TOPICS AND PROBLEMS FOR GRADUATION EXAM

Faculty of Computing and Telecommunications

Poznan University of Technology

Field of study:

Artificial Intelligence

1. [Introduction to computing] What is the difference between 1-bit adder and half-adder, and how to combine them to build an N-bit adder?
2. [Introduction to computing] Define regular expressions, give examples of how one can use them to process text data
3. [Introduction to artificial intelligence] Backpropagation algorithm for learning the parameters of a feedforward neural network.
4. [Introduction to artificial intelligence] Basic categories of problems considered in data mining (for example algorithms for clustering and classification).
5. [Introduction to programming] Shortly describe - based on examples - the following mechanisms: map, filter, zip, and list comprehension.
6. [Introduction to programming] Shortly describe object-oriented principles provided in Python.
7. [Introduction to programming] Shortly describe basic data structures provided in Python.
8. [Artificial life and cognitive systems] Explain how an evolutionary algorithm / evolutionary strategy / genetic programming / ant colony optimization / particle swarm optimization works.
9. [Artificial life and cognitive systems] Enumerate the components of a cognitive architecture and discuss their purpose.
10. [Introduction to probability] Describe conditional probability, theorem of total probability and the Bayes' rule (with example application)
11. [Introduction to probability] Describe the concept of random variable, its expectation and variance, and provide an example of a distribution of random variable.
12. [Introduction to probability] Describe the normal distribution, and how to compute probabilities concerning general normal random variables using the cumulative distribution function of a standard normal variable.
13. [Computer architecture with low-level programming] Describe how structures work in C and how they are passed to functions
14. [Computer architecture with low-level programming] List the registers and the most important instructions (data transfer, logical, arithmetic, comparison and conditional jumps) in the x86 architecture
15. [Algorithms and Data Structures] Give definitions and necessary and sufficient conditions for the problems of the Euler and Hamilton cycles for undirected and directed graphs.
16. [Algorithms and Data Structures] Which of the sorting algorithms is the best from the computational complexity point of view, justify why?
17. [Algorithms and Data Structures] Give algorithms finding the minimum spanning tree in a graph. State and justify the complexity of these algorithms.
18. [Algorithms and Data Structures] Describe the basic operations on a binary search tree i.e. create, search for an element and remove an element from the tree.
19. [Algorithms and Data Structures] Give the basic representations of a graph in a digital machine.

20. [Operating systems with concurrency programming] File system implementation — allocation methods, free-space management, integrity.
21. [Operating systems with concurrency programming] Interprocess synchronisation — semaphores, monitors, critical regions and its application to classical synchronisation problems (e.g. producer-consumer, readers-writers, dining philosophers).
22. [Operating systems with concurrency programming] Deadlock — detection, avoidance, prevention.
23. [Statistics] Describe graphical methods of presenting data and define basic central tendency and variability measures (with interpretations)
24. [Statistics] Describe the procedure of hypothesis testing
25. [Statistics] Describe the types of regression models and present the least squares method of estimation of linear regression parameters
26. [Information theory] Two-dimensional versions of entropy in data analysis
27. [Information theory] Shannon-Fano and Huffman coding algorithms
28. [Object programming] Explain the four basic principles of OOP
29. [Object programming] SOLID design principles
30. [Database systems] Relational data model (data structures, operations, integrity constraints).
31. [Database systems] Transaction and its properties.
32. [Database systems] Indexes in databases.
33. [Artificial intelligence] Solving problems by searching (general formulation, basic algorithms, special cases).
34. [Artificial intelligence] Reinforcement learning (formulation, assumptions, algorithm).
35. [Artificial intelligence] Bayesian networks (properties, inference).
36. [Combinatorial optimization]: Computational complexity of combinatorial optimization problems, approximation algorithms and approximability, hardness of approximation
37. [Combinatorial optimization]: Methods of solving combinatorial optimization problems in practice: greedy algorithms and matroids, metaheuristics, branch and bound algorithm
38. [Combinatorial optimization]: Network flow problems - formulations, solution methods, applications
39. [Combinatorial optimization]: Graph colouring – problem formulations, solution methods, applications
40. [Software engineering] Scrum as an example of agile methods.
41. [Software engineering] Software testing (i.e., unit/integration testing and acceptance testing).
42. [Software engineering] Software design (i.e., UML and design patterns).
43. [Computer networks] TCP/IP protocol suite.
44. [Computer networks] Basic functions of connecting devices: network interface card, modem, hub, switch and router.
45. [Computer networks] IP networks subnetting: motivation, rules and examples.
46. [Machine learning] Induction of classification trees from examples.
47. [Machine learning] Measures and methods for an experimental evaluation of classifiers and predictions models.
48. [Machine learning] Describe principles of constructing ensembles of classifiers.
49. [Elements of convex optimization]
50. [Elements of convex optimization]
51. [Data mining] Frequent itemset mining: algorithms, measures, applications.
52. [Data mining] Feature engineering techniques: discretization, normalization, outlier detection, binarization

53. [Data mining] Clustering techniques: k-means/k-medoids, density-based methods, EM, and agglomerative hierarchical clustering
54. [Data visualization] Visual encoding: marks and channels - their types and effectiveness
55. [Data visualization] Describe the types of tree/graph structure visualizations
56. [Robotics I] Describe the basic concepts in control theory: state space representation, observers, Kalman Filter, PID controllers
57. [Robotics I] Describe main principles of locomotion and software architectures for mobile robots
58. [Deep learning] Essential components and operation of contemporary recurrent neural network (preferably exemplified with LSTM)
59. [Deep learning] Residual connections: definition, motivations, and variants.
60. [Deep learning] Common loss functions used in deep learning (name and explain at least three of them)
61. [Internet applications] Explain the role of CSS and CSS preprocessors in web development
62. [Internet applications] Describe the purpose and structure of JavaScript Document Object Model
63. [Internet applications] HTTP protocol, its methods and status codes
64. [Operational research] Describe flow-shop and open-shop problems. Which one is easier to solve and why? Describe the general idea standing behind Johnson's algorithm.
65. [Operational research] Describe graphically how the simplex algorithm converges toward the optimum when solving a linear problem. Further, what factor has the most significant impact on the computational complexity of this method and why?
66. [Operational research] Describe shortly any two metaheuristics from: tabu search; simulated annealing; particle swarm optimization; evolutionary algorithm.
67. [Information retrieval] Vector space model (term frequency, inverse document frequency, similarity measures).
68. [Information retrieval] Using an inverted index and a suffix tree in information retrieval.
69. [Information retrieval] PageRank and HITS algorithms for ranking based on web structure.
70. [Computer vision] Name, define and characterise the four elementary morphological operations.
71. [Computer vision] Define the co-occurrence matrix and describe its applications in computer vision.
72. [Computer vision] Define the canonical camera arrangement (simple stereo) and derive from it the formula for (horizontal) disparity.
73. [Natural language processing] Define the idea of word embeddings and discuss the difference between static and dynamic word embeddings.
74. [Natural language processing] Define the named entity recognition task and propose 3 examples where it can be used.
75. [Natural language processing] Characterise the Transformer architecture and discuss its relation with GPT and BERT.
76. [Decision analysis] Preference disaggregation with the UTA method (preference information, preference model, provided results).
77. [Decision analysis] Classification with rough set approach (preference information, data structuring (lower and upper class approximations), preference model, rule induction algorithm).
78. [Decision analysis] Solution concepts in strategic games (pure and mixed Nash equilibria, equilibrium in dominant strategies, elimination of dominated strategies).
79. [Big data and distributed processing] Ordering of distributed events, Laport and vector clocks

80. [Big data and distributed processing] Big data definition, characteristics, and dimensions, noSQL models and CAP theorem
81. [Big data and distributed processing] Consensus problem and algorithms solving it
82. [Computational intelligence] Markov Decision Process as the basis for reinforcement learning modelling: Markov property, value modelling within MDP-based environment modelling (state value function, state-action value function), MDP-solving value-based methods, reinforcement learning as unknown MDP solving
83. [Computational intelligence] Value-based model-free reinforcement learning vs policy-based model-free reinforcement learning
84. [Computational intelligence] Bayesian optimization: key differences to other optimization approaches, key regression methods for objective function mean and variance surrogating (based on Gaussian Process Regression and algorithms based on decision tree ensembles)
85. [Robotics II] Coordination of behaviours in software architectures of mobile robots (methods, example architectures).
86. [Robotics II] The SLAM problem: definition and typical solutions (filter-based, graph-based).
87. [Robotics II] Map types in robotics, their properties, advantages, and areas of application.
88. [Cybersecurity] Authentication models in computer systems.
89. [Cybersecurity] Authorization models in computer systems.
90. [Cybersecurity] IPsec VPN.
91. [Semantic web and social networks] Semantic networks as a form of knowledge representation. RDF language to represent semantic networks (including how to represent n-ary relations using an RDF graph).
92. [Semantic web and social networks] What is an ontology? Explain what the 'open world' assumption is in OWL inference.
93. [Semantic web and social networks] The concept of knowledge graph. The task of learning knowledge graph embeddings (architecture, components of architecture, selected models).
94. [Internet of things] Sensor, transducer, actuator - explain their functions in IoT devices.