Towards a Collective Spatial Analysis

Proposal of a New Paradigm for Supporting the Spatial Decision-making from a Geoprospective Approach

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Abstract: This paper presents the progress of a research work that seeks to establish prospective spatio-temporal locations of goods, services or events in a given territory primarily through the application of concepts and/or tools that combine Collective Intelligence (CI), Geographic Information Science (GISc) and Complexity Theory. Relying on this notion, probable and plausible future scenarios could be projected to conduct various studies within the context of the Geoprospective (an emerging field of research aimed at issues of territorial forecasting), which might provide valuable alternatives in the decision-making process in order to carry out anticipatory actions to achieve or avoid such scenarios. In the light of the above, it is suggested that this kind of Collective Spatial Analysis (CSA) would provide a new paradigm about how to perform spatial analysis, the same that is based on a cognitive approach of a multidisciplinary group of users who collectively participate with their knowledge on an interdisciplinary basis, and not from a limited single user approach that uses geometric, statistical or mathematical geoprocessing algorithms.

1 INTRODUCTION

The spatio-temporal dimension should be considered transcendental in decision-making, specially when is intended to plan, organise and use the territory and its resources, since it is the geographical space in which most of the human activities are conducted and will take place. It is worth highlighting that the geographical space must be considered as a complex system; being understood by "complex" as something that stands out from complicated, characterised by nonlinearity, emergence and surprise, and that involves uncertainties that must be taken into account, particularly in strategic planning (Ratter, 2006; O'Sullivan et al., 2006; Pitman, 2005). From this point of view, research related to the territory should not be addressed from reductionist approach, splitting up and then adding parts, as in most cases, but through a set of interactions of its key components, selected according to the topic to be approached to, and bounded in time and space, as it is impossible to consider the full range of its elements, interactions and variants.

Given the complexity of the geographical space, the need for an interdisciplinary study of it is also manifested. Consequently, in this regard different approaches have emerged to analyse it for planning purposes; among others, the Territorial Intelligence (Peña, 2013), and the Geoprospective (Emsellem et al., 2012). In practice, both approaches differ slightly, nevertheless, according to the purpose of this work the Geoprospective approach will be addressed.

The Geoprospective is a relatively emerging research field whose concept emerged in 1968, and it was boosted since the year 2000, with the mere purpose of carrying out foreseeing tasks on territorial planning by integrating different methods and participants to provide results based an interdisciplinary approach. Under this approach, one or more future possible or plausible scenarios are intended to generate which will help early decision-making to achieve the objectives pursued (Emsellem et al., 2012; Godet et al., 2008; Houet and Gourmelon 2014).

As it is well known, so far this kind of scenarios can be generated through spatial analysis by using Geographic Information System (GIS), either using it as an independent tool or widening its capabilities to integrate (along with other conceptual, methodological, and technological resources) a Spatial Decision Support System (SDSS) (Buzai, 2011; Densham and Goodchild, 1994; Jankowski et al., 2014; Moon and Ashworth, 1992; Sugumaran and Degroote, 2011). In this respect, it is worth remarking that thanks to the introduction and proliferation of these technologies (GIS and SDSS), nowadays the term Spatial Analysis is mainly related to computerised processes executed by one single user; however, it should be pointed out that the Spatial Analysis not only can be performed through one or several geoprocessing functions, i.e., these types of scenarios not only can be generated from the available computational capabilities of the GIS to manipulate and analyse spatial data and which are "considerably influenced by the progress on information technology" (Zhao et al., 2012).

That is why this document presents the research progress that suggests the insertion of a new paradigm into Spatial Analysis, whose purpose is to generate spatio-temporal locations from the interdisciplinary study of geographical space, perceiving such space from the Complexity Theory perspective (Ratter, 2006), and for that purpose, based on the Collective Intelligence philosophy (Lévy, 2010), as well as some concepts and technologies of the recent Geographic Information Science (Blaschke and Merschdorf, 2014). As a consequence of the conceptualisation of this paradigm, a geotechnological tool has been developed, which will lead to determine geoprospective locations of goods, services and/or events, in order to support spatial decision-making.

2 SPATIAL ANALYSIS

In general, Spatial Analysis can be understood as the set of systematic procedures that allow studying the characteristics of the complexity of geographical space to draw conclusions, assumptions or solutions to certain questions that will help to better understand the world that surrounds us.

The concept of Spatial Analysis has also been addressed and extended by other disciplines such as Economics, Biology, and Ecology, nevertheless, it is considered as an elemental part for studying geographical space, especially from 1950's decade with the raise of the quantitative Geography, and later due to its inseparable linkage with Geographic Information Systems (Goodchild and Haining, 2004), thanks to which the term is widely associated as a computerised process, and in consequence, it is usual to notice that some studies used it as the equivalent of Geoprocessing, Spatial Statistics and even Spatial Data Analysis. Nonetheless, it must be specified that the latter concept corresponds to diverse tools that form different georeferenced data processings; and alone or in combination by themselves will allow to undertake a Spatial Analysis where the user's knowledge plays a crucial role (Fischer, 2006b; Fischer, 2006a; Fischer and Getis, 2010).

Nowadays, the Spatial Analysis is a very active area of research in the field of Geographic Information Science and it can be performed with simple visual and interactive observation data, systematically through GIS modelling (Longley et al., 2011), supported by software specially designed to solve problems of statistics, using algorithms of Computational Intelligence and Geostatistics (Fischer and Getis, 2010), and even by a combination of all of them; therefore it is applied in multiple spatio-temporal studies such as environment, security and defence, hazards and risks health, education, energy, communications, commerce, regional planning and development, among others.

Table 1: Methods and description to Spatial Analysis (Haller, 2007).

Spatial analysis method	Description
Queries	Retrieve information from database.
Measurements	Numerical value that describes geographic entities and relations between geographic entities.
Transformations	Changing, combining or comparing datasets.
Descriptive summaries	Descriptive statistics applied in GIS.
Optimisation	P-median problem – selecting ideal locations according to well-define rules.
Hypothesis testing	Make generalisations about the whole from a sample dataset.

Nevertheless, the user is the main component of any Spatial Analysis, whether designing geoprocessing algorithms and/or applying them to the qualitative and/or quantitative characteristics of the different layers. The user is who develops the procedures, chooses the variables, confirms the analysis and interprets the results by using his/her knowledge, feelings and experiences (Gomez and Jones 2010, p.32). Therefore, the same problem may be approached differently according to the reasoning of each user; and the potential to analyse and obtain the corresponding knowledge will vary according to the sort of data and methods to be used (Table 1 and Figure 1).

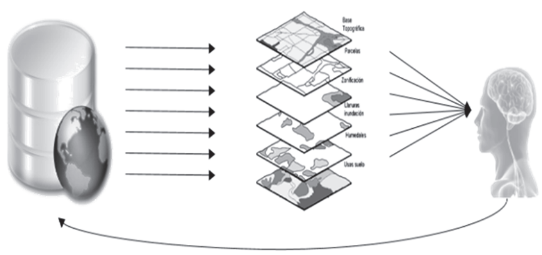

Figure 1: Traditional Spatial Analysis, from a single cognitive stance.

3 COLLECTIVE INTELLIGENCE IN GISc

"Collective intelligence has existed for at least as long as humans have", and it can be used from different perspectives (MIT, 2012), for example when studying the use and exchange of collective information in insect colonies, (Franks et al., 2002); in the research of fanatic feelings and emotions during a professional football game (Trappey et al., 2014); in the programming of Artificial Intelligence algorithms to create a recommendation system that provides filtered information from a great quantity of elements in field of the modern medicine (Pérez Gallardo et al., 2013), or in public administration for establish priorities in public health policy (Martì et al., 2014).

Due to this wide scope of applications, it is difficult to define Collective Intelligence without excluding some of its applications; hence, for the purposes of this work, it is understood by IC: "The capacity of human collectives to engage in intellectual cooperation in order to create, innovate, and invent" (Lévy, 2010). It can be noted that this philosophy is able to be applied from a reduced number of individuals to the whole humankind. Furthermore, it is necessary to identify the difference between Collective Intelligence and Collaborative Work (Patel et al., 2012), because while the first intends to develop knowledge together, the second only implies the interaction among the individuals to work towards common goals.

With regard to the scope of Geographic Information Science, some methods have been extensively developed that allow using geotechnologies, basically from a collaborative approach. Among the most outstanding are the Participatory Geographic Information Systems (PGIS), whose purpose is to stimulate the participation of society in collaborative research of its own territory (Sieber, 2006); subsequently the capabilities of these have been extended to make up Collaborative Geographic Information Systems (CGIS) (Balram and Dragićević 2006), which may also incorporate social network services and provide a working platform to share georeferenced information in real time as a Geocollaboration System (Chang and Li, 2013). On the other hand, the Spatial Decision Support Systems (SDSS) thus constitutes another tool sometimes made up for collaboration as a team, and are designed to support decision makers to solve the complex problems related to the space (Jankowski et al., 1997; Jelokhani-niaraki and Malczewski, 2015; Sugumaran and Degroote, 2011).

With the advent of Web 2.0, widespread dissemination of internet portals was launched where any person may contribute and look up in a simple way (like Wikipedia), which currently is known as Volunteered Geographical Information (VGI) (Goodchild, 2007). This practice is usually associated to the term Neogeography which defines the democratisation of the information that is used and uploaded by this sort of "non-expert" users (Hudson-Smith et al., 2009). In the same vein, from the collective production of geographical information, recently the VGI has accurately been called as Spatial Collective Intelligence (Spielman, 2014). Albeit, given the characteristics and nature of its production, a whole debate regarding the quality and the reliability of this information has also been created (Flanagin and Metzger, 2008; Spielman, 2014).

4 DISCUSSION: COLLECTIVE SPATIAL ANALYSIS (CSA)

Most of human activities are related to territory, and therefore, they constitute complex space systems that require an interdisciplinary study for proper planning and management. In this regard, the necessary analysis demands to locate and map out certain events in a space-time through spatial analysis carried out in a Geographic Information System; the same which is used independently or as part of a Spatial Decision Support System or a Collaborative Geographic Information System. However, this spatial analysis is invariably produced from a single cognitive stance, since nowadays, there are no means that allow collectively perform a Space Analysis for obtaining an interdisciplinary result.

Concerning the work undertaken, it can be seen that through Participatory Geographic Information Systems the society actually participates only providing local information for a specific purpose, but is not involved in a process of spatial analysis. In terms of Volunteered Geographic Information, it is observed a similar case, with the difference that in this exercise, the collective does not belong to the same local community, nor has it been expressly convened for that purpose. Yet, in both PGIS and the CGI, it can be stated that an operation of Spatial Collective Intelligence is performed (Spielman, 2014), since in both cases a collection of unique spatial knowledge is created through intellectual cooperation of a group, but emphasising that a task of Collective Spatial Analysis is not carried out.

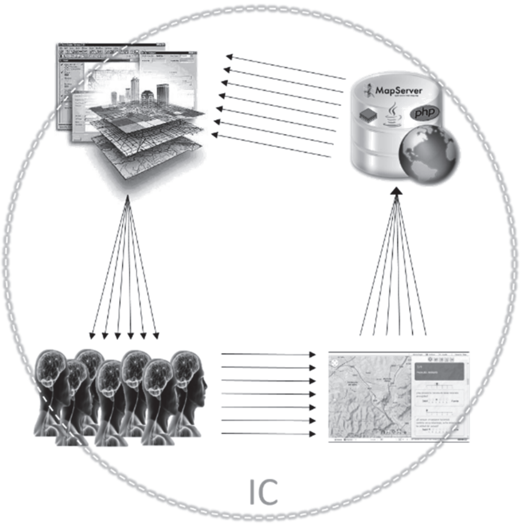

Figure 2: Collective Spatial Analysis, from a cognitive stance of group.

In the light of the above-mentioned, a paradigm is considered vital in the Spatial Analysis that supports new lines of research for the study of geographical space from the Collective Intelligence philosophy, which could be coined as a Collective Spatial Analysis, and is defined as the ability of a human collective -that cooperates intellectually- to investigate the complexity of geographical space in order to create, innovate or draw conclusions, assumptions or solutions to certain questions that will make a contribution for a better understanding of the world around us (Figure 2).

This aspect is crucial when is consider for example, that in geoprospective studies in order to support decision-making regarding planning or prevention, it is necessary to devise future scenarios within which space-time component of goods, services and/or events is extremely important, and also these scenarios will be more rational through the interdisciplinary opinion of a group of experts.

5 CONCLUSIONS

This paper has presented the progress of research, that seeking to establish geoprospective spatio-temporal locations of goods, services or events in the territory, has highlighted the need to open new lines of research to analyse the geographical space adopting the Collective Intelligence philosophy, because, as it can be seen, the range of possibilities suggests thinking of a new paradigm within the Spatial Analysis and the Collective Spatial Analysis.

To validate this assumption and as an example of possible applications, in this research, a Spatial Decision Support System Group G-SDSS tool has been developed, which is named Geospatial System of Collective Intelligence (SIGIC for its acronym in Spanish and Catalan), with which is intended to determine spatio-temporal locations in an interdisciplinary way (from the geoprospective approach) through the geo-consensus (agreement on territorial locations relative to different opinions) (Di Zio and Pacinelli, 2011).

It is considered that those geospatial features of the locations obtained through geo-consensus could even be used as an input pattern*, so that from it, the rest of the area under study is classified; for instance, through Neural Networks which have produced encouraging results in numerous geographical problems (Painho et al., 2004), being able to even employ this method of expert geo-consensus for supervised classification of remote sensing.

This does represent a significant advantage over the usual way of carrying out Spatial Analysis, if it is considered situations where there are insufficient data to perform geoprocessing, or in circumstances which are characterised by uncertainty as in the case of nonlinearity, emergency and surprise, and even, as support to narrow, guide, verify and/or correct the results of other Spatial Analysis alternatives.

Of course, questions remain unresolved, the fact is that the spatial analysis currently done with GIS is

* A pattern should be understood as an entity that is represented by a set of measured properties, and the relationships between them (Watanabe, 1985).

weak to support decision-making in situations like those presented here, specially because they are not designed for a group to develop in an interdisciplinary way, a spatial analysis on complex spatial scenarios.

Moreover, it is not intended to imply, nor intended this work to discredit the current way of doing spatial analysis. But it does to raise awareness regarding the necessity to consider new research lines in spatial analysis that take into account the participation of multidisciplinary groups to develop knowledge of geographic space in an interdisciplinary way, with the aim to refine what until now has been done; because as Albert Einstein hinted: in order to obtain different results, is imperative to do different things.

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