frac{\partial u}{\partial z} = -\frac{\partial P}{\partial x} + Re\left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} + \frac{\partial^2 u}{\partial z^2}\right),$$
$$\frac{\partial v}{\partial t} + u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} + w\frac{\partial v}{\partial z} = -\frac{\partial P}{\partial y} + Re\left(\frac{\partial^2 v}{\partial x^2} + \frac{\partial^2 v}{\partial y^2} + \frac{\partial^2 v}{\partial z^2}\right),$$
$$\frac{\partial w}{\partial t} + u\frac{\partial w}{\partial x} + v\frac{\partial w}{\partial y} + w\frac{\partial w}{\partial z} = -\frac{\partial P}{\partial z} + Re\left(\frac{\partial^2 w}{\partial x^2} + \frac{\partial^2 w}{\partial y^2} + \frac{\partial^2 w}{\partial z^2}\right),$$
$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0.$$

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Differential equations

Allow to find the speed of air and pressure at any point

It's very hard to solve

Sentiment analysis of the text

What is the sentiment of the text?

Options: positive, neutral, negative

Application: automatic analysis of feedback from users

Sentiment analysis of the text

"Many thanks! Apparently, this is exactly what is not enough for all foreign courses in Machine Learning and Knowledge Discovery. This theory, mathematics, the explanation of what, how it is arranged "in bowels"."

What sentiment?

Sentiment analysis of the text

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

What sentiment?

Sentiment analysis of the text

x - English text

$f(x)$ - its sentiment (takes values 0, 1, -1)

Can we write out a formula for x?

At the entrance - not at all numbers

Exact dependence may not exist

More difficult tasks!

1. What will be the demand for the product next month?
2. How much money will the store earn in a year?
3. Will the customer return the loan?
4. Will the patient get cancer?
5. Will the student pass the next session?
6. In the photo of the humanities or digithead?
7. Who will win the battle in the online game?

More difficult tasks!

1. Everywhere - very complex implicit dependencies
2. We can not express them by the formula
3. But there are a number of examples (texts with a known sentiment)
4. We will approximate the dependencies using examples

Data analysis and machine learning

It is about how to restore complex dependencies by the finite number of examples

References

1. Gareth James, Daniela Witten, Trevor Hastie and Robert Tibshirani. An Introduction to Statistical Learning. 2013.
2. Mohammed J. Zaki, Wagner Meira Jr. Data Mining and Analysis. Fundamental Concepts and Algorithms. Cambridge University Press, 2014.

References

Online courses

1. https://www.coursera.org/learn/machine-learning
2. https://www.coursera.org/learn/introduction-machine-learning
3. https://coursera.org/specializations/machine-learning-data-analysis

Task example

1. Network of restaurants
2. We want to open one more
3. Several siting options
4. Which of the options will bring the maximum profit?

kaggle.com, TFI Restaurant Revenue Prediction

Notation

1. x - sample - for which we want to make predictions (the exact location of the restaurant)
2. $\mathbb{X}$ - the space of all possible objects (all possible restaurant locations)
3. y - target - what is predicted (profit during the first year of operation)
4. $\mathbb{Y}$ - answer space - all possible values for the answer (all real numbers)

Training sample

1. We do not understand anything about the economy
2. But we have many objects with known answers
3. $X = (x_i, y_i)_{i=1}^{l}$ - training sample
4. l - sample size

Features

1. Objects are abstract entities
2. Computers only work with numbers
3. Factors, features - numerical characteristics of objects
4. d - number of features
5. $x = (x^1, \ldots, x^d)$ - feature description (vector)

About demography:

1. Average age of residents of the nearest district
2. Dynamics of number of inhabitants

About the property:

1. Average cost per square meter of housing nearby
2. Number of schools, banks, shops, gas stations
3. Distance to nearest competitor

About roads:

1. The average number of cars passing by day

Algorithm

1. $a(x)$ - an algorithm, a model - function predicting response for any object
2. Transform $\mathbb{X}$ into $\mathbb{Y}$
3. Linear model: $a(x) = w_1 x^1 + \cdots + w_d x^d$

Loss function

1. Not all algorithms are useful
2. $a(x) = 0$ - will not bring any benefit
3. The loss function is a measure of the correctness of the algorithm response
4. Predicted 10,000$ profit, in fact 5,000$ - it is good or bad?
5. Standard deviation: $(a(x) - y)^2$

Quality functional

1. The quality functional a the quality metric is a measure of the quality of the algorithm work on a sample
2. Mean Squared Error, MSE: $\frac{1}{l}\sum_{i=1}^{l}(a(x_i) - y_i)^2$
3. Less is better

Quality functional

1. Must comply with business requirements
2. One of the most important components of data analysis

Learning algorithm

1. There is a training sample and a quality functional
2. The family of algorithms A from what we choose the algorithm (all linear models: $A = \{w_1 x^1 + \cdots + w_d x^d | w_1, \ldots, w_d \in \mathbb{R}\}$)
3. Training: the search for the optimal algorithm in terms of the functional quality

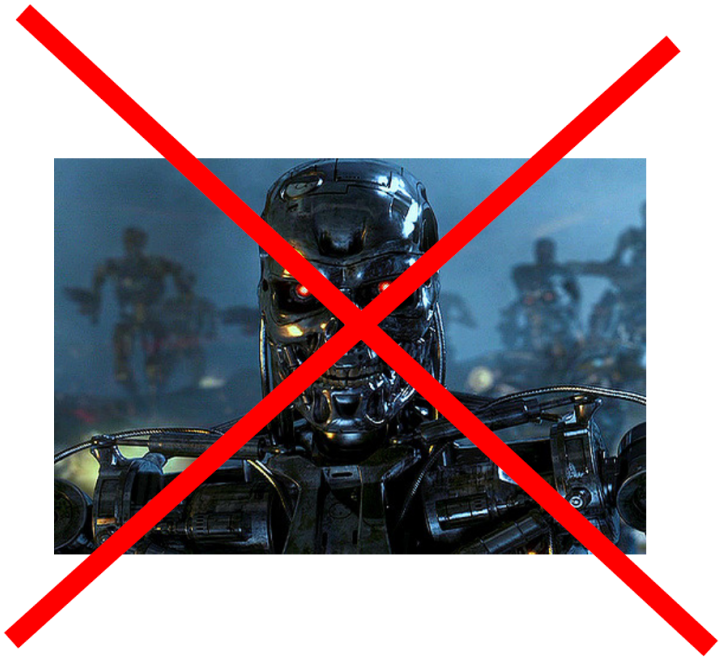
Machine learning

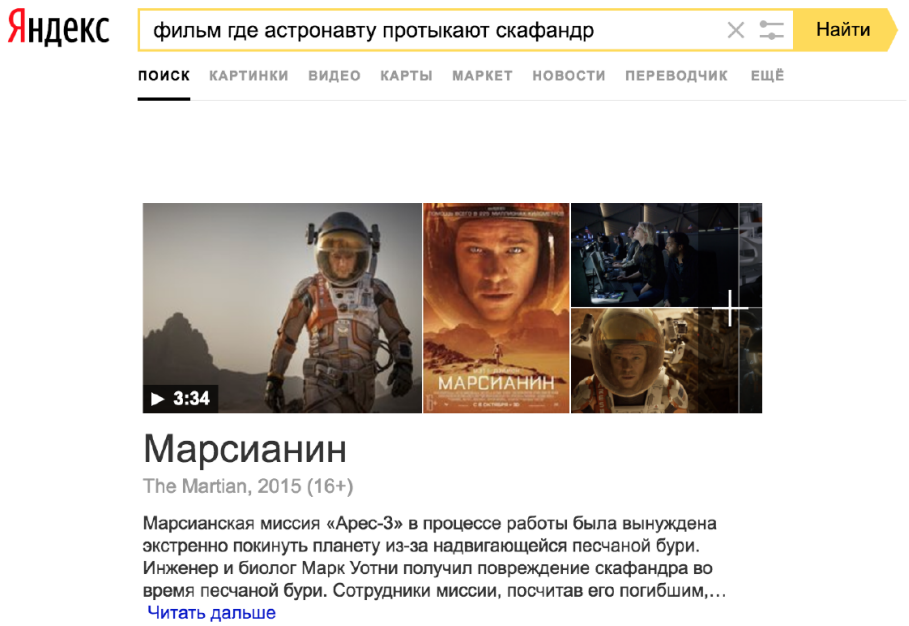
1. Training sample
2. Feature extraction
3. Learning model $\rightarrow a(x)$
4. New object $x \rightarrow$ new prediction

What you need to know

- How to formulate the task?
- How to extract the features?
- How to form a training sample?
- How to choose a quality metric?
- How to prepare data for training?
- How to train the algorithm?
- How to evaluate the quality of the algorithm?

Artificial Intelligence

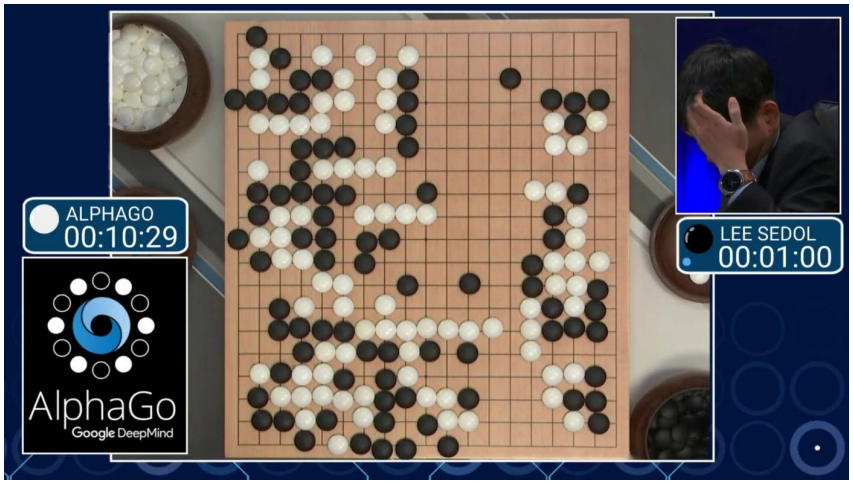




1. Strong AI - in 20-100 years
2. Specialized AI - now!

Artificial Intelligence

1. Model for playing Go
2. Evaluates the success of the turn
3. Studied by playing with myself
4. Defeated the world champion in 2017
5. For a long time, playing in Go was considered an impossible task for a computer



Annotating images


"man in black shirt is playing guitar."


"construction worker in orange safety vest is working on road."


"two young girls are playing with legos toy."


"boy is doing backflip on wakeboard."

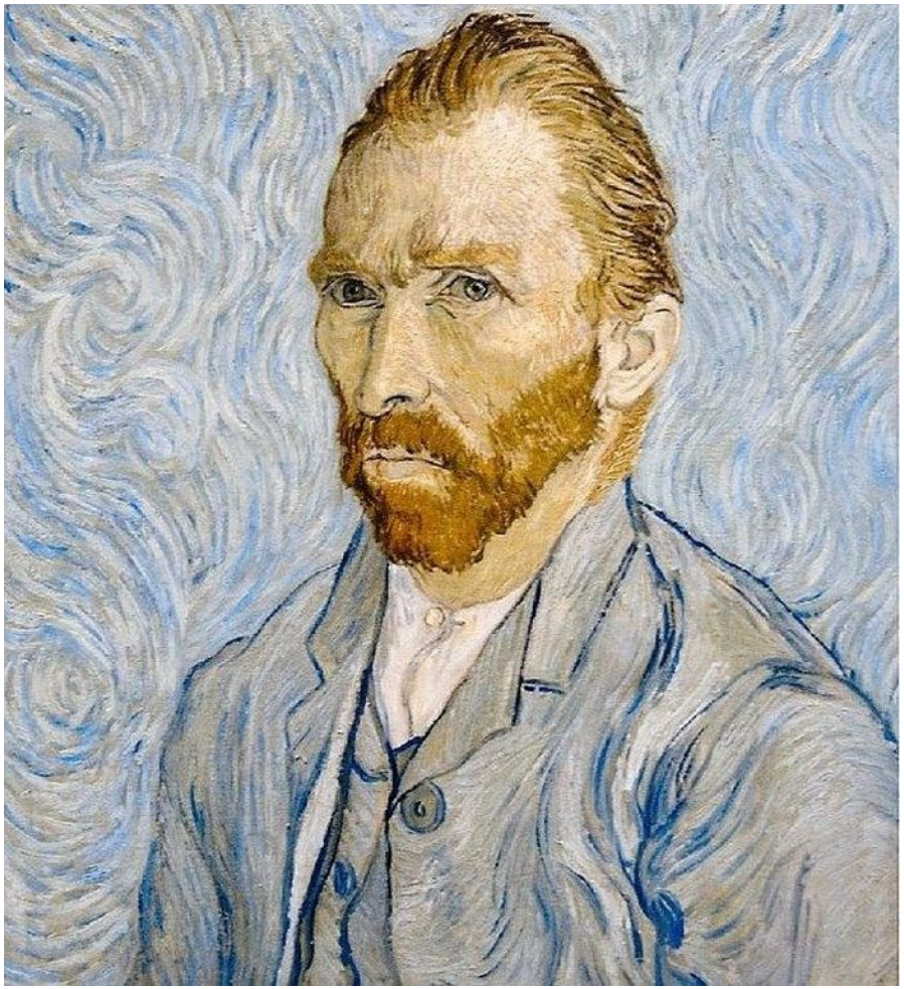

"girl in pink dress is jumping in air."


"black and white dog jumps over bar."


"young girl in pink shirt is swinging on swing."


"man in blue wetsuit is surfing on wave."

Style transfer



Artificial Intelligence

1. The model predicts whether the required chemical composition is obtained in result of melting
2. Reduces the consumption of ferroalloys by 5%
3. Savings of up to 23 million rubles per month
4. Joint project of Yandex and Magnitogorsk metallurgical Combine

Recommender systems

- Shelves of recommendations on Amazon generate 35% of all purchases
- Recommendations based on machine learning and analysis of large volumes of data

Why is this necessary?

- That's cool
  - Challenges
  - Movement towards artificial intelligence
- This is useful
  - Profit from data
  - Data-driven companies

How can you analyze data?

- Data scientist
  - Working with data
  - Knowledge of tools and methods
  - Experience in solving problems
- Manager
  - Understanding how machine learning works
  - Understanding bottlenecks, estimating deadlines
- Customer
  - Quality metrics
  - Data requirements
  - Limitations of modern approaches