TECHNISCHE UNIVERSITÄT DARMSTADT

Explanation:

Below you will find a tabular overview of the topics for the entrance exam for the study programs M.Sc. Artificial Intelligence and Machine Learning and M.Sc. Computer Science for the admission to the winter term 2023/24 as well as book recommendations for the preparation for the same.

Topic of the entrance exam	**Short overview of the content**	**Book recommendations**
Algorithms and Data Structures	• Data structures: array, list, binary search tree, B-tree, graph representation, hash table, heaps • Algorithms: sorting algorithms, string matching, graph traversal, insertion, search, and deletion for data structures, shortest path search, minimal spanning trees • Asymptotic complexity: run times, Big O notation, complexity classes P and NP, NP completeness • Algorithmic strategies. for example: Divide-and-Conquer, dynamic programming, brute-force, greedy, backtracking, meta heuristics	Introduction to Algorithms (3rd ed.); Cormen, Leiserson, Rivest, Stein; MIT Press
Parallel Programming	• Foundations of parallel systems • Parallel architectures • Programming models for parallel computing • Parallel algorithms • Significant practical programming exercises covering the above topics • If necessary introduction to base programming languages	Using MPI William Gropp, Ewing Lusk, Anthony Skjellum, 3rd edition, MIT Press Parallel Programming in OpenMP R. Chandra, L. Dagum, D. Kohr, D. Maydan, J. McDonald, R. Meno, Morgan Kaufmann Programming Massively Parallel Processors David B. Kirk, Wen-mei W. Hwu, 2nd edition, Morgan Kaufmann
Introduction to Compiler Construction	• Structure of compilers • Context-free grammars for the description of language syntax • Lexing and parsing techniques • Intermediate representations • Semantic analysis	Programming Language Processors in Java; Watt/Brown

	• Run-time organisation • Code generation • Software tools for compiler constructions • Implementation techniques for compilers	
Automata, Formal Languages and Decidability	• Introduction: transition systems, words, languages • Basic mathematical methods and proof patterns • Finite automata and regular languages, determinism and nondeterminism, closure properties and automata constructions, Kleene Theorem, Myhill-Nerode Theorem, pumping lemma • Grammars and the Chomsky hierarchy, context-free languages, pumping lemma, CYK algorithm; • Models of computation: PDA and Turing machines • Decidability and recursive enumerability in the Chomsky hierarchy	Introduction to Automata Theory, Languages, and Computation (3rd ed.); Hopcroft, John E.; Motwani, Rajeev; Ullman, Jeffrey D. (2013); Pearson.
Computer Security	Part I: Cryptography • Background in mathematics for cryptography • Security objectives: Confidentiality, Integrity, Authenticity • Symmetric and asymmetric cryptography • Hash functions and digital signatures • Protocols for key distribution Part II: IT-Security and Dependability • Basic concepts of IT security • Authentication • Access control models and mechanisms • Basic concepts of network security	M. Bishop, Computer Security: Art and Science, Addison Wesley, 2018 P.C.van Oorschot: Computer Security and the Internet, Springer, 2021 J. Katz, Y. Lindell: Introduction to Modern Cryptography, Chapman & Hall, 2020

	• Basic concepts of software security • Basic concepts of web security • Dependable systems: error tolerance, redundancy, availability	

Software Engineering	• Requirements Analysis
	• Domain Modelling
	• Object-oriented Analysis and Design
	• Software Architecture
	• Software Quality, in particular:
	  ○ Verification (among others, testing and static analysis)
	  ○ Software Metrics
	• Design Patterns
	• Refactoring
	• Software Evolution and Software Variability
		Software Engineering; Ian Sommerville; Pearson
		
		Design Patterns - Elements of Reusable Object-Oriented Software; E. Gamma, R. Helm, R. Johnson, J. Vlissides; Prentice Hall
		
		Writing Effective Use Cases; A. Cockburn; Pearson

Visual Computing	• Basics of perception • Basic Fourier transformation • Images, filtering, compression & processing • Basic object recognition • Geometric transformations • Basic 3D reconstruction • Surface and scene representations • Rendering algorithms • Color: Perception, spaces & models • Basic visualization	R. Szeliski, “Computer Vision: Algorithms and Applications”, Springer 2011 B. Blundell, “An Introduction to Computer Graphics and Creative 3D Environments”, Springer 2008
Introduction to Artificial Intelligence	Foundations: • Introduction, History of AI • Intelligent Agents Search: • Uninformed Search • Heuristic Search • Local Search • Constraint Satisfaction Problems • Games: Adversarial Search	Artificial Intelligence: A Modern Approach,;Stuart Russell, Peter Norvig; Pearson

	Planning: ● Planning in State Space ● Planning in Plan Space Decisions under Uncertainty: ● Uncertainty and Probabilities ● Bayesian Networks ● Decision Making Machine Learning: ● Neural Networks ● Reinforcement Learning Philosophical Foundations	
Probabilistic methods in computer science:	● Basics from probability theory, statistics and information theory. ● Probabilistic approaches to graph-based modeling in computer science ● Basic probabilistic problems and use of probabilistic methods o in practical computer science (e.g. run-time analysis of programs, data compression), o in technical computer science (e.g., reliability of hardware, caching), and o in applied computer science (e.g., simulation of stochastic systems, probabilistic robotics). ● Selected randomized algorithms, their analysis by 'The Probabilistic Method', algorithms for automated decision making and optimization ● Application of probabilistic methods in artificial intelligence (e.g. learning methods, neural networks) and data science ● Implementation of probabilistic methods by means of practical programming examples	M. Mitzenbacher, E. Upfahl: Probability and Computing, Cambridge University Press S.H. Chan: Probability for Data Science, Michigan University Press K. P. Murphy: Probabilistic Machine Learning, MIT Press D.J.C. MacKay: Information Theory, Inference, and Learning Algorithms, Cambridge University Press