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A geospatial indicator for assessing urban panoramic views

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ABSTRACT

We propose a general methodology for the visibility analysis of a selected landscape area, unit or set of features. Its initial field of application is in panoramic views of towns and cities, a dimension of landscape to which varied approaches have been made in recent years, both in iconographic studies and urban planning. The procedure is based on the calculation of visual exposure and includes two additional factors, namely the average vertical angle over the study area and the observation distance. The first is obtained from an extension to the visual exposure algorithm, and the second is evaluated through a weighting curve based on the ability to perceive details of the subject of interest. The result is an indicator we have called View Generation Potential (VGP), which assigns a value to each point in the territory on the basis of its capacity to produce panoramic views of the study area (town or city). The method is easy to use and sources can be readily accessed. VGP can provide useful information for decision-making in urban and land-use planning, which can be integrated into multi-criteria studies and enables the aesthetic and cultural qualities of the landscape of towns and their surrounding areas to be taken into consideration. It can also be used in the management of urban growth via the generation of land-use suitability maps, the treatment of free spaces and the creation of viewpoints.

1. Introduction

Landscape visibility analysis using automated methods normally seeks to identify areas that are visible from a particular point (viewsheds) (Stucky, 1998). Another frequently used variant of this procedure considers all points simultaneously and permits the user to select the most visible locations in any given area (total viewshed) (Tabik, Zapata, & Romero, 2013). Viewsheds have numerous applications in various fields, as described by Chamberlain and Meitner (2013). However, for several years, authors have been stressing the need to go beyond the binary model (visible/invisible) of visibility that typically results from calculating viewsheds (Fisher, 1996).

However, these procedures may not be suitable if we study the points that produce the greatest visibility over a particular area. We use the term "panoramic view" to refer to the possibility of viewing a significant part of a relatively large area that is especially interesting because of its nature or function. This type of area includes natural features, such as valleys, lakes, mountains and bays, or manmade spaces, such as large transportation centers, infrastructures (such as reservoirs), interesting or picturesque agrarian landscapes and urban settlements. In this article, we study panoramic views of towns and villages using a method that provides very useful information for territorial and landscape planning.

Panoramic views can improve the legibility and the aesthetic appeal of a particular scene. These views can also be used for monitoring and control purposes, which are advantageous for land-use management and planning. By definition, panoramic views are views in which large portions of particular areas of interest can be observed, and they can be studied via a visibility analysis using a geographical information system (GIS). Chamberlain and Meitner (2013) proposed various ways of overcoming the limitations of viewsheds in a study on surface entities by means of indicators, such as visual magnitude and visual exposure. Visual magnitude refers to "the number of square minutes that a unit of landscape or a structure occupies in the field of vision" (Iverson, 1985, p. 16), while visual exposure is a "measure of the visible portion of whatever is the focus of the investigation" (Llobera, 2003, p. 40). The calculation of visual magnitude implicitly incorporates the distance to the observer, whereas that of visual exposure does not take this factor into account. However, visual exposure has several advantages: it requires lower computational power (making it attractive for use in large extensive areas), it can be obtained directly from a digital elevation model (DEM), and it is easily

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accessible through open-source spatial data processing frameworks, such as SEXTANTE (Olaya, 2013).

In this paper, we use an indicator called "View Generation Potential" (VGP) to improve the procedure for calculating visual exposure. The goal is to produce a simple, quick assessment of the possibilities of obtaining panoramic views of towns and villages from within their boundaries and from nearby surrounding areas. We analyze the visual exposure of a town from each point of the study area while considering the average vertical angle at which the viewer perceives the town and the distance between the viewer and the town. Our method can also be used to analyze the visibility of any territorial entity that can be modeled as an area bounded within a perimeter.

In the next section, we discuss previous studies on visibility in towns and cities that focus on panoramic views. In Section 4, we provide a general description of the procedure. In Section five, we precisely describe the application of the procedure to a small town in southern Spain (Ardales, Málaga Province). To demonstrate the efficacy of the method, we also include summarized results of its application in three compact Spanish towns of different sizes and characteristics. We then conclude with a discussion of the possibilities and the limitations of the proposed method.

2. Panoramic views of towns and cities: previous research and town-planning approaches

2.1. Brief history of the study of panoramic views of towns and cities

Panoramic views of towns and cities form a specific dimension of the landscape that has fascinated artists and political decision makers for centuries. These views have been an important source of knowledge and pleasure (Kagan, 2000); as a result, they were immensely popular at particular times in history (Reps, 1984). These images have been depicted and presented in different media since the first atlases of cities in the 16th century. One of the most famous, the "Civitates Orbis Terrarum", was recently republished, which is a sign of renewed interest in these images (Füssel, 2008). Other examples include the panoramic views that first appeared in the second half of the 19th century. These images were eventually converted into modern representations and visualizations that inspired various urban development projects, such as the public spaces in Santiago (Chile) studied by Hidalgo (2009).

Panoramic views have been widely studied in recent decades by researchers in urban iconography, for example, Kagan (1986, 2000) and De Seta (2011). The city views painted by artists inevitably led to the study of cities and their evolution. The relationship between the two extremes (iconography and physical structure) clearly reflects the "trajective" nature that Berque (2013) assigns to landscapes or the complex historical relationship between "visual" and "built" landscapes (Cosgrove & Daniels, 1988). A continuous dialogue on cities and the manner in which they are perceived or represented has been established (Kolodney, 2012), i.e., how physical changes cause transformations in panoramic views (in situ or as depicted in any medium). The people of the city consider the views a social resource, i.e., an expression of their identity. The views also act as an economic benefit by attracting visitors.

However, town planning in the 20th century has shown scant interest in panoramic views of cities and their cultural importance as interesting landscape features. This indifference was noted by Owen (2003) in his work on English Hill Towns and by Chueca (1977), who studied Spain's provincial capitals. Classic treatises on urban design tend to gloss over this question, although the occasional tangential references can be found. Quaroni (1970) proposes that we go beyond two-dimensional ground-level planning and assess a city in terms of volume. Whistler and Reed (1977) use the word "townscape" to refer to the visual planning of a city, and Cullen (1971) refers to the "art of relationship" and proposes viewing a city as a whole when approaching its design, although he is mainly referencing landscapes inside a city.

In his classic work on the city image, the American urban planner Kevin Lynch observed that people preferred panoramic views of their cities, a trend he frequently noticed in the surveys he conducted (Lynch, 1960). His concept of "imageability" is very closely related to the possibility of viewing the city as a whole, i.e., broad visions are an excellent tool in which a pedestrian can scan the territory and establish mental maps of a city. As a result, Lynch suggests that we aim to make the "panoramic experience" of the city more common and that we perceive the city as a "total visible form" that must be organized by preparing a "visual plan" (Lynch, 1960).

Other than these partial approaches, there are few publications that establish specific urban planning procedures that consider the importance of panoramic views of cities in landscape terms. In his study of Hill Towns, Owen (2009) states that planners should consider people's experience of the external images of their towns and proposes a multi-stage method by which this could be achieved. In England, an important group responsible for conserving the nation's heritage developed a model for studying significant historic views in various British cities to manage proposed changes (English Heritage, 2011). This concept has also been addressed in recent years in various studies of the great cities of Europe. Paradigmatic cases include London (Greater London Authority, 2012) and Paris (Mairie de Paris, 2013), where a threshold plane for the height of new buildings is established within solid visual angles (Cassatella & Bagliani, 2012).

In Europe, this concept overlaps, to an extent, with the principles of the European Landscape Convention (ELC) (Council of Europe, 2000), i.e., the landscape should be considered "an area, as perceived by people" (Art. 1). The ELC states that all types of landscapes should be considered, not only those with exceptional scenic or heritage qualities; thus, panoramic views of any city must also be considered landscapes or complex perceptions of the territory.

In the United States of America, visibility analyses of different types of city views have been conducted in many parts of the country. Some of these analyses focus on the protection of viewsheds with historic or high scenic values. A compilation of various cases can be found in a study by the National Trust for Historic Preservation (2009), which is specifically devoted to this issue. Most of these cities followed similar procedures to those used in London or Paris by studying the visual corridors leading towards a city's main landmark, as in the case of Seattle (Krochalis, Cline, & Schell, 2002), or by selecting a set of outstanding viewpoints and analyzing their viewsheds, as in the cases of Portland (Portland Bureau of Planning, 1991) and Cincinnati (Cincinnati Department of Transportation & Engineering, 2007). In any case, all approaches implement partial strategies that do not establish systematic procedures for the assessment of panoramic views of a city.

2.2. Visibility analysis procedures: the importance of scale

Llobera (2003) presented two general guidelines for visibility studies. For studies of cities, he stressed the importance of the concept of "isovist", i.e., "the set of all points visible from a given vantage point in space and with respect to an environment" (Benedikt, 1979, p. 47). For the visibility analysis of natural environments or very wide areas, he applied the concept of viewsheds. In studies of cities, the observation distance is not normally taken into account in the algorithm because the study areas are small-scale urban environments. In the analysis of natural environments, how-