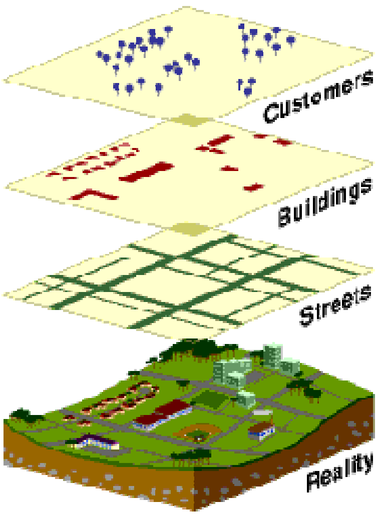
MODELLING BY GIS

Verka Jovanović and Đorđe Kadijević
GRADUATE SCHOOL OF GEOECONOMICS, Makedonska 21, 11000 Beograd

Abstract: *This paper explains what is GIS (Geographical Information System), underlines its value as a mindtool, presents two examples of modelling by GIS at a tertiary level, and examines critical issues of such a modelling relevant to the teaching/learning process and professional development of GIS teachers.*

KEY WORDS: GIS, MODELLING, TERTIARY EDUCATION, PROFESSIONAL TEACHER DEVELOPMENT

1. WHAT IS GIS?



Picture taken from
http://www.gis.com/whatisgis/

In simple terms, GIS is an information system comprising layers of information about a place that enables its better understanding.[1] Which of these layers (digital maps represented by tables) are to be combined depends on our goal such as locating a new store, analyzing environmental damage, and detecting a crime pattern in a city. A formal definition says that GIS is a system of hardware, software, data, and people enabling information of a particular location to be manipulated, analyzed and presented.

Contrary to earlier versions of this kind of software with limited database and calculation/analysis facilities, modern GISs such as ArcGIS (a complete, single, integrated system for geographic data creation, management, integration, and analysis; see http://www.esri.com/software/arcgis/) can be very able software environments that enable performing various geostatistical analyses based upon initial and derived (calculated) data utilizing the power of relational data bases. To illustrate such a versatility, let us give a simple example considering the nations of the worlds. Suppose that two layers of basic information on area and population are available. We can then relate these data, calculate population density, and create a world map presenting the density distribution. A next step may be to obtain descriptive statistics of the density of the continents and compare them. Another step may be to compare the statistics of the developed countries with that of others if, for example, the data on GDP are available.

[1] and perhaps taking appropriate societal actions

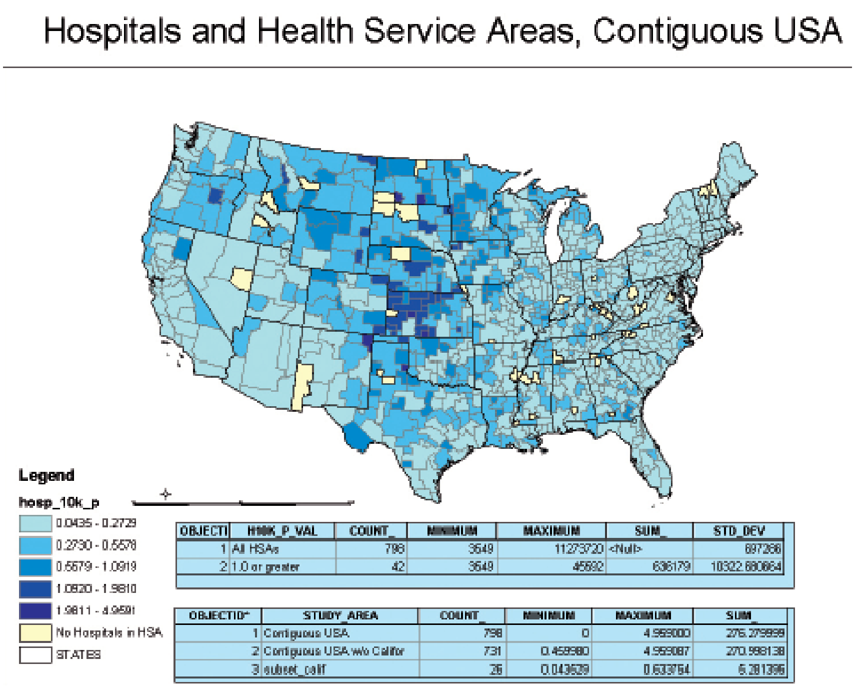
2. GIS AS A MINDTOOL

According to Jonassen, “mindtools represent a constructivist approach for using computers or any other technology, environment, or activity to engage learners in representing, manipulating, and reflecting on what they know, not reproducing what someone tells them.” [1, p. 10] Concerned with the development of critical thinking skills (evaluating, analyzing and connecting), creative thinking skills (elaborating, synthesizing and imagining) and complex thinking skills (designing, problem solving and decision making), he analyzes five kinds of mindtools: semantic organization tools (such as relational databases), dynamic modelling tools (such as spreadsheets), interpretations tools (such as tools for visualization), knowledge construction tools (such as tools for multimedia and hypermedia design) and conversation tools (such as tools for conferencing). Having in mind the versatility of modern GIS software combining the power of a semantic organization tool, a dynamic modelling tool and an interpretations tool, there is no doubt that GIS can be a powerful mindtool that help the user develop the above-mentioned thinking skills promoting genuine learning.

3. MODELLING BY GIS

To illustrate some modelling capabilities of the ArcGIS software, two examples will be presented here. One deals with hospital distribution, whereas the other copes with ozone concentration distribution. To avoid technical details of the software utilization, we will concentrate here just on conceptual issues.

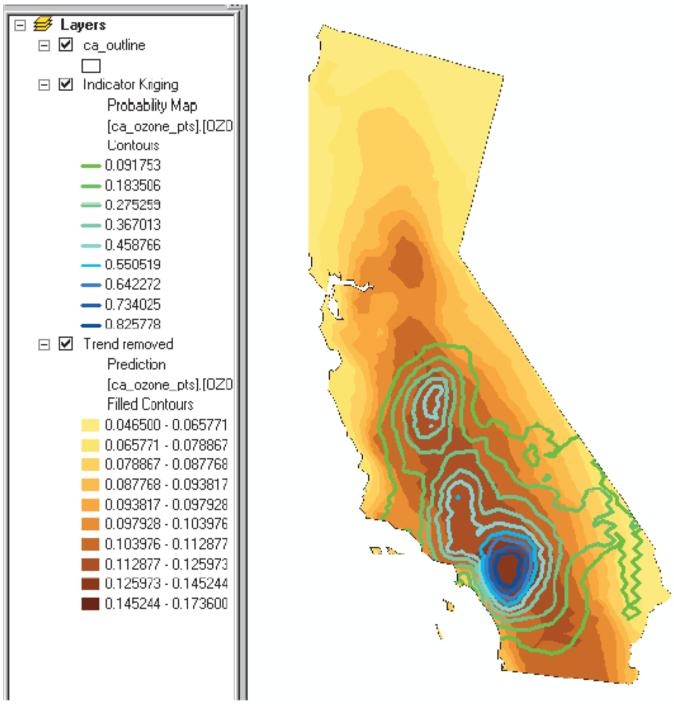
3.1 Hospital distribution



Picture taken from http://www.esri.com/news/arcuser/1002/files/hsa.pdf

When two layers of basic information on counties and hospital are available, we can relate these data, count hospitals in each of the counties, and then, by utilizing data on population, find out the number of hospitals per 10,000 people in each of the counties. Not only these numbers can be visualized producing a suitable coloured map showing the present level of health care. They can also be used to produce descriptive statistics comparing, for example, a particular county with the whole country. (see [2])

3.2 Ozone concentration distribution



Picture taken from
http://honeybee.helsinki.fi/GIS/y196/Using_ArcGIS_Geostat_Anal_Tutor.pdf

With data on average ozon concentration are available, the ArcGIS Geostatistical Analyst enables producing a continuous surface of ozone concentration, finding uncer-tainty of predictions, and obtaining probabilities that a critical concentration value is exceeded. To achieve an appropriate surface fitting, global trends in the data are to be considered, the lag size possibly adjusted[2], and local directional influence (or anisotropy[3]) in the semiva-riogram[4] taken into account. When several surface models have been produced, the best one[5] can be found through comparing two models at a time. And, finally, mapping the probability of ozone concentration exceeding a critical value can be realized by a number of methods. (see [3])

4. CRITICAL ISSUES OF MODELLING BY GIS

Bearing in mind GIS as a mindtool, modelling by GIS should be widely used in education, especially at tertiary level. Being a tool for semantic organization, dynamic modelling and interpretations, such a usage of GIS will certainly increase learning complexity. As there is little empirical research concerning GIS utilization (particularly in modelling), an implementation of modelling by GIS should be based upon the realization and an adequate treatment of possible critical issues of such an approach.

Considering less-demanded GIS activities, Schwarb, for example, indicates three critical issues: evaluation of the teaching units, development of more teaching units, and teacher training [4]. Examining the implementation and effectiveness of GIS technology and methods in secondary education in the USA, Kerski finds the following three critical issues: the influence of social, educational, and political factors; the alterer of the teaching/learning process; and professional development of teachers and their contact with the local community [5]. As regards professional development, Coulter and Polman call for "a better understanding of teachers' growth paths in supporting geospatially-enhanced inquiry" [6, p. 9].

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[2] the size of a distance class on the basis of which pairs of locations are grouped reducing thus the number of possible combinations
[3] things may be more alike in certain directions than in the others
[4] presents semivariance (or dissimilarity) of data points related to the distance between them
[5] with the mean prediction error closest to 0 and/or the root-mean-square standardized prediction error closest to 1

Having in mind the complexity of modelling by GIS, the influence of social, educational, and political factors and professional development of GIS teachers seem to be two main critical issues. Probably mainly due to the first one, GIS has been adopted by less than 2% of American high schools [5]. As regards the second one, GIS teachers can be recruited from teachers of geography, mathematics or informatics, but a solid knowledge in each of the three disciplines is to be acquired and continuously supported by professional development. Not only traditional, but also Internet-based forms of this development are to be utilized (see [7]). However, an enhtusiastic advocate of modelling by GIS should not forget that mathematical modelling has had so far mostly a marginal role in everyday mathematics education at all educational levels [8].

5. REFERENCES

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