

# Artificial Intelligence

Algorithms and Applications with Python

Syllabus



TECHNISCHE  
UNIVERSITÄT  
DARMSTADT

WIRTSCHAFTS  
INFORMATIK



AIAA 1 + 2



Dr. Dominik Jung  
[dominik.jung@jung-isec.de](mailto:dominik.jung@jung-isec.de)





## EXPERIENCE

- Since 2024** Team Lead Data Science & AI , Procurement & Purchasing, *Porsche AG*
- 2019 - 2024** Data Scientist, After-Sales, *Porsche AG*
- 2016-2019** Research Assistant, *Karlsruhe Institute of Technology (KIT)*

## EDUCATION

- 2016-2018** Dr. rer. pol., Information Systems, *KIT*
- 2015-2018** M.Sc., Practical Computer Science, *University of Hagen*
- 2013-2015** M.Sc., Information Management and Engineering, *KIT*
- 2009-2013** B.Sc., Media Economics & B.A., Applied Media and Communication Studies, *Imenau University of Technology*

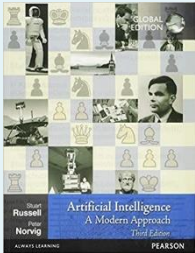
## RESEARCH INTERESTS

- Applied Artificial Intelligence
- Decision Intelligence, Decision Support
- AI-based Systems (*Robo-Advisors, Conversational Agents, DSS etc.*)



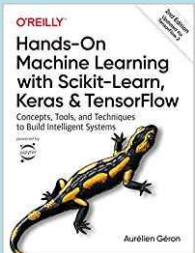
## Further Questions?

Please send me an email at  
[dominik.jung42@jung-isec.com](mailto:dominik.jung42@jung-isec.com)



Russell, S, & Norvig, P. *Artificial Intelligence: A Modern Approach*. Global Edition.  
*Main course book, relevant for all chapters*

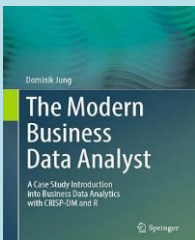
► Availability: ↗ [University Library Darmstadt](#) | ↗ [Amazon](#)



Géron, A. *Hands-on Machine Learning with Scikit-learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems*.

*Relevant for ch. 6 machine learning, ch. 7 neural networks, ch.9 natural language processing and ch.10 computer vision*

► Availability: ↗ [University Library Darmstadt](#) | ↗ [Amazon](#)

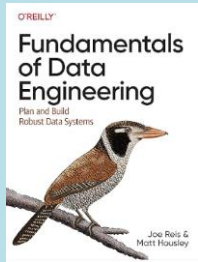


Jung, D. *The Modern Business Data Analyst: A Case Study Introduction into Business Data Analytics with CRISP-DM and R*

*Relevant for ch. 11 building productive AI-systems and the AI capstone*

► Availability: ↗ [Amazon](#)

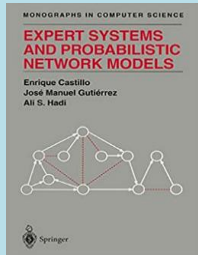
# Further Literature



Reis, J., & Housley, M. *Fundamentals of Data Engineering: Plan and Build Robust Data Systems.*

*Relevant for ch. 4 data and feature engineering with python and ch. 11 building productive AI-systems and the AI capstone.*

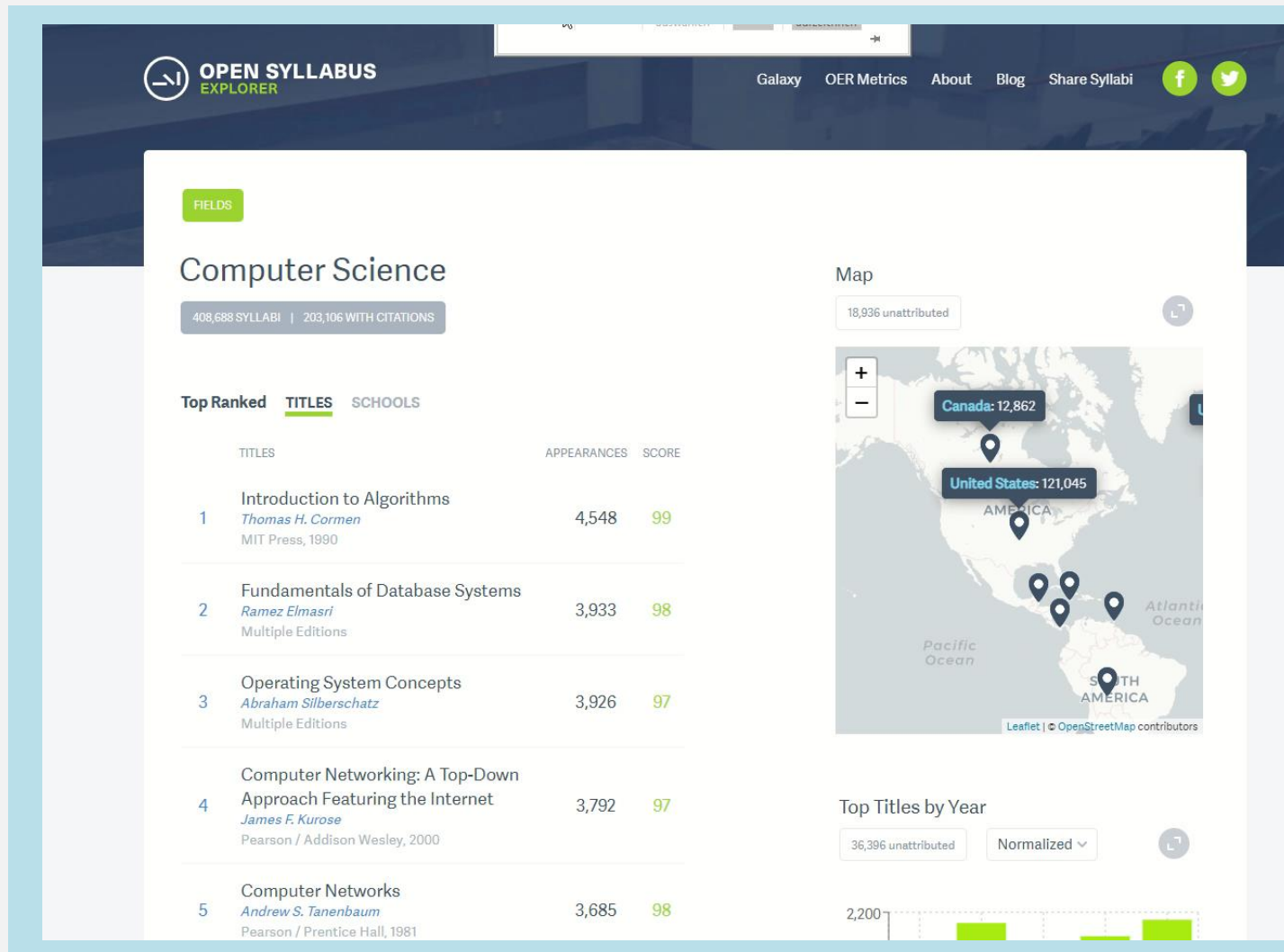
► Availability: ↗ [Amazon](#)



Castillo, E, Gutierrez, JM, & Hadi, AS. *Expert Systems and Probabilistic Network Models.* Springer Science & Business Media.

*Relevant for ch. 5 knowledge reasoning and representation*

► Availability: ↗ [Amazon](#)



Russell and Norvigs textbook is the most used AI teaching book in about 1500 universities world wide ([↗Open Syllabus](#)). Please use the complementary textbook website of this course for exercises and exam preparation. You find there further materials, tutorials and code examples ([↗AIMA Berkley](#)).

# Syllabus



This lecture is aimed at two complementary audiences:

- **Intermediate information systems / computer science students** who want to get a general understanding of artificial intelligence (AI), understand how AI works, and learn new strategies for solving diverse AI problems.
- **Students from other domains** who are planning to use AI methods (e.g. machine learning) in their future (e.g. thesis, internship) and want to understand why it works the way it does.



## What You Will Get Out of this Course

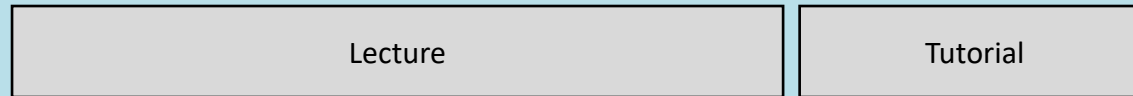
- This course **delivers the knowledge that I think an AI specialist should possess: a general understanding of the fundamentals coupled with a broad knowledge in central algorithms and concepts.** That means that you can **tactically learn more about a topic when needed.**
- At the end of this course, you will:
  - Be able to **design, implement and maintain AI systems in Python**
  - Have profound **knowledge about key concepts and algorithms** in AI
  - **Be good enough to sign up for advanced AI** related courses like machine learning, computer vision etc.
  - Have enough **basic knowledge to apply for beginner AI jobs** in industry



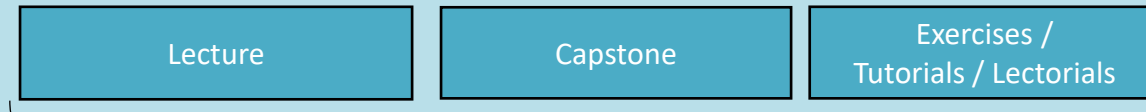
# Outline and Organization

## Course Organisation

traditional  
course



this  
course



equivalent to 27 traditional units (1 unit = 90 minutes lecture)

**Lecture:** on-site / online

**Lectorials:** online with Q&A after lecture

**Exercise and Tutorials:** on-site

## Guiding Principle of the Course

You're not being  
hired for  
knowledge, but  
how you apply the  
knowledge!

## Team



Dr. Dominik Jung  
[dominik.jung@jung-isec.de](mailto:dominik.jung@jung-isec.de)



Dr. Timo Sturm  
[sturm@is.tu-darmstadt.de](mailto:sturm@is.tu-darmstadt.de)


General Questions:  
[ki@is.tu-darmstadt.de](mailto:ki@is.tu-darmstadt.de)



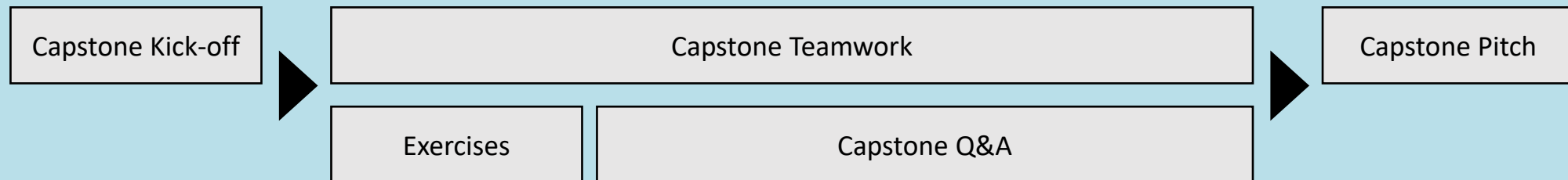
Please note that I revise this course every semester. If you visit this course and plan to write the exam later you have to check if some subchapters were added or excluded for the current exam. I do this due to the capstone project and new trends in AI.



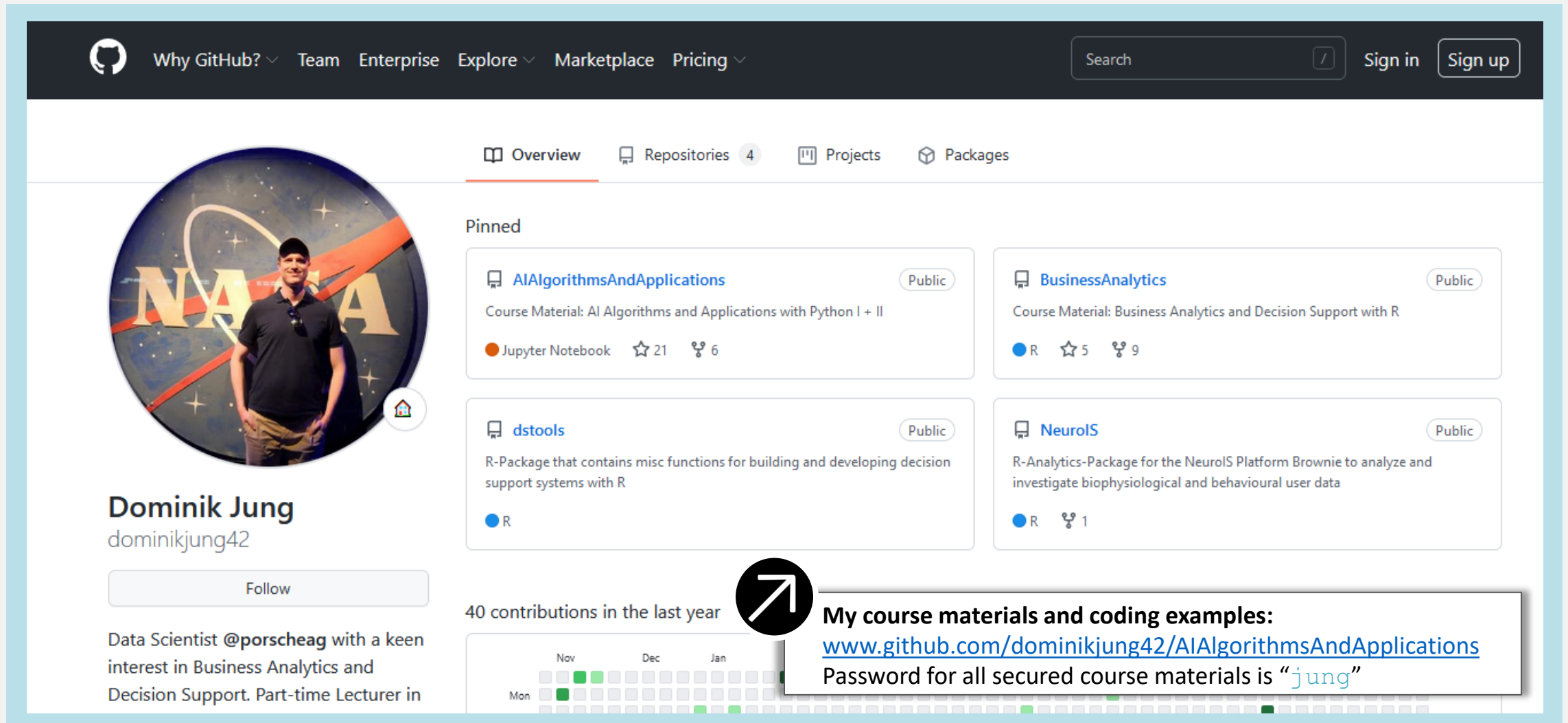
The course is planned as hybrid course (see next slides), while the latest lecture and tutorials will only be on-site.

ID	Date	Start	End	Room	Chapters and Content	Lecturer
1	Fr, 18.10.2024	9:50	12:25	S311/0012	<ul style="list-style-type: none"> <li>Syllabus</li> <li>Ch. 1 - Introduction into Artificial Intelligence</li> </ul>	Dr. Dominik Jung
2	Fr, 18.10.2024	14:25	15:55	S103/23	<ul style="list-style-type: none"> <li>Ch. 3 - Introduction into AI-Programming with Python</li> </ul>	Dr. Dominik Jung
3	Fr, 25.10.2024	9:50	12:50	S311/0012	<ul style="list-style-type: none"> <li>Ch. 2 - Search, Problem Solving, and Planning</li> </ul>	Dr. Timo Sturm
4	Fr, 01.11.2024	9:50	12:50	S311/0012	<ul style="list-style-type: none"> <li>Ch. 4 - Data and Feature Engineering with Python</li> <li>Ch. 5 - Knowledge Reasoning and Representation</li> </ul>	Dr. Dominik Jung
5	Fr, 01.11.2024	14:25 (tba 14:45)	17:55	S103/23	<ul style="list-style-type: none"> <li>Ch. 6 - Machine Learning</li> <li>Lectorial 1 + 2</li> </ul>	Dr. Dominik Jung
6	Fr, 08.11.2024	9:50	12:50	S311/0012	<ul style="list-style-type: none"> <li>Ch. 7 - Artificial Neural Networks and Deep Learning</li> <li>Lectorial 3</li> </ul>	Dr. Dominik Jung
7	Fr, 08.11.2024	14:25	17:55	S103/23	<ul style="list-style-type: none"> <li>Ch. 8 - Probabilistic Reasoning and Modelling</li> <li>Ch. 9 - Natural Language Processing</li> <li>Guest Lecture</li> <li>Lectorial 4</li> </ul>	Dr. Dominik Jung
8	Fr, 15.11.2024	9:50	12:50	S311/0012	<ul style="list-style-type: none"> <li>Ch. 10 - Computer Vision and Image Processing</li> <li>Lectorial 5</li> </ul>	Dr. Timo Sturm
9	Fr, 22.11.2024  Christmas Lecture	9:50	12:50	S311/0012	<ul style="list-style-type: none"> <li>Ch. 11 - Building Productive AI-based Systems</li> <li>Course Evaluation</li> </ul>	Dr. Dominik Jung
10	Fr, 29.11.2024	9:50	12:50	S311/0012	<ul style="list-style-type: none"> <li>Alternative date for cancelled lectures (hybrid)</li> </ul>	tbd
11	tbd	tbd	tbd	online	<ul style="list-style-type: none"> <li>Exam Q&amp;A (online)</li> </ul>	Dr. Dominik Jung

ID	Event	Date	Lecturer
1	<ul style="list-style-type: none"><li>Guest Lecture</li><li>Capstone Kick-off</li></ul>	Friday	Dr. Dominik Jung Porsche AG Team
2	<ul style="list-style-type: none"><li>Exercise</li></ul>	Thursday	Dr. Timo Sturm
3	<ul style="list-style-type: none"><li>Capstone Q&amp;A</li></ul>	Weekly	Porsche AG Team
4	<ul style="list-style-type: none"><li>Capstone Pitch</li></ul>	Friday	All







Why GitHub? ▾ Team Enterprise Explore ▾ Marketplace Pricing ▾

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Overview Repositories 4 Projects Packages

**Pinned**

- AIAgorithmsAndApplications** (Public)  
Course Material: AI Algorithms and Applications with Python I + II  
Jupyter Notebook ☆ 21 🔗 6
- BusinessAnalytics** (Public)  
Course Material: Business Analytics and Decision Support with R  
R ☆ 5 🔗 9
- dstools** (Public)  
R-Package that contains misc functions for building and developing decision support systems with R  
R
- NeuroIS** (Public)  
R-Analytics-Package for the NeuroIS Platform Brownie to analyze and investigate biophysiological and behavioural user data  
R 🔗 1

**Dominik Jung**  
dominikjung42

Follow

Data Scientist @porscheag with a keen interest in Business Analytics and Decision Support. Part-time Lecturer in

40 contributions in the last year

Nov Dec Jan

Mon

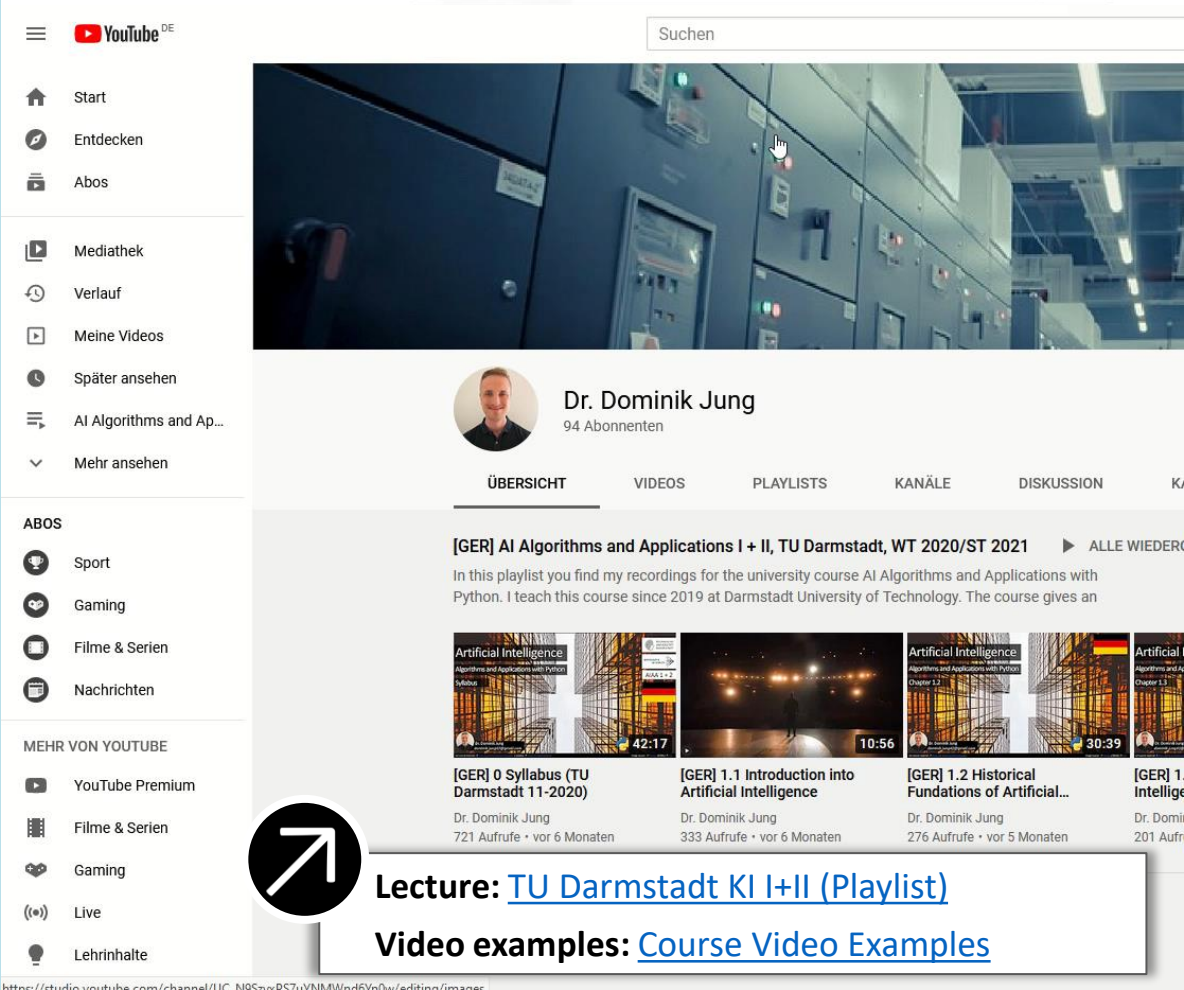
**My course materials and coding examples:**  
[www.github.com/dominikjung42/AIAgorithmsAndApplications](https://www.github.com/dominikjung42/AIAgorithmsAndApplications)  
Password for all secured course materials is "jung"

The screenshot shows the GitHub profile for 'aimacode'. The profile header includes the GitHub logo, navigation links (Product, Solutions, Resources, Open Source, Enterprise, Pricing), a search bar, and 'Sign in' and 'Sign up' buttons. The profile itself has a custom avatar with 'AI' and 'M' on a grid, the name 'aimacode', and a bio: 'Code for the book "Artificial Intelligence: A Modern Approach"'. It shows 1.9k followers, location in Berkeley, CA, and contact information. Below the header are tabs for Overview, Repositories (13), Projects, Packages, and People. The 'Popular repositories' section lists six repositories:

- aima-python** (Public): Python implementation of algorithms from Russell And Norvig's "Artificial Intelligence - A Modern Approach". 8k stars, 3.8k forks. Includes a Jupyter Notebook icon.
- aima-exercises** (Public): Exercises for the book Artificial Intelligence: A Modern Approach. 886 stars, 532 forks. Includes an HTML icon.
- aima-javascript** (Public): Javascript visualization of algorithms from Russell And Norvig's "Artificial Intelligence - A Modern Approach". 543 stars, 218 forks. Includes a JavaScript icon.
- aima-java** (Public): Java implementation of algorithms from Russell And Norvig's "Artificial Intelligence - A Modern Approach". 1.6k stars, 795 forks. Includes a Java icon.
- aima-pseudocode** (Public): Pseudocode descriptions of the algorithms from Russell And Norvig's "Artificial Intelligence - A Modern Approach". 868 stars, 420 forks.
- aima-lisp** (Public): Common Lisp implementation of algorithms from Russell And Norvig's "Artificial Intelligence - A Modern Approach". 101 stars. Includes a Common Lisp icon.

On the right side, the 'People' section states: 'This organization has no public members. You must be a member to see who's a part of this organization.' Below that, the 'Top languages' section shows a chart with Python, Scala, C#, Julia, and HTML.

A callout box with a black circle and a white arrow points to the 'aima-lisp' repository. The text inside the callout box reads: 'Official course book materials: <https://github.com/aimacode/>'.



**Lecture:** [TU Darmstadt KI I+II \(Playlist\)](#)

**Video examples:** [Course Video Examples](#)

## Hybrid/Online Lecture Setup

- Selected lecture recordings and exercises will be online available at Youtube on my channel:  
[www.youtube.com/c/dominikjung42](https://www.youtube.com/c/dominikjung42)
- Teaching material accompanying this lecture and all literature downloads and course material will be available in GIT:  
[www.github.com/dominikjung42](https://www.github.com/dominikjung42)
- Please feel free to comment the videos to solve the class room tasks.
- Click “” to get informed about new videos.





Please install

- Anaconda: <https://www.anaconda.com/distribution>
- GIT: <https://git-scm.com/downloads> | <https://gitforwindows.org>

until **next** lecture

You will need them to solve the exercises in this course



All tools of this course are available  
for Linux, Windows and Apple!



## Anaconda 2019.07 for Windows Installer

### Python 3.7 version

Download

64-Bit Graphical Installer (486 MB)

32-Bit Graphical Installer (418 MB)

### Python 2.7 version

Download

64-Bit Graphical Installer (427 MB)

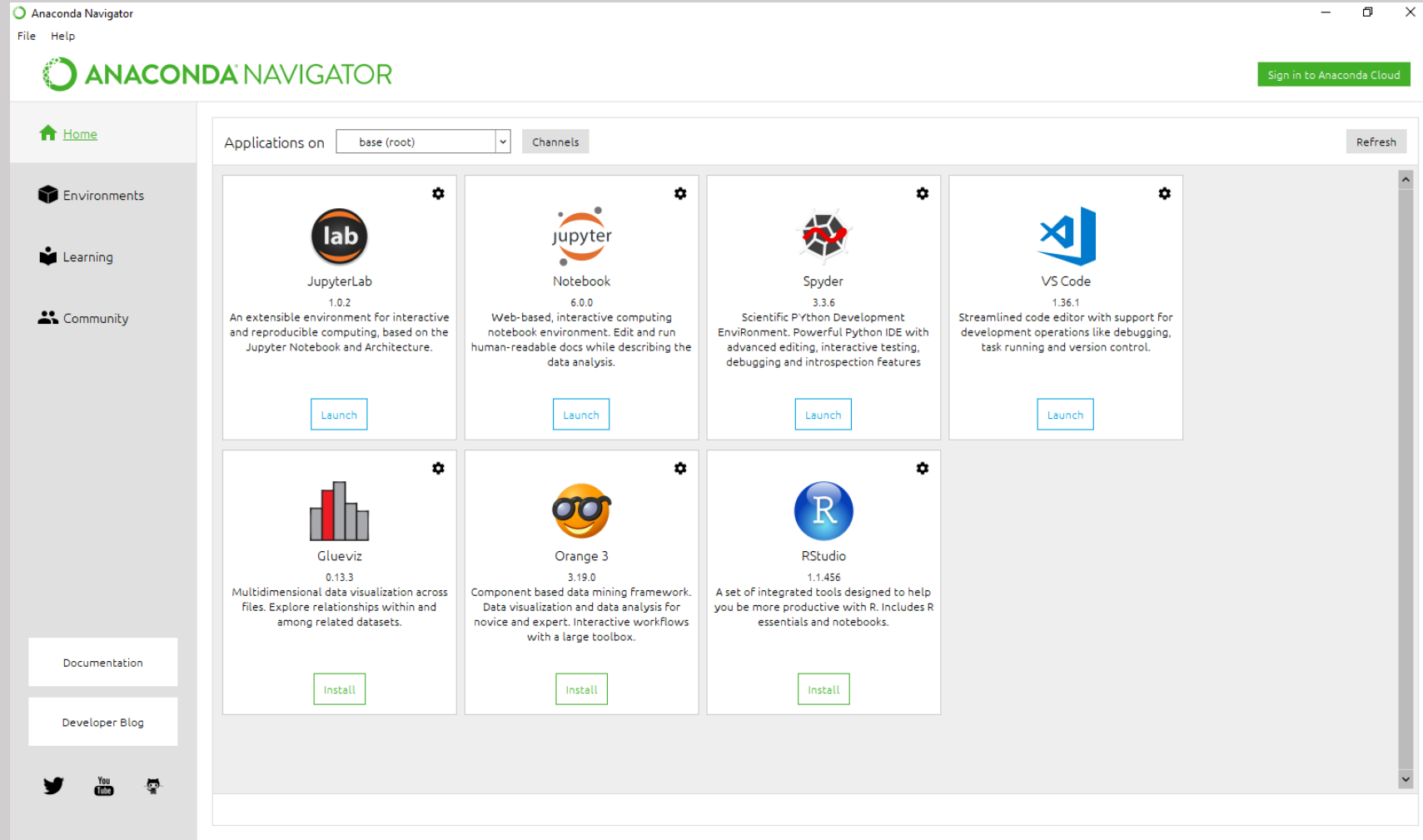
32-Bit Graphical Installer (361 MB)



**Anaconda Platform:**

<https://www.anaconda.com/distribution>

# Setup Anaconda







**git**

Search entire site...

**About**  
**Documentation**  
**Downloads**  
GUI Clients  
Logos  
**Community**

The entire **Pro Git book** written by Scott Chacon and Ben Straub is available to [read online for free](#). Dead tree versions are available on [Amazon.com](#).

## Downloads

Mac OS X Windows Linux/Unix

Older releases are available and the [Git source repository](#) is on GitHub.

Latest source Release  
**2.23.0**  
[Release Notes \(2019-08-16\)](#)  
[Download Source Code](#)

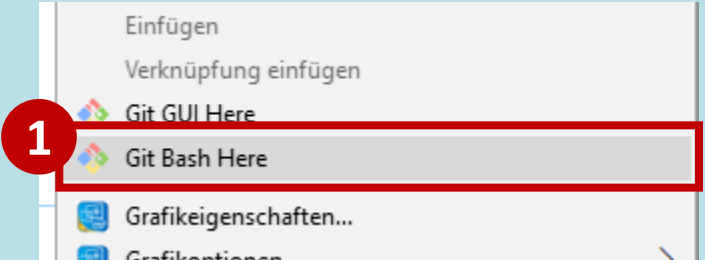
**GUI Clients**  
Git comes with built-in GUI tools ([git-gui](#), ...)

**Logos**  
Various Git logos in ...

**Git:**  
<https://git-scm.com/downloads>

# Setup GIT - Download the Course Material

## Console

- Register @git
- Make a new folder and make a right-click, choose "Git Bash Here"  

- Run the following lines of code in your Git Bash to setup your repository

```
git init
git config --global user.name "YOUR NAME"
git config --global user.email "YOUR EMAIL"
git clone "https://github.com/dominikjung42/AIAlgorithmsAndApplications.git"
```

- During the course, run the following lines of code to update your repository


```
git pull origin master
```



No reason to panic! If you have trouble contact me, I will help you to setup your repository!

# Or Download the Course Materials Manually

## Console

	dominikjung42 updated syllabus for WT2020	c3d2300 5 days ago	🕒 60 commits
📁	Capstone project	added report LATEX template	5 months ago
📁	Code	added sample data files for lecture 3	20 days ago
📁	Exams	added old exam for exercise	5 days ago
📁	Guest lectures	Updated lecture syllabus	8 months ago
1 📁	Lecture	updated syllabus for WT2020	5 days ago

- Open the Git repository and select the folder with the files you are interested in

2  [0 - Syllabus \(TU Darmstadt 11-2020\).pdf](#)

0 - Syllabus (TU Darmstadt 11-2020).pdf


- Click on the file you want to download



master AIAgorithmsAndApplications / Lecture / 0 - Syllabus (TU Darmstadt 11-2020).pdf Go to file

dominikjung42 updated syllabus for WT2020 Latest commit c3d2300 5 days ago History

1 contributor

2.86 MB

Click on "Download" 3 

  TECHNISCHE UNIVERSITÄT DARMSTADT  
WIRTSCHAFTS



# Teaching Material Icons



Important note



Definition



Referenced package/library



Referenced handout



Information about self-studying or other lectures (not explicitly exam relevant if not said otherwise)



Classroom question or task



Problem / Solution



Pro / Contra



Weblink or external resource

# Types of Tasks and Exercises

## Classroom Task



**Classroom task**

**Your turn!**

**Task** Please use the `str()` function to investigate the `cars` dataset. How many rows and columns does it have. Use the `isnull()` function, if you are not sure how to use the commands.

**Task** Please, try to retrieve the following values from the `cars` dataset:

- Return observations where the speed is bigger than 20
- Exclude observations 10-13 from the dataset
- Return only observations with speed bigger than 10 and smaller than 20

Decision Support Systems and Business Analytics  
with R by Dominik Jung

- Short tasks, workload should be about 5 minutes
- Solved during lecture
- Use it for exam preparation

## Classroom Case



**Business Case**

**Task** The *Junglvet* Whisky Company is interested in the geographical and spatial distribution of the Whisky market in Scotland. They plan to put the new 10 years Junglvet on the market. He is very body and smoky. For that purpose cluster the whiskies and find the most body and smoky group of whiskies. And plot them with ggplot on a map of Scotland to support the marketing and sales team. Try to structure your work according to the process model from the lecture. Before you build the cluster, try to understand the data. Please take a look if it is true that the most smoky and body Whisky distilleries are from Islay. Use the `whiskies.csv` file for your analysis.

Decision Support Systems and Business Analytics  
with R by Dominik Jung

- Simplified, real-world business-problems and cases
- Workload between 30-60 minutes
- Read and Discuss
- Use it to deepen your applied skills

## Challenge / Capstone



**Case Challenge**

**Case** The sinking of the RMS Titanic is one of the most infamous shipwrecks in history. On April 15, 1912, during her maiden voyage, the Titanic sank after colliding with an iceberg, killing 1502 out of 2224 passengers and crew. This sensational tragedy shocked the international community and led to better safety regulations for ships. One of the reasons that the shipwreck led to such loss of life was that there were not enough lifeboats for the passengers and crew. Although there was some element of luck involved in surviving the sinking, some groups of people were more likely to survive than others, such as women, children, and the upper-class. In this challenge, we ask you to complete the analysis of what sorts of people were likely to survive. In particular, we ask you to apply the tools of machine learning to predict which passengers survived the tragedy.

Spruce Cartoons

- General task with a wide focus on the different topics of the course
- Workload to pass the challenge is about 6-8 hours, and about 2-4 weeks fulltime for the capstone

## Business Case



**Business Case: Sentinel Program**

**01 Executive Summary**  
Virtual Case File for 1071 with a software application developed by the FBI between 2000 and 2005. The project was not close to completion when it was officially abandoned in January 2005, having turned into a complete mess for the FBI. In addition to wasting at least \$100 million, the Sentinel Program experienced numerous problems for the Bureau and its clients. Robert J. Mueller Jr. finally, \$100 million dollars were wasted on the first two attempts of the project (SIP + Sentinel) and a similar was found.

**02 Solution**  
• Sentinel Team was set up near the product owner in the basement of the Hoover Building  
• Staff reduced from 400 to 45, and in 1 year and 200 million, they were code complete. At a cost savings of more than 90 percent.

**03 Takeaways**  
• All project management gets things done  
• Agile development is cheaper

**04 Introduction**  
Who Killed the Virtual Case File?  
https://www.sprucecartoons.com/compelling/virtual-case-file

- Typical business case
- Discussed together

# Capstone Challenge @ Porsche AG (2022)



# Closed Book and Closed Notes Exam (preliminary!)\*

33 %

## BASIC CONCEPTS AND THEORETICAL BACKGROUND

- You will have to answer multiple questions related to basic concepts of the lecture or give basic definitions or formulas.
- Aka “knowledge questions”.

33 %

## APPLYING THEORY TO PRACTICE

- You will have to show that you understand the algorithms and concepts and that you can use them to solve a (business/real-life) problem.
- For this kind of task you might need your calculator or geometrical triangle, pen and eraser.

34 %

## PROGRAMMING

- You will have to write, read and understand code examples in the context of artificial intelligence problems (search, machine learning, etc.).
- Use the exercises, lectorials and the code examples to prepare!

*\*Note: It may be possible that the point distribution differs in the final exam*

# Which Content is Relevant for the Exam?

## Outline

### 2 Artificial Intelligence and Information Systems

#### 2.1 Artificial Intelligence Project Management

#### 2.2 Artificial Intelligence Project Lifecycle

#### 2.3 Skills and Roles in Artificial Intelligence Projects

#### 2.4 Types of Artificial Intelligence based Information Systems

##### ► What we will learn:

- How typical AI projects are implemented, and how their life cycle and phases look like
- What skills are needed to implement an AI project
- Why the industry needs AI specialists, and how typical AI jobs look like
- Which types of AI based information systems exist and how they can be used to solve real-world problems



Image source: Pixabay (2019) / CC0

##### ► Duration:

- 120 min

##### ► Relevant for Exam:

- 2.1-2.4

Artificial Intelligence: Building AI-Based Information Systems with Python - Dr. Dominik Jung

*Note: There might still be questions where you might need a basic understanding of the content of the excluded chapters*

## Always exam relevant

- **Lecture slides, lectorials and exercises** (*except excluded chapters on the overview*)
- **Referenced chapters of the course books and all literature downloads** available in GIT (*look at the folder "literature"*)
- The **handouts** for the business cases and the **discussion results**
- **Every teaching material** accompanying this lecture (**code examples**, guest lectures etc.)





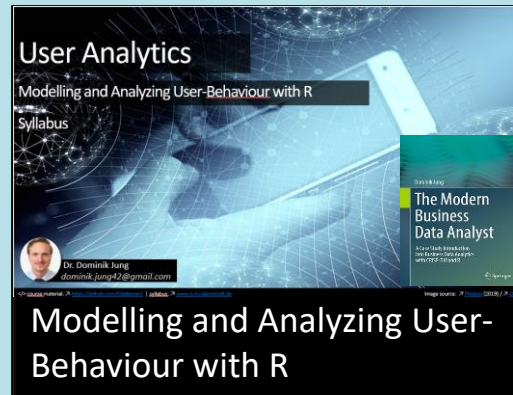
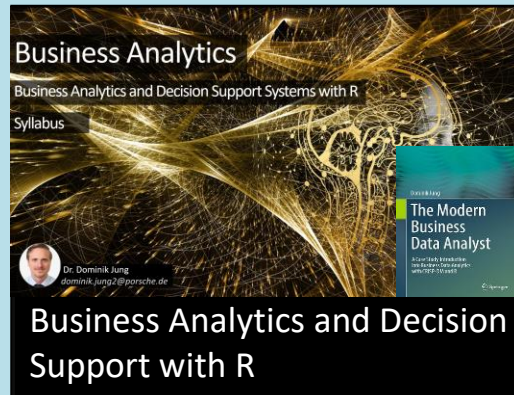
## Grading (preliminary)

Contact	Description	Distribution
<b>Exam</b> <i>Dr. Dominik Jung</i>	There will be a 90 minutes closed-book/closed-notes exam consisting of short-answer, and analytical questions covering all course material! One third will be general questions, one third related to tools, and the last third will be an overarching case.	60 %
<b>Capstone Project</b> <i>Dr. Timo Sturm + Capstone Partners</i>	Each participant is expected to join a team of about 4 students to analyze and work on a capstone project. Results should be delivered in a document. Further information will be presented at the capstone introduction.	40 %

- Both elements need to be passed (grade 4.0 or better): Failing (i.e., grade 5.0) the (1) Exam, or the (2) Case Study, or (3) the Exam and the Case Study, results in failing the entire course.
- There is no retake possibility for the Capstone project. Thus, if you fail the Capstone project, you need to retake the course next year!

# Related Courses

## Data Science Lectures



## Data Science Seminars



Check out my git repository for the course material and more information!

## Main literature

1. Rusell, S., & Norvig, P. (2016). *Artificial Intelligence: A Modern Approach*. Global Edition
2. Géron, A. (2017). *Hands-on machine learning with Scikit-Learn and TensorFlow: concepts, tools, and techniques to build intelligent systems*.
3. Castillo, E., Gutierrez, J. M., & Hadi, A. S. (2012). *Expert systems and probabilistic network models*. Springer Science & Business Media.

## Further reading

- I strongly recommend to take a look at the free available online version of the *Pro Git book*, written by Scott Chacon and Ben Straub and published by Apress, it is available online as pdf, epub and mobi (↗ [git-scm.com](https://git-scm.com)).
- *Rogerdudler Git Tutorial* (↗ <https://rogerdudler.github.io/git-guide>) gives an excellent introduction for getting started with git.
- I also can recommend to take a look at the GIT guide from *kbroman* (↗ [kbroman.org](http://kbroman.org)).