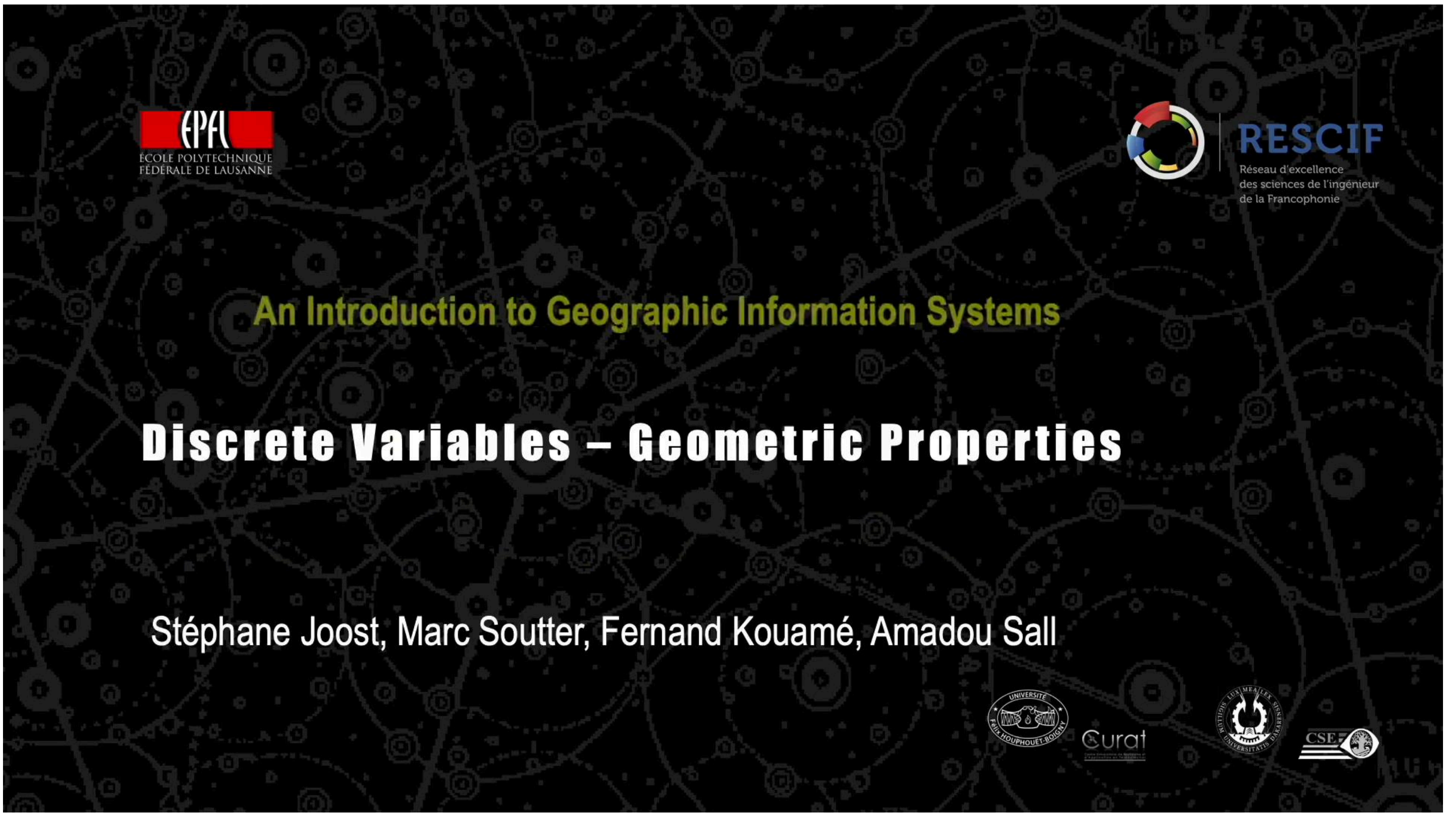
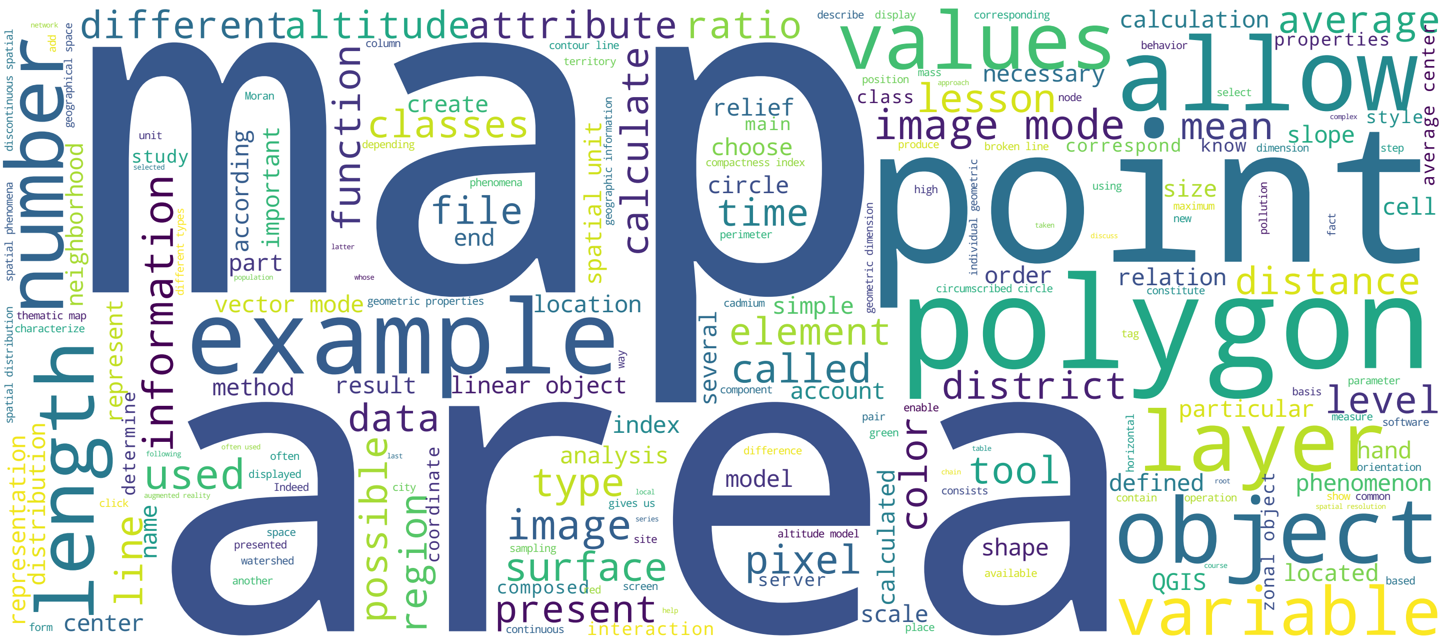

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE
RESCIF
Réseau d'excellence des sciences de l'ingénieur de la Francophonie
An Introduction to Geographic Information Systems
Discrete Variables – Geometric Properties
Stéphane Joost, Marc Soutter, Fernand Kouamé, Amadou Sall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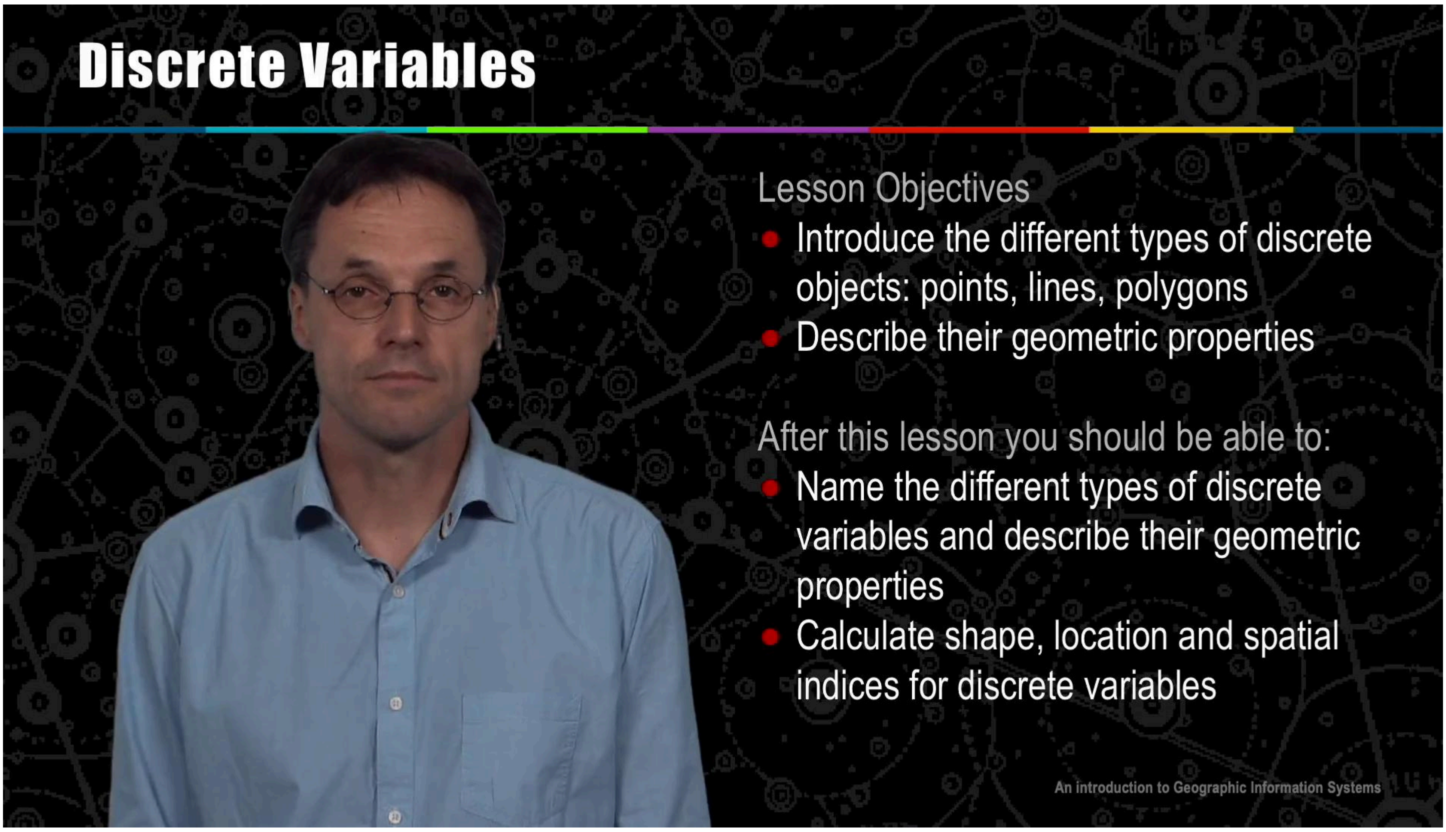
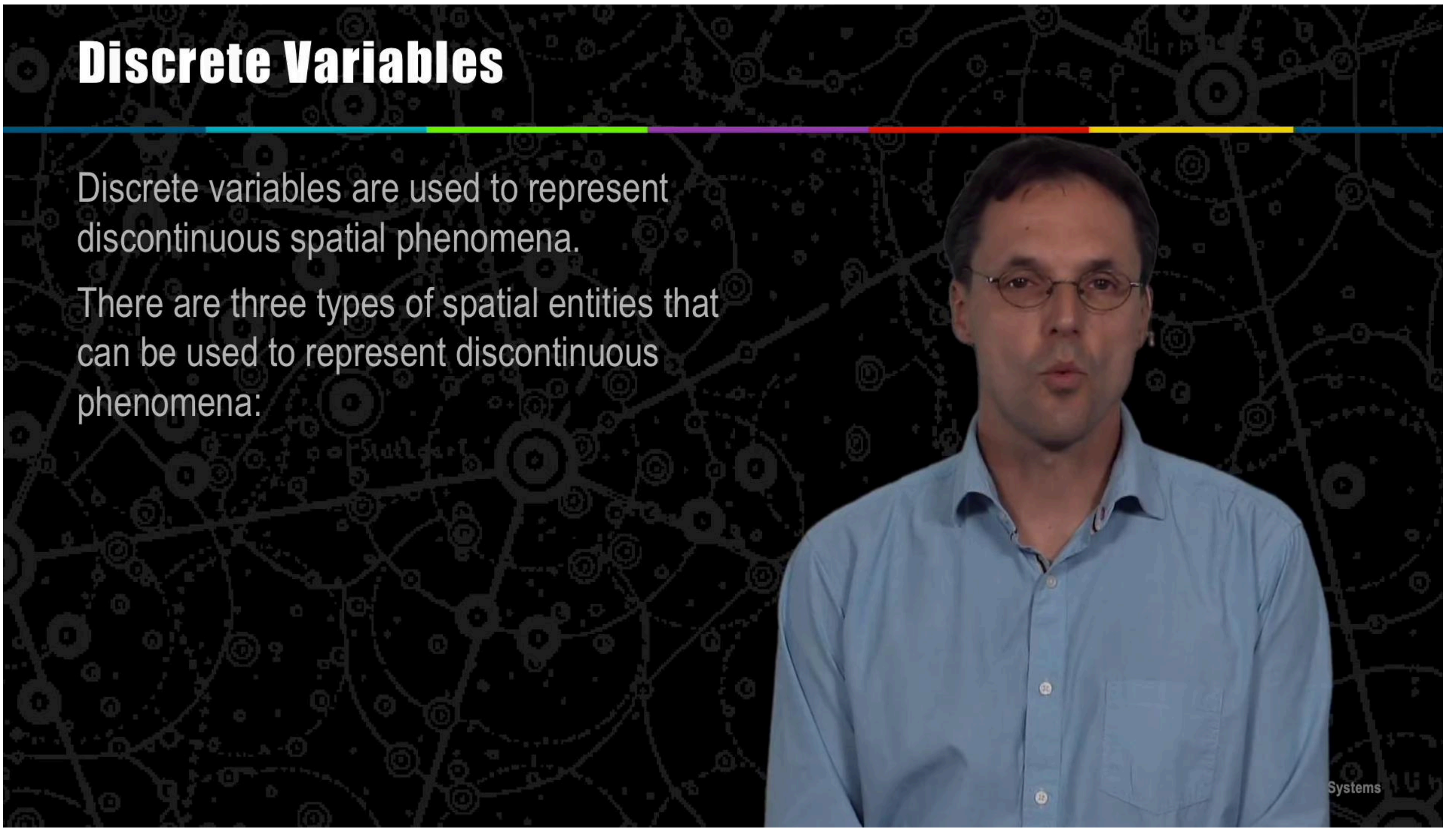


Welcome to this first lesson on geographic information analysis. This module is divided into four main chapters. First, we will discuss the discontinuous spatial phenomena before talking about the continuous spatial phenomena in the second part. Then, we will examine the particular case of numerical models of altitude before concluding with the interaction between layers of data of different types. The first part of this course on spatial modeling has allowed to describe the properties of the phenomena which take place on the surface of the earth. Their spatial distribution is either discrete or continuous. A continuous distribution concerns a phenomenon which is defined in all points in space such as the altitude or the temperature, for example, and it is modelized as a continuous surface. A discrete distribution is translated by an object-type model which is declined in punctual, linear or surface spatial units. And it is these discrete variables which we will discuss in this lesson. We will review the different types of discrete geographic variables and describe their geometric properties so that you are able subsequently to know these objects, to know their geometric properties and also to calculate forms, location and size indices.

Notes

Summary

0m 30s

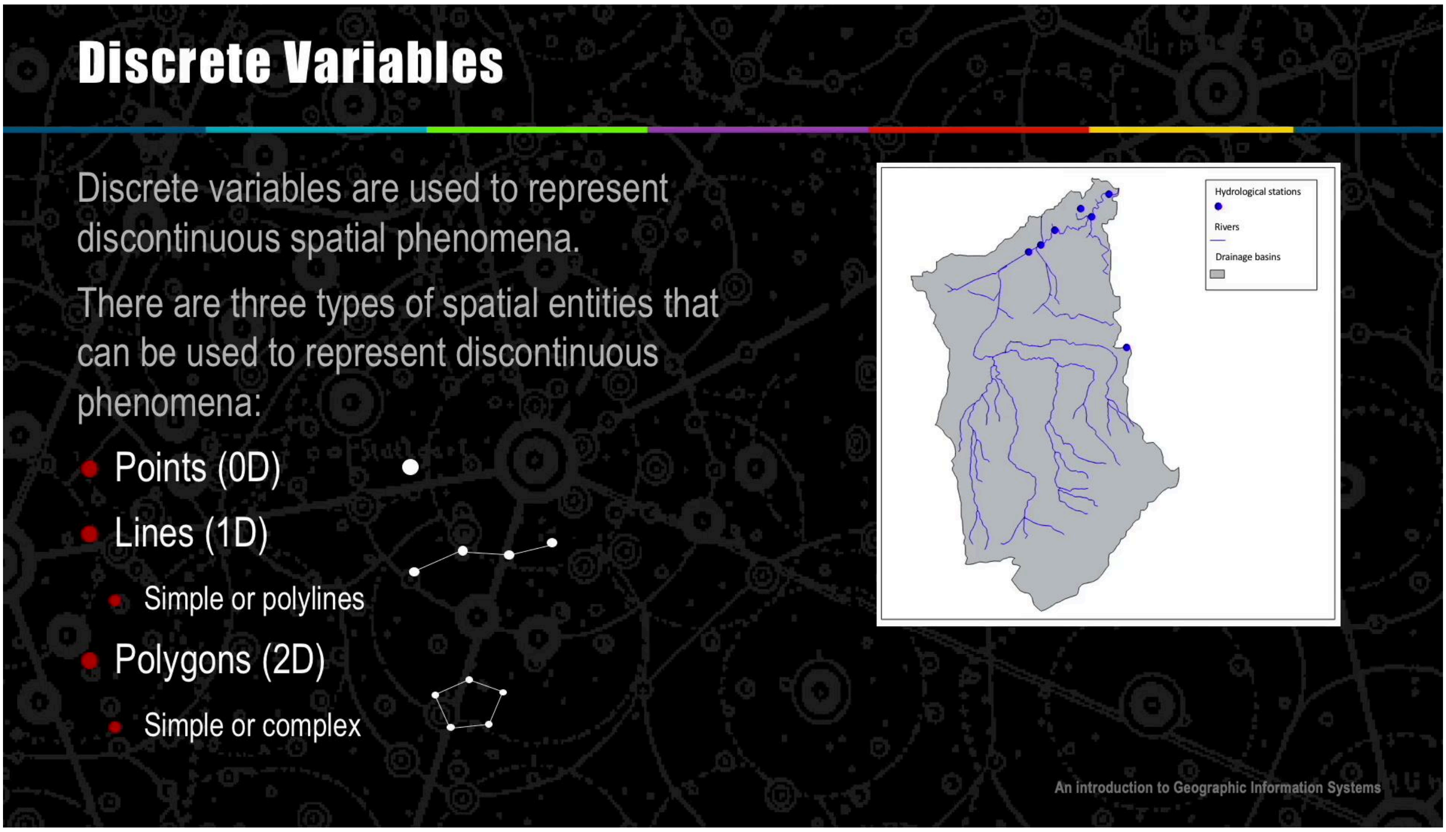


As mentioned earlier, discrete geographic variables are used to represent discontinuous spatial phenomena. We speak of discontinuous phenomena if the distribution of thematic properties of this phenomenon in geographical space is discontinuous.

Notes

Summary

2m 04s

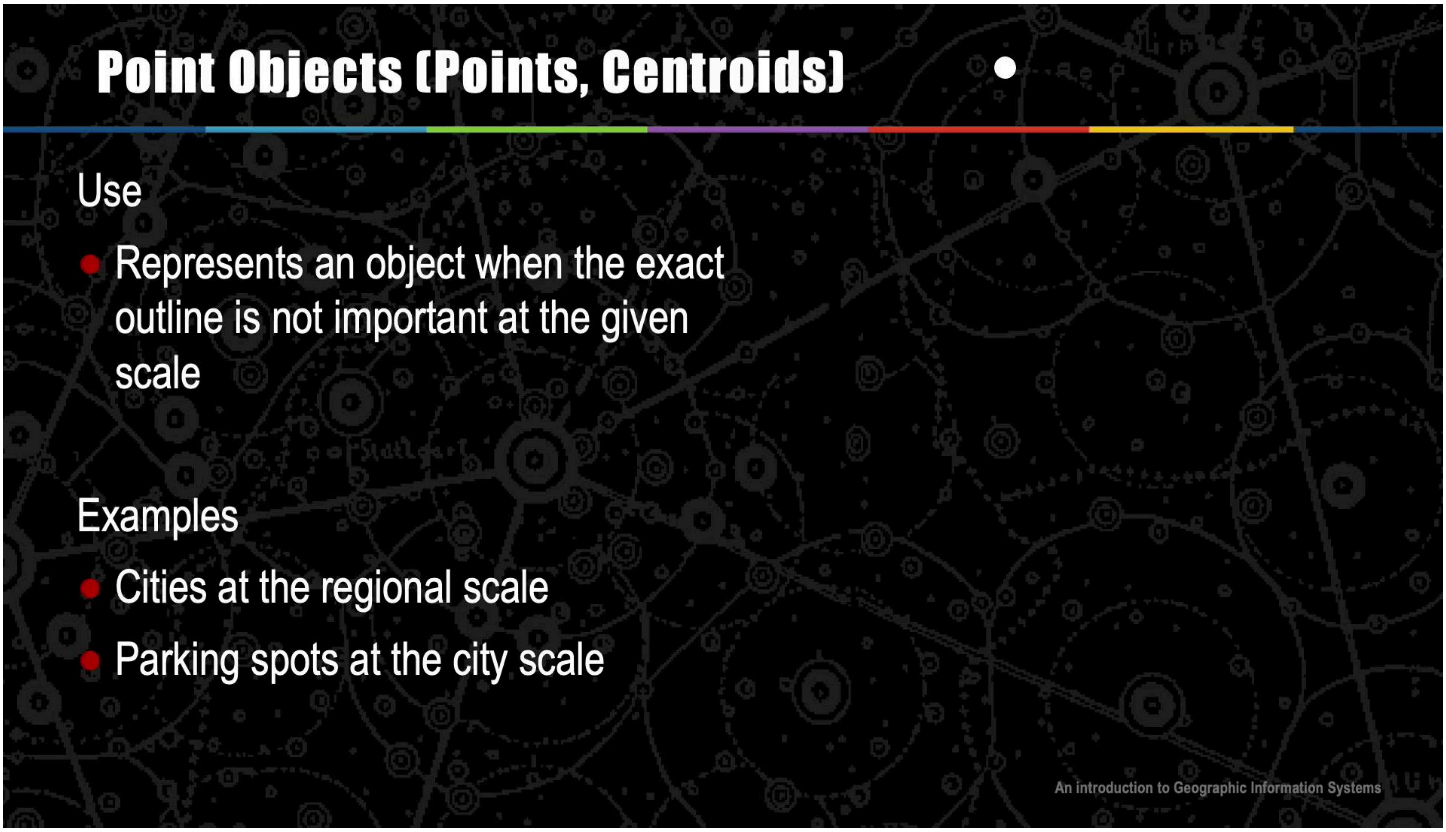


The three types of spatial entities which allow to represent discontinuous phenomena are the points, as here a series of hydrological stations, lines or multilines, which represent the hydrographic network in this figure, and finally the polygons, which serve to delimit surfaces, as here a watershed.

Notes

Summary

2m 25s

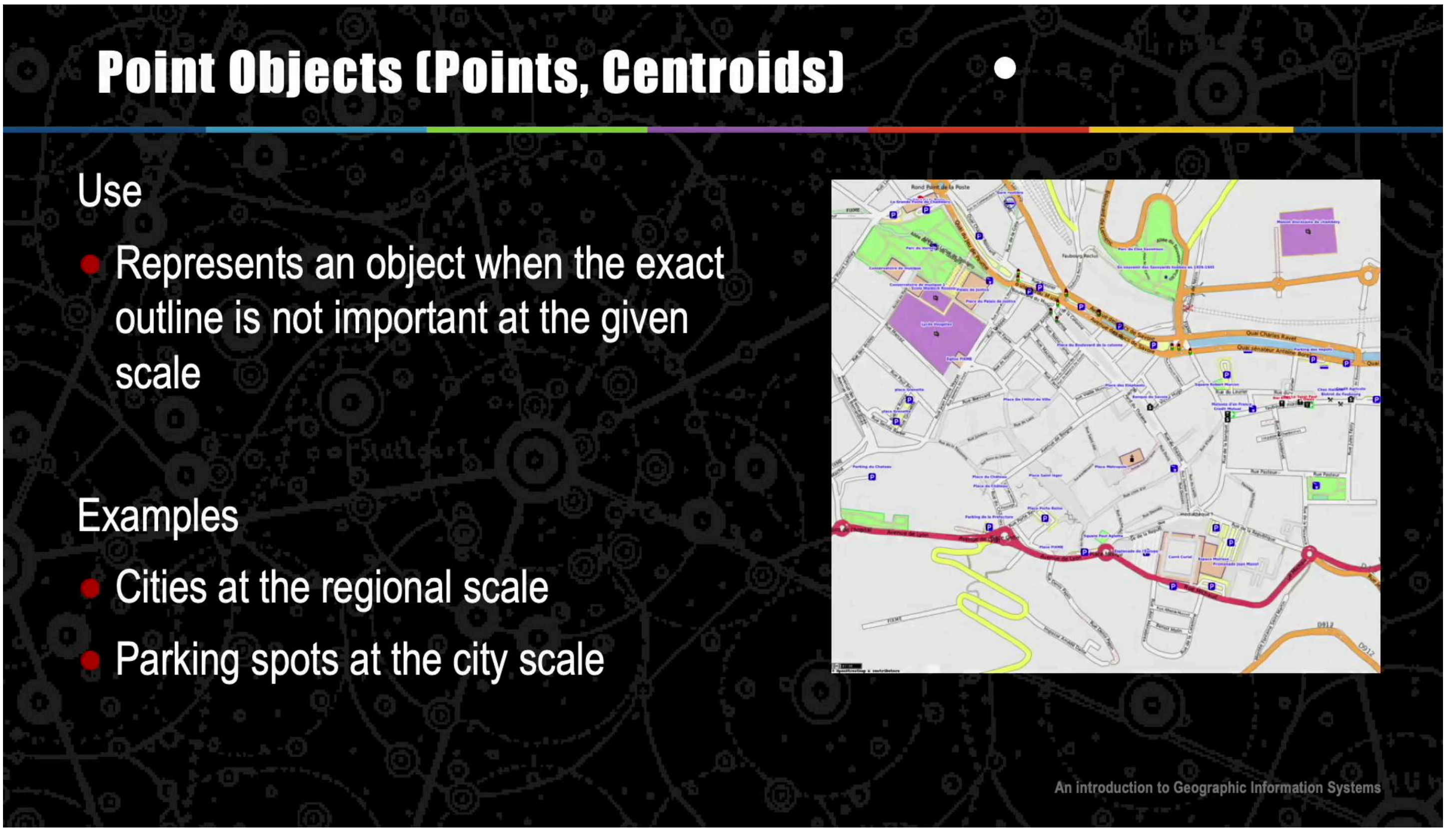


We should also note that the same object can be represented with various primitives according to the scale. For example, by zooming on the hydrological station which is located at the end of this arrow and which is represented by a point, we obtain its surface representation by means of a polygon.

Notes

Summary

2m 44s

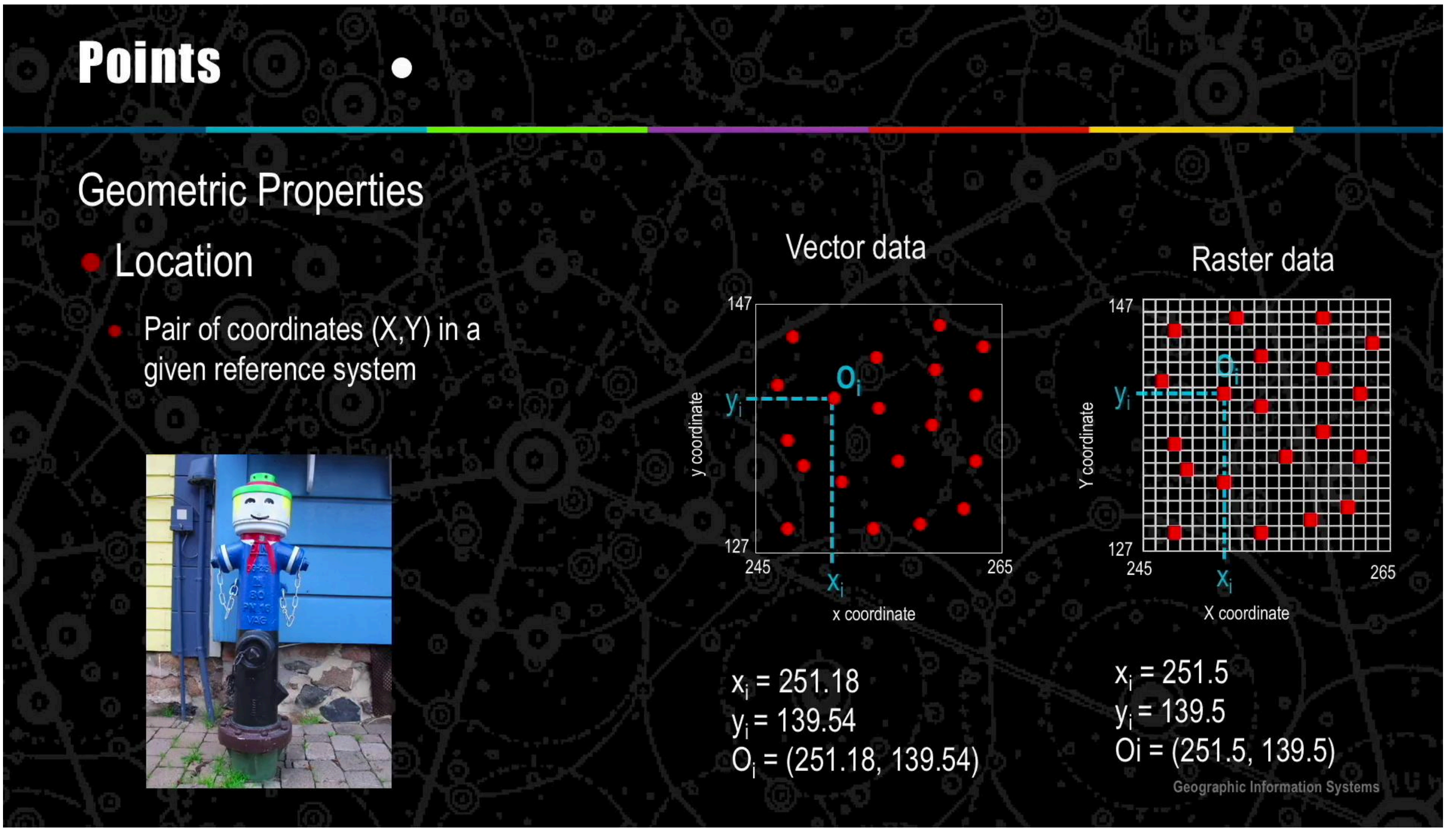


Points are often used to represent geographical objects whose exact contour cannot be represented on a given scale or if this contour is not important and this is the case of localities displayed on this map in the Marne region in France or that of the car parks of the city of Chambéry, illustrated here by a punctual pictogram.

Notes

Summary

3m 11s

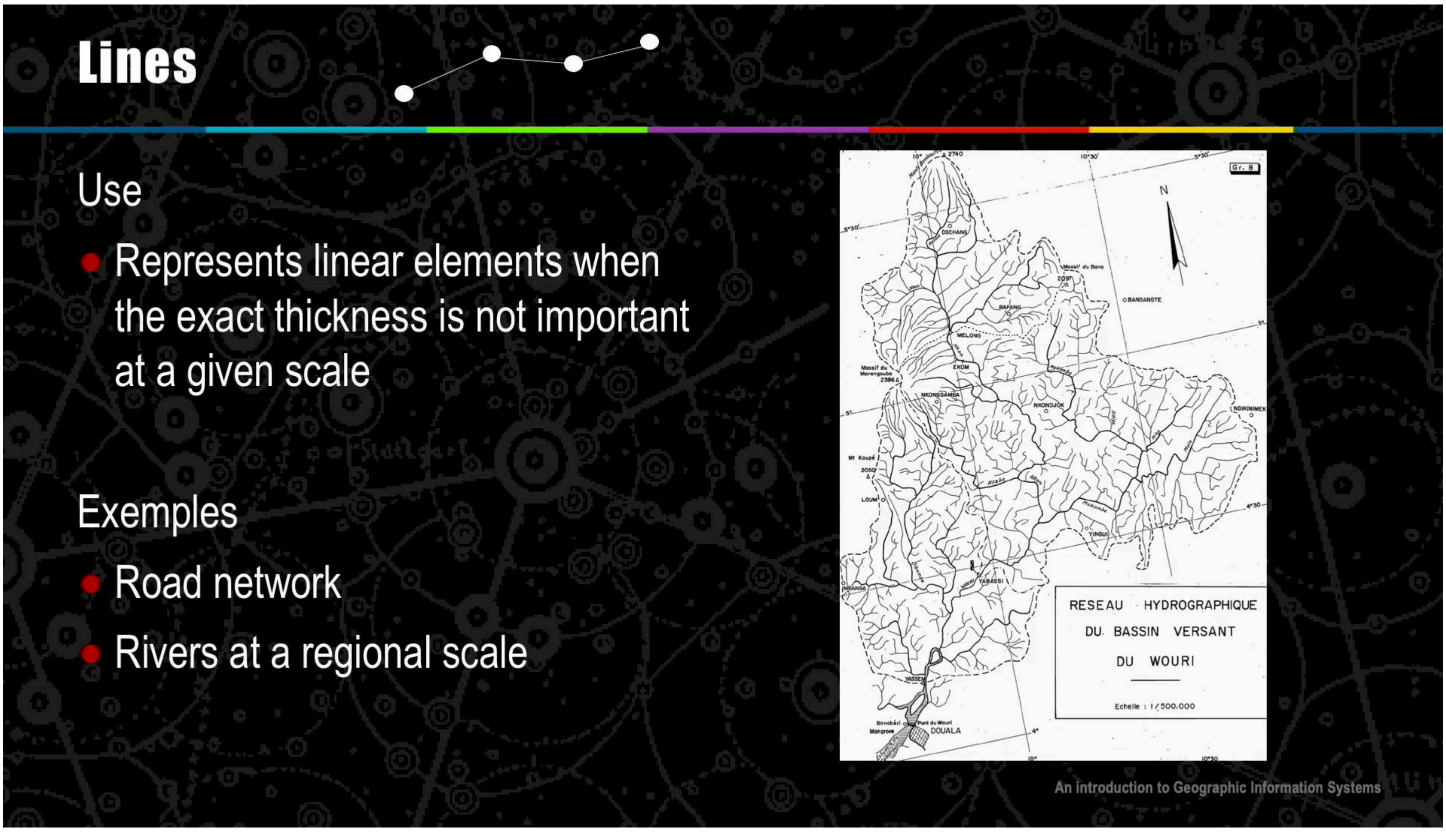


A punctual object, or what is called in image or raster mode a punctual region, has a geometric dimensions of 0 or 0D. Therefore, the unique individual geometric property of this object is its location, so a pair of geographic coordinates (X, Y), X for the longitude and Y for the latitude in object mode, or X for the line number and Y for the column number in image mode.

Notes

Summary

3m 33s

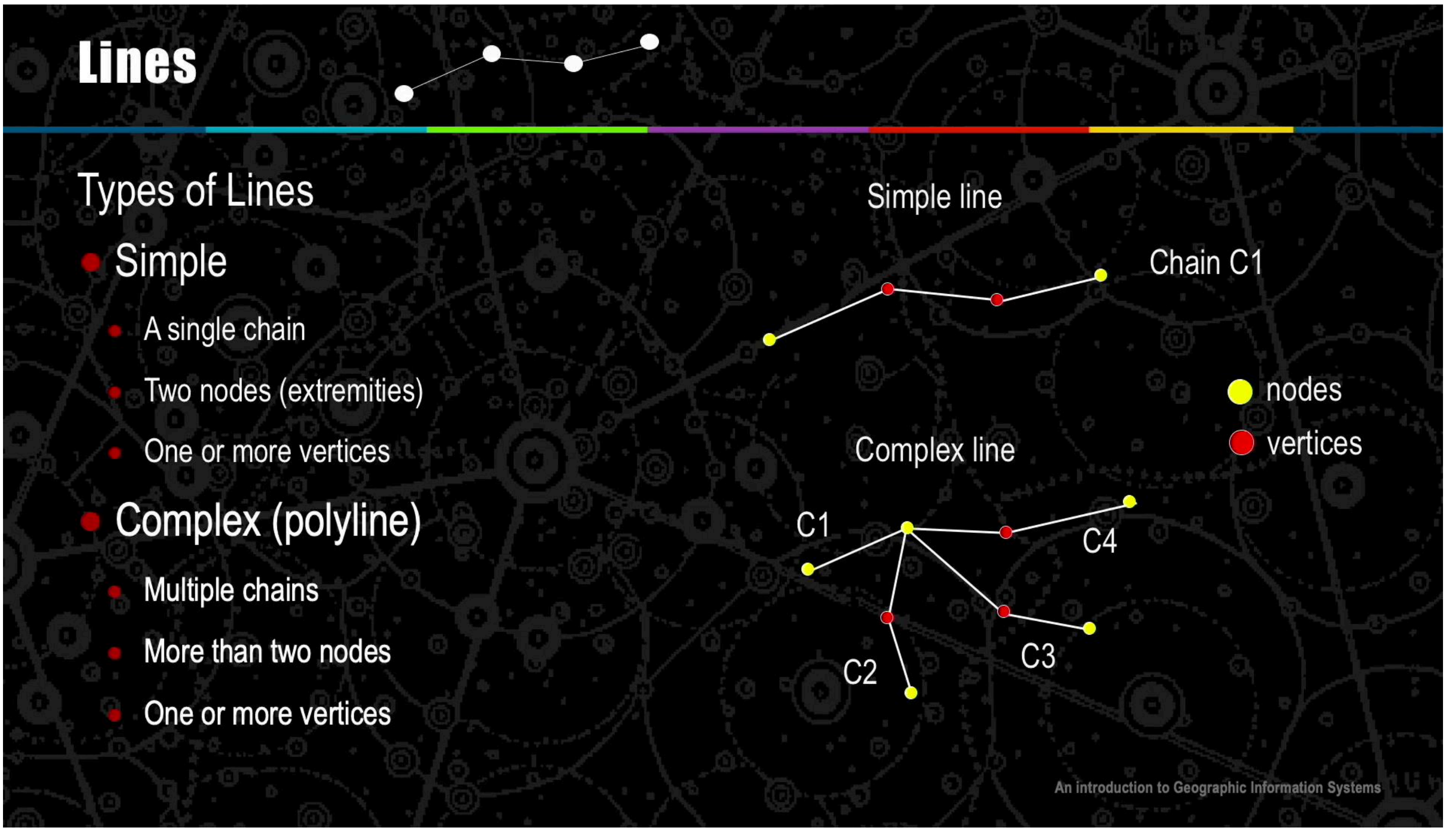


Single or polyline lines are used to represent linear geographic elements on the territory. For example, a road network, such as that of the Saône-et-Loire in France, or a hydrographic network, such as that of Wouri in Cameroon shown on the screen here.

Notes

Summary

4m 12s

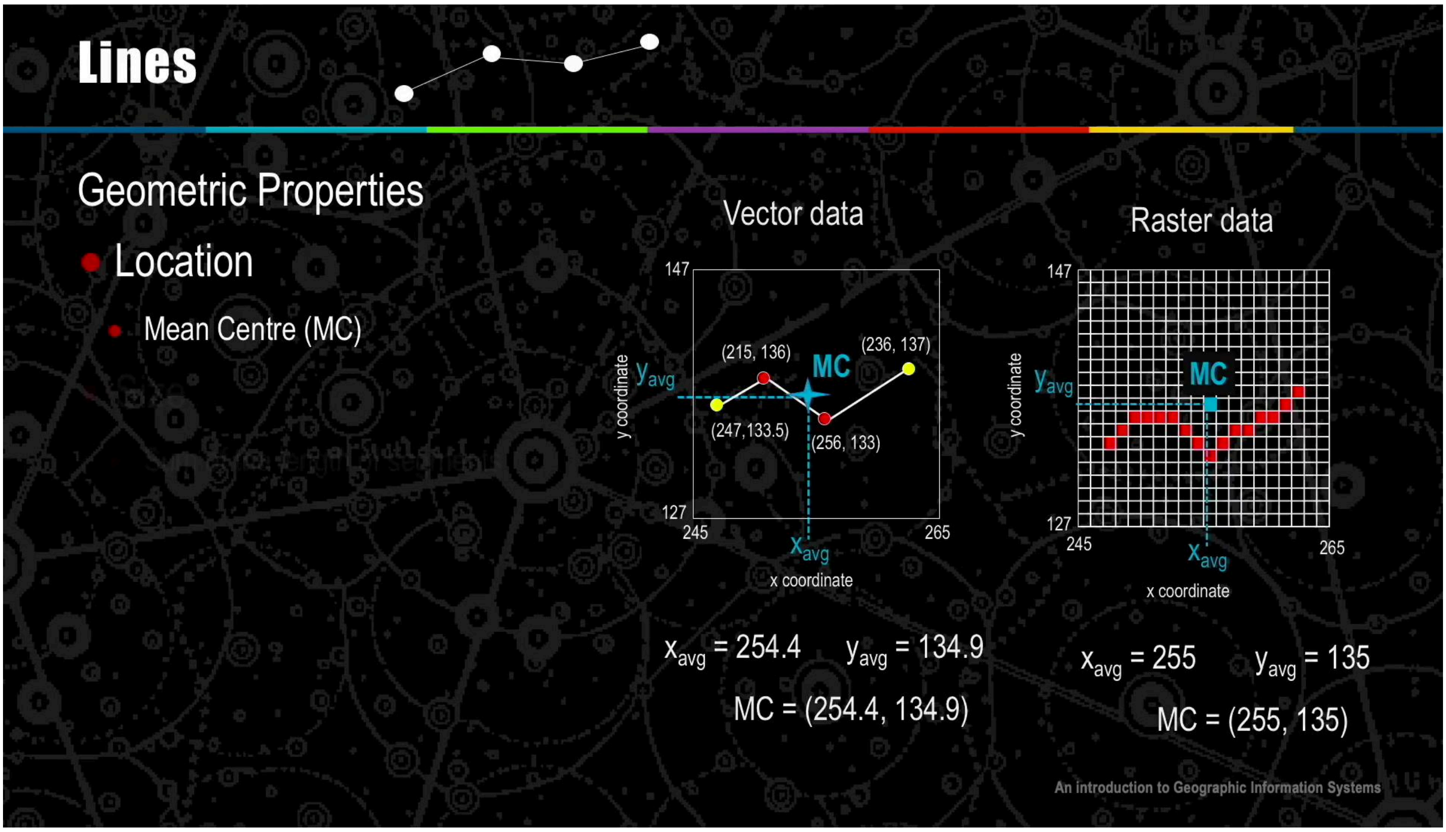


A linear object in vector mode or a linear region in image mode can be simple or complex. A simple linear object is composed of a single string in the topological sense, whereas a complex linear object is composed of several strings. A complex linear object can be considered either as a set of individual sections which are connected, or as a single entity which is then called a network.

Notes

Summary

4m 30s

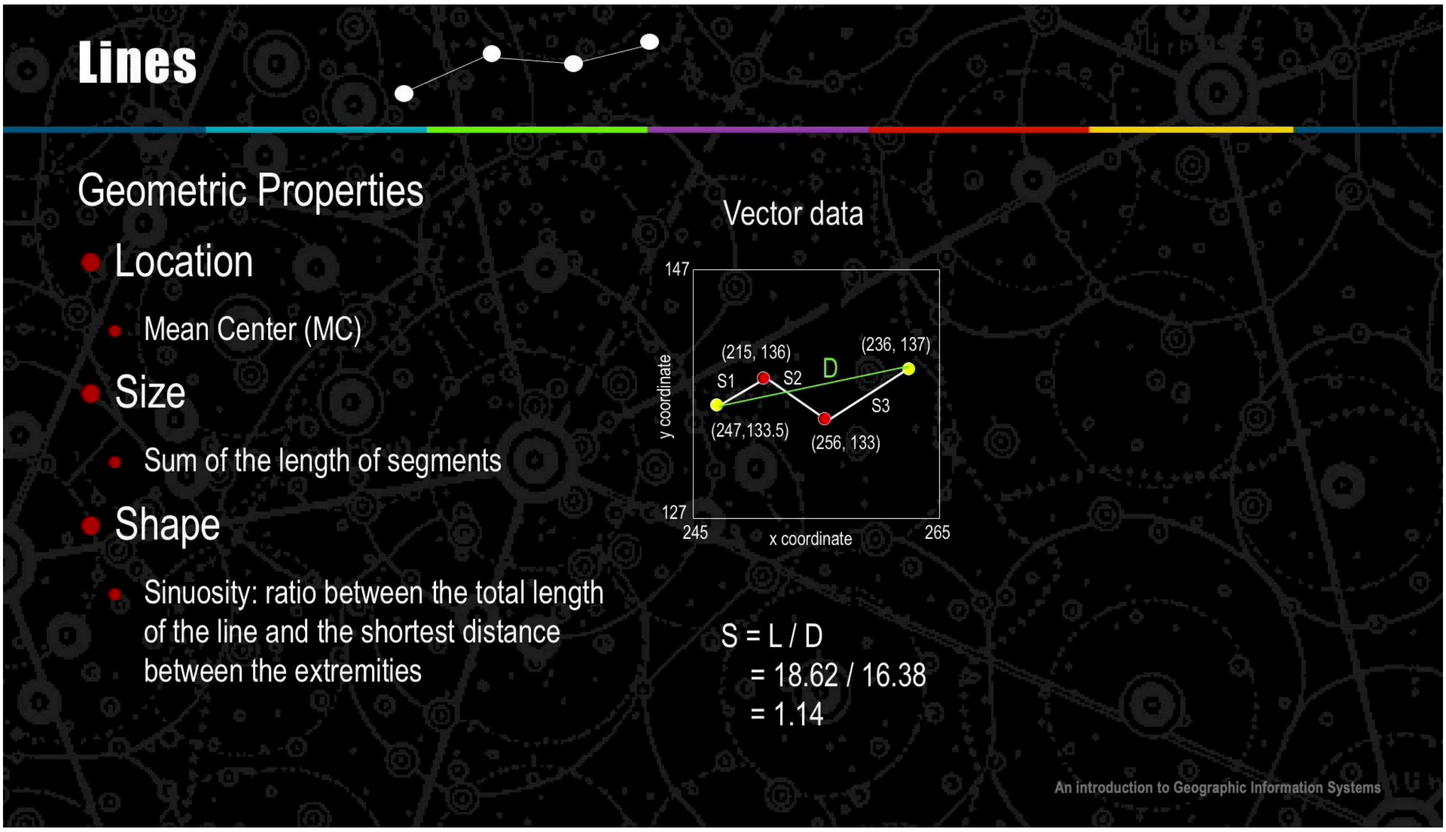


A linear object has a geometric dimensions of 1 or 1D. Its main individual geometric properties are the location, size and shape. The location is the average center CM calculated from the inflection points that are the vertices and the nodes of the broken line. It is also called the geometric gravity center. In image mode, the average center corresponds to the average of the X and Y coordinates of all the cells that make up the linear region.

Notes

Summary

4m 58s

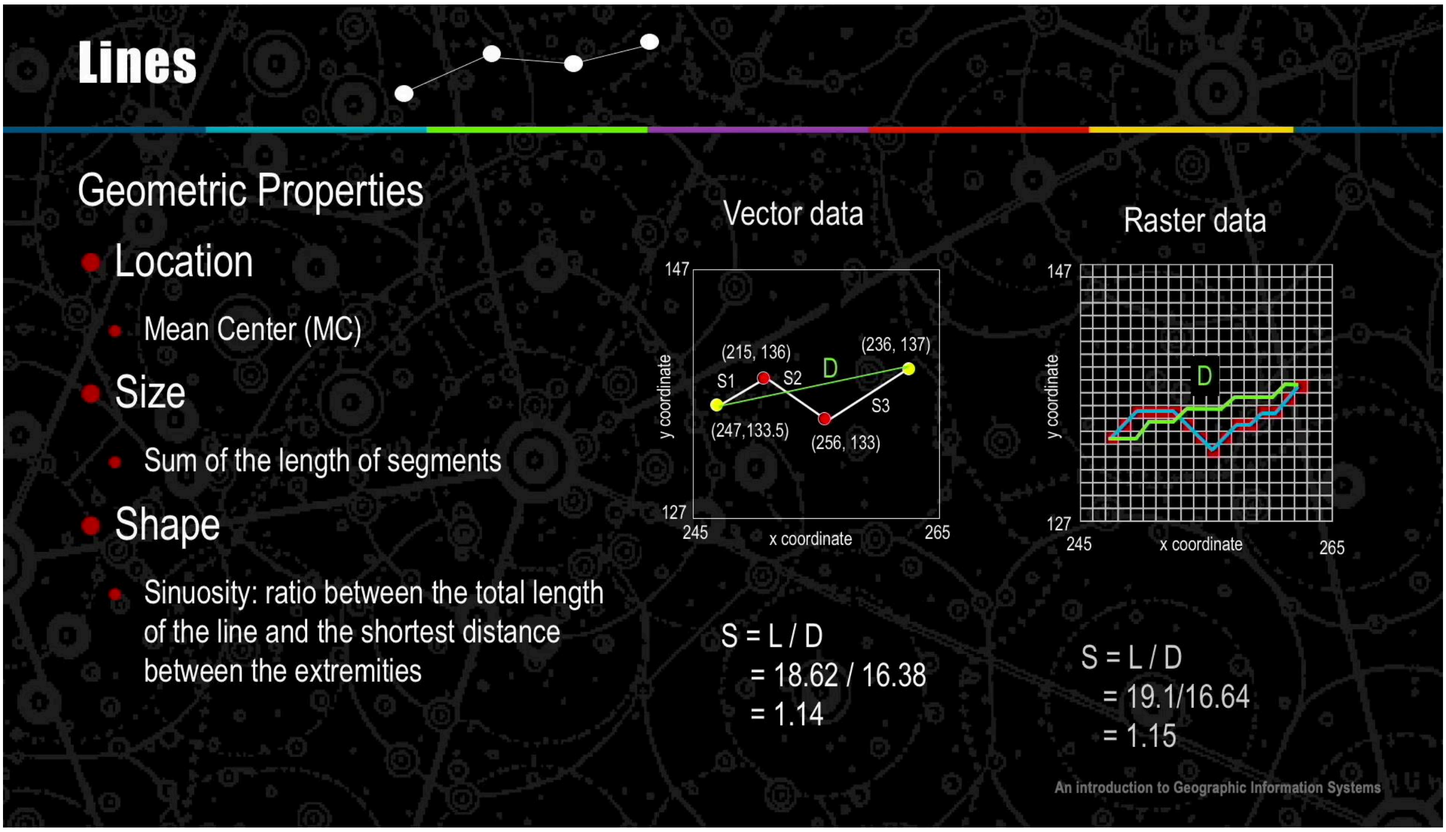


The size or length is the sum of the lengths of all the segments, in this case the length of S1 plus the length of S2 plus the length of S3 in vector mode, which gives us a total length of 18.62. In image mode, a formula must be used to calculate the length. This formula adds the types of displacements on the grid from the center of a pixel to the center of the adjacent pixel. And there are diagonal movements, for which a unit is equal to √2, and horizontal or vertical moves for which a unit is equal to 1. In the present case, there are 10 diagonal movements, so 10 times √2, plus 5 horizontal moves, so 5 times 1, which gives us a length of 19.1. The length in image mode is always overestimated. The shape or sinuosity is characterized by the ratio between the length L of the chain and the distance D between these two ends.

Notes

Summary

5m 30s



In image mode, this distance D is the shortest path between the two pixels that make up the ends of the chain. Here we find D by adding four times the root of 2 to 11 times 1, which gives us a value of 16.6.

Notes

Summary

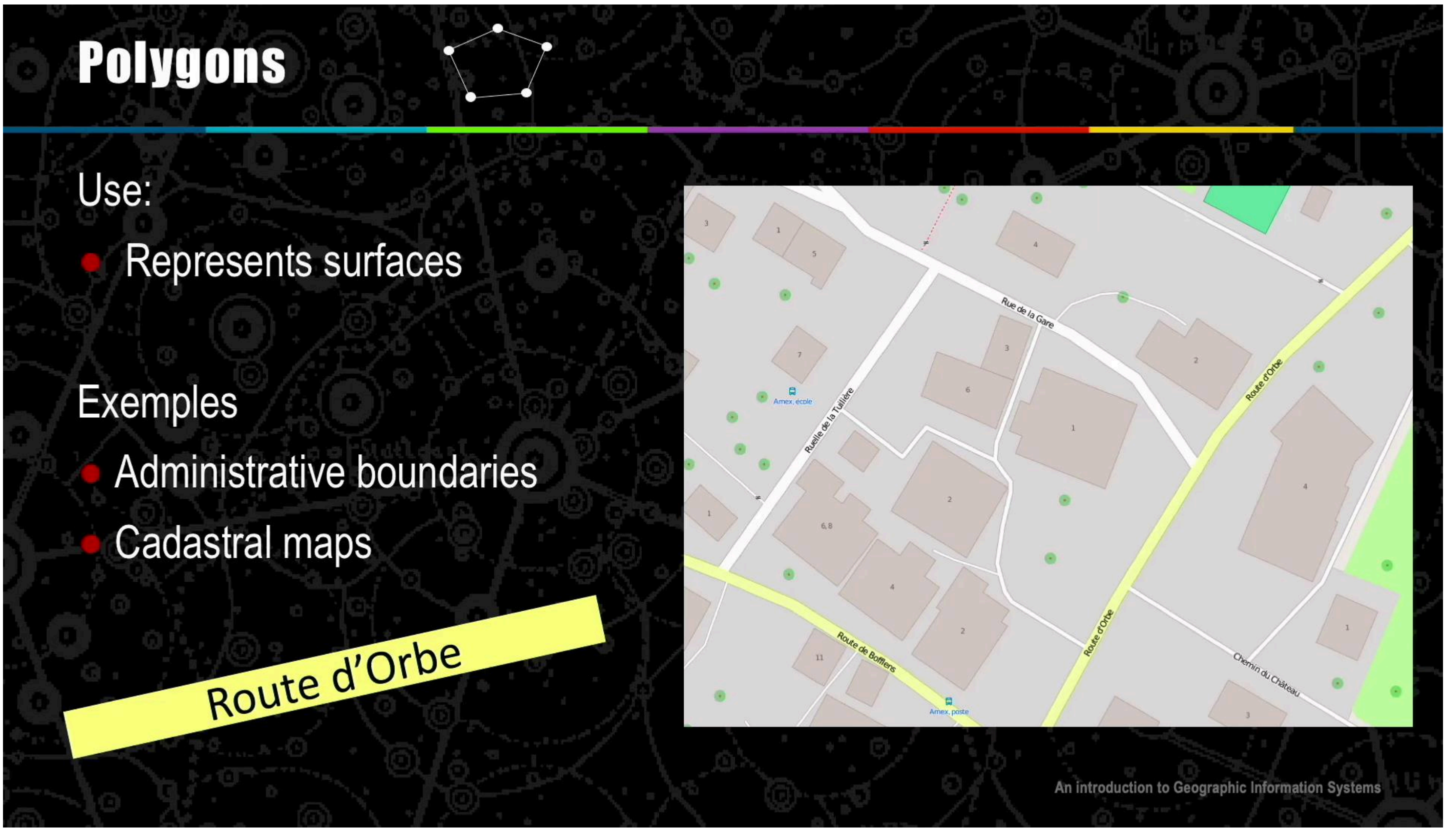
6m 31s

Let's move now to the polygons. The latter are most often used to represent surfaces. For example, administrative regions or statistical areas, or neighbourhood plans such as those in the vicinity of the Rijks museum in Amsterdam.

Notes

Summary

6m 56s

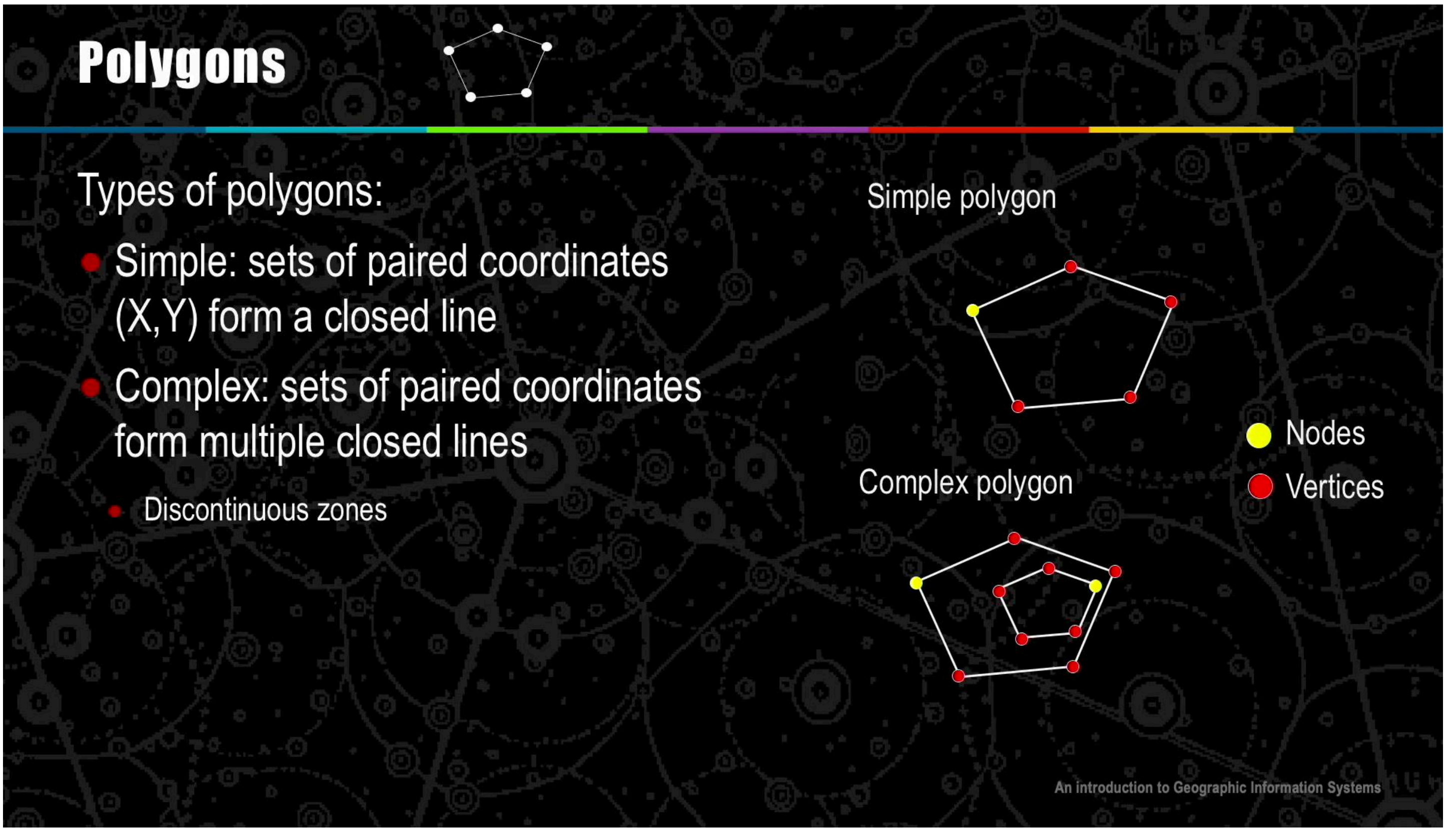


But it can happen that we represent linear objects by means of polygons when the scale of work demands it. This is the case, for example, of the road network represented on a cartographic large scale.

Notes

Summary

7m 14s

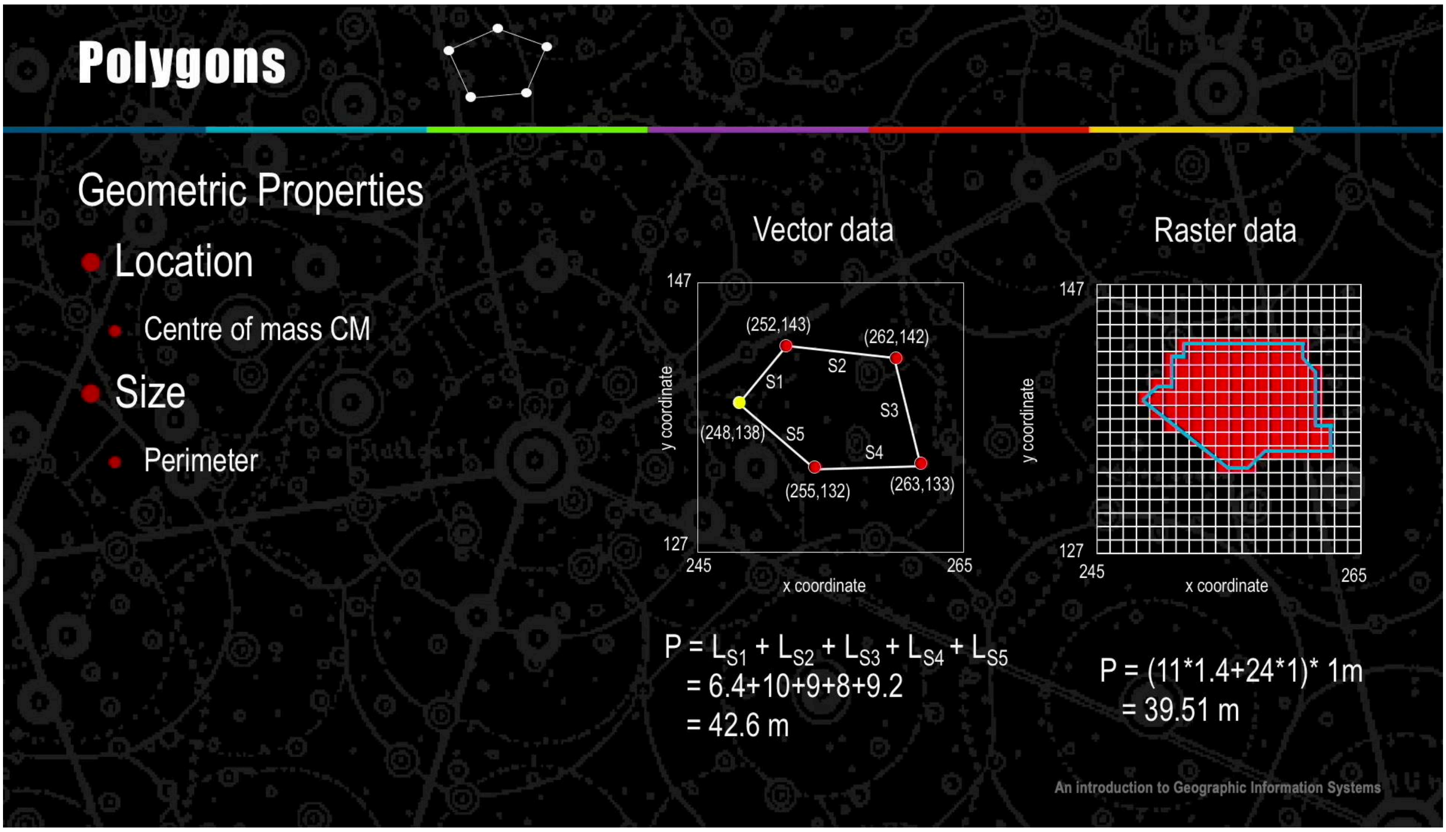


It is the closing of the broken line, so the repetition of the first pair of coordinates, which enables to characterize a polygon. A polygon or a zonal object or a zonal region in image mode, can be simple or complex. A simple zonal object is composed of a single spatial unit whereas a complex zonal object is made up of several discontinuous spatial units. A zonal object has a geometric dimension of 2 or 2D and its individual geometric properties are the location, size and shape.

Notes

Summary

7m 26s

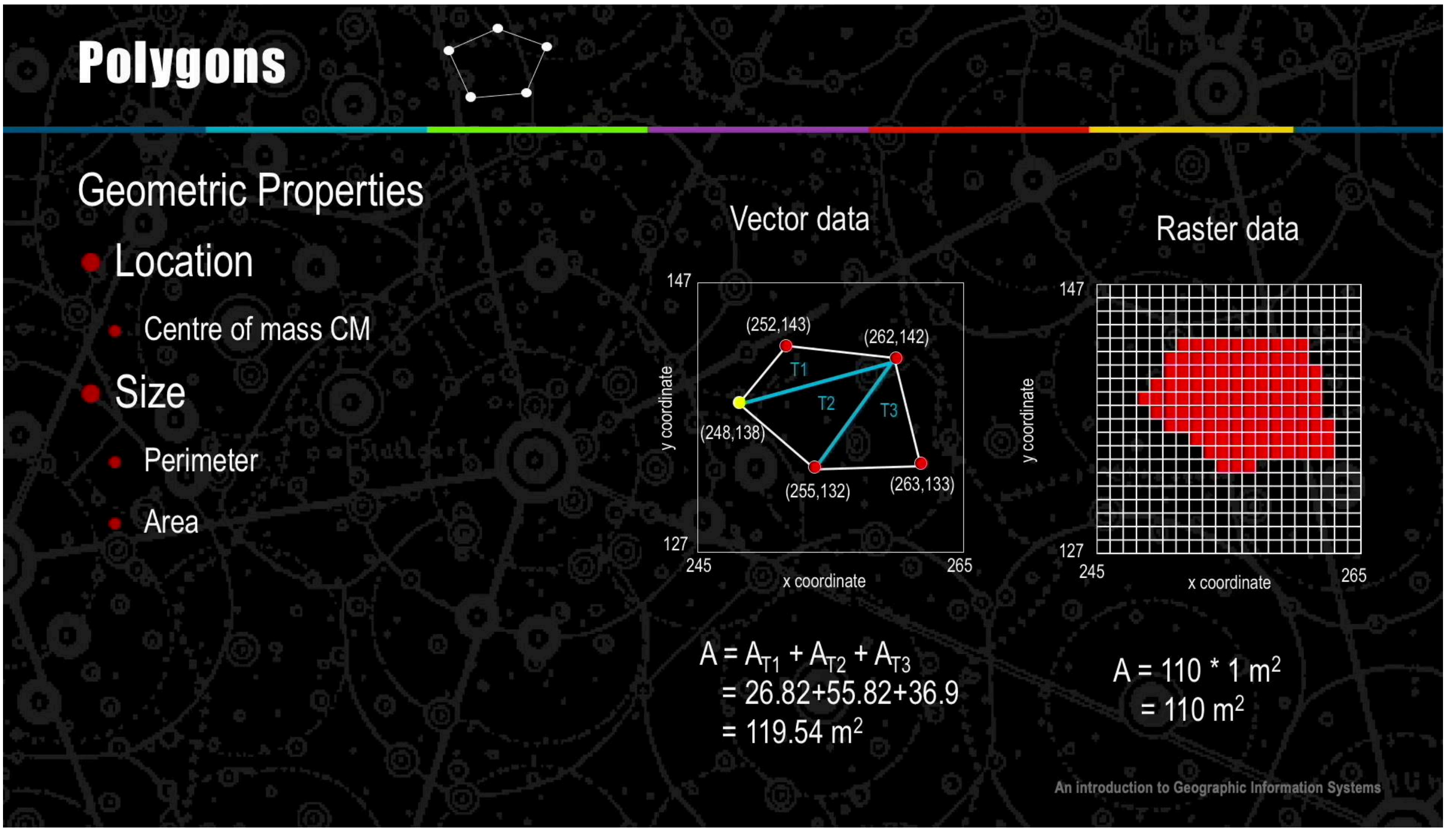


As for linear lines or regions, it is the center of mass which corresponds to the average center CM called the geometric gravity center. The position of the center of mass is calculated from the inflexion points of the closed broken line. These inflection points are the vertices and the nodes. We simply calculate the average of X and the average of Y in vector mode and in image mode the center of mass is the average center of all the cells that make up the region. There are two size variables, the perimeter and the area. In vector mode, the perimeter is the sum of the lengths on all sides, so S1 to S5 of the polygon, and in image mode, the perimeter can be calculated in two ways: we can do this on one hand by means of the Manhattan metric, which consists in counting the number of outer faces of the pixels which constitute the polygon, here 50, and which systematically produces an overestimated value. We can also calculate the sum of the distances at the center of the cells by using √2 for each unit of diagonal distance and 1 for the horizontal and vertical moves. In image or raster mode, the calculation of the perimeter using the sum of the distances at the center of the cells is underestimated or overestimated depending on the shape of the region measured.

Notes

Summary

8m 02s

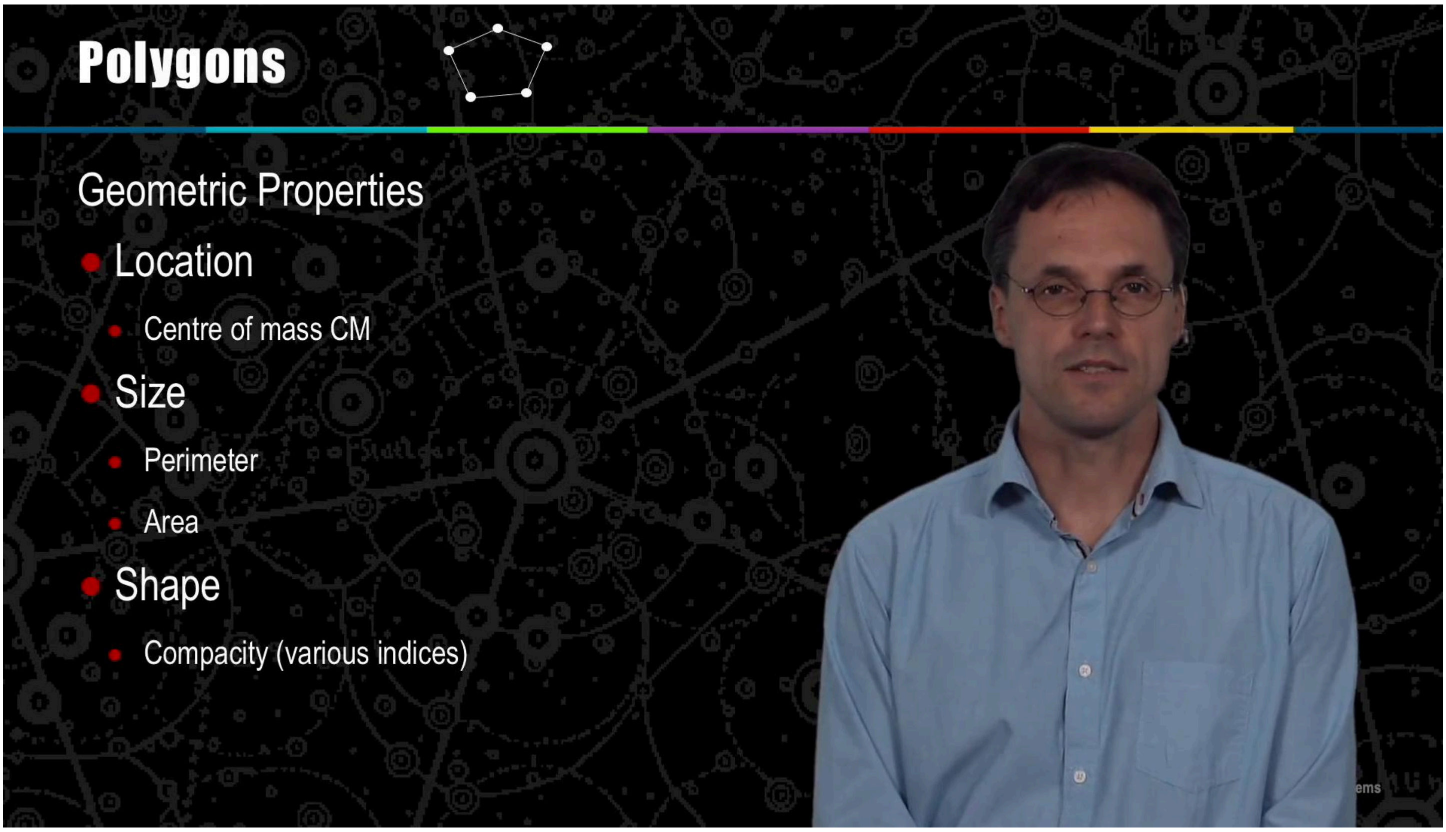


The surface or area of a region is the second size indicator. In vector mode, the area of a polygon is the sum of the areas of the triangles T1 to T3 which compose it. Let's remember that the surface of a triangle is equal to its base multiplied by its height, divided by two. In image mode, however, it is enough to count the number of pixels of which the region is constituted, so 110 here. The finer the spatial resolution of the mesh, the closer the value of the area to the calculated value in object mode.

Notes

Summary

9m 23s

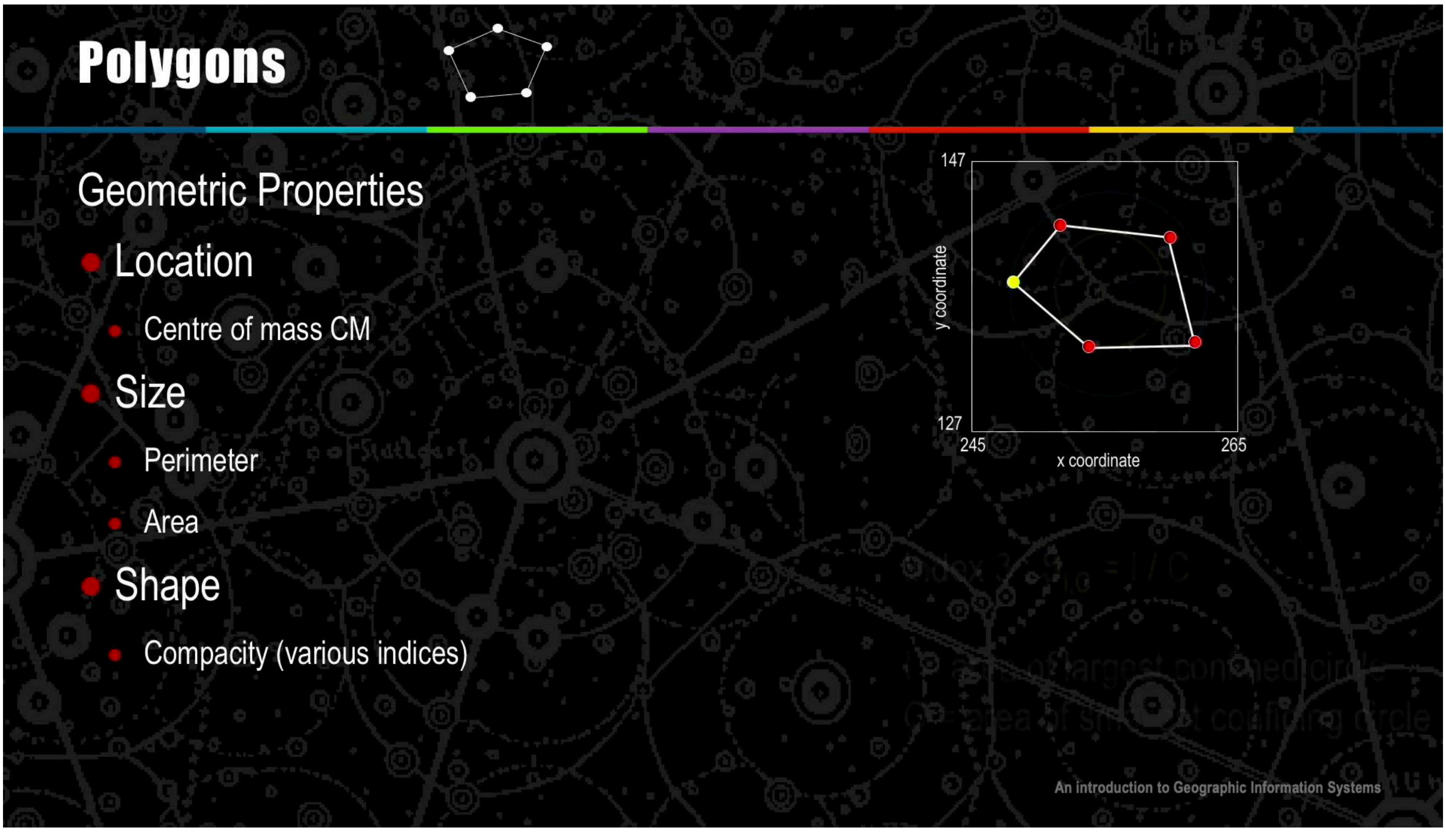


The shape indices make comparisons between objects possible independently of the description scale and the size. They are expressed in reference to a particular form. The most common is the compactness index, which refers to a compact geometric shape like the circle. The compactness indices apply to object and image modes. The sense is the same in both cases and only the calculation procedures are different. We will only use the vector mode to present the indices.

Notes

Summary

9m 56s

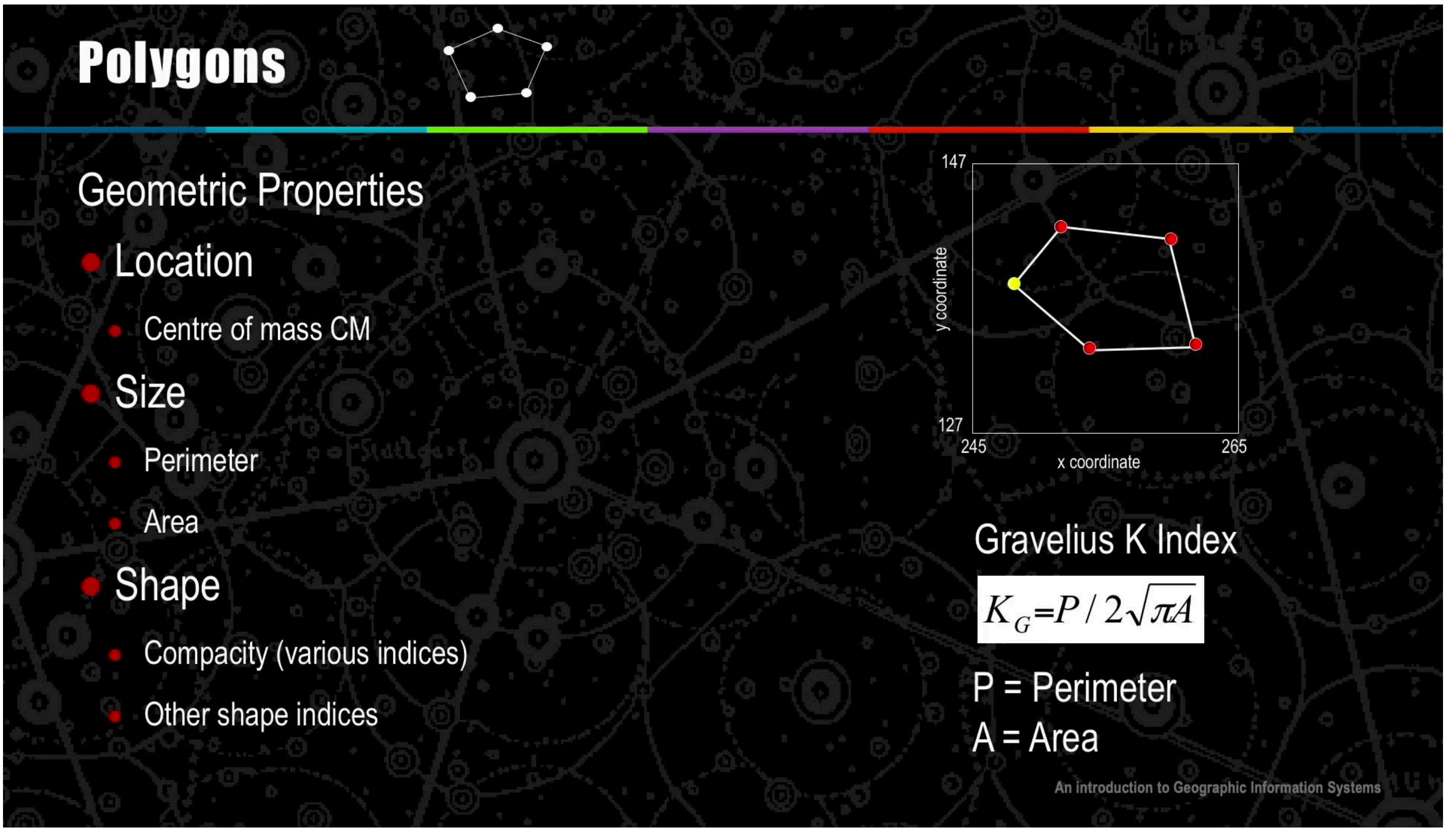


The first compactness index which we propose here is the ratio between the area of the object A and the area of the circumscribed circle C. The second compactness index is the ratio between the area of the object A and the area of a circle of a diameter equal to the length of the major axis L, here in green. The third index is the ratio between the area of the inscribed circle I and the area of the circumscribed circle C.

Notes

Summary

10m 25s

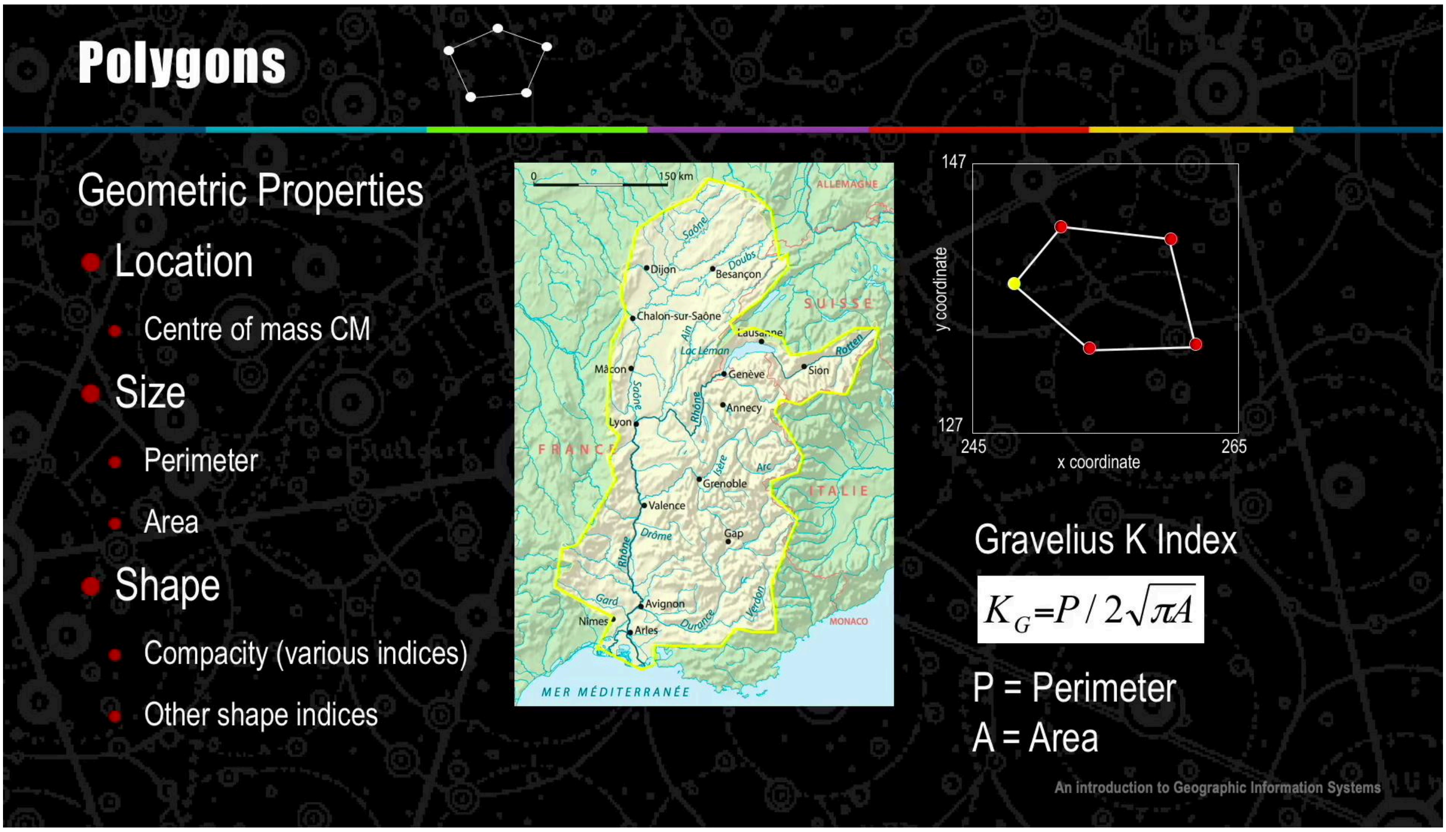


The fourth index that we present is the ratio between the radius R of a circle of area equal to the area of the measured polygon, and the radius RC of the circumscribed circle. The fifth compactness index consists in calculating the ratio between the radius RI of the inscribed circle, and the radius RC of the circumscribed circle. These five indices express in different ways the relative compactness of an object in relation to that of a compact reference shape, which is the circle. The maximum compactness value of the index is 1. The longer the shape, the more the value tends to 0. Finally, it is important to mention the Gravelius index, also called the Shape index. It is equal to the perimeter divided by twice the root of Pi, multiplied by the area of the polygon.

Notes

Summary

10m 54s



This index is used to estimate the compactness of watersheds, such as that of the Rhone, which we now see on the screen.

Notes

Summary

11m 42s