Computer Science MSc Final Exam topics

Mathematics and the theory of computation

1. Mathematical basics of machine learning (linear algebra, information and probability theory, numeric calculations, optimization) and basic concepts (under and overfitting, associative learning, reinforcement learning, validation, supervised/non-supervised learning).

2. Data preparation for machine learning, dimension reduction, linear/non-linear regression, subsampling, principal component analysis, cleaning/transforming/merging data.

3. Classification and clustering in machine learning, mixed models, energy minimization, k-means, hierarchical clustering, Bayesian theory in machine learning, simple and deep neural networks, kernel-based classifiers.

4. The main ingredients of symmetric cryptosystems; their advantages and disadvantages. The description of DES and AES.

5. The main ingredients of asymmetric cryptosystems; their advantages and disadvantages. The RSA algorithm and its applications.

6. Important cryptographic protocols; key exchange, digital signature. The ingredients of the public key infrastructure; the certification and registration authority. Applications of certificates.

7. Search and sort, complexity bounds: extensions of searching; lower bound on the complexity of sorting, classification of sorting algorithms by principle, linear time sorting algorithms. Basic discrete optimization problems, backtracking algorithms.

8. Graph algorithms: non-optimization problems; problems with polynomial time solution, lower bounds on the time complexities; NP-complete problems, suboptimal algorithms, theoretical bounds on the goodness of approximations.

9. Randomized algorithms: average complexity, using randomness for finding approximate solutions, random heuristic. Parallel computational models: CRCW and CREW, massively parallel and net algorithms, communication cost.

10. Unconstrained and constrained optimization of multivariable functions, local and global extrema, first-order necessary conditions. Line search methods (search directions, descent direction, step length).

11. Optimization of multivariable functions: trust-region methods. Newton's method, quasi-Newton methods.

12. Optimization of multivariable functions: conjugate gradient methods. Algorithms for nonlinear least-squares problems (Gauss-Newton method, Levenberg-Marquardt method).

Information technology

1. Data models and their implementations. Relation, object, object-relation, XML and NoSQL databases. Practical database design and UML.
2. Query processing and optimization, database tuning. Modelling and architectures of information systems.
3. Data Warehousing and OLAP. Information retrieval.
4. The programmable graphics pipeline. Incremental raster graphics algorithms for drawing 2D primitives. Filling and clipping. Basic interpolating and approximating curves. Joining curves.
5. Coordinate systems. 2D and 3D transformations. Classification and composition of transformations. Transformation between coordinate systems. Viewing and projections.
6. Surface representation techniques. Data structures for surfaces. Visibility algorithms. Light and material properties. Illumination and shading models. Texturing.
7. Definition of data mining and its role in the knowledge discovery process. Basic data mining tasks. Preprocessing. Explorative data analysis.
8. Supervised data mining: decision trees, regression, rule-based classifiers, nearest neighbour method, Bayes classification, artificial neural networks, support vector machines.
9. Unsupervised data mining: association rules, distance and similarity, clustering, anomaly detection.