Chapter 06 | Session F3

Simulating Visibility in Small Public Spaces

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Abstract
This paper presents a natural surveillance analysis method for the design of open public spaces, in a digital, 3d modelling environment. Utilising a ray casting method, the model facilitates the computation of varying natural surveillance levels of an open public space during the day.As agents of surveillance, the model takes into account, the occupants of the surrounding buildings and the passers by using the main pedestrian routes; and as objects of surveillance, the pedestrians spending time in the analysed space. Facade openings and visible obstructions are considered the main static variables. The use is demonstrated through a case study on a public plaza, by computing changing visibility conditions throughout the course of a day, based on varying activity levels of surrounding buildings and pedestrian paths. Potential benefits are discussed. It is suggested but not investigated in this paper that considering the visibility of an urban space during its design can help increase the safety and comfort of its users.

Introduction

Quality of urban public spaces are measured by their usability and their users' comfort; spaces that the user spends time in by choice, as opposed to obligation, are considered well designed (1). User comfort in public spaces can be linked to physical, psychological and social conditions (2). Departing from Jane Jacobs' "Eyes on the Street," theory (3), this research presumes a direct relationship between a space's visibility and the perceived and actual safety in a public space; one of the factors that effect the psychological conditions for user comfort.

Also referred by many studies as 'natural surveillance,' the visibility of public spaces are linked with crime levels and this relationship has been studied extensively. In "Creating Defensible Space," Newman suggested that the visibility of the pathways between the carpark and the entrance of a residential block from the street level windows, has a significant impact on the safety and security in the area (4). In a study by Lopez and Van Nes (5), significant correlations were found between the inter-visibility of building entrances and frequency of incidences of burglary and theft.

There are several studies and methods that quantitatively analyse the visibility conditions in built environments. 'Isovists' first introduced by Tandy (6), are sets of all points in a volume that are visible from a vantage point in space. Benedikt, studied Isovists further and developed measures for their properties (7). Turner, introduced the Visibility Graph Analysis method (8), which facilitates computing graphs that show mutually visible points in a space. More recently, Koltsova et. al., (9) studied visibility conditions in an urban environment and developed a tool utilising a ray casting method to analyse visible facade surfaces from urban streets.

This research is motivated by and based on the studies linking visibility conditions with perceived safety and comfort of open public spaces, but does not investigate this relationship further, rather, it proposes a methodology and computational model to calculate the visibility of an urban space based on its physical properties and usage patterns. The model has been converted into a design tool that computes and visualises visibility conditions of an urban public space in the 3d modelling environment of Rhinoceros3d Software and a visual programming plugin Grasshopper. This tool has been developed by custom Python codes in Grasshopper, simplifying its use and facilitating realtime analysis of visibility conditions on a 3d digital model.

The methodology presented in this paper aims to serve designers for the purpose of quickly determining visibility conditions in an open urban space, responding to modifications in the 3d modelling environment in real time. The paper does not aim to investigate the crime - visibility relationship or elaborate on mathematical models of visibility calculations. Rather, the purpose has been to propose a method and a tool to facilitate easy manipulation of variables in a 3d modelling environment and test the usability of the suggested tool to quickly assess changing conditions in an existing urban space. The method and tool presented in this paper is novel in that they make it possible for designers to assess varying visibility conditions dependent on activity schedules of local facilities throughout the day, the size and shape of facade openings surrounding the public space and through adjustable variables, to easily compute the effect of several conditions that change in the daily lifecycle of an open public space.

Methodological Procedures

The study consists of three stages: development of the model for the visibility computation, the modelling of an existing urban space suitable for visibility computation and computation of visibility maps of the modelled urban public space.

For the development of the computation model, Rhinoceros3d software with the Grasshopper Plugin was utilised. Through the visual programming interface of the Grasshopper Environment, values of variables assigned to parametrically modelled features can easily be adjusted by the user through sliders. These variables will be stated as adjustable variables through the rest of this paper.

For this study, visibility is defined as the possibility of seeing a point from another point with the naked eye and a ray-casting method has been utilised to compute visibility of points from predefined vantage points.

In the first layer of the model, the percentage of an urban space's visibility from the facade openings of the surrounding buildings is computed. For this, the urban space and it's surrounding buildings are modelled. The ground plane within the limits of the urban square is then divided into a grid, the resolution of which is an adjustable variable in the model. The number of grid cells should be decided considering an optimisation between a high resolution evaluation and computational efficiency.

A line is drawn along the width of the facade openings of the buildings facing the space, 150cm above the floor level and 50cm inside the facades; and equidistant vantage points are placed along these lines. The location of this line is an adjustable variable in the model, and it can be determined based on the specific use of the building, or even the space where the window is. For example, if the building is a workplace with desks located close to the windows, this line can be placed 110 centimetres above the ground, and 60 centimetres inside the window, which would facilitate the computation of visibility from points as close to a sitting occupant's eye-level as possible. The density of the equally distributed points on this line is also an adjustable variable, which can be determined based on the frequency of use of the space the window belongs to. The number of these vantage points are decreased in relation with the level of the storey they belong to; the street level windows require more vantage points then the upper level windows as their distance from the square is smaller.

Next, the centre of each grid square on the ground plane is connected to each vantage point with a line; and the line is eliminated if it intersects an obstruction or is longer than a maximum visibility distance of 30m. This distance is an adjustable variable, and it can be determined based on the chosen distance to be considered a limit that would allow for clear visibility. If the visibility is to be considered a direct determinant of safety, this variable could be set as the maximum distance that would allow for a spectator to interfere with an act of crime. The obstructions, in this study, include the trees and two kiosks located in the square. Any urban element that is modelled in the 3d modelling environment can be set as an obstruction element in the model.

In the second layer, the percentage of the urban space's visibility from the pedestrian routes within and around the public space is computed. The popular pedestrian routes and boundaries of the commonly used neighbouring open spaces are determined and populated with vantage points, again 150 cm above ground. Repeating the procedure followed for the vantage points inside the building's windows, vision lines are created connecting these points to each grid cell's centre on the ground plane of the public space to be assessed. The lines are eliminated if they intersect with obstructions or exceed a predefined maximum length.

In the final step, the total number of lines that connect to a grid cell's centre is calculated, and divided by the maximum number of lines that connect to any grid cell among all the instances to be analysed in the modelled space. The grid is then given a gradient of colours based on the range of values assigned, demonstrating its regions' level of visibility. This value is a percent ratio of the number of vision lines reaching a point on the plane to the maximum number of visibility lines reaching a point on the plane throughout the day, so the gradient colours represent an assessment of visibility levels within the range determined by the most visible and the least visible points in the public square, through out the times of the day. If more than one public space is to be compared for visibility, this divider value should be determined based on the best visible point in the overall assessment or as an independent value, greater than the highest number of visibility lines any of the grid points receive in the assessment, at the busiest hour of the day.

The vantage points located inside the windows of the surrounding buildings are grouped and linked to the building's occupancy schedule so that they are activated or deactivated accordingly. The vision lines distributed on the pedestrian pathways that go through or by the square are linked with schedules that activate and deactivate them. These schedules are also designed as adjustable variables.

Since the model works in real time, design decisions can be made through testing various operations on the 3d model and observing the visibility values that update simultaneously, adjusting occupancy schedules or popular pathways.

Case Study of an Urban Public Space

To test the developed method on an actual public space, an urban square in Istanbul's Karakoy neighbourhood was selected. The reason for the choice of this square is due to the high level of variance in the use patterns of the surrounding buildings, thus the expectation of frequent changes in the visibility levels of the square. Additionally, the existence of a ferry port close to the square that provides short distance transportation in the city, and the proximity of the square to a recently gentrified area with several cafes and restaurants, create a number of popular pedestrian routes going through or by the square, that are active at varying time periods during the day.

The square in Karakoy was modelled with the surrounding buildings and the plane defining the boundaries of the area to be analysed was populated with a grid of points (Fig.1). The density of the grid was set to 2m x 2m for this study, for practicality.
A line to compute the vantage points were created for each window facing the square (Fig. 2).

Fig 1. Model and Analysis Grid

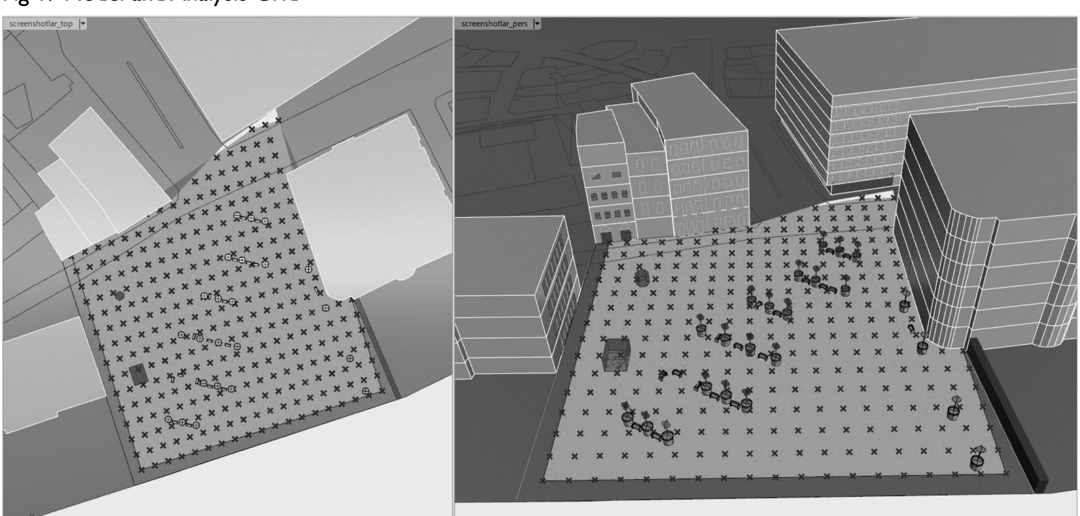
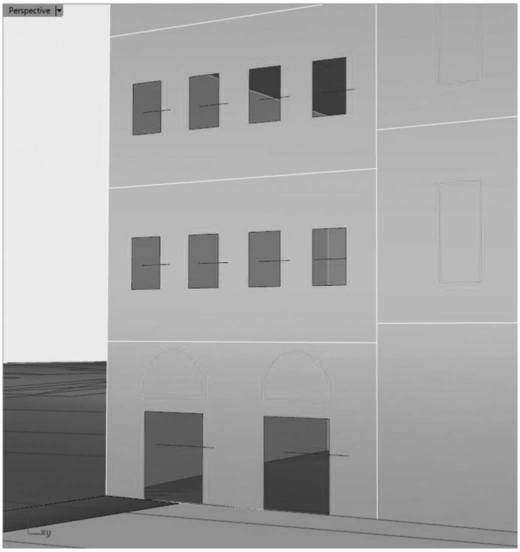


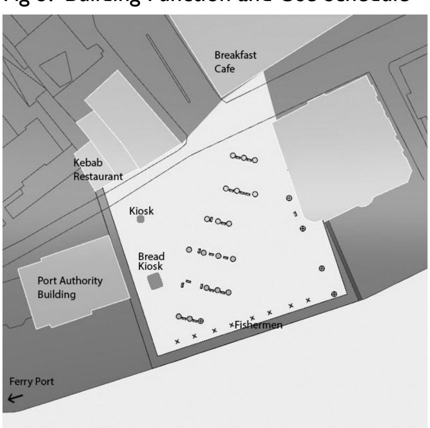
Fig 2. Lines for Vantage Points



A table of active use schedules was created for the three actively used adjacent buildings, the main pedestrian routes and the ferry port neighbouring the square. The actively used buildings are: the port authority office building, the kebab restaurant and the breakfast cafe. Fishermen line-up at the waterside boundary of the square at early morning hours and the pedestrian path activity hours vary based on the operation hours of the ferry port and surrounding buildings. The uses of the buildings labeled on plan and a table illustrating the operating hours of these facilities can be seen in Figure 3. The inactive buildings surrounding the square were excluded in the calculations.

Next, using the model developed, the visibility maps were created for each time frame that indicated a change in the active use schedule.

Fig 3. Building Function and Use Schedule



	Port Authority Building	Kebab Restaurant	Bread and Pastry Kiosk	Kiosk	Breakfast Cafe	Ferry Operation Hours	Fishermen
6.00 - 7.00							
7.00 - 8.00							
8.00 - 17.00							
17.00 - 19.00							
19.00 - 21.00							
21.00 - 22.00							
22.00 - 23.00							
23.00 - 6.00							

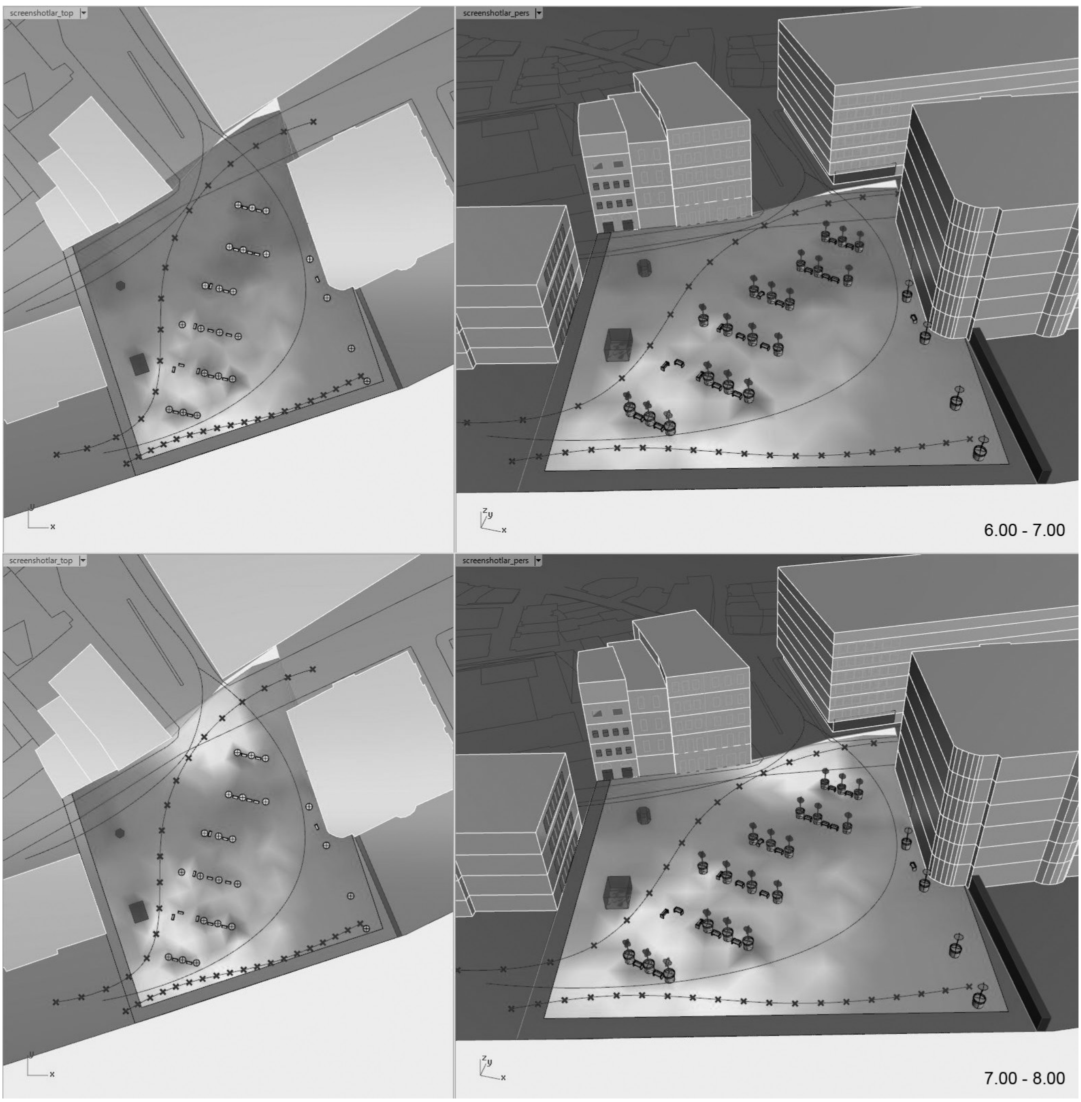
Results

The time frames for which visibility maps were calculated are 6.00 - 7.00, 7.00 - 8.00, 8.00 - 17.00, 17.00 - 22.00, 22.00 - 23.00 and 23.00 - 6.00, which were selected based on the variance in occupancy and activity conditions of the buildings and pedestrian paths. The hours between 17.00 - 22.00 show unvarying use patterns and therefore are represented by a single analysis map (Fig 5). There are no buildings or pedestrian paths between the hours of 23.00 - 6.00 that are active so the visibility map has not been presented here.

The resulting gradient maps are shown in Figures 4, 5 and 6. A colour gradient ranging between blue and red was used where blue indicates the most visible areas and red indicates those that are not seen at all.

The images show that, for the analysed square, the visibility conditions show significant variance during the course of a day, and the operation hours of the ferry port that is not adjacent but close to the square have a direct influence on the visibility conditions in this open, public space. Also, the time frame between 8.00 - 17.00 and 17.00 - 22.00 are the most favourable in terms of visibility. The fishermen, who line up to fish by the waterfront between 6.00 and 7.00 create more favourable visibility conditions close to this boundary of the square as opposed to the side by the buildings which are inactive during this timeframe.

Fig 4. Visibility Analyses of 6.00 - 7.00 and 7.00 - 8.00



The case study is helpful in demonstrating that the proposed method and accompanying tool facilitates a rapid and practical means to assess the visibility conditions of an urban, open space based on the surrounding buildings' facade opening locations and sizes, popular pedestrian paths passing through or by the open space, as well as the variance of these conditions based on the activity schedules of the buildings and pedestrian paths.

Fig 5. Visibility Analyses of 8.00 - 17.00 and 17.00 -22.00

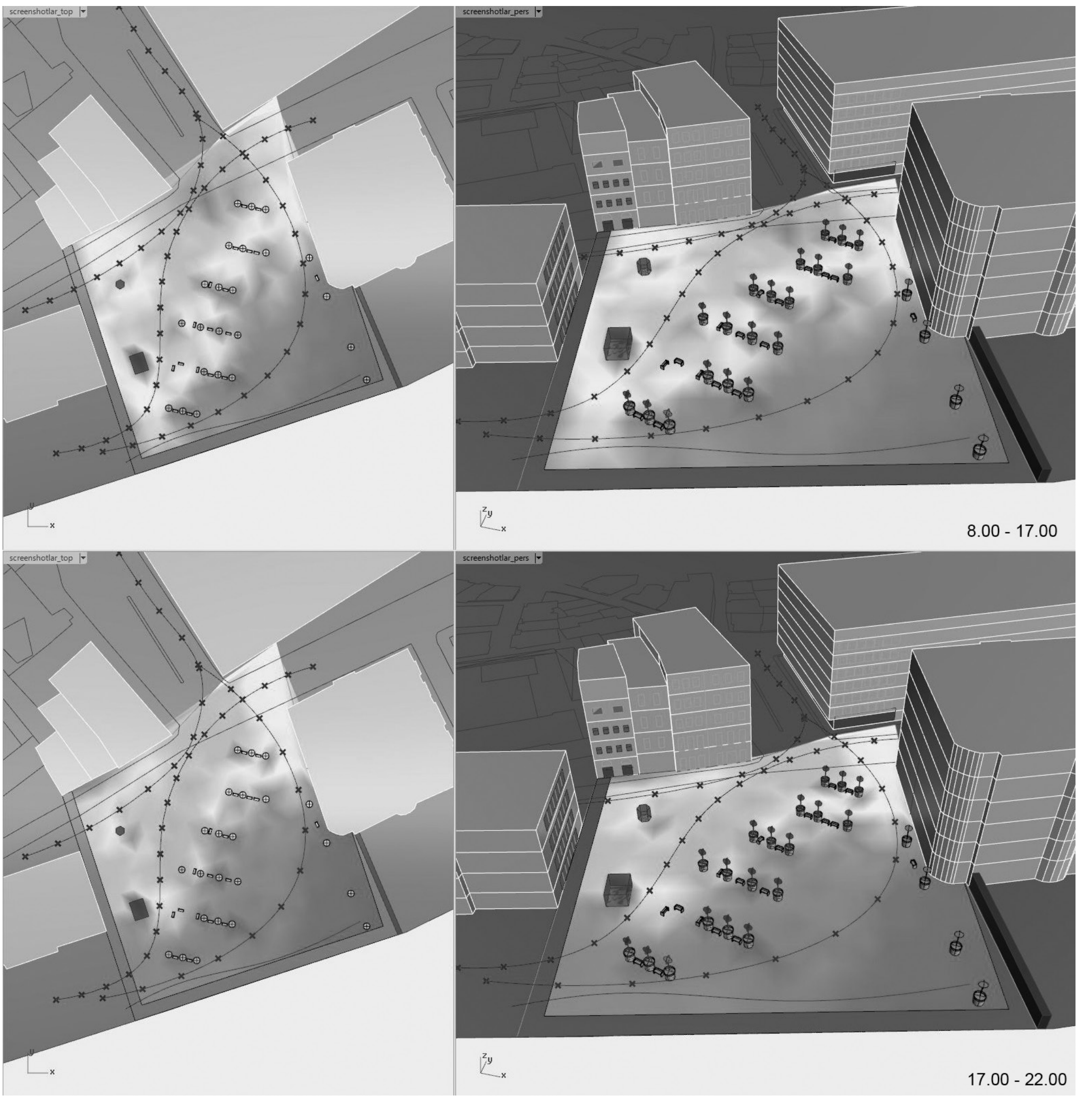
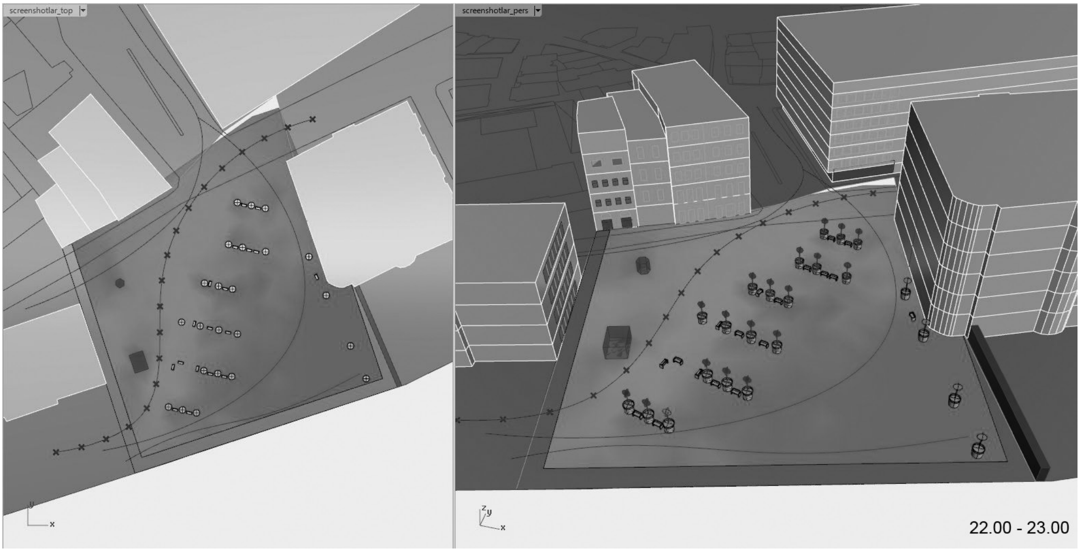


Fig 6. Visibility Analysis of 22.00 - 23.00



Discussion

In this paper, a method and a tool aimed to support design decisions for small, urban spaces was presented. The method facilitates the computation of visibility conditions of open public spaces; a critical factor determining the perceived safety and comfort of the users of public space. A case study, demonstrating the use of the model was presented accompanied by final results.

Among many possible cases where this method and tool can be utilised are the assessment of visibility conditions when; buildings facing public open squares are to be demolished or the construction of new buildings are proposed to replace them; activity generating facilities from urban furniture to open performance stages are to be introduced to specific locations at open public spaces; or the operation schedules and access points of public facilities or transportation services are to be determined. Additionally, it is proposed that the visibility conditions simulated by this method would be a valuable input in the design processes of open spaces such as kindergartens, children's play areas, school courtyards, university campuses and elderly residential facilities. The developed tool is intended to be evaluated with practicing architects and urban designers in addressing some similar design scenarios.

The suggested link between visibility and safety conditions in an open public space, which is part of the motivation behind this study, was not investigated but is supported by a wide range of literature on the subject. It should be subject of another study to seek correlations between the results of observations at open public spaces with the visibility maps created for them by the proposed method. Undeniably, there are several other factors that play a significant role in creating safe and comfortable public spaces.

One of the technical limitations of the proposed method is, the computation of vantage points through division of linear paths created inside the buildings' windows, parallel to the windows' length. While each window on the adjacent facades was assumed to provide a viewable area on the square based on its position and size; the function of the building, the number of users of the building, and even the interior layouts of the rooms within each building can conceivably effect the visibility conditions of the square. Another limitation may be the computation of pedestrian vantage points based on an averaged curvilinear representation of the pathways; while actual pedestrian movement patterns consist of several curves that may more accurately be represented as a field or a plane. One essential weakness in the model is that the distances of the vantage points to the square, are only limited by a single adjustable value (set as 30m for the case study) and their density varies only based on their level in the building. An impact factor inversely relative to the distance of each vantage point from the grid points on the square may also be added to the model. These issues are intended to be addressed in further studies. Eventually, rather than a stand alone design tool, it is suggested that the method becomes a visibility-safety layer as a module for a comprehensive urban analysis and design tool for an evidence based, data driven design approach for small scaled, open public spaces.

Notes

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