GIS technologies for Urban Quality of Life analysis

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Abstract: The understanding and assessment of urban complexity from the approach of Urban Quality of Life is essential in order to achieve more sustainable cities, as the perception of citizens is incorporated in urban analysis. This new form of urban study must rely on ICT and GIT technologies, since they enable the gathering and managing of a considerable amount of data that will help characterize urban reality, and more specifically on GIS, due to their potential as a communication and dissemination tool for the results and the new forms of public participation they can encourage.

The article reflects on the (necessary) evolution of urban analysis methodologies: several examples of urban studies accomplished through GIS implementation are presented and some interesting applications of ICT in urban management are identified. Hence, the way of understanding cities is changing and analysis, decision-making and management processes must adapt to these changes.

Key words: Urban Quality of Life, Urban Management, ICT, GIS.

Introduction
The urban sustainability approach and the growing recognition of public participation processes, which serve as the basis for an appropriate urban management, call for the development of new urban analysis tools that will help turn the citizen into the core of the management of cities, understood as a combination of interrelated and dependent elements (a complex system).

Quality of Urban Life represents an inclusive concept of that complexity; it makes possible to integrate qualitative aspects into the analysis and features citizens as key components of it. On the other hand, the development of Geographic Information Systems and other technologies are leading to changes in urban understanding, representation and analysis, close to this approach.

In the article new technologies for urban management emerged over the last years are discussed, in addition to their enormous potential to develop new urban analysis methodologies that consider cities as complex and dynamic spaces and add public participation throughout the analysis process.
Urban analysis in the information age

Although the idea of Smart-City as a synonym of sustainable city may be questionable (the widespread use of technologies into the city is unclear) it is a very interesting concept as it aims to maximize the potential of new technologies in order to mitigate urban issues and ensure livability in cities.

Smart-Cities are based on the idea that urban strategies require deep environmental knowledge and this can only be achieved by means of computer technologies. Some of the key principles include the need for monitoring urban infrastructures in real time (transport, water, energy) and to combine ICT and web 2.0 technology in order to optimize management and decision-making processes and provide innovative solutions, adapted to urban complexity, with ease. Therefore the key component of this initiative is the use of smart computer technologies for urban management improvement by intensive monitoring of urban environment.

This idea about the need for monitoring urban reality is not a new concept (urban indicators have a long history of use in order to characterize the most relevant urban factors and to evaluate their evolution throughout time) but until recently it was inconceivable that such a large amount of information would be available.

From an interdisciplinary approach, cities are complex and dynamic entities and thus new analysis tools, that are able to generate the data needed to characterize urban reality as optimal as possible, are required. Accordingly, real time monitoring as proposed in Smart Cities offers an interesting reference, even if it does not resolve how to integrate qualitative aspects into the monitoring process.

On the other hand, that information must be integrated and combined for quality urban knowledge generation. In this respect, it is worth mentioning the importance of new Geographic Information Technologies (GIT) in the efficient management of the enormous volume of data to cope with. GIT are a set of specialized ICT (Information and Communication Technologies) used as a support tool to collect, manage and analyze georreferenced data that enable spatial information visualization and facilitate their communication, dissemination and exchange. The most prominent technologies among GIT nowadays are remote-sensing technologies (RS), the Global Positioning Systems (GPS) and Geographic Information Systems (GIS). GIS, in particular, present an enormous potential for urban analysis due to their capacity to combine information in different layers and study the relation between them.

Urban studies using GIS technologies

GIS technologies are currently used in any discipline that requires the combination of cartographic maps and databases: cadastral management, urban transport modeling, infrastructure planning, study of natural hazards... The following examples illustrate some of
the utilities of GIS for managing and interpreting information (objective and / or subjective) in different urban studies.

Assessment of the quality of the housing stock by multicriteria evaluation techniques and geographic information systems (2011). García-Almirall, M. P., & García Vaquero, P. [1]: The aim is to identify the level of degradation of the living conditions in Barcelona, conducted by indicators obtained from the INE and the cadastre which were spatially represented by GIS. Among the data provided by the INE the following parameters are considered: accessibility to buildings, lack of running water, age of the building, conservation, the existence of sink inside the house ... Residential land plots with over 40 m² dedicated to industrial uses, existence of below-ground residential use and substandard housing indicator, were some of the data, among others, provided by the cadastre. Combining techniques of Multi Criteria Evaluation and GIS technology the results for each indicator are calculated and represented by thematic maps and the areas with the highest proportion of substandard housing are identified (by weighting indicators).

The salzburg quality of urban life study with GIS support. (2011). Keul, A. G., & Prinz, T. [2]: It relies on a bottom-up strategy. Through door to door interviews, data were obtained on the perception of the quality of urban life in several districts of Salzburg that were obtained, such as housing satisfaction, the sense of security or perception quality of life. Responses from neighbors were geolocated and analyzed using a geographic information system, which enabled to establish relationships between the subjective aspects analyzed; for example, the feeling of safety increased with familiarity with neighbors, and housing satisfaction increased in relation to the years that they had been living in the area. These subjective aspects were also related to objective aspects: people living in apartment blocks were less satisfied with their quality of life than those living in townhouses. In terms of gender and age, women perceived a better quality of urban life than men, and older people were more satisfied than younger ones.

Using GIS to derive region-wide patterns of quality of urban life dimensions: Illustrated with data from the brisbane-SEQ region. (2011). Chhetri, P., Stimson, R., & Western, J. [3]: This study aimed to analyze the attractiveness of the neighborhoods in the vicinity of Brisbane, to try to establish a pattern when choosing the location of housing. Surveys to neighbors about quality of life are combined with objective measures of environmental characteristics, and then implemented by SIG. The indicators (or subjective variables) selected included: proximity to family and friends, short distances to parks, schools, shopping and work and feeling familiar with the area. Subsequently objective indicators that reflect these subjective aspects were sought. Some indicators referring proximity to services were readily determined using GIS. Others, such as "proximity to friends and family" were replaced with available data taken from official surveys (in this case, the percentage of people visiting others in the same suburb). Through GIS, thematic maps of the distribution of each variable considered were obtained and a pattern on how the residents of Brisbane chose the location of housing was set.
The above examples show that GIS is a useful tool to manage large amount of data and facilitate the integrated analysis of them, but do not pose a substantial contribution from a methodological point of view. The form of data collection and consideration of public perceptions respond to conventional approaches. However, the enormous potential of GIS for urban analysis and the ICT revolution raises the need for an evolution also in urban analysis methodologies, that must adapt to the possibilities these technologies offer.

Towards a new use of GIS
The widespread use of ICT has changed our lifestyle, the places we live and how we relate to people; it has changed the emotional, spatial and temporal dimension in which we live and work. The influence of the Internet and online culture is undeniable in many areas of society. Over the years, the sophistication of the technology has increased just as it has the way we use them in our daily lives. The evolution of new technologies and the spread of its use has also brought about an evolution in SIG applications, thanks mainly to the widespread use of GPS and Internet technologies, and the development of tools that have facilitated interoperability between technologies, that is, "the ability to use various applications and data together so that they can "understand" each other and there are no difficulties resulting from the use of different formats or structures". (Olaya, V., 2011). [4]

It is essential to know the possible innovative uses of these technologies to understand the potential that GIS can have for urban analysis. Some of the current trends in this field are named below.

The third dimension (3D GIS).

The addition of the third dimension in the representation of urban models reflects a recognizable environment for everyone (not just experts) and converts that representation in a communication and dissemination tool. It also facilitates the understanding of the relationship between the non-geometric data associated with urban objects. From a systemic approach this consideration of urban reality (also in height) is essential.

The use of 3D GIS technology is now extending to analyze urban issues such as sun exposure of facades, visual quality (visibility of close and remote objects), analysis of wind flows in urban environments or the study of air quality and human exposure.

The study "Assessment of visual landscape for large areas using GIS, internet surveys and statistical methodologies" (Roth, M., & Gruehn, D., 2012) [5] is based on an assessment of landscape quality in large areas from Germany, by using internet surveys, GIS and statistical methodologies. The process followed was: photos of the area were taken with physical components that could evoke scenic quality (relief, vegetation, water bodies...). These images were integrated into a GIS in 3D together with other geo-data, which enabled to build a model that could reproduce the elements in each photo viewed from the exact point where it had been taken. The study participants visualized models and performed an online survey regarding quality components of the landscape that had perceived, such as visual diversity,
distinctive elements, beauty etc. The results allowed to relate the objective components of the landscape with the sensations they produce in people, and conduct a statistical model for the development of a map of scenic quality of the landscape on a larger scale.

Data inventory

Data or urban information collection is one of the most important aspects for the implementation of these technologies and often supposes the main problem in the implementation of projects using GIS. Data quality is essential, thus the information must be current, trustworthy and available in a user-friendly format. Most existing geographic data are generated by state agencies, although it is also possible to obtain data locally for a specific project.

The systemic and dynamic approach to the city requires a large amount of urban information; it involves the shift to detailing urban environment, to give rise to new levels of complexity. While aerial images can determine quite accurately the shape of the ground and height of the decks and facilitates extrusion of the 2D model generated, it is the land and panoramic images that provide more reliable details about soil, vegetation, details facades, urban furniture...

In this regard, a number of technologies have been developed for urban detailed inventorying, alternative to traditional media (based on surveying with GPS and characterization of urban elements in the field phase), such as Mobile Mapping.

The Mobile mapping involves carrying inventory by capturing reality with 3D scanners and panoramic photographs. In a single output a massive catch of information is done, which will allow the geometric positioning and subsequent characterization of the elements from the office; indeed, infinite inventories can be perform with this one data collection.

Real-time urban monitoring

Today, thanks to the Internet virtually any kind of information can be shared and exchanged. We have acces to a large amount of information, from tourist information to the so-called volunteered geographic information or other user-created content. From this interaction between the urban environment and new technologies, new alternative forms for urban knowledge creation appear. The internet devices allow to produce information in different formats: images, video, text... In this context, an emerging concept is the so-called "Internet of Things" (IoT).

The concept "Internet of Things" involves the extension of Internet to the real world of physical objects. It suggests that in a future scenario, any device or object (any lamppost, building, ...) will have a unique identifier on the Internet that will allow them to communicate and transmit information in real time. For this reason, IoT is considered to have an enormous capacity to improve the lives of citizens in many areas such as health, education, innovation, transport, security... The billions of sensors, devices and objects interconnected that make up the network of the Internet of Things can radically transform urban management processes.
With minimal power consumption, these devices (integrated into the urban furniture, for example) may have multiple applications: Citizens can view the current and past state, for example, of levels of CO\textsubscript{2}, noise or any other incident in the pollution through some official website and / or public media in the city. They could also learn about the weather, traffic or other services with the useful information generated.

The neocartography: Participatory Mapping and Gis 2.0

An alternative way of creating urban knowledge has emerged. The internet devices allow to produce information in the form of images, video, text... thus users become not only consumers but also creators of information. Social and technological innovations have led to changes in these practices, and at present, non-expert users can perform mapping activities through the use of various technological devices and simple applications of Web-based mapping, printing on the representation of the urban space their own vision of it. Thanks to the Internet new ways to generate information about the land have been created on the land, these data being voluntary and based on the co-production between users (crowdsourcing).

These initiatives are called mapping or participatory mapping. A clear example of this type of initiative is the Open Street Map project, based on a collaborative model and the geopositioning data collected by GPS.

Other interesting examples: "FixMyStreet" (Great Britain) and its Spanish counterpart "Arreglamicalle" provide a space in which citizens inform and exchange information on the state of the city, specifically of the streets and public spaces. Reviews and photos can be shared and positioned on a map.

There are also projects that integrate GIS technology with these concepts of collaborative online; they are called 2.0 GIS or GIS "wikification". These projects are based on the integration of expert knowledge and the one coming from the voluntary and mass collaboration, with the aim to decentralize and democratize the construction of urban knowledge.

Conclusions

An evolution in the use of GIS for urban reality analysis is occurring thanks to the development of ICT and TIG technologies and the massive use of the Internet. Technologies for the inventory of urban elements that allow to emerge a greater degree of detail. This increase in the level of detail is also favored by the use of 3D cartography, which becomes a legible communication and dissemination tool of urban knowledge. The term "Internet of Things" and intensive monitoring of urban phenomena allow the development of strategies for more effective management of city and accelerate response times. Door to door surveys and online questionnaires to ascertain the perception of citizens are complemented by collaborative mapping initiatives. All this turns GIS technologies into a very interesting tool for achieving urban management processes based on sustainability, urban quality of life and a better and greater public participation.
References


Other references

