

TECHNOLOGIES IN EDUCATION  
**UNIVERSITY** NSU

MICROELECTRONICS  
**INNOVATIONS**  
CATALYTIC  
MATERIALS  
**ASSEMBLY**  
**POINT**

SCIENTIFIC  
LABORATORY  
**HYBRID**  
MATERIALS  
GEOPHYSICS  
**ENGINEERING**  
ENERGY CONSERVATION  
**BIOTECHNOLOGY**  
GEOCHEMISTRY  
NANOTECHNOLOGY

**HIGH**  
ENERGIES  
SEMIOTICS  
**SCIENCE**  
MATHEMATICAL MODELING

**DRUG**  
DESIGN

DEVELOPMENT  
**ELEMENTARY**  
**PARTICLES**  
THE ARCTIC REGIONS  
**DARK**  
MATTER

**QUANTUM**  
TECHNOLOGIES  
BIOMEDICINE  
**APPLIED**  
STUDIES  
PHOTONICS  
**ASTRONOMY**  
GLOBAL PRIORITY  
**ASTROPHYSICS**  
BIOINFORMATICS

**LASER**  
**PHYSICS**  
KNOWLEDGE  
ECONOMY  
**GEOLOGY**  
ARCHEOLOGY  
COGNITIVE TECHNOLOGIES

IT  
DEEP  
LEARNING  
**BRAIN**  
**STUDY**

**N\*** Novosibirsk  
State  
University  
\*THE REAL SCIENCE

# Introduction to Machine Learning

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*Department of Mathematics and Mechanics*

# Course Overview

- Github: [https://github.com/luumsk/NSU\\_ML](https://github.com/luumsk/NSU_ML)
- Email: [khue.luu@g.nsu.ru](mailto:khue.luu@g.nsu.ru)
- Telegram: @khueluu
- Notes:
  - Theory + practice (\*)
  - Lectures + assignments + personal final project
  - Extra points

# Get to know Machine Learning

What is Machine Learning?

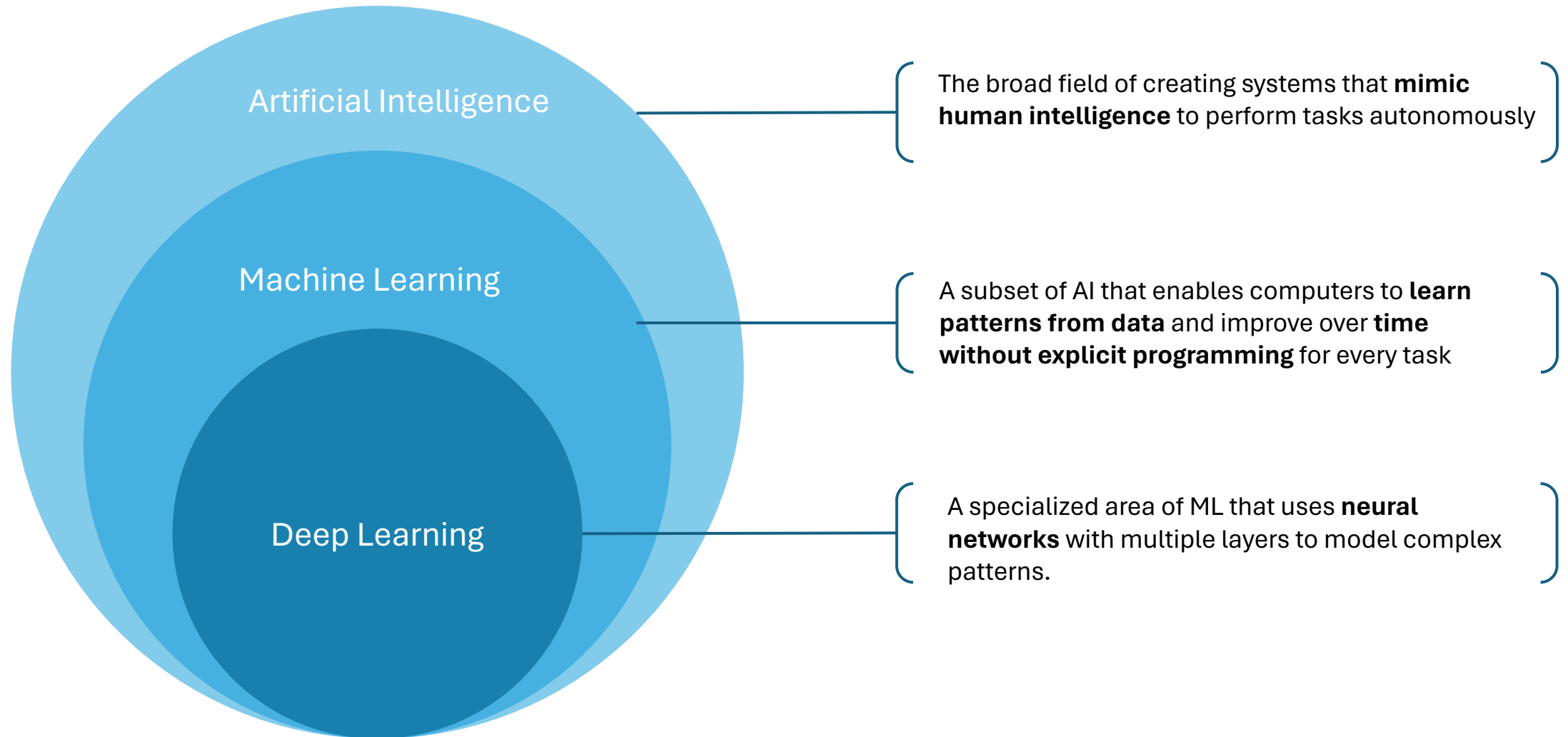
Applications of Machine Learning

Types of Machine Learning

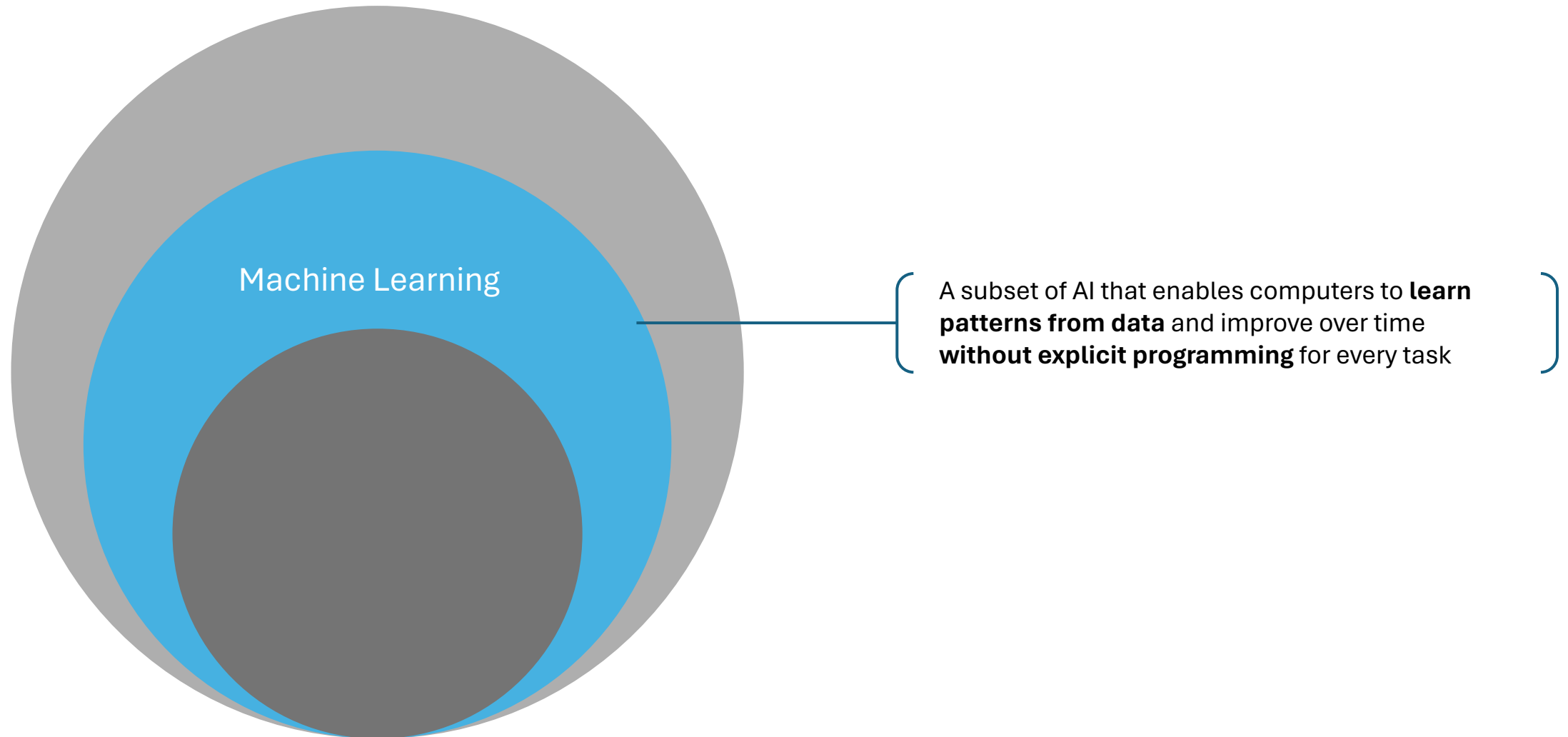
Machine Learning pipeline

Component of a Machine Learning pipeline

# What is machine learning?



# What is machine learning?



# Machine Learning Engineer Salary in Russian Federation

This page is an excerpt of the much more complete compensation information available in [ERI's Assessor Series](#).

**RUB 2,126,200**

Average Salary

**RUB 1,022/hr**

Average Hourly

**RUB 97,593**

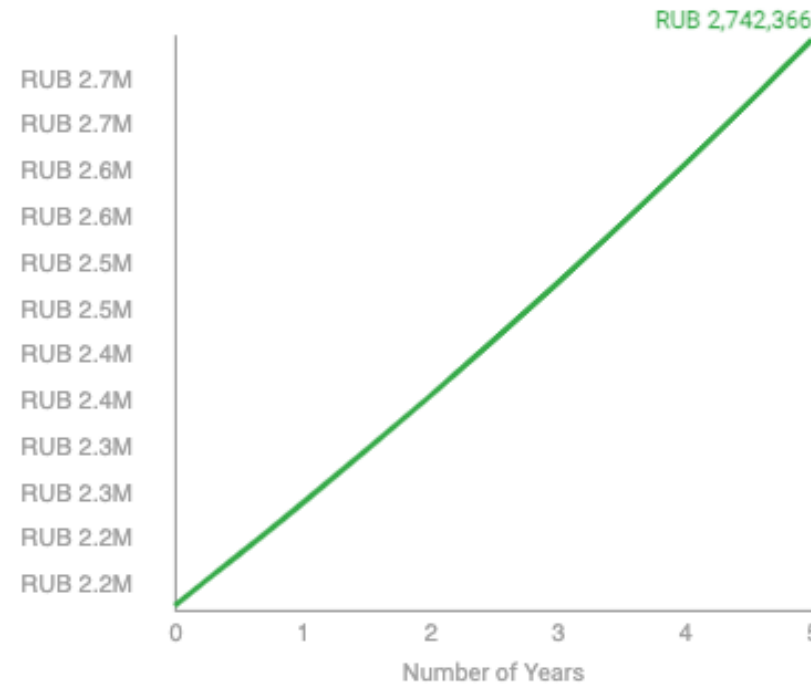
Average Bonus

Estimated salary in 2029:

**RUB 2,742,366**

5 Year Change:

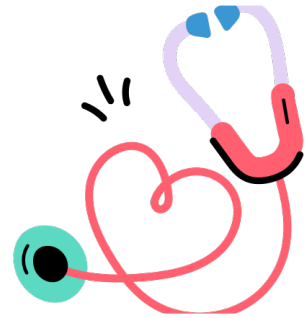
▲ 29 %



## Job titles

- Machine Learning Engineer
- Data Scientist
- Research Scientist (Machine Learning)
- Applied Machine Learning Scientist
- Machine Learning Analyst
- Lead Machine Learning Scientist
- Director of Machine Learning
- Chief AI Officer

# Applications of machine learning



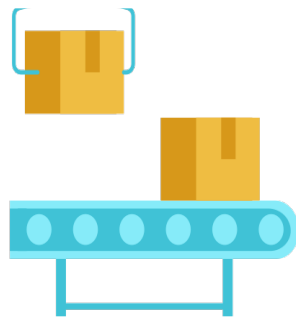
Healthcare



Finance



E-commerce



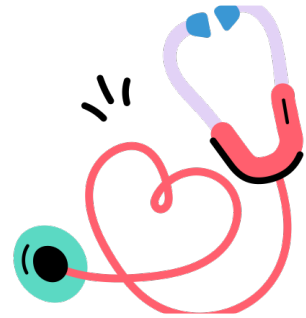
Manufacturing



Transport and  
Logistic

# Applications of machine learning

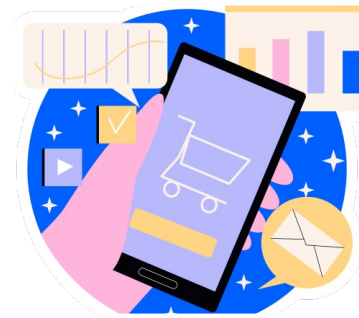
- Diagnostics
- Predictive Analytics
- Personalized Medicine



Healthcare



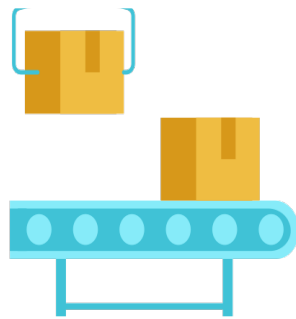
Finance



E-commerce

- Recommendation Engines
- Customer Segmentation
- Inventory Management

- Fraud Detection
- Credit Scoring
- Algorithmic Trading



Manufacturing

- Predictive Maintenance
- Quality Control
- Supply Chain Optimization



Transport and Logistic

- Route Optimization
- Traffic Prediction



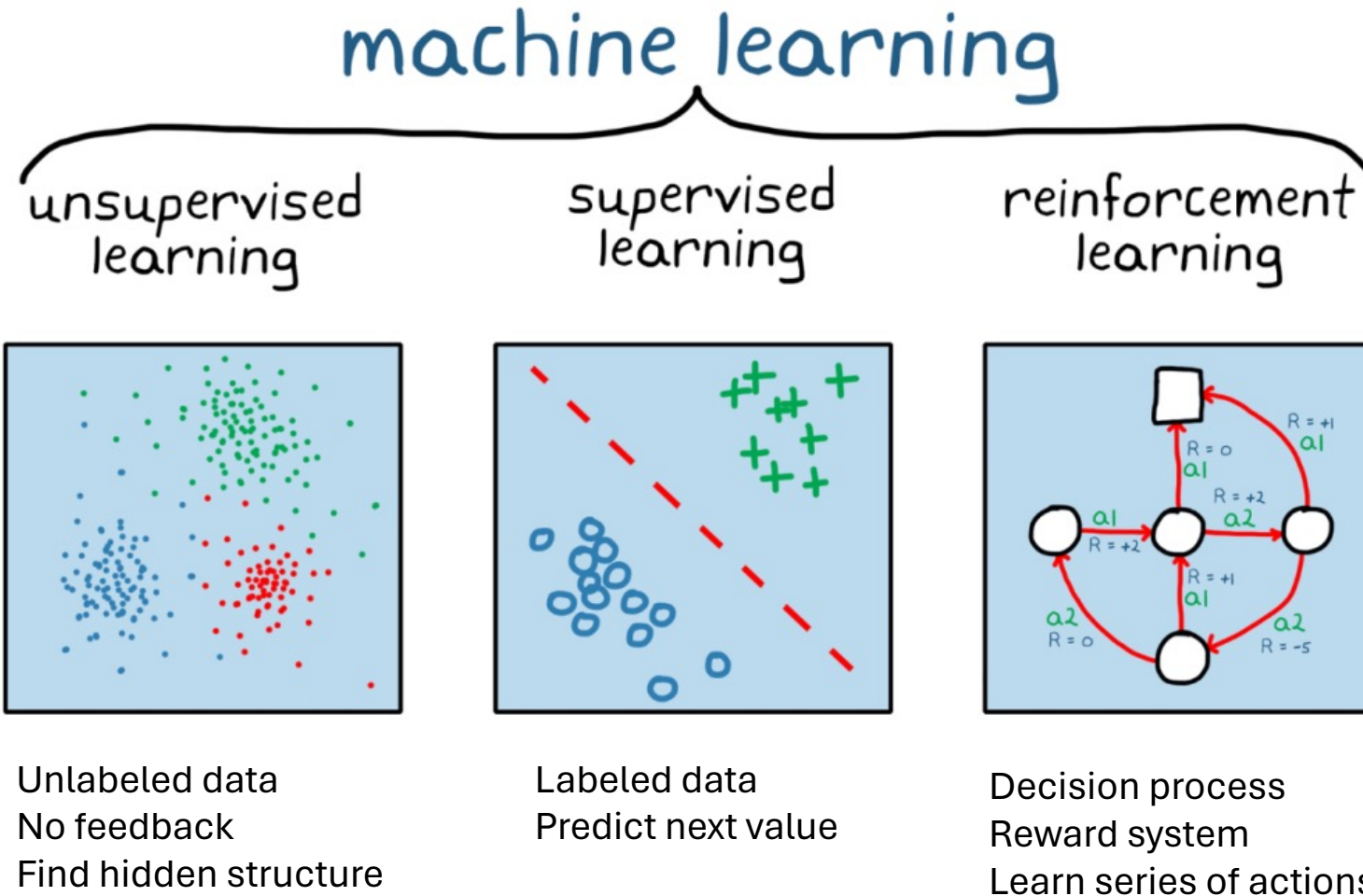
What ML applications you know/being used in your country?



What ML applications you are interested in?



# Types of machine learning



# Types of Supervised Learning



## Regression



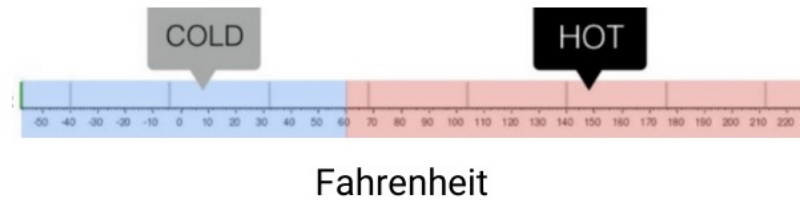
What will be the temperature tomorrow?



## Classification

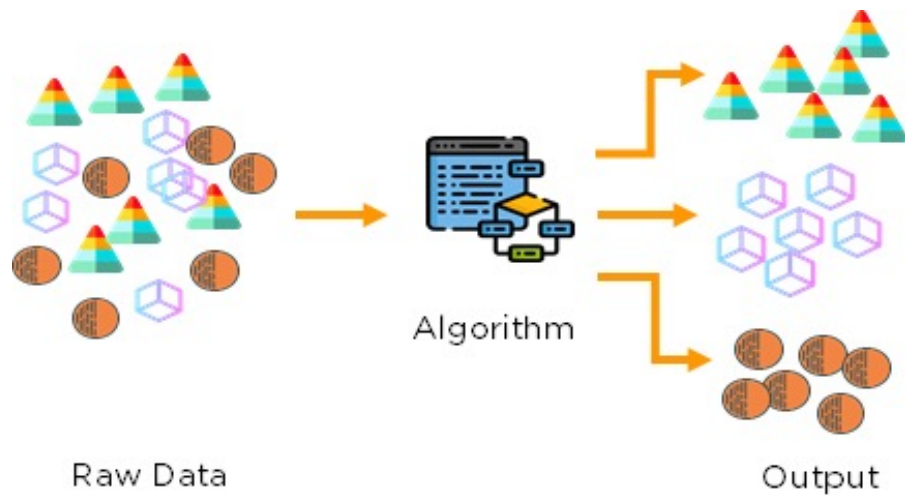


Will it be hot or cold tomorrow?

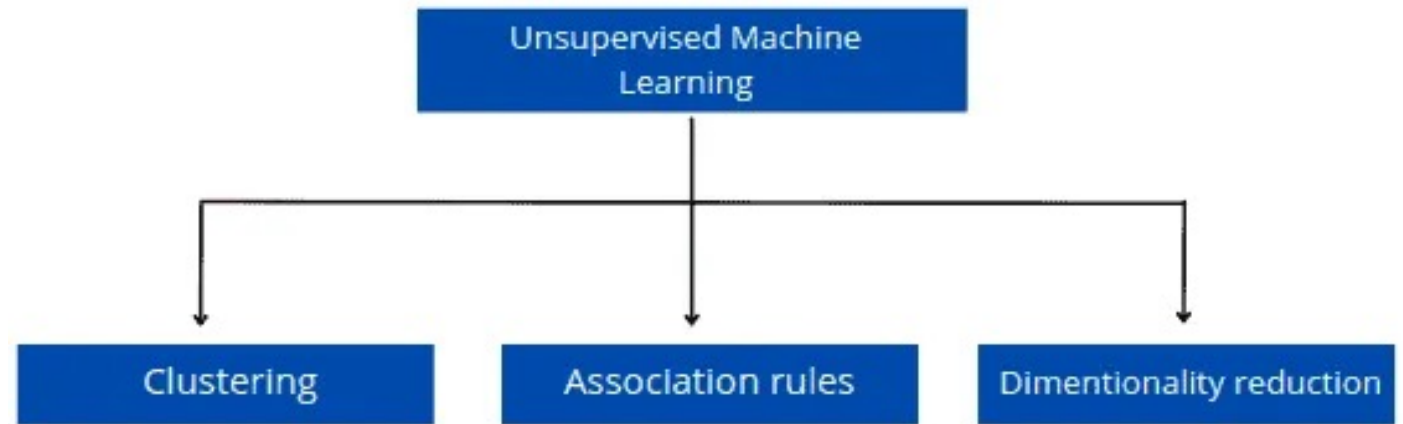


Binary/  
Multi-class

# Types of Unsupervised Learning



Source: <https://medium.com/analytics-vidhya/beginners-guide-to-unsupervised-learning-76a575c4e942>



Source: <https://hands-on.cloud/ml-unsupervised-learning-guide/>

# What type of ML problem do you think it is?

**Scenario 1:** A bank wants to predict whether a new applicant will default on a loan. They have data on previous applicants, including income, credit score, and past financial behavior.

**Question:** What type of machine learning problem is this, and why?



# What type of ML problem do you think it is?



**Scenario 2:** An e-commerce company wants to group its customers into different segments to better tailor its marketing strategy. They have information on customer behavior, such as purchase frequency, spending habits, and browsing history, but they do not know how which customer belongs to which group.

**Question:** What type of machine learning problem is this, and why?

# What type of ML problem do you think it is?



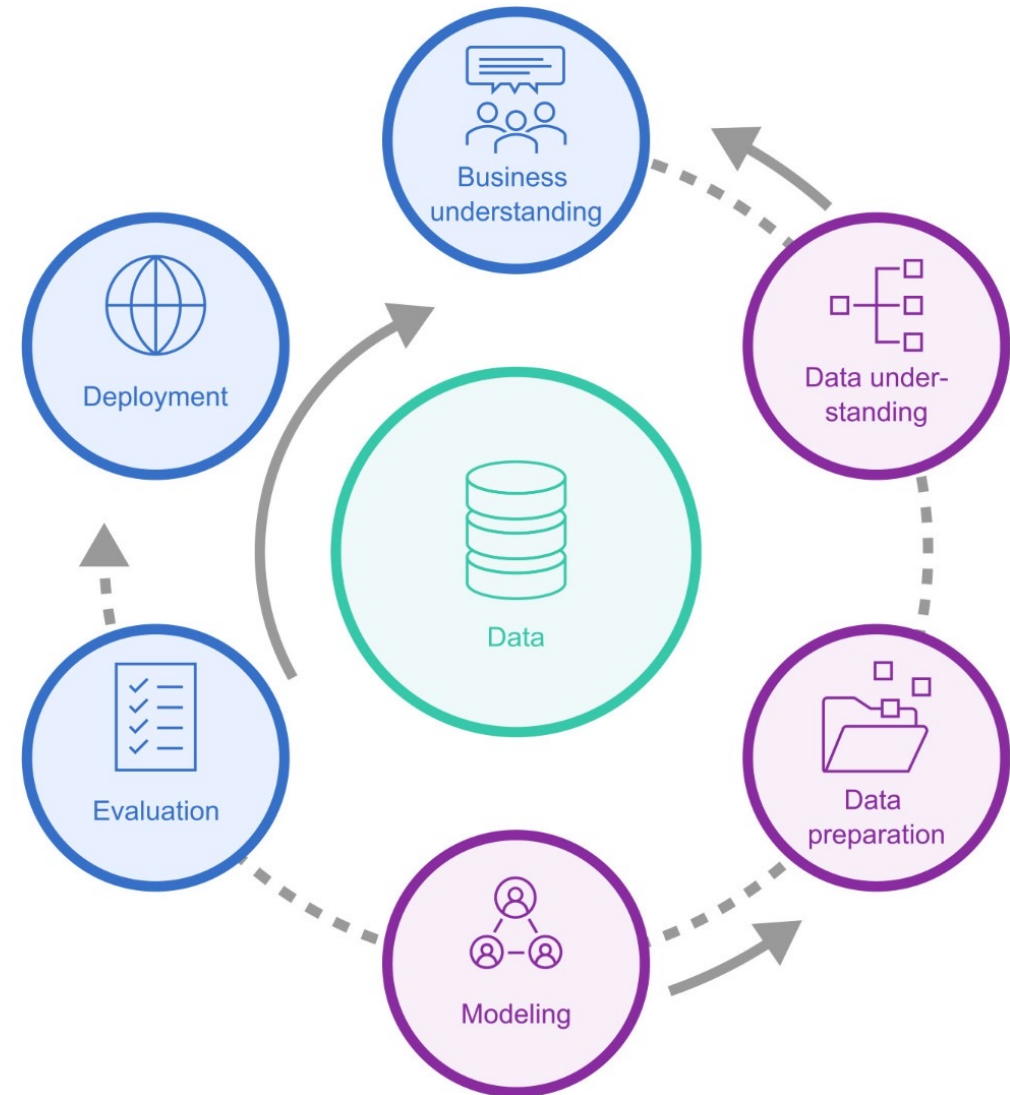
**Scenario 3:** Imagine a robotic vacuum cleaner that navigates around a house, cleaning floors and avoiding obstacles. The robot has to learn how to move efficiently, avoid furniture, and return to its charging station when its battery is low. The robot doesn't start with any prior knowledge about the house layout or where obstacles are located.

**Question:** What type of machine learning problem is this, and why?

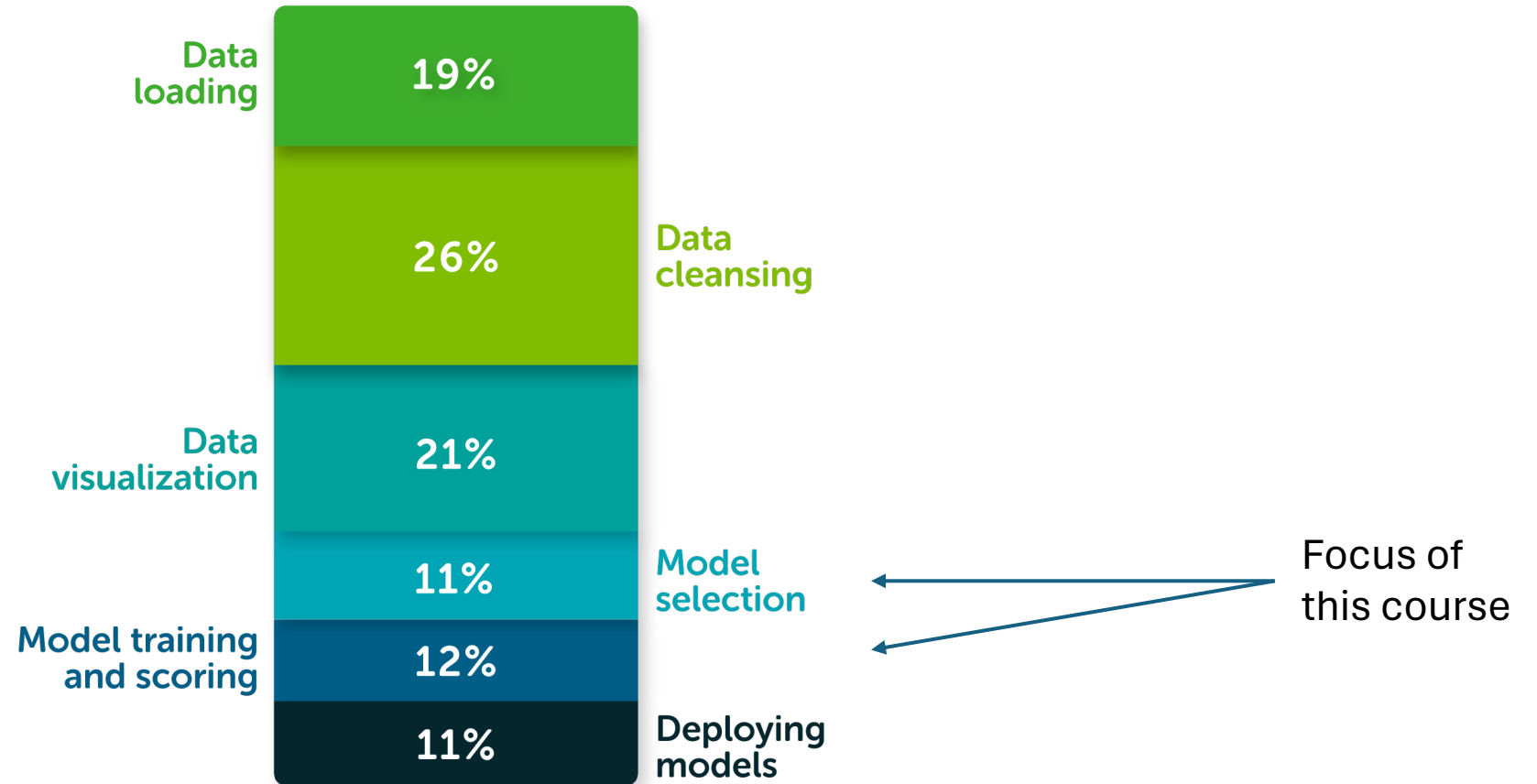


# Machine learning pipeline

Cross-Industry Standard Process for Data Mining (CRISP-DM)



# Time allocation for ML tasks



# Components of a machine learning pipeline

- **Input Data**

- Raw data used to train the model, containing independent variables (predictors) and, in supervised learning, target labels.

- **Features**

- Selected attributes from the data that represent relevant information, influencing model accuracy and performance.

- **Model**

- The algorithm or mathematical representation that learns patterns in the data (e.g., linear regression, decision trees).

- **Model Output (Prediction)**

- The result generated by the model, such as predicted labels, probabilities, or continuous values.

- **Evaluation Metrics**

- Measures like accuracy, precision, and recall used to assess model performance and generalization.

# Some practical aspects

Underfitting vs Overfitting

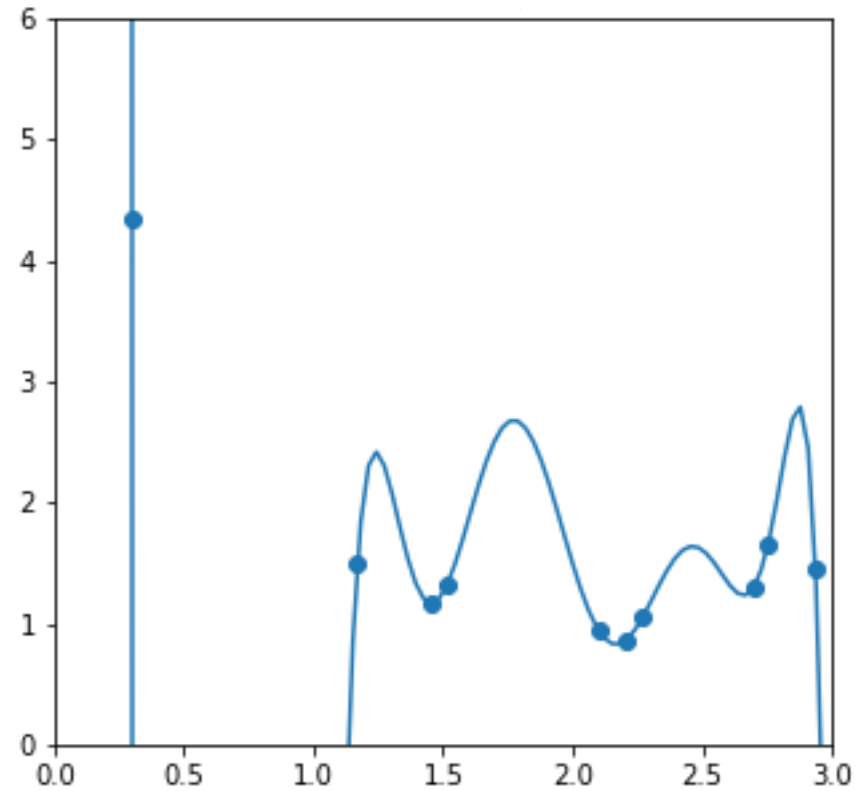
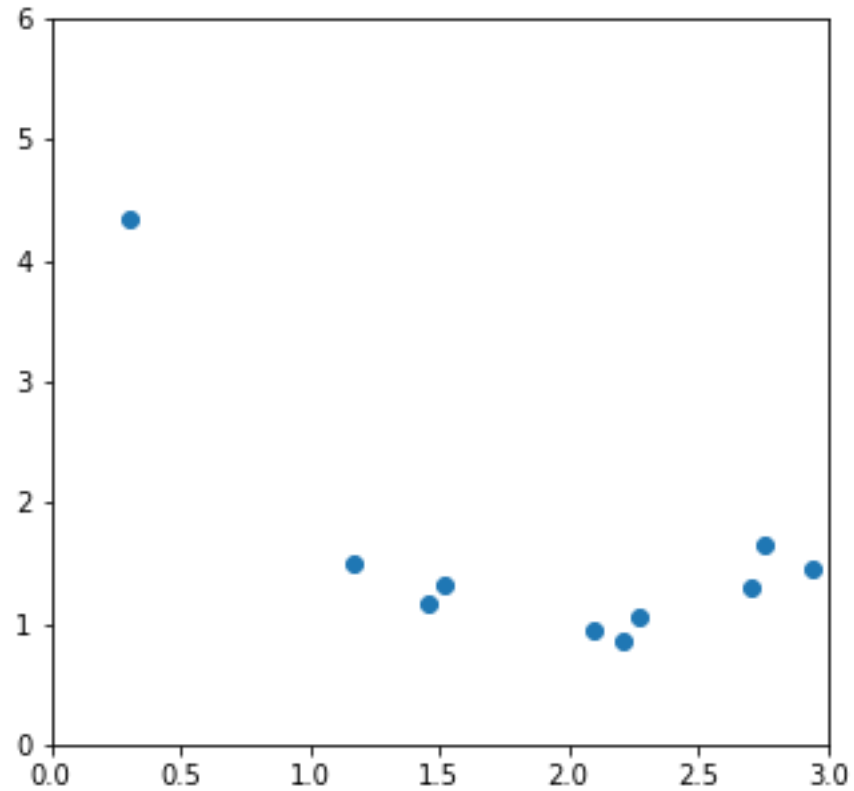
Training, validation, and test dataset  
splitting

Cross-validation

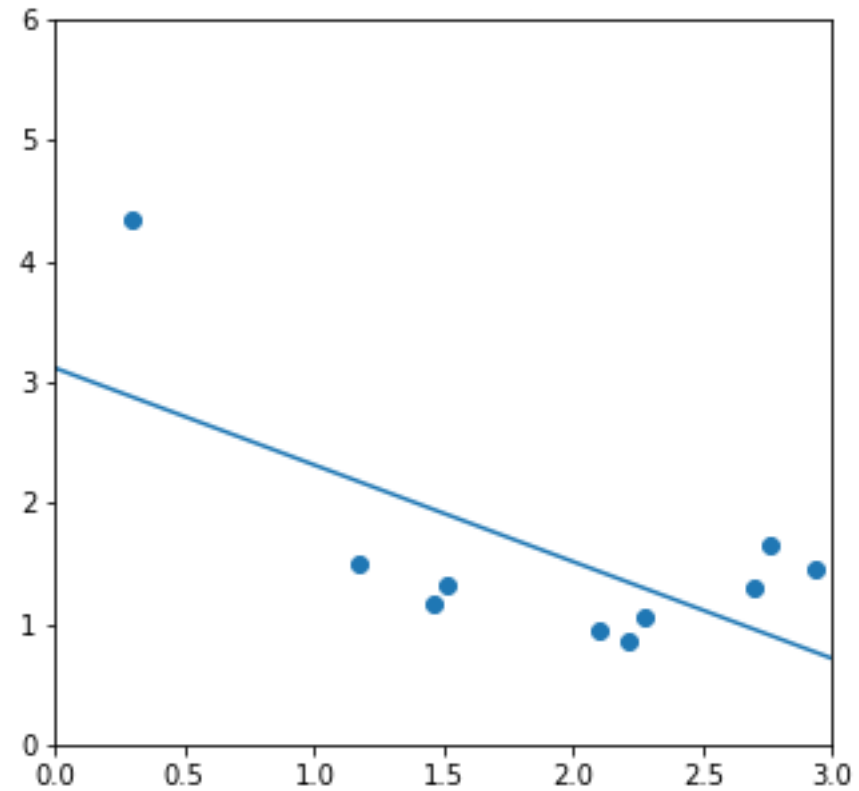
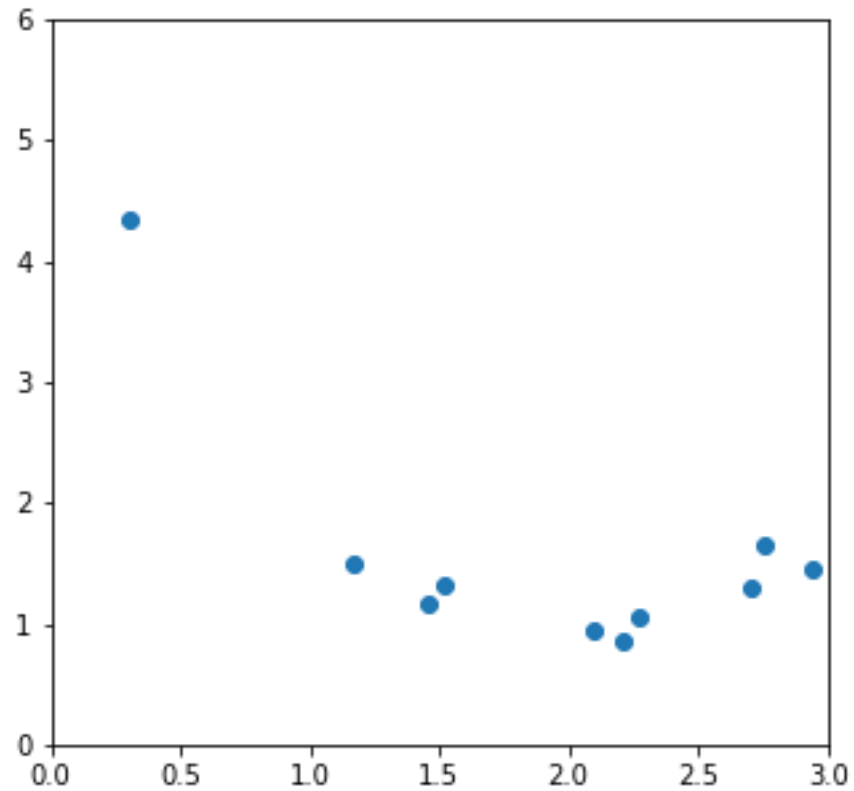
Hyperparameters tuning

Ensemble method

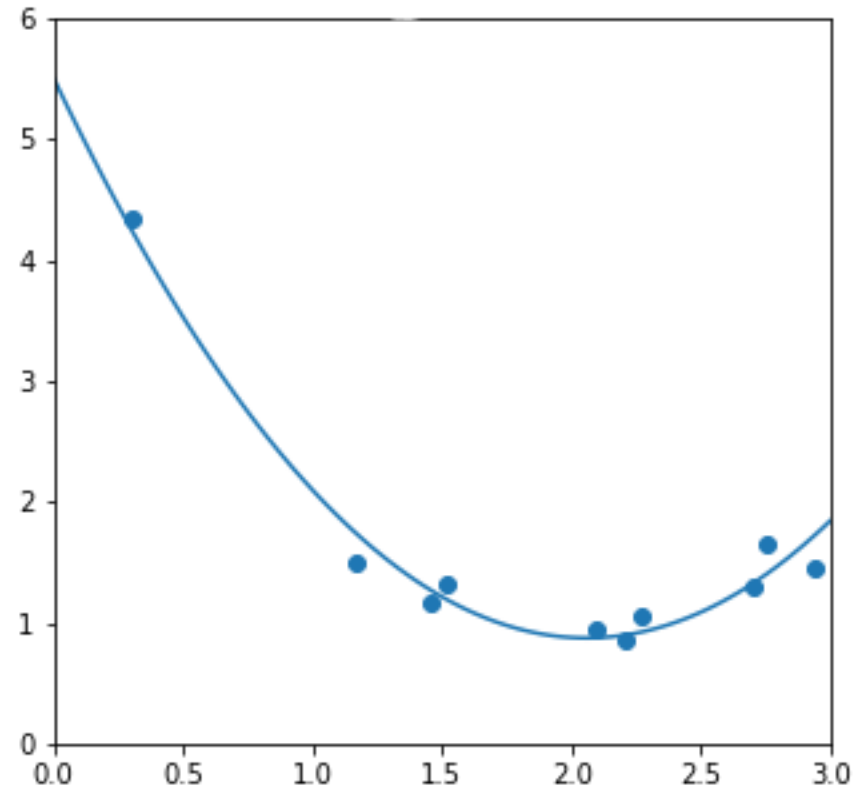
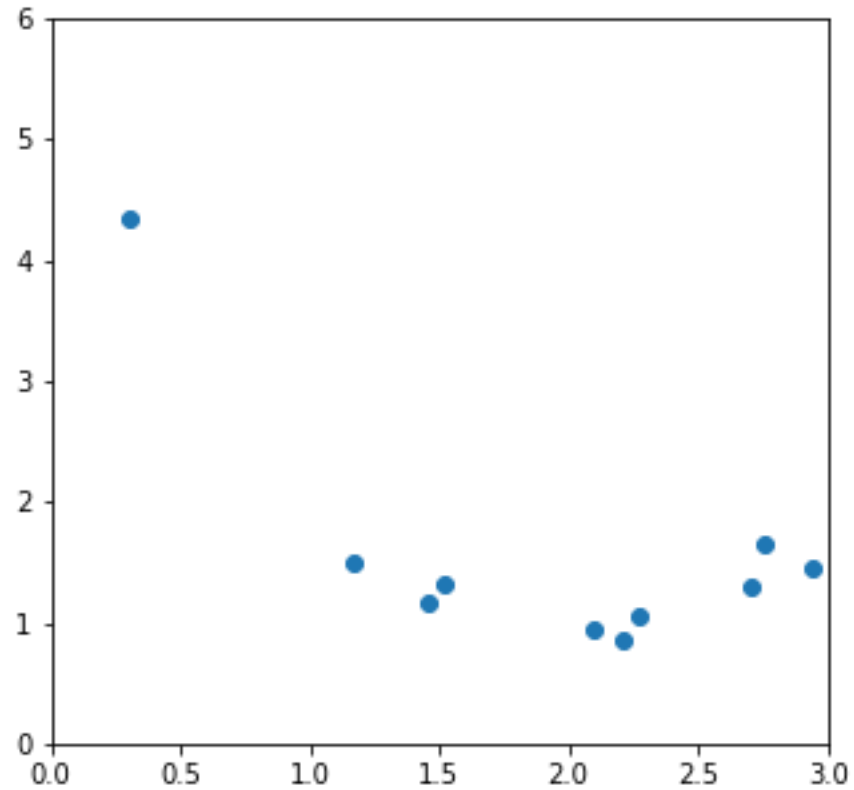
# Choosing the function class



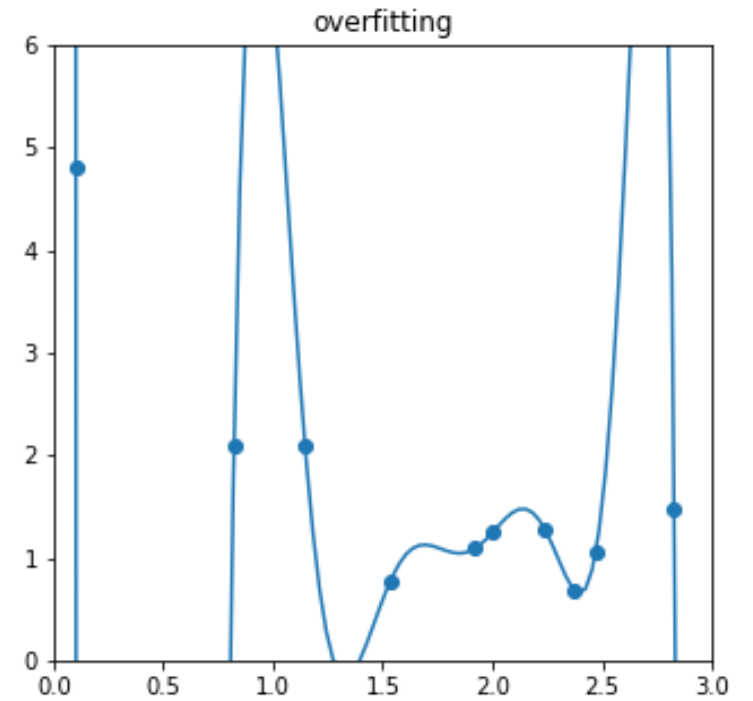
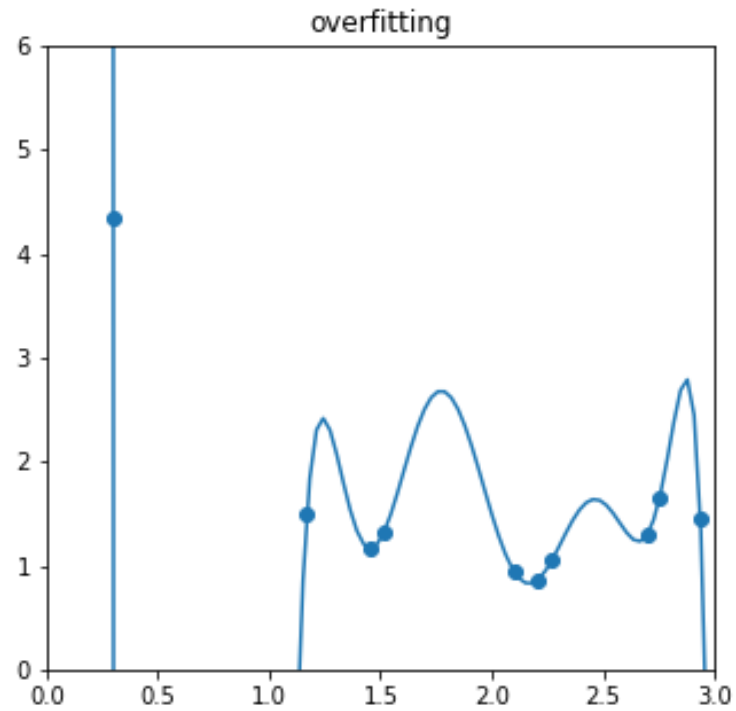
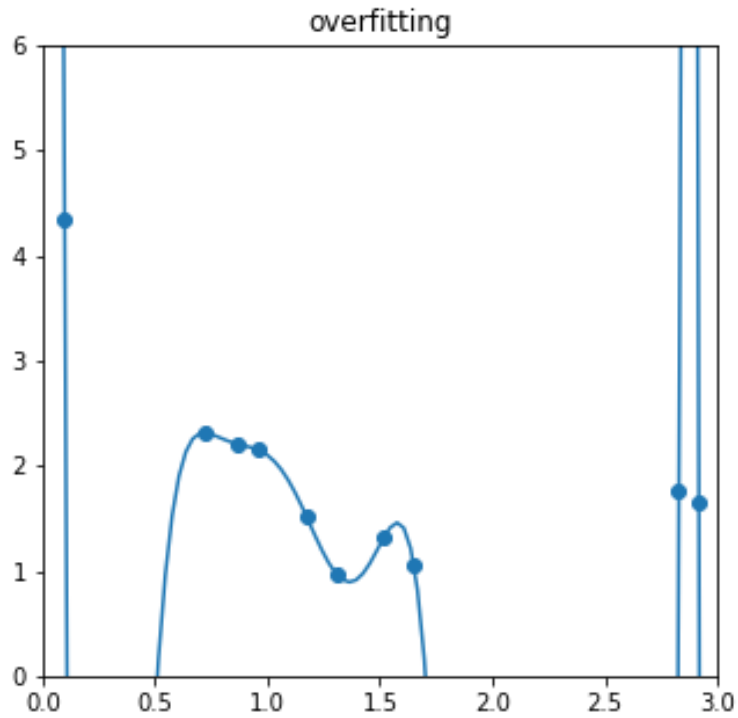
# Choosing the function class



# Choosing the function class

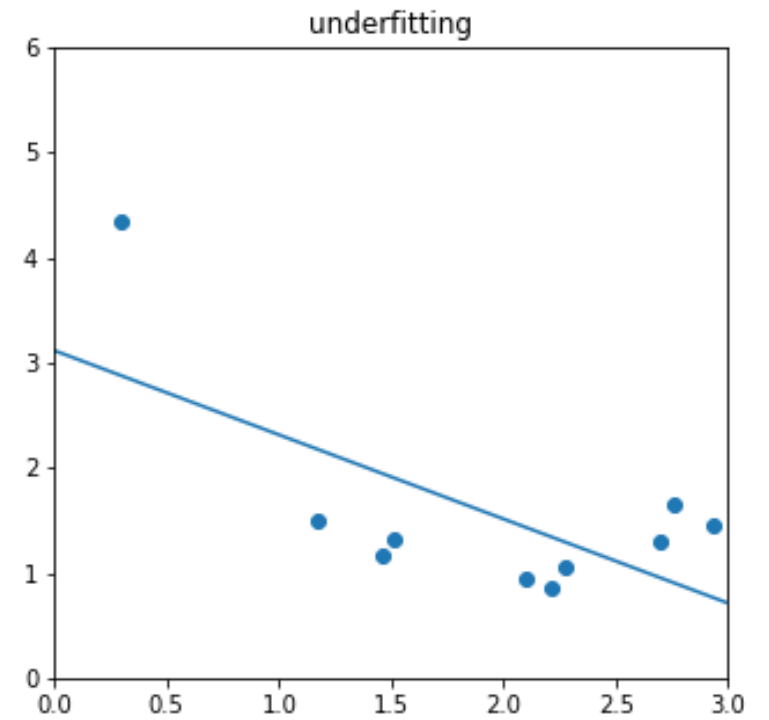
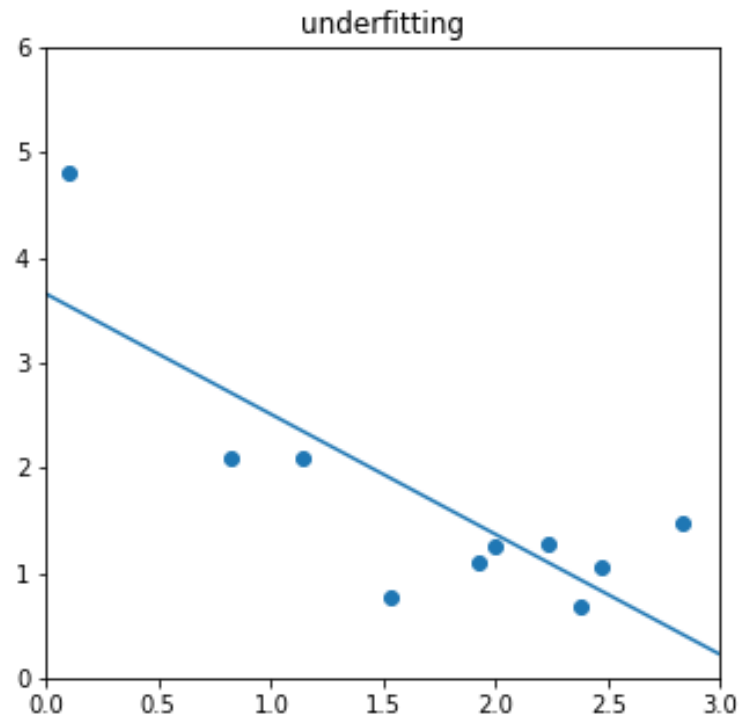
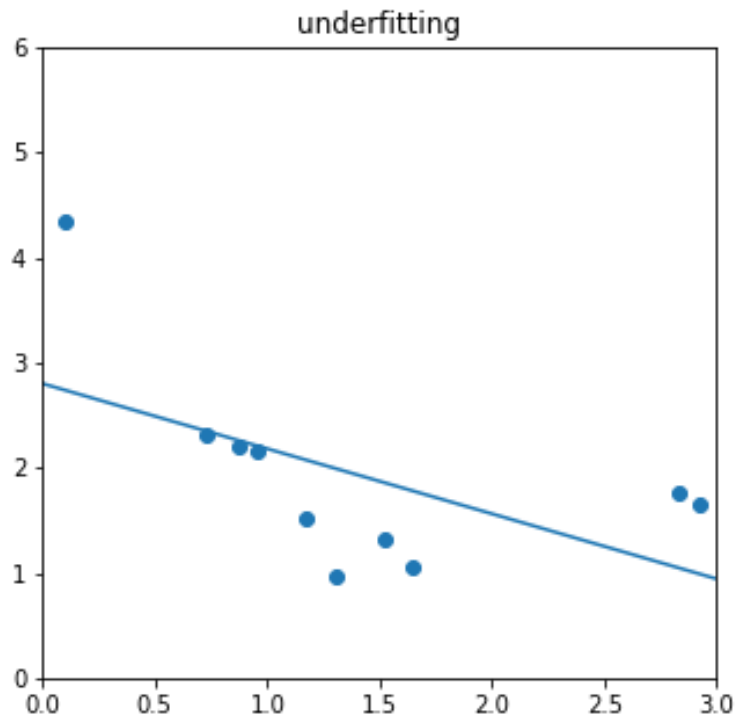


# High Variance

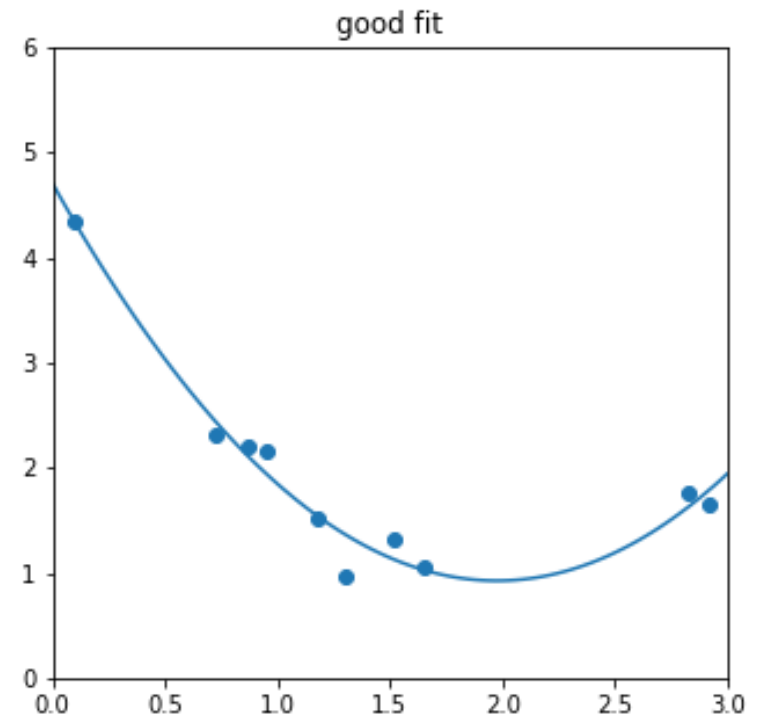
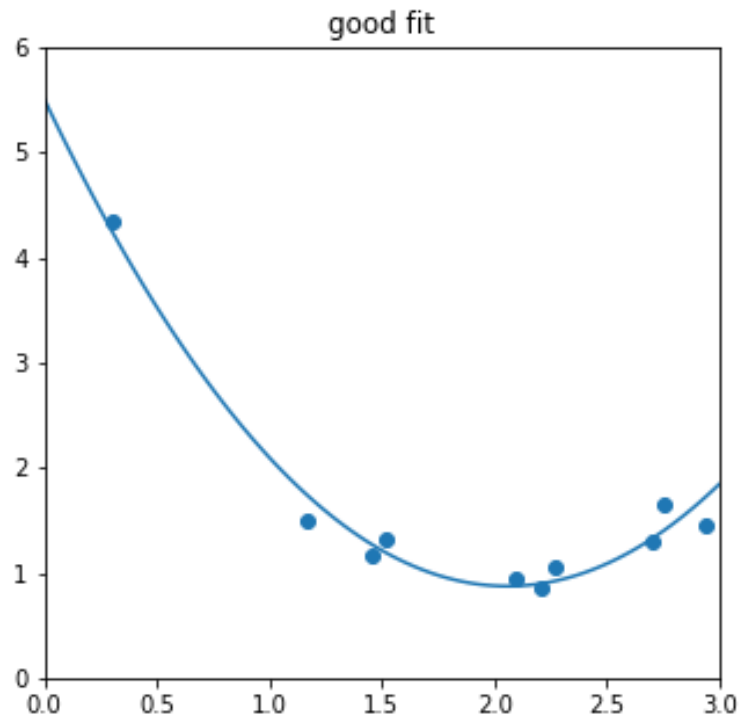
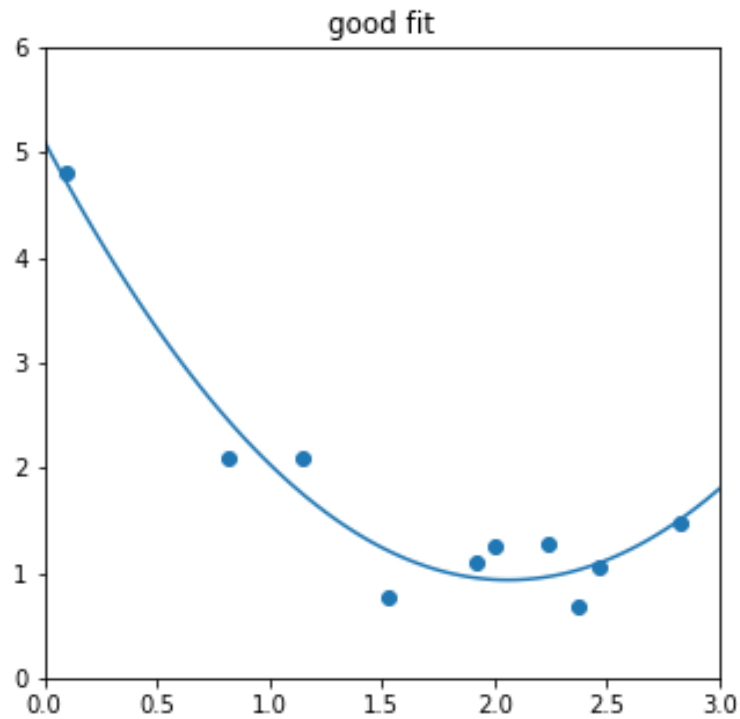




# High Bias



# Optimal Bias and Variance



# Overfitting and Underfitting

- A model with a **high bias** and **low variance** is an **underfit** model. It does not sufficiently represent the statistical relationships in our data.
- A model with **high variance** and **low bias** is an **overfit** model, because it captures relationships that are too specific to the exact data we happen to train it on. These relationships may not exist in the general distribution and are likely spurious.

# Dataset splitting

- **Training Dataset**

- Used to train the model by allowing it to learn patterns and relationships.
- Typically the largest portion of the data (e.g., 60-70%).

- **Validation Dataset**

- Used to tune model parameters and prevent overfitting.
- Helps evaluate model performance during training but isn't used to train the model directly.

- **Test Dataset**

- A completely separate dataset used for final model evaluation.
- Provides an unbiased assessment of model performance on new data.

# Cross-validation

- **Purpose:** An approach to maximize data usage for training and validation.
- **Process:** The dataset is split into  $k$  "folds." Each fold is used as a validation set while the remaining  $k-1$  folds are used for training.
- **Common Approach:**  $k$ -fold Cross-Validation (e.g., 5-fold), where results are averaged across folds.
- **Benefit:** Provides a more robust evaluation, reducing the risk of overfitting and underfitting

# Hyperparameter Tuning

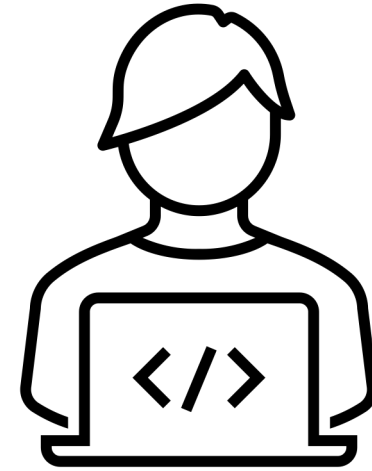
- **Definition:** The process of optimizing model settings (hyperparameters) that aren't learned from data, such as learning rate, number of neighbors (in k-NN), or max depth (in decision trees). **Goal:** To improve model accuracy, reduce overfitting, and achieve the best possible performance. **Methods:** **Grid Search:** Tests all possible combinations of hyperparameters within a predefined range.
- **Random Search:** Samples random combinations of hyperparameters, offering faster exploration.
- **Tools:** GridSearchCV and RandomizedSearchCV in scikit-learn.

# Ensemble Method

- **Definition:** Combines multiple models to improve overall performance by reducing errors and capturing more complex patterns.
- **Types:**
  - **Bagging:** Trains multiple models on random subsets of data (e.g., Random Forest).
  - **Boosting:** Sequentially trains models, each focusing on correcting errors from the previous one (e.g., AdaBoost, Gradient Boosting).
  - **Stacking:** Combines outputs of multiple models through a meta-model to improve predictions.
- **Benefits:** Increases accuracy, robustness, and generalization, often outperforming individual models.

# Practice

Sources to learn Machine Learning  
Lab work





# Sources to learn ML

- Scikit learn: <https://scikit-learn.org/stable/>
- Kaggle: <https://www.kaggle.com/>
- Machine Learning Mastery: <https://machinelearningmastery.com/>
- Books: <https://github.com/josephmisiti/awesome-machine-learning/blob/master/books.md>

# Lab

Link:

[https://github.com/luumsk/NSU\\_ML/blob/main/Labs/lab1.ipynb](https://github.com/luumsk/NSU_ML/blob/main/Labs/lab1.ipynb)

# References

- <https://acropolium.com/blog/machine-learning-in-healthcare-use-cases-benefits-and-success-stories/>
- <https://www.enjoyalgorithms.com/blogs/classification-and-regression-in-machine-learning>
- <https://hands-on.cloud/ml-unsupervised-learning-guide/>
- <https://medium.com/analytics-vidhya/beginners-guide-to-unsupervised-learning-76a575c4e942>
- <https://www.erieri.com/salary/job/machine-learning-engineer/russian-federation>
- <https://www.tealhq.com/job-titles/machine-learning-scientist>