

Use Cases of Mathematics in Data Science

Learning Objectives

By the end of this lesson, you will be able to:

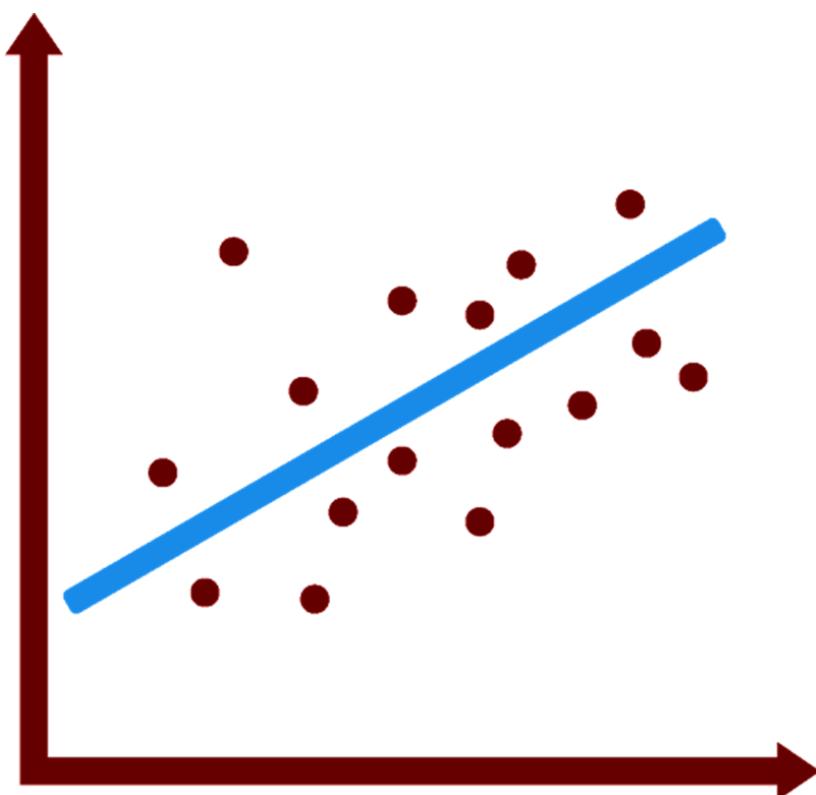
- Explain the role of mathematics in data science applications
- Implement the use of linear algebra in machine learning
- Identify the application of probability theory in predictive modeling and hypothesis testing
- Illustrate the importance of statistical methods in healthcare
- Identify mathematical concepts behind recommender systems and Bayesian inference



Getting Started with Machine Learning Algorithm

Linear Regression

Linear regression is a technique used to model the relationship between two variables by fitting a linear equation to the observed data.



Principal Component Analysis (PCA)

A statistical technique used to reduce the number of dimensions in a dataset while preserving its variability



It relies heavily on linear algebra concepts such as eigenvectors and eigenvalues.

Linear Regression

Linear regression can be solved by solving a system of linear equations using matrix algebra.

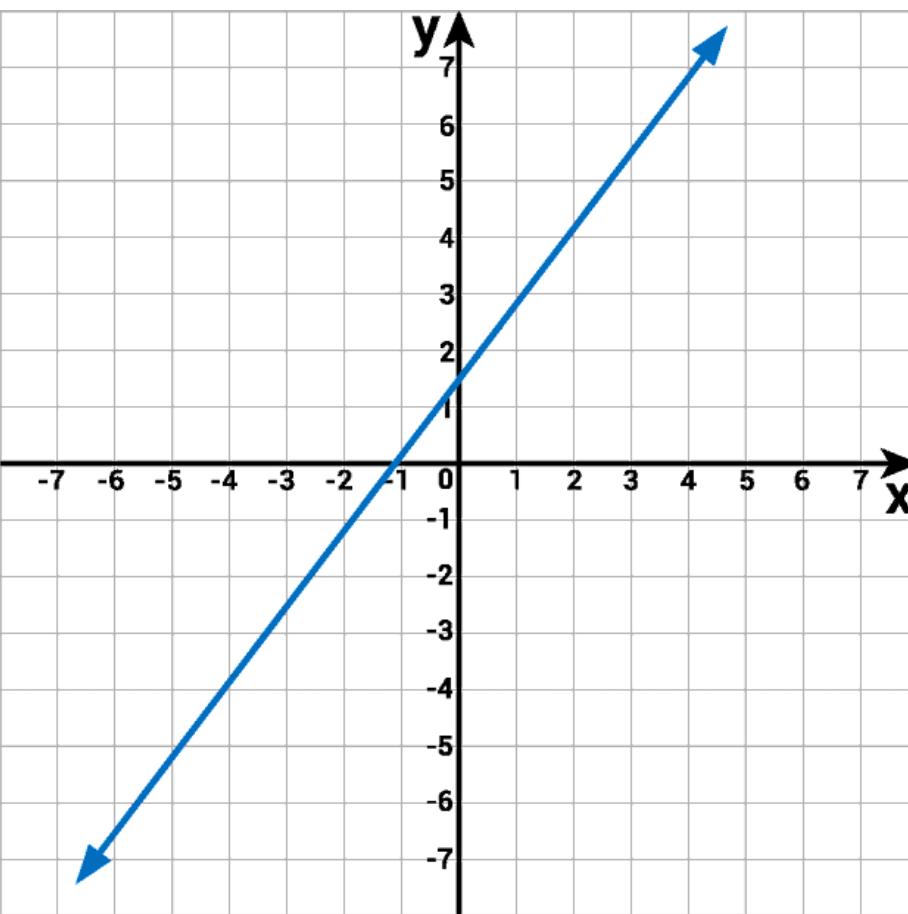
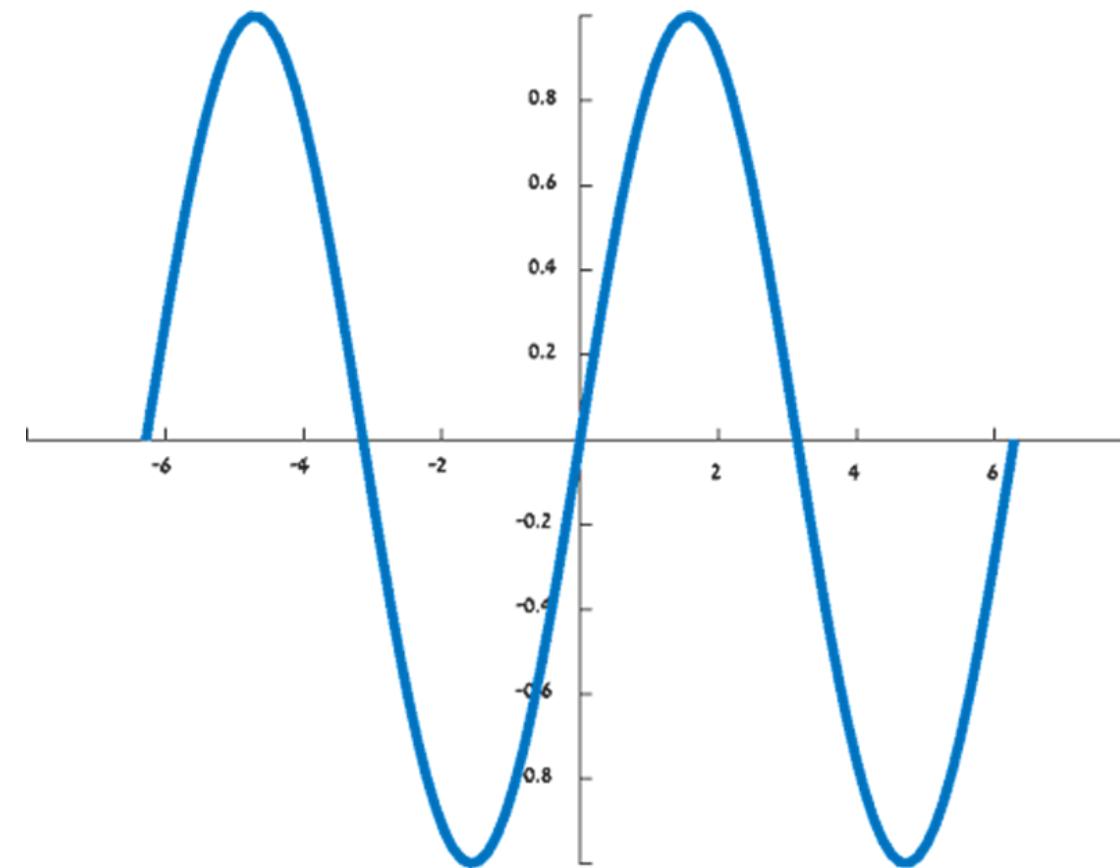


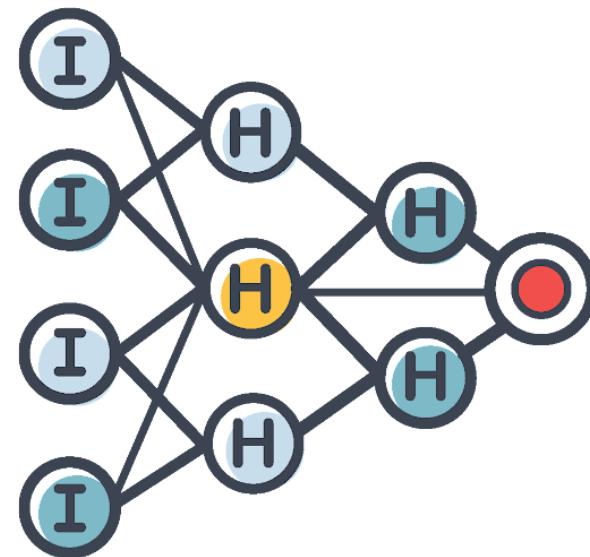
Image and Signal Processing

Techniques such as Fourier analysis, wavelet transforms, and image compression rely heavily on linear algebra.

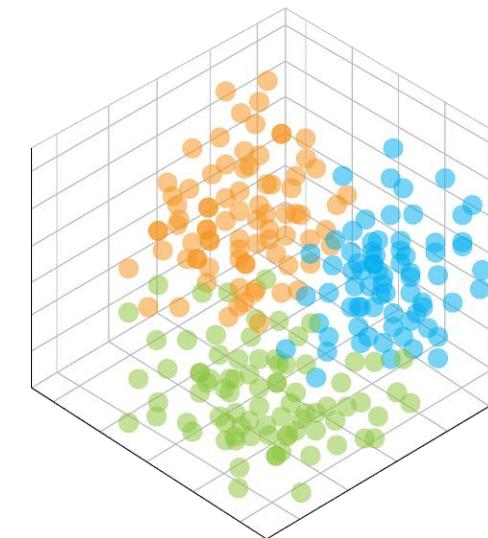


Machine Learning Algorithms

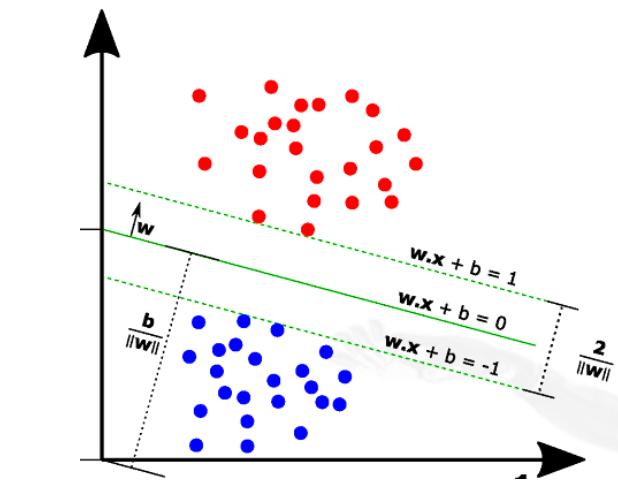
Many machine learning algorithms, such as neural networks, support vector machines, and clustering algorithms, rely on linear algebra.



Neural networks



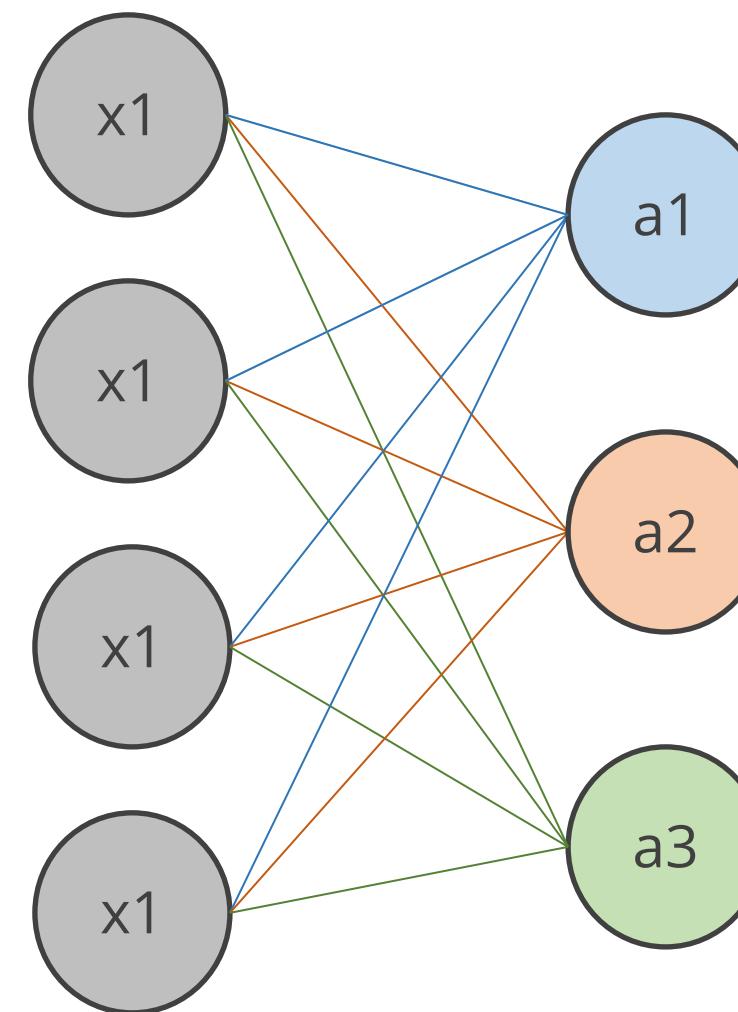
Clustering



Support vector machines

Machine Learning Algorithms

Neural networks involve performing matrix multiplications and applying nonlinear transformations to the results.



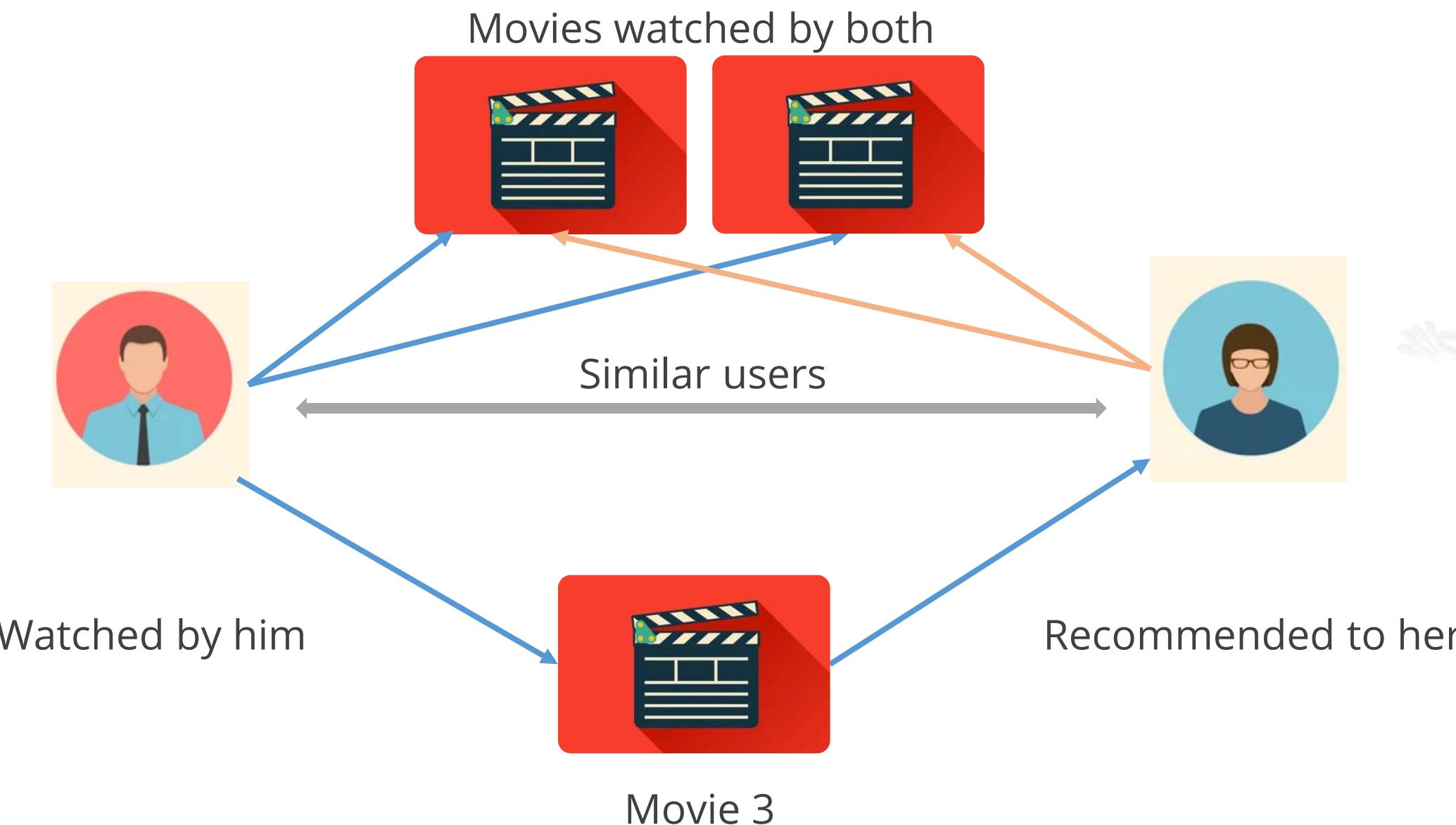
Recommender Systems

Recommender systems are used to predict a user's preferences for products or services.



Recommender Systems

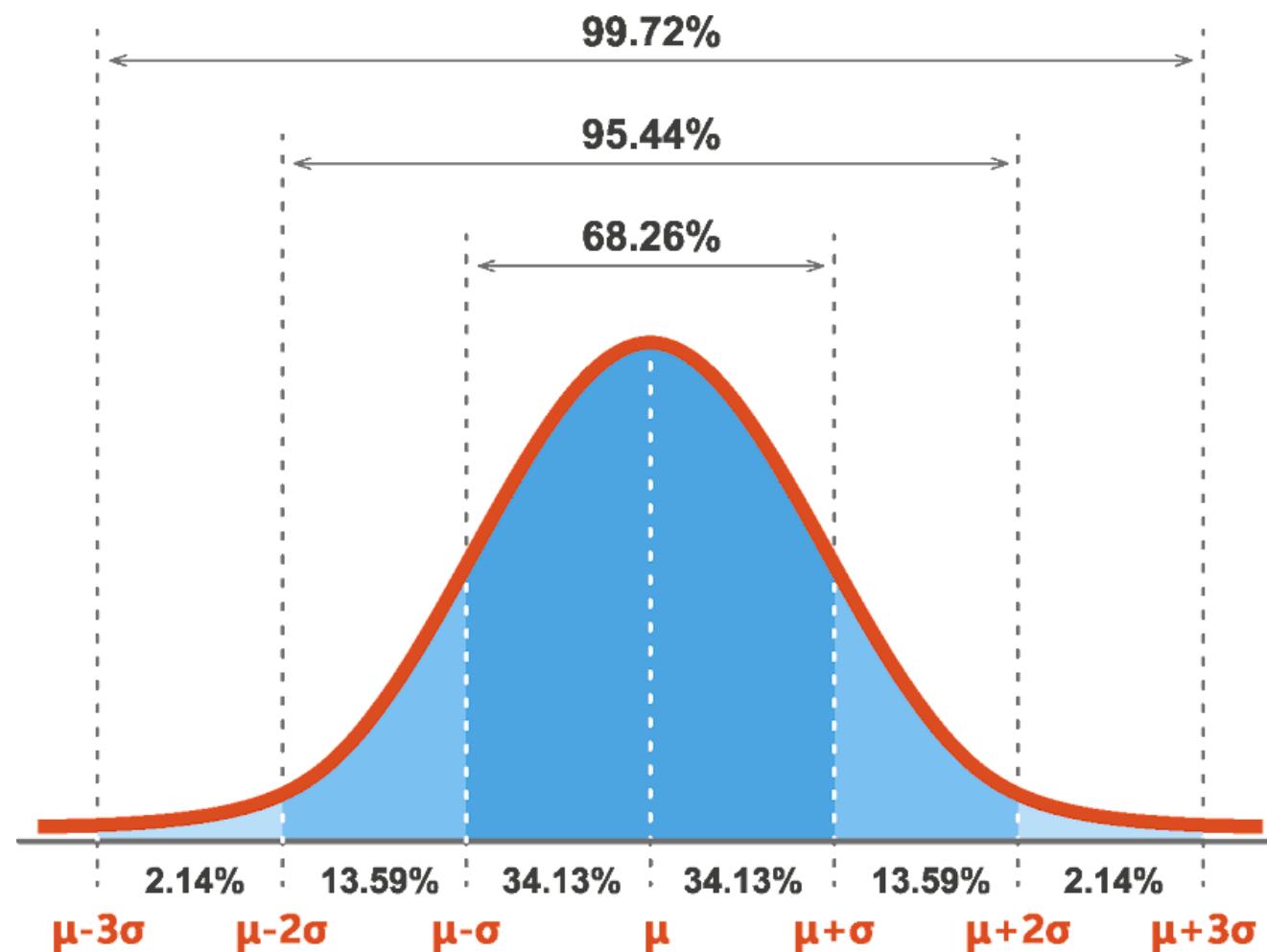
Collaborative filtering, a common technique used in recommender systems, involves computing the similarity between users or items using linear algebra concepts.



Use Cases of Probability

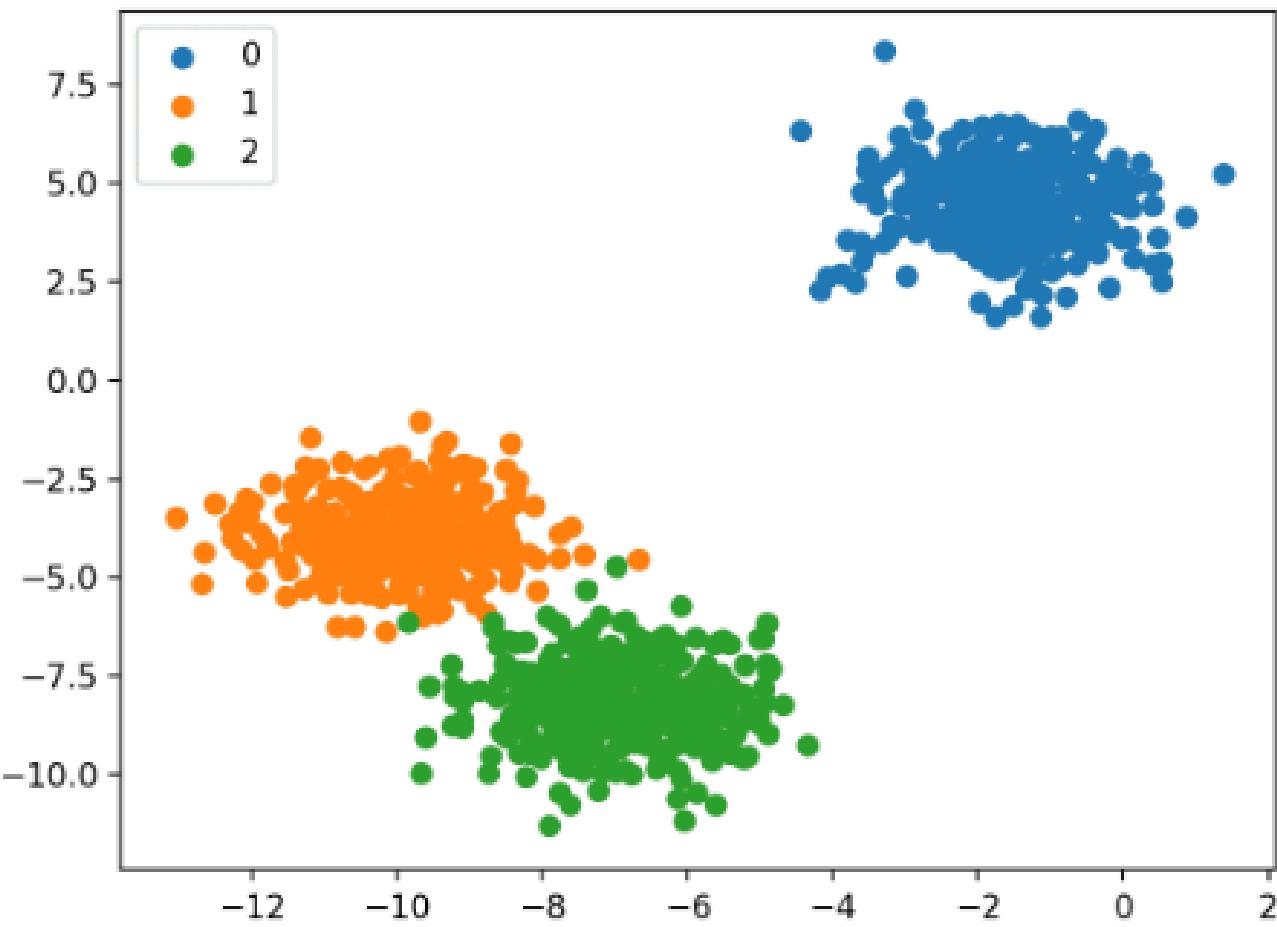
Predictive Modelling

Probability theory is used to model the probability distribution of variables in a dataset.



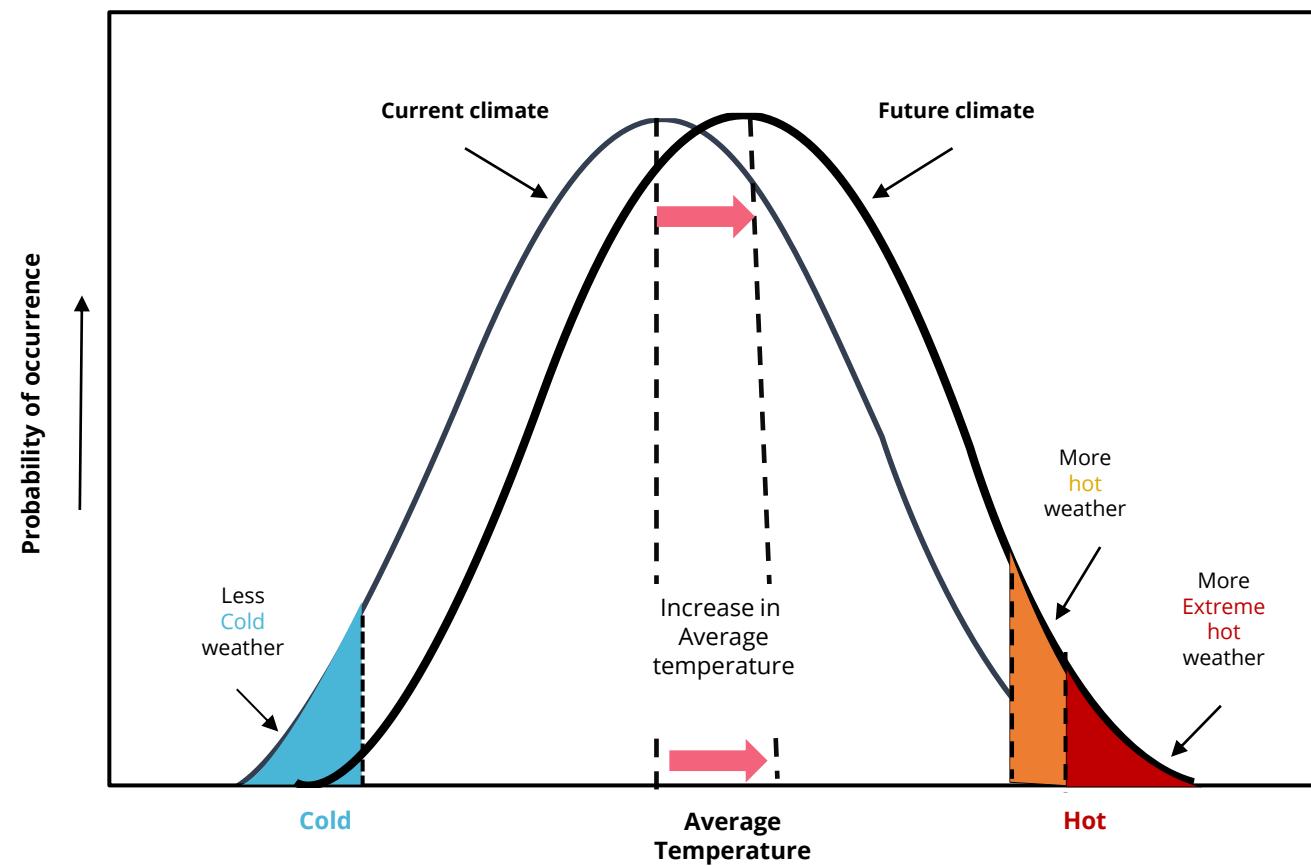
Predictive Modelling

In a classification problem, probability theory can be used to model the probability of a data point belonging to a particular class.



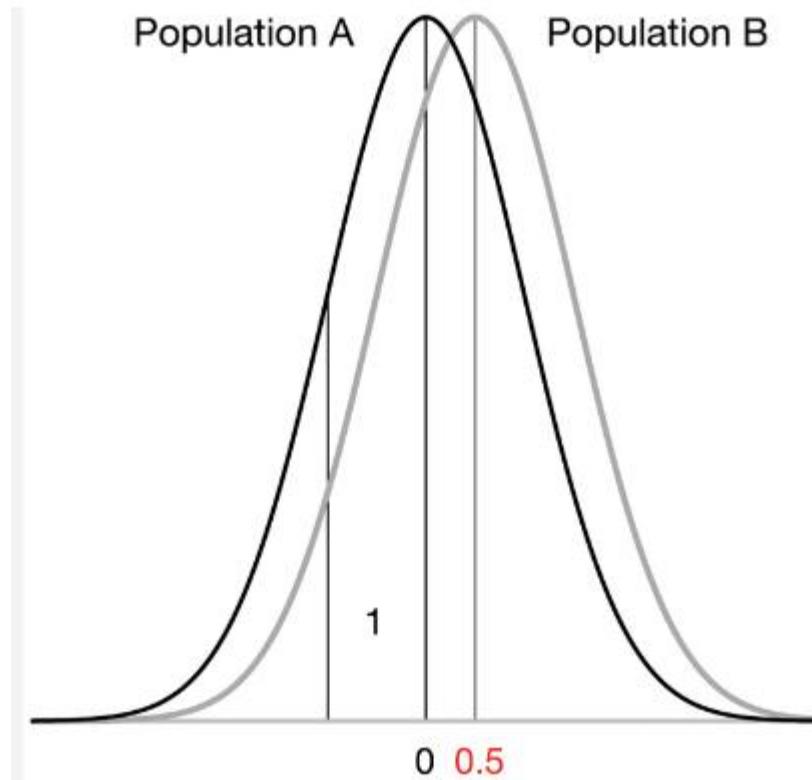
Hypothesis Testing

Probability theory is used to test hypotheses about the relationships between variables in a dataset.



Hypothesis Testing

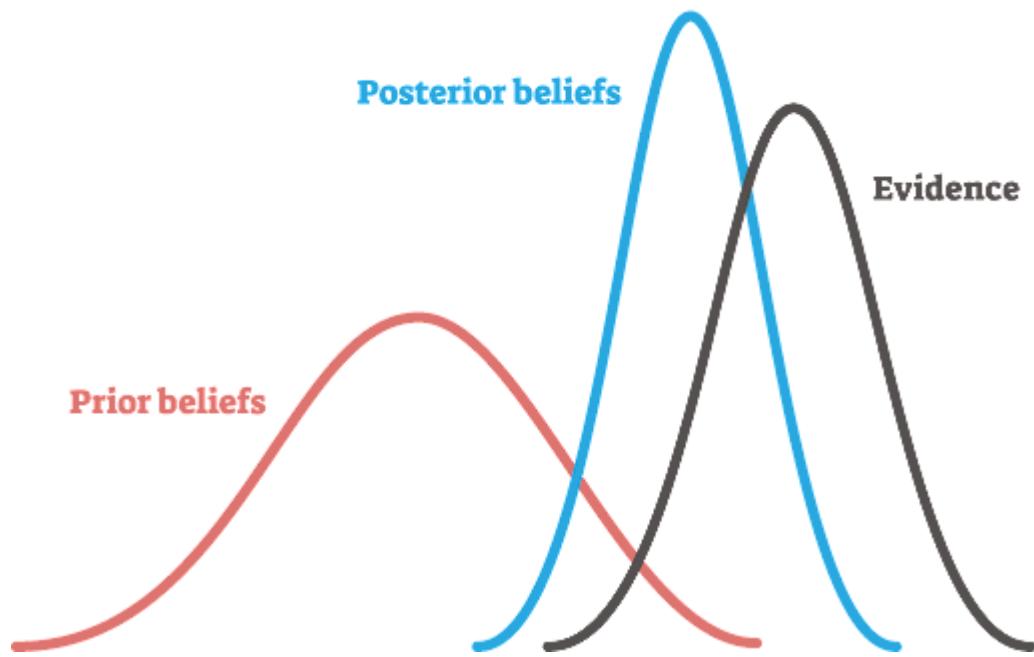
To test if there is a difference in the means of the two populations:



- Calculate the probability of observing the difference of means, using probability theory.
- The assumption being there is no difference between the populations.

Bayesian Inference

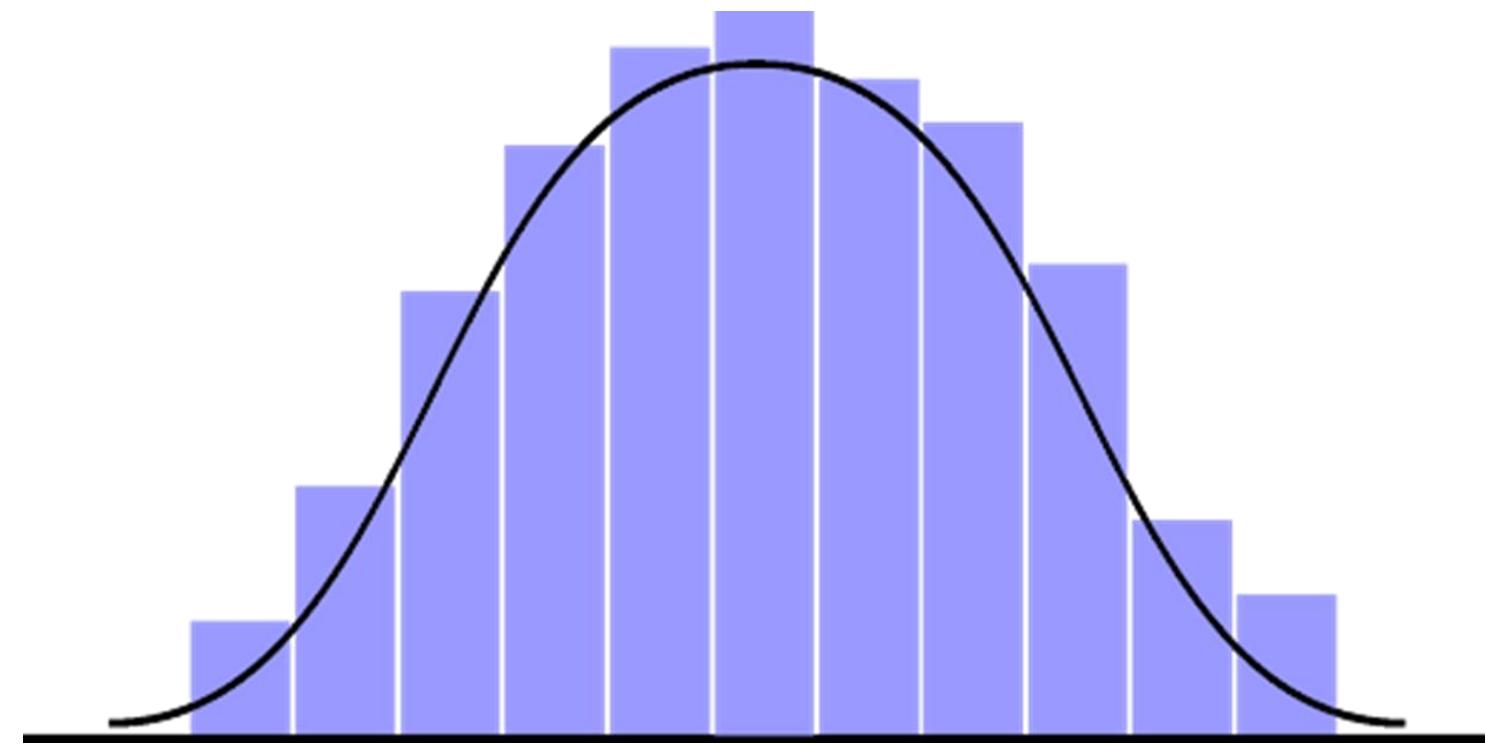
It is a statistical technique that uses probability theory to update the probability of a hypothesis as new data becomes available.



This technique is useful where prior knowledge about the system is available.

Monte Carlo Simulation

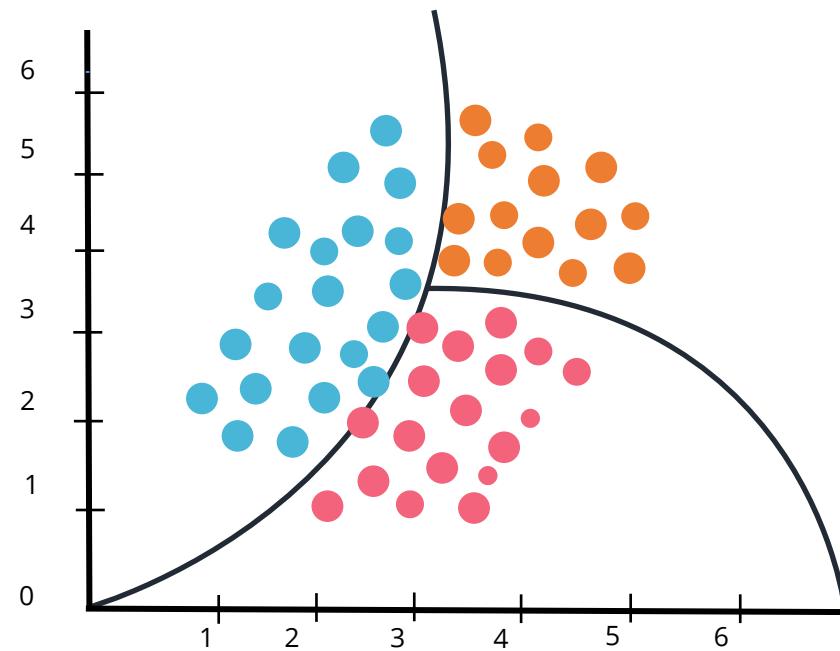
It is a technique used to estimate the probability distribution of a complex system by generating random samples from the system.



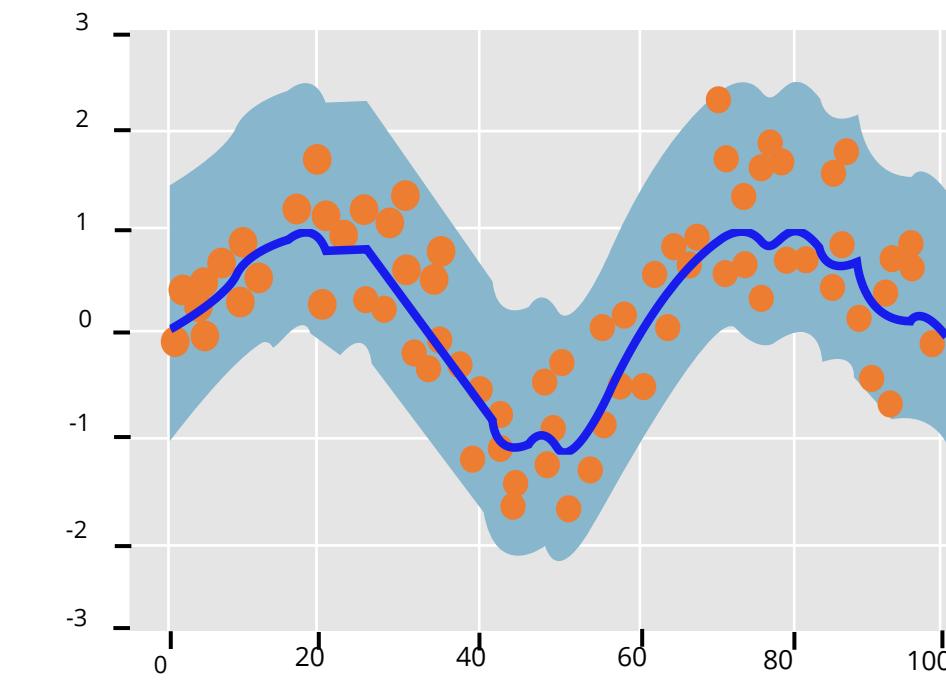
It is useful when the system cannot be modeled analytically.

Machine Learning Algorithms

ML algorithms such as Naive Bayes and Gaussian processes rely on probability theory.



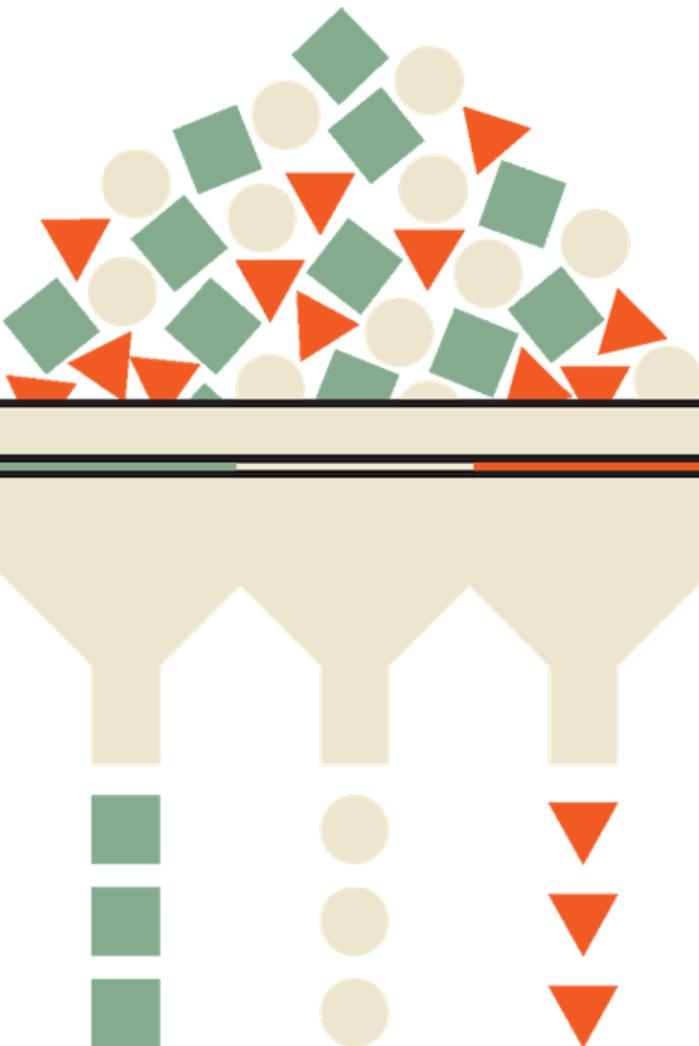
Naive bayes classifier



Gaussian process

Machine Learning Algorithms

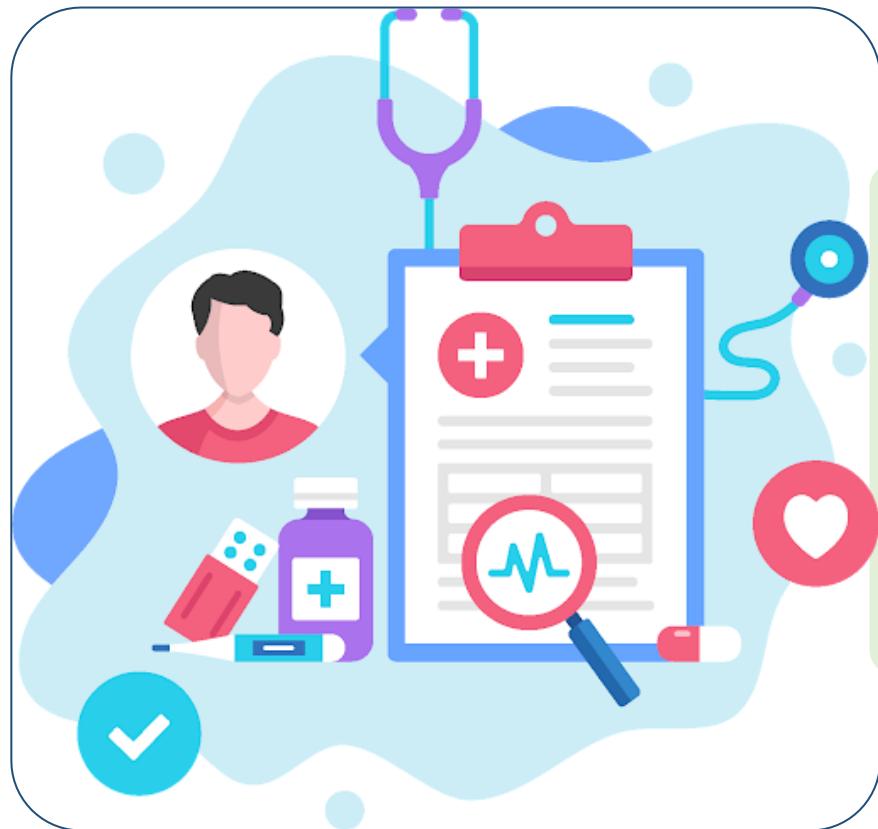
Nave Bayes is a classification algorithm that models the probability of a data point belonging to a class given its features.



DATA AND ARTIFICIAL INTELLIGENCE

Use Cases in Healthcare

Predictive Modeling



- Using data from demographics, clinical measurements, and medical history, mathematics is utilized to create models that forecast patient outcomes.
- These models can help identify high-risk patients and inform treatment decisions.

Epidemiological Studies



Mathematics is used to analyze large datasets of health-related information to identify patterns of disease incidence, prevalence, and mortality rates.

This analysis can help researchers identify risk factors, monitor disease outbreaks, and develop preventative.

Clinical Trials

Mathematics plays a crucial role in the design and analysis of clinical trials.

Statistical techniques are used to ensure that the study is powered to detect the effects of the intervention being tested and to control for confounding variables.



Medical Imaging



Mathematics is used to develop image-processing algorithms that can extract features from medical images, such as tumors, blood vessels, and organs.

These algorithms can help physicians diagnose and monitor diseases and conditions, such as cancer, cardiovascular disease, and neurological disorders.

Precision Medicine

- Mathematics is used to analyze large amounts of genomic data to identify biomarkers that can be used to tailor treatments to individual patients.
- This analysis can help identify genetic variations that may impact drug efficacy and guide the development of targeted therapies.

