DOCTORAL SCHOOL OF INFORMATICS
COMPLEX EXAM SUBJECT

Geospatial information (main subject)

Geoinformatics represents an interdisciplinary field for studying theories, methods, and applications of spatial analysis, spatial data handling, management, visualization and modelling. It includes the acquisition, management, analysis, and visualization of spatial information and data, which includes data on locations, distances, directions, and other spatial properties. The key techniques used in spatial informatics include computer sciences, geographic information systems, remote sensing, spatial statistics, and spatial data mining. These techniques allow analysts to collect, store, manipulate, and analyse large volumes of spatial data, and to derive meaningful insights and actionable information from them. Spatial informatics is an important and rapidly growing field that is transforming the way we understand and manage spatial information, and how we use it to address real-world challenges and opportunities. The complex exam covers the following areas.

1. Trends in the development of information systems, their functional directions, and the evolution of hardware and network technologies.
2. A brief history of the development of GIS, an introduction to the basic concepts and characteristics of geoinformatics, and the presentation of the five fundamental questions.
3. General overview of vector data model. Types of vector data structures, and the most important vector desktop and data exchange file formats. Vector data models: characteristics of the spaghetti model and the topological model. The attribute table. The concept of layers. Vector data in GIS software.
4. Geoprocessing and spatial relationships: operations performed on geometry (buffer, intersection, difference, symmetric difference, etc.). Spatial queries (intersects, crosses, overlaps, contains, within, etc.).
5. Vector GIS analyses: thematic mapping (data classification methods like natural breaks, equal intervals etc.), conditional queries, spatial indexing (grid index, quadtree, R-tree), and binary search.
6. Basic concepts of the raster data model (pixel, spatial resolution, electromagnetic spectrum, color models). Typical file formats of the raster data model and their properties. The concept of georeferencing. Raster data in GIS software.
7. Types of raster data: characteristics of satellite images and drone imagery; basic concepts (panchromatic images, imagery captured in the visible spectrum, multi- and hyperspectral images), digital images (scanned images and maps), and terrain models.
8. Image processing in geoinformatics: Fourier transform, filtering techniques (low-pass and high-pass filters, edge detection, smoothing filters, and other filters). Overview of classification algorithms: supervised (random forest, support vector machine, maximum likelihood, etc.) and unsupervised (K-means clustering, ISODATA clustering) classification methods; interpolation methods (IDW, TIN, kriging, etc.).
9. Fundamentals of database management: relational databases, records, fields, key fields, table relationships, indexing (B-tree, R-tree index), client–server systems, and storage engines. Describe a database management system. Handling spatial data in database management systems. Data exchange between database management systems and GIS software.

10. Graph theory. Describe the graph data structure: basic concepts, representation methods, and traversal techniques. Also explain how it relates to geoinformatics. Application possibilities of graph data structures (e.g., network modeling). Spatial pathfinding methods, the concept of minimum-cost paths, and spanning trees.
11. Terrain modeling. Classification of terrain models based on data structure, represented data, and covered area. Description of global and regional terrain models and possibilities for their creation. Methods for creating local models (LiDAR, models created by stereophotogrammetry). Application of terrain models in GIS software: visualization methods and analysis possibilities.
12. Algorithms in geoinformatics: convex hull, bounding box, and algorithms for constructing the minimum bounding box (oriented envelope). Presentation of line simplification (node reduction) and smoothing algorithms. Vectorization of lines, pattern recognition, OCR. Overview of other algorithms used in geoinformatics.
13. Sources of vector and raster data. Present Hungarian and international data repositories or organizations and their websites from which data can be downloaded free of charge (or free after registration) for educational and research purposes. What types of data are these, and what GIS analyses can they be used for?
14. GIS system design and project management: strategic planning, database design, implementation, documentation, resource planning, and scheduling.

Literature

- De Smith, M. J., Goodchild, M. F., & Longley, P. (2021). Geospatial analysis: a comprehensive guide to principles, techniques and software tools. Troubador publishing ltd. ISBN 13 978-1-912556-05-2 ebook, https://www.spatialanalysisonline.com/
- Banerjee, Sudipto; Carlin, Bradley P.; Gelfand, Alan E. (2014), Hierarchical Modeling and Analysis for Spatial Data, Second Edition, Monographs on Statistics and Applied Probability (2nd ed.), Chapman and Hall/CRC, ISBN 9781439819173
- Geospatial Analysis online: https://www.spatialanalysisonline.com/
- Ungvári Zsuzsanna: Spatial Databases. Lecture notes. 2025.
- https://www.inf.elte.hu/dstore/document/227926/ungv%C3%A1ri_zsuzsanna_spatial_databases_jegyzet_vegleges.pdf