International Institute of Information Technology, Hyderabad

Spatial Informatics (GS2.401)
Monsoon 2025

Time: 180 minutes

Total Marks: 90

Note:

- If needed, make suitable assumptions and state them clearly when answering. <u>No doubts will be clarified during the exams.</u>
- Use figures appropriately to better communicate your idea and approach.
- ***<u>Write all answers clearly, concisely, and without ambiguity. Ensure your choices and explanations are easy to read and unconfusing.</u>

Part I. Multiple Choice Questions [Choose the most accurate answer.]   20 x 1m= 20m

1) Building Function Classification relies most critically on which combination of variables?
    a. Building height + slope
    b. Land use + number of floors + POI categories
    c. Presence of rooftop solar panels
    d. Building's nearness/farness to the lakes in the city

2) Which spatial indicator best distinguishes urban vs rural settlements in satellite imagery?
    a. NDVI variance
    b. Surface temperature
    c. Built-up density & connectivity
    d. Spatial distribution of the artificial waterbodies

3) For multi-temporal urban expansion analysis, which method best captures "new built-up growth"?
    a. NDBI time-series analysis
    b. Connectivity analysis of buildings from roads
    c. Change detection using NDVI comparison
    d. Buffer analysis around road network

4) Kharif vs Rabi cropland separation is best achieved using:
    a. combined index of soil moisture with slope
    b. time-series NDVI and NDWI signatures
    c. rectangularity metric of the crop field
    d. Accessibility of the water structures

5) Which evaluation metric is MOST appropriate to assess building function classification accuracy?
    a. RMSE
    b. Intersection over Union (IoU)

c. Confusion matrix with user's and producer's accuracy
d. Precision only

6) In drought-year agriculture analysis, which parameter would show earliest crop stress signals?
   a. Soil ruggedness index
   b. waterbody area reduction
   c. Soil moisture + NDVI reduction
   d. Increase in land surface temperature

7) Forest change to agriculture is best detected using:
   a. analysis of NDVI for the period of one year
   b. Normalized Burnt Area ration
   c. year-long variations in soil moisture
   d. LST diurnal amplitude

8) Which combination is most appropriate for enhancing waterbody detection from satellite imagery?
   a. NDVI high + NDBI high
   b. NDWI high + NDVI low
   c. SAVI high + NDVI high
   d. NDWI low + NDBI high

9) River meandering analysis over time requires:
   a. Channel centerline extraction from multi-temporal images
   b. River water flow analysis
   c. NDWI histograms
   d. Slope analysis of the riverbed

10) Seasonal reservoir changes should be mapped using:
   a. watershed delineation
   b. Summer–monsoon soil moisture difference
   c. Streams detection from flow accumulation
   d. Summer–monsoon NDWI difference

11) Urban change transition matrix essentially captures:
   a. Direction of the urban sprawl
   b. A binary map showing where change has happened
   c. it is similar to the confusion matrix in land use/cover classification
   d. Change of a land use/cover class to another

12) A strong positive Moran's I value for NDVI in a region implies:
   a. High-NDVI areas are randomly distributed
   b. High-NDVI cells are surrounded by low-NDVI cells
   c. Similar NDVI values cluster spatially
   d. NDVI values decrease with elevation

13) Which topological error occurs when two polygons share a boundary but do not touch exactly?
   a. Self-intersection
   b. Gap
   c. Planar enforcement
   d. Overshoot

14) For EV charging station planning, which dataset is the MOST essential?
   a. Building density map
   b. Locations of commercial buildings
   c. Vehicle emission data for a given city
   d. Mobility flows + land use + road network

15) Urban Heat Island (UHI) intensity is best computed using:
   a. Building function classes
   b. Surface temperature difference between urban & rural pixels
   c. Digital Surface Model from LiDAR point cloud
   d. Road network density

16) Estimating diurnal occupancy of buildings relies primarily on features:
   a. Population distribution + Building types + mobility patterns
   b. Building height + number of floors
   c. Accessibility to the recreational facilities
   d. Mobility patterns + traffic/congestion data

17) Land-slide susceptibility and risk analysis typically integrate:
   a. building + road n/w density
   b. DEM, rainfall, land use, soil's moisture retention capacity
   c. NDVI + flow accumulation analysis of the region
   d. cropping patterns in the region with drainage n/w

18) Which factor is most influential in nighttime UHI effects?
   a. Soil's heat retention capacity
   b. Heat retention by built-up surfaces
   c. Humidity of the city
   d. Heat retention by the lakes in the city

19) Which network analysis method is most relevant for optimal placement of EV charging stations?
   a. Fleet optimization
   b. OD computation
   c. Coverage analysis
   d. Tessellation

20) A "snap" operation in topology correction primarily helps with:
   a. Reducing raster noise
   b. Aligning nearly-coincident vertices

c. Eliminating dangles
d. merge two geometries

Part II. Answer the following

4 x 5m = 20m

21) For cartographic generalization answer following:
   a. **Define** cartographic generalization
   b. **State and define** any one method for cartographic generalization with **example figure**
   c. State one positive and one negative impacts this method.

22) In the context of terrain characterization:
   a. Define the ruggedness index statistics that can be used to describe the terrain.
   b. Explain how it is calculated? (state the formula and example if necessary)
   c. State it's importance in terrain analysis with the help of real-world use case

23) Explain with the help of appropriate figure the concept of multiple returns in LiDAR data. Explain in detail how can this be used to identify deciduous forest in spring vs winter?

24) For each of the following scenarios, identify the most appropriate type of network analysis and explain your choice in detail (indicate the data & its characteristics too).
   a. An emergency response team needs to decide on where to construct the new hospital that minimizes travel time for all accident hotspots in the city.
   b. A telecom operator wants to check how well the existing cell towers serve the city and whether there are any gaps.

Part III. Answer any 5 questions of the following

5 x 10m= 50m

25) a. Compare OGC web services WMS, WFS, and WCS? Explain with the help of a real-world use case why do we need three different services to achieve interoperability?
   b. Use your project topic as an example and explain in detail how will you build a web service for it? Draw the framework showing the framework of this web service, clearly mark the important components, data exchanges, etc.

26) a. Explain in detail the concept of spatial autocorrelation? Describe how it is computed? (use figures if required)
   b. Explain whether the spatial autocorrelation is related to the spatial interpolation? Justify your answer through the concept of variogram and Kriging interpolation.

c. Lets say, you are building an App that can show the Temperature of any given location. Briefly explain how you will build such an App using spatial techniques, based on the data available from Indian Meteorological Department's (IMD) weather stations.

27) Take an example of flood disaster and explain why **disaster situational awareness** is important:

a. Clearly list the necessary datasets required and their roles.

b. Clearly list the spatial functions are required and their roles.

c. Based on the datasets and spatial functions, draw the detailed framework, clearly showing data inputs/output, modules with the spatial function you proposed.

d. Explain how disaster management authorities will interact with the system (consider explaining through 1 or 2 queries).

28) Inclement (bad) weather impacts the flow of traffic over roads. Sometimes, bad weather causes incidents (accidents) which in-turn impact the traffic speed and flow. Generally, traffic simulation models assume good weather condition. We want to build a system to simulate the traffic flow based on the weather forecast, especially during bad weather. Assume that you have access to the traffic simulation tool which will take "average traffic speed" as one input parameter among others. Make other necessary assumptions. (Hint: think, in reality how would you drive a car during bad weather)

a. Design (draw) the framework and clearly label each component/module, inputs/outputs

b. Clearly list the necessary spatial datasets required and their roles.

c. Clearly list the spatial functions that are required and their roles.

d. Explain the working of the entire framework with the help of above dataset and spatial functions

29) a. Explain the meaning of topology in the spatial data. What is its core property? State briefly with the help of example figure.

b. Use the concepts of arc-node, polygon-arc, and arc-polygon topologies, write down tables showing the vector model for following spatial data. (Nodes: N1, N2..,N6, Arcs: L1, L2,…, Polygons: A, B,..,E)
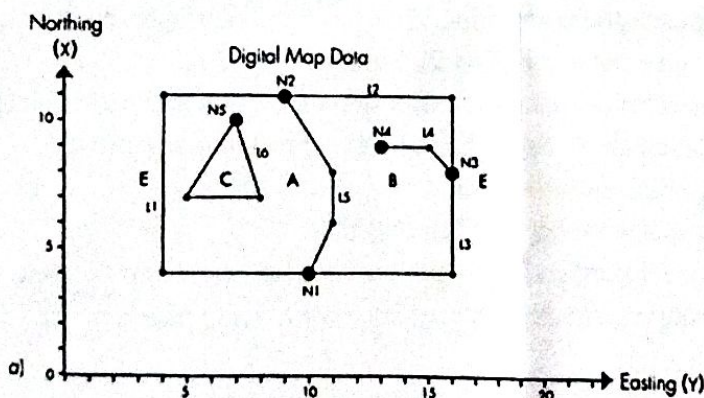
e. Recall the concept of spatial overlay and apply it for the following scenario in which the leftside map is a land use/cover map and the rightside map is a soil type map. Draw the map showing the combined information, i.e. land use/cover+soil type. Provide the necessary details explaining how you obtained the final map (e.g. spatial functions involved, how did you merge the attributes, etc.).
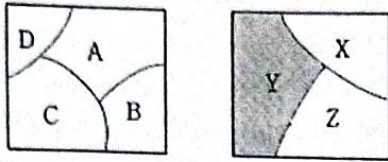
30) GHMC wants to develop a system to dynamically assess the road conditions in the city so that the patch work can be prioritize and the problem is addressed with reduced time. For this purpose, they collaborated with the companies like Ola and Zomato. GHMC build a mobile app which uses the mobile sensors such as accelerometer and gyroscope to collect information on vehicle vibrations, which is a proxy for the road condition. This mobile app is installed in the mobiles of company employees. For example, imagine how you feel when your car goes over a pothole.

a. Describe in detail through the system diagram your approach to develop such system covering aspects from data collection to visualizing various insights. (Hint: This data is a spatio-temporal data)

b. Clearly state how the data look and how do you propose to store it?

c. State what insights you would want to extract from this data and which spatial functions do you propose to achieve it. State any other data required for this purpose.

d. How do you propose to disseminate the insights to the GMHC personnel?

31) As a planner working for a town municipality, you are asked to demarcate the land suitable for industrial zones, with a minimum area of 10hectares. (1ha = 100mx 100m). You have access to the following data sets. Describe how you would use a spatial technique to find suitable areas

- A land use map containing the following classes: Lakes, streams, forest, single cropping lands, double/triple cropping lands, wastelands, industry, low-density residential areas and high-density residential areas. The data set is stored in a raster format with a cell size of 10x10 m.
- A digital elevation model stored in a square raster. The raster has a 30 meter resolution.
- A vector data set containing cadastral information. Each parcel has attributes containing information about: Owner, value and dominating land use.
- A road data set. The roads are stored in a network data structure where each road link has attributes containing information about: Speed limit, length, travel time and owner.
- A vector data set containing railroads and stations.
- A vector data set with green zones that ought to be protected.
- Some of the conditions include that agriculturally productive lands should not be used, should be within 25kms from the rail stations, should be atleast 2km away from green zones and 3km away to residential areas.

Best of Luck!!