

Spatial Analysis of Building Indoor Environments Using 3D Isovist

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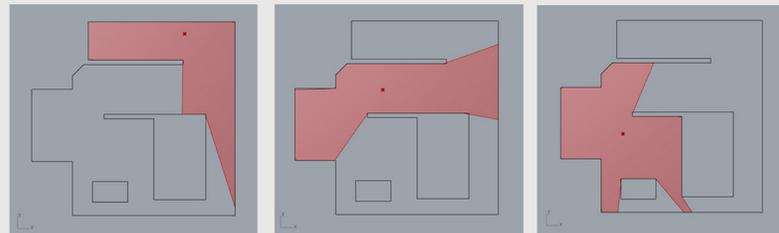
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Introduction

Isovist is an objective graphical means for comprehensive mapping of environments which represents the set of all points visible from a given point in space. In other words, the isovist can be thought of as the volume of space illuminated by a point source of light. Research in environment and behavior suggests that isovist analysis captures perceptually and behaviorally relevant properties of space and can relate to issues like wayfinding and users' experience of buildings.

Current isovist methods mainly accept a planar representation of an environment such as a floor plan drawing of a building and they produce a 2-dimensional analysis. While helpful, this has some shortcomings as some architectural characteristics are not captured by two-dimensional analysis. These include vertical characteristics of atrium spaces and areas in the building with staggered floor and ceiling heights. Therefore, for a comprehensive evaluation of environment we need to study a 3D isovist which can provide a volumetric measure of visual experience.

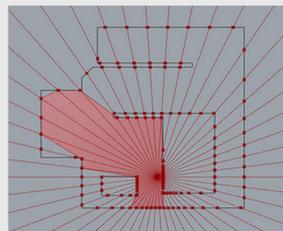
Because of some computational challenges, tools for calculating 3D isovists are rare. The current study proposes a method that departs from planar restrictions by using the parametric modeling capabilities in Rhino's Grasshopper plugin. For this purpose, a definition has been developed in Grasshopper and used to derive measures for 3D isovists using a hybrid method of ray-casting and voxel-packing.



Examples of isovist from various points

2D Isovist

In order to develop a conceptual model for 3D isovist, the first step was to understand how a 2D isovist works. In order to do so, a definition was developed in which lines were casted from a view point and then intersected with visual barriers. The closest intersection points to the view point were then selected to produce the 2D isovist.

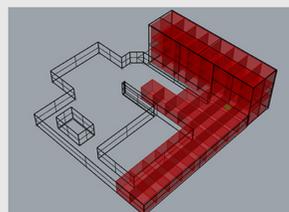


2D isovist

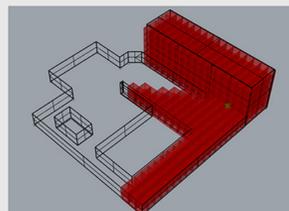
Voxel

Voxel is the 3-Dimensional equivalent of a pixel, therefore, using voxels allow to break objects down to the smallest pieces of shape. The advantage of using voxels is to control the resolution of a spatial analysis when complex data or computation is involved.

Voxels are often used in medical imaging and terrain imaging to represent data that is very complex and computationally intensive. The current study aims to apply a voxel analysis approach to the construction of 3D isovists, so that the lessons 3D isovists have to teach us about human visual experience become more accessible to architects and designers.



3D isovist: 8' voxels. Processing time: 2s.



3D isovist: 4' voxels. Processing time: 5s.

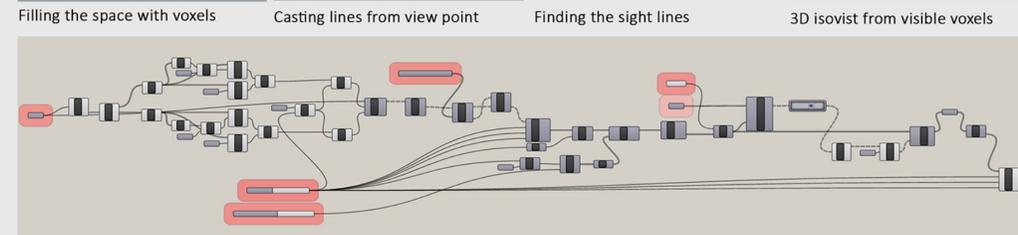
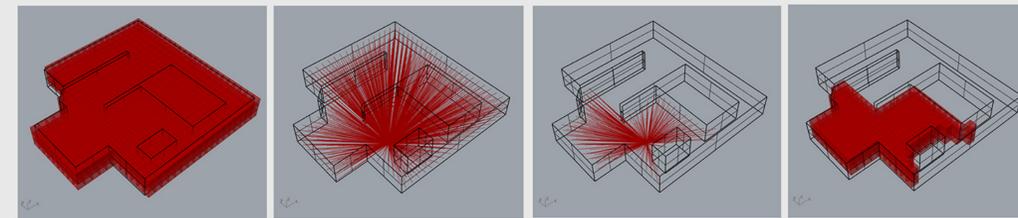
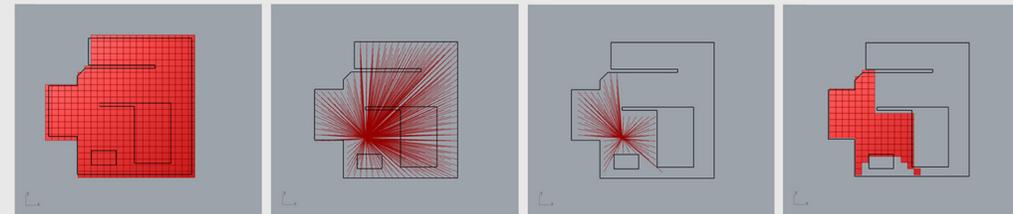
3D Isovist

Following the conceptual model for 2D isovist, a definition was developed for three-dimensional isovist. In this approach the space was first filled with voxels and the goal was to construct a 3D isovist by finding voxels that fall into the visible portion of space from a view point.

To start, lines were drawn between view point and voxels' centerpoints. Lines intersecting with visual barriers were excluded and the rest of sight lines were used to produce voxels that make up the 3D isovist volume.

In this approach voxels are created so that they fill up the whole space and have no or minimum voids among them. The definition is developed so that by changing the size of voxels their number is adjusted on the floor plan.

There are five main inputs that need to be inserted in the definition: the floor surface, visual barriers, view point, voxel size and number of voxels to fill the space in Z axis. If this number is selected 1, the definition will produce a 2D isovist as a result.

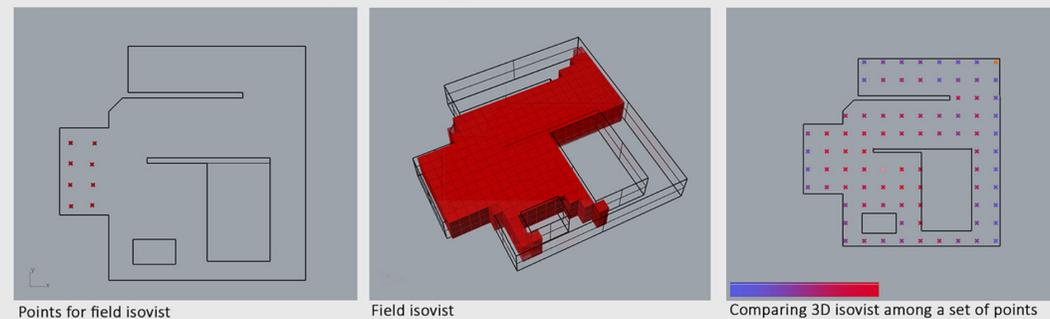


Grasshopper definition for 3D isovist.

Comparing 3D Isovists From a Set of Points and Field Isovist

The developed definition for 3D isovist can be used for multiple purposes. One application can be to study field isovist, which is the visible space from a set of points. The following picture on the left shows a set of hypothetical points from which we want to evaluate visible volume of space (middle picture).

The other application can be to color code and compare visible volume of space from a set of points, which is illustrated in the following picture on the right, where blue colors are showing points with minimum visibility and red color identifies points with highest visibility).



Points for field isovist

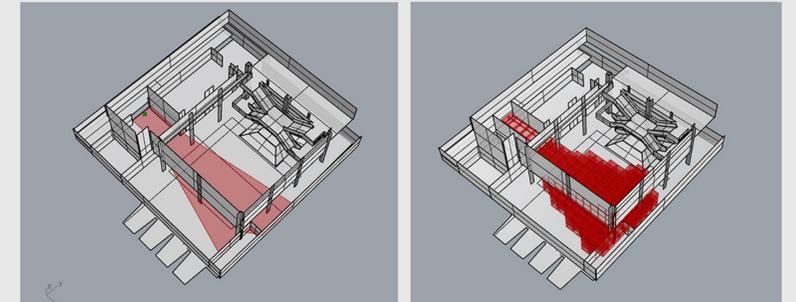
Field isovist

Comparing 3D isovist among a set of points

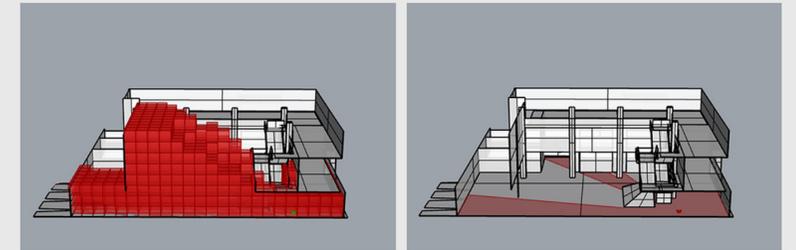
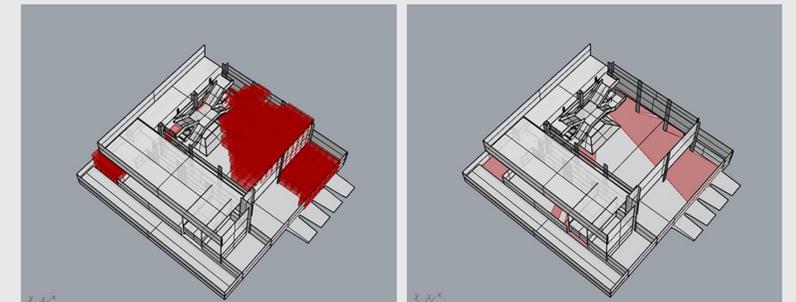
Comparing 2D and 3D Isovist

Besides the hypothetical setting presented so far, this study used the developed method for analysis of a part of student union building at University of Wisconsin-Milwaukee as shown below. This area, called Concourse, has a higher ceiling compared to other parts of the building. The following four pictures show 2D and 3D isovist from the same view point in space. The 3D isovists illustrate the amount of space that is visible to people as they move towards Concourse and can be used to study how this visibility may influence peoples' awareness of spaces that fall within their visual field.

Besides that, the 3D isovist shows how space is not nearly as visually permeable as it appears to be in the 2D isovist analysis, because there are walls blocking the view in the higher elevation.



2D and 3D isovist from another point in Concourse have been compared below. These pictures show how 3D isovist is able to provide us with a better estimate of the real-world visible space. Unlike the previous example, the 3D isovist below shows how 3D space is more visually permeable compared to a 2D isovist from the selected view point.



Conclusion

This study contributed to analysis of architectural environments relative to human perception and cognition by presenting a robust method for analysis of 3D isovist and measures derived from it.

The developed 3D isovist definition can be used to compare spatial properties of different areas in a model of a building or study the relationship between two or more spaces with a better approximate to the real world environment compared to a 2D isovist.