كلية العلوم
قـــــــــم الانظمة الطبية الذكية

Lecture: (3)

Geographic Information Systems (GIS)

Subject: Geographic Information and Spatial Data Types
Level: Third
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Introduction

Geographic Information Systems (GIS) are a powerful tool used to handle spatial data, which represent various aspects of the Earth's surface. These systems provide the ability to analyze and visualize data based on location, time, and spatial relationships. Spatial data types in GIS include vector and raster formats, each suitable for different types of geographical phenomena. The digitalization of geographic phenomena allows for efficient storage and manipulation of data, transforming raw information into actionable insights.

Models and Representations of the Real World

Modeling refers to the process of creating abstractions of real-world phenomena to simplify their analysis. In GIS, this abstraction is typically digital, involving the representation of physical features through data structures that allow for computational analysis. According to Goodchild (1998), the real world is represented in GIS using a combination of discrete and continuous data types, with each phenomenon being captured through a digital model that can be queried and manipulated. However, these models come with limitations in data resolution, storage capacity, and processing speed (Longley et al., 2015). Therefore, trade-offs are made when designing models to ensure that key aspects of the real world can be effectively represented within the technical constraints of the system.

Geographic Phenomena

Geographic phenomena can be defined as any event or object that has a spatial component. These phenomena are essential in spatial analysis, as they are subject to both geographical location and temporal attributes. For example, a river basin

can be considered a geographic phenomenon that changes over time due to factors like rainfall and water use. It is critical to assign both spatial coordinates and a time frame to these phenomena to ensure accurate representation (Coppock & Rhind, 2006). Understanding the temporal aspects of these phenomena is crucial when conducting studies that aim to analyze changes over time, such as in environmental monitoring or urban planning.

Types of Geographic Phenomena

Geographic phenomena vary in how they manifest across a study area. Some phenomena are ubiquitous, such as atmospheric pressure, which exists across the entire study region. Others, like geological formations or land-use types, may be present only in specific locations. This distinction influences how data is represented and analyzed within GIS. Discrete phenomena are represented through bounded areas or zones, whereas continuous phenomena are modeled using smooth functions that span the entire region (Burrough & McDonnell, 1998). Understanding the nature of these phenomena helps in selecting the appropriate data representation technique.

Geographic Objects

Geographic objects are well-defined entities that have specific locations, shapes, and sizes. These can be natural, such as rivers and mountains, or man-made, like roads and buildings. The spatial attributes of these objects—location, shape, size, and orientation—are fundamental for their representation in GIS. As emphasized by Zeiler (1999), the accurate representation of geographic objects is crucial for

applications in urban planning, transportation management, and environmental monitoring.

Geographic Fields

Geographic fields are a type of geographic phenomenon where each point in the study area has a value assigned to it. These fields can be either discrete or continuous. A continuous field, such as temperature or elevation, assumes that values change gradually across space, and this smooth variation is crucial for interpolation techniques (Tobler, 1970). In contrast, discrete fields, like soil type or land use, divide space into distinct categories. These fields are often used in land management and environmental monitoring to categorize areas based on specific attributes.

Data Types and Values

In GIS, data types can be classified into four categories: nominal, ordinal, interval, and ratio. Nominal data refers to categories with no inherent order, such as soil types or land-use classifications. Ordinal data represents categories with a natural order but without meaningful distances between categories, such as rankings of vegetation density. Interval data allows for computations like addition and subtraction, but lacks a true zero point, such as temperature. Ratio data, which includes true zero points, enables all arithmetic operations, such as elevation or distance measurements (McMaster & Shea, 1992).Each data type influences the types of analysis that can be performed, guiding the selection of appropriate methods for spatial analysis.

Boundaries

The concept of boundaries is critical when dealing with spatial objects that are continuous and measurable. Boundaries define the limits of geographic phenomena and are essential for accurately representing regions of interest. As demonstrated by Clarke (2003), the identification of boundaries is crucial for applications such as property delineation, environmental zoning, and land-use planning. GIS can utilize vector-based models to define these boundaries with precision, ensuring that spatial analyses are based on clear, well-defined regions.

Computer Representations of Geographic Information

In GIS, geographic information is typically represented using two main techniques: tessellation and vector representations. Tessellation is the division of space into regular or irregular cells, while vector representations use points, lines, and polygons to model objects and phenomena (DeMers, 2005). Both methods are used to represent different types of geographic data, with tessellations being ideal for continuous fields and vectors for discrete objects. Furthermore, the interpolation process allows for estimating values at unmeasured locations. For example, in environmental studies, researchers often use interpolation to estimate values such as soil moisture or air quality between known observation points. The use of various interpolation methods, such as linear or polynomial interpolation, enables GIS analysts to predict and visualize spatial phenomena with greater accuracy.