Geoinformatics MSc

Basics in science

Subject title: Spatial Reference Systems L

Name of person responsible for the subject: Dr. Gede Mátyás
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge
- Complex knowledge of the general geographical, cartographic, planning, mathematical and informatic principles, rules, relationships required for the practice of geoinformatics
- Knowledge of the current theories, models and literature of geoinformatics based on scientific results. He/she is aware of the possible development directions and limits of the field of geoinformatics.
- In his/her native language, he/she confidently uses the conceptual system and terminology describing natural processes and can adapt it to the conceptual framework of geoinformatics.
b, abilities
- Ability to interpret complex professional problems in the field of geoinformatics, to explore the necessary theoretical and practical background and to solve problems.
- Ability to initiate cooperation with design and development professionals and end users of geoinformatics results.
- Ability to use the professional vocabulary of geoinformatics in his/her mother tongue and English.
c, attitude
- Monitors professional and technological developments in the field of geoinformatics and the labour market trends.
- Committed to adhering to and making others adhere to quality requirements.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields.

Content of education:
Basic knowledge on the shape of the Earth, on the parametrization of surfaces approximating it, on the necessity and possibilities of transformations between different coordinate systems. Getting to know azimuthal, cylindrical, and conic map projections and their distortions for both large-scale and small-scale mapping. The planar coordinate systems of common map series.

System of evaluation: oral and/or written exam.

Literature:
- Snyder, J. P.: Map projections: A working manual U. S. Government Printing Office. Washington D.C. 397 p., 1987 ISBN: 9781782662228
- Fenna, D.: Cartographic Science: A Compendium of Map Projections, with Derivations. CRC Press. Boca Raton, FL. 504 p, 2007 ISBN: 9780849381690

Suggested literature
- Snyder, J. P.; Voxland, P. M.: An album of map projections. U. S. Government Printing Office. Washington D.C. 249 p. 1989 DOI: 10.3133/pp1453
- Grafarend, E. W., Krumm, F. W.: Map Projections: Cartographic Information Systems. Springer. Berlin. 714 p. 2006 ISBN: 9783540367024

Subject title: Spatial Reference Systems P

Name of person responsible for the subject: Dr. Kerkovits Krisztián
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge
- Complex knowledge of the general geographical, cartographic, planning, mathematical and informatic principles, rules, relationships required for the practice of geoinformatics
- Knowledge of the current theories, models and literature of geoinformatics based on scientific results. He/she is aware of the possible development directions and limits of the field of geoinformatics.
- In his/her native language, he/she confidently uses the conceptual system and terminology describing natural processes and can adapt it to the conceptual framework of geoinformatics.
b, abilities
- Ability to interpret complex professional problems in the field of geoinformatics, to explore the necessary theoretical and practical background and to solve problems.
- Ability to initiate cooperation with design and development professionals and end users of geoinformatics results.
- Ability to use the professional vocabulary of geoinformatics in his/her mother tongue and English.
c, attitude
- Monitors professional and technological developments in the field of geoinformatics and the labour market trends.
- Committed to adhering to and making others adhere to quality requirements.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields.

Content of education:
Basic knowledge on the shape of the Earth, on the parametrization of surfaces approximating it, on the necessity and possibilities of transformations between different coordinate systems. The planar coordinate systems of common map series. Basics of georeferencing and geomathematics.

System of evaluation: practical course mark based on course work.

Literature:

- Snyder, J. P.: Map projections: A working manual U. S. Government Printing Office. Washington D.C. 397 p., 1987 ISBN: 9781782662228
- Fenna, D.: Cartographic Science: A Compendium of Map Projections, with Derivations. CRC Press. Boca Raton, FL. 504 p, 2007 ISBN: 9780849381690

Suggested literature

- Snyder, J. P.; Voxland, P. M.: An album of map projections. U. S. Government Printing Office. Washington D.C. 249 p. 1989 DOI: 10.3133/pp1453
- Grafarend, E. W., Krumm, F. W.: Map Projections: Cartographic Information Systems. Springer. Berlin. 714 p. 2006 ISBN: 9783540367024

Subject title: Environmental systems

Name of person responsible for the subject: Dr. Szalai Zoltán
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge
- Knowledge of the interrelationships and interactions between geospheres
- Knowledge about the functioning of the major Earth systems
- Knowledge on the impact of human activities on Earth systems (including impacts on exogenous cycles)
b, abilities
- Confidently use concepts and terminology related to environmental systems in their mother tongue
- Ability to recognise and interpret the structure of environmental data
- Critical use of scientific sources
- Ability to identify and discuss environmental problems
c, attitude
- Accepts and adheres to the ethical principles of work and organizational culture, especially with regard to the copyright related to geoinformatics.
- Committed to adhering to and making others adhere to quality requirements.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields.

Content of education: Fundamentals of systems theory and the structure of the Earth systems. Fundamentals of Network Science: negative and positive feedback in the environment. Changes in the global terrestrial systems. Cycles in the Earth systems and their impact on the earth's surface and society. Biogeochemical cycles in geospheres: atmosphere and hydrosphere interactions; the global carbon cycle; the oxygen cycle and ozone depletion, the global nitrogen cycle. The climate system and climate change: natural and anthropogenic climate change. Opportunities and limitations of the human society in the terrestrial systems.

System of evaluation: oral and/or written exam.

Literature:

- David Huddart, Tim Stott: Earth Environment Past, Present and Future. Wiley-Blackwell. 2010.
- Kenneth Hamblin, Eric Christiansen: Earth's Dynamic System, Prentice Hall. 2003.

Suggested literature:

- Huggett, Richard J.: Climate, Earth Processes and Earth History. Springer. 1991.
- Haggett, Peter. Geography: A Global Synthesis. Pearson Education, 2001.

Subject title: Geostatistics - Geomathematics

Name of person responsible for the subject: Kovács József
Scientific degree of the person in charge: DSc

The aim of education:
a, knowledge
- Complex knowledge of the general geographical, cartographic, planning, mathematical and informatic principles, rules, relationships required for the practice of geoinformatics, especially in the following topics: geographical and spatial data collection at various scales;
- Spatial and temporal data analysis; data management
b, abilities
- Ability to interpret complex professional problems in the field of geoinformatics, to explore the necessary theoretical and practical background and to solve problems.
- Ability to initiate cooperation with design and development professionals and end users of geoinformatics results.
c, attitude
- Accepts and adheres to the ethical principles of work and organizational culture, especially with regard to the copyright related to geoinformatics.
- Committed to adhering to and making others adhere to quality requirements.
d, autonomy and responsibility
d) autonomy and responsibility:
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields.

Content of education: The aim of the course is to familiarise the student with the best known and most commonly used methods of geostatistics and geomathematics.
Variogram studies and kriging. Computations with the most important exploratory multivariate data analysis methods: cluster, discriminant and principal component and factor analysis. Basics of time series analysis: smoothing, decomposition methods, trend and periodicity. Basics of spectral analysis.

System of evaluation: practical course mark based on course work.

Literature:

- MCBRIDE, Graham B. Using statistical methods for water quality management: issues, problems and solutions. John Wiley & Sons, 2005., ISBN: 9780471470168
- ROGERSON, Peter. Statistical methods for geography. Sage, 2014., ISBN: 9781446295731
- MCCARROLL, Danny: Simple Statistical Tests for Geography, Taylor & Francis, 2016, ISBN 9781498758819

Suggested literature:

- DAVIS, John C.; SAMPSON, Robert J. Statistics and data analysis in geology. New York: Wiley, 2002., ISBN: 9780471172758
- ROGERSON, Peter. Spatial Statistical Methods for Geography, Sage Publications, 2021, ISBN 9781529707458
- ACEVEDO Miguel F.: Data Analysis and Statistics for Geography, Environmental Science, and Engineering, Taylor & Francis, 2019, ISBN 9780367866792

Economic, legal and human science

Subject title: Geography and data background of the information society

Name of person responsible for the subject: Dr. Jakobi Ákos
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge
- Complex knowledge of the general geographical, cartographic, planning, mathematical and informatic principles, rules, relationships required for the practice of geoinformatics, especially in the following topics: geographical and spatial data collection at various scales; use of cartographic processes; knowledge of geographical and spatial processes; collection, editing and analysis of spatial data
- Knowledge of the consequences of Industry 4.0-based operation and technological knowledge, cyber-physical systems, self-organizing mechanisms, and digitization and automation in the labour market inducing structural changes in production and supply chains, organization of production processes
- Knowledge of the principles, methodologies and procedures for the design, development and operation of geoinformatics processes in the field of Big Data - data mining
- Familiar with the possibilities, principles and problems of applying geoinformatics for public (e-government) and market purposes.
b, abilities
- Ability to interpret geographical/spatial phenomena, processes and information, and to plan, organize, manage and control processes in the field of geoinformatics.
- Ability to initiate cooperation, project work and team work with professionals in co-sciences and other related fields (geology, geography, geodesy, cartography, meteorology, environmental science, earth science, informatics, mathematics, statistics, archaeology).
- Ability to initiate cooperation with design and development professionals and end users of geoinformatics results.
- Ability to recognize and apply new problem-solving methods and procedures in his/her field and apply what he/she has learnt in a diverse, multidisciplinary environment.
- Ability to understand, plan and implement a quality management system for project-level tasks in the field of geoinformatics.
c, attitude
- Monitors professional and technological developments in the field of geoinformatics and the labour market trends.
- Committed to adhering to and making others adhere to quality requirements.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields.

Content of education: Different concepts and interpretations of the information society. How does the information society influence data generation processes? Digital divide. Geographical differences in information society development, statistical measuring of regional inequalities. Concepts of the information economy and the challenges of industry 4.0. The "death of distance" theory, the relationship between location independence, location dependence and geoinformation. ICT strategies and tools for regional development. The social and geographical implications of the „big data" concept. Digital traces: direct spatial data (human sensing, mobile communication spatial data). Digital traces: indirect spatial data (transaction data, web usage spatial data). Digital traces: indirect spatial data (spatial components of social media data, online social networks). The concept of smart cities, the "data-driven city", and e-government in space. The phenomena of the "surveillance society" and the GDPR regulation. The concept of virtual space (cyberspace), relationships between virtuality and reality

System of evaluation: oral and/or written exam.

Literature:

- Cairncross, Frances (1997) The death of distance. How the communication revolution will change our lives. Harvard Business School Press, Boston, USA.
- Jakobi, Ákos (2009) Diverse Approaches to the Importance of Geography: the Death of Geography or Geography Matters in the Information Age! In: Donert K, Ari Y, Attard M, O'Reilly G, Schmeinck D (ed.) Geographical Diversity. Berlin: Mensch und Buch Verlag, 2009. pp. 190-195.
- Karlsson, C. et al. (2010) ICT and Regional Economic Dynamics: A Literature Review. JRC Scientific and Technical Reports, European Commission, Joint Research Centre, Institute for Prospective Technological Studies, doi:10.2791/46419
- Graham, M. (2011) „Wiki Space: Palimpsests and the Politics of Exclusion". In: Geert Lovink and Nathaniel Tkacz (ed.): Critical Point of View: A Wikipedia Reader. Institute of Network Cultures, Amsterdam 2011, ISBN: 978-90-78146-13-1, pp. 269-282.
- Measuring the Information Society Report, International Telecommunication Union, 2017 ISBN: 9789261245115

Suggested literature:

- Jakobi, Ákos and Lengyel, Balázs (2015) Geovisualising unequal spatial distribution of online social network connections: a Hungarian example. In: Brus J, Vondrakova A, Vozenilek V (ed.) Modern Trends in Cartography, Springer International Publishing, Heidelberg - New York, pp. 227-240. (Lecture Notes in Geoinformation and Cartography) (ISBN:978-3-319-07925-7)
- Tóth, G ; Wachs, J ; Di Clemente, R ; Jakobi, Á ; Ságvári, B ; Kertész, J ; Lengyel, B (2021) Inequality is rising where social network segregation interacts with urban topology. NATURE COMMUNICATIONS 12 : 1 Paper: 1143 , DOI: 10.1038%2Fs41467-021-21465-0
- GDPR.eu, Horizon 2020 Programme of the European Union (2020) What is GDPR, the EU's new data protection law? https://gdpr.eu/what-is-gdpr/

Subject title: Spatial-social data sources

Name of person responsible for the subject: Dr. Jakobi Ákos
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge
- Complex knowledge of the general geographical, cartographic, planning, mathematical and informatic principles, rules, relationships required for the practice of geoinformatics, especially in the following topics: geographical and spatial data collection at various scales; use of cartographic processes; knowledge of geographical and spatial processes; collection, editing and analysis of spatial data; remote sensing, photogrammetry, geostatistics, modelling, visualization, and geoinformatics system building.
- Comprehensive knowledge and understanding of the key relationships and concepts in the field of geoinformatics, in particular in the following areas: geolocation data collection technologies, 2- and 3-dimensional geoinformatics modelling, geovisualization, spatial data infrastructures, geoinformatics programming and application development, vector and raster geoinformatics, digital image processing, web-based geoinformatics solutions, geoinformatics databases, applied geoinformatics systems.
- Comprehensive knowledge of the problem-solving principles, methodology and processes of the planning, development and operation processes of the geoinformatics field
b, abilities
- Ability to interpret complex professional problems in the field of geoinformatics, to explore the necessary theoretical and practical background and to solve problems.
- Ability to interpret geographical/spatial phenomena, processes and information, and to plan, organize, manage and control processes in the field of geoinformatics.
- Ability to collect data independently and organize spatial data into a database, as well as to organize the data with the tools of geoinformatics. Ability to perform operations and models with independently organized databases.
c, attitude
- Committed to environmentally conscious behaviour in his/her field and laboratory activities.
- Monitors professional and technological developments in the field of geoinformatics and the labour market trends.
- Committed to adhering to and making others adhere to quality requirements.
- Open to professional cooperation with professionals working in related fields.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.

Content of education: The course introduces the access, use and correct interpretation of socio-economic territorial databases available in electronic forms, which can also be used for GIS visualisation and analysis. The course deals with the spatial resolution of different socio-economic phenomena and with the related public or commercially available statistical data sources. Students learn how to fit data needs to the existing regional statistical databases. Students also learn to avoid misinterpretations arising from the method of statistical enumeration, and as a result to create content-adequate GIS outputs. Detailed topics in the context of spatial-social data: data addition, data replacement, homogenisation and aggregation of spatial and time series, elimination of bias due to changes in administrative positions, management of the "headquarters problem" in geolocalization, management of the effects of data protection restrictions, data estimation options. Examples of spatial-social databases to be introduced: HCSO databases, TEIR, international data sources: OECD, Eurostat, UN, ITU.

System of evaluation: practical course mark based on course work.

Literature:

- Anselin, L. (1992) Spatial Data Analysis with GIS: An Introduction to Application in the Social Sciences. National Center for Geographic Information and Analysis, University of California, Santa Barbara, CA, USA.

- Eurostat (2021) Statistical regions in the European Union and partner countries — NUTS and statistical regions 2021., DOI: 10.2785/850262
- HCSO (2020) Hungarian Statistical Review, Volume 3, Number 2.

Suggested literature:

- GDPR.eu, Horizon 2020 Programme of the European Union (2020) What is GDPR, the EU's new data protection law? https://gdpr.eu/what-is-gdpr/
- OECD (2019) Regional Outlook 2019. Leveraging Megatrends for Cities and Rural Areas. https://doi.org/10.1787/9789264312838-en

Subject title: Fundamentals of Economics

Name of person responsible for the subject: Dr. Szabó Pál
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge
- Complex knowledge of the general geographical, cartographic, planning, mathematical and informatic principles, rules, relationships required for the practice of geoinformatics, especially in the following topics: geographical and spatial data collection at various scales; use of cartographic processes; knowledge of geographical and spatial processes; collection, editing and analysis of spatial data
b, abilities
- Ability to interpret geographical/spatial phenomena, processes and information, and to plan, organize, manage and control processes in the field of geoinformatics.
- Ability to initiate cooperation with design and development professionals and end users of geoinformatics results.
c, attitude
- Monitors professional and technological developments in the field of geoinformatics and the labour market trends.
- Committed to adhering to and making others adhere to quality requirements.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields.

Content of education: The aim of the course is to introduce the students to the logic of economic thinking, as well as to get acquainted with the operation of economic systems. During the semester, students gain insight into the optimal decision-making of economic actors, the functioning of markets, and the failures of market coordination. The course is introductory in nature, its primary aim is to equip students with the knowledge necessary for the effective performance of tasks in applied geoinformatics.

System of evaluation: oral and/or written exam.

Literature:

- Mankiw, G. N. (2017). Principles of Economics (8th Edition), South-Western College Publishing, Florence. ISBN-13: 9781285165875
- Krugman, P., Obstfeld, M. & Melitz, M. (2017). International Economics: Theory and Policy, Global Edition. Pearson Education Limited. **ISBN:** 9781292214870
- Brakman, S., Garretsen, H., & van Marrewijk, C. (2019). An Introduction to Geographical and Urban Economics. Cambridge University Press, Cambridge. ISBN: 9781108418492
- Overman, H. G. (2018). GIS Data in Economics. In: Vernengo, M., Caldentey, E. P., Rosser, B. J. (eds) The New Palgrave Dictionary of Economics. Palgrave Macmillan, London.

Suggested literature:

- Hirshleifer, J., Glazer, A., & Hirshleifer, D. (2005). Price Theory and Applications: Decisions, Markets, and Information (7th Edition). Cambridge University Press, Cambridge. ISBN: 978521523424
- Stock, W. (2012). Introduction to Economics: Social Issues and Economic Thinking. John Wiley & Sons, New Jersey. ISBN: 9780470574782
- Dasgupta, P.: Economics (2007). A Very Short Introduction. Oxford University Press, Oxford. ISBN: 9780192853455

- Steger, M. (2020). Globalization: A Very Short Introduction (Very Short Introductions). Oxford University Press, Oxford. ISBN: 9780198849452

Basics in geoinformatics

Subject title: Data mining and cloud-based solutions

Name of person responsible for the subject: Dr. Gede Mátyás
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge
- Comprehensive knowledge of the problem-solving principles, methodology and processes of the planning, development and operation processes of the geoinformatics field, especially in the following areas: database management, Big Data data-mining, primary and secondary data collection, Earth observation, spatial and temporal data analysis, modelling and simulation of processes, network analysis, 3-dimensional modelling, geovisualization, geostatistical solutions, web-based geoinformatics services, spatial services development, geoinformatics programming, development of geospatial applications, open-source geoinformatics.
- Understandings, knowledge and application of mobile field, laboratory and practical materials, tools and methods of geoinformatics.
b, abilities
- Ability to collect data independently and organize spatial data into a database, as well as to organize the data with the tools of geoinformatics. Ability to perform operations and models with independently organized databases.
- Ability to recognize and apply new problem-solving methods and procedures in his/her field and apply what he/she has learnt in a diverse, multidisciplinary environment.
c, attitude
- Accepts and adheres to the ethical principles of work and organizational culture, especially with regard to the copyright related to geoinformatics.
- Open to professional cooperation with professionals working in related fields.
- Committed to adhering to and making others adhere to quality requirements.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields.

Content of education:
Main topics:

1. Crowdsourcing in spatial data. Data quality, evaluation. Comparing crowdsourced data with national databases. Data protection.
2. Tools and techniques in Data Mining.
3. The OpenStreetMap database. Copyright and licenses. Editing OSM data in the web with JOSM. Downloading data from the OSM with Overpass Turbo API.
4. Usage and import of spatial data in geoinformatics software (QGIS, ArcGIS). Building databases from downloaded data.
5. Geocoder applications in the web. Getting data from web with scripts.
6. Automations in data mining.
7. Cloud-based solutions in spatial data science.
8. Free and open databases: SRTM, ETOPO1, Corine, statistical data, etc. WMS and WFS services.

System of evaluation: practical course mark based on course work.

Literature:

- Pang-Ning Tan, Michael Steinbach, Vipin Kumar: Introduction to Data Mining. Pearson Education Inc., 2019 ISBN: 9780133128901, 0133128903
  https://www-users.cs.umn.edu/~kumar001/dmbook/index.php#chapters
- OpenStreetMap WIKI: https://wiki.openstreetmap.org/wiki/Main_Page., 2020

Suggested literature:

- Arsanjani, Zipf, Mooney, Helbich (eds.): OpenStreetMap in GIScience: Experiences, Research, and Applications. Springer, 2015. ISBN: 9783319142807
- Ian H. Witten, Eibe Frank, Mark A. Hall, Christopher J. Pal: Data mining. Practical Machine Learning Tools and Techniques. ELSEVIER SCIENCE & TECHNOLOGY. 2017. ISBN 9780128042915
  https://www.cs.waikato.ac.nz/~ml/weka/book.html

Subject title: Geospatial algorithms L

Name of person responsible for the subject: Dr. Gede Mátyás
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge
- Knowledge of the current theories, models and literature of geoinformatics based on scientific results. He/she is aware of the possible development directions and limits of the field of geoinformatics.
- Comprehensive knowledge and understanding of the key relationships and concepts in the field of geoinformatics, in particular in the following areas: geovisualization, geoinformatics programming and application development, vector and raster geoinformatics, digital image processing.
b, abilities
- Ability to interpret complex professional problems in the field of geoinformatics, to explore the necessary theoretical and practical background and to solve problems.
- Ability to recognize and apply new problem-solving methods and procedures in his/her field and apply what he/she has learnt in a diverse, multidisciplinary environment.
- Ability to use the professional vocabulary of geoinformatics in his/her mother tongue and English.
c, attitude
- Accepts and adheres to the ethical principles of work and organizational culture, especially with regard to the copyright related to geoinformatics.
- Committed to adhering to and making others adhere to quality requirements.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields.

Content of education:
The course introduces students to fundamental algorithms and data structures in computer science, which are also widely used in geoinformatics. The second half of the course focuses on the geospatial field and takes an outlook on well-known geospatial algorithms and data structures.

- Basic data structures: array, linked list, stack, queue. Priority queue, heap data structure.
- Basic algorithms: summation, counting, maximum selection, conditional variants, linear search, logarithmic search.
- Sorting: bubble sort, insertion sort, maximum sort, quicksort, merge sort, complexity analysis.
- Graph representation (adjacency matrix, edge list). Graph traversal (BFS, DFS).
- Minimum cost path graph algorithms (Dijkstra, Bellman-Ford).
- Minimum spanning trees (Red-Blue rules, Prim algorithm, Kruskal algorithm)
- Scalar indexing: binary tree, search tree, AVL-tree, B (2-3) tree
- Spatial indexing: grid index, kd-tree, adaptive kd-tree, quadtree, R-tree
- Topological algorithms: Crossing Number, Shamos-Hoey, Bentley-Ottman, Greiner-Hormann.
- Topological data structures: winged-edge, half-edge.
- Convex hull algorithms: Jarvis's march, Graham's scan, Quickhull, Chan's algorithm
- Clustering and classification: K-means, ISODATAA

System of evaluation: oral and/or written exam.

Literature:

- T. H. Cormen, C. E. Leiserson, R. L. Rivest, C. Stein: Introduction to Algorithms, The MIT Press, 2009, ISBN: 9780262033848
- H. Samet: The Design and Analysis of Spatial Data Structures, Addison-Wesley, 1994, ISBN: 9780201502558

Suggested literature

- P. Rigaux, M. O. Scholl, A. Voisard: Spatial Databases: With Application to GIS, Morgan Kaufmannn, 2001, ISBN: 9781558605886
- M. de Berg, O. Cheong, M. van Kreveld, M. Overmars: Computational Geometry, Springer, 2008, ISBN: 9783540779735

Subject title: Geospatial algorithms P

Name of person responsible for the subject: Dr. Gede Mátyás
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge
- Knowledge of the current theories, models and literature of geoinformatics based on scientific results. He/she is aware of the possible development directions and limits of the field of geoinformatics.
- Comprehensive knowledge and understanding of the key relationships and concepts in the field of geoinformatics, in particular in the following areas: geovisualization, geoinformatics programming and application development, vector and raster geoinformatics, digital image processing.
b, abilities
- Ability to interpret complex professional problems in the field of geoinformatics, to explore the necessary theoretical and practical background and to solve problems.
- Ability to recognize and apply new problem-solving methods and procedures in his/her field and apply what he/she has learnt in a diverse, multidisciplinary environment.
- Ability to use the professional vocabulary of geoinformatics in his/her mother tongue and English.
c, attitude
- Accepts and adheres to the ethical principles of work and organizational culture, especially with regard to the copyright related to geoinformatics.
- Committed to adhering to and making others adhere to quality requirements.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields.

Content of education:
The course introduces students to fundamental algorithms and data structures in computer science, which are also widely used in geoinformatics. The second half of the course focuses on the geospatial field and takes an outlook on well-known geospatial algorithms and data structures.

- Introduction to Python. Literals and variables, data types, User input management. Control structures (sequences, conditional executions, iterations). Exception handling (try & except).
- Functions: built-in functions, function definition, arguments & parameters, return value.
- Collection data structures in Python: lists, dictionaries, tuples, sets.
- Basic algorithms: summation, counting, maximum selection, conditional variants, linear search, logarithmic search.
- Sorting: bubble sort, insertion sort, maximum sort, quicksort, merge sort, complexity analysis.
- Tabular data processing (CSV, Excel files), pandas library. Plotting and diagram visualization of scalar data (matplotlib library).
- Spatial data management: vector formats (geopandas library), raster formats (rasterio library)
- Graph representation (adjacency matrix, edge list). Graph traversal (BFS, DFS).
- Minimum cost path graph algorithms (Dijkstra, Bellman-Ford). Priority queue, heap data structure.
- Minimum spanning trees (Red-Blue rules, Prim algorithm, Kruskal algorithm)
- Scalar indexing: binary tree, search tree, AVL-tree, B (2-3) tree
- Spatial indexing: grid index, kd-tree, adaptive kd-tree, quadtree, R-tree
- Topological algorithms: Crossing Number, Shamos-Hoey, Bentley-Ottman, Greiner-Hormann.
- Topological data structures: winged-edge, half-edge.
- Convex hull algorithms: Jarvis's march, Graham's scan, Quickhull, Chan's algorithm
- Clustering and classification: K-means, ISODATAA

System of evaluation: practical course mark based on course work.

Literature:

- T. H. Cormen, C. E. Leiserson, R. L. Rivest, C. Stein: Introduction to Algorithms, The MIT Press, 2009, ISBN: 9780262033848
- H. Samet: The Design and Analysis of Spatial Data Structures, Addison-Wesley, 1994, ISBN: 9780201502558

Suggested literature

- P. Rigaux, M. O. Scholl, A. Voisard: Spatial Databases: With Application to GIS, Morgan Kaufmannn, 2001, ISBN: 9781558605886
- M. de Berg, O. Cheong, M. van Kreveld, M. Overmars: Computational Geometry, Springer, 2008, ISBN: 9783540779735
- E. Matthes: Python Crash Course, No Starch Press, 2015, ISBN: 9781593279288

Subject title: Geoinformatics

Name of person responsible for the subject: Dr. Albert Gáspár
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge
- Complex knowledge of the general geographical, cartographic, planning, mathematical and informatic principles, rules, relationships required for the practice of geoinformatics
- Knowledge of the current theories, models and literature of geoinformatics based on scientific results. He/she is aware of the possible development directions and limits of the field of geoinformatics.
- Comprehensive knowledge and understanding of the key relationships and concepts in the field of geoinformatics
- Comprehensive knowledge of the problem-solving principles, methodology and processes of the planning, development and operation processes of the geoinformatics field
b, abilities
- Ability to interpret complex professional problems in the field of geoinformatics, to explore the necessary theoretical and practical background and to solve problems.
- Ability to recognize and apply new problem-solving methods and procedures in his/her field and apply what he/she has learnt in a diverse, multidisciplinary environment.
- Ability to use the professional vocabulary of geoinformatics in his/her mother tongue and English.
c, attitude
- Monitors professional and technological developments in the field of geoinformatics and the labour market trends.
- Committed to environmentally conscious behaviour in his/her field and laboratory activities.
- Committed to adhering to and making others adhere to quality requirements.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields.

Content of education: The aim of the course is to overview the most commonly used concepts in the application of GIS and to explain their context. The topics covered during the semester are: vector and raster data systems; topologies and types of geodatabases and an overview of the OGC standard; dimensions and attributes; the relationship between databases and visualisation and geoinformatics modelling; geoinformatics in society, data communication; interpretation of geoinformatics data (principal component analysis, BigData, machine learning, etc.).

System of evaluation: oral and/or written exam.

Literature:

- Kemp, K. (Ed.). (2008). Encyclopedia of geographic information science. Sage. ISBN 978-1-4129-1313-3
- Lemmens, M. (2011). Geo-information: technologies, applications and the environment (Vol. 5). Springer Science & Business Media. ISBN 978-94-007-1666-7

Suggested literature:

- Karimi, H. A. (Ed.). (2014). Big Data: techniques and technologies in geoinformatics. Crc Press.
- Egenhofer, M. J., Clarke, K. C., Gao, S., Quesnot, T., Franklin, W. R., Yuan, M., & Coleman, D. (2016). Contributions of GIScience over the past twenty years. Advancing geographic information science: The past and the next twenty years, 9-34

Subject title: Measurments and data collection

Name of person responsible for the subject: Dr. Kovács Béla
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge
- Theoretical/practical knowledge of satellite positioning and navigation systems
- Knowledge of field data collection equipment
- Theoretical and practical knowledge of general tools for geoinformatics and geodesy
b, abilities
- Ability to orientate spatially with or without instruments
- Ability to interpret (special) maps
- Ability to program and operate field data collection equipment
- Ability to locate and navigate with and without instruments
- Ability to select and locate a sampling site
- Ability to carry out planned measurements using ground and airborne (e.g. GNSS instrument, drone) field data collection equipment
c, attitude
- Monitors professional and technological developments in the field of geoinformatics and the labour market trends.
- Committed to environmentally conscious behaviour in his/her field and laboratory activities.
- Committed to adhering to and making others adhere to quality requirements.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields.

Content of education:
- planning and execution of field measurements and data collection
- objective and subjective sources of danger, emergency management
- map reading, use of maps, orienteering on field
- theory and practice of GNSS
- sub-metre and sub-mm level satellite-based positioning
- errors in field measurements and how to eliminate/reduce them
- mapping of sampling locations and GI data collection
- how to navigate on field
- UAV/drones in fieldwork
- mobile mapping equipment and solutions

System of evaluation: practical course mark based on course work.

Literature:
- Hofmann-Wellenhof, Bernhard, Lichtenegger, Herbert, Wasle, Elmar, 2008. GNSS – Global Navigation Satellite Systems, Springer-Verlag Wien, ISBN: 978-3-211-73012-6
- Esmat Bekir: Introduction to Modern Navigation Systems,World Scientific Publishing Company, 2007
- Mohinder S. Grewal, Lawrence R. Weill, Angus P. Andrews: Global Positioning Systems, Inertial Navigation, and Integration, Wiley, 2007, ISBN: 978-0-470-09971-1

Suggested literature:

- Laurie Tetley etal: Electronic Navigation Systems, Taylor & Francis, 2012, ISBN: 978-0-7506-5138-7
- GIS – Collecting Field Data (https://guides.library.yale.edu/GIS/Collector)

Subject title: Spatial Databases

Name of person responsible for the subject: Dr. Gede Mátyás
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge
- Comprehensive knowledge and understanding of the key relationships and concepts in the field of geoinformatics, in particular in the following areas: geolocation data collection technologies, 2- and 3-dimensional geoinformatics modelling, geovisualization, spatial data infrastructures, geoinformatics programming and application development, vector and raster geoinformatics, digital image processing, web-based geoinformatics solutions, geoinformatics databases, applied geoinformatics systems.
b, abilities
- Ability to collect data independently and organize spatial data into a database, as well as to organize the data with the tools of geoinformatics. Ability to perform operations and models with independently organized databases.
- Ability to create geoinformatics systems to support and assist decision makers.
- Ability to recognize and apply new problem-solving methods and procedures in his/her field and apply what he/she has learnt in a diverse, multidisciplinary environment.
- Ability to use the professional vocabulary of geoinformatics in his/her mother tongue and English.
c, attitude
- Accepts and adheres to the ethical principles of work and organizational culture, especially with regard to the copyright related to geoinformatics
- Committed to adhering to and making others adhere to quality requirements.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields.

Content of education:
Main topics:
Introduction to PostgreSQL (where clauses, simple and aggregating functions join among tables /left, right, inner, outer joins/, subqueries)
Spatial data storing in PostGIS. WKT and WKB format, EWKT. Data conversion functions, handling projections. Spatial indexing. Graphic visualization of spatial data.
Measuring and calculation object sizes (for example: distances, area, perimeter, azimuth, bounding boxes)
Geometry processing: buffer, centroid, convex and concave hull, line simplification, line smoothing. Creating different types of geometries.
Geoprocessing in PostGIS (difference, intersection, symmetrical difference, union), topological evaluation
Complex geoprocessing in PostGIS
Creating, modifying and deleting spatial databases.
Working with raster data: satellite images and digital elevation models (data storing, georeferencing, data conversion, multi-channel satellite image, raster mathematics)
Developing simple websites visualizing spatial data.

System of evaluation: practical course mark based on course work.

Literature:

- PostGIS Documentation: https://postgis.net/documentation/
- Nagy G.: Spatial databases online lecture notes 1-6. chapters.
  https://regi.tankonyvtar.hu/hu/tartalom/tamop425/0027_SDO1/index.html
  https://regi.tankonyvtar.hu/hu/tartalom/tamop425/0027_SDO2/index.html
  https://regi.tankonyvtar.hu/hu/tartalom/tamop425/0027_SDO3/index.html

https://regi.tankonyvtar.hu/hu/tartalom/tamop425/0027_SDO4/index.html
https://regi.tankonyvtar.hu/hu/tartalom/tamop425/0027_SDO5/index.html
https://regi.tankonyvtar.hu/hu/tartalom/tamop425/0027_SDO6/index.html

Suggested literature:

- PostgreSQL Documentation: https://www.postgresql.org/docs/
- Obe.E Regina: PostGIS in Action. Shelter Island, Manning, 2015. ISBN: 9781935182269

Subject title: Digital terrain models

Name of person responsible for the subject: Dr. Telbisz Tamás
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge
- Geographic and spatial data collection at different scales, use of cartographic procedures
- Geostatistics, 2- and 3-dimensional geographic modelling, visualization
b, abilities
- Perform operations and model building with self-organised databases.
- Ability to creatively and methodically process, evaluate, interpret and analyse measurement results and draw conclusions from them.
- Ability to use the professional vocabulary of geoinformatics in his/her mother tongue and English.
c, attitude
- Monitors professional and technological developments in the field of geoinformatics and the labour market trends.
- Committed to environmentally conscious behaviour in his/her field and laboratory activities.
- Accepts and adheres to the ethical principles of work and organizational culture, especially with regard to the copyright related to geoinformatics.
- Committed to adhering to and making others adhere to quality requirements.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields.
- In accordance with his/her professional competencies, he/she can be assigned with responsibility for development and operation in geoinformatics systems.

Content of education:
Introduction to digital terrain models.
Concept of digital terrain models, varieties, GRID and TIN models.
Application of digital terrain models.
Different base data to create digital terrain models (contour maps, GPS, radar, LiDAR).
DTM databases (SRTM, ASTER, GMTED, national datasets).
Digitization practice.
Theory of interpolations (Linear interpolation, kriging, etc.)
DTM visualisations.
Derived maps (slope, aspect, curvature, etc.) practice and theoretical background.
DTM error types, detection and correction.

System of evaluation: practical course mark based on course work.

Literature:

- Li Z, Zhu C, Gold C (2005): Digital Terrain Modeling. Principles and Methodology. CRC Press, 340 p., ISBN 9780415324625.
- Rabus, B., Eineder, M., Roth, A., Bamler, R. (2003): The shuttle radar topography mission – a new class of digital elevation models acquired by spaceborne radar. ISPRS Journal of Photogrammetry and Remote Sensing, 57(4):241-262.

Suggested literature:

- Burrough, P.A. – McDonnell, R.A (1998): Principles of Geographical Information Systems. – Oxford University Press, Oxford, 306 p., ISBN: 9780198742845

- Florinsky IV (2016): Digital Terrain Analysis in Soil Science and Geology. Academic Press, Elsevier, ISBN 978-0-12-804632-6
- Maune DF, Nayegandhi A (edt) (2007): Digital Elevation Model Technologies and Applications: The DEM Users Manual. ASPRS, 2nd edition, ISBN 978-1570830822
- Wilson J. P., Gallant J. C. (eds.) (2000): Terrain Analysis: Principles and Application. John Wiley & Sons, USA

Subject title: Satellite Remote Sensing L

Name of person responsible for the subject: Dr. Mari László
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge:
- Complex knowledge of the general geographical, cartographic, planning, mathematical and informatic principles, rules, relationships required for the practice of geoinformatics, especially in the following topics: geographical and spatial data collection at various scales; use of cartographic processes; knowledge of geographical and spatial processes; collection, editing and analysis of spatial data; remote sensing, photogrammetry, geostatistics, modelling, visualization, and geoinformatics system building
- Comprehensive knowledge and understanding of the key relationships and concepts in the field of geoinformatics, in particular in the following areas: geolocation data collection technologies, 2- and 3-dimensional geoinformatics modelling, geovisualization, spatial data infrastructures, geoinformatics programming and application development, vector and raster geoinformatics, digital image processing, web-based geoinformatics solutions, geoinformatics databases, applied geoinformatics systems.
b, abilities
- Ability to interpret geographical/spatial phenomena, processes and information, and to plan, organize, manage and control processes in the field of geoinformatics.
- Ability to collect data independently and organize spatial data into a database, as well as to organize the data with the tools of geoinformatics. Ability to perform operations and models with independently organized databases.
- Ability to design value-added services, especially concerning Earth observation.
c, attitude
- Monitors professional and technological developments in the field of geoinformatics and the labour market trends.
- Committed to adhering to and making others adhere to quality requirements.
- Accepts and adheres to the ethical principles of work and organizational culture, especially with regard to the copyright related to geoinformatics.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields

Content of education: Types of optical band remote sensing satellites (LANDSAT, SPOT, IRS, Sentinel, etc.). CORINE landcover databases and applications. The European *Copernicus* Program. Image interpretation of super high resolution satellites (IKONOS, QuickBird, WorldView, etc.). The concept of digital image processing. Digital image processing tools. Multispectral images. Hyperspectral images. Theoretical bases of image classification.

System of evaluation: oral and/or written exam.

Literature:

- William Emery and Adriano Camps: Introduction to Satellite Remote Sensing: Atmosphere, Ocean, Land and Cryosphere Applications; 860p., Elsevier Inc., 2017, ISBN 9780128092545
- Emilio Chuvieco: Fundamentals of Satellite Remote Sensing: An Environmental Approach (3rd Edition) 598 p. CRC Press, 2010 ISBN: 9781138583832

Suggested literature:

- Nicolas Baghdadi and Mehrez Zribi (ed.) Land Surface Remote Sensing in Urban and Coastal Areas 350 p., Elsevier Inc., 2017, ISBN 9781785481604

- Fu W., Ma J., Chen P., Chen F. (2020) Remote Sensing Satellites for Digital Earth. In: Guo H., Goodchild M.F., Annoni A. (eds) Manual of Digital Earth. Springer, Singapore. https://doi.org/10.1007/978-981-32-9915-3_3

Subject title: Satellite Remote Sensing P

Name of person responsible for the subject: Dr. Mari László
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge:
- Complex knowledge of the general geographical, cartographic, planning, mathematical and informatic principles, rules, relationships required for the practice of geoinformatics, especially in the following topics: geographical and spatial data collection at various scales; use of cartographic processes; knowledge of geographical and spatial processes; collection, editing and analysis of spatial data; remote sensing, photogrammetry, geostatistics, modelling, visualization, and geoinformatics system building
- Comprehensive knowledge and understanding of the key relationships and concepts in the field of geoinformatics, in particular in the following areas: geolocation data collection technologies, 2- and 3-dimensional geoinformatics modelling, geovisualization, spatial data infrastructures, geoinformatics programming and application development, vector and raster geoinformatics, digital image processing, web-based geoinformatics solutions, geoinformatics databases, applied geoinformatics systems.
b, abilities
- Ability to interpret geographical/spatial phenomena, processes and information, and to plan, organize, manage and control processes in the field of geoinformatics.
- Ability to collect data independently and organize spatial data into a database, as well as to organize the data with the tools of geoinformatics. Ability to perform operations and models with independently organized databases.
- Ability to design value-added services, especially concerning Earth observation.
c, attitude
- Monitors professional and technological developments in the field of geoinformatics and the labour market trends.
- Committed to adhering to and making others adhere to quality requirements.
- Accepts and adheres to the ethical principles of work and organizational culture, especially with regard to the copyright related to geoinformatics.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields

Content of education: Visual interpretation of optical band remote sensing satellites images (LANDSAT, SPOT, IRS, Sentinel, etc.). Computer aided image interpretation. Image interpretation of super high resolution satellites (IKONOS, QuickBird, WorldView, etc.). Image transformation. Re-sampling methods. Image correction procedures. Basic image enhancement techniques. Convolution filters. Index calculations, vegetation indices. Types of classification, clustering, supervised classification.

System of evaluation: practical course mark based on course work.

Literature:

- William Emery and Adriano Camps: Introduction to Satellite Remote Sensing: Atmosphere, Ocean, Land and Cryosphere Applications; 860p., Elsevier Inc., 2017, ISBN 9780128092545
- Emilio Chuvieco: Fundamentals of Satellite Remote Sensing: An Environmental Approach (3rd Edition) 598 p. CRC Press, 2010 ISBN: 9781138583832

Suggested literature:

- Nicolas Baghdadi and Mehrez Zribi (ed.) Land Surface Remote Sensing in Urban and Coastal Areas 350 p., Elsevier Inc., 2017, ISBN 9781785481604

- Fu W., Ma J., Chen P., Chen F. (2020) Remote Sensing Satellites for Digital Earth. In: Guo H., Goodchild M.F., Annoni A. (eds) Manual of Digital Earth. Springer, Singapore. https://doi.org/10.1007/978-981-32-9915-3_3

Subject title: Map design and editing L

Name of person responsible for the subject: Dr. Reyes Nunez José Jesús
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge
- Complex knowledge of the general geographical, cartographic, planning, mathematical and informatic principles, rules, relationships required for the practice of cartography
- Familiar with the specific tools of the geoinformatics discipline, learn the cartographic elements of field survey procedures, data management and analysis, effective cartographic representation solutions in a geoinformatics environment;
- Knowledge and use of spatial data collection technologies, their cartographic aspects and key elements.
b, abilities
- Ability to select the most effective cartographic tools and software to solve a given task, depending on its complexity;
- Ability to systematically process, evaluate, interpret and analyse the measurement results and to support the drawing of conclusions from these results in cartographic terms, and to visualise them in an optimal way;
- Ability with the acquired cartographic knowledge to carry out effective, user-oriented planning, development and consultancy tasks in the operation of GIS, decision support systems and expert systems.
c, attitude
- Open to professional cooperation with professionals working in related fields.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields.

Content of education: The map. The concept of map. Scale, projection, generalization, graphical legend. Classification of maps according to scale. Map types: base maps, general maps, thematic maps. Sources of map making.
Maps for the public. Types and concepts. General characteristics, scale and legend. Additions to maps: insets, name registers, search grids, alphabetical arrangement.
Map frame. Types of frames. Map model. Map extract. Form of the map sheet. Technical symbols on the map. Legend and explanation of symbols. The process and phases of map making.
Map content. Aspects of representation. Characteristics of objects and phenomena. Map elements. Layers of map content: relief, planimetric features, place names. Representation methods. Generalization: steps, guidelines, limits.
Relief. Representation of relief. Modern cartographic methods. Relationship between method, scale and map type. Planimetric features I. Drainage, elements and groups. Hydrographic objects. Representation of hydrographic features in various scales.
Planimetric features I. Borders. Categories of borders and their representation. Transportation features, their categories and representation. Land coverage. Representation of vegetation in various scales. Representation of land-use and geographical zones of vegetation cover. Representation of built-up areas and settlements.
Geographical names: Place names. Labelling of places. Writing systems. Names in Latin script. Types of place names and categories of their representation. Parts of names. Typography of labelling place names. Letter types and traditions of labelling. Names referring to points and point-like features. Settlement names. Hydrographic names of point elements. Names of characteristics geographical points (peaks, passes). Explanatory names. Names referring to areas. Hydrographic names referring to areas. Micro topographical names. Physical landscape regions in cartography. Names of historical-geographical regions. Administrative names. Names of states and administrative divisions. Names of protected areas. Names of linear elements. Hydrographic names of linear features. Representation of administrative names referring g

to area and line. Names of public domains. Types of supplementary information on maps. Pictograms and their representation.
Atlases. Types of atlases. Atlases of map sheets. Atlases of separate maps. Editing atlases.
Historical maps. The use of historical maps. Types of historical maps. Spatial representation of historical events. Showing dynamism on a static base. Publications. Relationship between the legend of popular maps and historical maps. Real historical map.
Cartographic fieldwork. Reconnaissance. Maps for orientation on the terrain. Revising tourist maps. Updating city maps. Sources of updating and revision.

System of evaluation: oral and/or written exam.

Literature:

- Kraak, M.-J., Ormeling, F. (2020) Cartography: Visualization of Geospatial Data. Fourth Edition. CRC Press. ISBN 9781138613959
- Brewer, C. A. (2015) Designing Better Maps: A guide for GIS users. First edition. Esri Press. ISBN: 9781589484405

Suggested literature:

- Crampton, J. W. (2011) Mapping: A Critical Introduction to Cartography and GIS. First edition. Wiley-Blackwell. ISBN-13: 978-1405121729
- Field, K. (2018) Cartography. First edition. Esri Press. ISBN-13: 978-1589484399
- Raisz, E. (1948) General Cartography. McGraw-Hill Book Company: New York.

Subject title: Vector-Based GIS (QGIS)

Name of person responsible for the subject: Dr. Ungvári Zsuzsanna
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge
- Complex knowledge of the general geographical, cartographic, planning, mathematical and informatic principles, rules, relationships required for the practice of geoinformatics, especially in the following topics: geoinformatics system building
- Comprehensive knowledge of the problem-solving principles, methodology and processes of the planning, development and operation processes of the geoinformatics field
- Knowledge of the specific tools of geoinformatics, ability to apply field survey procedures, data management and analysis, and visualization solutions.
b, abilities
- Ability to interpret complex professional problems in the field of geoinformatics, to explore the necessary theoretical and practical background and to solve problems.
- Ability to creatively and methodically process, evaluate, interpret and analyse measurement results and draw conclusions from them.
- Ability to recognize and apply new problem-solving methods and procedures in his/her field and apply what he/she has learnt in a diverse, multidisciplinary environment.
c, attitude
- Monitors professional and technological developments in the field of geoinformatics and the labour market trends.
- Accepts and adheres to the ethical principles of work and organizational culture, especially with regard to the copyright related to geoinformatics.
- Committed to adhering to and making others adhere to quality requirements.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields.

Content of education: The goal of this course is to show the basic tools and applications of open-source GIS exploiting the possibilities of the software QGIS and GRASS. Alongside user-level applications of vector raster and 3D systems, contemporary trends (mesh, topologic data structures) are considered, as well. Finally, smaller components (e. g. plugins) are developed on the system using the API of the software at a beginner level.

System of evaluation: practical course mark based on course work.

Literature:

- Sherman, G.: The PyQGIS Programmer's Guide: Extending QGIS 3 with Python 3. Locate Press. 252 p. 2018. ISBN: 9780998547725
- Menke, K.: Discover QGIS 3.x: A Workbook for Classroom or Independent Study. Locate Press. 406 p. 2019. ISBN: 9780998547763

Suggested literature

- Farkas G.: Practical GIS. Packt Publishing. 272 p. 2017. ISBN: 9781787123328
- Petrasova, A., Harmon, B., Petras, V., Tabrizian, V., Mitasova, H.: Tangible Modeling with Open Source GIS. Springer. 202 p. 2018, ISBN: 9783319893020

Subject title: Vector-based GIS (ArcGIS)

Name of person responsible for the subject: Dr. Kohán Balázs
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge
- Confidence in the use of vector-based geospatial software
- Knowledge of the basic concepts of vector spatial information systems
- Knowledge to produce thematic maps to meet all needs
b, abilities
- Ability to interpret complex professional problems in the field of geoinformatics, to explore the necessary theoretical and practical background and to solve problems.
- Ability to interpret geographical/spatial phenomena, processes and information, and to plan, organize, manage and control processes in the field of geoinformatics.
c, attitude
- Accepts and adheres to the ethical principles of work and organizational culture, especially with regard to the copyright related to geoinformatics.
- Committed to adhering to and making others adhere to quality requirements
- Monitors professional and technological developments in the field of geoinformatics and the labour market trends.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields.

Content of education: The purpose of the course is to present the basic tools and applications of vector GIS using the possibilities of ArcGIS software. The course teaches the students through the most important steps of GIS projects. After learning about data sources and formats, they learn how to manage map layers, the basics of georeferencing and digitalization. They get acquainted with the concepts of geodatabase, attribute table, subtype, domain, topology, join, spatial join, relate. Using SQL, they master the capabilities of attribute data analysis, and use the ArcGIS toolbar to perform spatial analysis. Finally, they learn how to create printable or even web-based maps based on the results.

System of evaluation: practical course mark based on course work.

Literature:

- Roger Tomlinson: Thinking about GIS. ESRI Press, Redlands, USA, 2007 ISBN: 9781589483484
- https://learn-arcgis-learngis.hub.arcgis.com/

Suggested literature:

- Michael Law – Amy Collins: Getting to Know ArcGIS Desktop, fifth edition, (2018) pp 768. ISBN: 9781589485105
- https://downloads.esri.com/LearnArcGIS/pdf/instructional-guide-for-the-arcgis-book-2e.pdf

Subject title: Application of ArcGIS-based Server and Web GIS

Name of person responsible for the subject: Dr. Kohán Balázs
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge
- Understand the basics of server and web GIS and their potential for presenting and sharing geographical processes and spatial data
b, abilities
- Familiar with the Esri group of products for server and web GIS, while being able to integrate products and services from other software
- Ability to build a database from spatial data and then share the data according to different needs, making it editable by specific groups or by anyone
- Ability to create different mapping applications that provide data collection, data management, geovisualisation for any discipline dealing with spatial data
c, attitude
- Accepts and adheres to the ethical principles of work and organizational culture, especially with regard to the copyright related to geoinformatics.
- Committed to adhering to and making others adhere to quality requirements
- Monitors professional and technological developments in the field of geoinformatics and the labour market trends.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields.

Content of education: The aim of the course is to teach our students the basics of server and web GIS through ArcGIS Server Software. In a complex desktop-server-web architecture, the students have the opportunity to learn a complete GIS workflow from the building of the database to making web mapping applications. They build a GIS database from their own data, then they publish the data through various services. Finally, they create their own map application. Through this process, they will get familiar with other ESRI software (Portal, Online), and they will learn to integrate other services into the system (WMS, WMTS).

System of evaluation: practical course mark based on course work

Literature:

- Di Martino, Sergio & Peron, Adriano & Tezuka, Taro. (2013). Web and Wireless Geographic Information Systems. Journal of Spatial Information Science. 6. 10.5311/JOSIS.2013.6.145.
- Roger Tomlinson: Thinking about GIS. ESRI Press, Redlands, USA, 2007 ISBN: 9781589483484
- https://learn-arcgis-learngis.hub.arcgis.com/

Suggested literature:

- Keller, G. Randy (1946-) (szerk.), Baru, Chaitanya (szerk.): Geoinformatics: cyberinfrastructure for the solid Earth sciences. Cambridge, Cambridge University Press, 2011 ISBN: 9780521897150
- N.M. Naidu: Geoinformatics and geostatistics. New Delhi, SBS Publishers & Distributors, 2009 ISBN: 9788189741983
- Peterson, Michael. (2017). Advances in Cartography and GIScience: Selections from the International Cartographic Conference 2017. 10.1007/978-3-319-57336-6.
- Sample, John & Ioup, Elias. (2010). Tile-Based Geospatial Information Systems. 10.1007/978-1-4419-7631-4.

Subject title: GIS Project

Name of person responsible for the subject: Dr. Reyes Nunez José Jesús
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge
- An intensive synthesis of knowledge acquired in the previous years, covering all areas (research, programming, data presentation, drafting)
- Factual and problem-specific (detailed) knowledge of the specific task
- Knowledge of the partner institution in the case of an external data provider
b, abilities
- Independent problem-solving, decision-making on technical issues, in the field and in an office environment
- Structuring, planning and carrying out complex tasks
- Developing vocabulary and professional expression in oral and written reports
c, attitude
- Accepts and adheres to the ethical principles of work and organizational culture, especially with regard to the copyright related to geoinformatics.
- Committed to adhering to and making others adhere to quality requirements.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields.

Content of education:
Students independently but driven by instructors carry out a complex task on the basis of previous studies. The tasks must contain the interpretation of problem solving of a relevant topic in GIS environment or creating and interpretation of a complex spatial information system.
Segments of the task:

- formulation of the topic and the basic questions
- data collection, digitization
- designing the database / programming
- queries
- analysis, evaluation of the results, conclusions
- development of the system and publication of the results
- documentation of the project
- oral presentation of the workflow and results

System of evaluation**:** practical course mark based on course work.

Literature:

- Roger Tomlinson: Thinking about GIS. ESRI Press, Redlands, USA, 2007 ISBN: 9781589483484
- Dent, Torguson, Hodler: Cartography – Thematic Map Design. McGraw-Hill Education, 2008 ISBN: 9780697384959

Suggested literature:

- Slocum, McMaster, Kessler, Howard: Thematic Cartography and Geographic Visualization. Pearson, 2008. ISBN: 9780132298346
- Tyner, J.: Map Design. The Guilford Press, New York, 2010 ISBN: 9781462517121

Subject title: High Resolution Remote Sensing L

Name of person responsible for the subject: Dr. Jung András
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge
- Comprehensive knowledge of the problem-solving principles, methodology and processes of the planning, development and operation processes of the geoinformatics field, especially in the following areas: database management, Big Data data-mining, primary and secondary data collection, Earth observation, spatial and temporal data analysis, modelling and simulation of processes, network analysis, 3-dimensional modelling, geovisualization, geostatistical solutions, web-based geoinformatics services, spatial services development, geoinformatics programming, development of geospatial applications, open-source geoinformatics.
- Knowledge of the specific tools of geoinformatics, ability to apply field survey procedures, data management and analysis, and visualization solutions. Knowledge and use of spatial data collection technologies, available databases and spatial information software, as well as open-source and commercial geoinformatics software, cloud-based geoinformatics solutions.
- Understandings, knowledge and application of mobile field, laboratory and practical materials, tools and methods of geoinformatics.
b, abilities
- Ability to collect data independently and organize spatial data into a database, as well as to organize the data with the tools of geoinformatics. Ability to perform operations and models with independently organized databases.
- Ability to creatively and methodically process, evaluate, interpret and analyse measurement results and draw conclusions from them.
- Ability to recognize and apply new problem-solving methods and procedures in his/her field and apply what he/she has learnt in a diverse, multidisciplinary environment.
c, attitude
- Accepts and adheres to the ethical principles of work and organizational culture, especially with regard to the copyright related to geoinformatics.
- Open to professional cooperation with professionals working in related fields.
- Committed to adhering to and making others adhere to quality requirements.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields.

Content of education: This course introduces the principles, the methods and the techniques of high-resolution remote sensing. The imaging and non-imaging optical data acquisition workflow will be discussed with special attention to multi- and hyperspectral measurements. Different platforms (handheld, UAV, airborne, underwater, etc.) will be shown with their application areas. The theory and application of field spectroscopy will be discussed in detail, even its importance in proximal and satellite remote sensing. An overview will be given about active and passive high resolution remote sensing systems in a multidisciplinary context. The state-of-the-art of science and technology in a domestic and international approach will be presented, while highlighting the future developments. Special attention will be given to new scientific results, industrial applications and comparative studies. After completing this course, the students will be able to select and apply high resolution remote sensing techniques and methods to support their own scientific work, research and geospatial evolvement.

System of evaluation: oral and/or written exam.

Literature:

- He, Yuhong, and Qihao Weng, eds. (2018) High spatial resolution remote sensing: data, analysis, and applications. CRC press, ISBN 9780429470196
- Thenkabail, Prasad S., and John G. Lyon, eds. (2016) Hyperspectral remote sensing of vegetation. CRC press, ISBN 9781138066250
- McCoy, Roger M. (2005) Field methods in remote sensing. Guilford Press, ISBN 1-59385-080-8

Suggested literature:

- Vohland, M. and Jung, A. (Eds). (2021) Hyperspectral Imaging for Fine to Medium Scale Applications in Environmental Sciences. MDPI, ISBN 978-3-0365-0878-8
- Toro, F. G., Tsourdos, A. (Eds.). (2018) UAV sensors for environmental monitoring. MDPI Publishing. MDPI, ISBN 978-3-03842-754-4
- Gonzalez, F. and Tsourdos, A. (Eds) (2018) UAV or Drones for Remote Sensing Applications (Volume 1). MDPI, ISBN 978-3-03897-092-7

Subject title: High resolution remote sensing P

Name of person responsible for the subject: Dr. Jung András
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge
- Comprehensive knowledge of the problem-solving principles, methodology and procedures of the planning, development and operation processes of the geoinformatics field, especially in the following areas: database management, Big Data - data mining, primary and secondary data collection, earth observation, spatial and temporal data analysis, processes modelling and simulation, network analysis, 3-dimensional modelling, geovisualization, geostatistical solutions, web geoinformatics services, development of spatial services, geoinformatics programming, development of GIS applications, open-source GIS.
- Has knowledge of the specific tools of the geoinformatics field, is able to apply field survey procedures, data management and analysis, and representation solutions. Knows and uses spatial data collection technologies, available databases and GIS software, as well as open-source and commercial geoinformatics software, cloud-based geoinformatics solutions.
- Understand, know and apply the mobile field, laboratory and practical possibilities, tools and methods of remote sensing.
b, abilities
- Ability to creatively and systematically process, evaluate, interpret, analyse and draw conclusions from measurement results.
- Ability to collect data independently and organize spatial data into a database, as well as to organize the data with the tools of geoinformatics. Able to perform operations and model with independently organized databases.
- Is able to recognize and apply new problem-solving methods and procedures in his / her field and apply what he / she has learned in a diverse, multidisciplinary environment.
c, attitude
- Accepts and adheres to the ethical principles of work and organizational culture, especially with regard to the copyright related to geoinformatics.
- Open to professional cooperation with professionals working in related fields.
- Committed to adhering to and making others adhere to quality requirements.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields.

Content of education: During the internships, students will learn the basics, tools, and methods of near-ground remote sensing. With the related software and hardware infrastructure. They perform imaging and non-imaging optical data collection in the form of independent measurements, master multispectral and hyperspectral measurement techniques, learn about the application possibilities of different platforms (ASD FieldSpec, QMini, UHD185, multicopter, Flir, etc.). The exercises provide a detailed insight into the data collection process of field spectroscopy and its role in the field of ground-truthing. We review in detail the near-earth device system and multidisciplinary position of high-resolution active and passive remote sensing. We deal separately with industrial applications and their scientifically demanding approach. Using statistical and image processing software, students evaluate their measurement results and their usability. After completing the exercises, the student will be able to assemble the hardware, software and method elements necessary for his / her independent scientific work.

System of evaluation: practical course mark based on course work.

Literature:

- Vohland, M., A. Jung, eds. (2020) Hyperspectral Imaging for Fine to Medium Scale Applications in Environmental Sciences. Remote Sens. 12(18), 2962; https://doi.org/10.3390/rs12182962
- pdf materials published by the instructor on ELTE-CANVAS system

Suggested literature:

- Rossel, R. A. V., McBratney, A. B., Minasny, B. (Eds.). (2010) Proximal soil sensing. Springer Science & Business Media. ISBN 978-90-481-8859-8
- McCoy, Roger M. (2005) Field methods in remote sensing. Guilford Press, ISBN 9781593850791

Subject title: Open Source WebGIS

Name of person responsible for the subject: Dr. Gede Mátyás
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge
- Complex knowledge of the general geographical, cartographic, planning, mathematical and informatic principles, rules, relationships required for the practice of geoinformatics, especially in the following topics: geovizualization, geoinformatics system engineering, programming, web geoinformatics solutions, services, open source geoinformatics
b, abilities
- Ability to understand complex technical problems, identifying the necessary theoretical and practical background and solving problems
- Ability to design value-added services
- Ability to create decision support geoinformation systems
c, attitude
- Monitors professional and technological developments in the field of geoinformatics and the labour market trends.
- Committed to adhering to and making others adhere to quality requirements.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields.

Content of education:

- General structure and components of WebGIS applications
- Introduction to OpenLayers; creating a simple web map page
- Displaying rasters in OpenLayers
- Displaying vector data in OpenLayers
- Managing vector styles
- Adding interactive functions to the map
- Integrating third party geocoding and routing services
- Fundamentals of MapServer, the role and structure of a Mapfile
- Integrating OpenLayers and MapServer
- Feature classification and basic styling in MapServer
- Complex styling in MapServer
- Using queries through WMS

System of evaluation: practical course mark based on course work.

Literature:

- Gede Mátyás: The OpenLayers 5 API alapjai. http://mercator.elte.hu/~saman/edu/ol5/
- Gede Mátyás: MapServer tutorial. http://mercator.elte.hu/~saman/edu/mapserver/

Suggested literature:

- Thomas Gratier, Paul Spencer, Erik Hazzard: OpenLayers 3: Beginner's Guide. ISBN: 9781782162360Gábor Farkas: Mastering OpenLayers 3. ISBN: 9781785281006
- Pericles S. Nacionales, Jeff McKenna: MapServer tutorial. https://www.mapserver.org/tutorial/

Subject title: Project management in informatics

Name of person responsible for the subject: Dr. Gregorics Tibor
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge
- Basic management and leadership skills to perform tasks related to the profession.
- Knowledge of the possibilities, principles and problems of the application of geoinformatics for state (e-government) and market purposes.
b, abilities
- Ability to manage processes and projects related to the field of geoinformatics at managerial level.
- Ability to perform problem solving, planning, development, operation, management and consulting tasks in the operation of geoinformatics systems, decision support systems and expert systems. Ability to work with decision makers.
- Ability to assess the business, market and innovative value of the planned and implemented geoinformatics systems, as well as their compliance with user and social needs.
c, attitude
- Open and committed to critical feedback and evaluation based on self-assessment.
- Accepts and adheres to the ethical principles of work and organizational culture, especially with regard to the copyright related to geoinformatics.
- Open to professional cooperation with professionals working in related fields.
d, autonomy and responsibility
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.

Content of education:
The aim of the course is to train students to be able to oversee their work environment, to be able to work in group on projects, and possibly lead these groups.
First, we clarify the concept of the project and the important elements that accompany the project (project rectangle). Understanding the role of a project can be attributed to a deeper examination of the project as well as a detailed study of the project life cycles (Preparation, Start-up, Planning, Follow-up, Closing, Project Afterlife). We focus on the project planning phase (network planning, time analysis, resource scheduling). Among the project management methodologies, agile methods that are best fitting current industry needs are discussed in details. General project management issues such as:

- What makes a team effective?
- Based on personality models, how can we optimize communication, collaboration, conflict management, and motivation between team members?
- What makes a good leader?
- How to prevent burnout?

are also discussed.
We also examine the project in its broader context, we provide an insight into the issue of corporate culture, analyse the advantages and disadvantages of organizational models and the optimal choice. Given the prevalence of customer service, we deal separately with the method of providing high quality customer service.

System of evaluation: oral and/or written exam.

Literature:

- A Guide to the Project Management Body of Knowledge: PMBOK Guide Author: Project Management Institute Publisher: Project Management Institute Year Published: 2013 Edition: 5 th ISBN: 9781935589679
- Practice Guide (Project Management Institute, 2017, ISBN: 9781628253825)

Suggested literature:

- Scott Berkun: The Art of Project Management. O'Really. ISBN: 978-1600330537
- A Guide to the Project Management Body of Knowledge (PMBOK® Guide) — Sixth Edition and Agile

Obligatory optional courses – Module A

Subject title: Automatizing spatial analysis

Name of person responsible for the subject: Szalkai Gábor
Scientific degree of the person in charge: PhD

The aim of education:
a) knowledge:
- Complex knowledge of the general geographical, cartographic, planning, mathematical and informatic principles, rules, relationships required for the practice of geoinformatics, especially in the following topics: geographical and spatial data collection at various scales; use of cartographic processes; knowledge of geographical and spatial processes; collection, editing and analysis of spatial data; remote sensing, photogrammetry, geostatistics, modelling, visualization, and geoinformatics system building
- Knowledge of the current theories, models and literature of geoinformatics based on scientific results. He/she is aware of the possible development directions and limits of the field of geoinformatics.
- Comprehensive knowledge and understanding of the key relationships and concepts in the field of geoinformatics, in particular in the following areas: geolocation data collection technologies, 2- and 3-dimensional geoinformatics modelling, geovisualization, spatial data infrastructures, geoinformatics programming and application development, vector and raster geoinformatics, digital image processing, web-based geoinformatics solutions, geoinformatics databases, applied geoinformatics systems.
b, abilities
- Ability to interpret geographical/spatial phenomena, processes and information, and to plan, organize, manage and control processes in the field of geoinformatics.
- Ability to interpret complex professional problems in the field of geoinformatics, to explore the necessary theoretical and practical background and to solve problems.
- Ability to collect data independently and organize spatial data into a database, as well as to organize the data with the tools of geoinformatics. Ability to perform operations and models with independently organized databases.
c, attitude
- Committed to environmentally conscious behaviour in his/her field and laboratory activities.
- Monitors professional and technological developments in the field of geoinformatics and the labour market trends.
- Committed to adhering to and making others adhere to quality requirements.
- Shares his/her knowledge, considers it important to communicate the results of geoinformatics.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.

Content of education: The aim of the course is to learn how to use the VBA interface and programming language behind Excel so that the student will be able to automate the transformation of data tables in spatial analysis and to easily perform tasks that are difficult to perform in the normal menu system.

System of evaluation: practical course mark based on course work.

Literature:

- Steven Roman: Writing Excel Macros with VBA, 2nd Edition, O'Reilly 2002 ISBN: 9780596003593
- https://www.tutorialspoint.com/vba/vba_quick_guide.htm
- https://docs.microsoft.com/en-us/office/vba/api/overview/

Suggested literature:

- Automating GIS-processes, https://automating-gis-processes.github.io/site/
- Bill Jelen, Tracy Syrstad: Microsoft Excel 2019 VBA and Macros, 2018, Book 978-1-5093-0611-4

- Michael Alexander, John Walkenbach: Excel VBA Programming for Dummies, 2018, ISBN 1119077397

Subject title: GIS in R

Name of person responsible for the subject: Dr. Magyari Enikő
Scientific degree of the person in charge: DSc

The aim of education:
a, knowledge
- Comprehensive knowledge of the problem-solving principles, methodology and processes of the planning, development and operation processes of the geoinformatics field, especially in the following areas: database management, Big Data data-mining, primary and secondary data collection, Earth observation, spatial and temporal data analysis, modelling and simulation of processes, network analysis, 3-dimensional modelling, geovisualization, geostatistical solutions, web-based geoinformatics services, spatial services development, geoinformatics programming, development of geospatial applications, open source geoinformatics.
- Knowledge of the specific tools of geoinformatics, ability to apply field survey procedures, data management and analysis, and visualization solutions. Knowledge and use of spatial data collection technologies, available databases and spatial information software, as well as open source and commercial geoinformatics software, cloud-based geoinformatics solutions.
b, abilities
- Ability to interpret complex professional problems in the field of geoinformatics, to explore the necessary theoretical and practical background and to solve problems.
- Ability to interpret geographical/spatial phenomena, processes and information, and to plan, organize, manage and control processes in the field of geoinformatics.
- Ability to creatively and methodically process, evaluate, interpret and analyse measurement results and draw conclusions from them.
c, attitude
- Monitors professional and technological developments in the field of geoinformatics and the labour market trends.
- Committed to adhering to and making others adhere to quality requirements.
- Committed to environmentally conscious behaviour in his/her field and laboratory activities.
- Accepts and adheres to the ethical principles of work and organizational culture, especially with regard to the copyright related to geoinformatics.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields.

Content of education: The aim of this course is to briefly introduce students to the basics of R programming language and then describe the ability of R, the software widely used by researchers and statisticians to help the work of geographers, cartographers and GIS specialist. During the course, the following four main topics are concerned: (1) GIS data management (raster/vector databases, cooperation with other geospatial software); (2) solving GIS tasks (geometric operations, transformations, interpolations); (3) visualization of geospatial data (map display, additional map symbols, base maps, interactive maps); (4) calculation with spatial descriptive statistics.

System of evaluation: practical course mark based on course work.

Literature:

- W. N. Venables, D. M. Smith, R Core Team: An introduction to R. https://cran.r-project.org/doc/manuals/r-release/R-intro.pdf
- Roger S. Bivand, Edzer J. Pebesma, Virgilio Gómez-Rubio: Applied Spatial Data Analysis with R. http://gis.humboldt.edu/OLM/r/Spatial%20Analysis%20With%20R.pdf

Suggested literature:

- Barry Rowlingson: Geospatial Data in R And Beyond! www.maths.lancs.ac.uk/~rowlings/Teaching/UseR2012/static/talk1.pdf
- Francisco Rodriguez-Sanchez: Spatial data in R: Using R as a GIS. http://pakillo.github.io/R-GIS-tutorial/
- Robin Lovelace, James Cheshire, Rachel Oldroyd és mtsai.: Introduction to visualising spatial data in R. cran.r-project.org/doc/contrib/intro-spatial-rl.pdf

Subject title: The applications of GIS in physical geography

Name of person responsible for the subject: Bíró Tamás
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge
- Knowledge of the specific tools of geoinformatics, ability to apply field survey procedures, data management and analysis, and visualization solutions. Knowledge and use of spatial data collection technologies, available databases and spatial information software, as well as open source and commercial geoinformatics software, cloud-based geoinformatics solutions.
- Understandings, knowledge and application of mobile field, laboratory and practical materials, tools and methods of geoinformatics.
- In his/her native language, he/she confidently uses the conceptual system and terminology describing natural processes and can adapt it to the conceptual framework of geoinformatics.
b, abilities
- Ability to interpret complex professional problems in the field of geoinformatics, to explore the necessary theoretical and practical background and to solve problems.
- Ability to understand, plan and implement a quality management system for project-level tasks in the field of geoinformatics.
- Ability to collect data independently and organize spatial data into a database, as well as to organize the data with the tools of geoinformatics. Ability to perform operations and models with independently organized databases.
c, attitude
- Monitors professional and technological developments in the field of geoinformatics and the labour market trends.
- Committed to adhering to and making others adhere to quality requirements.
- Accepts and adheres to the ethical principles of work and organizational culture, especially with regard to the copyright related to geoinformatics.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields.

Content of education:
Introduction into theory and practice of project-based physical geographical research using Geoinformatics (GIS) is the principal goal of this course. The aim of this practical course is to use routines of handling and analysing digital elevation models and geostatistics obtained previously in order to solve problems that are in the focus of physical geographical studies. Consequently, the course allows to recognize the opportunities and limitations of GIS-based analyses in classical physical geographical and geomorphological research. Students could gain practice in managing research projects including finding out relevant research questions, using effective research methodology and analysing/publishing data and results due to the project-based learning and workflow.

System of evaluation: practical course mark based on course work.

Literature:

- Otto, J.C., Prasicek, G., Blöthe, J. and Schrott, L., 2018: GIS applications in geomorphology. In: Comprehensive Geographic Information Systems; Huang, B., Ed.; Elsevier Inc.: Bonn, Germany, pp.81-111.; doi:10. 1016/B978-0-12-409548-9.10029-6
- Tarolli, P., 2014: High-resolution topography for understanding Earth surface processes: Opportunities and challenges. Geomorphology, 216, pp. 295-312. doi: https://doi.org/10.1016/j.geomorph.2014.03.008

Suggested literature:

- Davis, J.C. 2002: Statistics and Data Analysis in Geology, 3rd Edition. John Wiley & Sons., New York, 656 p.; ISBN: 9780471172758
- Reddy, G.P.O. 2018: Remote Sensing and GIS for Geomorphological Mapping. In: Reddy G., Singh S. (eds) Geospatial Technologies in Land Resources Mapping, Monitoring and Management. Geotechnologies and the Environment, vol 21. Springer, Cham. doi: https://doi.org/10.1007/978-3-319-78711-4_12

Subject title: Creating Databases in Human Geography

Name of person responsible for the subject: Bottlik Zsolt
Scientific degree of the person in charge: PhD

The aim of education:
a) knowledge
- Use of database management software
- Knowledge of basic database concepts
- Systematic structuring of data
b) abilities
- Understanding complex technical problems
- Interpretation of spatial phenomena
- Complex processing of results
c) attitude
- Committed to environmentally conscious behaviour in his/her field and laboratory activities.
- Committed to adhering to and making others adhere to quality requirements.
- Shares his/her knowledge, considers it important to communicate the results of geoinformatics.
- Open to professional cooperation with professionals working in related fields.
d) autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.

Content of education: The course is based on the use of MS Access. The aim of the course is to acquaint students with the initial steps of database construction and to organize the data of a specific socio-geographical phenomenon into relations, as well as to start and further develop the construction of the database. This process will introduce students to the basic database elements (tables, queries, forms, reports) and their use. The procedures for designing the database will be mastered through the problem of sorting the data. They will also learn about methods that simplify data entry and limit errors. Algorithms that ensure the fastest possible retrieval of data information will also help them to use other GIS-based systems.

System of evaluation: practical course mark based on course work.

Literature:

- Alexander, M – Kusleika R. (2018): Access 2019 Bible. John Wiley and Sohn Inc, New York 1136 p.
- Ron McFadyen (2016): Relational Databases and Microsoft Access, Open Textbook, https://open.umn.edu/opentextbooks/formats/609
- Steven Roman (2002): Access Database, Design and Programming, O'Reilly, ISBN 978-0596002732

Suggested literature:

- McGrath, M. (2019): Access in easy steps - illustrated using Access 2019: Illustrating using Access 192 p.
- Pratt, P. – Last, M. (2016): Shelly Cashman Series Microsoft®Office 365 & Access®2016: Comprehensive, 856 p.
- Garry Robinson (2004): Real World Microsoft Access Database Protection and Security, Springer, DOI:10.1007/978-1-4302-0793-1

Subject title: CAD-based GIS

Name of person responsible for the subject: Bottlik Zsolt
Scientific degree of the person in charge: PhD

The aim of education:
a) knowledge
- Confident in the use of vector based geospatial software
- Knowledge of the basic concepts of vector-based GIS
- Ability to produce maps to meet all requirements
- Knowledge of CAD commands
b, abilities
- Ability to interpret complex professional problems in the field of geoinformatics, to explore the necessary theoretical and practical background and to solve problems.
- Ability to interpret geographical/spatial phenomena, processes and information, and to plan, organize, manage and control processes in the field of geoinformatics.
c, attitude
- Accepts and adheres to the ethical principles of work and organizational culture, especially with regard to the copyright related to geoinformatics.
- Committed to adhering to and making others adhere to quality requirements.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields.

Content of education: The aim of the course is to learn the basics of AutoCAD software. The course topic covers the joint use of ArcGIS software too, as it is essential for GIS specialists to know the transition among these software programs. As CAD software solutions are preferred and often used in municipal GIS, the examples during the course and the practical tasks and project tasks are related to the geographical scale of settlements.

System of evaluation: practical course mark based on course work.

Literature:

- An Introduction to AutoCAD for Beginners. Learn about AutoCAD. Autodesk - AutoCAD. online, https://images-na.ssl-images-amazon.com/images/I/C1BxaOC0-IS.pdf
- The Hitchhiker's Guide to AutoCAD. Autodesk Help. online, https://knowledge.autodesk.com/support/autocad/learn-explore/caas/CloudHelp/cloudhelp/2020/ENU/AutoCAD-Core/files/GUID-2AA12FC5-FBB2-4ABE-9024-90D41FEB1AC3-htm.html

Suggested literature:

- Elliot J. Gindis – Robert C. Kaebisch (2021): Up and Running with AutoCAD 2021. Elsevier. ISBN 978-0-12-823117-3. DOI https://doi.org/10.1016/C2019-0-04914-X
- Rick Ellis – Russell Martin (2020): A Practical Guide to AutoCAD Map 3D 2020. ISBN 978-1934865460.

Subject title: Environment and GIS

Name of person responsible for the subject: Dr. Magyari Enikő
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge
- Knowledge of national and international conservation categories
- Knowledge of spatial data bases used in nature conservation
- Knowledge of the vocabulary of nature conservation
- Negotiation skills in spatial data management for nature conservation projects
b, abilities
- Management of nature conservation data using geographic information software
- Active participation in the preparation of conservation project plans
- Competence in dealing with domestic nature conservation problems
c, attitude
- Accepts and adheres to the ethical principles of work and organizational culture, especially with regard to the copyright related to geoinformatics.
- Committed to environmentally conscious behaviour in his/her field and laboratory activities.
- Monitors professional and technological developments in the field of geoinformatics and the labour market trends.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.

Content of education: The aim of the course is to introduce students to the basic issues of nature conservation (species-level protection, habitat protection, population protection) and to give a brief overview of national and international nature conservation classification systems. After that, students study GIS challenges facing nature conservation, gain insight into the GIS databases of nature conservation, conduct landscape character surveys in a freely chosen sample area, get acquainted with the GIS database of NATURA 2000 sites, use realistic ecosystems. A practical task relating to the protection of wetlands in the Carpathian Basin will be solved by creating a map database of present and past wetlands and determining restoration potentials. At the end of the course, the effects of invasive species on the ecosystems are introduced and the history of the spread of an invasive species is depicted through GIS databases using some examples.
Course structure:
1. History of nature conservation (domestic, international), basic concepts (Relationship between nature conservation and environmental protection, Objects and levels of nature conservation, domestic protection categories, Forms of nature conservation activity)
2-3. GIS challenges before nature conservation: practical examples
4-5. Landscape character studies in GIS, project task
6-7. GIS system of the Natura 2000 network, project task
8. National Ecosystem Service Mapping and Assessment Program (NÖSZTÉP)
9-10. Land cover - ecosystem - ecosystem service, project task
11-12. Extent of loss and restoration potential of wetlands in the Carpathian Basin by joint evaluation of soil, surface cover and habitat maps using GIS methods (based on Decleer et al 2016), project task
13. Invasive (alien) species and conservation issues. Use of major Hungarian invasive animal and plant species, nature conservation treatments, Hungarian national parks, http://web.okir.hu/sse/?group=TIR OKIR.

System of evaluation: practical course mark based on course work.

Literature:

- Haines, Aubrey (1996). The Yellowstone Story: A History of Our First National Park: Volume 1 Revised Edition. Yellowstone Association for Natural Science, History of Education.
- Primack, B.R. (2014): Essentials of Conservation Biology, Sixth Edition. Boston University
- Dyke, F. (2003) Conservation Biology: Foundations, Concepts, Applications

Suggested literature:

- Harvey, F; Mei-Po Kwan; Pavlovskaya M (2005): Introduction: Critical GIS, Cartographica, Volume 40 Issue 4, Winter, DOI: 10.3138/04L6-2314-6068-43V6
- ESRI (2007): GIS for Wildlife Conservation, https://www.esri.com/~/media/Files/Pdfs/library/bestpractices/wildlife-conservation.pdf
- Geneletti, D (2004): A GIS-based decision support system to identify nature conservation priorities in an alpine valley, Land Use Policy, Volume 21, Issue 2

Subject title: Spatial energy planning

Name of person responsible for the subject: Dr. Munkácsy Béla
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge
- Knowledge of the specific tools of geoinformatics, ability to apply field survey procedures, data management and analysis, and visualization solutions. Knowledge and use of spatial data collection technologies, available databases and spatial information software, as well as open source and commercial geoinformatics software, cloud-based geoinformatics solutions.
- Understandings, knowledge and application of mobile field, laboratory and practical materials, tools and methods of geoinformatics.
- Knowledge in the main characteristics of renewable energy sources, the operating principles of the technologies that use them and the spatial representation of their main technical characteristics.
- Understands the principles and interrelationships of sustainable energy systems and is able to place technologies in the modern energy system due to wide perspective
b, abilities
- Ability to interpret complex professional problems in the field of geoinformatics, to explore the necessary theoretical and practical background and to solve problems.
- Ability to recognize and apply new problem-solving methods and procedures in his/her field and apply what he/she has learnt in a diverse, multidisciplinary environment.
- Ability to collect data independently and organize spatial data into a database, as well as to organize the data with the tools of geoinformatics. Ability to perform operations and models with independently organized databases
c, attitude
- Committed to environmentally conscious behaviour in his/her field and laboratory activities.
- Monitors professional and technological developments in the field of geoinformatics and the labour market trends.
- Committed to adhering to and making others adhere to quality requirements.
- Accepts and adheres to the ethical principles of work and organizational culture, especially with regard to the copyright related to geoinformatics.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects

Content of education: The purpose of this subject is to analyse the energy technologies described by the instructor on a project-based basis and to learn how to solve problems with geospatial support. Its main components are:
Section 1:
Energy systems (local, regional, national), trends, main development directions;
Characteristics of renewable energy sources and energy conversion technologies, their relationship to geographical space;
Case studies on the relationship between energy and GIS;
Environmental and energy-related (spatial) databases;
Section 2:
Geo-database construction, data management;
Spatial optimization of resources, site selection;
Modelling, production of statements: energy balances, geostatistics
Section 3:
Project work: self-employment with the chosen technology/plot, with the possibility of consultation;

System of evaluation: practical course mark based on course work.

Literature:

- Bent Sørensen: Renewable Energy. Physics, Engineering, Environmental Impacts, Economics and Planning. Academic Press. 1056 p. 2017 ISBN: 9780128026106
- Stoeglehner, G. (2020). Integrated spatial and energy planning: a means to reach sustainable development goals. Evolutionary and Institutional Economics Review. doi:10.1007/s40844-020-00160-7

Suggested literature:
Publications from the following journals:

- Renewable and Sustainable Energy Reviews;
- International Journal of Energy Planning and Management;
- Journal of Cleaner Production;

Subject title: Specific GIS software solutions

Name of person responsible for the subject: Dr. Kohán Balázs
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge
- Using previously acquired knowledge and experience, a high level of proficiency in almost any geographic information software and the ability to transfer this to others.
- Practical use of GIS in a wide range of subjects
- Producing user manuals
b, abilities
- Ability to interpret complex professional problems in the field of geoinformatics, to explore the necessary theoretical and practical background and to solve problems.
- Ability to interpret geographical/spatial phenomena, processes and information, and to plan, organize, manage and control processes in the field of geoinformatics.
c, attitude
- Accepts and adheres to the ethical principles of work and organizational culture, especially with regard to the copyright related to geoinformatics.
- Committed to adhering to and making others adhere to quality requirements
- Committed to environmentally conscious behaviour in his/her field and laboratory activities.
- Monitors professional and technological developments in the field of geoinformatics and the labour market trends.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields.

Content of education: The aim of the course is to familiarize the students with software products that were made for special purposes. Each student chooses a software program, they learn its use, then they make a short description about it, and show its use to other students via examples.

System of evaluation: practical course mark based on course work.

Literature:

- Roger Tomlinson: Thinking about GIS. ESRI Press, Redlands, USA, 2007 ISBN: 9781589483484
- https://www.researchgate.net/publication/323945547_Fundamentals_of_GIS

Suggested literature:

- https://www.researchgate.net/publication/331566663_Introduction_to_SAGA_GIS
- https://www.hec.usace.army.mil/software/hec-ras/documentation/HEC-RAS%205.0%20Reference%20Manual.pdf

Subject title: Hydrologic modelling

Name of person responsible for the subject: Dr. Telbisz Tamás
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge
- Complex knowledge of the general geographical, cartographic, planning, mathematical and informatic principles, rules, relationships required for the practice of geoinformatics, especially in the following topics: geographical and spatial data collection at various scales; use of cartographic processes; knowledge of geographical and spatial processes; collection, editing and analysis of spatial data; modelling
- Knowledge of the current theories, models and literature of geoinformatics based on scientific results. He/she is aware of the possible development directions and limits of the field of geoinformatics.
b, abilities
- Ability to interpret complex professional problems in the field of geoinformatics, to explore the necessary theoretical and practical background and to solve problems.
- Ability to creatively and methodically process, evaluate, interpret and analyse measurement results and draw conclusions from them.
- Ability to use the professional vocabulary of geoinformatics in his/her mother tongue and English.
c, attitude
- Committed to environmentally conscious behaviour in his/her field and laboratory activities.
- Monitors professional and technological developments in the field of geoinformatics and the labour market trends.
- Committed to adhering to and making others adhere to quality requirements.
- Open and committed to critical feedback and evaluation based on self-assessment.
- Accepts and adheres to the ethical principles of work and organizational culture, especially with regard to the copyright related to geoinformatics.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields.

Content of education:
Hydrological data types (precipitation, infiltration evapotranspiration, runoff).
Types and aims of hydrological models.
Drainage network derivation from DTMs.
Calculation of drainage basin characteristics.
Simple rainfall-runoff model creation using DTM.
Project work.

System of evaluation: practical course mark based on course work.

Literature:

- Li Z, Zhu C, Gold C, 2005: Digital Terrain Modeling. Principles and Methodology. CRC Press, 340 p., ISBN 9780415324625.
- Rabus, B., Eineder, M., Roth, A., Bamler, R. (2003): The shuttle radar topography mission – a new class of digital elevation models acquired by spaceborne radar. ISPRS Journal of Photogrammetry and Remote Sensing, 57(4):241-262.
- O'Callaghan, J.F., Mark, D.M., 1984: The extraction of drainage networks from digital elevation data. – Computer Vision, Graphics and Image Processing, 28, 323–344.

Suggested literature:

- Freeman, T.G., 1991: Calculating catchment are with divergent flow based on a regular grid. – Computers and Geosciences, 17(3), 413–422.
- Kiss, R. Determination of drainage network in digital elevation models, utilities and limitations. Journal of Hungarian Geomathematics, 2, 16-29., 2004
- Moore, I.D., Grayson, R.B., Ladson, A.R., 1991: Digital terrain modelling: A review of hydrological, geomorphological, and biological applications. – Hydrological Processes. 5(1), 3–30.
- Burrough, P.A. – McDonnell, R.A: Principles of Geographical Information Systems. – Oxford University Press, Oxford, 306 p., 1998 ISBN: 9780198742845
- Tarboton, D.G., 1997: A New Method for the Determination of Flow Directions and Contributing Areas in Grid Digital Elevation Models. – Water Resources Research, 33(2), 309–319.

Subject title: Nature conservation and GIS

Name of person responsible for the subject: Magyari Enikő
Scientific degree of the person in charge: DSc

The aim of education:
a, knowledge
- Knowledge of national and international nature conservation categories
- Knowledge of spatial databases used in nature conservation
- Knowledge of nature conservation vocabulary
- Has negotiation skills in spatial data management for conservation projects
b) abilities
- Management of nature conservation data using geographic information software
- Active participation in the preparation of conservation project plans
- Competence in dealing with domestic nature conservation problems
c, attitude
- Accepts and adheres to the ethical principles of work and organizational culture, especially with regard to the copyright related to geoinformatics.
- Committed to environmentally conscious behaviour in his/her field and laboratory activities.
- Monitors professional and technological developments in the field of geoinformatics and the labour market trends.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.

Content of education:
The aim of the course is to introduce students to the basic issues of nature conservation (species-level protection, habitat protection, population protection) and to give a brief overview of national and international nature conservation classification systems. After that, students study GIS challenges facing nature conservation, gain insight into the GIS databases of nature conservation, conduct landscape character surveys in a freely chosen sample area, get acquainted with the GIS database of NATURA 2000 sites, use realistic ecosystems. In relation to the protection of wetlands in the Carpathian Basin, a practical task will be solved by creating a map database of present and past wetlands and determining restoration potentials. At the end of the course, the effects of invasive species on the ecosystems are introduced and the history of the spread of an invasive species is depicted through GIS databases using some examples.

System of evaluation: practical course mark based on course work.

Literature:

- Haines, Aubrey (1996). The Yellowstone Story: A History of Our First National Park: Volume 1 Revised Edition. Yellowstone Association for Natural Science, History of Education.
- Primack, B.R. (2014): Essentials of Conservation Biology, Sixth Edition. Boston University
- Dyke, F. (2003) Conservation Biology: Foundations, Concepts, Applications

Suggested literature:

- ed. Tom Mueller, Gretchen F. Sassenrath (2015). GIS Applications in Agriculture, Volume Four, Conservation Planning, Taylor & Francis, ISBN 9781032098807
- ed. Basil G. Savitsky and Thomas E. Lacher Jr. (1998). GIS Methodologies for Developing Conservation Strategies, Columbia University Press, ISBN 9780231100267
- Nikos Krigas, Kimon Papadimitriou and Antonios D. Mazaris (2011). GIS and ex situ Plant Conservation, IntechOpen, DOI: 10.5772/50525

Obligatory optional courses – Module B

Subject title: Cartographic elements in geoinformatics

Name of person responsible for the subject: Dr. Zentai László
Scientific degree of the person in charge: DSc

The aim of education:
a, knowledge
- Familiar with the general cartographic and IT principles and rules necessary for the operation of geoinformatics;
- Knowledge of the specific tools of the geoinformatics discipline, the cartographic elements of field survey procedures, data management and analysis, effective cartographic representation in a geoinformatics environment;
- Knowledge and use of spatial data collection technologies, their cartographic aspects and key elements.
b, abilities
- Ability to select the most effective cartographic tools and software to solve a given task, depending on the complexity of the task;
- Ability to systematically process, evaluate, interpret and analyse the results of measurements and to support the drawing of conclusions from these results in cartographic terms, and to visualize them in an optimal way;
- Ability with the acquired cartographic knowledge to carry out effective, user-oriented planning, development and consultancy tasks in the operation of GIS, decision support systems and expert systems.
c, attitude
- Shares his/her knowledge, considers it important to communicate the results of cartography.
- Open to professional cooperation with professionals working in related fields.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields.

Content of education: The main aim of this course is to deliver the basic cartographic and IT elements and knowledge for the MSc students of geoinformatics. The primary task of geoinformatics is the analysis of spatial data, decision preparation and decision support. One of the most important tools for this is the map, the cartographic representation, the optimal data visualization. For the effective application of geoinformatics tools and software, for the proper visualization of our data, it is essential that students have a thorough knowledge of cartography, which can be well applied in any software environment, in any field of geoinformatics.
The primary goal of the course is to acquire the cartographic approach, to apply the most important, most effective elements of cartography in an IT, but mainly geoinformatics environment. The course facilitates the preparation to deal with cartographic problems that arise during the design, development, implementation and operation of geoinformatics systems. We lay emphasis on the development of cartographic skills in the theoretical and scientific problems of geoinformatics, and on the preparation for scientific research.

System of evaluation: oral and/or written exam.

Literature:

- Kraak, MJ–Ormeling, F.: Cartography, Visualization of Spatial Data, Fourth edition, CRC Group, 2021, 261 p., ISBN 9781138613959
- Field, K.: Cartography, ESRI Press, 2018, 576 p., ISBN: 9781589484399

- United Nations: Mapping for a Sustainable World, United Nations, 2020, DOI: https://doi.org/10.18356/9789216040468c001

Suggested literature:

- Del Lima, M.: Handbook of Cartography, Callisto Reference, 2015, 326 p., ISBN 1632393778
- Cynthia Brewer: Designing Better Maps, 250 p., ESRI Press, 2015, ISBN: 9781589484405
- Gretchen N. Peterson : Cartographer's Toolkit: Colors, Typography, Patterns, PetersonGIS, 2012. 184 p.; ISBN 9780615467948

Subject title: Operating systems

Name of person responsible for the subject: Dr. Kovács Béla
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge
- Knowledge of open- and closed-source operating systems
- Knowledge of distributed resource and supercomputing systems
- Knowledge of virtualised computing environments
- Installation and operation of linux systems
- Operation of field data collection devices
- Mobile device architecture

b, abilities
- Ability to use non MS-based operating systems (Unix, linux, android, etc.)
- Ability to install and operate open-source operating systems in real and virtualised environments
- Ability to perform basic management of cloud-based systems
- Program and operate field data collection tools
- Ability to perform basic management of computer local area networks

c, attitude
- Accepts and adheres to the ethical principles of work and organizational culture, especially with regard to the copyright related to geoinformatics.
- Committed to adhering to and making others adhere to quality requirements.

d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields.

Content of education:
- the basics of operating systems, terms and acronyms (UNIX, linux, free, non-free, BSD, CC, etc.)
- the core of UNIX-based systems
- the core of GNU/linux-based systems
- the TCP/IP networks
- UNIX/linux base commands and system programs
- virtualisation and paravirtualization techniques
- Debian/Ubuntu-based systems
- RH/CentOS-based systems
- other operating systems (Android, BSD etc.)
- create and manage the graphical UI
- mini systems, microcomputers, filed data loggers

System of evaluation: practical course mark based on course work.

Literature:
- Online help and manual pages of the selected operating systems (https://man7.org/linux/man-pages/)
- Modern Operating Systems, Andrew S. Tanenbaum and Herbert Bos, 4th edition, Pearson plc. 2015, ISBN: 978-0133591620

Suggested literature:
- UNIX Tutorial for Beginners (http://www.ee.surrey.uk/Teaching/Unix)

- A Practical Guide to Linux Commands, Editors, and Shell Programming, Mark G. Sobell, 3rd Edition, Pearson plc. 2012, ISBN: 978-0133085044
- UNIX and Linux System Administration Handbook, by Evi Nemeth, Garth Snyder, Trent Hein, Ben Whaley, Dan Mackin, 5th Edition, Addison-Wesley Professional, 2017, ISBN: 978-0134277554

Subject title: Drones in field spectroscopy

Name of person responsible for the subject: Dr. Jung András
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge
- Comprehensive knowledge of the problem-solving principles, methodology and procedures of the planning, development and operation processes of the geoinformatics field, especially in the following areas: database management, Big Data - data mining, primary and secondary data collection, earth observation, spatial and temporal data analysis, processes modelling and simulation, network analysis, 3-dimensional modelling, geovisualization, geostatistical solutions, web geoinformatics services, development of spatial services, geoinformatics programming, development of GIS applications, open-source GIS.
- Knowledge of the specific tools of the geoinformatics field, ability to apply field survey procedures, data management and analysis, and representation solutions. Knowledge and use of spatial data collection technologies, available databases and GIS software, as well as open-source and commercial geoinformatics software, cloud-based geoinformatics solutions.
- Understanding, knowing and applying the mobile field, laboratory and practical applications, tools and methods of remote sensing.
b) abilities
- Ability to creatively and systematically process, evaluate, interpret, analyse and draw conclusions from measurement results.
- Ability to collect data independently and organize spatial data into a database, as well as to organize the data with the tools of geoinformatics. Able to perform operations and model with independently organized databases.
- Ability to recognize and apply new problem-solving methods and procedures in his/her field and apply what he/she has learned in a diverse, multidisciplinary environment.
- Ability to collect data independently and organize spatial data into a database, as well as to organize the data with the tools of geoinformatics. Ability to perform operations and models with independently organized databases.
- Ability to recognize and apply new problem-solving methods and procedures in his/her field and apply what he/she has learnt in a diverse, multidisciplinary environment.
c, attitude
- Accepts and adheres to the ethical principles of work and organizational culture, especially with regard to the copyright related to geoinformatics.
- Open to professional cooperation with professionals working in related fields.
- Committed to adhering to and making others adhere to quality requirements.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields.

Content of education: The declining size and the increasing performance of portable field devices and the proliferation of multicopters have had a significant impact on field data collection, documentation, and mapping. GIS specialists also perform field work, including the production, verification or qualification of measurement results. Multicopters and other rigid-wing unmanned aerial platforms will play a significant role in this data collection process. Their applicability has accelerated tremendously, and their development and spread are unstoppable. Acquiring the theoretical and practical knowledge necessary for use and application is the basic goal of the course. A part of the training is to perform independent flight exercises, to get acquainted with the data collection and processing workflows. Understanding the operation of drone sensors (thermal, multi- and hyperspectral, Lidar, etc.), mastering its application possibilities.

System of evaluation: practical course mark based on course work.

Literature:

- Elliott, Z.P (2019) The Drone Pilot Handbook - ISBN-13-978-1675964255
- pdf materials published by the instructor on ELTE-CANVAS system

Suggested literature:

- Calafate,C. T., Tropea, M. (Eds.) (2020) Unmanned Aerial Vehicles Platforms, Applications, Security and Services. MDPI Publishing. ISBN 9783039367092
- www.easa.europe.eu
- ASA Test Board (2020) Remote Pilot Test Prep 2021. ISBN13(EAN): 9781619549753

Subject title: GIS-based cartography

Name of person responsible for the subject: Dr. Reyes Nunez José Jesús
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge
- Comprehensive knowledge and understanding of the key relationships and concepts in the field of geoinformatics, in particular in the following areas: geolocation data collection technologies, 2- and 3-dimensional geoinformatics modelling, geovisualization, spatial data infrastructures, geoinformatics programming and application development, vector and raster geoinformatics, digital image processing, web-based geoinformatics solutions, geoinformatics databases, applied geoinformatics systems.
- Understandings, knowledge and application of mobile field, laboratory and practical materials, tools and methods of geoinformatics.
b, abilities
- Ability to creatively and methodically process, evaluate, interpret and analyse measurement results and draw conclusions from them.
- Ability to collect data independently and organize spatial data into a database, as well as to organize the data with the tools of geoinformatics. Ability to perform operations and models with independently organized databases.
- Ability to recognize and apply new problem-solving methods and procedures in his/her field and apply what he/she has learnt in a diverse, multidisciplinary environment.
c, attitude
- Accepts and adheres to the ethical principles of work and organizational culture, especially with regard to the copyright related to geoinformatics.
- Committed to adhering to and making others adhere to quality requirements.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields.

Content of education: During the theoretical introduction to the course, the students become acquainted with the relation between geoinformatics and the world of general graphic software, presenting topics related to the antecedents, features, modules and applications. In the practices, students learn about the interaction of geoinformatics with drawing and editing options, importing and georeferencing GIS and graphic files, as well as preparing base maps, creating thematic maps and formatting a map sheet using a GIS module in a general graphic program. Students will be able to use topology-based drawing commands, to edit objects based on their attributes, to define attribute-based filters, to generate a nomenclature automatically and manually, and finally display the generated maps on printed and different interactive digital media (e.g. web and mobile devices).

System of evaluation: practical course mark based on course work.

Literature:

- Avenza (2020) MAPublisher 10.6: What's new? Accessible on: https://www.avenza.com/help/mapublisher/10.6/index.html?whats_new_in_mapublisher.htm
- Dodge, M., McDerby, M. and Turner, M. John (2008) Geographic visualization: concepts, tools and applications. Wiley&Sons, Ltd. ISBN 978-0-470-51511-2

Suggested literature:

- Peterson, G. N. (2020) GIS Cartography: A Guide to Effective Map Design, Third Edition. Taylor & Francis Limited, ISBN 0367857944, 9780367857943

- Cairo, A. (2016) The truthful art: data, charts, and maps for communication. New Riders. ISBN 13: 9780321934079
- Sui, D., Elwood, S. and Goodchild, M.(2013) Crowdsourcing Geographic Knowledge (VGI in theory and practice). Springer, ISBN: 978-94-007-9826-7

Subject title: Map design and editing P

Name of person responsible for the subject: Dr. Reyes Nunez José Jesús
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge
- Complex knowledge of the general geographical, cartographic, planning, mathematical and informatic principles, rules, relationships required for the practice of cartography
- Familiar with the specific tools of the geoinformatics discipline, learn the cartographic elements of field survey procedures, data management and analysis, effective cartographic representation solutions in a geoinformatics environment;
- Knowledge and use of spatial data collection technologies, their cartographic aspects and key elements.
b, abilities
- Ability to select the most effective cartographic tools and software to solve a given task, depending on its complexity;
- Ability to systematically process, evaluate, interpret and analyse the measurement results and to support the drawing of conclusions from these results in cartographic terms, and to visualise them in an optimal way;
- Ability with the acquired cartographic knowledge to carry out effective, user-oriented planning, development and consultancy tasks in the operation of GIS, decision support systems and expert systems.
c, attitude
- Open to professional cooperation with professionals working in related fields.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields.

Content of education:
Map types: base maps, general maps, thematic maps. Sources of map making.
Maps for the public. Types and concepts. General characteristics, scale and legend. Additions to maps: insets, name registers, search grids, alphabetical arrangement.
Map frame. Types of frames. Map model. Map extract. Form of the map sheet. Technical symbols on the map. Legend and explanation of symbols. The process and phases of map making.
Map content. Aspects of representation. Characteristics of objects and phenomena. Map elements. Layers of map content: relief, planimetric features, place names. Representation methods. Generalization: steps, guidelines, limits.
Relief. Representation of relief. Modern cartographic methods. Relationship between method, scale and map type. Planimetric features I. Drainage, elements and groups. Hydrographic objects. Representation of hydrographic features in various scales.
Planimetric features Borders. Categories of borders and their representation. Transportation features, their categories and representation. Land coverage. Representation of vegetation in various scales.
Representation of land-use and geographical zones of vegetation cover. Representation of built-up areas and settlements.
Geographical names: Place names. Labelling of places. Writing systems. Administrative names. Names of states and administrative divisions. Names of protected areas. Names of linear elements. Hydrographic names of linear features. Representation of administrative names referring g to area and line. Names of public domains.
Atlases. Types of atlases. Atlases of map sheets. Atlases of separate maps. Editing atlases.
Historical maps. The use of historical maps. Types of historical maps. Spatial representation of historical events. Showing dynamism on a static base. Publications. Relationship between the legend of popular maps and historical maps. Real historical map.

Cartographic fieldwork. Reconnaissance. Maps for orientation on the terrain. Revising tourist maps. Updating city maps. Sources of updating and revision.

System of evaluation: practical course mark based on course work.

Literature:

- Kraak, M.-J., Ormeling, F. (2020) Cartography: Visualization of Geospatial Data. Fourth Edition. CRC Press. ISBN 9781138613959
- Brewer, C. A. (2015) Designing Better Maps: A guide for GIS users. First edition. Esri Press. ISBN: 9781589484405
- Kraak, Roth, Ricker, Kagawa, Le Sourd: Mapping for a Sustainable World, United Nations-ICA, 2021, DOI: https://doi.org/10.18356/9789216040468, ISBN (PDF): 9789216040468

Suggested literature:

- Crampton, J. W. (2011) Mapping: A Critical Introduction to Cartography and GIS. First edition. Wiley-Blackwell. ISBN-13: 978-1405121729
- Field, K. (2018) Cartography. First edition. Esri Press. ISBN-13: 978-1589484399
- Raisz, E. (1948) General Cartography. McGraw-Hill Book Company: New York.

Subject title: 3D modelling in geoinformatics

Name of person responsible for the subject: Dr. Albert Gáspár
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge
- Complex knowledge of the general geographical, cartographic, planning, mathematical and informatic principles, rules, relationships required for the practice of geoinformatics, especially in the following topics: geographical and spatial data collection at various scales; knowledge of geographical and spatial processes; collection, editing and analysis of spatial data; photogrammetry, geostatistics, modelling, visualization
- Comprehensive knowledge and understanding of the key relationships and concepts in the field of geoinformatics, in particular in the following areas: geolocation data collection technologies, 2- and 3-dimensional geoinformatics modelling, geovisualization, spatial data infrastructures, geoinformatics programming and application development, vector and raster geoinformatics
b, abilities
- Ability to interpret geographical/spatial phenomena, processes and information, and to plan, organize, manage and control processes in the field of geoinformatics.
- Ability to collect data independently and organize spatial data into a database, as well as to organize the data with the tools of geoinformatics. Ability to perform operations and models with independently organized databases.
c, attitude
- Monitors professional and technological developments in the field of geoinformatics and the labour market trends.
- Committed to environmentally conscious behaviour in his/her field and laboratory activities.
- Committed to adhering to and making others adhere to quality requirements
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields.

Content of education: The aim of the course is to learn about the relationship between three-dimensional modelling and geoinformatics (geodatabases, data models, etc.) and to apply the knowledge in practice. The course is practice-oriented. The focus is on the simulation of problems and tasks encountered in real geoinformatics modelling. Task resolution highlights the essence of operations, which is software independent. The student is not asked to give the exact answer to the question, but to solve the problem with the correct result. 3D modelling in the course means modelling phenomena that are either continuous in space or fill the space under study (e.g. temperature, air pressure, soil, rocks, contamination, groundwater, etc.).

System of evaluation: practical course mark based on course work.

Literature:

- Albert, G.: *3D modeling in GIS (lecture notes)*, 117 p., 2016
- Abdul-Rahman, A., & Pilouk, M. (2007). *Spatial data modelling for 3D GIS*. Springer Science & Business Media. ISBN 978-3-540-74166-4

Suggested literature:

- El-Sheimy, N., Valeo, C., & Habib, A. (2005). *Digital terrain modeling: acquisition, manipulation, and applications*. Artech House. ISBN 978-1580-539210

- Lee, J., & Zlatanova, S. (Eds.). (2008). *3D geo-information sciences*. Springer Science & Business Media. ISBN: 978-3-540-87394-5

Subject title: Geodesy

Name of person responsible for the subject: Dr. Kovács Béla
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge
- Knowledge of the theoretical principles of positioning on the ground;
- Knowledge of the types of geodetic measurements, the best-known procedures and instruments used;
- Knowledge of the technical content of spatial data obtained by modern geodetic methods, their applicability in the process of creating map databases
b, abilities
- Ability to select the most appropriate geodetic data extraction method for the task in question, taking into account the technical and accuracy requirements of the task;
- Ability to evaluate the technical content of spatial data generated by geodetic methods and their incorporation into map databases, and to use spatial data obtained by geodetic methods.
c, attitude
- Knowledge of geodetic survey methods and tools, data acquisition technologies, helps to develop an appropriate attitude in professional cooperation with professionals working in the field of surveying
- Committed to environmentally conscious behaviour in his/her field and laboratory activities.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields.

Content of education:
- The student becomes acquainted with the role of geodesy in mapping/creating map databases.
- The student forms a concept about the elements and practical implementation of reference systems.
- The student gets acquainted with the basics of geolocation, types and tools of geodetic measurements and modern methods of geodetic data acquisition.
- The participant will learn the use of geodetic field surveying instruments.

System of evaluation: Oral and/or written exam.

Literature:
- B. Hofmann-Wellenhof and H. Moritz: Physical Geodesy, Springer-Verlag Wien, 2005.
- Lu, Zhiping, Qu, Yunying, Qiao, Shubo: Geodesy, Introduction to Geodetic Datum and Geodetic Systems, Springer, 2014.

Wolfgang Torge, Jürgen Müller: Geodesy, Walter de Gruyter, 2012

Suggested literature:
- Günter Seeber: Satellite Geodesy, Walter de Gruyter, 2003
- Peter J.G. Teunissen, Alfred Kleusberg: GPS for Geodesy, Springer Science & Business Media, 2012

Subject title: Geovisualization

Name of person responsible for the subject: Dr. Török Zsolt Győző
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge
- Complex knowledge of the general geographical, cartographic, planning, mathematical and informatic principles, rules, relationships required for the practice of geoinformatics, especially in the following topics: use of cartographic processes, visualization
- Knowledge of the current theories, models and literature of geoinformatics based on scientific results. He/she is aware of the possible development directions and limits of the field of geoinformatics.
- Comprehensive knowledge of the problem-solving principles, methodology and processes of the planning, development and operation processes of the geoinformatics field, especially in the following areas: geovisualization
- Knowledge of the basic processes of vision, brain imaging, spatial orientation and navigation
- Knowledge and use of experimental tools and methods for testing the usability of geovisualisation interfaces
b, abilities
- Ability to interpret complex professional problems in the field of geoinformatics, to explore the necessary theoretical and practical background and to solve problems.
- Ability to creatively and methodically process, evaluate, interpret and analyse measurement results and draw conclusions from them.
- Ability to recognize and apply new problem-solving methods and procedures in his/her field and apply what he/she has learnt in a diverse, multidisciplinary environment.
c, attitude
- Open to professional cooperation with professionals working in related fields.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields.

Content of education: The course presents the fundamentals of human cognitive visualization as an essential part of geoinformatics technology. The effective use of geoinformation systems depends on visual interfaces, maps and other cartographic representation forms. Visualization is interpreted as a cognitive process supported by external representation. Explore human vision, brain processes of human visual imagery, the processing and pathways of spatial information. Object recognition, the functions of the hippocampus in the human memory system. Cognitive map and spatial cognition: orientation, wayfinding, navigation. Study supporting human navigation through a visual interface. Pattern recognition and the horizontal organization of the map. Visual hierarchy and directing visual attention. Map user, use and usability studies: tools, methods and research results. UI and UX research in geoinformatics: interactive and adaptive technologies.

System of evaluation: oral and/or written exam.

Literature:

- Colin Ware 2011: *Information Visualization: Perception for Design. Interactive Technologies.* Wiley, New York. ISBN: 1558608192
- MacEachren, A.M. 2004: *How Maps Work: Representation, Visualization and Design.* (New York: Guilford Press. ISBN: 0898625890
- Keim, Daniel, Jörn Kohlhammer, Geoffrey Ellis, Mansmann 2010: *Mastering the Information Age. Solving Problems withVisual Analytics.* Eurographics Association, Goslar. ISBN: 9783905673777

Suggested literature:

- Bertin, Jacques 1983: *Semiology of Graphics. Diagrams, networks, maps.* Univ. of Wisconsin Press, Madison. ISBN: 9780299090609.
- Tufte, Edward 2001: *Envisioning information.* Plenum Press, Boston, ISBN: 9780961392116
- Çöltekin, A., Bleisch, S., Andrienko, G., Dykes J. (2017). Persistent Research Challenges in Geovisualization. *International Journal of Cartography* (3) 115-139.
- Griffin, A. L., White, T., Fish, C., Tomio, B., Huang, H., Sluter, C. R., … Picanço, P. (2017). Designing across Map Use Contexts: A Research Agenda. *International Journal of Cartography*, 3(sup1), 90–114.
- Török, Zsolt Győző – Török, Ágoston 2019: Cognitive Data Visualization—A New Field with a Long History. In: Klempous, Ryszard - Jan Nikodem - Péter Zoltán Baranyi (eds.): *Cognitive Infocommunications, Theory and Applications*, Springer International, ISBN: 978-3-319-95995-5

Subject title: Image processing

Name of person responsible for the subject: Dr. Gede Mátyás
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge
- Complex knowledge of the general geographical, cartographic, planning, mathematical and informatic principles, rules, relationships required for the practice of geoinformatics
- Knowledge of the current theories, models and literature of geoinformatics based on scientific results. He/she is aware of the possible development directions and limits of the field of geoinformatics.
- Knowledge in digital image processing
- Knowledge about geoinformatics programming and application development
b, abilities
- Ability to interpret complex professional problems in the field of geoinformatics, to explore the necessary theoretical and practical background and to solve problems.
- Ability to creatively and methodically process, evaluate, interpret and analyse measurement results and draw conclusions from them.
c, attitude
- Accepts and adheres to the ethical principles of work and organizational culture, especially with regard to the copyright related to geoinformatics.
- Committed to adhering to and making others adhere to quality requirements.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields.

Content of education:
Digital image processing and computer vision fundamentals and its use in geoinformatics

- Introduction to OpenCV/Python
- Basic image operations: load, display, crop, save. Various image representations (RGB, HSV, grayscale, binary) and conversions between them.
- Drawing operations
- Fundamentals of convolutional filters, most common kernel types
- Edge detection, line detection
- Feature detection. Training and using HAAR Cascades
- Character and text recognition using PyTesseract
- Camera calibration, stereo image evaluation

System of evaluation: practical course mark based on course work.

Literature:

- Adrian Rosebrock: Practical Python and OpenCV. 2016. https://www.pyimagesearch.com/practical-python-opencv/
- Joseph Howse, Joe Minichino: Learning OpenCV 4 Computer Vision with Python 3. Packt, 2020. ISBN: 9781789531619

Suggested literature:

- Mokhtar Ebrahim: Python Image Processing Tutorial (Using OpenCV). https://likegeeks.com/python-image-processing/

- GeeksforGeeks: OpenCV Python Tutorial. https://www.geeksforgeeks.org/opencv-python-tutorial/

Subject title: Thematic data visualization methods L

Name of person responsible for the subject: Dr. Albert Gáspár
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge
- Acquire knowledge of the history of cartography
- Learn the concepts, types and characteristics of data
- Knowledge in the types and characteristics of graphical representations and the methods to construct professionally correct thematic maps
- Interpret data (and maps) and draw conclusions
b, abilities
- Develops the graphic vision
- Ability to distinguish between reliable and unreliable data sources
c, attitude
- Accepts and adheres to the ethical principles of work and organizational culture, especially with regard to the copyright related to geoinformatics.
- Committed to adhering to and making others adhere to quality requirements.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields.

Content of education:
Topic and requirements of the semester. Literature and theory of thematic cartography. Cartographic generalization.
Overview of data representation techniques. Types of base maps.
History and development of thematic cartography.
Data sources, data types and their critical evaluation.
Characteristics of the field-specific thematic maps. Map types in Geosciences.
Maps of environmental, economic and social phenomena.
Thematic maps in education.
Thematic maps on special-purpose and in communication (e. g. maps in media).
Thematic atlases.
Colour theories. Maps in black and white.
Visualization of information. Relationship of graphic symbols and data representation.
Projections of thematic maps.
Thematic cartography in Geoinformatics.
Thematic maps on Internet.
Editing and processing errors on thematic maps.

System of evaluation: practical course mark based on course work.

Literature:

- Dent, Torguson, Hodler: Cartography – Thematic Map Design. McGraw-Hill Education, 2008 ISBN: 9780697384959
- Slocum, McMaster, Kessler, Howard: Thematic Cartography and Geographic Visualization. Pearson, 2008. ISBN: 9780132298346

Suggested literature:

- Tyner, J.: Map Design. The Guilford Press, New York, 2010 ISBN: 9781462517121

- Peterson, G. N.: GIS Cartography. A guide to effective map design. CRC Press, 2015, ISBN: 9781482220674

Subject title: Thematic data visualization methods P

Name of person responsible for the subject: Dr. Albert Gáspár
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge
- Acquire knowledge of the history of cartography
- Learn the concepts, types and characteristics of data
- Knowledge in the types and characteristics of graphical representations and the methods to construct professionally correct thematic maps
- Interpret data (and maps) and draw conclusions
b, abilities
- Develops the graphic vision
- Ability to distinguish between reliable and unreliable data sources
c, attitude
- Accepts and adheres to the ethical principles of work and organizational culture, especially with regard to the copyright related to geoinformatics.
- Committed to adhering to and making others adhere to quality requirements.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields.

Content of education:
Students prepare different types of thematic maps from data sets provided by the instructor or they do independent research and team work, but driven by instructor, on a complex thematic topic. This task consists of searching for special data and learning the characteristics of a socio-economic or geographic field for a specified area. Students also have to prepare documentation on their work or to prepare a descriptive, technical text on the topic they work on. The aim of this course is to meet as many data formats as possible and work with the main thematic map types.

System of evaluation: practical course mark based on course work.

Literature:

- Roger Tomlinson: Thinking about GIS. ESRI Press, Redlands, USA, 2007 ISBN: 9781589483484
- Dent, Torguson, Hodler: Cartography – Thematic Map Design. McGraw-Hill Education, 2008 ISBN: 9780697384959

Suggested literature:

- Slocum, McMaster, Kessler, Howard: Thematic Cartography and Geographic Visualization. Pearson, 2008. ISBN: 9780132298346
- Tyner, J.: Map Design. The Guilford Press, New York, 2010 ISBN: 9781462517121
- Malloy, N. R..: Essential Modeling Techniques for Geospatial Analysis Using ArcGIS. Geospatial institute, EUREKA, 2020

Subject title: Development of scripts and plugins in geoinformatics software

Name of person responsible for the subject: Dr. Gede Mátyás
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge
- Knowledge of the current theories, models and literature of geoinformatics based on scientific results. He/she is aware of the possible development directions and limits of the field of geoinformatics.
- Comprehensive knowledge and understanding of the key relationships and concepts in the field of geoinformatics, in particular in the following areas: geolocation data collection technologies, 2- and 3-dimensional geoinformatics modelling, geovisualization, spatial data infrastructures, geoinformatics programming and application development, vector and raster geoinformatics, digital image processing, web-based geoinformatics solutions, geoinformatics databases, applied geoinformatics systems.
- Knowledge of the specific tools of geoinformatics, ability to apply field survey procedures, data management and analysis, and visualization solutions. Knowledge and use of spatial data collection technologies, available databases and spatial information software, as well as open-source and commercial geoinformatics software, cloud-based geoinformatics solutions.
b, abilities
- Ability to interpret complex professional problems in the field of geoinformatics, to explore the necessary theoretical and practical background and to solve problems.
- Ability to initiate cooperation with design and development professionals and end users of geoinformatics results.
- Ability to create geoinformatics systems to support and assist decision makers
c, attitude
- Accepts and adheres to the ethical principles of work and organizational culture, especially with regard to the copyright related to geoinformatics.
- Committed to adhering to and making others adhere to quality requirements.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields.

Content of education:
In the first part of the semester, the students are getting familiar with the development of plugins in QGIS. In the second half of the semester, they acquire practice in the scripting of ArcGIS with Python. At the end of the semester, the students will be able to script this software while solving individual tasks. Some planned examples:

1. Exercises in QGIS
    a. Basics of module development
    b. Creating animated KML files in QGIS
    c. Generalizing buildings in QGIS
    d. Correcting generalized digital elevation models with river geometry
    e. EOTR sheet finding plugin.
2. Scripting in ArcGIS
    a. Introduction to scripting in ArcGIS
    b. Creating Relief energy maps from digital elevation models with various grid size
    c. Getting information from digital elevation models based on vector type data
    d. Route planning/networks
    e. Geocoding scripts
    f. Sequential map printing. Exporting layers from a given area. Setting predefined styles with scripts.

System of evaluation: practical course mark based on course work.

Literature:

- QGIS online Documentation, PyQGIS Developer Cookbook: https://docs.qgis.org/3.4/en/docs/pyqgis_developer_cookbook/
- Gary Sherman: PyQGIS Programmer's Guide. Extending QGIS 3 with Python 3. LocatePress LLC. ISBN: 9780998547725
- ArcGIS Pro Desktop: Creating Tools with Python. https://desktop.arcgis.com/en/arcmap/10.3/analyze/creating-tools/a-quick-tour-of-creating-script-tools.htm

Suggested literature:

- QGIS Plugins: https://plugins.qgis.org/
- Tateosian, L.: Python for ArcGIS, Springer, 2015. ISBN: 9783319183985

Subject title: Dedicated Geospatial Information Systems

Name of person responsible for the subject: Dr. Jung András
Scientific degree of the person in charge: PhD

The aim of education:
a, knowledge
- Comprehensive knowledge of the problem-solving principles, methodology and processes of the planning, development and operation processes of the geoinformatics field, especially in the following areas: database management, Big Data data-mining, primary and secondary data collection, Earth observation, spatial and temporal data analysis, modelling and simulation of processes, network analysis, 3-dimensional modelling, geovisualization, geostatistical solutions, web-based geoinformatics services, spatial services development, geoinformatics programming, development of geospatial applications, open-source geoinformatics.
- Knowledge of the specific tools of geoinformatics, ability to apply field survey procedures, data management and analysis, and visualization solutions. Knowledge and use of spatial data collection technologies, available databases and spatial information software, as well as open-source and commercial geoinformatics software, cloud-based geoinformatics solutions.
- Understandings, knowledge and application of mobile field, laboratory and practical materials, tools and methods of geoinformatics.
b, abilities
- Ability to creatively and methodically process, evaluate, interpret and analyse measurement results and draw conclusions from them.
- Ability to collect data independently and organize spatial data into a database, as well as to organize the data with the tools of geoinformatics. Ability to perform operations and models with independently organized databases.
- Ability to recognize and apply new problem-solving methods and procedures in his/her field and apply what he/she has learnt in a diverse, multidisciplinary environment.
c, attitude
- Accepts and adheres to the ethical principles of work and organizational culture, especially with regard to the copyright related to geoinformatics.
- Committed to adhering to and making others adhere to quality requirements.
d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields.

Content of education: This course introduces how geospatial information system applications serve the public or community´s interest and needs. Special attention will be paid to environmental or urban geospatial information systems. Furthermore, geospatial information systems will be discussed for the health sector, land use and -design process, telecommunication, transport, resource management, supply networks and -chains. Business-related applications will be presented as well, such as geomarketing, LBS and mobile LBS with community interest. A general overview will be given about domestic and international tendencies, visions and forecasts, development practices and theories, while considering human resources and the labour market perspectives. After completing the course, the students will be able to classify, select or evaluate geospatial information systems to make better geospatial decisions.

System of evaluation: oral and/or written exam.

Literature:

- Tian, B. (2016). GIS technology applications in environmental and earth sciences. CRC Press, ISBN 9781498776042

- Vieux, Baxter E. (2016). Distributed hydrologic modeling using GIS. Springer, ISBN 978-94-015-9710-4
- De Smith, M. J., Goodchild, M. F., & Longley, P. (2007). Geospatial analysis: a comprehensive guide to principles, techniques and software tools. Troubador publishing ltd., ISBN 13 978-1-912556-05-2

Suggested literature:

- Heritage, S. N. (2018). EcoServ-GIS v. 3.3: A toolkit for mapping ecosystem services (GB scale).
- Rai, P. K., and Nathawat, M. S. (2017). Geoinformatics in Health Facility Analysis. Springer, ISBN 978-3-319-44624-0
- Estaville, Lawrence E. (2012). Geospatial workforce trends in the United States. In Geospatial Technologies and Advancing Geographic Decision Making: Issues and Trends, pp. 82-89. IGI Global, ISBN 9781466602588

Subject title: Topography

Name of person responsible for the subject: Dr. Zentai László
Scientific degree of the person in charge: DSc

The aim of education:
a, knowledge
- Knowledge in the structure and content of topographic maps and map databases;
- Knowledge of the tools and processes of topographic survey and database construction;
- Familiar with Hungarian state topographic map databases and the possibilities of using state data.

b, abilities
- Ability to select the most appropriate state topographic map data for the task in hand, depending on the complexity of the task;
- Ability to participate in the creation of topographic maps and map databases.

c, attitude
- The acquisition of a map database approach helps to develop an appropriate attitude to professional cooperation with professionals working with state cartographic data in related fields

d, autonomy and responsibility
- Independence regarding the thorough examination and elaboration of professional issues and processes.
- Feels responsible for meeting and making others meet the deadlines. He/she is responsible for his/her work and for his/her co-workers' work in projects.
- With his/her knowledge and skills of geoinformatics, he/she cooperates responsibly with professionals in other fields.

Content of education:
The subject of geodesy. Positioning, units of measure. Locating points. Gravitational space, surfaces, elevation. Surfaces replacing the Earth. Projections, distortions. Sheet systems. Measurements, geodetic problems on plane. Measurement errors, accuracy, propagation of error. Point system of surveying. Networks. Marking points on the terrain. Geodetic instruments. Basics of optics. Theodolites. Horizontal measurement of angle. Methods of measuring. Orientation tools. Regular errors of theodolite. Positioning of points. Methods, calculations, building networks. Measuring distances. Optical tools of telemetry. Trigonometry. Measurement errors. Measuring elevations. Methods of determining elevation differences. Trigonometric, geometric and physical levelling. Levelling by satellites. Global positioning in geodesy. Types of GNSS (GPS, GLONAS, GALILEO, local navigation systems). Measurement methods and errors. GNSS services (permanent networks, GPRS). Detailed surveying. Instruments (Cartesian system, polar system, use of GPS, elevations, longitudinal and cross profiles, point clouds of mobile mapping systems). Cartographic visualization methods. Analogue and digital maps. Cartographic data models. Cadastral base maps and their content. Digital base maps. Standards and regulations. Surveying public utilities. Public utility maps.

System of evaluation: oral and/or written exam.

Literature:

- B. Hofmann-Wellenhof and H. Moritz, Physical Geodesy, Springer-Verlag Wien, 2005.
- Lu, Zhiping, Qu, Yunying, Qiao, Shubo: Geodesy, Introduction to Geodetic Datum and Geodetic Systems, Springer, 2014.
- Wolfgang Torge, Jürgen Müller: Geodesy, Walter de Gruyter, 2012

Suggested literature:

- Günter Seeber: Satellite Geodesy, Walter de Gruyter, 2003
- Peter J.G. Teunissen, Alfred Kleusberg: GPS for Geodesy, Springer Science & Business Media, 2012