A landscape potential characterization: spatial template of pedestrian ambient fields within the urban fabric

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A LANDSCAPE POTENTIAL CHARACTERIZATION: SPATIAL TEMPLATE OF PEDESTRIAN AMBIENT FIELDS WITHIN THE URBAN FABRIC

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Abstract

Through interacting with urban and architectural spaces, pedestrian pathway’s ambient fingerprints delineate ambiences with identifiable characteristics, thus characterizing landscape perception potentialities. Based on a measure of the surrounding open spaces using isovists, our proposal consists in building a sensory Digital Terrain models (DTM) in which the entropy of the function of radial distances is used as a third dimension. As a case study, the distribution of entropy of the Place Royale square in Nantes (France), presented in a dedicated DTM, helps us characterizing the space « intimacy quality » for each observation point. This measure constitutes a relevant indicator of spatial wealth, revealing several perspectives occurrences for a given point of view during an urban walk. This way, this geotopical process establishes a spatial potential, so as to provide to a pedestrian the ability to reach specified townscapes to be contemplated. This sensorial investigation aims to constitute a tool basis for multi-sensorial planning and design process.

Keywords

Landscape analysis, open spaces, isovist, sensory Digital Terrain Model, ambio-potential, sociotope

Introduction

In the manner of the biologists' biotope concept, which is an area of uniform physical environmental conditions providing a living place for a biological community, the sociotope concept has been defined as a delineated area where use values and social meanings are uniform [1][2][3].

The word sociotope is used in both anthropology and sociology. The Swedish social psychologist Lars Dencik applied the sociotope concept in 1995 to describe the children social life world [4]. The German anthropologist Elisabeth Katching-Fasch in 1998 described “the city as a ‘sociotope’ of multicultural lifestyles” [5]. The German landscape architect Werner Nohl used sociotopes in 2001 to describe social types of urban settings [6]: this meaning has been extensively used in Sweden for urban planning practice by Alexander Ståhle [3].

As summarized by [2], the sociotope corresponds to the commonly perceived direct use values of a place by a specific culture or group. It is shaped by a multiplicity of lifestyles connected to a specific place and it can be categorized as more or less local (or global). This raises questions about the landscape's perception and use characteristics with respect to the physical layout, space, material and furnishing. Questions related to the planning process, land use and conflicts of interest are also raised, in addition to design issues such as space requirements and aesthetic considerations.

The surroundings can be regarded as a perceptual matrix, while the remarkable visual patches, in similarity to the terminology of landscape ecology [7], can be linked together using corridors/paths or stepping stones so that they constitute a connected phenomenon in the city landscape. Such corridors can be used in the urban planning process to plan visual access to parks, green areas, so as to remarkable monuments or areas.

The discourse on the contents and density of the cities [8] therefore gets additional arguments against the exploitation of open spaces. Such discourse should, in actual fact, focus on the quality and accessibility of the open spaces [9] or remarkable areas.

Even if the aforementioned perception can obviously not be reduced to its visual component, one must admit that the visual field is predominant in the human perception of the urban fabric. Therefore, we will develop specific indicators to improve the visibility access to the “remarkable” items, namely in order to localize amenities access inequalities in a given territory, leading to a “geotropic” environmental enhanced cognitive mapping.

Therefore, [10] notices that there were “many attempts to translate visual-perception research into architectural and urban design. The best known contribution in urban-planning studies is perhaps [11]”. In his book, Lynch asserts “We are continuously engaged in the attempt to organize our surroundings, to structure and identify them […] it should be possible to give [cities] a form which facilitates these organizing efforts rather than frustrates them”. As explained by [10], city mental maps can help to describe a sort of image of the city but also to evaluate the ‘legibility’ of a built context. Based on this concept of legibility, [11] introduces the derived notion of “imageability” which is a kind of indicator of the evocation power of an environment.

These two key concepts have been enriched by a third one introduced by the Space Syntax theory. Indeed, [12] defines the notion of intelligibility as “the degree to which what we can see from the spaces that make up the system – that is how many other spaces are connected to it – is a good guide to what we cannot see, that is the integration of each space into the system as a whole”.

[13] reminds us that "Walls and ceilings, buildings and trees, are positioned in such a way as to modulate experience: not just the experience of those very walls and ceilings (and buildings and trees), but the experience of the people and signs, images and machines, and so on, that move about and populate the room or cityscape". To this end, the "theory of isovists" was developed [14].

In [15], several isovists measures have been translated into basic spatial qualities hypotheses. [16] addresses the interactions between partial isovists fields and human way finding performance. In [17], partial isovists fields have been used to exhibit the fact that it is worth taking strategic visual properties into account in the design of a patrimonial tour in a historic city center. [18] uses isovist to establish the relationship between landscape openness and wellbeing.

Nevertheless, as noted by [19], the great advances in understanding the optical physics of intervisibility in urban environments do not suffice to real perceptual understanding. What we see, and what we make of what we see, are questions that drive many, including researchers, planners, designers, computer programmers, cognitive and environmental psychologists, sociologists, geographers and others. We need to consider some of the non-Cartesian determinants of perception, including cognitive, cultural, and other psychological factors. That is the reason why [19] concludes with some 'real' open-ended questions which remain interesting areas for investigation. Thus, [19] asked for useful metrics - qualitative or quantitative – that can be used to describe visibility from a line or an area, not just from a point: “visibility calculations may be expanded to become more interesting and useful to landscape planners and designers is to consider the ways in which views from not just points, but also from lines, sequences, and areas, may be computed and characterized”.

The present paper is an attempt to answer this key question. It exposes a method to synthesize the visibility in the whole of a given urban fabric, using a dedicated digital model.

Shape of the open-spaces – brief overview of visibility analysis

In the 1970s, two main approaches emerge in the visibility analysis context: the concept of viewshed (by analogy to the hydrologic watershed) in terrain and landscape analysis and the concept of isovist in architecture and urban space.

The viewshed analysis is a traditional way of analyzing a visibility field. It is defined as the part of terrain visible from a viewpoint (analogous to the outlet of the watershed), and is basically applied to the landscape with terrain and topographic differentiation. As noticed in [20], viewshed analysis in GIS is rarely applied to urban settings because the operation is based on raster data or TIN (triangular irregular network) data structure, which have problems of accuracy in representing complex geometry of urban form.

An isovist is the set of all points in an environment of opaque surfaces that are visible from a given point (the limit of the isovist is an artificial one functioning something like a horizon in the absence of any other intervening surfaces). This 2D bounded polygon is a useful tool to define the open space concept. From a morphological point of view, open spaces are usually defined as the empty space, the void, between the surrounding buildings. However, although these open spaces are not material components of the physical world, they can be conceived as part and parcel of our urban heritage [21]. [22] puts the emphasis on the fundamental motivations of conducting visibility analysis research. He noticed that the key questions "how far can we see", "how much can we see", and "how much space is enclosed" are relevant to develop urban design strategies.

Essentially, isovists describe local geometrical properties of spaces with respect to individual observation points and weight all the possible view directions equally (see Fig. 1). An isovist is a 2D horizontal slice of pedestrian's surrounding space.

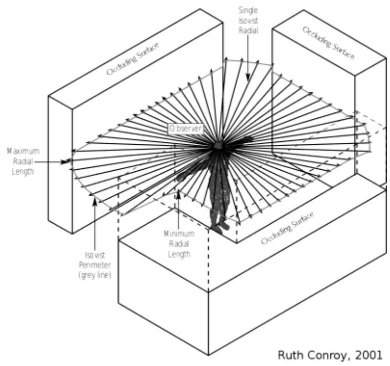

Figure 1. Isovist symbolic representation [23]. The observer is comparable to a visual sensor with an aperture angle equal to 360 degrees. Corresponding isovist is the set of all points visible from his given punctual position taking surrounding occluding surfaces into account.

The method in detail

The aim of the present paper is to characterize the landscape potential of a given place, focusing on visibility question. Therefore, the method we need has to evaluate and characterize visibility in a systematic way all over the shape. In order to let this method remain easily and widely repeatable, we want it to be based on “classical” data of vector type (such as the BD Topo®, provided by the French national provider of reference geographic information, IGN). That is why, in the following use case, we present a simulation that is only based on a polygonal buildings layer.

The simplified schema presented in Fig. 2, sums up the whole spatial process we have developed. It is composed of seven main tasks.

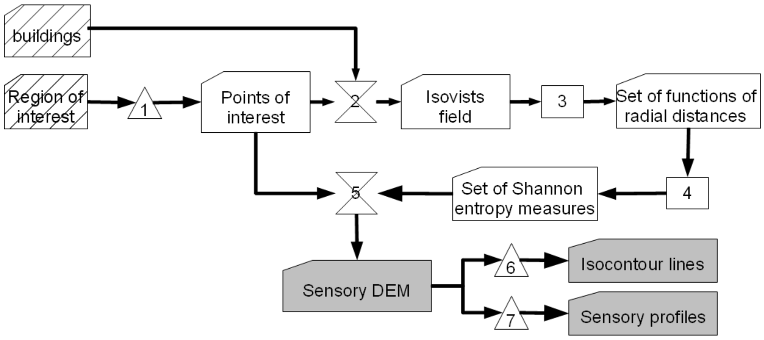

Figure 2. The geo-processing schema we have adopted. Input maps are 45 degrees wide hatched, intermediate results have no background color and final output results are gray colored.

The first task consists in a sampling of the given region of interest into a set of points. Each of them is the node of a regular orthogonal grid that covers the whole of the input shape. The numerous they are (the finer the mesh is), the more accurate the fin al result will be. In the second task, an isovists field computation is performed, based on the one hand on this set of equidistant punctual positions and, on the other hand, on the buildings layer.

In the third task, for each isovist, a 2π periodic function of radial distances is produced. As described in [24], it corresponds to an angular abscissa sampling process. More precisely, the isovist polygon, which is a complex shape, is transformed into a 1D real-valued function. This reduction of the dimension space is achieved through the discretization of the isovist in polar coordinates with a regular angle.

The fourth task consists in a Shannon entropy computation. In this task, the previously mentioned 1D real-valued function (which is a function of radial distances) is treated as a sequence of independent and identically-distributed random variables. In each viewpoint (for each isovist), a numerical value (the Shannon Entropy) is computed. All these values are combined, in a spatial join query, with the set of points of interest. The aim is to provide each of these points with a sort of "elevation" value so as to obtain a so-called Digital Terrain Model (DTM). In this DTM, for each given punctual position, the 3rd dimension is a measure of the surrounding open spaces using an isovists indicator based on the information theory (more precisely on the Shannon entropy).

With such a DTM-based schematic representation of the city open spaces, we are able to identify not only equipotential curves relative to visual perception criteria (fifth task), but also to extract some "profile plots" all-along virtual curves (sixth and seventh tasks).

Use case and result

The study site is a main square in the historic city centre of Nantes. Called *Place Royale*, it has been designed by the architect Mathurin Crucy in 1788. This square matches the classicism criteria in architecture. It places emphasis on symmetry, proportion, geometry, the regularity of facades and openings. It is of about 80 meters length and 70 meters wide, with a fountain on its east-side.

Encompassing the immediate surroundings of the square, the region of interests we focus on, is of exactly 10,000 m². Therefore, because we have decided to handle digital model with metric accuracy, we have 10,000 points of interest to process. In the following map (Fig. 3), each pixel corresponds to a 1 m² portion of space. Its color corresponds to an estimation of the surroundings in the center of the corresponding location. More precisely, the pixel color is consecutively given by an estimation of the entropy value of the isovist fingerprint at this view-point.

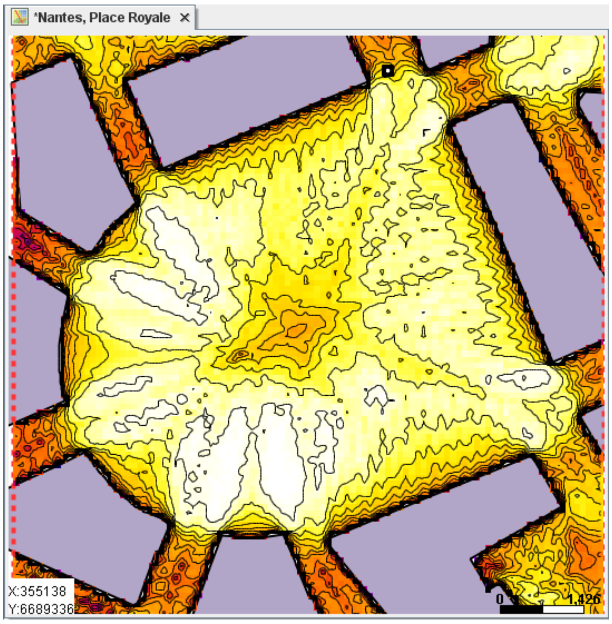

Figure 3. In this DTM based representation, the Shannon Entropy of the distribution of the radial lengths of each isovist shape has been plotted, so as several isocontour lines which emphasize equipotential areas.

In the map presented in the Fig. 3, the pixel's color corresponds to an estimation of the "unpredictability" of the visible surroundings, assuming the view-point is located in the center of the corresponding place (of 1 m²). More precisely, when the entropy value is equal to 1 (when the pixel's color tends to become white), the disorder in the radial distances function is maximal. When the entropy value is equal to 0 (when the pixel's color tends to become dark), the "signal" is fully predictable and the radial distances function is constant (that is, the corresponding isovist is a disc in which the viewpoint is the center). This proxemy indicator provides an approach of urban space "intimacy quality" of the facades distribution of the *Place Royale* square in Nantes.

Despite the symmetry of the square, the DTM itself appears asymmetric, with a sort of skeleton in its center. This skeleton joins the points of lowest entropy potential.

Providing information about visual (space) variability for each point of the perceived space (leading to a visual homeostasis quantification), entropy measure constitutes a relevent indicator of spatial wealth, in a perspective viewpoint of the perceived landscape. If high entropy level signs a quasi-uniform perspective for each view angle of an observation point, low-entropy level reveals visual access to many perspectives for a given point of view: this marks a higher choice of spatial occurrences during an urban walk.

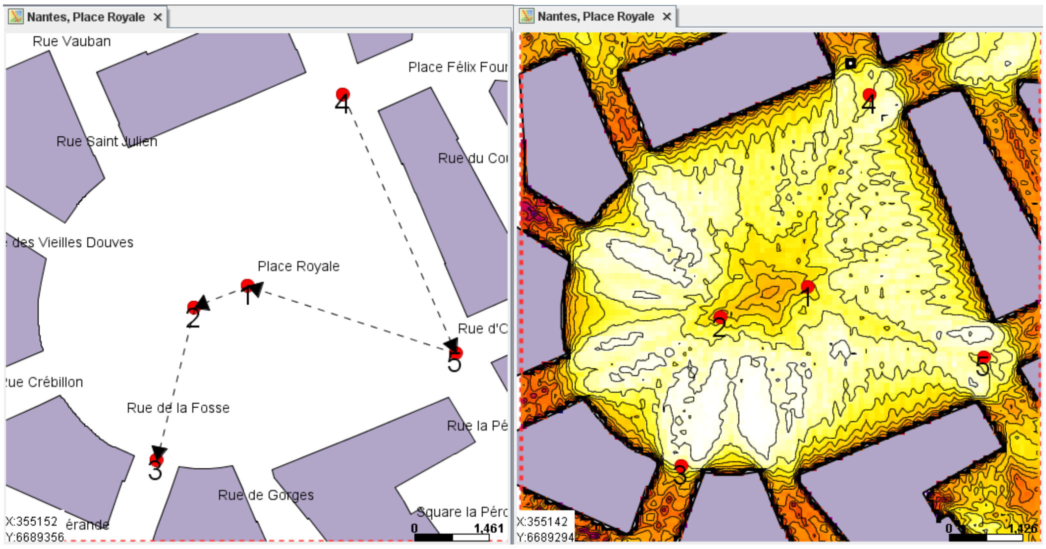

Figure 4. Five different positions have been identified and joined (from north to south) using a poly-line. They all correspond to credible pedestrian locations in this central district of Nantes city. The two first ones are located in the true middle of the square whereas the three others are much more at the outskirts.

To illustrate the type of use that we can make from this DTM based representation, we have decided to focus more particularly on five different pedestrian positions across the square (see Fig. 4) and to produce the corresponding panoramic snapshots (see Fig. 5, Fig. 6, Fig. 7, Fig. 8, Fig. 9).

As may be noticed, Fig. 5 and 6 exhibit situations of a homogeneous landscape where the viewpoint seems to match the center of the open space. In these two cases, the opaque edges (the buildings) seem to be far from the point of view. In the opposite, Fig. 7, 8, and 9 exhibit situations of inhomogeneous landscape where opaque edges (buildings) are fairly intrusive in the pedestrian viewshed.

Figure 5. Panoramic snapshot at the 1st position.

Figure 6. Panoramic snapshot at the 2nd position.

Figure 7. Panoramic snapshot at the 3rd position.

Figure 8. Panoramic snapshot at the 4th position.

Figure 9. Panoramic snapshot at the 5th position.

The profile plot presented in Fig. 10 corresponds to a continuous representation of the Shannon entropy value all along the polyline presented previously in Fig. 4. As may be seen, the two lowest peaks correspond to the locations of 1st and 2nd points whereas the three highest peaks are close to the three other points.

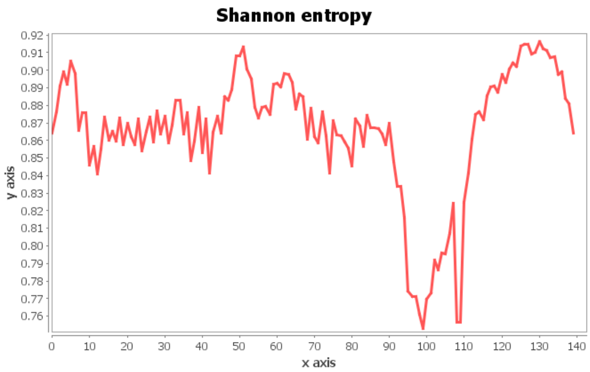

Figure 10. Profile of the polyline presented in the Fig. 4 (using the Shanon entropy measure).

Concluding remarks and outlook

Through the presentation of a visual environment informational analysis, this paper exhibit ambient structural attributes of an urban neighborhood, based on a landscape visual space geo-topical modeling.

In the current paper, we have tried to give an answer to one of [19]'s key questions. Indeed, the DTM representation based on sort of sensory values gives us the ability to plot different representations (more anthropocentric) of the urban fabric. To sum up, we have focused on a well-known square in the historical city centre of Nantes, we have sampled it with a fine metric grain and then, in each of the sampling point we have calculated the corresponding isovist.

Even if all these computations still have to do with the optical physics of intervisibility, the resulting maps represent an advanced overview of the complexity and the richness of the urban fabric. Indeed, it combines both a global and systematic method to handle the whole square (zenithal approach) with a set of immersed view-points (tangential approaches).

This study emphasizes the fact that the field oriented analysis of the city (the one that focus on the open-spaces) is a relevant method to model and characterize the urban fabric. It is therefore a promising alternative to the atomist [25] based approach (in the atomist conception of space, each item corresponds to a tangible spatial object such as a building). With such a method, we do not emphasize the buildings themselves but the void in-between them. The resulting new urban “objects” are however interesting because they provide a relevant way to describe, analyze, and maybe also partition, the urban fabric.

Moreover, this angular perspective variability computation should also provide a spatial potential, allowing a pedestrian to diversify his visual landscape during his walk. This constitutes a main parameter for urban pedestrian itinerary choice, thus implementing the walkthrough complexity at each point of the explored space.

Future challenge is to investigate the inter-sensorial ambient-scape as a basis of a multi-sensory conception in townscape planning and design.

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