

ISA

Geographic Information Systems 2026/2027

Lesson 02 - Information Systems, vector data structure

UNIVERSIDADE
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AGRONOMIA

Topics

- Information Systems
- Geographic Information Systems
- Geographic data characteristics
- Geographic data storage
- Vector data structure
- Vector data – types of geometry

Information Systems

- Information systems (IS) are widely used in many different contexts
- IS are designed to collect, process and store data and aim to distribute data (at least, to distribute information)
- An IS always represent a small part of reality
- Reality may be interpreted and described in many ways:

reality is complex and has many characteristics; it is not possible to represent all of them in only one information system

each information system only represents one given conceptualization of reality
Can be linked (e.g:
<https://www.fao.org/agrovo/c/linked-data/>)

each information system only represents a description of some reality characteristics – the choice of these characteristics depends on the each IS purposes

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Information Systems - components

IS have several components:

- **Hardware** – physical devices enabling computing, data processing & communication
- **Software** – programs/applications controlling hardware operations & enabling data processing.
 - Operating Systems
 - Application (end-user programs)
- **Data** – information on a subject, portraying a portion of reality
 - Databases
 - Metadata
- **People** – users and IT professionals who develop, manage, and use information systems
- **Procedures** – commands to combine components above to process data & produce the preferred output (information)

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Database

- Database is a set of interrelated data
 - one database represents the **characteristics** of reality that are **significant** to solve a **given set of problems**
- Databases are implemented through a **Database Management System (DBMS)**
 - DBMS are a specific category of software applications
- There are several available DBMS
 - Most commonly used: **relational DBMS** (allowing the creation of relational databases)
Examples: Microsoft Access, Oracle, SQL Server, PostgreSQL, MySQL, ...
 - Some are open-source software (PostgreSQL, MySQL) but most of them are commercial software

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Information Systems - categories

- Office automation
- Enterprise systems
- Process control systems
- Decision support systems
- Expert systems
- ...
- **Geographic Information systems**

These categories are very loose. For instance, presently, many enterprise systems are also geographic information systems

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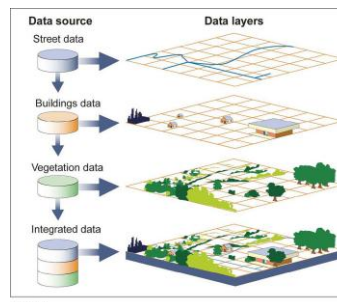
Geographic Information Systems

Components of a Geographic Information Systems (GIS):

- Hardware
- Software
- Data
- People
- Procedures

Created to solve complex problems requiring **spatial operations** on **data located in space**, including:

- storage
- management
- processing
- analysis
- modelling
- visualization



Source: GAO

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GIS – Software Component

Others solutions: gvSIG, MapInfo Pro, Google Earth Engine, PostGIS, ENVI

QGIS vs. ArcGIS Pro

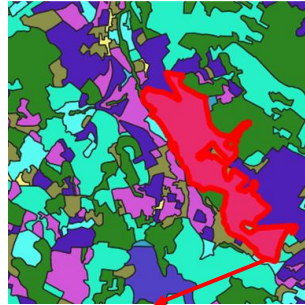


Cost	Free and open source	Proprietary, requires a paid license and additional paid licenses for modules
OS	Windows, macOS and Linux	Windows
Interface	traditional	dynamic, ribbon
Functionality	wide range	wide range, more advanced in some areas (3D)
Plugins	many, from the community	some, from ESRI and partners
Format support	many	some
CRS support	many, with transforms on the fly	some, with transforms on the fly

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GIS – Data Component

- GIS data describe the characteristics of **geographic objects** (also called spatial objects, geographic entities, geographic phenomena or **features**)
- In GIS, every geographic object is described by its characteristics
 - **spatial characteristics** identify its location on the Earth surface
 - **non-spatial characteristics** describe its other properties relevant to the GIS purposes



COS2007I2 - Feature Attributes

fid	404
CLC12code	21
CLC12descr	Arable land
CLC11code	2
COS12	2.1

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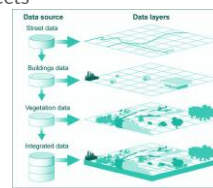
Spatial characteristics

- There are several methods to identify locations on the Earth surface
 - **Continuous methods** use coordinates referred to a given **Coordinate Reference System (CRS)**
 - **Discrete (indirect) methods** use references to other spatial objects with known coordinates
Examples:
 - address codes
 - administrative boundaries
 - Landmarks (<https://www.google.com/maps?q=Torre%20de%20belem>)
- Coordinates and CRS will be further detailed later on ...

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Non-spatial characteristics

- Non-spatial characteristics are similar to those included in conventional IS
 - examples: land coverage class, parcel owner, municipality name, main town, number of inhabitants ...
 - some characteristics can be hierarchically structured (land coverage classes, among many others)
- Non-spatial characteristics are stored as **attributes** of the geographic objects
- In GIS, non-spatial characteristics are usually organized by **themes**
 - examples: soil use, land cover, administrative borders, heights
 - in the GIS context, themes are often called **layers**



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Data structures & storage

- Data storage may use
 - either a **vector data structure**
 - or a **raster data structure**
- Data are stored in files
 - file formats specifically designed to store geographic data:
 - geopackage (.gpkg) - SQLite container, open standard (QGIS native format)
 - shapefile (.shp) - composed of several files (.shp, .shx, .dbf, .prj, .sbn, .sbx, ...)
 - Geodatabase (.gdb) - ArcGIS proprietary format
 - Drawing Exchange Format (.dxf)
 - DGN file format
 - DWG file format, ...
- Some are **open**, non-proprietary, **platform-independent** and **standards-based** file formats & can be used by almost all GIS applications;
- Other are proprietary & probably, can only be used by a small number of GIS applications (often only one)

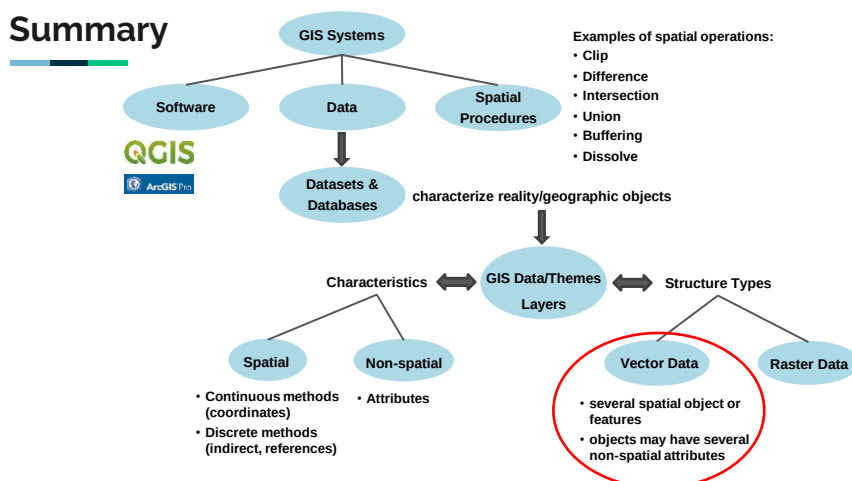
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GIS – Procedures Component

- **Spatial Analysis** – a set of analytical methods based on data about **location** in space (the Earth surface) of natural (concrete or abstract) objects or phenomena
 - sometimes involving also other types of data
- Spatial Analysis involves the usage of **spatial operations** – operations using the values of the coordinates representing locations on the Earth surface
 - Examples of spatial operations:
 - Clip
 - Difference
 - Intersection
 - Union
 - Buffering
 - Dissolve
 - Map Algebra, ...

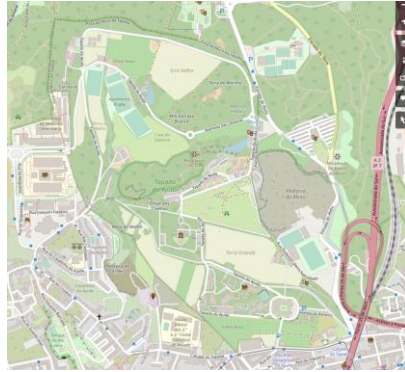
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Summary



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The vector data structure

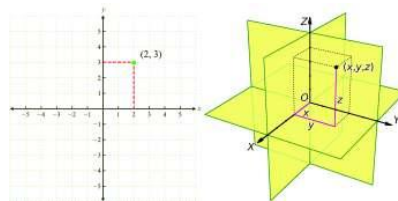


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The vector data structure

- The location on the Earth surface of geographic objects is represented as **points**, **lines** or **polygons**

- These representations can be:
 - 2D
(longitude/meridian/x & latitude/parallel/y)
 - 3D
(longitude/meridian/x, latitude/parallel/y, height/elevation/z)



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The vector data structure

- Every **point** is defined by an ordered pair (x,y) or by a triplet of coordinates (x,y,z) referenced to a given Coordinate Reference System (CRS)
 - The pair or triplet of coordinates is composed with numbers (real numbers in the CRS map units)
- Every **line** is defined by an ordered set of points (in this context also called vertexes or vertices)
 - Lines can also be 3D when their vertices are 3D
- Every **polygon** is defined by a line which starting and ending point coincide (so-called closed line)
 - Polygons can also be 3D when their vertices are 3D

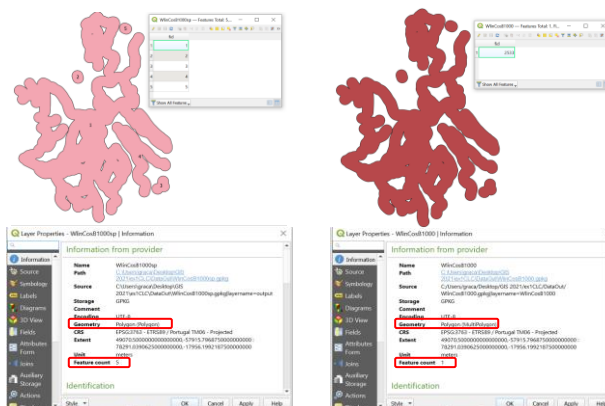
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Types of geometry

- **Singlepart features** are elementary features (point, line or polygon)
- **Multipart features** are composed by elementary features (ex.: archipelagos, discontinuous municipalities, ...)

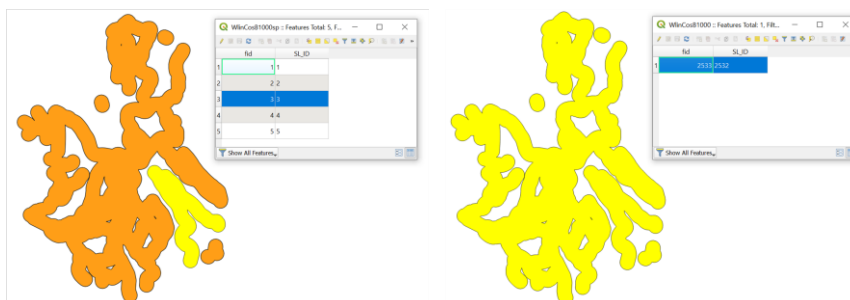
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Singlepart vs Multipart geometries



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Selecting Singlepart vs Multipart geometries



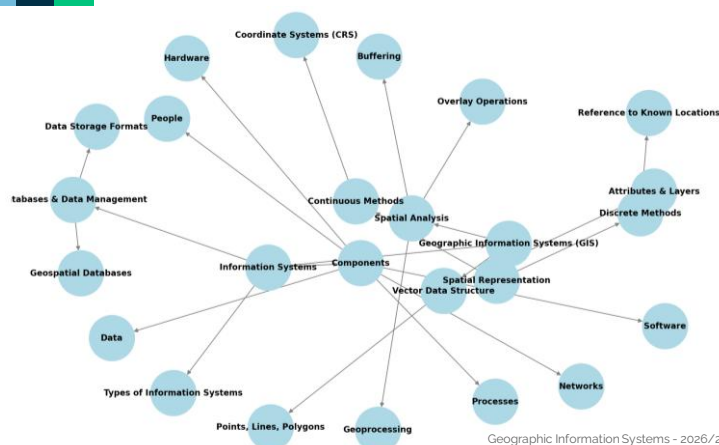
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Types of geometry

- **Singlepart features** are elementary features (point, line or polygon)
- **Multipart features** are composed by elementary features
(ex.: archipelagos, discontinuous municipalities, ...)
- Presently, technology imposes that all objects in a layer (or theme) share a common geometric type:
 - singlepart point
 - singlepart line
 - singlepart polygon
 - multipart point (MultiPoint)
 - multipart line (MultiLine)
 - multipart polygon (MultiPolygon)

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Summary Network



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Credits

The structure and content of the course, including most of the slides and exercises was developed by Professor Graça Abrantes (SIG 2021_2022) and Professor Rui Figueira (SIG 2023_2024)

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