

FINAL EXAM TOPICS
JUNE 2019
COMPUTER SCIENCE MSC
COMPULSORY SUBJECT

Automata and formal languages

1. The unicity and the algorithmic construction of the minimal automaton.
2. Parikh's theorem and its consequences.

Application of Linear Programming

3. Duality, dual simplex algorithm. Integer programming.
4. Assignment and transportation problem.

Advanced Programming

5. Generic programming, templates, expression templates, metaprogramming.
6. Standard Template Library implementation and usage: data streams, manipulators, generic algorithms, predicates, function objects, generic containers and iterators .

Advanced Image Processing

7. Morphological operations on binary and multiscale images; Skeletonization: distance transform, thinning, Voronoi-skeleton.
8. Textures: statistical texture features, syntactic texture description.

On-line Algorithms

9. Definition of competitive ratio and asymptotic competitive ratio. Ski rental problem, and algorithms for its solution. The paging problem, FIFO and the marking algorithms. Scheduling, list algorithm for scheduling.
10. The definition of the bin packing problem, algorithms NF, FF, BF. Proof: NF is 2-competitive. No online algorithm exists for bin packing with smaller asymptotic competitive ratio than $4/3$. Multidimensional generalizations of bin packing. NFSr strip packing algorithm.
11. The Web caching problem and the algorithm Landlord. The data acknowledgment problem and the algorithm Alarm. The online k-server problem and the double coverage algorithm.

Machine Learning

12. The basic notions of machine learning: feature extraction, the curse of dimensionality, no free lunch theorem, Occams razor, generalization and overfitting, measuring the training error.
13. Bayes decision theory and the related concepts. The maximum likelihood parameter estimation method for Gaussian curves and for Gaussian Mixture Models.
14. Supervised learning methods (non-parametric learning, neural nets, support vector machines, decision trees).)

Advanced Graphical Algorithms

15. Geometrical transformations: Transformation Pipeline, Special Transformations, Quaternions.
16. Realistic scene: Environment mapping, Bump mapping, Reflections, Planar Shadow.

Advanced Approximate and Symbolic Computations

17. Orthogonal transformations and their usage in numerical linear algebra (orthogonal-triangular decompositions, QR-algorithm).
18. Interpolation and approximation of continuous functions (spline and trigonometric interpolation, least-squares and uniform approximation).

Program Systems Development

19. Distributed system, issues, architectures.
20. Data persistence solutions (ORM, NoSQL, ...)

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ELECTIVE SUBJECTS (select subjects worth 20 credits)

Data Mining

1. Data representation and transformation: measurement scales, discrete and continuous variables, supervised and unsupervised discretization. Mean-centering, standardizing and whitening. Dimension reduction techniques (PCA, SVD, CUR, LDA).
2. Similarities and distances (edit distance, Minkowski distance, Mahalanobis distance, Jaccard distance/similarity, cosine distance/similarity) and the theory behind Locality Sensitive Hashing (LSH), AND/OR amplifications.
3. Frequent pattern mining, market basket analysis, association rule mining. The A Priori principle and the A priori algorithm, Park-Chen-Yu algorithm. FP-trees and FR-growth algorithm.
4. Data mining algorithms: PageRank, personalized PageRank and HITS (Hubs and Authorities) algorithms.

Game theory

5. Matrix games and their connection to LP. Minimax theorem.
6. n-person non-cooperative games. Nash equilibria and its applications.
7. Cooperative games, core, stable sets and matching and the Shapley value.

Nonlinear programming

8. Convex sets and convex functions in optimization
9. Iterative procedures for unconstrained problems
10. Equality- and inequality constrained optimization

Software development

11. What types of MFC applications are supported by Visual Studio C++ (Dialog Based, SDI, MDI) and the main features of them? What are the most important settings of the Application Wizard, the services, the functioning of the generated initial skeleton code?
12. The main features of the Dialog Boxes used in Visual Studio MFC C++ applications. How to create, display and close them? The communication between the dialog box shown on the screen and the dialog box object instance. What are the most frequent dialog controls and how to use them?
13. The features of the ODBC database connection library: data sources, connection string, etc. How to use different data sources (dBase, Excel, MS Access, Oracle, etc.) in Visual Studio MFC C++ Applications, and the role of the CRecordset class?

Computer Vision

14. Single view geometry (absolute conic and its image, vanishing point and line, orthocenter theorem, calibration).
15. Stereo (Epipolar geometry, fundamental matrix, essential matrix, computation of the fundamental matrix).
16. 3D reconstruction (Disparity and depth, stereo correspondence, projective reconstruction theorem, Stratified reconstruction).

17. Motion (3D motion and motion field, motion parallax, optical flow and its computation, aperture problem, image brightness constancy equation, tracking as probabilistic inference).

Embedded Systems

18. Debugging non-PC-based embedded systems (software and hardware debugging methods, their advantages and disadvantages).
19. Real-time programming (soft and hard real-time systems; how to make a non-real-time system to a real-time one).
20. Raspberry Pi programming (controlling peripherals and simple circuits via GPIO pins using Python)

Distributed Application Development

21. Data type system and the control structures of the C# language, comparing them to C++ and Java. Compilation of Windows Forms and Console applications, application of .NET assemblies and ANSI C dynamic link libraries.
22. The elements of Windows Forms application programming, types of Forms and controls, how to create and dispose them. The features of the most frequent controls like textbox, richeditbox, pushbutton, listbox, listview.
23. The development of .NET C# Windows Forms applications, menus, MDI applications, and serialization. Application of Resources, Settings, the role of the CultureInfo class.
24. The development of applications based on database services. How to execute database SQL queries and display the results on Windows Forms? Implementing binding between data table columns and controls, the BindingNavigator class.

Image registration ea

25. Representation of linear transformations and their execution on digital grids using interpolation. Main properties of transformations (rigid-body, similarity, affine, planar homography) and interpolation methods (nearest neighbor, linear, cubic, B-Spline).
26. Point-pair based registration methods. Main properties. 2D rigid body solution. Registration of point clouds.
27. Registration based on intensity similarity for unimodality and multimodality problems. Multi-resolution approach.

Non-conventional Databases

28. Spatial databases (pure relational, object-relational, and spatial datatype based solutions, spatial indices). Temporal databases. Spatial and temporal database solutions in Oracle.
29. Multimedia databases. Content-based image retrieval. Semi-structured datamodel, XML. Multimedia database and XML solutions in Oracle.
30. NoSQL databases (consistency, scalability, CAP theorem and consequences, replication). Key-value-, column-, document-, and graph stores. NoSQL solutions in Oracle.

Tree automata

31. Definition of the different types of tree automata. Regular tree grammars. Comparison of the class of tree languages recognized by tree automata and the class of tree languages generated by regular tree grammars.
32. Operations of forests. Regular expressions, Kleene's theorem for tree automata.
33. Minimization of tree automata.

Network Science

34. Network metrics and measures
35. Large scale structure of networks, Erdős-Rényi random graphs
36. Models of network formation, percolation

Speech Recognition and Statistical Natural Language Processing

37. The general working scheme of speech recognizers. Feature extraction methods.
38. Hidden Markov Models and their application to speech recognition.
39. Stochastic language models: N-gram, P-CFG and treebank-based methods.

Artificial neural networks and their applications

40. Multilayered neural networks and their training algorithm (back-propagation)
41. Deep neural networks, convolutional neural networks, recurrent neural networks

Parallel Programming

42. General properties of parallel systems (processes, process interaction, communication, efficiency). Definitions and usage of semaphores, monitors.
43. Java support for parallelism (lifecycle of threads, thread management, monitors in Java).
44. Parallelism in the Occam language (elements, processes, communication).
45. Parallel constructs of the PVM library (elements, tasks, communication).