# Three dimensional isovist analysis method.

**Rodrigo Culagovski** / Pontificia Universidad Católica, Chile / **rodrigo@culagovski.net http://culagovski.net**

**Abstract** *This paper presents a three dimensional method of isovist analysis implemented in the MaxScript programming language. The script accepts as its input a standard three dimensional model of the buildings and terrain being analyzed, upon which a N×N grid is projected. Each square of this grid is assigned a height value, thereby producing a simplified surface description which is amenable to mathematical analysis. A three dimensional isovist is then generated for each grid square, by placing an observation point 1.5 meters above its center and finding the intersection of a series of rays from this point to the input model. The distance from the observation point to the intersection is summed over for all the angles studied giving a compound isovist measurement for the grid square under consideration.*

## Three dimensional isovists

Isovists have been widely applied to the analysis of the built environment since their formal definition (Benedikt and Davis, 1969). The majority of these efforts have been limited to two dimensional models, which by themselves cannot account for the specificity and variation encountered in real, three-dimensional structures and spaces. The work presented here seeks to address this shortcoming, by proposing a simple method to generate isovist fields from a standard volumetric model. MaxScript was chosen for its simplicity and the advantage of being embedded in a robust, popular CAD package.

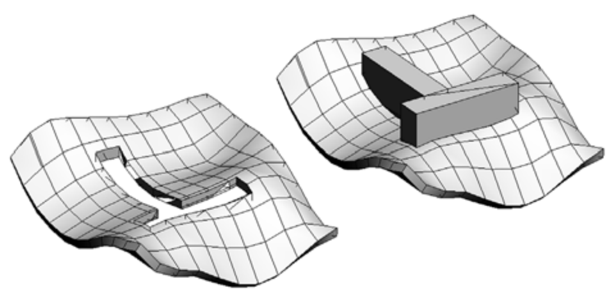

*Figure 1* *Base models Sa and Sb*

## Implementation

The application takes as its input two standard three dimensional meshes that represent the buildings and terrain to be analyzed: Sa, which represents all the surfaces from which the isovist is to be measured, and Sb, that represents the surfaces towards which the isovist will be measured. Intuitively, Sa represents every place where an observer could stand (and observe), for example a system of terraces, whereas Sb represents the entire are she would be observing, in the same example, perhaps the same terraces, plus a series of houses, rooftops, etc., that are not accessible to the observer. Sb does not have to be similar in size to Sa.

In figure 1, we assume the existence of an inaccessible "T"-shaped volume on a sloped surface that blocks views on each of its sides.

A matrix M of size N×N is defined where each Mij is assigned a height value corresponding to the intersection of a ray projected vertically onto Sa. This is represented volumetrically by a "box" model.

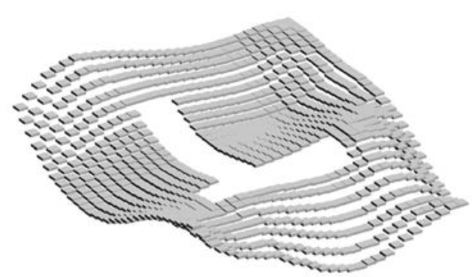

*Figure 2* *Box model of Sa with N=30*

For every Mij we calculate a value V:

$$V_{ij} = \sum_{\theta=0}^{P} \sum_{\phi=0}^{P} D_{ij}[(\frac{\theta \times 360}{P}),(\frac{\phi \times 60}{P} - 45)]$$

*Figure 3 Equation 1*

Where P represents the number of rays to be cast in plan and elevation (the total number of rays is P2) and Dij($\alpha$,$\beta$) is defined as the distance between the observation point located 1.5m over Mij and the intersection of a ray projected from this point towards Sb in the direction defined by the spherical coordinates $\alpha$,$\beta$. This analysis function is O(n2) , allowing a fairly precise analysis in polynomial time. A bounding box is assumed around the mesh. This is explained visually in figure 4.

Vij is normalized and represented on a color scale where white represents the largest isovist and black the smallest, giving a graphic representation of the isovist field of the mesh.

**Limitations** The described method has a series of shortcomings:

1. Edge effects such as those apparent in figure 6. This is a methodological problem, and can be addressed by the careful selection of the study areas, though some effects will always remain.

2. Resolution related artifacts such as diagonal 'lines' that appear in the isovist field that are related to the number of divisions P as applied in equation 1. This is related to the precision of the analysis, which can be adjusted upwards dependant on the processing power and time available.

3. The method calculates P2 rays for each point, which is a large sample but doesn't take into account the entire surface. This makes the process O(n2). If the method where to take into account every other point on the mesh M, the program would be O(n4), and precise measurements would quickly become unfeasible.

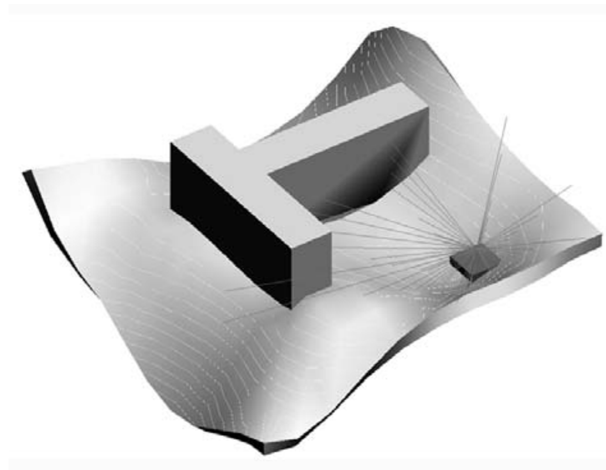

*Figure 4 Ray casting.*

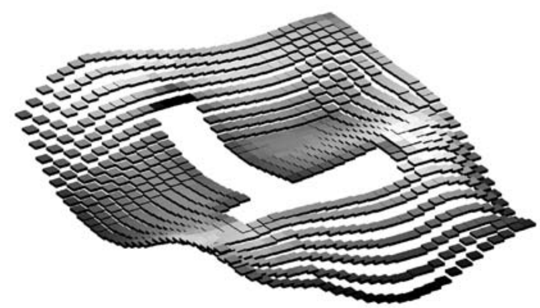

*Figure 5 Isovist field representation, N=30.*

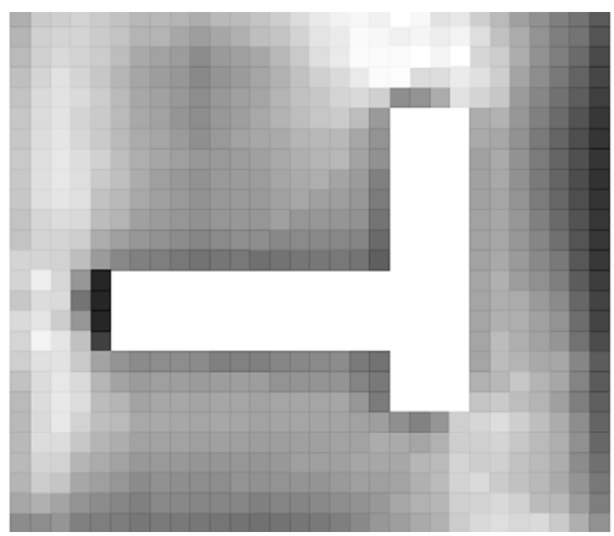

*Figure 6 Isovist field plan view, N=30.*

**Conclusions** This simple method for generating three dimensional isovist field analyses could have a series of applications, both for architectural and planning purposes, including lot plans and commercial buildings. More generally, the ease of development afforded by the scripting languages prevalent in modern CAD packages allow independent professionals to generate customized applications on an ad-hoc basis in response to their own changing needs. This emancipation from premade, standardized tools should allow design professionals the same freedom to generate their own analytical models and scenarios that spreadsheet programs give to those who work mainly with numbers. Architects and planners should not limit themselves to simplifications, intuition or rules of thumb when faced with complex problems, but rather embrace this complexity as their natural environment.

**Acknowledgments** Thanks to Margarita Greene Z. and Hugo Mondragón, for their help, encouragement and guidance.

This research was carried out as part of the work on my thesis for the Magister en Arquitectura program of the Pontificia Universidad Católica de Chile, and as an associate researcher of the FONDECYT project “Seguimiento y analisis de los procesos de recuperacion y repoblamiento de los centros urbanos”, with Margarita Greene Z. as thesis advisor and main researcher and financed by the “Comisión Nacional de Investigación Científica y Tecnológica” of the Chilean government.

**References** Davis, L. And Benedikt, M. :1979, ***Computational models of space: Isovists and isovist fields,*** Computer Graphics Image Processing. 11(1), pp. 49-72,.

**Keywords** *Isovist, viewshed, analysis, model, volumetric, visibility*