Geoinformatics MSc final exam topics

Theoretical

1. Describe the procedure of building process and spatial models and present an analytical and numerical simulation solution. What are the steps of model testing from verification to simulation, illustrate the process with an example of modelling a chosen environmental process! How are the spatial modelling modules of geoinformatics systems constructed, describe the general and software-specific solutions of a geoinformatics software modelling system!

2. Demonstrate the traditional spatial data collection methods used in geoinformatics and the more modern, e.g. mobile GIS technologies. Describe in detail the geodetic methods, both terrestrial and satellite, global and national reference frames and transformation procedures. Explain the typical sources of error, the limits of measurement accuracy, the error correction procedures and corrections used, e.g. for GNSS systems. Under which conditions and for which dynamic phenomena can GNSS technology be applied in geodynamics?

3. Characterize the development of geospatial databases and their aims in the solution of environmental problems, based on knowledge of data collection strategies, data quality, pre-processing and data services. In this context, describe the phenomena of volunteered geographical information (crowdsourced data collection and 'citizen science'), data cubes and big data and their impact. Present an overview of environmental monitoring, including remote sensing data available at different scales and early warning systems.

4. In the topic of environmental informatics, highlight the specificities, spatial and temporal parameters, and applicability of point, image, and map-based land use, meteorological and climatic, hydrological, ecological, soil, topographic and 3D, air and water quality, and environmental databases and services available at different scales. The focus is on international databases, but the student may also present examples from his/her own country. Describe the role of cloud computing geospatial platforms. Also give an overview of administrative, spatial planning and land information systems.

5. Explain the technical parameters of aerial photography, analog and digital aerial photography, and the process of flight planning, with special reference to drone surveys. What are the steps of digital photogrammetric orientations and what are the coordinate systems used? Justify why aerial triangulation with block adjustment is the most common solution in today's digital photogrammetric workflow! How are point cloud, DSM, and orthophoto produced as photogrammetric output? What are the most common applications of drone imagery and spatial databases?

6. What are the types of digital elevation models and how do we distinguish between them? Describe the technology of laser (Lidar) data acquisition, the steps of point cloud cleaning and filtering. What are the most common point selection and interpolation methods in elevation modelling, highlight and describe each method in detail, and highlight the advantages and

disadvantages of the selected methods! Describe the derivatives and applications of elevation models.

7. What is the role of open-source data and software in GIS workflows? What are the advantages and disadvantages of using them? Give examples of freely available global, regional, and local data sources. Which open source softwares are most commonly used for geospatial tasks? Highlight and describe one of them! How can the functionality of these softwares be extended?

8. What is the role of web-based resources and technologies in GIS? Which technologies are suitable for publishing spatial data on the web? Describe the possible distribution of GIS functionalities in a client-server architecture and give specific examples of each case. How do WMS and WFS work? Demonstrate this with a concrete example. How can spatial data from WWW be integrated into desktop GIS systems?

9. Describe the advantages and disadvantages of using Python to develop geospatial applications. Describe the geoinformatics, domain-specific programming tools and programs in terms of usability (learning, complexity, accessibility, environment, documentation, developer communities), interoperability (OS, environments: software, API, virtual), syntax (OOP, variable handling, indentation, types, etc.), interdisciplinarity (Artificial Intelligence, data science, automation, etc.) and geoinformatics application potentials through examples.

10. Describe the physical principles of remote sensing and the resolutions of remotely sensed images (spatial, spectral, temporal, and radiometric). Describe the digital image acquisition process, and the differences, advantages, and disadvantages between optical multispectral and hyperspectral imaging (number of channels, bandwidth, image classification, information content). Describe the importance of the near- to mid-infrared range in vegetation mapping and present a classification method of your choice (machine learning, NN, spectral separation, etc.).

11. Describe the physical principles of thermal infrared (TIR) remote sensing and the processing of thermal remote sensing images. Describe the resolutions (spatial, spectral, temporal, and radiometric) of TIR images that can be acquired with different sensors and the differences, advantages, and disadvantages between TIR images. Describe the physical principles of microwave remote sensing and the process of microwave satellite imaging and processing (e.g. Sentinel-1 - sigma0, interferometric coherence). Describe the applications of microwave satellite imagery in time series analysis (inland water mapping, plant phenology, etc.).

Practical

1.a/ Build a simulation process model of an environmental process in a modeling system of your choice, explain the model variables, the relationships, and the differential equations used for the calculations. Run the simulation, present and evaluate the results in a variety of ways using reference data. b/ How can you use GIS models to address a spatial and/or environmental problem of your choice (e.g. site selection, contamination spreading, flooding)? What software environment, data, and workflow would you use?

2. Plan and present a monitoring survey of a dynamic spatial phenomenon (geological, geomorphological, hydrological, meteorological, etc.), specifying the tools and software, as well as additional databases and other spatial information you would choose to solve the task.

3. Design the structure of a database for storing spatial data (e.g. a cadastre of protected sites of a municipality, a web map of a national park). What criteria would you use to choose among the available data storage technologies?

4. Plan an aerial drone survey of an environmental hazard, including which UAV tool and planning software you would use for the survey. Describe and justify which digital photogrammetry and GIS software you would select for image and data processing and publishing! How would you check the quality and accuracy of the data produced and the reliability of the information to be provided to the intervening organisation?

5. Determine the catchment area of a settlement in an intermountain basin using geographic information tools. What data would you use? How would you model topography and runoff? What geographic information tools would you use to delineate the catchments?

6. How would you build a GIS project based exclusively on open source technologies (e.g. a cadastre of protected sites of a municipality; a web map of a national park)? Describe in detail the data collection, data storage, data analysis, and data visualisation steps. What criteria would you use to choose among the open-source technologies available?

7. How would you develop a framework for storing and publishing spatial data on the web and displaying in a thin client application (e.g. a cadastre of protected sites of a municipality, a web map of a national park)? Draw up an outline of the framework and define the role of each component. What criteria would you use to choose among the available technologies?

8. Demonstrate rainforest area loss in Indonesia using a Python application! In your presentation, discuss the data source of the Python application, its runtime environment, the libraries to be used, the structure and main units of the Python code and how the results are presented.

9. Perform a radiometric correction (ToA reflectance) of a raw Landsat satellite image (containing L0- DN values) in a chosen image processing software or programming environment based on the given metafile data.

10. Using reference data (e.g. crop map, land cover map), determine the area of each crop species or land cover class based on the Sentinel-2 image by image classification. Plan to determine the overall accuracy, producer, and user accuracy of the classification by classes.

11. Prepare an NDVI time series analysis for a sample area based on the given vector boundary (kml, shp polygon) of the area for 2 years in a cloud-based system, e.g. in the ESA Copernicus Data Space Ecosystem.

12. Based on different databases, create a geoinformatics solution for the optimal land use of a given area. Describe the applied environmental factors and specify which data layers, with which content and time scale could be used to determine the optimal land use at regional and local scales.