



Spatial Analysis Methods of Raster Data Used into the Geographical Information Systems

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Abstract

The most important feature of a GIS is its ability to perform spatial analysis, ie to process spatial (geographical) data in order to obtain information (reports) regarding the studied area. Through this feature of spatial analysis the GIS software differs to other software, such as CAD. The spatial analysis is the process of modeling, examination and interpretation of model results. Following the spatial analysis it can be extracted or created new information about a set of geographic data. This paper aims to treat two methods of raster spatial analysis, namely the raster spatial analysis and map algebra functions and the spatial analysis based on some statistical analysis: local, neighborhood, regional and global.

Keywords: spatial analysis, cells, functions, GIS, raster

Introduction

In the case of the raster object model (image) which is represented it divided into a series of square cells arranged in rows and columns (grid). The cell is indivisible being named as pixel and depending on the phenomenon represented; they receive certain values that define the color to be displayed. The raster image is a distinct layer.

Each pixel is defined by three groups of 8 bits (24 bits in total), with values between 0 and 255, defining the amount of red, green and blue that are combined in order to obtain a certain color. In the right proportions of red, green and blue they can be combined to form black, white, 254 gray scales and a wide variety of colors (16,777,216). The raster images are depending on their resolution. The resolution is expressed in dots per inch or dpi. The raster images are composed of a fixed number of pixels. The total number of pixels (resolution) and the amount of information per each pixel (color intensity) determines the quality of a raster image. An image that has stored 24 bits of color it has a higher quality of shading than an image that has only 16 bits, but less than one of 48 bits. So as an image quoted at 640 x 480 pixels (therefore it contains 307 200 pixels) will appear in poor quality, with fewer opportunities for zoom, while an image listed 1280 x 1024 (1.31072 million pixels) is given to special quality.

The RASTER model is used to be represented the continue details without a clearly defined border. (Ex. Map rainfall, slope map, etc.). The raster data can be as follows: the thematic data – the land use, the soil types, the relief etc.; The Spectral data – the satellite images; The images – scanned maps.

The cells that form a raster image are arranged in rows and columns thereby forming a square matrix. The rows are parallel to the Ox axis and the columns with the Oy axis. Such a cell corresponds to a line and a column. Oxy is the system origin and it is placed in the top left of the image. The image coordinate system can be changed through geo-referencing.

The RASTER data can be divided in 2 categories of data as follows:

- Images (tiff, jpeg, sid, png)
- Grids (native form ArcGis)

The advantages of this model are: the data structure is simple; the overlapping and combining of the layers is much easier to achieve; the simplicity of the raster data allows the possibility of performing spatial analysis; the raster data facilitates the spatial simulation because each spatial entity has the same size and shape; the plotting of the raster is not made without supplementary processing; the similarity of the raster data with remote sensing data.

The disadvantages of this model are: the raster data are a major consumer of memory; the raster data are not useful for the linear representations of elements (eg rail), or at a high-resolution (R = 100m), a house cannot be represented anymore; the quality of the graphics data presentation is lower.

The description of the spatial analysis methods

The analysis of the raster spatial analysis is similar with the data vector analysis, but with a series of differences. The main difference is the nature of the data on which the spatial analysis is performed. If in case of the vector analysis it is operated with points, lines and

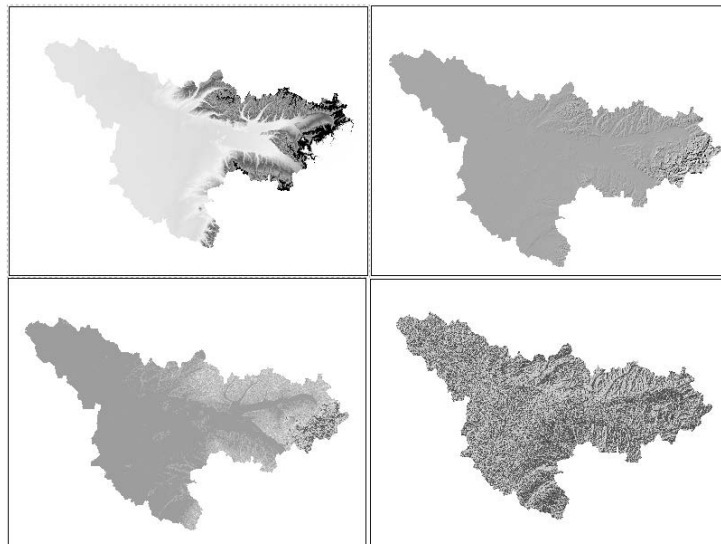


Fig. 1. Examples of Raster data

Rys. 1. Przykład danych rastrowych

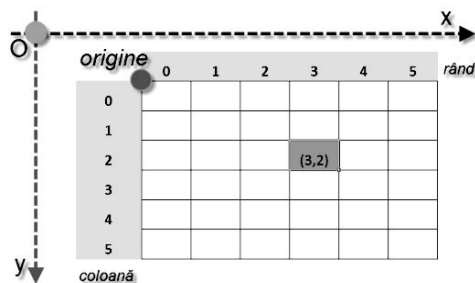


Fig. 2. Image coordinate system

Rys. 2. Układ współrzędnych obrazu

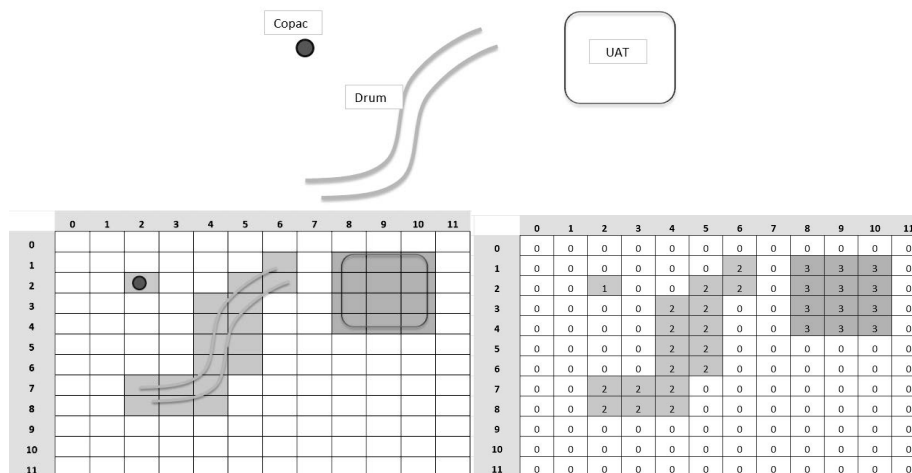


Fig. 3. Way of displaying and recording the data

Rys. 3. Sposób wyświetlania i rejestrowania danych

polygons, in the raster analysis it is operating with cells. The raster model is generally used for continuous data. The properties of continuous data changes in a smooth manner, over a surface, for example maps of the slope, the altitude or the slope exhibition.

The spatial analysis based on Raster data can be grouped on:

- Functions of statistic analysis: Local, Focal, Zonal and Global
- Map algebra – the calculation of algebraic expressions - to define the geographical analysis as algebraic expressions. This allows the users to take real-world data and to apply algebraic functions to achieve new results.



Fig. 4. Example of raster – Imagine

Rys. 4. Przykład rastra – obraz

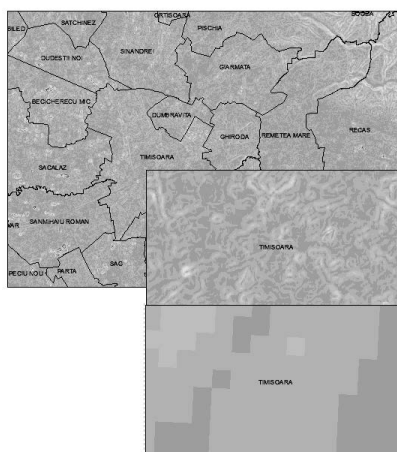


Fig. 5. Example of raster – Grid

Rys. 5. Przykład rastra – Siatka

- Field analysis
- Hydrographic analysis
- Raster Data reclassification
- Mapping distance – the calculation of the distance which can be made also based on the vector data
- Interpolation methods, which can be made also based on the vector data

Functions of statistic analysis: local, focal, zonal and global ones

Local functions

The local functions of statistic analysis have as result a grid in which each cell is determined after there are made some arithmetic operations over the values of the cells from the same location.

Focal functions

The focal function of statistic analysis have as result a raster in which the resulted cells values (OUTPUT) from each location are the result of some functions of the same cells but also of the values of the focal cells (mentioned above) around the initial cell (INPUT).

The focal functions can be of many types: Focal sum, Focal mean, Focal max, Focal min, Focal range, Focal majority, Focal minority, FocalSTD, Focal variety.

Zonal functions

The zonal functions create a raster where each cell value depends on the initial values of the cells and the association with a particular location area.

The zonal functions can be of many types: Zonal sum – Focal sum, Zonal mean – Focal mean, Zonal Maxim – Focal max, Zonal Min – Focal min, Zonal range – Focal range, Zonal majority – Focal majority, Zonal minority – Focal minority, Zonal deviation standard – FocalSTD, Zonal variety – Focal variety.

Global functions

The global functions creates a new raster in which the output value at each location of the cell is a potentially function of all cells with datasets in a raster input. The value of each cell of the output raster is a function of all cells in the potential of the input raster.

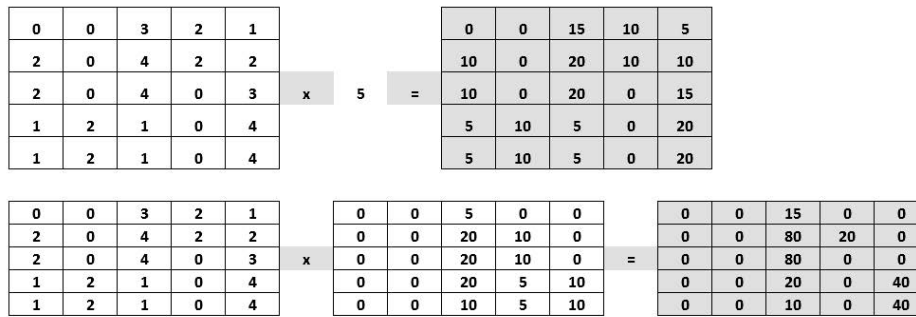


Fig. 6. Example of statistic local function
 Rys. 6. Przykład statystycznej funkcji lokalnej

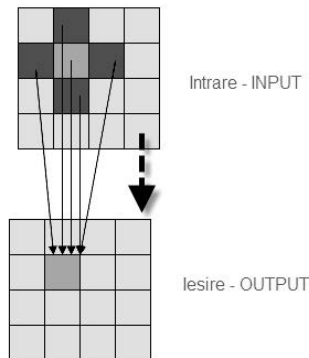


Fig. 7. Way of functioning of a focal function
 Rys. 7. Sposób funkcjonowania funkcji ogniskowej

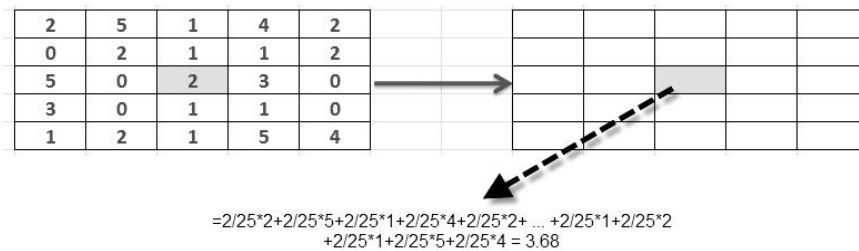


Fig. 8. Example of focal functions
 Rys. 8. Przykład funkcji ogniskowych

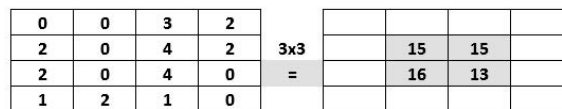


Fig. 9. Example of Focal sum
 Rys. 9. Przykład sumy kontrolnej

Map algebra

Map algebra is a set of tools for handling the geographic data, the concept being introduced in the early 80s by Dr. Dana Tomlin (Harvard). Map algebra gathers functions and operators that enable spatial analysis of two or more raster, of the same size, and the result of these analysis are stored in a raster again. The operators of Map Algebra are arithmetic operators based on mathematical functions (addition, subtraction, multiplication

or division), the relational operators (minimum, maximum, average), the operators of logic (based on Boolean algebra) or the operators of trigonometric operations working with two or more raster.

Arithmetical operators +, -, *, /

Based on the arithmetical operators it can be added, subtracted, multiplied or divided two or more raster.

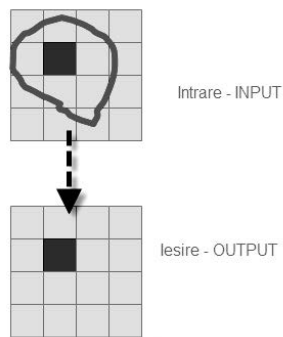


Fig. 10. Way of functioning of a zonal function
Rys. 10. Sposób funkcjonowania funkcji strefowej

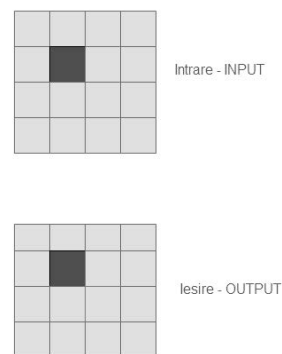
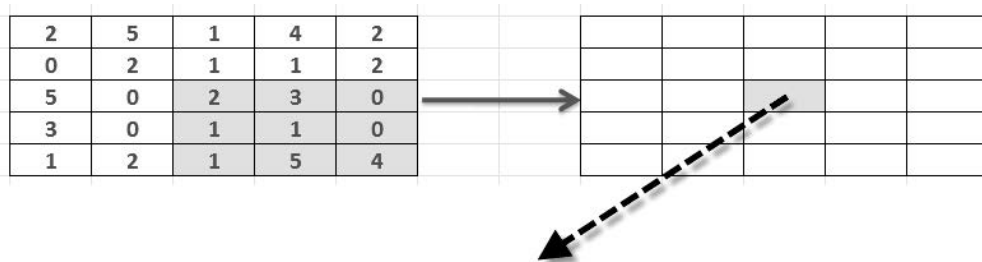


Fig. 12. Way of functioning of a global function
Rys. 12. Sposób funkcjonowania funkcji globalnej



$$2/9*(2+3+0+1+1+0+1+5+4)=3.77$$

Fig. 11. Example of Zonal Average
Rys. 11. Przykład średniej zonowej

RASTER 1				RASTER 2				RASTER REZULTAT								
INPUT								OUTPUT								
1	2	3	4	+	2	4	6	8	=	3	6	9	12			
5	6	7	8		10	1	2	14		1	6	15	1	8	21	24
9	10	1	12		8	20	2	24		2	7	30	3	36		
13	1	4	15		1	6	26	2		8	30	3	2	39	4	2

Fig. 13. Example of adding 2 raster
Rys. 13. Przykład dodania 2 rastrow

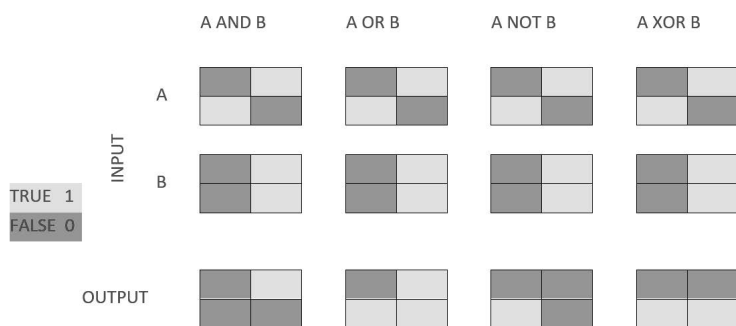


Fig. 14. Example of Boolean operators
Rys. 14. Przykład operatorów Boole'a

Relational operators: <, <=, <>, =, >, >=

Based on these operators it can be built some logical tests whose result is the real value - TRUE - 1 or false value - FALSE - 0.

Logical operators (boolean) – and, or, not, xor

The Boolean or logic operators were introduced by the British mathematician G. Boole in 1854 in order to manipulate the logical expressions based on the mathematical models. These operators use Boolean true or false logic, the TRUE values being represented with the numerical value 1 and the FALSE values with the numerical value 0.

Conclusions

The spatial analysis helps us to extract the meaningful data from the distributed and being processed data. So, it can be obtained data associations, patterns that can be characterized, or that lead to predictions or to understand the phenomena. The operations involved in the GIS modeling can be made directly on the maps layers together with their attributes. The result of spatial analysis is to enable the spatial and spaceless query and (of the attributes) and generating some new data from the existing ones. A problem that arises is the choice of the operations and also their order of action over the data.

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Metody analizy przestrzennej danych rastrowych stosowanych w systemach informacji geograficznej

Najważniejszą cechą GIS jest jego zdolność do wykonywania analiz przestrzennych, tj. do przetwarzania danych przestrzennych (geograficznych) w celu uzyskania informacji (raportów) dotyczących badanego obszaru. Dzięki funkcji analizy przestrzennej oprogramowanie GIS różni się od innych oprogramowań takich jak CAD. Analiza przestrzenna jest procesem modelowania, badania i interpretacji wyników modelu. Dzięki analizie przestrzennej można wyodrębnić lub utworzyć nową informację o zbiorze danych geograficznych. Artykuł ma na celu przedstawienie dwóch metod analizy przestrzennej rastrowej, a mianowicie przestrzennej analizy rastrowej i funkcji algebry mapy oraz analizy przestrzennej na podstawie analizy statystycznej: lokalnej, sąsiedzkiej, regionalnej i globalnej.

Słowa kluczowe: analiza przestrzenna, komórki, funkcje, GIS, raster