Friedrich-Alexander-Universität
Technische Fakultät

Machine Learning
Data Analytics

Machine Learning for Time Series Exercise

Richard Dirauf, M.Sc.
Machine Learning and Data Analytics (MaD) Lab
Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU)
MLTS Exercise, 31.10.2024

MLTS Exercise – Organization

Thursday, 12:15-13:45, Seminar room 0.68 (Werkstoffwissenschaften)

Recordings from 2022/23 available, but content is changing this semester!

Five topics with two exercise sessions each:

- Session 1: Recap of topic and introduction of coding task
- Session 2: Solution to coding task and questions

Recommended: solve coding task as homework

Slides and tasks uploaded on StudOn

Questions: Exercises or Forum

MLTS Exercise – Organization

Introduction (31.10.2024)

Bayesian Linear Regression (07.11.2024)

Bayesian Linear Regression (14.11.2024)

Kalman Filter (21.11.2024)

Kalman Filter (28.11.2024)

Dynamic Time Warping (05.12.2024)

Dynamic Time Warping (12.12.2024)

No exercise planned (19.12.2024)

Holiday

RNN + LSTM (09.01.2025)

RNN + LSTM (16.01.2025)

Transformers (23.01.2025)

Transformers (30.01.2025)

What is your major?

Computer Science		Advanced Signal Processing & Communications Engineering	
Computational Engineering		Communications and Multimedia Engineering	
Data Science		Electrical Engineering	
Artificial Intelligence		Mechatronics	
Mathematics		Medical Engineering	
Business Informatics		Something else?	

Python experience?

No experience	
1 semester	
2 semesters/1 year	
More than 1 year	

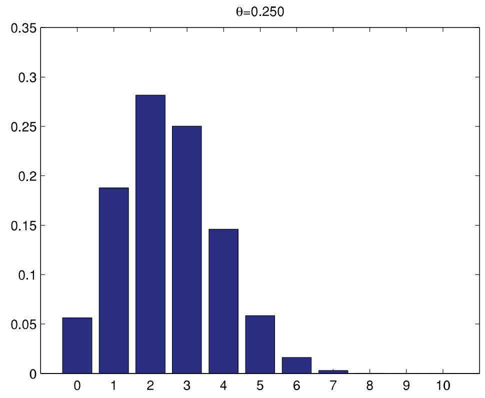
MLTS Exercises
Basics

Probability distributions

MLTS Exercise 01

- Discrete

  probability mass function (pmf)



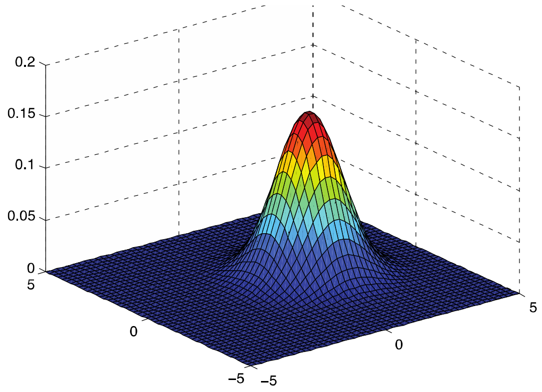
Binomial distribution

- Continuous

  probability density function (pdf)

$$0 \leq p(x) \leq 1$$

$$\int_{-\infty}^{+\infty} p(x)dx = 1$$



Gaussian (normal) distribution

Mean or **expected value** of a distribution

Discrete distribution $\mathbb{E}\left[X\right] \triangleq \sum_{x\in\mathcal{X}} x\ p(x)$

Continuous distribution $\mathbb{E}\left[X\right] \triangleq \int_{\mathcal{X}} x\ p(x)dx$

The expected value of function f

Discrete distribution $\mathbb{E}[f] \triangleq \Sigma_{x\in\mathcal{X}} f(x)p(x)$

Continuous distribution $$\mathbb{E}[f] \triangleq \int_{\mathcal{X}} f(x)p(x)dx$$

Variance

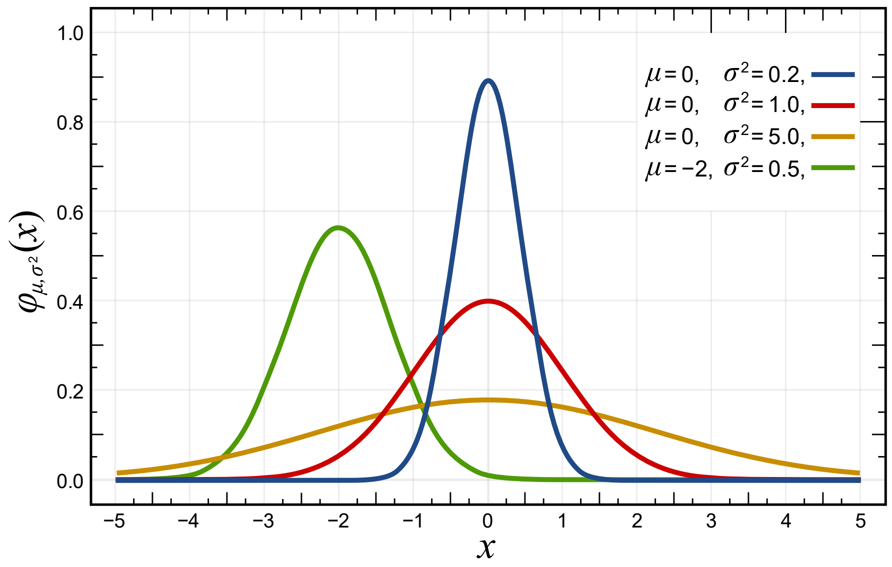
MLTS Exercise 01

The **variance** is a measure of the spread of a distribution

$$\begin{aligned}\operatorname{var}[X] &\triangleq \mathbb{E}\left[(X-\mu)^2\right] = \int (x-\mu)^2 p(x)dx \\ &= \int x^2 p(x)dx + \mu^2 \int p(x)dx - 2\mu \int xp(x)dx = \mathbb{E}\left[X^2\right] - \mu^2\end{aligned}$$

The standard deviation is defined as

$$\operatorname{std}[X] \triangleq \sqrt{\operatorname{var}[X]}$$

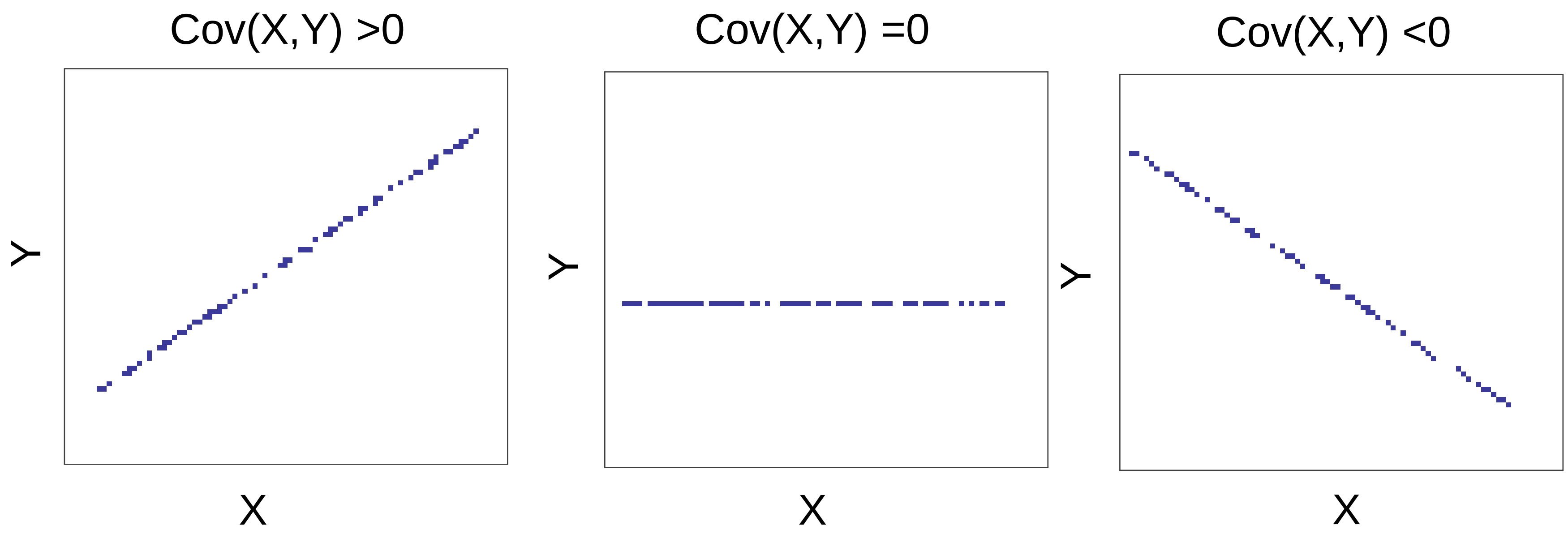


https://de.wikipedia.org/wiki/Normalverteilung

Covariance

MLTS Exercise 01

$$\operatorname{cov}[X,Y] \triangleq \mathbb{E}[(X-\mathbb{E}[X])(Y-\mathbb{E}[Y])] = \mathbb{E}[XY] - \mathbb{E}[X]\,\mathbb{E}[Y]$$



Basic rules of probability

MLTS Exercise 01

- Probability of the **joint distribution** X and Y as follows

$$p(X, Y) = p(X|Y)p(Y)$$

this is sometimes called the **product rule**.

- We define the **marginal distribution** as follows

$$p(X) = \sum_y p(X, Y) = \sum_y p(X|Y = y)p(Y = y)$$

where we are summing over all possible states of Y.

This is sometimes called the **sum rule**.

- The product rule can be applied multiple times to yield the chain rule of probability:

$$p(X_{1:D}) = p(X_1)p(X_2|X_1)p(X_3|X_2, X_1)p(X_4|X_1, X_2, X_3)\dots p(X_D|X_{1:D-1})$$

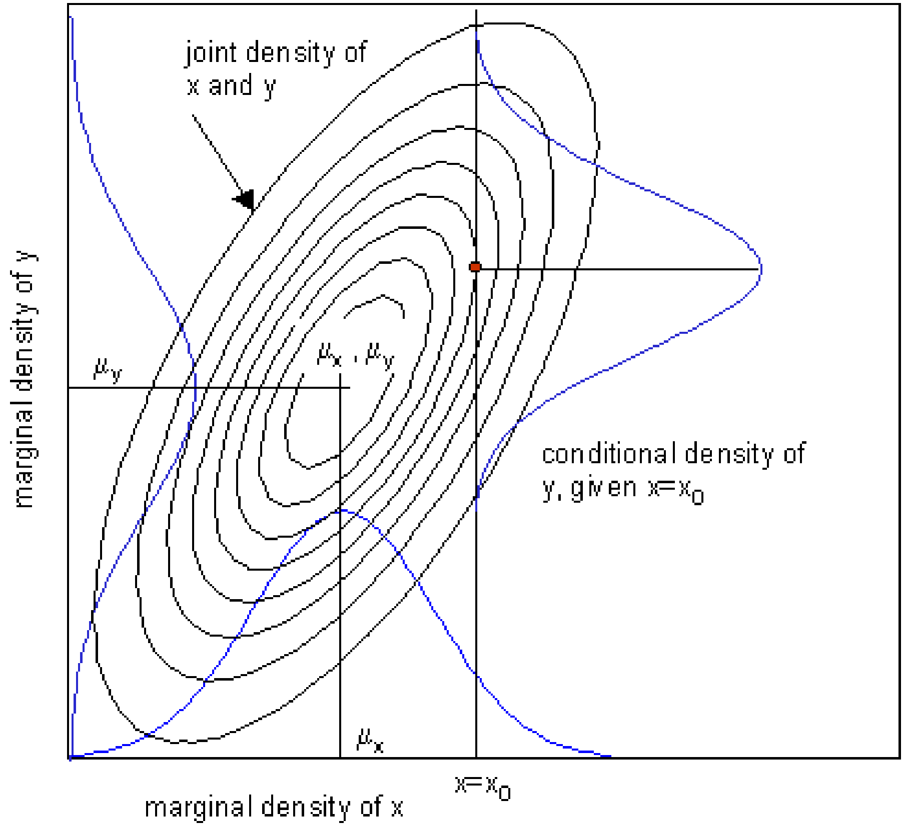
On one glance

MLTS Exercise 01

Concepts of joint, marginal, and conditional probabilities

$$x \sim \mathcal{N}(\mu_x, \sigma_x^2)$$

$$y \sim \mathcal{N}(\mu_y, \sigma_y^2)$$



https://statistical-engineering.com/probability-and-statistics/joint-marginal-conditional-distributions/

Bayes rule

MLTS Exercise 01

$$\underbrace{\boxed{p(X=x|Y=y)}}_{\text{Posterior probability}} = \frac{p(X=x, Y=y)}{p(Y=y)} = \frac{\underbrace{\boxed{p(X=x)}}_{\text{Prior probability}}\underbrace{\boxed{p(Y=y|X=x)}}_{\text{Likelihood}}}{\underbrace{\boxed{\sum_{x'} p(X=x')p(Y=y|X=x')}}_{\text{Marginal likelihood}}}$$

Thank you for your attention!

Any questions?