Geocomputation and Urban Planning

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1 Introduction

Sixteen years ago, Franklin (1992) estimated that about 80% of data contain georeferenced information.

To date, the availability of geographic data and information is growing, together with the capacity of users to operate with IT tools and instruments. Spatial data infrastructures are growing and allow a wide number of users to rely on them. This growth has not been fully coupled to an increase of knowledge to support spatial decisions.

Spatial analytical techniques, geographical analysis and modelling methods are therefore required to analyse data and to facilitate the decision process at all levels. Old geographical issues can find an answer thanks to new methods and instruments, while new issues are developing, challenging researchers towards new solutions. The introduction to this volume aims at contributing to the development of new techniques and methods to improve the process of knowledge acquisition.

In this scenario, Openshaw (1998; 2000), at the end of 1990s, coined the term Geocomputation, considering two main issues: intensity of the process and increase of knowledge and intelligence. This expression has been interpreted according to several meanings. Ehlen et al (2002) analyze four aspects of Geocomputation: from a high performance computing point of view, as a set of spatial analysis methods, as the essential aspects of Geocomputation and as their relationship with GIS. The first aspect is related with research on parallel and grid computing; this domain is represented by a small community among researchers on Geocomputation. While the first topic is completely distinct from the others, the remaining three issues are strongly related among them. During the first time of using computers in geography field, it was widely widespread opinion that computers would become slaves of quantitative geographers, but when GIS came, roles changed. Geographers became computer slaves (Gahegan 1999), driven by the availability of data, software and processing power and the need to implement suited-for-purpose solutions. However, geographers as users of GIS are (and should be) to-date not limited to "the mechanism of which buttons to press, but on how to work sensibly with geography in mind" (Unwin 2005). For this reason, great part of geocomputational applications do not adopt commercial GIS softwares. In order to find solutions which could better fit their models and methods, geographers prefer to develop their own softwares or extensions of GIS (Longley 1998). In such sense, Geocomputational tools and solutions are good candidates, together with GIS software, to represent to date's parts of the "geographer's toolbox"

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(Haggett 2001) to address complex geographical issues. The Geocomputational expression is related to the development and the application of new theories, methods and tools in order to provide better solutions to complex geographical problems (Fotheringham et al 1997; Couclelis 1998).

2 Geocomputational Applications in Urban Planning

The geocomputational analysis discussed in this volume, could be classified according to three main domains of applications; the first one related to spatial decision support system and to spatial uncertainty, the second connected to artificial intelligence, the third based on all spatial statistics techniques.

In the field of spatial planning, the complexity of decision making processes has been one of the major issues for over thirty years. In fact, spatial planning is characterized by a multiplicity and a complexity of different actors, objectives, feedbacks and by the active role of "time" considered as both constructor and destroyer of interests, opportunities, resources in the planning process (Lombardo and Petri 2008).

The complexity of interactions between different actors involved in decision processes, regarding actions of territorial transformation, often makes these processes neither predictable, nor concordant in scope (Faludi 1987).

Then, in this new vision of urban planning and modelling, a new concept of decision making emerges and it is based on the search of the so called "optimal compromise" (Roy 1979 1985; Vinke 1981 1992), instead of on the search of the "best" solution.

The search of such compromise is located in an evolutionary context comprising both the study of preference systems by different actors involved in urban and territorial dynamics and the analysis of the effects of sustainable alternatives.

In this context decision support tools are developed and these tools, together with the development of data bases, generate the systems known as Spatial Decision Support System, in which a data base is combined with query procedures and at least with one method of comparison and ordering of alternatives (Bana and Costa 1990; Vincke 1992). In fact, Spatial Decision Support Systems (SDSSs) can be considered as interactive, computer-based systems devised to support decision makers in achieving a higher effectiveness while solving a semi-structured decision problem involving territorial aspects (Malczewski 1999 2006b; Arentze and Borger 1996; Lapucci et al. 2005).

In the field of SDSSs the concept of interaction between the user(s) (who can have different degrees of experience and/or competence in the decision problem under study) and a computer-based system containing tools able to both analyze spatial data and to model spatial decision problems is central.

Densham (1991) suggests that SDSSs should have specific characteristics and some of them are reported below:

- a dedicated design to solve unstructured problems;
- a powerful and user friendly interface;
- a specific tool for interactive and recursive problem solving;
- the capability to combine analytical models flexibility with available data;
- the possibility to explore solution space by building alternatives.

According to Malczewsky (Malczewski 1999; 2006a), the general framework of a SDSS comprises three main components (reported below) and the decision maker is considered as a part of the system itself:

1. a database management system (DBMS) and a geographic data base able to coordinate all the function relative to information management (i.e. data storage, record, extraction from various sources, etc.);
2. a model based management system (MBMS) containing the library of different models necessary for decision making processes and the routines to maintain and manage them;
3. a dialogue generation and management system (DGMS), containing all the procedures for information input/output from and to the system.

The devise of an efficient SDSS enables to integrate two separate tool sets (models and data) into a unified system where the contribute of geographic information sciences is in the knowledge of spatial and attribute data processing in a GIS environment, and the contribute of spatial analysis resides in the knowledge of territorial modelling.

Each discipline involved in environmental planning uses a different approach to represent its own vision of reality. Geological sciences or hydraulics evaluate risks by consistent mathematical models, which are relevantly different to non linear models employed in ecology, and, at the same time, information about significance and value of cultural heritage in a given environment does not easily correspond to value attribution. Different ways of managing values correspond to each method of giving information. The growing importance of the relationship between disciplines and technological innovation in environmental analyses leads to a dangerous consciousness about the possibility of managing great amounts of data, by the use of Geographic Information Systems (Murgante and Las Casas 2004).

A new difficulty rises to the fore, regarding the need of traducing G.I.S. supported complex analyses and evaluative routines into planning instruments which have only crisp definition of zoning, due to their normative issues in land-use regulation. Often objects do not have crisp boundaries or do not have boundaries at all (Couclelis 1992; Burrough and Andrew 1996). In fact, Couclelis (1996) highlights the uncertain nature of entities and the uncertain mode of observing real world, even if the user's purpose is certain (land-use zoning).

Figure 1 reports a classification of uncertainty in spatial information. Geographical information can be certain or not. In the case of well defined data, a degree of uncertainty can be eliminated using probability theory or, in case of several alternatives, it can be solved by adopting multicriteria methods. Poorly defined data have been classified in three groups.

Some data are said to be ambiguous if they can have at least two particular interpretations. Ambiguity leads to a discordance in data classification due to a different perception of the phenomenon. Inaccuracy produces uncertainty in the case of low quality of data, due to a certain degree of error.

Great part of GIS functionality is based on Boolean operators which are founded on a two-valued logic. Vagueness (Erwig and Schneider, 1997) takes into account multi-valued logic and it is based on the concept of "boundary region", which includes all elements that cannot be classified as belonging to a set or to its complement (Pawlak, 1998).

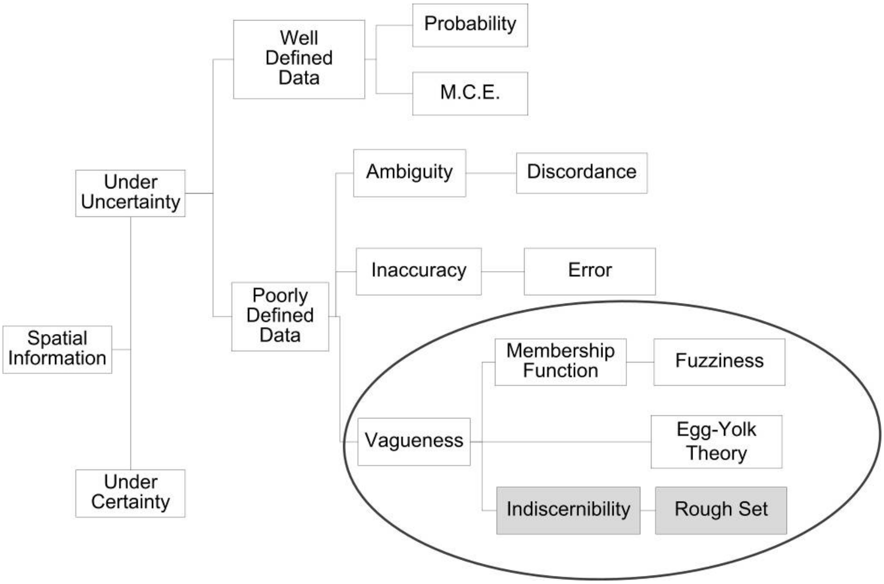

Fig. 1. A Classification of uncertainty in spatial information (adapted from Murgante et al 2008)

Three theoretical approaches to vagueness exist: the first one is based on fuzzy set theory (Zadeh, 1965), which accounts for partial membership of elements to a set; the second is Egg-Yolk Theory (Cohn and Gotts 1996, Hazarika and Cohn 2001) based on the concepts of “egg”, i.e. the maximum extension of a region, and “yolk”, i.e. the inner region boundary; the third approach is rough set theory (Pawlak, 1997).

In urban and territorial planning, the abandon of deterministic approaches to decision analysis has been quickly developed thanks also to the great opportunities provided by powerful computer tools able to manage very large data bases, to execute more complex comparisons and to support the new simulation tools.

Instruments derived from *Artificial Intelligence* coupled with *GIS systems* consent detailed elaboration on various data types (i.e. thematic maps, population density, transport infrastructures, productive settlements, environmental surveys etc.) and enable to extract and build knowledge directly from experimental data and also to represent the extracted knowledge in form of rules involving the spatial dimension (Lombardo and Petri 2008).

Large amounts of data are available to analyze and simulate the evolution of urban and territorial systems, but the value of those data mainly depends on the capability to exploit knowledge from them. On this purpose, innovative and efficient tools and methods can be found in the field of *Data Mining* and *Knowledge Discovery from Databases* (KDD), the former being the core of the latter (Bonchi et al 2004).

In fact, KDD is a multi-disciplinary field which merges concepts and techniques from different research areas, such as statistics, artificial intelligence, export systems, machine learning, pattern recognition, information retrieval, high performing computing and data visualization (Bonchi and Pecori, 2004).

Data Mining (DM), the nucleus of KDD, is an essential process where intelligent methods are implemented in order to extract data patterns; it comprises a class of database applications which searches hidden patterns in a group of data that can be used to predict future behaviors.

Machine Learning (ML) is a subfield of artificial intelligence concerning the development of techniques which allow computers to "learn"; more specifically it is a method for creating computer softwares by the analysis of data sets. Machine learning overlaps heavily with statistics, since both fields study the analysis of data, but unlike statistics, it is concerned with the algorithmic complexity of computational implementations (Kanewski and Maignan 2006).

Artificial neural networks, *decision trees*, *genetic programming* and *Bayesian networks* are some of the most powerful and well-known machine learning topics.

In urban planning, environment machine learning can be a powerful instrument to increase the capabilities and the potentialities of spatial decision support systems. On the hypothesis that human expert knowledge is based on applying decision criteria to a given domain, ML systems can be built with the peculiarity to learn how to identify these criteria, with sufficient access to domain specific information sources (Oh et al. 2006, Peng and Gero 2006).

In urban and territorial planning, the final aim of spatial modeling and simulation systems is to open new knowledge windows by working on the relations acting in time and space between spatial phenomena. Those models can support decision makers in better understanding the consequences of their choices and to help them in the decision making process itself.

The first generation of models and systems was often based on simple input-output relations, weak in terms of behavioural principles and spatial scale. Most of them were based on the assumption of perfect and full information, so that uncertainty was rarely addressed, but in a territorial context characterized by an increasing *uncertainty,* forecasts are inevitably subjected to several limitations.

Geocomputational methods for urban planning may therefore include innovative approaches to reasoning based on human tolerance uncertainty, incompleteness, imprecision and fuzziness in decision-making processes (Diappi 2004).

With the development of chaos theory and powerful tools offered by GIS and soft computing, traditional complex models were replaced by new ones as Cellular Automata and Multi Agent Systems (Batty 2001; Benenson and Portugali 1997).

While the former ones are often based on the belief that simple rules and principles are sufficient to generate complex emerging patterns, the latter are mainly focused on the analysis of the strategic choice of actors involved in a urban environment. Even though some multi agent systems are still based on simple, primary data driven principles, others are trying to deeply investigate the behavioral foundation of models (van Leeuwen and Timmersmans 2006, Petri et al 2008).

An important element on which the analysis urban modelling has to be focused is the identification of *rules*: we refer to spatial simulation tools which, based on the definition of the territorial system elements (agents, sub areas, etc.) and of the environment enveloping them, allow the simulation of the relations between elements and between elements and their environment (e.g. Cellular Automata, Multi Agent Systems) (Lombardo and Petri 2008).

In the context of simulation applied to territorial sciences, the building of evolution rules applied to the "actors" (be they individuals, groups, or spatial unities) follows three main approaches:

1. the adoption of well established theories: rules are derived from analytical models as in Harrys and Wilson's model (Wilson 1981, 2000; Lombardo and Rabino 1983) or economical models such as Discrete Choice Models (Heppenstall et al. 2005);
2. the "building" of rules based on "expert knowledge": those rules derive from the modeler's know-how of from common sense. Such rules can follow the BDI (Beliefs, Desires and Intentions) framework (Nonas and Poulovassilis 1998) or the "Activity Based Approach" (Ettema and Timmermans 1995);
3. the "discovery" of rules: this is the more complex approach as rules are derived directly from data, by techniques belonging to the field of Artificial Intelligence, such as Decision Tree Induction, Neural network, Genetic Algorithms, Bayesian Networks etc. This way often produces limited sets of rules, because it needs still more studies and developments, but presents some advantages, as specified below:
    - It enables to extract (possible new) knowledge from very large spatial data bases;
    - It consents to derive rules specific for the study area;
    - It enables to verify the rules adopted in approaches 1) and 2);
    - It verifies if and what rules are unchanging in time;
    - It represents a way to build new theories.

The geocomputational approach adopts the third type of rules, as it assumes that information processing should itself be able to find out rules through a learning procedure.

The main aim of spatial analysis is a better understanding of spatial phenomena aggregations and their spatial relationship. Spatial statistical analyses are techniques which use statistical methods in order to determine if data show the same behaviour of the statistical model. Data are treated as random variables. Events are spatial occurrences of the considered phenomenon, while points are each other arbitrary locations. Each event has a set of attributes describing the nature of the event. Intensity and weight are the most important attributes; the first one is a measure identifying the event strength, the second is defined by the analyst who assigns a parameter in order to define if an event is more or less important according to some criteria.

According to Bailey and Gatrell (1995) spatial statistics techniques can be grouped in three main categories: Point Pattern Analysis, Spatially Continuous Data Analysis and Area Data Analysis.

The first group considers the distribution of point data in the space. They can follow three different criteria:

- random distribution: the position of each point is independent of the others points;
- regular distribution: points have an uniform spatial distribution;
- clustered distribution: points are concentrated in some building clusters.

The second group takes into account the spatial location and the attributes associated to points, which represent discrete measures of a continuous phenomenon. The third group analyzes aggregated data which can vary continuously through space and can be represented as point locations. This analysis aims to identify relationships among variables and *spatial autocorrelation.* If some clusters are found in some regions and a positive spatial autocorrelation is verified during the analysis, it can describe an attraction among points. The case of negative spatial autocorrelation occurs when deep differences exist in their properties, despite the closeness among events. It is impossible to define clusters of the same property in some areas; a sort of repulsion occurs. Null autocorrelation arises when no effects are surveyed in locations and properties. Null autocorrelation can be defined as the case in which events have a random distribution over the study area (O'Sullivan and Unwin, 2002). Essentially, the autocorrelation concept is complementary to independence: events of a distribution can be independent if any kind of spatial relationship exists among them.

Spatial distribution can be affected by two factors:

- first order effect, when it depends on the number of events located in one region;
- second order effect, when it depends on the interaction among events.

If these two definitions seem more clear, it is not as much clear as the recognition of these effects over the space.

Among widely used spatial analytical techniques, point pattern analysis represents one of the more interesting and adopted ones. This is also due to the fact that point structures are among the easier ones to use, process and represent by means of spatial analytical programmes and GIS softwares, consisting of a minimum set of coordinate pairs with – or without – attribute data for those locations. If the simple scatterplot of point features helps in giving some information about the pattern under exam, however more refined techniques can be applied to better understand it. Techniques and methods to analyse first and second order properties have been implemented, measures based on density, i.e. Kernel Density Estimation, and those relying on distance, i.e. Nearest Neighbor Analysis and K – functions, respectively.

Space representation in such sense is a simplified one, as geomorphologic features and human actions, in terms of built environment and infrastructures, do not arise automatically when we simply consider a (flat) study region of space (an area) and a set of events (points) in a two-dimensional space.

Only recently some efforts have been made, thanks to improved processing power and algorithms, to include some of the physical and human constraints onto spatial analytical techniques, and in point pattern analysis in particular. This is an effort to go further the 'classical' geographical assumption of isotropy and homogeneity of space, therefore modeling it in a more realistic way. Networks, in particular, have been considered, in order to adapt analytical methods to a space influenced by the presence and the actions of humans, especially urban areas.

In fact, many human-related events in space are related to network-led spatial features as road transport network, therefore over non-homogeneous, non-Euclidean spaces. Recently, Batty (2005) recalled a need to implement more refined network analytical techniques into GIS software. Miller (1999) as well, noted that assuming space as continuous and planar is too strong for analyzing events occurring in a subset of such space.

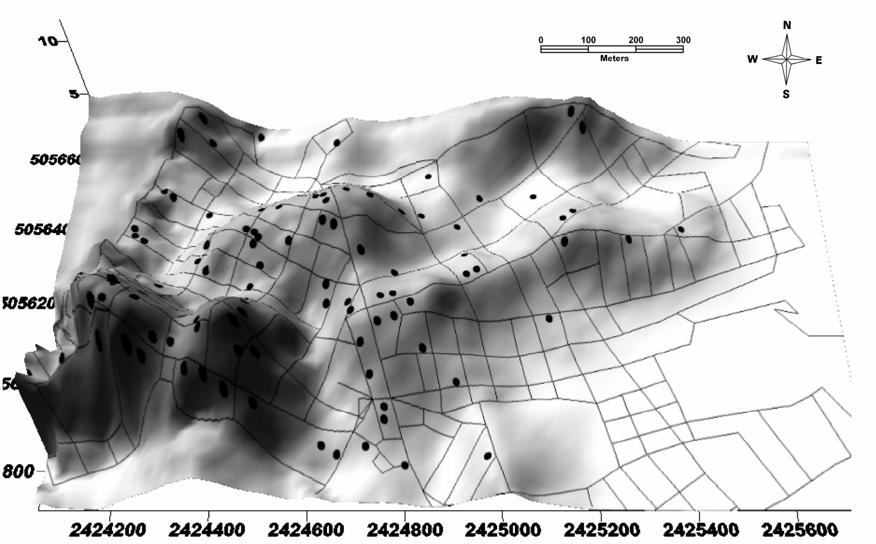

Fig. 2. Density estimation on networks: Example of linear Network Density Estimation (NDE) over banks and insurance company in the central urban area of Trieste – Italy (adapted from Borruso 2008)

In recent years, authors involved in spatial analysis focused mainly on second order properties, as Nearest Neighbor Analysis (Okabe et al 1995) and *K* - functions on networks (Okabe and Yamada 2001) and their application to real cases (Yamada and Thill 2004, 2007). Recently other authors (Borruso 2005, 2008 and Downs and Horner 2007a,b) studied network-related analytical techniques for first order point pattern analysis, actually adapting Kernel Density Estimation to a network structure. In their applications they focused respectively on density of human activities in a network urban space (Figure 2) implementing a method called Network Density Estimation (NDE) and on networks of movement trajectories of animals for home ranges estimation, Network-based Kernel Density Estimation.

Spatial Statistics has not been used enough in the field of urban planning. Planners generally prefer to carry out the traditional statistical analysis, pasting results to the geographical entity. Compared to classical statistical analyses, autocorrelation techniques allow to discover where the concentration of several indicators is located. An application of autocorrelation methods in order to produce more detailed analyses for urban regeneration policies and programs has been applied in Bari municipality (Murgante et al 2008). Generally, a municipality proposes an area as suitable for a urban regeneration program, considering the edge of neighbourhoods established by bureaucrats. Socio-economic analysis can account for a huge amount of data related to the whole neighbourhood. Nevertheless sometimes it is possible that only a part of a neighbourhood is interested by social degradation.

In these cases the indicator is diluted and it does not capture the phenomenon throughout its importance. Furthermore, it is possible that the more deteriorated area belongs to a part of two different adjacent neighbourhoods.

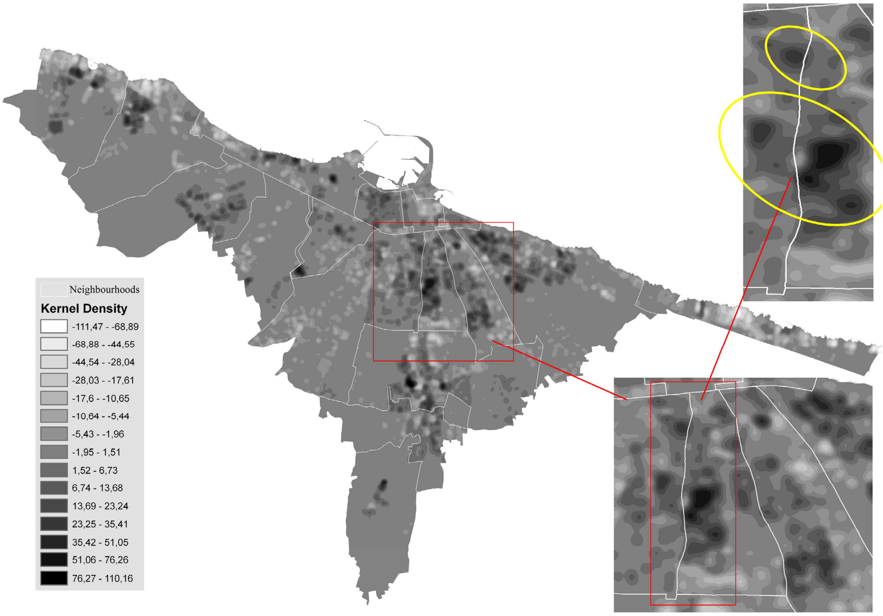

Fig. 3. Synthetic index of Kernel Density Estimation of social indicator (adapted from Murgante et al 2008)

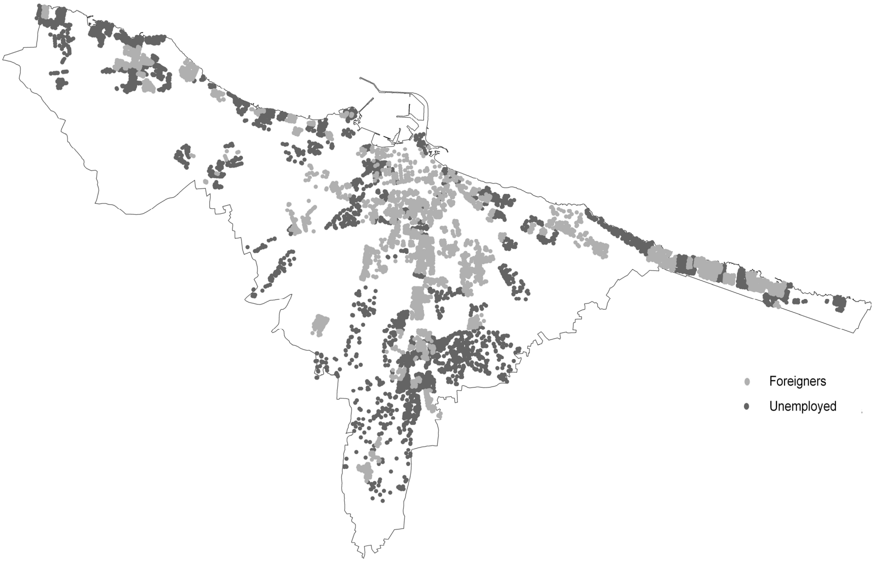

Fig. 4. Comparison of medium and high values of spatial autocorrelation of unemployment rate and foreign population per 100 residents (adapted from Murgante et al 2008)

Considering distributed data for each building, it is possible to apply spatial statistics techniques. Figure 3 highlights two important issues. Highest values (black areas) represent the concentration of several negative social indicators. The two details on the right panel of figure 3 show how areas with high values are located on both parts of neighbourhood boundary and zones which need more urgent interventions are situated across the white line inside the oval. This kind of measure shows all limits of traditional analyses.

In order to determine the exact location of these problems, further analyses are needed. It is important to adopt local autocorrelation measures. Getis and Ord's function is a suitable index to determine where several phenomena are concentrated and consequently where policies should be applied.

Considering Getis and Ord's function for two or more variables at the same time (figure 4), it is possible to achieve interesting interpretations. Areas with the strongest autocorrelation of immigration are far from zones with high concentration of unemployed. This means that no spatial correlation exists between immigration and unemployment.

3 The Chapters of This Volume

Socio-economics in space and time is always one of the cornerstone of urban planning. City development needs Knowledge about service locations and residential tendencies. In order to improve choices of decision makers about urban strategies, statistical and learning algorithms could produce a socio-economical distribution of town trends. *Tuia et al* present a new approach adopting an unsupervised classification method, based on Ward's classification and self-organized maps, in order to analyze the socio-economic structure of Vaud and Geneva cantons in Western Switzerland.

Borruso and *Porceddu* focus on the observation of urban form and functions in order to identify a method for the cartographic definition and representation of CBD (Central Business District). The paper is based on analyses related to spatial statistics in a GIS environment, especially point pattern analysis to model the spatial distribution of central activities within an urban area, in order to highlight hotspots as a measure of centrality. In particular, kernel density is used to test concentration of activities and, therefore, delineating CBD, presenting evidence from two urban areas in Northeastern Italy (Trieste and Udine).

Montrone et al present a paper where statistical data are used to identify territorial zones characterized by the presence of urban poverty, related to real estate ownership and the availability of residential services. In particular, a Total Fuzzy and Relative (TFR) approach is applied in order to detect, within clusters of poverty at urban level, differences in individual accessibility to the real estate market, capturing the multidimensional characteristics of the phenomenon and to allow comparisons over space and time. The approaches were implemented and improved using SaTScan methodology, a circle-based spatial-scan statistical method for poverty hot spot detection, with an application to the urban area of Bari (Italy).

The paper by *Cutini* starts from the concept of segregation of social housing in urban peripheries to implement a methodological approach based on configurational techniques to analyse urban settlements. In particular, edges of towns are examined, in order to account for the effects of the configuration of the urban grid on their condition of segregation and marginality. The purpose is to test the configurational techniques on several case studies, so as to prove them as a reliable and useful tool to analyse and understand such areas and to support town planning. Local Italian cases, such as the cities of Leghorn, Pisa and Grosseto, are analysed, observing the edges of these urban settlements, trying to find a way for understanding, describing, and even measuring their actual level of segregation and marginality.

Spatiotemporal aspects are fundamental in risk management. The increase of economical and social costs, following disaster, has led to a prevention strategy for damage reduction. Furthermore, this strategy can guarantee a briefer time to recover system efficiency. A preventive measure ensuring a better accessibility and evacuation may be the right approach to urban planning. Risk analysis has not been used enough in the field of transportation systems; just several experiences exist in analyzing material and immaterial infrastructures' vulnerability. In the great part of cases there is the need to design evacuation measures during the event or immediately after it. For this reason models and algorithms calibrated before the events are not suitable in emergency conditions. *Di Gangi* presents a new approach based on a mesoscopic dynamic traffic assignment (DTA) model, which acquires information during the evacuation simulation of an urban area considering the connected flow phenomena.

The contribute of *Moons et al* is still related to traffic safety. Since 1990s Levine (1995a 1995b 1998) developed several experiences about spatial concentration of vehicle crashes. *Moons et al* face the problem of accident hot spots location applying local autocorrelation indexes. But a simple use of local indicators of spatial association is impossible on a road network, because of a great spatial discontinuity. For this reason, the use of Moran Index has been tailored using Monte Carlo simulation, in order to solve this problem.

Visual impact assessment has always been totally neglected in urban planning, particularly in the location of new neighbourhoods. In order to increase the level of objectivity of visual analysis, GIS can be an useful tool. Since 1990s a lot of applications have been developed using the viewshed for visual impact assessment. Viewshed computation identifies every cell visible from one or more observation points. In order to improve viewshed analysis two extension have been realized: multiple and cumulative viewshed. The former combines all single viewsheds with union operators, the latter sums all single viewsheds using map algebra. While multiple viewshed produces a binary grid which distinguish visible from not visible objects, cumulative viewshed provides information on how many objects can be seen in a certain zone. *Danese et al* have developed a new viewshed operator, *Identifying Viewshed*, which shows how many and which targets are visible from a certain cell.

The contribute of *Ioannilli* and *Rocchi* addresses the problem of Urban Canopy Parametrization (UCP) which allows to describe geometric and morphological characteristics of urban agglomerations by a range of parameters derived from the analysis of high resolution databases.

This issue has a great relevance in the study of meso-scale meteorological models used to study air quality and pollutant dispersion processes in urban areas. The analytical approaches, present in literature, do not consider the process spatial resolution to simulate fluid dynamics and thermodynamics in and around buildings and other urban structures which can modify atmospheric characteristics.

Authors implement an innovative method which aims to analytically determine some of the UCP parameters in an automatic procedure implemented by Arcgis 9. Input data are in the vectorial numerical geodatabase of IX district of Rome city.

Very few studies are now available, concerning the application in existing urban contexts of theoretical models of urban roughness parameters estimation. A comparison among the devised procedure and the most relevant model, available from literature, is performed: it highlights that the analytical approach, adopted by the authors, can be suitable for every urban context and for any wind direction.

Geographical information is characterized by an extremely complex nature. Geographic data can be represented in multiple scale and grids may come from different sources and can be generated at different times, and especially, may have different semantics. Moreover, usually, the quality of data lacks in terms of accuracy and completeness. On the other hand, the management of geographic data in the long term is necessary for a lot of activities based on the management of spatio-temporal data. *Plumejeaud et al* define a theoretical framework for storing, managing, querying, evaluating and analysing different thematic indicators associated with geographic data, ensuring at the same time the observance of quality parameters. A data model based on the objects paradigm is presented. It takes into account thematic, spatial, hierarchical and temporal component of geographical information allowing a long-term modelling of geographic data and related indicators. Relying on this model, a system architecture for the assessment of missing values, based on geographic and thematic ontologies, is proposed.

The paper by *Carneiro et al* deals with an application of GIS and Airborne Light Detection and Ranging (LIDAR) data analysis for computation of buildings visibility, solar exposition and extraction of morphological indicators in the context of urban group analysis and morphogenesis geosimulation. A simulation model is implemented using GIS and LIDAR data aimed at urban simulation and at understanding dynamics of cities and metropolis, as auto-organized urban systems, as well as at simulating and analyzing form and shape of a city. Their application deals with the urban area of Lausanne (Switzerland).

The issue of urban expansion characterization is carried out by *Telesca et al* introducing a new approach in which spatial fractal analysis is applied to multidate satellite imagery. The understanding and the monitoring of urban expansion processes are a challenging issue concerning the availability of both time-series data set and updated information on current urban spatial structure and city edges in order to define and locate the evolution trends. In such a context, an effective contribution can be offered by satellite remote sensing technologies, which are able to provide both historical data archive and up-to-date imagery. The paper is focused on fractal analysis of the border of four small towns in southern Italy, using multidata NASA Landsat images acquired in 1976, 1991 and 1999. The border was analyzed using the box counting method, a well-known technique to estimate the spatial fractal dimension that quantifies the shape irregularity of an object. Such method computes the degree of irregularity of city borders, therefore the higher the fractal dimension, the more irregular the border. Analyzing and comparing three different years, the process of urban morphology variation is observed and the value of the fractal dimension of the urbanized area enables to determine whether their structure can be described as more or less regular. The relevance of the technique used here is that it provides a reliable way of quantifying the urban structure and its transformation through time.

Voiron-Canicio presents a new modelling approach dealing with the spatial spreading of built-up areas in order to both predict the broad outlines of urbanized areas extension on a regional scale and to provide decision makers with a system which allows them to explore spatial consequences of different urbanization policies. The devised spatial model, even though similar to cellular automata approach, presents the peculiarity to use image processing methods and mathematical morphology (MM) algorithms. MM is an efficient image processing method which offers several advantages over other techniques, in particular it preserves edge information, uses shape-based processing and is computationally efficient. MM is relevant for analysing phenomena where both the structural description and the determination of laws co-exist.

In this model, spatial spread process depends on both proximity and morphology of built-up areas located in a space whose configuration also determines the shape of spatial spread: such features explain the "spatio-morphological" qualifier given to this model. The spreading process of built-up areas is based on dilations and closing transformations. The model is deterministic and assumes that spreading process is essentially complied with an elementary rule of distance to the built-up areas, which explains the major part of the spreading process and goes beyond the prescriptions registered in the documents of town planning. Experimentations are conducted on the coastal part of Languedoc study area in Southern France. The model is carried out with multitemporal data and enables to simulate urbanized areas spread and predict future built-up surfaces up to 2010.

The spatio-morphological model presented provides interesting results which demonstrate that spatial rules simply based on notions of distance, shape and neighbourhood suffice to describe the major part of built-up areas spread, independently of town planning constraints.

Blecic et al introduce a Multi Agent Geosimulation Infrastructure (MAGI) which aims to be a “good” tool for urban and territotial planning: it therefore must have specific characteristics, in terms of modularity, flexibility, user-friendliness, generality, adaptability, computational efficiency and cost-effectiveness.

The Multi Agent Geosimulation Infrastructure presented is designed and developed for the purpose of supporting the process of Multi Agent System (MAG) model building, while at the same time offering a rich environment for carrying simulations and conducting controlled experiments. MAGI is an integrated environment allowing users to build *ad hoc* agent-based geosimulation models, then the main strength of the tool lies in the generality of underlying meta-model, embodying the possibility to model a large variety of real systems. Modelling environment has many features for developing and carrying simulation models; in fact, besides modelling “mobile” agents, the generality of meta-models covers also the family of cellular automata-like models with “static” agents, without making compromises to the simplicity and elegance of the modelling practice.

The MAGI modelling and simulation infrastructure presents characteristics, features and computational strategies particularly relevant for strongly geo-spatially oriented agent-based simulations. The infrastructure is composed of a development environment for building and executing simulation models, and a class library based on open source components. Differently from most of the existing tools for geosimulation, both raster and vector representation of simulated entities are allowed and managed with efficiency. Several characteristics of MAGI model are discussed in the paper: generality, user-friendliness and modelling flexibility, interoperability with GIS datasets and computational efficiency. A specific attention is given to one of the distinctive aspects of multi-agent geosimulation models: the process of agents' spatial perception.

In the complex and multifaceted field of Multi Agent Sistem (MAS), *Lapucci et al* deal with the development of a system able to analyse the dynamics of sustainable mobility of an historic city centre in Tuscany (central Italy). The focus of the entire analysis is the extraction and the study of agent behavioural rules adopting a bottom-up participative method. The Activity-Based micro-simulation approach is adopted: it consists in the possibility of obtaining the behavior of a complex urban system at meso or macro scale, as derived from millions of choices performed by individuals belonging to the system itself. On this purpose, both a detailed "temporal" Geodatabase and a dedicated population sample are devised: the former contains spatio-temporal information on private activities and public services (delivered over time) offered by the city, the latter introduces participative methods in order to reconstruct citizens' preferences on mobility demand. In this second step, both a paper questionnaire and an on-line one are designed for the survey; the last one is implemented by a WEB-GIS application for the spatial location of agent journeys and city services. The model final step comprises the extraction of agents (residents and commuters) behavioral rules from both territorial and survey data by Artificial Intelligence tools. Two different Data Mining techniques are adopted: at first Decision Trees are used in the exploratory phase and rules (extracted in an IF-THEN form) allow to identify the important variables connected to each target choice; in a second phase, the most relevant variables are employed as input data for the *Bayesian Networks* able to extract conditional probability distribution tables necessary for the model implementation. The model elaboration, currently in progress, its testing on Pisa case study and the tools implemented till now already represent a new decision support system useful both to plan sustainable mobility policies and to locate new activities inside the city centre, in order to improve the quality of present services.

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