Geospatial System of Collective Intelligence: A technological application for the interdisciplinary study of the geographical space complexity

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1. INTRODUCTION

The geographical space constitutes a complex system in which human activities take place; such principle that equally applied to past and future activities, either. Moreover, it is actually on the geographical space where various events that affect or benefit these activities are manifested; therefore, it is essential that when planning, organising and undertaking each of these activities, the spatio-temporal component is considered from an interdisciplinary perspective.

One way to conduct planning regarding the geographic space, is through generation of scenarios displaying alternatives, either to take appropriate measures from a present time, or simply to project the ideal state to be achieved; and this usually can be obtained through different technological and methodological tools that allow to build mathematical and statistical models[1], as well as graphic patterns or a combination of these, as in the case of the use of Spatial Decision Support Systems (SDSS).

The Spatial Decision Support Systems are designed to help decision-makers to solve complex problems related to geographical space, and are mainly based on the technology of Geographic Information Systems (GIS), which together with other components can create robust systems for group collaboration (Chang & Li, 2013; Jankowski, Nyerges, Smith, Moore, & Horvath, 1997; Jelokhani-niaraki & Malczewski, 2015; Sugumaran & Degroote, 2011).

Concerning these Collaborative Systems, while if it is true that they do allow to plan, organise and undertake the issue to be addressed from a multidisciplinary or quasi-interdisciplinary perspective, they are not able to produce the model of a likely scenario from an interdisciplinary approach; that because invariably this process is performed with tools and methods of spatial analysis that are selected and systematically executed by a single individual user, i.e., from a limiting single user approach. Thus, resulting alternatives will be given from this sole perspective.

That is why in this paper, we present the research progress in the conception, development and validation of a Group-Spatial Decision Support System application (G-SDSS) named Geospatial System of Collective Intelligence (SIGIC for its acronym in Catalan and Spanish), aimed to support the decision-making process in geographic complex scenarios, mainly regarding the planning, organisation and/or use of resources in the territory, through modelling of spatio-temporal locations of goods, services and/or events derived from interdisciplinary consensus of a group of experts -the conceptualisation of this system has allowed us to suggest the paradigm of Collective Spatial Analysis- (Castillo Rosas, Núñez Andrés, Monguet Fierro, & Jiménez Vélez, 2015).

1.1 Background

As is well known, the term Collective Intelligence has different meanings and applied from different perspectives in a wide field of knowledge, such as for example, the exchange of information on insect societies (Franks, Pratt, Mallon, Britton, & Sumpter, 2002), the research on emotions and feelings of

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[1] For the purpose of this work is meant by model, the graphic representation of objects or events to meet requirements for specific information in a reference system linked to the Earth.

sport fans during an American Football match (Trappey, Smith, Trappey, Chen, & Tung, 2014), or either to establish priorities in health policy formulated by the Public Administration (Martì, Monguet, Trejo, Escarrabill, & Constante I Beitia, 2014).

However, although the Collective Intelligence, as a natural process, has been present from the very existence of humankind (MIT, 2012), currently, it has gained unprecedented importance due to the widespread development of Web 2.0 applications, which have enabled a collaborative work to generate new knowledge, understood in this sense as authentic exercises of Collective Intelligence, that according to Pierre Levy is "the capacity of human collectives to engage in intellectual cooperation in order to create, innovate and invent" (Lévy, 2010).

It is thanks to these technologies and such concept as well, that today is possible to categorise countless applications that generate and/or processed data, and furthermore, organised them to create information which in a greater or lesser extent increases the useful knowledge in the decision-making process in order to solve diverse problems. Although in many cases this type of data and information is discredited mainly in terms of quality, due to its nature of production and /or uncontrolled processing; in this regard, we believe that for certain purposes, the ad-hoc selection of a working group and a control mechanism, such as consensus tools on condition of anonymity, would improve the quality of data and information, and also may provide important feedback to those who perform these tasks.

In the case of systems designed to collectively generate useful knowledge in the process of decision-making for complex problems related to the geographic space (SDSS), as mentioned earlier, these systems do not allow modelling of likely scenarios in an interdisciplinary way; nevertheless, it must be acknowledge important developments that have enabled synchronous or asynchronous collaboration of working groups on this scope, such as Participatory Geographic Information Systems (PGIS) (Sieber, 2006), Collaborative Geographic Information Systems (CGIS) (Balram & Dragićević, 2006) and Geocollaboration Systems (Chang & Li, 2013).

Therefore, considering that many human activities require the planning of spatio-temporal aspects through collaboration and interdisciplinary consensus building, the Geospatial System of Collective Intelligence presented in this work has been developed using the characteristics of a SDSS, that along with the benefits of the Web 2.0, enables asynchronous and collaborative work of a multidisciplinary group; the same one that using the anonymity and mechanisms of spatial consensus, or conveniently denominated geo-consensus, helps generate models of spatio-temporal locations of goods, services and/or events. Hence, in this system converge for the first time: concepts, technologies and/or methods of Collective Intelligence, Complexity Theory, Spatial Decision Support Systems (SDSS), Group Decision Support Systems (GDSS), and Geoprospective, among the most important.

1.2 Archetype model operation

The Geospatial System of Collective Intelligence has been conceived on the basis of the contributions of the spatial version of the Delphi Method (Di Zio & Pacinelli, 2011) as well as the Vector Consensus Model (Monguet et al., 2012). This development basically consists of a Group Spatial Decision Support System (G-SDSS) application in which a multidisciplinary group of experts, suitably selected for the issue to be addressed, can asynchronously give an opinion and anonymously complete a survey which seeks to locate on a map the most suitable sites (or less suitable, depending on the context) with regard to goods, services or events. To do this, the system can store and display regulatory and communicative elements such as documents, pictures, videos, reports, laws, maps and other qualitative and quantitative information to help understand and study the corresponding theme based on problems, needs, available resources, delimitation in time and space, purpose of the study, objectives to be achieved, etc.

As the expert panel members advance through the survey, placing on the map and briefly arguing their "opinions" Figure 1 [a] and [c], the application calculates and displays in real time several

circumferences [b] which point out the area in which it is at least the fifty percent of the group's opinions; analogous to the classical Delphi Method that indicates the group's consensus between the first and third quartile (Di Zio & Pacinelli, 2011). The size of these circles then represents a relative degree of the achieved consensus between the views of the group, for example, as shown in Figure 1, question number five (corresponding to the red circle), presents a greater consensus among experts than in the case of question number one (blue circle).
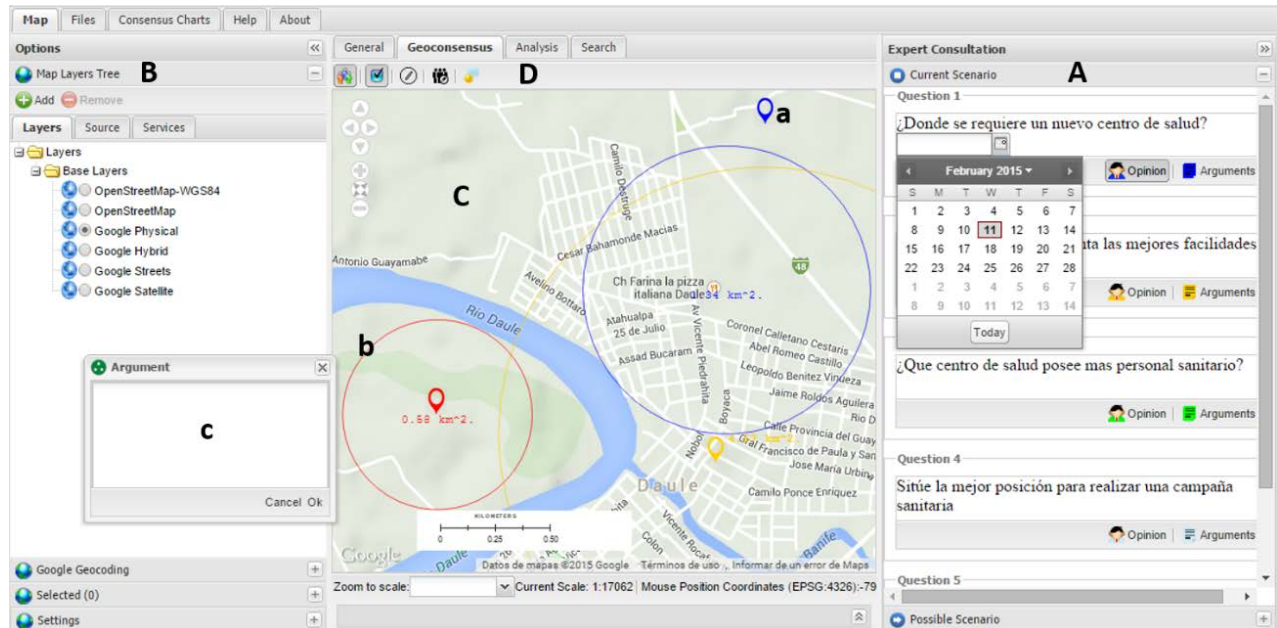
Fig 1. Geospatial System of Collective Intelligence user Interface. Based on GetSDI Geoportal Open-Source Software; where it is possible to locate the following components: **A**. Questions Panel; **B**. Options Panel; **C**. Review Panel; **D**. Tools of geo-consensus.

Thus, each expert can actually visualise in real time if his or her opinion is within or outside the geo-consensus area, as in the cases of questions number five (red) and one (blue), respectively. Furthermore, each participant can see the arguments presented by other experts, putting forward own arguments with the aim of defending his/her opinion; whereby immediate feedback is provided, in order to strengthen, and where is deemed appropriate, to reconsider those decisions regarding the chosen locations. Unlike the spatial version of Delphi method in which the geo-consensus is obtained after different sequential rounds of feedback, in this case it is intended to obtain the agreement of the group in a given period of time, in which participants have access the application as frequently as is necessary, and as many times as desired either; as well as changing their minds as often as considered required (T. J. Gordon, 2009; T. Gordon & Pease, 2006; T. Gordon, 2008).

We believe that this application can be used with appropriate adaptation in various relevant areas related to the complexity of geographical space, such as environment, security and defence, natural hazards, civil protection, health, education, energy, communications, commerce, development and spatial planning, among others. We also presume that in this way, it is possible to provide a multiple and an interdisciplinary overview, as well as a wide range of alternatives to facilitate decision-making, among which may refine and put into context strengths and vulnerabilities of specific geographical points, so as to plan, organise and take the necessary actions aimed at preventing or precipitating the projected scenario in the resulting model through geo-consensus.

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