Frankfurt School of Finance & Management
German Excellence. Global Relevance.

Master in Applied Data Science Course Selection*

Due to scheduling constraints, **you cannot combine MADS core courses with MADS concentration courses within a same quarter**.

Core Courses

Quarter 1	Quarter 2
Quantitative Fundamentals	Computational Statistics & Probability*
Algorithms & Data Structures	
Intro to Data Analytics in Business	

**module description not available yet*

Quarter Schedules for core courses:

Quarter 1:	Academic period:	30 August – 16 October 2021
	Exam Week:	18 October – 23 October 2021
Quarter 2:	Academic period:	25 October – 11 December 2021
	Exam Week:	13 December – 18 December 2021

Concentration Courses

Quarter 1	Quarter 2
Text Mining & Natural Language Processing	AI - The New Frontier
Deep Learning	

Quarter Schedules for concentration courses:

Quarter 1:	Academic period:	30 August – 23 October 2021
	Exam Week:	25 October – 30 October 2021
Quarter 2:	Academic period:	01 November – 11 December 2021
	Exam Week:	13 December – 18 December 2021

**Current as of May 2021. This module catalogue is subject to change.*

Quantitative Fundamentals [QUM71112]

Modulkoordinator		Nagler, Jan					
Studiengang		Master in Applied Data Science					
Studienabschnitt		1st Semester Q1					
Moduldauer		1 Semester					
Pflicht-/Wahlpflichtmodul		Pflicht					
Credits:		6					
Häufigkeit des Angebots		Jährlich					
Sprache		Englisch					
Workload:	150 h	Präsenz-unterricht:	37 Acade	Vorlesungs-vorbereitung:	90 h	Prüfungs-vorbereitung:	32 h
Voraussetzungen für die Teilnahme		Mathematics on high-school level, in particular algebra and analysis.Very basic knowledge in Python including NumPy, available, e. g., at Github, http://cs231n.github.io/python-numpy-tutorial/					

Kurzbeschreibung / Lerninhalte	**Part 1: Linear Algebra** 1. Scalars, Vectors, Matrices, and Tensors 2. Matrix and Vector Multiplication 3. Identity and Inverse Matrices 4. Linear Dependence and Span 5. Norms • Measuring the size of a vector with Lp • The Euclidean norm (L2) • The max norm (L1) • Frobenius norm 1. Special kinds of matrices • Diagonal • Symmetric • Unit vector & unit norm • Orthogonal vectors and orthogonal matrices 1. Eigendecomposition 2. Singular Value Decomposition 3. The Moore-Penrose Pseudoinverse 4. The Trace Operator and Determinant **Part 2: Useful functions, Iterated maps and Convergence Problems** 1. Sigmoid function 2. Softplus 3. Derivatives 4. Simple maps 5. Chaotic maps 6. Convergence Problems **Part 3: Probability** 1. Introduction to Probability • Discrete varibales and probability mass functions • Continuous cariables and probability density functions • Marginal and conditional probability • Chain rule • Independence and conditional Independence • Bayes rule • Expectation, Variance and Covariance • Transformation of random variables 1. Common Probability Distributions • Bernoulli distribution • "Multinoulli" distributions • Gaussian distribution • Exponential and Laplace • Dirac distribution and cumulative distributions 1. Bayesian networks 2. Self-information & Entropy

<table>
<tr><td>Qualifikationsziele / Lernergebnisse</td><td>

can use matrices to formulate problems,
can use matrix algebra to determine solubility within a given problem formulation,
can use matrix algebra to solve problems,
can use norms to formulate and measure distances in datasets,
can identify parameters to quantification of numerical convergence
can formulate and modify convergence criteria and overcome computational convergence difficulties
can identify distributions that properly describe a given probabilistic problem
can formulate and solve problems formulated in sets of conditional probabilities
can identify and formulate conditionally dependences and independences to reduce problem complexity
can solve problems with correlated stochastic variables and data
can formulate and solve causal models

</td></tr>
<tr><td>Lernformen, Methodik und Betreuung</td><td>The course will consist in theoretical lectures, where theory and theoretcial insights are covered. In addition, there will be tutorials and Python exercises, where students will begin work on that week`s programming assignment, which will completed outside of class.
The Professor will be available to help students.</td></tr>
<tr><td>Art der Prüfungsleistungen im Modul und Akkumulationspunkte</td><td>
<table>
<tr><td>Type of Assessment</td><td>Duration</td><td>Performance Points</td><td>Due Date or Date of Exam</td></tr>
<tr><td>Written exam</td><td>120 minutes</td><td>120</td><td>Exam Week</td></tr>
</table>
</td></tr>
<tr><td>Literaturhinweise</td><td>

Gentle, J.E. (2017). Matrix Algebra: Theory, Computations, and Applications in Statistics, 2nd. Ed. Springer.
Savov, I. (2017). No Bullshit Guide to Linear Algebra. 2nd Ed. Minireference Co.
Murphy, K. P. (2012). Machine Learning: A Probabilistic Perspective, MIT Press.
Cover, T. M and Thomas, J. A. (2006). Elements of Information Theory, 2nd Edition. Wiley.

</td></tr>
</table>

Modulstruktur	**Session Topic Preparation** 1 Scalars, Vectors, Matrices, Tensors, Matrix and Vector Multiplication 2 Identity and Inverse Matrices, Linear Dependence and Span 3 Norms 4 Special kinds of matrices 5 Eigendecomposition, Singular Value Decomposition 6 The Moore-Penrose Pseudoinverse, The Trace Operator and Determinant 7 Useful functions 8 Iterated maps and Convergence Problems 9 Introduction to Probability: Discrete variables and probability mass functions, Continuous variables and probability density functions, Marginal and conditional probability, Chain rule, Independence and Conditional Independence, Bayes rules, Expectation, Variance and Covariance 10 Common Probability Distributions 11 Bayesian networks Self-Information & Entropy
Verwendbarkeit für andere Module und Programme	Machine Learning 1, Machine Learning 2, Thesis
Letztes Freigabedatum	06.09.2019

Algorithms & Data Structures [QUM71122]

Modulkoordinator		Andonians Salmas, Vahe					
Studiengang		Master in Applied Data Science					
Studienabschnitt		1st semester Q1					
Moduldauer		1 Semester					
Pflicht-/Wahlpflichtmodul		Pflicht					
Credits:		6					
Häufigkeit des Angebots		Jährlich					
Sprache		Englisch					
Workload:	150 h	Präsenz-unterricht:	37 Acade	Vorlesungs-vorbereitung:	90 h	Prüfungs-vorbereitung:	32 h
Voraussetzungen für die Teilnahme		Students need a laptop with Python 3 installed.					

Kurzbeschreibung / Lerninhalte	• ***Introduction to algorithms***
	• ***Introduction to Python***
	  • *Expressions*
	  • *Variables*
	  • *Conditions*
	  • *Iterations*
	• ***Functions, scoping, and abstraction in Python***
	  • *Functions and scoping*
	  • *Global Variables*
	  • *Files*
	  • *Modules*
	• ***Analyzing algorithms***
	• ***Introduction to git***
	• ***Sorting***
	  • *Merge Sort*
	  • *Quicksort*
	• ***Object oriented programming***
	• ***Elementary data structures***
	  • *Stacks and queues*
	  • *Linked lists*
	  • *Hash tables*
	  • *Binary search trees*
	• ***Structured types in Python***
	  • *Tuples*
	  • *Dictionaries*
	  • *Classes*
	  • *Functions as objects*
	• ***Introduction to NumPy***
	• ***Introduction to Pandas***

Qualifikationsziele / Lernergebnisse	Knowledge: By the time students finish the module, they can • define algorithms and data structures • recognize algorithms and data structures • explain algorithms and data structures • which build the foundation of software engineering Skills: • Students practice the programming language Python • Students design basic computational algorithms as narrative • Students analyze basic computational algorithms as narrative • Students implement basic computational algorithms in Python Competence: On successful completion of this module, students can • demonstrate theory and practice of software engineering • apply theory and practice of software engineering • illustrate theory and practice of software engineering • solve an unknown problem theoretically using algorithms

<table>
<tr><td>Lernformen, Methodik und Betreuung</td><td>Theory is explained during class and broadcasted using Zoom, students will apply this during class in individual and group assignments</td></tr>
<tr><td>Art der Prüfungsleistungen im Modul und Akkumulationspunkte</td><td>
<table>
<tr><td>Type of Assessment</td><td>Duration</td><td>Performance Points</td><td>Due Date or Date of Exam</td></tr>
<tr><td>Individual assignments</td><td>one week each</td><td>50</td><td>10.09.2020/20. 09.2020/08. 11.2020</td></tr>
<tr><td>Group assignments</td><td>one week each</td><td>20</td><td>20.09.2020/27. 09.2020</td></tr>
<tr><td>Final exam</td><td>50 minutes</td><td>50</td><td>During exam week</td></tr>
</table>

In order to fully assess the students competences in understanding and applying algorithms and data structures in both theory and practice, three types of assessment are needed.

The assessment gradually build upon each other which negates the overlap in submission.
One of the four individual assignments consists of two parts.</td></tr>
<tr><td>Literaturhinweise</td><td>Students will be provided.</td></tr>
<tr><td>Modulstruktur</td><td>Session Topic Preparation
1 Introduction to algorithms
2 Introduction to Python
3 Functions, scoping, and abstraction in Python;
4 Analyzing algorithms;
sorting algorithms
5 Introduction to git;
sorting algorithms
6 Object Oriented Programming
7 Object Oriented Programming
8 Elementary data structures
9 Elementary data structures
10 Structured data types in Python
11 Introduction to NumPy and Pandas</td></tr>
<tr><td>Verwendbarkeit für andere Module und Programme</td><td>This introductory course to Software Engineering using Python builds the foundation for all other courses using programming.</td></tr>
<tr><td>Letztes Freigabedatum</td><td>06.09.2019</td></tr>
</table>

Introduction to Data Analytics in Business
[INF71112]

Modulkoordinator		Roßbach, Peter					
Studiengang		Master in Applied Data Science					
Studienabschnitt		1st semester Q1					
Moduldauer		1 Semester					
Pflicht-/Wahlpflichtmodul		Pflicht					
Credits:		6					
Häufigkeit des Angebots		Jährlich					
Sprache		Englisch					
Workload:	150 h	Präsenz-unterricht:	37 Acade	Vorlesungs-vorbereitung:	90 h	Prüfungs-vorbereitung:	32 h
Voraussetzungen für die Teilnahme		Knowledge in Probability Theory and Statistics; Knowledge in Python including NumPy and Pandas					
Kurzbeschreibung / Lerninhalte		Data Analytics (or Data Science) is an emerging field in industry and academics. It covers methodologies, algorithms, and processes to tackle the challenges in times of big data, where we are confronted with large amounts of high-dimensional data of different types. While the classical statistical approach has some weaknesses in this context, new ways and methods of data analysis have been established under the term machine learning. Today, they are widely used in science and practice benefitting from calculation power of modern computer technologies. This course provides an introduction into the field of Data Analytics, covering computational techniques and algorithms for finding and analyzing patterns even in large-scale datasets. Topics to be covered include data preparation, integration, analysis, visualization, segmentation, classification, prediction and decision making. Students will implement and apply the methods using the programming language Python and the related libraries.					

<table>
<tr><td>Qualifikationsziele / Lernergebnisse</td><td>

Knowledge:
Students will acquire a comprehensive understanding of the challenges of data analysis in times of big data and learn how to apply modern methods of data analytics to different application areas, i.e. they can:
- Explain the specifics of data analysis in the case of big data
- Explain the differences between statistics and machine learning
- *Apply modern methods of data analytics to different application areas*

Skills:
Students learn to analyze data, choose the appropriate modeling techniques and to construct models for decision support. They also learn how to implement the data analytics processes using Python as a modern analytical language. They are able to:
- Choose the appropriate methods according to the problem to solve
- Develop the analytics processes via different data analytics tools
- Train and tune the models to achieve the optimal results
- *Analyze the resulting models to find the best solution*

Competence:
Students are qualified to find and analyze patterns in data and to transform the gained knowledge into managerial decisions. They acquire a fundamental background to fulfill the demands of a modern data scientist. They are able to:

- Understand the underlying business problems
- Identify the problem relevant data
- Build quantitative models to solve the problem choosing from a variety of methods
- Transform the models results into managerial decisions

</td></tr>
<tr><td>Lernformen, Methodik und Betreuung</td><td>Lecture with in-class and home exercises using Python and Scikit-learn.</td></tr>
<tr><td>Art der Prüfungsleistungen im Modul und Akkumulationspunkte</td><td>

<table>
<tr><th>Type of Assessment</th><th>Duration</th><th>Performance Points</th><th>Due Dte or Date of Exam</th></tr>
<tr><td>Group Project at the end of the course including written paper and presentation</td><td>40min presentation & 40 pages paper</td><td>120</td><td>During exam week</td></tr>
</table>

</td></tr>
</table>

Literaturhinweise	General Introduction: • Alpaydin, E. (2016): Machine Learning: The New AI, MIT Press Essential Knowledge • Schutt, R.; O'Neil, C. (2013): Doing Data Science, O'Reilly Media Methods and Algorithms: • Alpaydin, E. (2016): Introduction to Machine Learning, Third Edition, MIT Press • Hastie, T.; Tibshirani, R.; Friedman, J. (2009): The Elements of Statistical Learning, Second Edition, Springer Implementation: • Aurélien Géron (2017): Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems, O'Reilly • Raschka, Sebastian (2015): Python Machine Learning, Packt Publishing
Modulstruktur	1. Data Analytics 1.1 What is Data Science? 1.2 Statistics and Machine Learning 1.3 Data Preparation 1.4 Exploratory Data Analysis 2. Methods, Algorithms, and Applications 2.1 Classification 2.2 Regression 2.3 Interpretable Machine Learning 2.4 Segmentation
Verwendbarkeit für andere Module und Programme	All quantitative modules in the following semesters. Thesis.
Letztes Freigabedatum	06.09.2019

Deep Learning [MGT75019]

Modulkoordinator		Ellsaesser, Florian					
Studiengang		MSc MADS					
Studienabschnitt		3rd semester Q1					
Moduldauer		1 Semester					
Pflicht-/Wahlpflichtmodul		Pflicht					
Credits:		6					
Häufigkeit des Angebots		Jährlich					
Sprache		Englisch					
Workload:	150 h	Präsenz-unterricht:	37 Acade	Vorlesungs-vorbereitung:	122 h	Prüfungs-vorbereitung:	-
Voraussetzungen für die Teilnahme		Machine Learning I and II					
Kurzbeschreibung / Lerninhalt		This module covers deep neural networks, which are currently the “workhorse” of machine learning and most commonly used method. We start with a quick recap of simple neural networks, which were only of limited success in their applications and then move on to introduce the theory of deep neural networks and why, in contrast, they have been so successful. Our main purpose will be to understand the theoretical background necessary to employ deep neural networks to solve problems of image recognition and language processing. Particularly, we focus on different theoretical concepts behind deep neural networks that are essential for building successful applications. This includes the working and effect of stochastic gradient decent and mini batch, activation functions, such as ReLu (rectifier linear unit), drop out and regularization, as well as different architectures (Convolutional Neural Networks as well as Long Short Term Memory neural networks). The module has a practical focus, taking theory and then applying it immediately in each class. After an initial introduction, participants will be asked to form teams to solve a practical machine learning problem using deep learning methods.					

<table>
<tr><td>Qualifikationsziele / Lernergebnisse</td><td>At the end of the module students should be able to:
List the most important deep learning approaches
Recognize modern deep neural network machine learning methods
Explain modern deep neural network machine learning methods
Apply deep neural networks to a number of practical problems using appropriate algorithmic structures and optimization
Analyze optimization metrics for a solution they have defined in order to distinguish whether neural network learning proceeded correctly
Evaluate which of a series of models performs best
Evaluate why this is so, particularly why increasing model complexity should (or should not) add predictive accuracy</td></tr>
<tr><td>Lernformen, Methodik und Betreuung</td><td>Most of the content that we are going to use will be in Jupyter notebooks. For each class, you will have to complete a small programming assignment in the Jupyter notebook.</td></tr>
<tr><td>Art der Prüfungsleistungen im Modul und Akkumulationspunkte</td><td><table>
<tr><td>Type of examination</td><td>Duration or length</td><td>Performance Points</td><td>Due date or date of exam</td></tr>
<tr><td>Final assignment</td><td>6 weeks</td><td>60</td><td>08.11.2020</td></tr>
<tr><td>Continuous assignments</td><td>2 weeks</td><td>60</td><td>19.10.20/20.10.20/21.10.20/23.10.20/24.10.20</td></tr>
</table>
In order to fully assess the students competences in both theory and practice, more than one type of assessment is needed.</td></tr>
<tr><td>Literaturhinweise1</td><td>There is no set text-book, but students are expected to read the recommended papers and texts for every class in advance of the class.</td></tr>
</table>

Modulstruktur	**Session Topic** **Recap of neural network basics** - Perceptron model, perceptron update rule - XOR Problem - Basic feed forward neural networks - Regularising neural networks - Hyperparameter optimisation methods **Problem of generalization** -Bias-Variance trade-off - Overfitting - Regularisation methods **Training setup for neural networks** - Introduction to TensorFlow - Getting data into TensorFlow - TensorFlow Core and train APIs - Debugging and visualisation, - Tensor Board - Keras **Current neural architectures and their application** - Problem domains, datasets and baselines - Convolutional neural networks and recurrent neural networks **Memory networks - Motivation** - Extension of temporal architectures - Neural Turing Machine **Unsupervised learning with neural models** **Transfer learning** - Practical need for transfer - Methods and catastrophic forgetting **Deploying deep neural networks** - Learning models - Project design principles - Architecture concerns - Validation,Performance **Practical application case study**
Verwendbarkeit für andere Module und Programme	Frontiers of AI; Master's Thesis
Letztes Freigabedatum	11.03.2021

Text Mining & NLP [INF73370]

Modulkoordinator		Ellsaesser, Florian					
Studiengang		Master in Applied Data Science					
Studienabschnitt		3rd semester Q2					
Moduldauer		1 Semester					
Pflicht-/Wahlpflichtmodul		Pflicht					
Credits:		6					
Häufigkeit des Angebots		Jährlich					
Sprache		Englisch					
Workload:	150 h	Präsenz-unterricht:	44 h	Vorlesungs-vorbereitung:	106 h	Prüfungs-vorbereitung:	-
Voraussetzungen für die Teilnahme		Introduction to Machine Learning I and II and Deep Learning					
Kurzbeschreibung / Lerninhalte		This module is focused on applying machine learning techniques to gain language understanding. Natural language processing is one of the main sub-fields of machine learning and has driven major algorithmic break-throughs in recent years. Language is a form of time series so break throughs in natuarl language processing such as LSTM networks have been closely connected to advances in machine learning in general. The module is thus taking a twofold approach. On the one hand we will introduce general machine learning techniques that can deal with time series and show how they can effectively applied to give computers language understanding. On the other hand, we will combine these techniques with domain specific applications such as word embedding, semantic distance and dependency tree parsing. The module takes a practical approach combining theory with practice, so roughly 50% of the module will be theory and 50% will be practice.					

<table>
<tr><td>Qualifikationsziele / Lernergebnisse</td><td>After completion of this class students should be able to:
Recognize the latest machine learning techniques to gain language understanding through computational techniques.
Translate the knowledge gained on NLP algorithms to novel language processing problems.
Apply natural language processing techniques to business problems to better understand the sentiment of customers, their needs and how they may be persuaded.
Analyze the most advanced machine learning techniques such as LSTM networks in a domain specific context, in our case natural language processing.
Evaluate which model is most appropriate for a problem, based on accuracy and convergence metrics of the optimization.</td></tr>
<tr><td>Lernformen, Methodik und Betreuung</td><td>Most of the content that we are going to use will be in Jupyter notebooks. For each class, you will have complete a small programming assignment in the Jupyter notebook.</td></tr>
<tr><td>Art der Prüfungsleistungen im Modul und Akkumulationspunkte</td><td><table><tr><td>Type of examination</td><td>Duration or length</td><td>Performance Points</td><td>Due date or date of exam</td></tr><tr><td>Individual assignments</td><td>6 weeks</td><td>60</td><td>04.12.2020</td></tr><tr><td>Continuous assignments</td><td>2 weeks</td><td>60</td><td>19.11.20/27. 11.20/28.11.20/ 03.12.20</td></tr></table>
In order to fully assess the students competences in both theory and practice, more than one type of assessment is needed.</td></tr>
<tr><td>Literaturhinweise</td><td>There is no set text-book, but students are expected to read the recommended papers and texts for every class in advance of the class.</td></tr>
<tr><td>Modulstruktur</td><td>Session Topic Preparation
1 Introduction Read lecture material
2 Part of Speech Tagging, Dependency Parsing Read lecture material
3 Semantics I Read lecture material
4 Semantics II Read lecture material
5 Sequence to Sequence Modelling Read lecture material</td></tr>
<tr><td>Verwendbarkeit für andere Module und Programme</td><td>Frontires of AI Thesis</td></tr>
<tr><td>Letztes Freigabedatum</td><td>08.03.2021</td></tr>
</table>

AI - The New Frontier [INF73450]

Modulkoordinator		Ellsaesser, Florian					
Studiengang		Master in Applied Data Science					
Studienabschnitt		3rd semester Q2					
Moduldauer		1 Semester					
Pflicht-/Wahlpflichtmodul		Pflicht					
Credits:		6					
Häufigkeit des Angebots		Jährlich					
Sprache		Englisch					
Workload:	150 h	Präsenz-unterricht:	37 Acade	Vorlesungs-vorbereitung:	122 h	Prüfungs-vorbereitung:	-
Voraussetzungen für die Teilnahme		Deep Learning					
Kurzbeschreibung / Lerninhalte		The course is a course in advanced and current topics in AI. Each year we will focus on 2-3 topics that are at the frontier of AI research and industrial application. The current content of the course is: • Causal Inference • General Adversarial Neural Networks • Deep Reinforcement Learning					
Qualifikationsziele / Lernergebnisse		Upon completion, the student will be able to • List the main challenges in machine learning for Causal Inference, General Adversarial Neural Networks and Deep Reinforcement Learning. • Identify the current scientific and technical literature in deep learning. • Discuss the current scientific and technical literature in deep learning. • Interpret research and the main findings of papers. • Debate research and the main findings of papers. • Chose an appropriate modelling structure for a novel problem based on the latest scientific literature. • Present research findings and their implications for a data-science project to others.					
Lernformen, Methodik und Betreuung1		Seminar & Lecture style.					

<table>
<tr><td>Art der Prüfungsleistungen im Modul und Akkumulationspunkte</td><td>
<table>
<tr><td>Type of Assessment</td><td>Duration</td><td>Performance Points</td><td>Due Date or Date of Exam</td></tr>
<tr><td>Final assignment</td><td>6 weeks</td><td>60</td><td>20.01.2021</td></tr>
<tr><td>Continuous assignments</td><td>2 weeks</td><td>60</td><td>05.12.20/17.12.20/18.12.20/17.02.21/19.01.21</td></tr>
</table>
In order to fully assess the students competences in both theory and practice, more than one type of assessment is needed.
</td></tr>
<tr><td>Literaturhinweise</td><td>Literature is provided within the course.</td></tr>
<tr><td>Modulstruktur</td><td>Day 1: Causal Inference
Day 2: GAN- General Adversarial Networks
Day 3: Reinforcement learning
Day 4: Deep Reinforcement Learning
Day 5: Deep Reinforcement Learning</td></tr>
<tr><td>Verwendbarkeit für andere Module und Programme</td><td>Thesis</td></tr>
<tr><td>Letztes Freigabedatum</td><td>04.03.2020</td></tr>
</table>