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TOWARDS A LANDSCAPE POTENTIAL. A METHOD BASED ON A SYSTEMATIC CHARACTERIZATION OF THE SURROUNDING URBAN FABRIC THROUGH THE VISUAL DYNAMICS OF PEDESTRIANS

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The pedestrian mobility is a way to understand how a person might experience the void in between the buildings (this void defines a space portion as a shape) and therefore the urban fabric itself. The present paper aims to characterize landscape potentialities through pedestrian perception. Our proposal consists in building a set of sort of sensory Digital Elevation Models in which the third dimension is computed based on a measure of the surrounding open spaces using isovists. More precisely, we present three different DEMs: a first one corresponds to the isovist area in each point, the second one corresponds to its drift value (a frequently used indicator in isovist fields) and the third one corresponds to its kurtosis value. At last we combine all these DEMs with different pedestrian pathways so as to obtain corresponding sensory fingerprints.

Keywords: landscape analysis, open spaces, isovist, sensory Digital Elevation 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 [1][2][3]. As summarized by [2], the sociotope corresponds to the commonly perceived direct use values of a place by a specific culture or group. 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, [4] 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 [5]". 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 [4], 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, [5] 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, [6] 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".

The work [7] 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 [8].

In [9], several isovists measures have been translated into basic spatial qualities hypotheses. In its turn the work [10] addresses the interactions between partial isovists fields and human wayfinding performance. In [11], 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 centre. The work [12] uses isovist to establish the relationship between landscape openness and well-being.

Nevertheless, as noted by [13], 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 psychologists, and others. We need to consider some of the no trigonometric determinants of perception, including cognitive, cultural, and other psychological factors. That is the reason why [13] concludes with some 'real' open-ended questions which remain interesting areas for investigation. Thus, [13] 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 view-shed (by analogy to the hydrologic watershed) in terrain and landscape analysis and the concept of isovist in architecture and urban space.

The view-shed analysis is a traditional way of analysing 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 [14], view-shed 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 [15]. [16] 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 good urban design.

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.

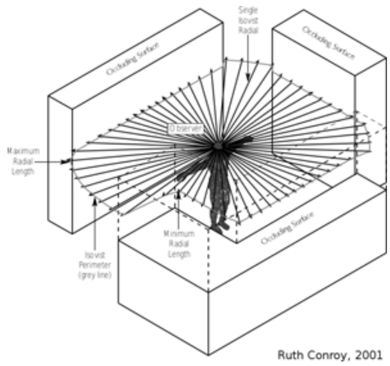

Figure 1. Isovist symbolic representation [17].
The observer is comparable to a visual sensor with an aperture angle equal to 360 degrees.
Corresponding isovist is the set of all points visible from his given punctual position
taking surrounding occluding surfaces into account

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 both a polygonal buildings layer and a linear pathways layer.

The simplified schema presented on Figure 2, sums up the whole spatial process we have developed. It is composed of six main tasks.

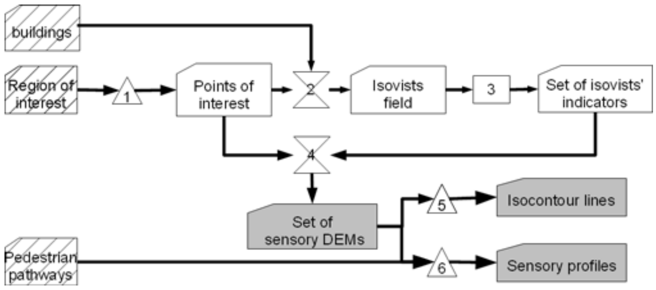

Figure 2. The geo-processing schema we have adopted.
Input maps are 45 degrees wide hatched, intermediate results have no background colour
and final output results are grey coloured

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, three different indicators are calculated. The first indicator, defined by [8], corresponds to the area of the isovist itself. The second one, defined by [18], is the drift. The drift is the Euclidean-distance between the location from which the isovist is generated (the so-called view-point) and the centre of gravity of the isovist shape. At last, the third indicator, defined by [19], is the Kurtosis of the distribution of the radial lengths of each isovist.

The fourth task consists in three join queries between, on the one hand, the set of isovists indicators, and on the other hand, the 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 Elevation Model (DEM). In this DEM, for each given punctual position, the 3rd dimension is a measure of the surrounding open spaces using one of the three isovists indicators already mentioned.

With such a DEM-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 pedestrian pathways (sixth task).

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 (see Fig. 3).

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 DEMs with metric accuracy, we have 10,000 points of interest to process. In the three following maps (Figures 4, 5, and 6), each pixel corresponds to a 1 m² portion of space. Its colour corresponds to an estimation of the surroundings in the centre of the corresponding location. More precisely, the pixel colour is consecutively given by an estimation of the area of the isovist at this view-point, then by its drift, and, at last, by its Kurtosis.

In the map presented on the Figure 4, the pixel's colour corresponds to an estimation of the area of the visible surroundings, assuming the view-point is located in the centre of the corresponding place (of 1 m²). The hot spots (red coloured) correspond to places where surroundings are wide (from 10,000 to 15,000 m²), intermediate values (from 2,000 to 10,000) are blue coloured, and at last, lowest values are green coloured.

Despite the symmetry of the square, the DEM (based on areas) itself appears asymmetric, with a clear line of highest potential in its south-west side. In each of the corresponding locations, the great value is due to far vantage towards *place Graslin* square (west side) or towards *Orleans*' Street (east side).

Figure 3. Four photographic snapshots from the *Place Royale* square.
The first one (top left) corresponds to the beginning of the first pathway (south-east, connected to the *Orléans*' street).
The second one (top right), is the start of the second pathway (connected to the *de l'Arche sèche* street).
The third one (bottom left), is the start of the third pathway (connected to the *de la fosse* street).
At last, the fourth one is a panoramic view of the square. It has been shot from the entrance
of the *Crebillon*'s street (output point of the first pathway)

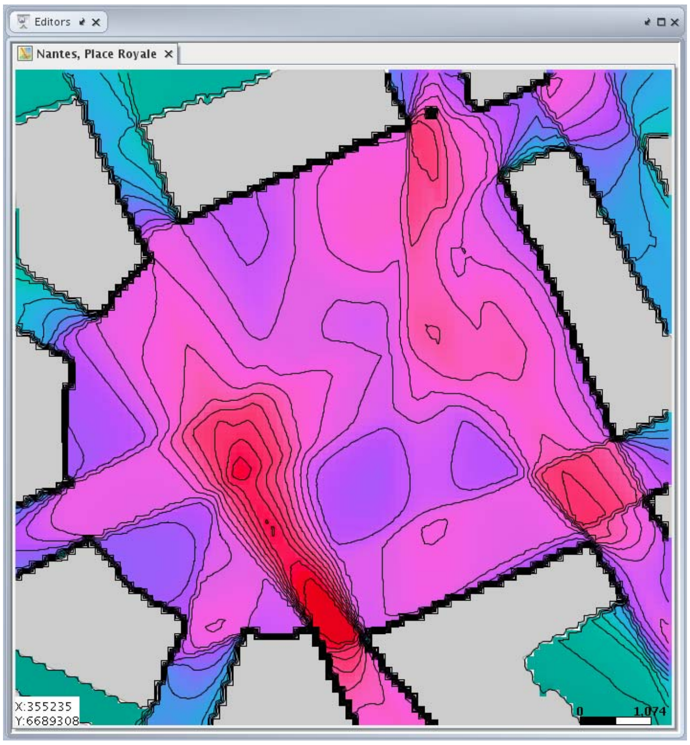

Figure 4. A digital "elevation" model in which elevation values have been replaced by measures
of the surroundings (in this case, the area of the isovist in the corresponding view point).
Moreover, several isocontour lines have been plotted so as to emphasize some equipotential areas

In the map presented on Figure 5, the pixel's colour corresponds to an estimation of the drift of the visible surroundings, assuming the view-point is located in the centre of the corresponding place. The drift, as an Euclidean distance from the view-point to the centre of gravity of the isovist, is a sort of measure of the compliance of the visual environment to the physical surroundings. The greatest this value is, the more far the view point is located from the centre of the corresponding shape.

In the following map (see Fig. 5), a hot-spot (red coloured) corresponds to a place where these two points (the view-point and the shape's centre) are far from each other. On the contrary, a green coloured pixel is a location where they overlap: in this case, the visual impression matches the physical feeling. As may be noticed, the open to *Crebillon*, *de la fosse* and *d'Orleans* main streets, correspond to places with such a coincidence. There is also a green spot in the south part not far from the opening towards the *de Gorges* Street. In this isle of "centrality", some street performer frequently displays his paints.

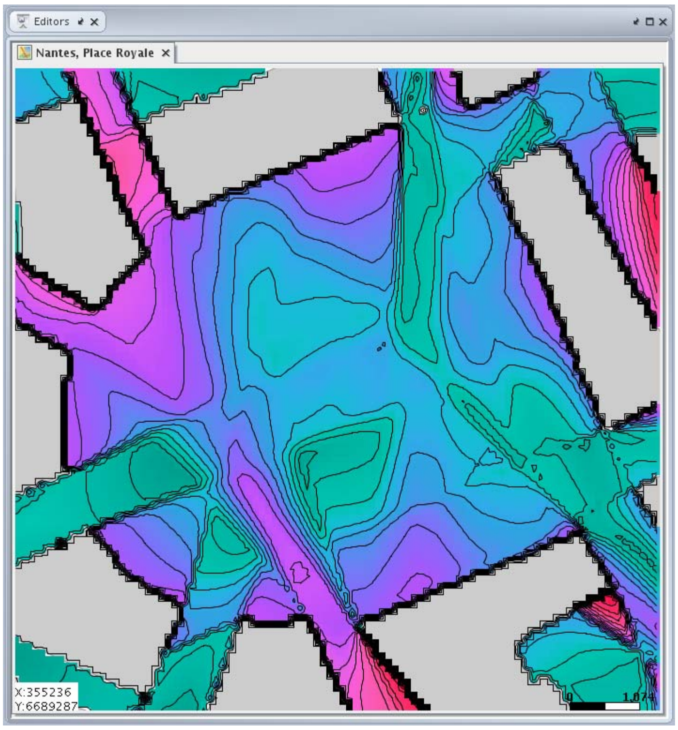

Figure 5. A digital "elevation" model in which elevation values have been replaced by measures of the surroundings (in this case, the drift of the isovist in the corresponding view point). Moreover, several isocontour lines have been plotted so as to emphasize some equipotential areas

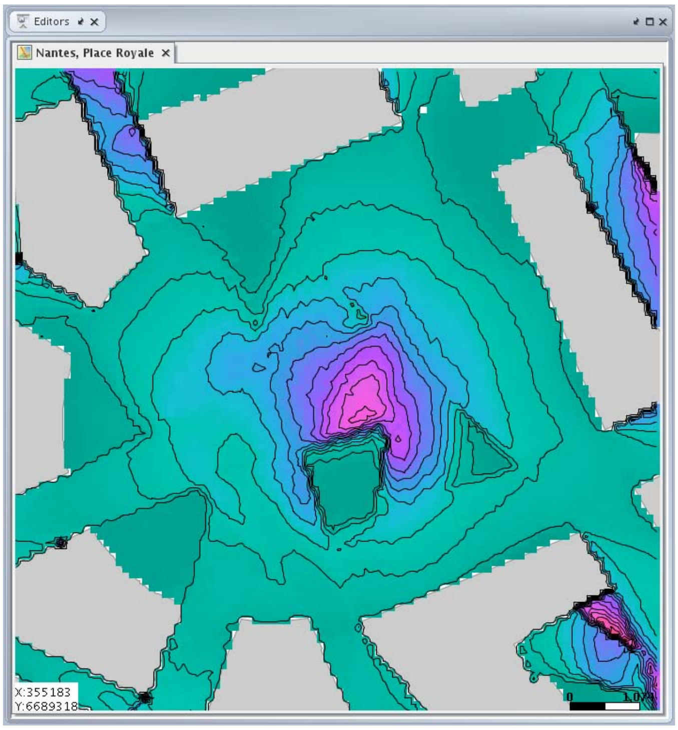

Figure 6. In this DEM based representation, the Kurtosis of the distribution of the radial lengths of the isovist shape has been plotted, so as several isocontour lines which emphasize equipotential areas

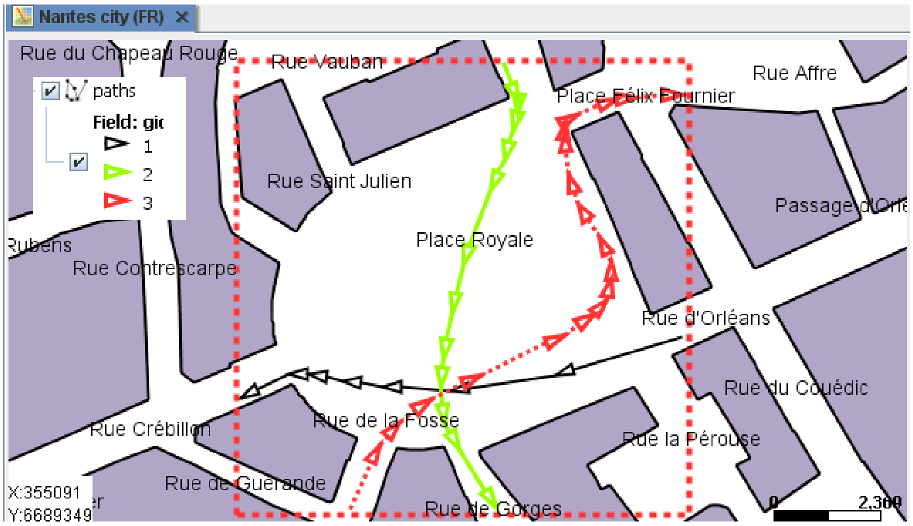

Figure 7. Three different pathways have been identified.
They all correspond to classical courses in this central district of Nantes city.
The first one (black coloured) is part of a pedestrian tour from 50 hostages main street (and the main tramway stop called *Commerce*) to the *Graslin* square through the *Crebillon* famous shopping street.
The second one (green coloured) leads from the car park called Bretagne to the Commerce square.
At last, the third one (red coloured), is part of a pedestrian pathway from the multilevel covered street (*passage Pommeray*) to the town hall

To illustrate the type of use that we can make from these DEM based representations, we have decided to focus more particularly on three different pedestrian pathways across the square (see Fig. 7). The two first paths are of the same length, 100 meters, while the last one is of about 145 meters. As may be noticed with the profile plots on the Figure 8, even if the second path is quite stable and high valued in term of area values, it varies a lot in term of drift values (twice compared to the two other paths) so as in term of Kurtosis values (twice compared to the two other paths).

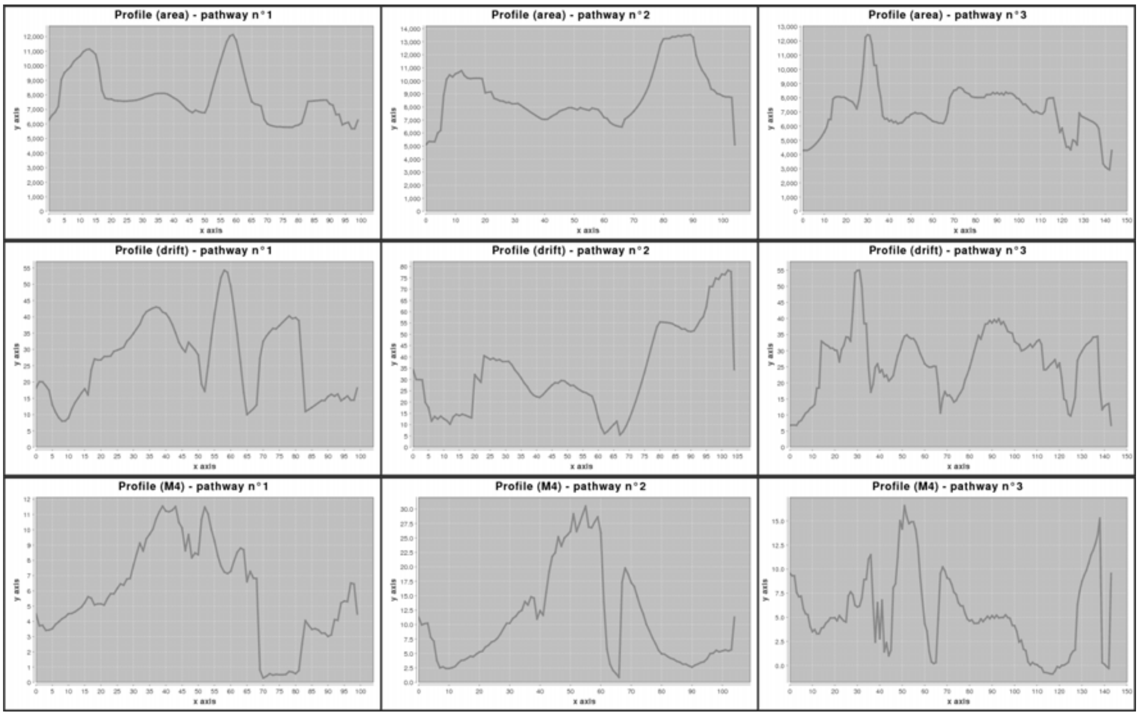

Figure 8. Nine different profile plots. One per pathway and per isovist indicator

Concluding Remarks and Outlook

In the current paper, we have tried to give an answer to one of [13]'s key questions. Indeed, the three DEM representations based on sort of sensory values give 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 [20] 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, analyse, and maybe also partition, the urban fabric.

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