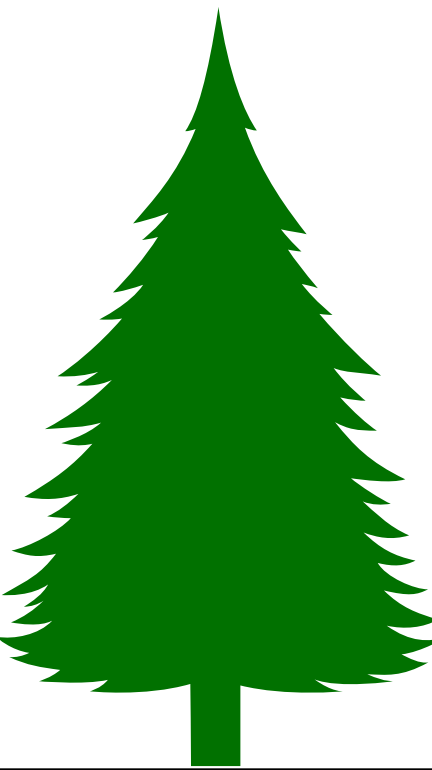
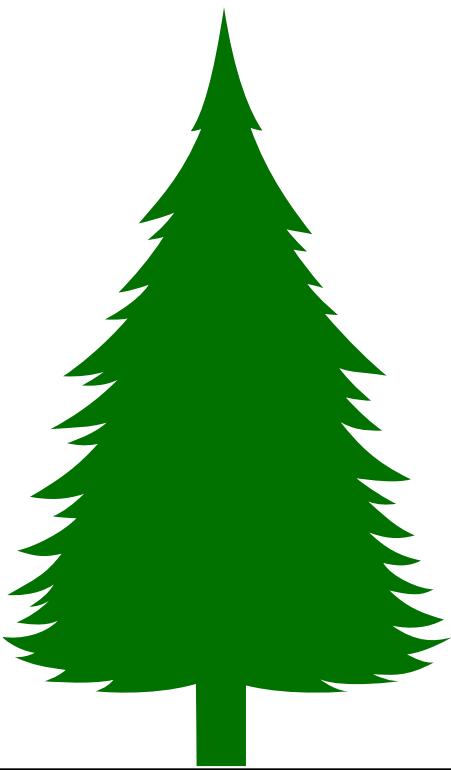


# Werkzeuge für das wissenschaftliche Arbeiten

## *Python for Machine Learning and Data Science*

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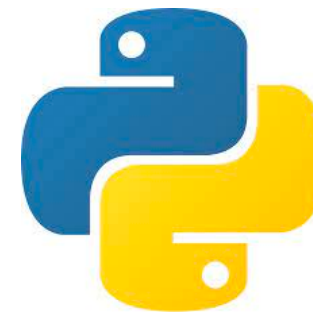
# Inhaltsübersicht

1. Programmiersprache Python

a) *Einführung, Erste Schritte*

b) *Grundlagen*

c) *Fortgeschritten*



2. Auszeichnungssprachen

a) *LaTeX, Markdown*

L<sup>A</sup>T<sub>E</sub>X



3. Benutzeroberflächen und Entwicklungsumgebungen

a) *Jupyter Notebooks lokal und in der Cloud (Google Colab)*

4. Versionsverwaltung

a) *Git, GitHub*



5. Wissenschaftliches Rechnen

a) **NumPy, SciPy**



6. Datenverarbeitung und -visualisierung

a) Pandas, matplotlib, NLTK

7. Machine Learning (scikit-learn)

a) Grundlegende Ansätze (Datensätze, Auswertung)

b) Einfache Verfahren (Clustering, ...)



8. DeepLearning

a) TensorFlow, PyTorch, HuggingFace Transformers



# Themen

## I. Projektaufgabe 3

### 1. Herangehensweise & Tipps



*Heute*

# Themen

- I. Projektaufgabe 3
  1. Herangehensweise & Tipps
- II. Wissenschaftliches Rechnen
  1. NumPy
  2. SciPy



*Heute*

# Themen

## I. Projektaufgabe 3

### 1. Herangehensweise & Tipps

## II. Wissenschaftliches Rechnen

### 1. NumPy

### 2. SciPy

## III. Reguläre Ausdrücke



*Heute*

# Projektaufgabe 3

## „Git, Markdown und LaTeX“

### 1. Git-Repository clonen

# Projektaufgabe 3

## „Git, Markdown und LaTeX“

1. Git-Repository clonen
2. Readme-Datei

# Projektaufgabe 3

## „Git, Markdown und LaTeX“

1. Git-Repository clonen
2. Readme-Datei
3. LaTeX
  - *Gutes* LaTeX
  - Grafik
  - Temporäre Dateien



# Projektaufgabe 3

## „Git, Markdown und LaTeX“

1. Git-Repository clonen
2. Readme-Datei
3. LaTeX
  - *Gutes* LaTeX
  - Grafik
  - Temporäre Dateien
4. Python-Code
  - Versionen aufräumen
  - Branch mergen

# Projektaufgabe 3

## „Git, Markdown und LaTeX“

1. Git-Repository clonen
2. Readme-Datei
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  - *Gutes* LaTeX
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  - Temporäre Dateien
4. Python-Code
  - Versionen aufräumen
  - Branch mergen
5. Push auf GitHub

# Projektaufgabe 3

## „Git, Markdown und LaTeX“

1. Git-Repository clonen
2. Readme-Datei
3. LaTeX
  - *Gutes* LaTeX
  - Grafik
  - Temporäre Dateien
4. Python-Code
  - Versionen aufräumen
  - Branch mergen
5. Push auf GitHub
6. Abgabe (im Moodle)

# Herangehensweise & Tipps

- Schrittweise vorgehen

# Herangehensweise & Tipps

- Schrittweise vorgehen
- LaTeX
  - Beispiele aus Vorlesung nutzen
  - Inhalt soll bleiben, Form kann und soll leicht abweichen
  - Temporäre Dateien löschen

# Herangehensweise & Tipps

- Schrittweise vorgehen
- LaTeX
- Beispiele aus Vorlesung nutzen
- Inhalt soll bleiben, Form kann und soll leicht abweichen
- Temporäre Dateien löschen
- Regelmäßig Commits machen

# Herangehensweise & Tipps

- Schrittweise vorgehen
- LaTeX
- Beispiele aus Vorlesung nutzen
- Inhalt soll bleiben, Form kann und soll leicht abweichen
- Temporäre Dateien löschen
- Regelmäßig Commits machen
- Eigenes Repository als weiteres Remote hinzufügen

# Herangehensweise & Tipps

- Schrittweise vorgehen
- LaTeX
- Beispiele aus Vorlesung nutzen
- Inhalt soll bleiben, Form kann und soll leicht abweichen
- Temporäre Dateien löschen
- Regelmäßig Commits machen
- Eigenes Repository als weiteres Remote hinzufügen
- Den richtigen Branch in den richtigen Branch mergen



# II.

# Wissenschaftliches Rechnen

## *1. NumPy*

# Installation



- Python Paket
  - <https://numpy.org/>

# Installation



- Python Paket
  - <https://numpy.org/>
- Installation z.B. mit `pip3 install numpy`

# Installation



- Python Paket
  - <https://numpy.org/>
- Installation z.B. mit pip3 `install numpy`
- Import

# Installation



- Python Paket
  - <https://numpy.org/>
- Installation z.B. mit pip3 `install numpy`
- Import

```
import numpy  
import numpy as np
```

# Installation



Wir verlassen nun die Python-Standardbibliothek

- Python Paket
- <https://numpy.org/>
- Installation z.B. mit pip3 `install numpy`
- Import

```
import numpy  
import numpy as np
```

Üblich: Import mit kurzem Namen

# Warum NumPy?

- Matrix- und Array-Operationen (N-dimensional)

# Warum NumPy?

- Matrix- und Array-Operationen (N-dimensional)
- Mathematische und Numerische (Standard-)Funktionen




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- Matrix- und Array-Operationen (N-dimensional)
- Mathematische und Numerische (Standard-)Funktionen
- Hohe Performance

# Warum NumPy?

- Matrix- und Array-Operationen (N-dimensional)
- Mathematische und Numerische (Standard-)Funktionen
- Hohe Performance
- Verbindung und Nutzung in anderen Paketen (z.B. SciPy)

# Warum NumPy?

- Matrix- und Array-Operationen (N-dimensional)
- Mathematische und Numerische (Standard-)Funktionen
- Hohe Performance  Intern in C-Code
- Verbindung und Nutzung in anderen Paketen (z.B. SciPy)

# Arrays

```
import numpy as np
```

```
one = np.array([1, 2, 3, 4, 5, 6])
```

```
two = np.array([  
    [1, 2, 3, 4],  
    [5, 6, 7, 8],  
    [9, 10, 11, 12]])
```

```
print(one)
```

```
print(two)
```

```
print(one.shape)
```

```
print(two.shape)
```

```
print(one[0])
```

```
print(two[0])
```

```
print(one[2:])
```

```
print(two[:,0])
```

# Arrays

```
import numpy as np
```

```
one = np.array([1, 2, 3, 4, 5, 6])
```

```
two = np.array([  
    [1, 2, 3, 4],  
    [5, 6, 7, 8],  
    [9, 10, 11, 12]])
```

```
print(one)      [1 2 3 4 5 6]
```

```
print(two)      [[ 1  2  3  4]  
                [ 5  6  7  8]  
                [ 9 10 11 12]]
```

```
print(one.shape)
```

```
print(two.shape)
```

```
print(one[0])
```

```
print(two[0])
```

```
print(one[2:])
```

```
print(two[:,0])
```

# Arrays

```
import numpy as np
```

```
one = np.array([1, 2, 3, 4, 5, 6])
```

```
two = np.array([  
    [1, 2, 3, 4],  
    [5, 6, 7, 8],  
    [9, 10, 11, 12]])
```

```
print(one[0])
```

```
print(two[0])
```

```
print(one)      [1 2 3 4 5 6]
```

```
print(two)      [[ 1  2  3  4]  
                 [ 5  6  7  8]  
                 [ 9 10 11 12]]
```

```
print(one[2:])
```

```
print(two[:,0])
```

```
print(one.shape) (6,)
```

```
print(two.shape) (3, 4)
```

# Arrays

```
import numpy as np
```

```
one = np.array([1, 2, 3, 4, 5, 6])
```

```
two = np.array([  
    [1, 2, 3, 4],  
    [5, 6, 7, 8],  
    [9, 10, 11, 12]])
```

```
print(one)      [1 2 3 4 5 6]
```

```
print(two)      [[ 1  2  3  4]  
 [ 5  6  7  8]  
 [ 9 10 11 12]]
```

```
print(one.shape) (6,)
```

```
print(two.shape) (3, 4)
```

```
print(one[0])    1
```

```
print(two[0])    [1 2 3 4]
```

```
print(one[2:])
```

```
print(two[:,0])
```

# Arrays

```
import numpy as np
```

```
one = np.array([1, 2, 3, 4, 5, 6])
```

```
two = np.array([  
    [1, 2, 3, 4],  
    [5, 6, 7, 8],  
    [9, 10, 11, 12]])
```

```
print(one)      [1 2 3 4 5 6]
```

```
print(two)      [[ 1  2  3  4]  
                 [ 5  6  7  8]  
                 [ 9 10 11 12]]
```

```
print(one.shape) (6,)
```

```
print(two.shape) (3, 4)
```

```
print(one[0])   1
```

```
print(two[0])   [1 2 3 4]
```

```
print(one[2:])  [3 4 5 6]
```

```
print(two[:,0]) [1 5 9]
```



# Arrays

```
import numpy as np
```

```
one = np.array([1, 2, 3, 4, 5, 6])  
two = np.array([  
    [1, 2, 3, 4],  
    [5, 6, 7, 8],  
    [9, 10, 11, 12]])
```

Liste bzw. Liste von Listen in  
Array konvertieren

Zugriff über  
Index

```
print(one)      [1 2 3 4 5 6]
```

```
print(two)      [[ 1  2  3  4]  
                [ 5  6  7  8]  
                [ 9 10 11 12]]
```

```
print(one.shape) (6,)
```

```
print(two.shape) (3, 4)
```

Array hat ein  
Attribut shape

```
print(one[0])   1
```

```
print(two[0])   [1 2 3 4]
```

```
print(one[2:])  [3 4 5 6]
```

```
print(two[:,0]) [1 5 9]
```

Slicing auch hier,  
Dimensionen mittels , trennen

# ND-Arrays

```
import numpy as np
```

```
one = np.zeros(5)  
two = np.ones((5,5))
```

```
print(one, one.shape)  
print(two, two.shape)
```

```
three = np.ndarray((2,2), dtype=np.float32)  
four = np.ndarray((2,2), dtype=np.int64)
```

```
print(three, three.shape)  
print(four, four.shape)
```

```
print(two.ndim, two.size)
```

# ND-Arrays

```
import numpy as np
```

```
one = np.zeros(5)  
two = np.ones((5,5))
```

```
print(one, one.shape)  
print(two, two.shape)
```

```
[0. 0. 0. 0. 0.] (5,)
```

```
[[1. 1. 1. 1. 1.]  
 [1. 1. 1. 1. 1.]  
 [1. 1. 1. 1. 1.]  
 [1. 1. 1. 1. 1.]  
 [1. 1. 1. 1. 1.]] (5,5)
```

```
print(two.ndim, two.size)
```

```
three = np.ndarray((2,2), dtype=np.float32)  
four = np.ndarray((2,2), dtype=np.int64)
```

```
print(three, three.shape)  
print(four, four.shape)
```

# ND-Arrays

```
import numpy as np
```

```
one = np.zeros(5)  
two = np.ones((5,5))
```

```
print(one, one.shape)  
print(two, two.shape)
```

```
[0. 0. 0. 0. 0.] (5,)
```

```
[[1. 1. 1. 1. 1.]  
 [1. 1. 1. 1. 1.]  
 [1. 1. 1. 1. 1.]  
 [1. 1. 1. 1. 1.]  
 [1. 1. 1. 1. 1.]] (5,5)
```

```
print(two.ndim, two.size)
```

```
2 25
```

```
three = np.ndarray((2,2), dtype=np.float32)  
four = np.ndarray((2,2), dtype=np.int64)
```

```
print(three, three.shape)  
print(four, four.shape)
```

# ND-Arrays

```
import numpy as np
```

```
one = np.zeros(5)  
two = np.ones((5,5))
```

```
print(one, one.shape)  
print(two, two.shape)
```

```
[0. 0. 0. 0. 0.] (5,)
```

```
[[1. 1. 1. 1. 1.]  
 [1. 1. 1. 1. 1.]  
 [1. 1. 1. 1. 1.]  
 [1. 1. 1. 1. 1.]  
 [1. 1. 1. 1. 1.]] (5,5)
```

```
print(two.ndim, two.size)
```

```
2 25
```

```
three = np.ndarray((2,2), dtype=np.float32)  
four = np.ndarray((2,2), dtype=np.int64)
```

```
print(three, three.shape)  
print(four, four.shape)
```

```
[[1.67e-43 1.36e-43]  
 [1.60e-43 1.54e-43]] (2, 2)
```

```
[[ -9223372036854775808 2305851798912965847]  
 [          4485873667 7546421577360895877]]  
(2, 2)
```

# ND-Arrays

```
import numpy as np
```

```
one = np.zeros(5)  
two = np.ones((5,5))
```

```
print(one, one.shape)  
print(two, two.shape)
```

```
[0. 0. 0. 0. 0.] (5,)
```

```
[[1. 1. 1. 1. 1.]  
 [1. 1. 1. 1. 1.]  
 [1. 1. 1. 1. 1.]  
 [1. 1. 1. 1. 1.]  
 [1. 1. 1. 1. 1.]] (5,5)
```

```
print(two.ndim, two.size)
```

```
2 25
```

Array unter  
Angabe von  
Dimensionen mit  
0en oder 1en

Leeres Array (zufällige  
Werte) gegeben  
Dimension und Typ

```
three = np.ndarray((2,2), dtype=np.float32)  
four = np.ndarray((2,2), dtype=np.int64)
```

```
print(three, three.shape)  
print(four, four.shape)
```

```
[[1.67e-43 1.36e-43]  
 [1.60e-43 1.54e-43]] (2, 2)
```

```
[[ -9223372036854775808 2305851798912965847]  
 [ 4485873667 7546421577360895877]]  
(2, 2)
```

Neben shape gibt es  
auch ndim und size

# Arrays umformen

```
import numpy as np
```

```
one = np.arange(6)  
print(one, one.shape)
```

```
two = one.reshape(3,2)  
print(two, two.shape)
```

```
three = np.expand_dims(one, axis=0)  
print(three, three.shape)
```

```
four = np.expand_dims(one, axis=1)  
print(four, four.shape)
```



# Arrays umformen

```
import numpy as np
```

```
one = np.arange(6)  
print(one, one.shape)
```

```
two = one.reshape(3,2)  
print(two, two.shape)
```

```
[0 1 2 3 4 5] (6,)
```

```
[[0 1]  
 [2 3]  
 [4 5]] (3, 2)
```

```
three = np.expand_dims(one, axis=0)  
print(three, three.shape)
```

```
four = np.expand_dims(one, axis=1)  
print(four, four.shape)
```



# Arrays umformen

```
import numpy as np
```

```
one = np.arange(6)  
print(one, one.shape)
```

```
two = one.reshape(3,2)  
print(two, two.shape)
```

```
[0 1 2 3 4 5] (6,)
```

```
[[0 1]  
 [2 3]  
 [4 5]] (3, 2)
```

```
three = np.expand_dims(one, axis=0)  
print(three, three.shape)
```

```
[[0 1 2 3 4 5]] (1, 6)
```

```
four = np.expand_dims(one, axis=1)  
print(four, four.shape)
```

# Arrays umformen

```
import numpy as np
```

```
one = np.arange(6)  
print(one, one.shape)
```

```
two = one.reshape(3,2)  
print(two, two.shape)
```

```
[0 1 2 3 4 5] (6,)
```

```
[[0 1]  
 [2 3]  
 [4 5]] (3, 2)
```

```
three = np.expand_dims(one, axis=0)  
print(three, three.shape)
```

```
[[0 1 2 3 4 5]] (1, 6)
```

```
four = np.expand_dims(one, axis=1)  
print(four, four.shape)
```

```
[[0]  
 [1]  
 [2]  
 [3]  
 [4]  
 [5]] (6, 1)
```

# Arrays umformen

```
import numpy as np
```

```
one = np.arange(6)  
print(one, one.shape)
```

```
two = one.reshape(3,2)  
print(two, two.shape)
```

```
[0 1 2 3 4 5] (6,)
```

```
[[0 1]  
 [2 3]  
 [4 5]] (3, 2)
```

Es gilt `four[3, 0] == three[0, 3]`

```
three = np.expand_dims(one, axis=0)  
print(three, three.shape)
```

```
[[0 1 2 3 4 5]] (1, 6)
```

```
four = np.expand_dims(one, axis=1)  
print(four, four.shape)
```

```
[[0]  
 [1]  
 [2]  
 [3]  
 [4]  
 [5]] (6, 1)
```

# Arrays um

Hinzufügen einer (leeren) Dimension.  
Hier Achse „0“, also Werte landen in Achse 1.  
Zugriff dann per `three[:,0], 3]`

```
import numpy as np
```

```
one = np.arange(6)  
print(one, one.shape)
```

```
two = one.reshape(3,2)  
print(two, two.shape)
```

```
[0 1 2 3 4 5] (6,)
```

```
[[0 1]  
 [2 3]  
 [4 5]] (3, 2)
```

Werte des Arrays in  
eine andere Form  
bringen

```
three = np.expand_dims(one, axis=0)  
print(three, three.shape)
```

```
[[0 1 2 3 4 5]] (1, 6)
```

```
four = np.expand_dims(one, axis=1)  
print(four, four.shape)
```

```
[[0]  
 [1]  
 [2]  
 [3]  
 [4]  
 [5]] (6, 1)
```

Hinzufügen einer (leeren) Dimension.  
Hier Achse „1“, also Werte landen in Achse 0.  
Zugriff dann per `four[3, :,0]`

Es gilt `four[3, 0] == three[0, 3]`

# Zugriff und Filter

```
import numpy as np

one = np.arange(20)
two = np.flip(one)
print(one)
print(two)

print(one[(one % 2 == 1)])

print(one > 10)
print(two > 10)

print(np.nonzero(two > 10))

print(np.flatnonzero(two > 10))

print(one[(one > 10)])
print(one[(two > 10)])
```

# Zugriff und Filter

```
import numpy as np
```

```
one = np.arange(20)
```

```
two = np.flip(one)
```

```
print(one)
```

```
print(two)
```

```
[ 0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19]
[19 18 17 16 15 14 13 12 11 10  9  8  7  6  5  4  3  2  1  0]
```

```
print(one[(one % 2 == 1)])
```

```
print(one > 10)
```

```
print(two > 10)
```

```
print(np.nonzero(two > 10))
```

```
print(np.flatnonzero(two > 10))
```

```
print(one[(one > 10)])
```

```
print(one[(two > 10)])
```

# Zugriff und Filter

```
import numpy as np
```

```
one = np.arange(20)
```

```
two = np.flip(one)
```

```
print(one)
```

```
print(two)
```

```
[ 0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19]
[19 18 17 16 15 14 13 12 11 10  9  8  7  6  5  4  3  2  1  0]
```

```
print(one[(one % 2 == 1)])
```

```
[ 1  3  5  7  9 11 13 15 17 19]
```

```
print(one > 10)
```

```
print(two > 10)
```

```
print(np.nonzero(two > 10))
```

```
print(np.flatnonzero(two > 10))
```

```
print(one[(one > 10)])
```

```
print(one[(two > 10)])
```

# Zugriff und Filter

```
import numpy as np
```

```
one = np.arange(20)
```

```
two = np.flip(one)
```

```
print(one)
```

```
print(two)
```

```
[ 0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19]
[19 18 17 16 15 14 13 12 11 10  9  8  7  6  5  4  3  2  1  0]
```

```
print(one[(one % 2 == 1)]) [ 1  3  5  7  9 11 13 15 17 19]
```

```
print(one > 10)
```

```
[False False False False False False False False False False False True True True True True True True True True True]
```

```
print(two > 10)
```

```
[ True True True True True True True True True True False False False False False False False False False False]
```

```
print(np.nonzero(two > 10))
```

```
print(np.flatnonzero(two > 10))
```

```
print(one[(one > 10)])
```

```
print(one[(two > 10)])
```



# Zugriff und Filter

```
import numpy as np
```

```
one = np.arange(20)
```

```
two = np.flip(one)
```

```
print(one)
```

```
print(two)
```

```
[ 0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19]
```

```
[19 18 17 16 15 14 13 12 11 10  9  8  7  6  5  4  3  2  1  0]
```

```
print(one[(one % 2 == 1)])
```

```
[ 1  3  5  7  9 11 13 15 17 19]
```

```
print(one > 10)
```

```
[False False False False False False False False False False False True True True True True True True True True True True]
```

```
print(two > 10)
```

```
[ True  True  True  True  True  True  True  True  True  True False False False False False False False False False False False]
```

```
print(np.nonzero(two > 10))
```

```
(array([0, 1, 2, 3, 4, 5, 6, 7, 8]),)
```

```
print(np.flatnonzero(two > 10))
```

```
print(one[(one > 10)])
```

```
print(one[(two > 10)])
```

# Zugriff und Filter

```
import numpy as np
```

```
one = np.arange(20)
```

```
two = np.flip(one)
```

```
print(one)
```

```
print(two)
```

```
[ 0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19]
[19 18 17 16 15 14 13 12 11 10  9  8  7  6  5  4  3  2  1  0]
```

```
print(one[(one % 2 == 1)])
```

```
[ 1  3  5  7  9 11 13 15 17 19]
```

```
print(one > 10)
```

```
[False False False False False False False False False False False True True True True True True True True True True]
```

```
print(two > 10)
```

```
[ True True True True True True True True True True False False False False False False False False False False]
```

```
print(np.nonzero(two > 10))
```

```
(array([0, 1, 2, 3, 4, 5, 6, 7, 8]),)
```

```
print(np.flatnonzero(two > 10))
```

```
[0 1 2 3 4 5 6 7 8]
```

```
print(one[(one > 10)])
```

```
print(one[(two > 10)])
```

# Zugriff und Filter

```
import numpy as np
```

```
one = np.arange(20)
```

```
two = np.flip(one)
```

```
print(one)
```

```
print(two)
```

```
[ 0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19]
[19 18 17 16 15 14 13 12 11 10  9  8  7  6  5  4  3  2  1  0]
```

```
print(one[(one % 2 == 1)]) [ 1  3  5  7  9 11 13 15 17 19]
```

```
print(one > 10) [False False False False False False False False False False False True True True True True True True True True True]
print(two > 10) [ True True True True True True True True True True False False False False False False False False False False]
```

```
print(np.nonzero(two > 10)) (array([0, 1, 2, 3, 4, 5, 6, 7, 8]),)
```

```
print(np.flatnonzero(two > 10)) [0 1 2 3 4 5 6 7 8]
```

```
print(one[(one > 10)]) [11 12 13 14 15 16 17 18 19]
print(one[(two > 10)]) [0 1 2 3 4 5 6 7 8]
```

# Z and Filter

Herausfiltern bestimmter Werte

Boolsches Array wählt die zurückzugebenden Indizes aus.

```
import numpy as np
```

```
one = np.arange(20)
```

```
two = np.flip(one)
```

```
print(one)
```

```
print(two)
```

```
[ 0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19]
[19 18 17 16 15 14 13 12 11 10  9  8  7  6  5  4  3  2  1  0]
```

```
print(one[(one % 2 == 1)])
```

```
[ 1  3  5  7  9 11 13 15 17 19]
```

Vergleich ergibt hier ein neues boolesches Array

```
print(one > 10)
```

```
print(two > 10)
```

```
[False False False False False False False False False False False True True True True True True True True True True]
[ True  True  True  True  True  True  True  True  True  True False False False False False False False False False False]
```

```
print(np.nonzero(two > 10))
```

```
(array([0, 1, 2, 3, 4, 5, 6, 7, 8]),)
```

```
print(np.flatnonzero(two > 10))
```

```
[0 1 2 3 4 5 6 7 8]
```

```
print(one[(one > 10)])
```

```
print(one[(two > 10)])
```

```
[11 12 13 14 15 16 17 18 19]
```

```
[0 1 2 3 4 5 6 7 8]
```

Nicht die Werte, sondern die Indizes

# Operationen

```
import numpy as np
```

```
a = np.array([1, 2])
```

```
b = np.array([1, 1])
```

```
print(a + b)
```

```
print(a * b)
```

```
print(a + 2)
```

```
print(a * 2)
```

```
A = np.array([[1, 2],  
              [3, 4]])
```

```
B = np.array([[5, 6],  
              [7, 8]])
```

# Operationen

```
import numpy as np
```

```
a = np.array([1, 2])
```

```
b = np.array([1, 1])
```

```
print(a + b)      [2 3]
```

```
print(a * b)
```

```
print(a + 2)
```

```
print(a * 2)
```

```
A = np.array([[1, 2],  
              [3, 4]])
```

```
B = np.array([[5, 6],  
              [7, 8]])
```

# Operationen

```
import numpy as np
```

```
a = np.array([1, 2])
```

```
b = np.array([1, 1])
```

```
print(a + b)      [2 3]
```

```
print(a * b)      [1 2]
```

```
print(a + 2)
```

```
print(a * 2)
```

```
A = np.array([[1, 2],  
              [3, 4]])
```

```
B = np.array([[5, 6],  
              [7, 8]])
```

# Operationen

```
import numpy as np
```

```
a = np.array([1, 2])
```

```
b = np.array([1, 1])
```

```
print(a + b)      [2 3]
```

```
print(a * b)      [1 2]
```

```
print(a + 2)      [3 4]
```

```
print(a * 2)
```

```
A = np.array([[1, 2],  
              [3, 4]])
```

```
B = np.array([[5, 6],  
              [7, 8]])
```



# Operationen

```
import numpy as np
```

```
a = np.array([1, 2])  
b = np.array([1, 1])
```

```
print(a + b)      [2 3]
```

```
print(a * b)      [1 2]
```

```
print(a + 2)      [3 4]
```

```
print(a * 2)      [2 4]
```

```
A = np.array([[1, 2],  
              [3, 4]])  
B = np.array([[5, 6],  
              [7, 8]])
```

# Operationen

```
import numpy as np
```

```
a = np.array([1, 2])  
b = np.array([1, 1])
```

```
print(a + b)      [2 3]
```

```
print(a * b)      [1 2]
```

```
print(a + 2)      [3 4]
```

```
print(a * 2)      [2 4]
```

```
A = np.array([[1, 2],  
              [3, 4]])  
B = np.array([[5, 6],  
              [7, 8]])
```

```
print(A + B)
```

```
print(A * B)
```

```
print(A @ B)
```

```
print(A.sum(), A.sum(axis=1), A.sum(axis=0))
```

```
print(B.min(), B.max())
```

```
print(A + a)
```

# Operationen

```
import numpy as np
```

```
a = np.array([1, 2])  
b = np.array([1, 1])
```

```
print(a + b)      [2 3]
```

```
print(a * b)      [1 2]
```

```
print(a + 2)      [3 4]
```

```
print(a * 2)      [2 4]
```

```
A = np.array([[1, 2],  
              [3, 4]])  
B = np.array([[5, 6],  
              [7, 8]])
```

```
print(A + B)      [[ 6  8]  
                  [10 12]]
```

```
print(A * B)
```

```
print(A @ B)
```

```
print(A.sum(), A.sum(axis=1), A.sum(axis=0))
```

```
print(B.min(), B.max())
```

```
print(A + a)
```

# Operationen

```
import numpy as np
```

```
a = np.array([1, 2])  
b = np.array([1, 1])
```

```
print(a + b)      [2 3]
```

```
print(a * b)      [1 2]
```

```
print(a + 2)      [3 4]
```

```
print(a * 2)      [2 4]
```

```
A = np.array([[1, 2],  
              [3, 4]])  
B = np.array([[5, 6],  
              [7, 8]])
```

```
print(A + B)      [[ 6  8]  
                 [10 12]]
```

```
print(A * B)      [[ 5 12]  
                 [21 32]]
```

```
print(A @ B)
```

```
print(A.sum(), A.sum(axis=1), A.sum(axis=0))
```

```
print(B.min(), B.max())
```

```
print(A + a)
```

# Operationen

```
import numpy as np
```

```
a = np.array([1, 2])  
b = np.array([1, 1])
```

```
print(a + b)      [2 3]
```

```
print(a * b)      [1 2]
```

```
print(a + 2)      [3 4]
```

```
print(a * 2)      [2 4]
```

```
A = np.array([[1, 2],  
              [3, 4]])  
B = np.array([[5, 6],  
              [7, 8]])
```

```
print(A + B)      [[ 6  8]  
                  [10 12]]
```

```
print(A * B)      [[ 5 12]  
                  [21 32]]
```

```
print(A @ B)      [[19 22]  
                  [43 50]]
```

```
print(A.sum(), A.sum(axis=1), A.sum(axis=0))
```

```
print(B.min(), B.max())
```

```
print(A + a)
```

# Operationen

```
import numpy as np
```

```
a = np.array([1, 2])  
b = np.array([1, 1])
```

```
print(a + b)      [2 3]
```

```
print(a * b)      [1 2]
```

```
print(a + 2)      [3 4]
```

```
print(a * 2)      [2 4]
```

```
A = np.array([[1, 2],  
              [3, 4]])  
B = np.array([[5, 6],  
              [7, 8]])
```

```
print(A + B)      [[ 6  8]  
                  [10 12]]
```

```
print(A * B)      [[ 5 12]  
                  [21 32]]
```

```
print(A @ B)      [[19 22]  
                  [43 50]]
```

```
print(A.sum(), A.sum(axis=1), A.sum(axis=0))  
10 [3 7] [4 6]
```

```
print(B.min(), B.max())
```

```
print(A + a)
```

# Operationen

```
import numpy as np
```

```
a = np.array([1, 2])  
b = np.array([1, 1])
```

```
print(a + b)      [2 3]
```

```
print(a * b)      [1 2]
```

```
print(a + 2)      [3 4]
```

```
print(a * 2)      [2 4]
```

```
A = np.array([[1, 2],  
              [3, 4]])  
B = np.array([[5, 6],  
              [7, 8]])
```

```
print(A + B)      [[ 6  8]  
                 [10 12]]
```

```
print(A * B)      [[ 5 12]  
                 [21 32]]
```

```
print(A @ B)      [[19 22]  
                 [43 50]]
```

```
print(A.sum(), A.sum(axis=1), A.sum(axis=0))  
10 [3 7] [4 6]
```

```
print(B.min(), B.max())  
5 8
```

```
print(A + a)
```

# Operationen

```
import numpy as np
```

```
a = np.array([1, 2])  
b = np.array([1, 1])
```

```
print(a + b)      [2 3]
```

```
print(a * b)      [1 2]
```

```
print(a + 2)      [3 4]
```

```
print(a * 2)      [2 4]
```

```
A = np.array([[1, 2],  
              [3, 4]])  
B = np.array([[5, 6],  
              [7, 8]])
```

```
print(A + B)      [[ 6  8]  
                 [10 12]]
```

```
print(A * B)      [[ 5 12]  
                 [21 32]]
```

```
print(A @ B)      [[19 22]  
                 [43 50]]
```

```
print(A.sum(), A.sum(axis=1), A.sum(axis=0))  
10 [3 7] [4 6]
```

```
print(B.min(), B.max())  
5 8
```

```
print(A + a)      [[2 4]  
                 [4 6]]
```



# Operationen

```
import numpy as np
```

```
a = np.array([1, 2])  
b = np.array([1, 1])
```

```
print(a + b) [2 3]
```

```
print(a * b) [1 2]
```

```
print(a + 2) [3 4]
```

```
print(a * 2) [2 4]
```

Elementweise  
Operation

```
A = np.array([[1, 2],  
              [3, 4]])  
B = np.array([[5, 6],  
              [7, 8]])
```

Broadcasting  
(Skalar wird auf  
Array angewandt)

```
print(A + B) [[ 6  8]  
             [10 12]]
```

```
print(A * B) [[ 5 12]  
             [21 32]]
```

```
print(A @ B) [[19 22]  
             [43 50]]
```

Matrixmultiplikation

```
print(A.sum(), A.sum(axis=1), A.sum(axis=0))
```

```
10 [3 7] [4 6]
```

```
print(B.min(), B.max())  
5 8
```

Auswahl der Achse,  
über die  
„gerechnet“ werden  
soll.

```
print(A + a) [[2 4]  
             [4 6]]
```

Broadcasting  
(Array wird auf  
Array angewandt)

# Beispiel: Formel

$$d_e(x, y) = \sqrt{\sum_{i=1}^n (x_i - y_i)^2}$$

# Beispiel: Formel

$$d_e(x, y) = \sqrt{\sum_{i=1}^n (x_i - y_i)^2}$$

```
import math

def d_e_py(x, y):
    r = 0
    for x_i, y_i in zip(x, y):
        r += (x_i - y_i)**2
    return math.sqrt(r)

print(d_e_py(
    [1, 2, 1],
    [1, 3, 2]
))
```

# Beispiel: Formel

$$d_e(x, y) = \sqrt{\sum_{i=1}^n (x_i - y_i)^2}$$

```
import math

def d_e_py(x, y):
    r = 0
    for x_i, y_i in zip(x, y):
        r += (x_i - y_i)**2
    return math.sqrt(r)
```

```
print(d_e_py(
    [1, 2, 1],
    [1, 3, 2]
))
```

```
import numpy as np
```

```
def d_e_numpy(x, y):
    return np.sqrt(
        np.power(
            (x - y),
            2
        ).sum()
    )
```

```
print(d_e_numpy(
    np.array([1, 2, 1]),
    np.array([1, 3, 2])
))
```

# Beispiel: Formel

$$d_e(x, y) = \sqrt{\sum_{i=1}^n (x_i - y_i)^2}$$

```
import math

def d_e_py(x, y):
    r = 0
    for x_i, y_i in zip(x, y):
        r += (x_i - y_i)**2
    return math.sqrt(r)
```

```
print(d_e_py(
    [1, 2, 1],
    [1, 3, 2]
))
```

1.4142135623730951

```
import numpy as np
```

```
def d_e_numpy(x, y):
    return np.sqrt(
        np.power(
            (x - y),
            2
        ).sum()
    )
```

```
print(d_e_numpy(
    np.array([1, 2, 1]),
    np.array([1, 3, 2])
))
```

# Beispiel: Formel

Schleife über die Elemente in x und y

$$d_e(x, y) = \sqrt{\sum_{i=1}^n (x_i - y_i)^2}$$

```
import math

def d_e_py(x, y):
    r = 0
    for x_i, y_i in zip(x, y):
        r += (x_i - y_i)**2
    return math.sqrt(r)

print(d_e_py(
    [1, 2, 1],
    [1, 3, 2]
))
```

Ausnutzen der Operationen von NumPy, Elemente nicht selbst betrachtet!

1.4142135623730951

```
import numpy as np

def d_e_numpy(x, y):
    return np.sqrt(
        np.power(
            (x - y),
            2
        ).sum()
    )

print(d_e_numpy(
    np.array([1, 2, 1]),
    np.array([1, 3, 2])
))
```

# Beispiel: Geschwindigkeit

```
import timeit
```

```
x = np.random.rand(1000000)  
y = np.random.rand(1000000)
```

```
print(timeit.timeit('d_e_numpy(x, y)', number=50, globals=globals()))
```

```
x_list = x.tolist()  
y_list = x.tolist()
```

```
print(timeit.timeit('d_e_py(x_list, y_list)', number=50, globals=globals()))
```

# Beispiel: Geschwindigkeit

```
import timeit
```

```
x = np.random.rand(1000000)  
y = np.random.rand(1000000)
```

```
print(timeit.timeit('d_e_numpy(x, y)', number=50, globals=globals()))
```

1.1560903569989023

```
x_list = x.tolist()  
y_list = x.tolist()
```

```
print(timeit.timeit('d_e_py(x_list, y_list)', number=50, globals=globals()))
```



# Beispiel: Geschwindigkeit

```
import timeit
```

```
x = np.random.rand(1000000)  
y = np.random.rand(1000000)
```

```
print(timeit.timeit('d_e_numpy(x, y)', number=50, globals=globals()))
```

1.1560903569989023

```
x_list = x.tolist()  
y_list = x.tolist()
```

```
print(timeit.timeit('d_e_py(x_list, y_list)', number=50, globals=globals()))
```

3.5860290519995033

# Beispiel: Geschwindigkeit

```
import timeit
```

```
x = np.random.rand(10000000)  
y = np.random.rand(10000000)
```

```
print(timeit.timeit('d_e_numpy(x, y)', number=50, globals=globals()))
```

Zeitmessung der Numpy-Funktion (Mittel über 50 Durchläufe)

1.1560903569989023

```
x_list = x.tolist()  
y_list = x.tolist()
```

```
print(timeit.timeit('d_e_py(x_list, y_list)', number=50, globals=globals()))
```

Zeitmessung reines Python

3.5860290519995033

# Speichern und Laden

```
import numpy as np
```

```
x = np.array([[1,2],[3,4]])  
y = x.T # x.transpose()
```

```
np.save('array_x', x)  
x_1 = np.load('array_x.npy')  
print(x_1)
```

```
np.savetxt('array_x.txt', x)  
x_2 = np.loadtxt('array_x.txt')
```

# Speichern und Laden

```
import numpy as np
```

```
x = np.array([[1,2],[3,4]])  
y = x.T # x.transpose()
```

```
np.save('array_x', x)  
x_1 = np.load('array_x.npy')  
print(x_1)
```

```
[[1 2]  
 [3 4]]
```

```
np.savetxt('array_x.txt', x)  
x_2 = np.loadtxt('array_x.txt')
```

# Speichern und Laden

```
import numpy as np
```

```
x = np.array([[1,2],[3,4]])  
y = x.T # x.transpose()
```

```
np.save('array_x', x)  
x_1 = np.load('array_x.npy')  
print(x_1)
```

```
[[1 2]  
 [3 4]]
```

```
np.savetxt('array_x.txt', x)  
x_2 = np.loadtxt('array_x.txt')
```

array\_x.txt

```
1.00000000000000000000e+00 2.00000000000000000000e+00  
3.00000000000000000000e+00 4.00000000000000000000e+00
```

# Speichern und Laden

```
import numpy as np
```

```
x = np.array([[1,2],[3,4]])  
y = x.T # x.transpose()
```

```
np.save('array_x', x)  
x_1 = np.load('array_x.npy')  
print(x_1)
```

```
[[1 2]  
 [3 4]]
```

```
np.savetxt('array_x.txt', x)  
x_2 = np.loadtxt('array_x.txt')
```

array\_x.txt

```
1.0000000000000000e+00 2.0000000000000000e+00  
3.0000000000000000e+00 4.0000000000000000e+00
```

```
np.savez('arrays', x=x, y=y)
```

```
with np.load('arrays.npz') as arrays:  
    print(type(arrays))
```

```
x_3 = arrays["x"]  
y_3 = arrays["y"]
```

```
print(x_3, y_3)
```

# Speichern und Laden

```
import numpy as np
```

```
x = np.array([[1,2],[3,4]])  
y = x.T # x.transpose()
```

```
np.save('array_x', x)  
x_1 = np.load('array_x.npy')  
print(x_1)
```

```
[[1 2]  
 [3 4]]
```

```
np.savetxt('array_x.txt', x)  
x_2 = np.loadtxt('array_x.txt')
```

array\_x.txt

```
1.0000000000000000e+00 2.0000000000000000e+00  
3.0000000000000000e+00 4.0000000000000000e+00
```

```
np.savez('arrays', x=x, y=y)
```

```
with np.load('arrays.npz') as arrays:  
    print(type(arrays))
```

```
<class 'numpy.lib.npyio.NpzFile'>
```

```
x_3 = arrays["x"]  
y_3 = arrays["y"]
```

```
print(x_3, y_3)
```



# Speichern und Laden

```
import numpy as np
```

```
x = np.array([[1,2],[3,4]])  
y = x.T # x.transpose()
```

```
np.save('array_x', x)  
x_1 = np.load('array_x.npy')  
print(x_1)
```

```
[[1 2]  
 [3 4]]
```

```
np.savetxt('array_x.txt', x)  
x_2 = np.loadtxt('array_x.txt')
```

array\_x.txt

```
1.0000000000000000e+00 2.0000000000000000e+00  
3.0000000000000000e+00 4.0000000000000000e+00
```

```
np.savez('arrays', x=x, y=y)
```

```
with np.load('arrays.npz') as arrays:  
    print(type(arrays))
```

```
<class 'numpy.lib.npyio.NpzFile'>
```

```
x_3 = arrays["x"]  
y_3 = arrays["y"]
```

```
print(x_3, y_3)
```

```
[[1 2]  
 [3 4]]  
[[1 3]  
 [2 4]]
```



# Speichern und Laden

```
import numpy as np
```

```
x = np.array([[1,2],[3,4]])  
y = x.T # x.transpose()
```

Ein einzelnes  
Array eine Datei  
speichern  
(einzeln → .npy)

```
np.save('array_x', x)  
x_1 = np.load('array_x.npy')  
print(x_1)
```

```
[[1 2]  
 [3 4]]
```

```
np.savetxt('array_x.txt', x)  
x_2 = np.loadtxt('array_x.txt')
```

array\_x.txt

```
1.0000000000000000e+00 2.000000  
3.0000000000000000e+00 4.000000
```

Array als Text-  
datei speichern  
(menschenslesbar,  
aber langsamer  
und größer)

```
np.savez('arrays', x=x, y=y)
```

Mehrere Arrays  
in einer Datei  
speichern  
→ .npz

```
with np.load('arrays.npz') as arrays:  
    print(type(arrays))
```

```
<class 'numpy.lib.npyio.NpzFile'>
```

```
x_3 = arrays["x"]  
y_3 = arrays["y"]
```

```
print(x_3, y_3)
```

```
[[1 2]  
 [3 4]]  
[[1 3]  
 [2 4]]
```

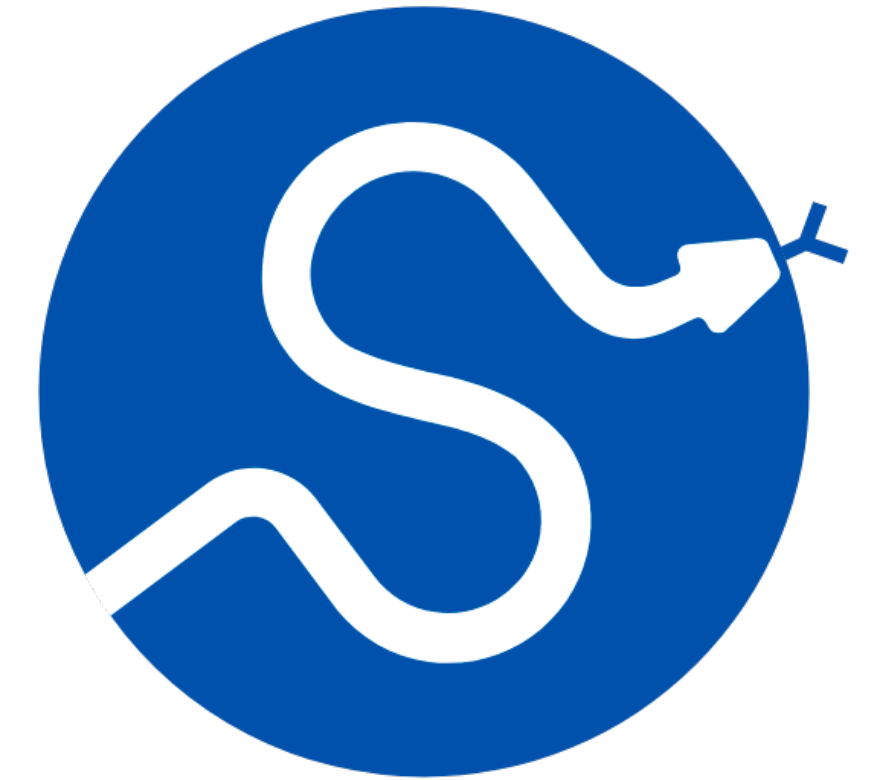
Öffnen einer .npz  
erzeugt eine Art  
Wörterbuch für  
die hinzugefügten  
Arrays

# II.

# Wissenschaftliches Rechnen

## *2. SciPy*

# Installation



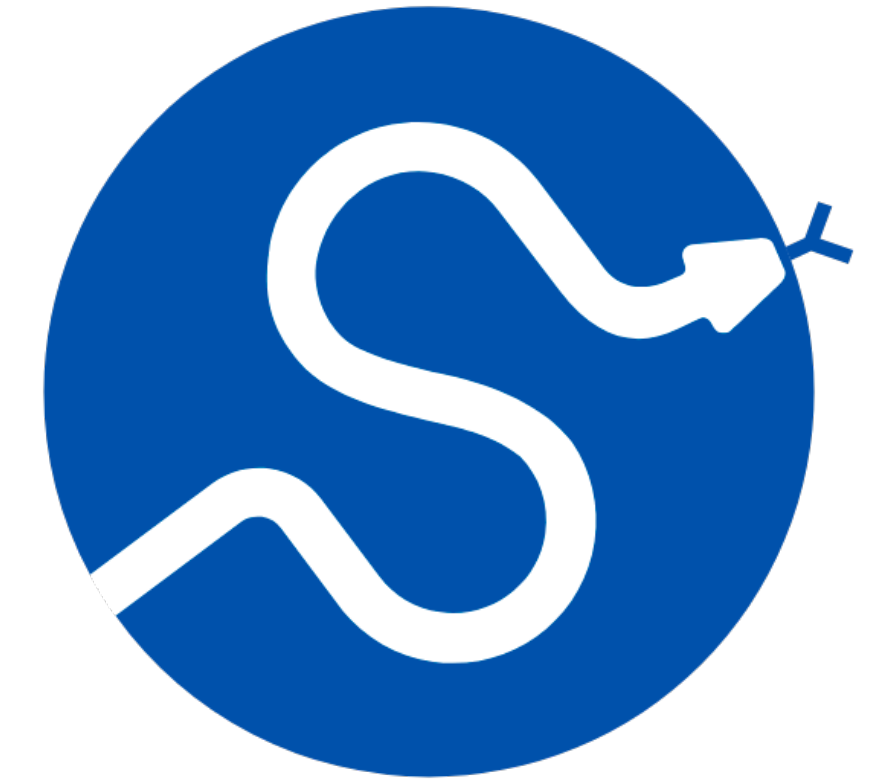
- Python Paket
- <https://scipy.org/>

# Installation



- Python Paket
  - <https://scipy.org/>
- Installation z.B. mit `pip3 install scipy`

# Installation



- Python Paket
  - <https://scipy.org/>
- Installation z.B. mit `pip3 install scipy`
- Import

# Installation



- Python Paket
  - <https://scipy.org/>
- Installation z.B. mit pip3 `install scipy`
- Import

```
import scipy
```

# Warum SciPy?

- Sammlung wichtiger mathematische Funktionen
- Erweiterung von NumPy (nutzt NumPy intern)
  - NumPy bietet Basis (Matrizen & Datenstrukturen)
  - SciPy bietet Algorithmen für Anwendungen

# SciPy Teilpakete

- Fourier Transformationen `scipy.fft`
- Dünnbesetzte Matrizen `scipy.sparse`
- Distanzfunktionen `scipy.spatial.distance`
- Lineare Algebra `scipy.linalg`
- Statistische Funktionen `scipy.stats`



# SciPy Teilpakete

- Fourier Transformationen `scipy.fft`
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- Lineare Algebra `scipy.linalg`
- Statistische Funktionen `scipy.stats`

Ähnlich zu `numpy.linalg`

# Dünnbesetzte Matrizen

$$I_4 = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

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$$I_4 = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

```
import numpy as np

i_20_n = np.identity(20, dtype=np.int64)

print("Number of elements",
      i_20_n.size)
print("Size of element",
      i_20_n.itemsize)
print("Bytes used",
      i_20_n.nbytes)
```

# Dünnbesetzte Matrizen

$$I_4 = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

```
import numpy as np

i_20_n = np.identity(20, dtype=np.int64)

print("Number of elements",
      i_20_n.size)           400
print("Size of element",
      i_20_n.itemsize)      8
print("Bytes used",
      i_20_n.nbytes)       3200
```

# Dünnbesetzte Matrizen

$$I_4 = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

```
from scipy.sparse import (  
    bsr_array, coo_array,  
    csc_array, csr_array,  
    dia_array, dok_array,  
    lil_array  
)
```

```
import numpy as np
```

```
i_20_n = np.identity(20, dtype=np.int64)
```

```
print("Number of elements",  
      i_20_n.size)           400  
print("Size of element",  
      i_20_n.itemsize)      8  
print("Bytes used",  
      i_20_n.nbytes)       3200
```

```
from scipy.sparse import identity  
i_20_s = identity(20, dtype=np.int64, format='dia')
```

```
print("Number of elements",  
      i_20_s.data.size + i_20_s.offsets.size)  
print("Size of element",  
      i_20_s.data.itemsize, i_20_s.offsets.itemsize)  
print("Bytes used",  
      i_20_s.data.nbytes + i_20_s.offsets.nbytes)
```

# Dünnbesetzte Matrizen

$$I_4 = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

```
from scipy.sparse import (  
    bsr_array, coo_array,  
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    dia_array, dok_array,  
    lil_array  
)
```

```
import numpy as np
```

```
i_20_n = np.identity(20, dtype=np.int64)
```

```
print("Number of elements",  
      i_20_n.size)           400  
print("Size of element",  
      i_20_n.itemsize)      8  
print("Bytes used",  
      i_20_n.nbytes)       3200
```

```
from scipy.sparse import identity  
i_20_s = identity(20, dtype=np.int64, format='dia')
```

```
print("Number of elements",  
      i_20_s.data.size + i_20_s.offsets.size)  21  
print("Size of element",  
      i_20_s.data.itemsize, i_20_s.offsets.itemsize)  8 4  
print("Bytes used",  
      i_20_s.data.nbytes + i_20_s.offsets.nbytes)  164
```



# Dünnbesetzte Matrizen

$$I_4 = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Verschiedene Formate je nach Aufteilung der 0en und der benötigten Funktionen.

```
from scipy.sparse import (  
    bsr_array, coo_array,  
    csc_array, csr_array,  
    dia_array, dok_array,  
    lil_array  
)
```

```
import numpy as np
```

```
i_20_n = np.identity(20, dtype=np.int64)
```

```
print("Number of elements",  
      i_20_n.size)           400  
print("Size of element",  
      i_20_n.itemsize)      8  
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      i_20_n.nbytes)       3200
```

```
from scipy.sparse import identity  
i_20_s = identity(20, dtype=np.int64, format='dia')
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```
print("Number of elements",  
      i_20_s.data.size + i_20_s.offsets.size)  21  
print("Size of element",  
      i_20_s.data.itemsize, i_20_s.offsets.itemsize)  8 4  
print("Bytes used",  
      i_20_s.data.nbytes + i_20_s.offsets.nbytes)  164
```

Jede 0 wird als Zahl abgespeichert

# Ünnbesetzte Matrizen

$$I_4 = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Verschiedene Formate je nach Aufteilung der 0en und der benötigten Funktionen.

Nur die von 0 verschiedenen Werte und deren Position speichern

```
from scipy.sparse import (
    bsr_array, coo_array,
    csc_array, csr_array,
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```

```
import numpy as np
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print("Size of element",
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print("Bytes used",
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```

```
from scipy.sparse import identity
i_20_s = identity(20, dtype=np.int64, format='dia')

print("Number of elements",
      i_20_s.data.size + i_20_s.offsets.size)           21
print("Size of element",
      i_20_s.data.itemsize, i_20_s.offsets.itemsize)   8 4
print("Bytes used",
      i_20_s.data.nbytes + i_20_s.offsets.nbytes)     164
```

400 \* 8 = 3200

20 \* 8 + 1 \* 4 = 164



# Statistische Funktionen

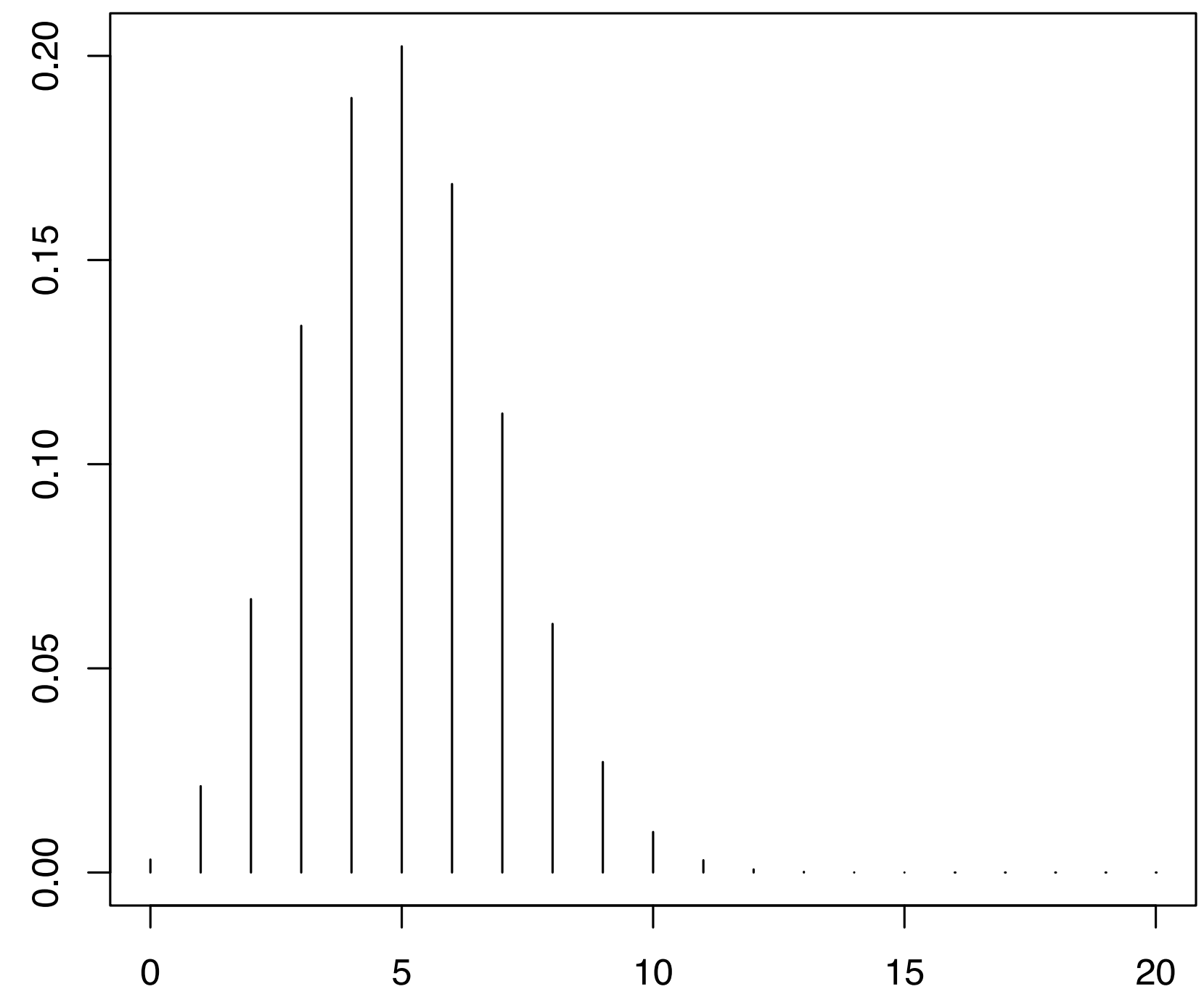
Beispiel: Binomialverteilung

$$P(X = k) = \binom{n}{k} p^k (1 - p)^{n-k}$$

# Statistische Funktionen

Beispiel: Binomialverteilung

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# Statistische Funktionen

Beispiel: Binomialverteilung

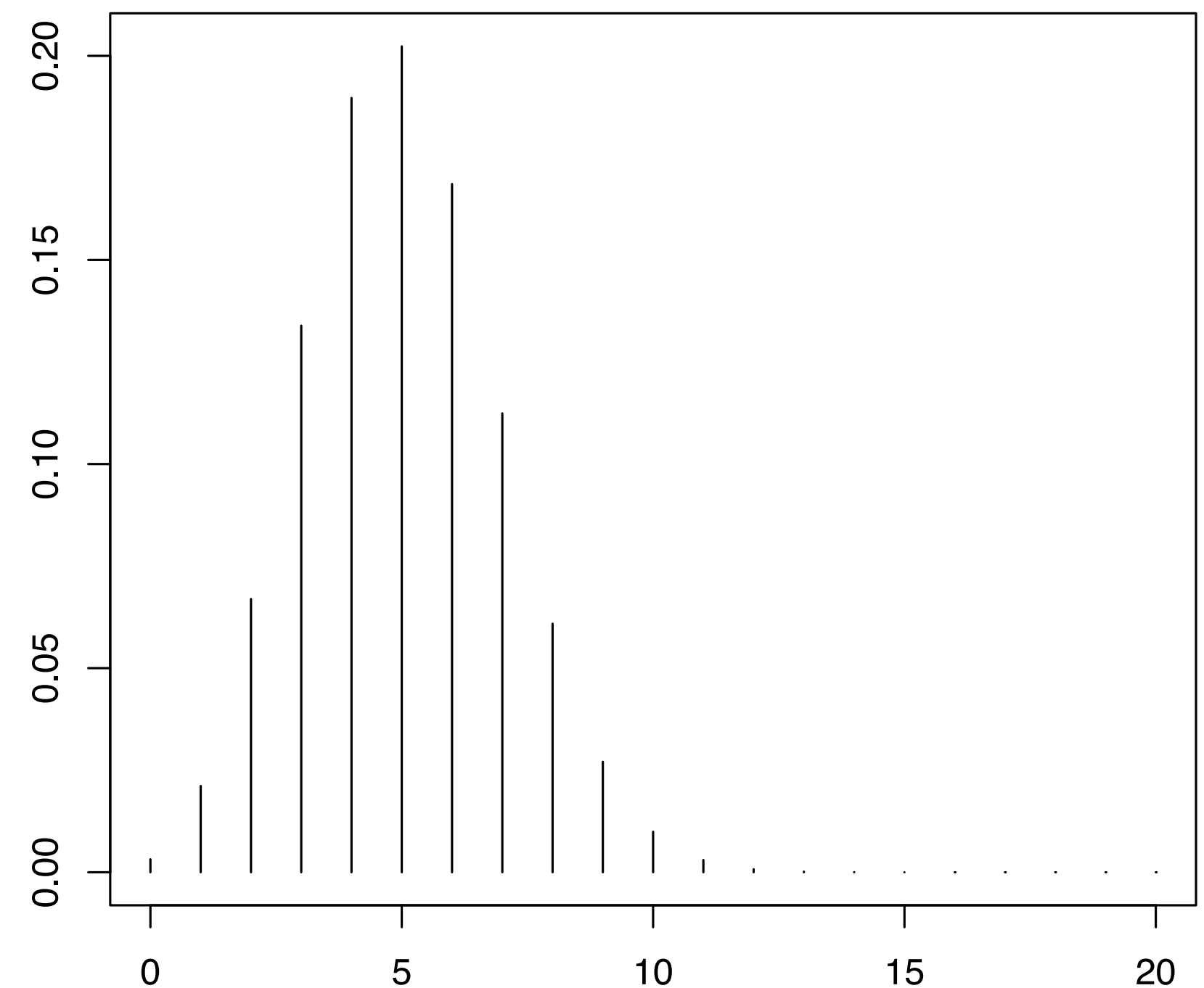
$$P(X = k) = \binom{n}{k} p^k (1 - p)^{n-k}$$

```
from scipy.stats import binom
```

```
n, p = 20, 0.25
```

```
mean, variance = binom.stats(n, p, moments='mv')
```

```
print(mean, variance)
```



# Statistische Funktionen

Beispiel: Binomialverteilung

$$P(X = k) = \binom{n}{k} p^k (1 - p)^{n-k}$$

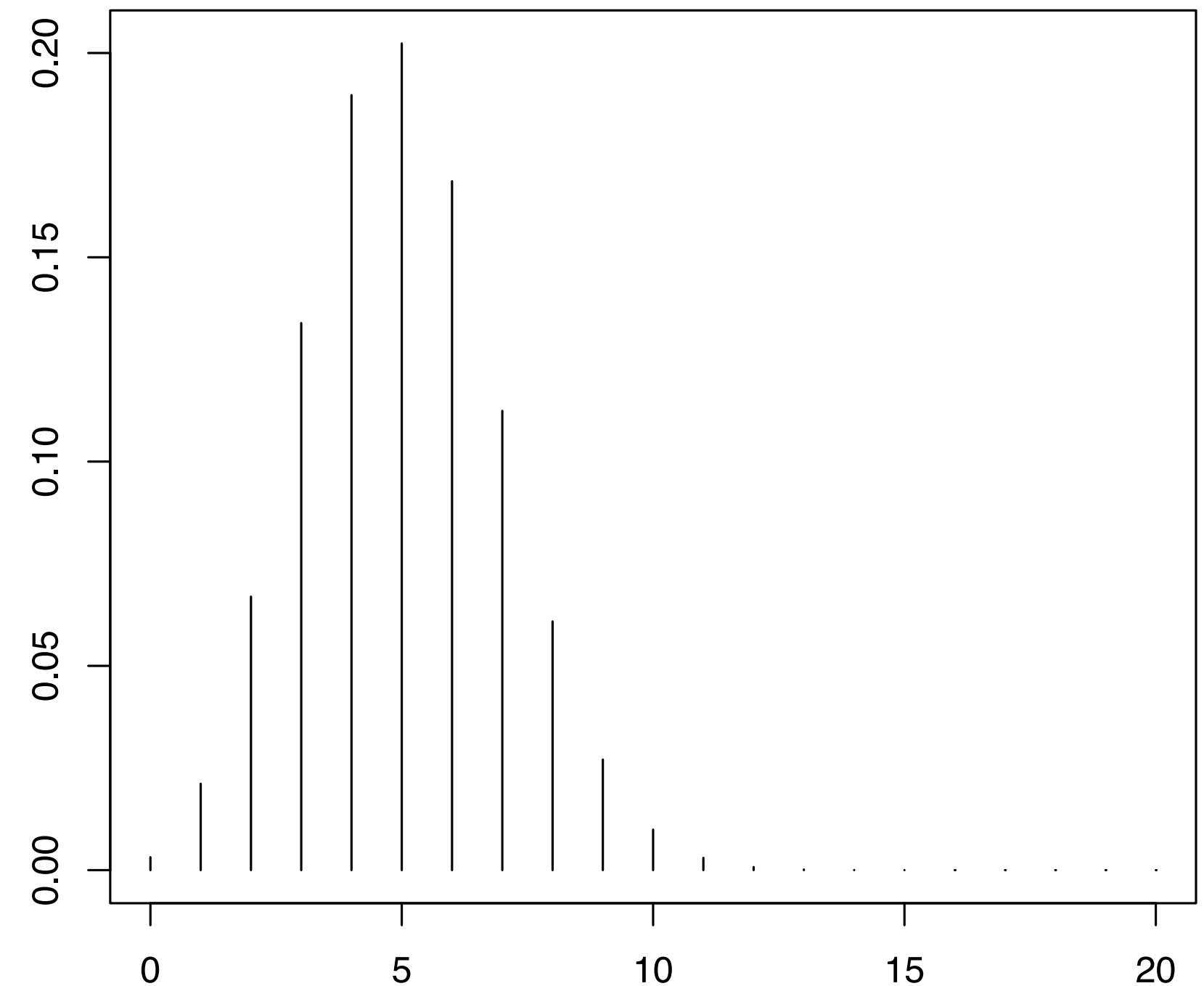
```
from scipy.stats import binom
```

```
n, p = 20, 0.25
```

```
mean, variance = binom.stats(n, p, moments='mv')
```

```
print(mean, variance)
```

```
5.0 3.75
```



# Nochmal: Beispiel Geschwindigkeit

```
import timeit
x = np.random.rand(1000000)
y = np.random.rand(1000000)

print(timeit.timeit('d_e_numpy(x, y)', number=50, globals=globals()))
1.1560903569989023

x_list = x.tolist()
y_list = x.tolist()

print(timeit.timeit('d_e_py(x_list, y_list)', number=50, globals=globals()))
3.5860290519995033

from scipy.spatial import distance

print(timeit.timeit('distance.euclidean(x, y)', number=50, globals=globals()))
```

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3.5860290519995033

from scipy.spatial import distance

print(timeit.timeit('distance.euclidean(x, y)', number=50, globals=globals()))
0.09451730299952033
```

# Nochmal: Beispiel Geschwindigkeit



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y = np.random.rand(1000000)
```

```
print(timeit.timeit('d_e_numpy(x, y)', number=50, globals=globals()))
```

1.1560903569989023

```
x_list = x.tolist()
y_list = y.tolist()
```

```
print(timeit.timeit('d_e_py(x_list, y_list)', number=50, globals=globals()))
```

3.5860290519995033

```
from scipy.spatial import distance
```

```
print(timeit.timeit('distance.euclidean(x, y)', number=50, globals=globals()))
```

0.09451730299952033

Eine eigene Implementierung mittels NumPy ist zwar schon schneller, aber SciPy bietet eine besser optimierte Implementierung.



# Nochmal: Beispiel Geschwindigkeit



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import timeit
x = np.random.rand(1000000)
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Eine eigene Implementierung mittels NumPy ist zwar schon schneller, aber SciPy bietet eine besser optimierte Implementierung.

1.1560903569989023

```
x_list = x.tolist()
y_list = y.tolist()
```

```
print(timeit.timeit('d_e_py(x_list, y_list)', number=50, globals=globals()))
```

3.5860290519995033

```
from scipy.spatial import distance
```

```
print(timeit.timeit('distance.euclidean(x, y)', number=50, globals=globals()))
```

0.09451730299952033

Nutzt intern wiederum  
`numpy.linalg.norm`

<https://docs.scipy.org/doc/scipy/reference/generated/scipy.spatial.distance.euclidean.html>




# Zusammenfassung

- I. Projektaufgabe 3
  1. Herangehensweise & Tipps
- II. Wissenschaftliches Rechnen
  1. NumPy
  2. SciPy
- III. *Reguläre Ausdrücke*



# Zusammenfassung

- I. Projektaufgabe 3
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Aufgabe 3 bleibt über Weihnachten freigeschaltet.  
Die Bearbeitungszeit ist also drei Wochen ohne die zwei Wochen Weihnachten.



# Inhaltsübersicht

1. Programmiersprache Python
  - a) *Einführung, Erste Schritte*
  - b) *Grundlagen*
  - c) *Fortgeschritten*
2. Auszeichnungssprachen
  - a) *LaTeX, Markdown*
3. Benutzeroberflächen und Entwicklungsumgebungen
  - a) *Jupyter Notebooks lokal und in der Cloud (Google Colab)*
4. Versionsverwaltung
  - a) *Git, GitHub*
5. Wissenschaftliches Rechnen
  - a) *NumPy, SciPy*
6. Datenverarbeitung und -visualisierung
  - a) **Pandas, matplotlib, NLTK**
7. Machine Learning (scikit-learn)
  - a) Grundlegende Ansätze (Datensätze, Auswertung)
  - b) Einfache Verfahren (Clustering, ...)
8. DeepLearning
  - a) TensorFlow, PyTorch, HuggingFace Transformers