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UNCONVENTIONAL MAPS: GEOGRAPHY BEYOND THE REAL TERRITORIES

ALEXANDRU-IONUŢ PETRIŞOR[1]

ABSTRACT - Space is a concept that acquired in time new meanings shifting it from concrete to abstract and adding or subtracting dimensions. Even the geographical space is now claimed as object of study by other disciplines, such as ecology or spatial planning. Along with the concept of "space", these sciences discovered the potential of geographical approaches, especially of the techniques based on using the Geographical Information Systems, and consequently maps found applications even beyond conventional spaces. The paper examines several mapping approaches, used by other disciplines or even by geography, which go beyond or distort the geographical reality, in an attempt to test the hypothesis according to which such methodological imports were productive for the recipient disciplines. The analysis of six approaches (bacterial geography, time space analyses, spatial interpolation maps, bubble maps, body viewer, and network maps) confirms the hypothesis, but underlines the need for caution in interpreting the results in relationship with the territorial reality, especially when unconventional maps are drawn over the real space.

Keywords: space, kriging, bacteria, Body Viewer, ScapeToad

INTRODUCTION

While the times of greater geographical discoveries seem to be far behind, modern geography records a rapid progress, expanding to over 30 branches (Rosenberg, 2009). Most of them resulted from the relationships established by geography with other sciences, consisting of importing and exporting both concepts and methods. As a result, geography was generalized as a science of the organized space (Ianoş and Heller, 2006). However, while productive in many respects (Ianoş, 2000; Petrişor, 2008), such exchanges induced to the geographers the fear of losing their object of study (Ianoş and Heller, 2006). If geographers are a little bit sceptical, professionals from other fields, even non-spatial (Ianoş, 2000), have found geographical methods, particularly mapping and especially GIS-based mapping, to be productive tools, extremely useful in their activity.

A theoretical development facilitating their application was redefining the concept of 'space' associated with the geographical methods. Essentially, space has been seen concretely or abstractly as one-, two- or multi-dimensional (Petrişor, 2008, 2011) and geographical techniques were used over such spaces, often different from the territorial reality, to produce results interpreted according to the theoretical framework of the new discipline. The process led to the emergence of a new science, called Geographical Information Science (briefly GIScience), dealing with the application of geospatial techniques to answer essential scientific questions (Goodchild, 1992, 2004).

In epistemological terms, the transfer of concepts and methods is discussed by synergetics, a science of analogies between natural and human sciences regardless of the scale (Haken, 1977). From this perspective, the application of geographic methods in other fields resulted into changes of the method, or at least the way of interpreting the results (Petrişor, 2011).

This paper attempts to review several unconventional applications of geographical methods, going as much as possible beyond the conventional geographical data and space, in other areas in

[1] Faculty of Urbanism, "Ion Mincu" University of Architecture and Urbanism, 18-20 Academiei Street, Sector 1, 010014 Bucharest, and National Institute for Research and Development in Constructions, Urbanism and Sustainable Spatial Development URBAN-INCERC, 266 Pantelimon Road, Sector 2, 021652 Bucharest, Romania.
E-mail: alexandru_petrisor@yahoo.com

order to see whether they made a significant contribution to the progress of other sciences and what the limitations in their application were. The approaches are discussed with respect to their potential to become information systems and be used to assess causal relationships.

UNCONVENTIONAL MAPS

1. Methodology for selecting the case studies

While there are numerous unconventional representations and methods, this paper discusses six case studies, each of them different from the others. The selection of cases was based on four criteria, summarized in Table 1. First, the field of applying the methods was sought to be as diverse as possible. Two examples are taken from ecology, two from planning, one from medicine and one from the information science. Second, the type of representation was concrete (if looking at 'real' maps) or abstract (if representing a concept rather than a territorial entity). Third, the importance of geographical details was different; for some of the representations, neither the scale, nor the orientation (north, south etc.) was important; for others, both were equally important; and for some of them, one of the two was important and the other was not. Finally, the truth value of the results was assessed. This question addresses the final product resulted from analyzing the information represented: is it a reality? Can it be measured? Is it a simple suggestion, giving a general idea on a phenomenon?

Table 1. *Methodological matrix for the selection of cases*

Case study	Field	Type of representation (concrete or abstract)	Geography matters? (scale, orientation)	Truth value of the results
Bacterial geography	Ecology	Concrete	Yes, but only at the micro-scale; true orientation does not matter	True and measurable
Time space analyses	Ecology	Concrete	Discrete scale, orientation defined by the axes, not geography	True, not measurable (extrapolated)
Spatial interpolation	Planning	Concrete	Scale and orientation matter	Suggestions, not measurable
Bubble maps	Planning	Concrete	Scale is distorted, orientation is real	Not real (exaggerated), not measurable
Body viewer	Medicine	Abstract	Scale and orientation do not matter	True, measurable
Mapping networks	Information science	Abstract	Scale and orientation do not matter	Suggestions, not measurable

2. Bacterial geography

Mapping and performing spatial analyses of the microscopic realm – a true geographical space at a different scale – was the main focus of the activity carried out by a group of researchers at the University of South Carolina led by Professor Alan W. Decho. The underlying hypothesis was phrased starting from the definition of remote sensing as "*acquiring of data about an object without touching it*" (Jensen, 2000) and stated that microscopy is just a particular type of remote sensing, different only by scale, and microscopic images can be consequently analyzed using digital image processing and classification in conjunction with GIS as a research tool. The hypothesis was tested building up an approach to transform confocal imagery in GIS maps and analyze the sinecology and autecology of micro-organisms. The approach was verified first on issues where answers were already known in order to validate it (e.g., boring processes (Petrişor and Decho, 2004) and calcification of $CaCO_3$ in stromatolites (Petrişor et al., 2004b), reconstruction of biovolumes (Petrişor et al., 2004a) or determination of particle density - Petrişor and Decho, 2007), and later as a research tool to look at the orientation of cyanobacteria towards the top of precipitates in relationship to the light (Petrişor and Decho, 2006). To exemplify the approach, Fig. 1 displays an unpublished map resulted from applying the approach to analyze the spatial relationship between two groups of bacteria, sulphate-reducing bacteria (SRBs) and cyanobacteria, in an attempt to explore their synecological relationships. The image displays the SRBs living in close proximity (10 µm) of cyanobacteria in black, and other SRBs in grey.

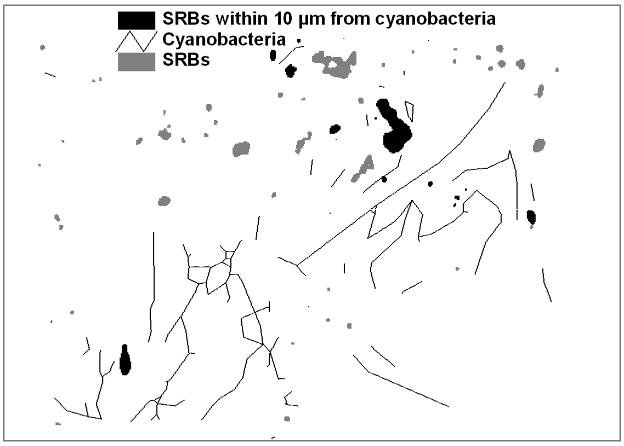


Figure 1. *Spatial distribution of cyanobacteria and sulphate-reducing bacteria (SRBs). SRBs located within 10 µm from cyanobacteria appear in black, others in gray*

Discussion. The approach presented here describes the concrete world, but at an unseen, microscopic scale. Due to this characteristic, the real geography (orientation and scale) have a different value. The orientation is not important in a geographical way (north, south, etc.), but with respect to microscopic milestones: top of precipitates (Petrişor and Decho, 2006), other species, etc. On a similar note, the scale is important to check the spatial relationships between the elements of the microscopic realm, as in the example shown in Figure 1. The technique analyzes spatial relationships in order to take scientific decisions on the interaction between the elements. However, when using it, the researcher must be cautious on causality, as the spatial relationship does not necessarily involve a phenomenological one. The results are measurable, quantifiable and correspond to the reality of the microscopic realm, indicating the potential of the approach to be used as a research tool.

3. Time space analyses

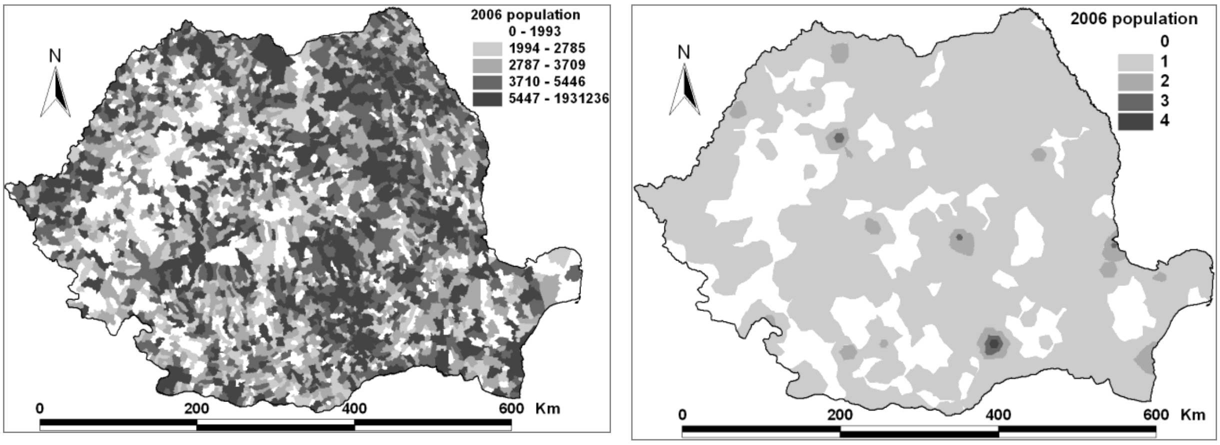
The occurrence of phenomena with a certain periodicity can easily be visualized in a virtual space determined by the two time variables accounting for its periodicity. The instrument was used to reveal climate changes or assess long term ecological changes using kriging over a space defined by the month and year when a certain value was recorded or computed (Petrişor et al., 2011). To exemplify the approach, Figure 2 displays unpublished data from the second study. A map of the number of primary consumers in Matiţa and Merhei shallow lakes (Danube Delta) covering the monthly evolution during 1980-2007 indicates the same trend referred in the cited paper: primary consumers drop down after 1980 and, due to ecological restoration, show a slight return to the end.

Figure 2. *Monthly distribution of primary consumers in Matiţa (A) and Merhei (B) shallow lakes (Danube Delta) during 1980-2007*

Discussion. The method goes beyond the geographical space to create its own: the two time variables define a space replacing the cardinal one. However, in this space the analyses are performed using geographical tools. The scale is discrete and also 'imposed' by the time variables. The results are extrapolations and cannot be measured (e.g. the areas of each class corresponding to low or high numbers of species can be determined, but have no practical relevance). By combining information from different layers (time variability at two levels) to create new information (hotspots of high or low abundances), the method shows its potential for scientific decision making and as a research tool.

4. Spatial interpolation maps

Spatial interpolation techniques are used to produce a surface covering a geographic space starting from sample values measured at different locations based on some mathematical assumption. The result is a generalization providing an overall idea on the spatial distribution of a phenomenon and cannot be interpreted geographically, since the limits between the classes of values lack the precise territorial relevance. To exemplify the approach, Figure 3 uses 2006 data on the population of Romania by administrative unit, producing two maps. One is a conventional chloropleth map, and the second is a radial extrapolation map derived from the first by assigning the population of each unit to its geometric centre and interpolating the centres using a radial interpolation function. While the first map displays exact limits, the second one disregards the geographical limits in displaying the information.



(A) Conventional chloropleth representation (intervals derived based on quantiles)

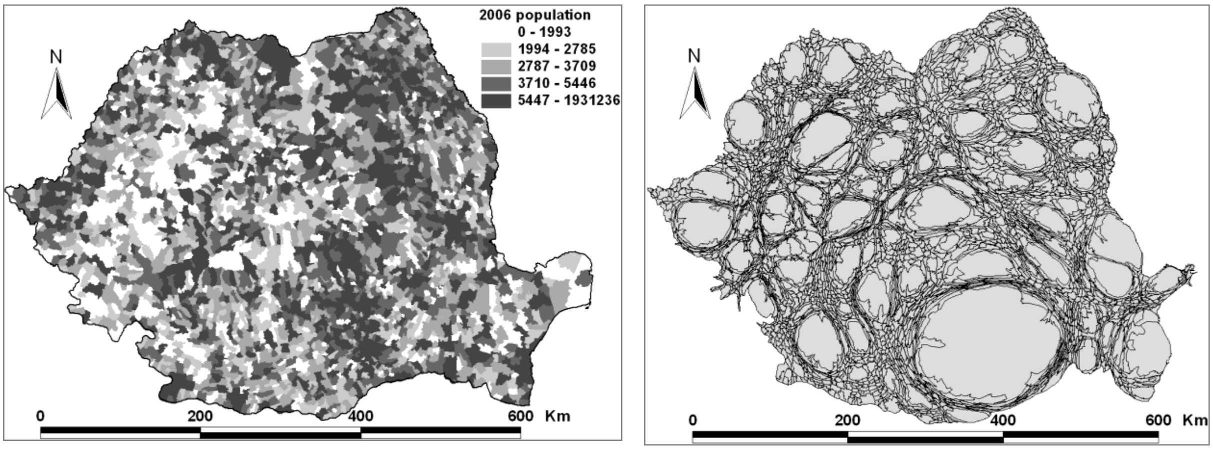
(B) Radial interpolation of centres based on the population of each unit

Figure 3. *2006 population of Romania: (A) conventional versus (B) interpolation-based representations*

Discussion. ‘Spatial interpolation’ describes a class of methods rather than a single approach. Real world geographical data are used to produce results that consist of surfaces generated over the real space; orientation is important and corresponds to the real one, the scale is preserved, but results cannot be interpreted as real surfaces. They are just suggestions indicating the general distribution of phenomena, and even if measurements can be made, they have to real correspondence. While for research purposes the choice of many parameters leading to different results becomes an issue, as the author of the study must justify each choice, in terms of planning the technique is helpful in the participatory decision making processes where such parameters emerge from the stakeholders.

5. “Bubble” maps

ScapeToad (http://scapetoad.choros.ch) is a free product used to generate distorted surfaces, proportional to a certain statistical variable (Cosinschi-Meunier, 2012). Such maps also lack the precise territorial relevance, but allow specialists from other disciplines to visualize peaks of the statistical distribution of certain variables in relationship to their geographic location. To exemplify the approach, Figure 4 uses the same 2006 data on the population of Romania by administrative unit, producing two maps. One is the same conventional chloropleth map, and the second is a ScapeToad map, which disregards even more the geographical limits in displaying the information, but allows for better pinpointing the populated centres.



(A) Conventional chloropleth representation (intervals derived based on quantiles)

(B) ScapeToad exaggeration pinpointing the populated places

Figure 4. *2006 population of Romania: (A) conventional versus (B) ScapeToad exaggeration*

Discussion. Bubble maps start again from the real space, distorting the orientation and space to produce results that do no longer correspond to reality and cannot be measured, but are very suggestive. The method can find application in communicating information to spatial planners and to the public (provided that the public understands the rationale beyond exaggerations), stressing out key point.

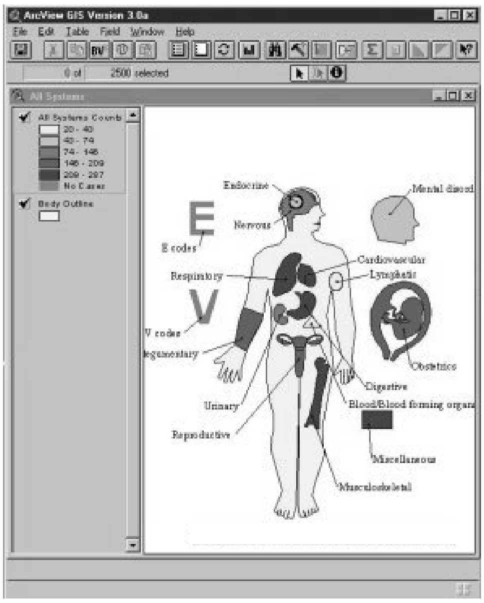


Figure 5. *BodyViewer screenshot: visualizing medical information*

5. Body viewer

The application (Figure 5) was developed for health care professionals, such as epidemiologists and physicians, by GeoHealth, Inc., of Redlands, California, and used by CorVel. While embedding a classical GIS to display geographically referenced data, the application has a component showing a standard shape of the human body and the main organs, used to visualize medical data, such as the frequency of diseases, cost of interventions, etc. (Lang, 2000).

Discussion. The method does not use a real space, but a conventional one. While not geographical in the true sense (does not make use on the orientation or scale), it is a true information system, combining medical data with statistical evidence to help out the decision making process. In this case, the medical planning decision allows for identifying the priorities of intervention.

6. Mapping networks

One of the first networks to be mapped was the International Network, a.k.a. the Internet. The first map was produced by Bell Labs in 1998 and featured on the cover of December 1998 Wired

(Cheswick et al., 2000). In addition to the Internet, science networks were also a topic of interest worldwide (FlowingData, 2011) or at national levels (AdAstra, 2006). Such maps revealed interesting patterns of citations within and between continents (Poor, 2009).

Discussion. The method uses an imaginary space to represent different layers of information in a network: nodes and fluxes (including eventually some attributes). The potential of the approach to identify dense or sparse flows, and the items most connected (and thus important) indicates its potential for being used as a decision making tool in managing information.

RESULTS

Several unconventional mapping approaches were presented, some starting from or referring to the territorial reality and others defining their own space, often virtual. While the latest allow only for an interpretation of the results based on the background and theoretical developments of the discipline using them, the first ones could suggest a possible geographical interpretation. However, this could be deceiving, as the results lack the actual territorial significance and cannot be interpreted accordingly.

An important question relates to the utility of such approaches in the sciences where they were applied. The first two representations (‘bacterial geography’ and ‘time-space analysis’) show the application of unconventional maps to ecology. In the first case, the example reveals the potential of the method to analyze spatial relationships regardless of the spatial scale (while being cautious to causality – Dragomirescu, 1998) and the second indicates their ability to pinpoint specific phenomena. Spatial interpolation and bubble maps can easily communicate key points to urban planners during the dialogue with other professionals involved in the planning process (Petrişor, 2010). Moreover, the methods used in urbanism include urban composition, participatory, management and communication urbanism (Lacaze, 1990). The two types of maps, through their visual impact, can be used in communication, but also in management, in the decision making process, due to their ability to stress out the key points. The fifth method is useful to physicians and epidemiologists for easily visualizing medical information, while the last one allows for representations in a completely abstract space.

If taking a deeper look at these methods, the discussion can look at their potential for becoming an information system. The purpose of a Geographical Information System (GIS) is to “*capture, store, update, manipulate, analyze, and display all forms of geographically referenced information efficiently*” (Ioniţă and Moise, 2001). However, the definition shows what a GIS does, but not why. To answer the second question, it has to be stressed out that a GIS is a “*decision support system involving the integration of spatially referenced data in a problem solving environment*” (Cowen, 1998). The second definition points out to the fact that the analyses presented by the first definition are used to answer questions by exploring the spatial relationship between objects belonging to different layers of information. From this perspective, the utility of the approach presented is maximized when they become information management tools used in the decision making process, in other words when they exceed the status of simple representations to become a GIS. Using this criterion, ‘bacterial geography’ is a true GIS, as it explores spatial relationships between different species to decide whether they have an ecological relationship; spatial interpolation is a GIS, as it combines two time variables to underline hotspots that indicate an overall pattern leading to a scientific decision on the trends of biodiversity; and spatial interpolation maps can become a GIS if looking at the appropriate representation to argue for a decision. On the other hand, Bubble maps, the ‘Body viewer’ and network maps are simple representation techniques, which have a potential for becoming a GIS only if used in the decision making process.

While traditionally ‘geostatistical methods’ referred to spatial interpolation techniques, such as kriging, used to derive continuous surfaces starting from sample measurements (Johnston et al., 2001), a recent paper proposed the extension of this definition to include all methods situated at the interference of geography and statistics, based on the level of abstractness and relationship with the territorial reality in the interpretation of results (Petrişor, 2011). To provide a single example, geographers (and other scientist) often refer to the principle stated by Waldo Tobbler: “*all things are related, but nearby things are more related than distant things*” (Goodchild, 2004, 2007). This principle is at the core of the ‘cluster’ concept (Petrişor, 2011), but raises an important question: does the proximity (or distance, as an attempt of avoidance) of two items involve a relationship between them? The question can easily be generalized to ‘Does a spatial relationship involve a phenomenological one?’ Again from an epistemological standpoint, the answer is similar to the theory of correlations: while a phenomenological relationship has spatial consequences (the entities draw near or apart), the reverse is not necessarily true (Dragomirescu, 1998; Dragomirescu and Petrişor, 2009). For this reason, the use of geographical techniques to explore phenomenological relationships in other sciences should be restricted to exploration: identify patterns and try to see whether there are any phenomenological explanations, and then organize experiments to test whether the explanations hold (Tukey, 1977). Only when a phenomenological reason exists, spatial techniques can be used to confirm it.

CONCLUSIONS

Despite of their limitations, the examples discussed in this paper confirm the underlying hypothesis and indicate the potential of geographic methods to be used productively by other disciplines, while being cautious when interpreting the results. In addition, the methods can be efficient in planning as decision making and communication instruments, due to their ability of stressing out key issues. However, in all situations their use must take into account the fact that moving away from conventional spaces requires additional caution in deciphering the message. An important characteristic is their ability to reveal particular aspects hidden to conventional methods, sustaining their potential for being used as research instruments. Last but not least, the utility of the methods is maximized when they become an information system, by combining different layers of information based on spatial relationships in order to support the decision making process.

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