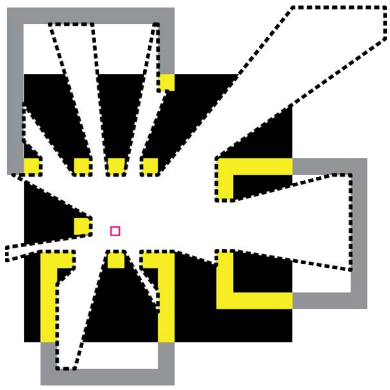


The Isovist_App: a basic user guide

Version 1.7

Sam McElhinney, 2024

Citation: McElhinney, S. (2024), 'The Isovist_App: a basic user guide', v1.7
http://www.isovists.org/user_guide/

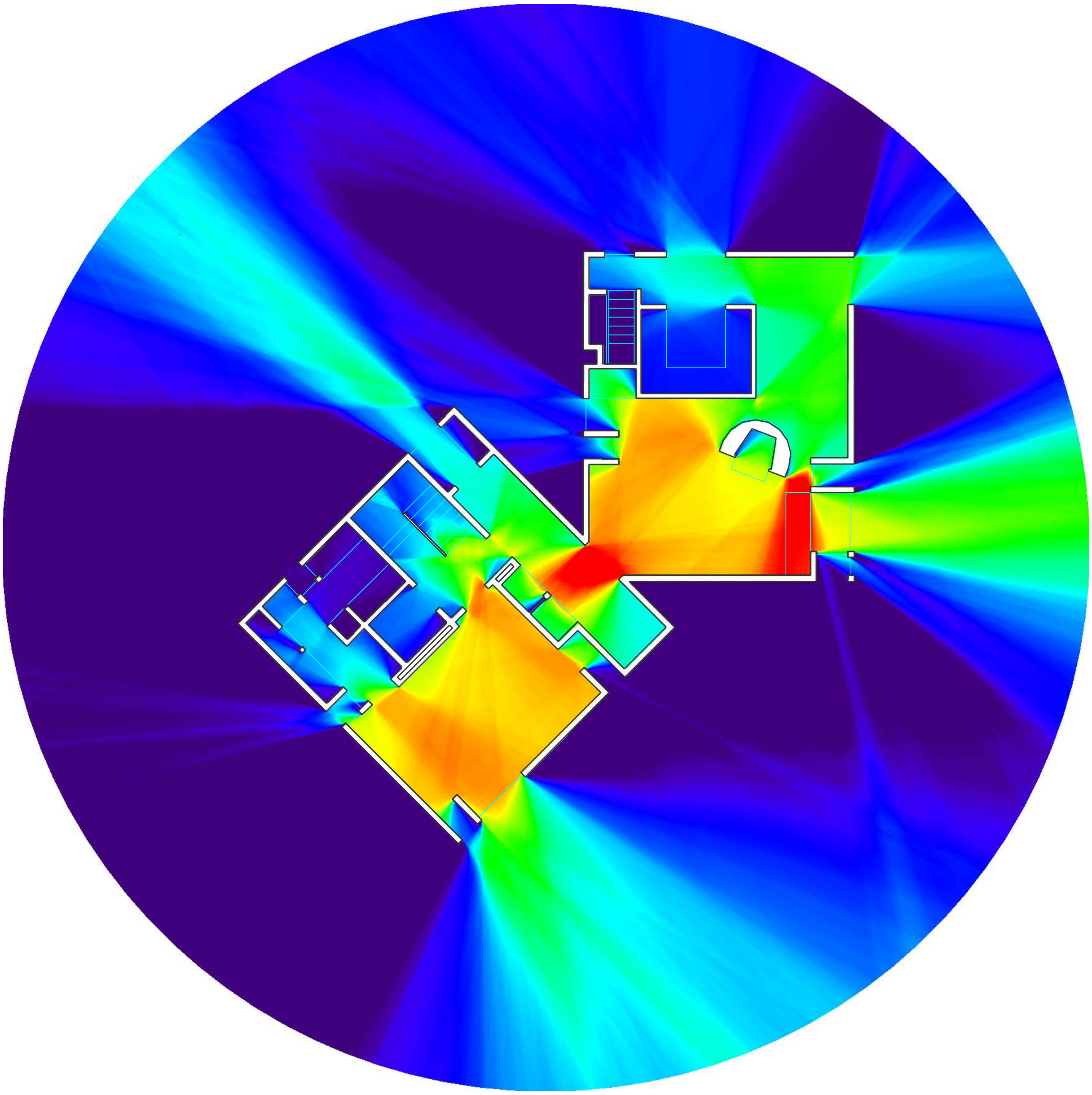
[Version 1.7 is a major update to accompany the release of isovist_2.4.9 in February 2024]

Contents

contents continued overleaf......

Acknowledgements:
Thank you to Michael Benedikt, for his guidance and friendship, to Sophia Psarra and Stephen Gage, for setting me on this path, and to Lizzie, for her patience and support.

Dedicated to Aoife, Afra and Evelyn.



Above: Expanded visibility fields in Kahn's Fisher House.

1 Introduction

The Isovist_App is a free multi-platform software tool. It has been designed as an intuitive interface to advance the learning and adoption of spatial analysis techniques at all levels, from undergraduate learning, to advanced research, and in design practice. It is based upon the spatial unit known as the 'isovist', defined as the finite volume of space that is visible at any given point at which a perceiver might exist.[1]

Every isovist has formal properties (such as size, shape, and so forth), as well as a set of relations to all other isovists within a space. Such properties and relations can be quantified—"measured"—and the (usually changing) values of these measures can be mapped through the entire space (all points) to create fields. The Isovist_App does so quickly and efficiently, in high-definition, using easily prepared plans or sections. As such it provides an alternative to traditional but computationally lengthy 'visibility graph analysis' methods[2], at resolutions that negate concerns of spatial grid definition associated with such work.

The measures and fields generated by the Isovist_App have been developed from the isovist literature based on Benedikt's 1979 paper, as well as from 'Space Syntax' literature based on the work of Bill Hillier and Julienne Hanson. The two literatures overlap, conceptually and in application. Isovist work tends to focus on buildings, interiors, and on human social and aesthetic experience and perception, whilst Space Syntax tends to focus on the city, behaviour and configurative aspects of space. The Isovist_App can be operated at any scale, from single rooms to urban street patterns, and so aims to be useful to both areas of interest.

Results from the Isovist_App can be output as high-resolution coloured pdfs, or as numeric point data. Such information allows intuitive and empirical exploration of experiential, navigational or socially significant affordances within existing or proposed spatial structures. Our aim is to help students, architects, designers and researchers to better understand the built environment and how people might respond to it.

1.1 What can the Isovist_App do?

The Isovist_App can show isovists directly, compute inherent geometrical or relational properties of them as 'measures' and display spatial representations of how such measures are distributed in space as 'fields'.

Of the twenty three different fields produced by the Isovist_App, ten are 'local' isovist measures that relate to occupant experience within space; Area, Perimeter, Closed Perimeter, Compactness, Occlusivity, Vista Length, Average Radial, Drift, Variance, and Skewness.[3] Five are 'global' Space Syntax-type measures that characterise configurational relations across a plan as a whole;[4] Choice, Mean Metric Depth, Mean Visual Depth, Mean Angular Depth, and Integration (HH).[5] The remaining eight measures are 'semi-local' or relational measures that span between local and global information; Directed Visibility, Co-Visibility, Overt Control,[6] Covert Control, Counterpoint, Metric Depth to Location, Visual Depth to Location and Angular Depth to Location.

In addition to rapid field analysis, the Isovist_App can conduct real-time justified graph diagramming, as well as point isovist, path isovist, region isovist and isovist agent analysis. It includes a scatter plot tool that can be used to review correlations (or lack thereof) between the massive data sets produced.

Collectively, the tools of the Isovist_App allow the user to examine and isolate spatial transformations or configurative properties with bearings upon 'understanding architecture'.

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[1] See Benedikt, M. (1979). 'To Take Hold of Space: Isovists and Isovist Fields'. *Environment and Planning B*. v6: pp.47-65.

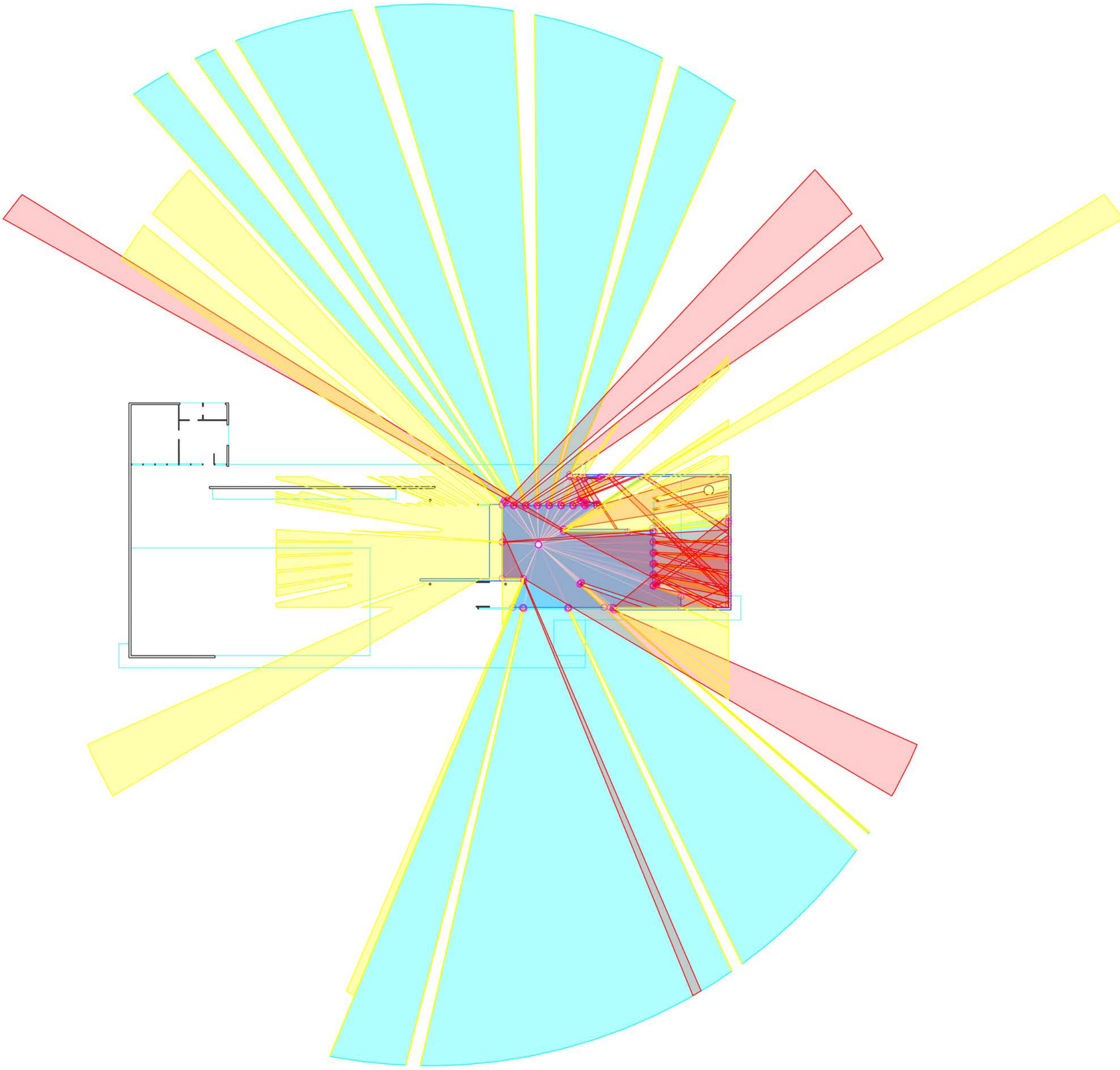
[2] Turner, A; Doxa, M; O'Sullivan, D; Penn, A. (2001a). "From isovists to visibility graphs: a methodology for the analysis of architectural space". *Environment and Planning B*. v28: pp.103–121, and Turner, A, (2001b). 'Depthmap: a program to perform visibility graph analysis', *Proceedings of the 3rd International Symposium on Space Syntax*, Georgia Institute of Technology, Atlanta, Georgia, for a definition of Controllability

[3] See Benedikt (1979) for the first definition of many of these metrics

[4] A good start point for exploration of such methodologies is Penn, A. (2003). 'Space Syntax And Spatial Cognition: Or Why the Axial Line?' *Environment and Behavior.* v35: pp.30 - 65 but the field is extensively published. See also Hiller, B. (1996, 2007). 'Space is the Machine: A configurational Theory of Architecture', UCL Press.

[5] See Hillier, B. and Hanson, J. (1984), 'The Social Logic of Space', Cambridge University Press: Cambridge. pp.108-109 for a definition of integration; and Teklenburg, J; Timmermans, H; Wagenberg, A. (1993) 'Space Syntax: Standardised Integration Measures and Some Simulations'. *Environment and Planning B.* v20: pp. 347 - 357

[6] See Hillier and Hanson (1984) for a definition of Control; and Turner, A, (2001b) for a definition of Controllability



Above: Visible, Reflected and Spectral isovist geometries in Mies' Barcelona Pavilion.

2 Getting started

2.1 First, does the Isovist_App correlate?

Yes. Key isovist field measures correlate with equivalent measures produced by DepthMapX methods, but are calculated in a tiny fraction of the time, for a far higher resolution of data points. A study demonstrating correlation of Isovist Mean Visual Depth against DepthMap Mean Visual Depth is provided on isovists.org.

2.2 System requirements

The Isovist_App uses the OpenGL standard to massively parallelise spatial calculations via algorithmic methods designed to run on high-performance modern graphics processor devices. Doing so allows production of a pixel-fine field of quantitative results, across hundreds of thousands of points, in near real-time.

Drivers for OpenGL are usually bundled with standard operating system graphics driver support software. In some instances, users may need to update such drivers. The software performs optimally on computer systems with discrete graphics cards, such as an NVidia GForce GT7XX, AMD Radeon R9 M370X, or higher specification. It has a best functionality on contemporary MacBook Pro machines; is known to work well on Dell XPS 15 series laptops; and should be operable on most Windows PC workstations with a contemporary 3d rendering setup.

Older machines may struggle to deliver the performance levels required to run the Isovist_App well. Proceed with caution if this is you.

2.3 Downloading and installing

The latest version of the Isovist_App for both Mac and PC can be found on isovists.org. Clicking on the links on the website will download a zip bundle. Once download is complete, the software can be installed by opening the zip file and extracting the contents to the applications folder. An alias icon can subsequently be dragged to the OS X dock or the PC desktop to allow ease of launch.

2.4 Running the software for the first time

The first time that the Isovist_App is launched in Mac OSX it may need to be 'right clicked' and the 'open' option chosen. PC users should be able to launch the software by double clicking on the .exe file or alias.

A sample plan is bundled with each release and should become visible on a successful launch. We advise that the user next checks the primary menu to review the frames per second (fps) at which the Isovist_App is running, the scan sampling progress and the number of lines in the drawing import. The frame rate, for instance, indicates that the software is functional; it will vary depending on user device and plan complexity, but a speed of 15fps upwards allows for reasonable interactive use. More contemporary computers can achieve speeds of over 100fps, at which point the analysis modes become near real-time.

Once the user is confident that the Isovist_App is running smoothly, the following 'How to' section provides a series of step by step guides that cover most required actions.

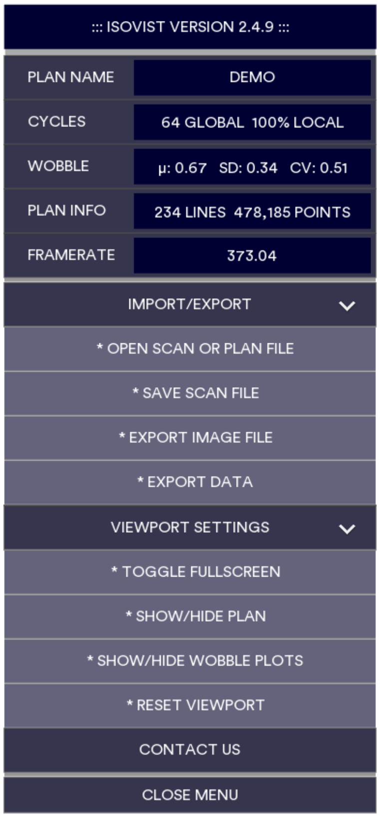
3 How to....

3.1 Perform basic functions:

3.1.1 Prepare and load a new drawing for analysis

The Isovist_App supports import of drawings in .dxf, .dwg (Autocad 2019 and earlier) and .svg formats. To assist in preparing drawing files, an example file of the Barcelona Pavilion, prepared for import, can be downloaded here. To import a drawing:

- First prepare your drawing in Autocad, Adobe Illustrator, or another cad editing software by organising the drawing elements onto one of four named layers (groups within an svg):
  - *'solid' for elements that block vision (e.g. walls)*
  - *'transparent' for elements that can be seen through (e.g. windows, balustrades)*
  - *'reflective' for elements that reflect vision (e.g. mirrors)*
  - *'annotations' for elements that you don't want to include in any calculations but do want to see (e.g. furniture, details)*
- If you choose not to name your drawing layers, you will have to assign the above material characteristics later in the app itself. See section 3.1.5 for information on how to do this.
- Ensure that any elements such as mask or textures are removed from the drawing, leaving only vector elements.
- Save the drawing as either a dxf, dwg or svg file.
- Launch the Isovist_App.
- Select 'Import/Export' from the primary menu at the top left of the screen, and then 'Open Scan or Plan file'. A file dialogue box should subsequently open to allow the import file to be chosen.
- After choosing the file, the screen should switch to a blinking icon whilst the file loads and the drawing is translated; this will take longer for larger files.
- When complete, the drawing should appear on your screen. Each of the specified layers should be coloured; solid in black, transparent in cyan blue, reflective in dark blue, and annotations in light grey.
- The name of the imported file should be visible in the main menu beside 'Plan name'; this can be edited if you wish.



Above: The Primary Isovist menu (expanded view).
Right: The Drawing and Setup menu (drawing and layer settings expanded).

3.1.2 Optimise and troubleshoot drawing imports

A little extra care during the preparation of a drawing can pay dividends for ease of subsequent analysis. Key points to be aware of include:

- Avoid unnecessary detail. The fewer lines used to describe a drawing, the faster the analysis will run and the clearer the outcomes will be. Details included in CAD are often extraneous to the issues of spatial definition; such details should be turned off if possible, or allocated as 'annotations'.
- Check the drawing to ensure that the lines intersect. Small gaps between line ends or where walls meet, can occasionally cause issues in the scan calculations; for instance, causing false results in an occlusivity field.
- Wherever possible, simple lines, basic shapes (circles, rectangles), and smoothed curves should be used in the drawing, rather than many very small fragment segments.
- If your import issue is persistent, please notify us and we will try and assist you.

3.1.3 Shrink the Isovist_App to a moveable window

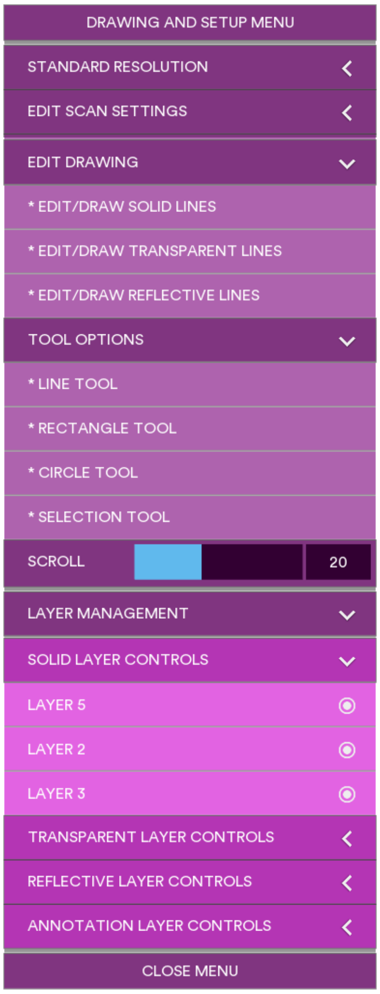
The Isovist_App viewport controls are all found within the primary menu at the top left of the screen. To switch between fullscreen and window modes:

- Select the 'Viewport settings' option from the primary menu, followed by 'Toggle Fullscreen'. If in fullscreen mode, the Isovist_App should now switch to a window, and vice versa.
- When in window mode, the window can be dragged around using the title strip, and minimised to a bar or maximised using the 'Min' and 'Max' buttons at the top right corner.

3.1.4 Edit an imported drawing

Sometimes errors in a drawing are only spotted after import and need to be fixed; or users may wish to test the outcome of spatial interventions to an analysis result. To allow this, the Isovist_App includes a basic set of drawing editing tools. To edit an imported drawing:

- Open the 'Drawing and Setup menu'.
- Select 'Edit Drawing', followed by the option that reflects the type of changes that you wish to make; either 'Edit/Draw Solid Lines', 'Edit/Draw Transparent Lines', or 'Edit/Draw Reflective Lines'.
- Next select 'Tool Options', followed by either 'Line tool', 'Rectangle tool', 'Circle tool' or 'Selection tool'.
- Once a tool is selected, lines can be drawn to the screen using the cursor. To delete a line or series of lines, select them and press the 'Delete selection' button in the Drawing and Setup menu.
- Once the required edits have been made, it is advisable to re-check the selected analysis areas (see 3.1.6 below).



3.1.5 Use layer management

Occasionally you may wish to vary layer material assignments in the app, rather than having them preset on import. To do this, the process is simple:

- When preparing your drawing for import, organise your drawing elements onto appropriate layers, but leave them un-named.
- Save the drawing as either a dxf, dwg or svg file.
- Launch the Isovist_App.
- Select 'Import/Export' from the primary menu at the top left of the screen, and then 'Open Scan or Plan file'. A file dialogue box should subsequently open to allow the import file to be chosen.
- After choosing the file, the screen should switch to a blinking icon whilst the file loads and the drawing is translated; this will take longer for larger files.
- When complete, the drawing should appear on your screen. With no layers having been pre-set, the whole drawing will appear black.
- Within the drawing and setup menu, a sub menu called 'Layer Management' should appear, with four layer control categories; solid, transparent, reflective and annotations.
- Within each category you should be able to view your original drawing layers, and toggle them on and off. As you do so, the material designation in the viewport plan drawing should change accordingly.
- Once the required changes have been made, it is advisable to re-check the selected analysis areas (see 3.1.6 below).

3.1.6 Set the scale and analysis areas of an import

Once a drawing has been imported, the software estimates the required area for analysis, and sets an overall scale. It is sensible to review these before conducting an analysis. To do this:

- Open the ‘Drawing and Setup menu’.
- Select ‘Edit Scan Settings’, followed by the ‘Select Scan Regions’ option.
- The view should update to show the areas selected for analysis in magenta.
- New areas can be added, or selected areas removed, by clicking with the cursor on the drawing.
- Once all required regions are set, the preview can be closed by clicking on any other menu option.

To review and set the drawing scale (essential for quantitative results):

- Open the ‘Drawing and Setup menu’.
- Select ‘Edit Scan Settings’, followed by the ‘Set Unit Scale’ option.
- The view should update to show a scale bar in magenta, and a blue slider should appear in the menu.
- Moving the slider will increase or decrease the scale bar size to a user defined ‘ten unit’ length. This provides a uniform unit length that is applied to all isovist calculations (area, vista, and so forth).
- To assist with accurate scaling, the user can reposition the origin point of the scale bar by clicking on the screen, and can zoom in and out of the drawing using the mouse scroll wheel.
- Once the required scale is set, the scale preview can be closed by clicking on any other menu option.

3.1.7 Change the resolution of a field analysis

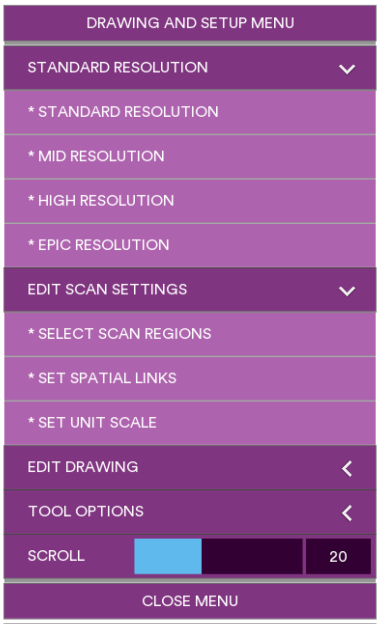
By default, the Isovist_App will run its analysis at a standard resolution that provides a fine gradation of data; typically between 500,000 and 1 million points per drawing. To increase this:

- Open the ‘Drawing and Setup menu’.
- Select ‘Standard Resolution’ followed by the preferred increased resolution option; ‘Mid’, ‘High’ or ‘Epic Resolution’.
- Take care! And consider your computer hardware capabilities. In many instances, the lowest resolution setting will suffice; higher settings provide more data, but take longer and can crash older machines.
- Once the required resolution has been set, it is advisable to re-check the selected analysis areas.

3.1.8 Increase the speed of zoom scrolling

Users can zoom in and out of drawings using the mouse scroll wheel. To control the sensitivity of scrolling:

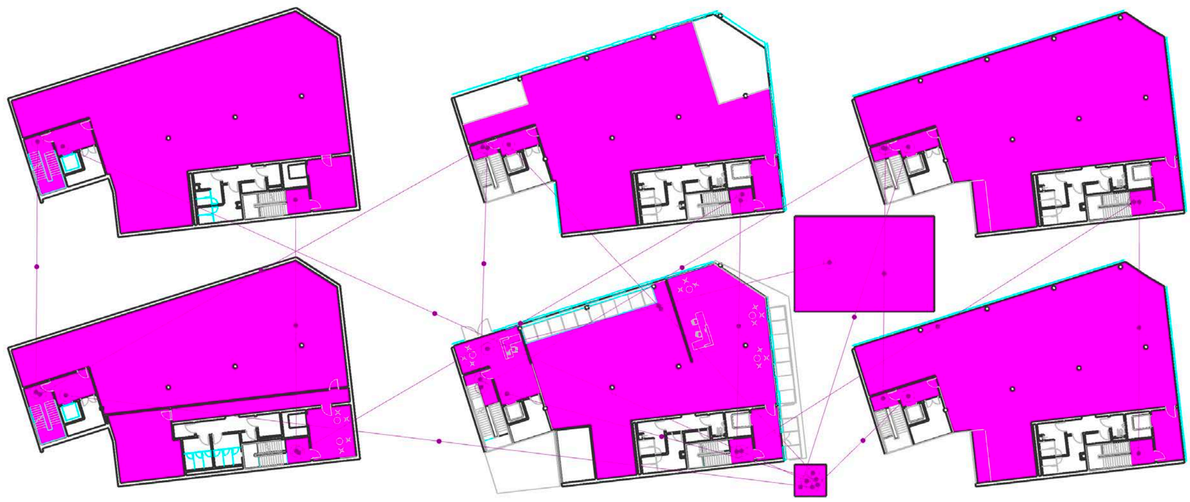
- Open the ‘Drawing and Setup menu’.
- Drag the blue slider titled ‘Scroll’ up or down to increase or decrease sensitivity.



3.1.9 Link areas of a drawing, such as floors in a plan

For more complex buildings and settings, it may be necessary to link analysis across multiple floors or areas of space. The Isovist_App allows for this to be done by means of user defined 'linkers', which affect the spatial analysis field results accordingly. To define linker objects:

- Open the 'Drawing and Setup menu'.
- Select 'Edit Scan Settings', followed by the 'Set Spatial Links' option.
- At this point, the view should highlight the areas that have been selected for analysis in magenta. Linker objects must start and end within the magenta regions.
- On the drawing on screen, click in the location that a link is required to start from, and a ringed dot will appear in dark purple.
- Move the cursor, and click again at the location that the link is required to end. A second ringed dot should appear, along with a linking line that represents the linker object.
- To delete a linker object, hover the cursor over the small purple dot at the centre of the link line. When changes to orange, click the cursor and the linker will be deleted.
- Once linkers have been set, the preview can be closed by clicking on any other menu option.



Above: Setting up a multi floor plan; areas for analysis in magenta, and floor to floor links shown in purple.
Left: The Drawing and Setup menu (resolution and scan settings expanded).

3.1.10 Save and reopen an analysis file

The Isovist_App uses a bespoke file format (.isovist) to save setup scan files. This is rarely used, but is available. To save a file:

- Select 'Import/Export' from the primary menu at the top left of the screen, and then 'Save scan file'. A file dialogue box should subsequently open to allow a location to be chosen and the file named.
- Wait… The file save can take time due to the volume of information involved. Once saving has commenced, normal scan analysis will resume; saving occurring in parallel as a background function. Whilst saving continues, the 'exit' button in the user menu will be greyed out.

To reopen an isovist analysis file:

- Select 'Import/Export' from the primary menu at the top left of the screen, and then 'Open Scan or Plan file'. A file dialogue box should subsequently open to allow the import file to be chosen.
- Whilst the file loads and the drawing data are reconstructed, the screen should switch to a blinking icon; this will take longer for larger files.
- When complete, the normal drawing view should become visible.

3.2 Run primary analysis

3.2.1 Place or remove isovists within a space

The ‘Isovist Analysis’ menu allows basic visual analysis using ‘point isovists’, ‘region isovists’, or ‘isovist agents’. On launching the software, point isovists are selected by default; the latter two options can be selected as alternatives using a drop-down menu. To place isovists within the drawing:

- Open the Isovist analysis menu.
- Click on the top drop down options to choose either ‘Point Isovists’, ‘Region Isovists’ or ‘Isovist agents’.
- ‘Point isovists’ can be calculated and released by the user moving the cursor and clicking at a point of interest. These identify the space that falls within the isovist from any single location.
- ‘Region isovists’ can be calculated by the user clicking and dragging the cursor. These identify all space that is visible from along the route that the cursor is dragged along.
- ‘Isovist agents’ can be released by the user clicking the cursor. These subsequently move independently, in a manner based on Turner’s agents;[7] that is, they move randomly towards available depth; but they do so without reference to an exosomatic visual graph, instead using real-time isovist calculations. A sub option for the agents allows the user to set them to move randomly towards available occlusivity, as well as depth.
- To remove the last calculated or released isovist, press the keyboard delete or backspace buttons.
- To remove all released isovists, press ‘Clear’ at the foot of the menu.

Various different isovist overlays can be chosen from the isovist menu, including intersection values and a ‘time-to-contact array' representation[8].

3.2.2 Change the overall isovist parameters

A series of parameters can be set for isovist calculation. Each parameter is controlled by a slider in the isovist analysis menu as follows:

- Isovist sweep (angle of view).
- Direction (heading that the isovist is ‘looking’ in).
- Far rim (how far the isovist can ‘see’).
- Near rim (an internal horizon that sets nearest visible isovist edges).

Setting a parameter affects all latter field analysis calculations and automatically resets all analysis.

3.2.3 View different spatial categories of isovist

Four spatial categories of isovist can be calculated and drawn. These depend on the material assignments made in the imported drawing. Each can be toggled on or off in the isovist analysis menu as follows:

- Select ‘Draw Accessible Isovists’ to calculate isovists that include all space seen and directly accessible from the isovist origin point;
- Select ‘Draw Visible Isovists’ to calculate isovists that include all space seen but inaccessible from the isovist origin point (such as space behind a window, or beyond a void);
- Select ‘Draw Reflected Isovists’ to calculate isovists that include all space made visible as the result of a line of sight being reflected in a mirror surface;
- Select ‘Draw Spectral Isovists’ to calculate isovists that include all space perceived ‘in a mirror’, but that is actually illusionary.

Each spatial category is drawn as a different colour isovist; blue for ‘accessible’, cyan for ‘visible’, red for ‘reflected’ and yellow for ‘spectral’. The user selection of isovist layers also determines the spatial categories measured in the field analysis calculations.

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[7] See Turner, A and Penn, A. (2002). ‘Encoding Natural Movement as an Agent-Based System: An Investigation into Human Pedestrian Behaviour in the Built Environment’ Environment and Planning B V29, pp. 473 - 490

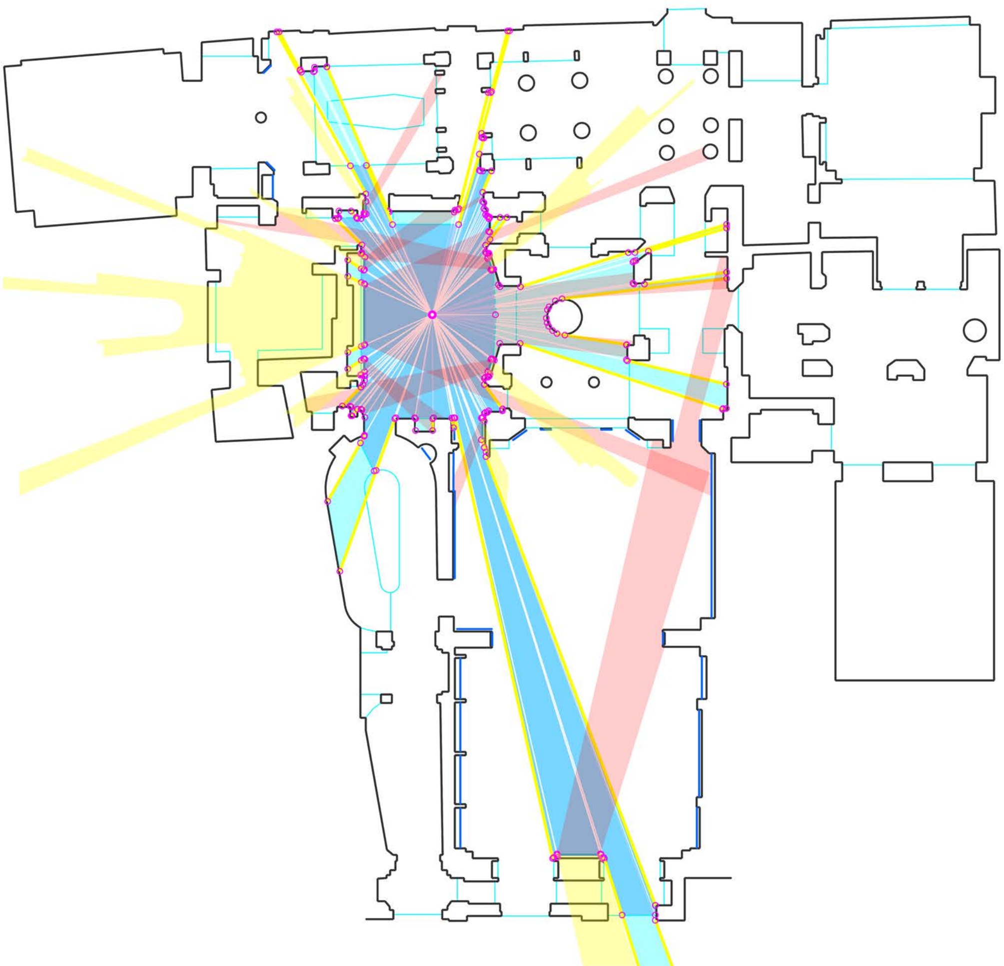
[8] Benedikt, forthcoming (2024)

3.2.4 Measure isovist values at the cursor location

The Isovist_App allows real time exploration of isovist metrics at points chosen by the user. To do so:

- Import the drawing to be analysed and check that the drawing scale is set to an appropriate value.
- Select 'Point Isovists' from the dropdown at the top of the Isovist analysis menu.
- Switch on the required visible spatial types for analysis (i.e. Accessible, Visible, Reflected or Spectral) in the isovist analysis menu.
- Set any preferred isovist parameters (i.e. sweep, direction, or rims) in the isovist analysis menu.
- Select 'Show isovist point values' from the isovist analysis menu. Doing so should reveal a magenta box in the lower left corner of the screen, with a list of metric titles (area, perimeter, and so forth).
- Move the cursor to the location to be examined. The values in the magenta box should update to reflect the isovist calculated the location of the cursor. Remember that the numeric values are dependent on the drawing unit scale previously set.

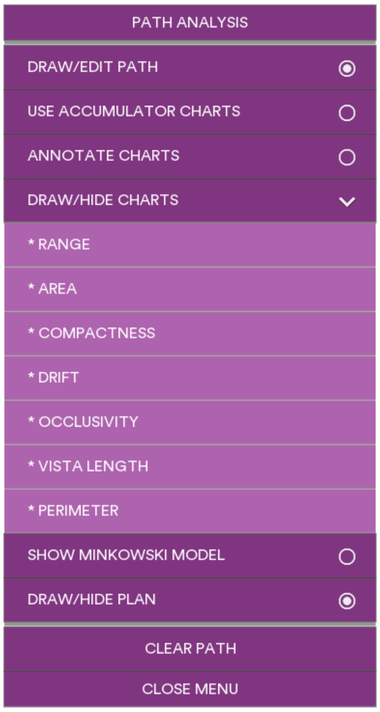
When accessible and visible isovists are drawn simultaneously, a 'Motor Containment' value is displayed in the isovist menu. Motor Containment is the ratio between the accessible area and visible area viewed from the cursor location.



Above: Accessible, Visible, Reflected and Spectral isovist geometries in the John Soane's Museum.

Left: The Isovist Analysis menu (expanded view).

3.2.5 Measure isovist values along a path



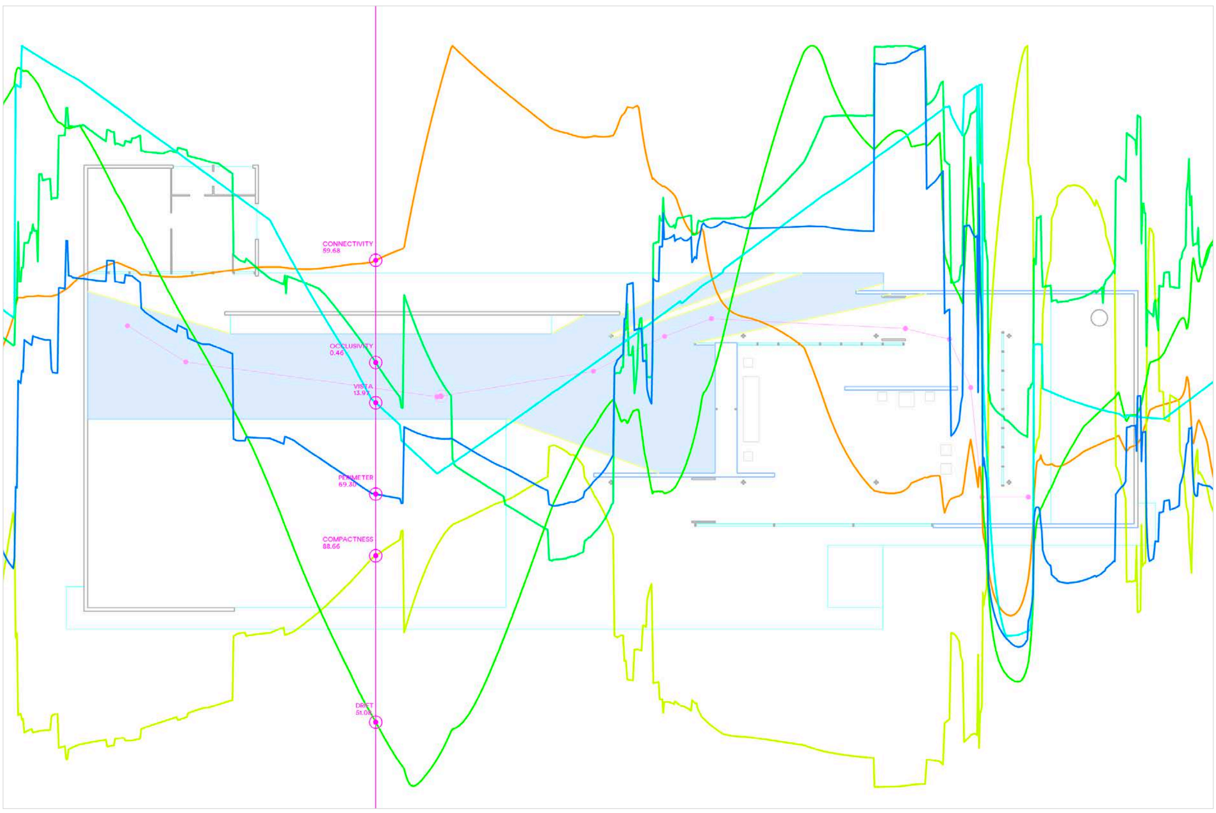
The 'Path Analysis' menu allows for slightly more advanced analysis of isovist metrics as they vary along a user defined route or path. To do this:

- Import the drawing to be analysed, check that the drawing scale is set to an appropriate value, and check that the correct regions for analysis have been selected.
- Switch on the required isovist spatial types for analysis (i.e. Accessible, Visible, Reflected or Spectral) in the isovist analysis menu.
- Set any preferred isovist parameters (i.e. sweep, direction, or rims) in the isovist analysis menu.
- Open the 'Path analysis menu'.
- Select the 'Draw/edit path' option, and click the cursor on the screen to set path nodes in a route across the drawing. Each cursor click will define a new path node.
- To relocate existing path nodes, hover the cursor over the node to be moved, and click drag the node to a new location.

As each node is added or moved the path calculations will update in real-time. Each new path segment is subdivided and the isovist at every point along it is calculated instantaneously. Geometric values are extracted from each isovist and from said values a set of dynamically updating line-charts are drawn across the viewport. To review different values along the path:

- Select and draw the required metric charts for interrogation using the 'draw/hide charts' option
- Switch the 'chart annotations' on using the respective toggle and move the cursor from left to right to vary the point of interrogation of the chart. An isovist will appear in the background drawing, along the length of the path to illustrate the respective location represented by the chart. Numeric values for that location will be annotated in magenta on the charts. Remember that the numeric values are dependent on the drawing unit scale previously set.
- To switch between distinct locational or accumulative values along the path charts, switch the 'use accumulator charts' option on or off.

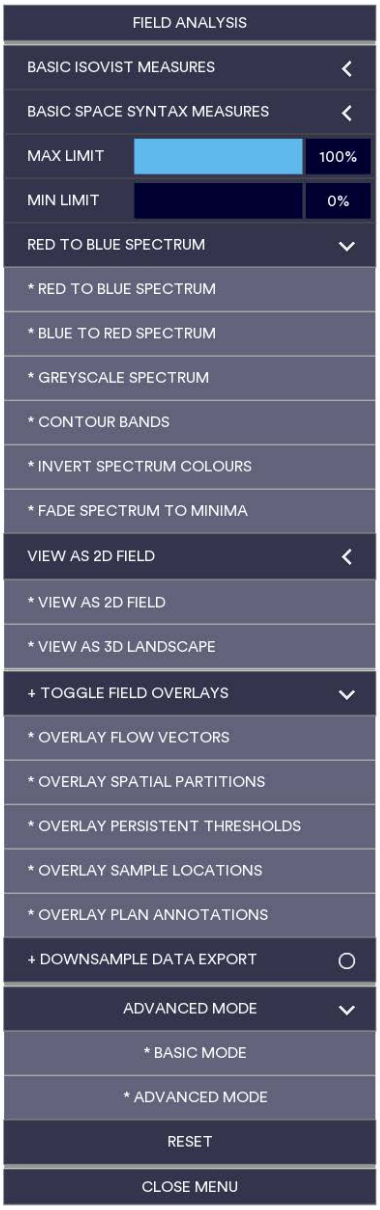
All calculated path data can be exported as a csv file by selecting the export data option from the main menu whilst the path analysis is displayed on screen.



3.2.6 Measure values in a field analysis

The 'Field Analysis' menu allows the user to assess the metric values at all locations in a space, and plot these in a colour representation, or a 'field'. A total of ten 'local' isovist fields and thirteen 'global' space syntax fields can be calculated by the Isovist_App. To generate and measure these fields:

- Import the drawing to be analysed, check that the drawing scale is set to an appropriate value, and check that the correct regions for analysis have been selected.
- Set any required links between different spatial regions by using the 'drawing and setup menu'.
- Switch on the required isovist spatial types for analysis (i.e. Accessible, Visible, Reflected or Spectral) in the isovist analysis menu. By default, field analysis is conducted just using 'accessible' isovist space.
- Set any preferred isovist parameters (i.e. sweep, direction, or rims) in the isovist analysis menu.
- Open the 'Field Analysis menu' and chose either the Basic or Advanced modes from the foot of the menu. The advanced mode gives access to extra field options, but slows the running of the calculations, so may not always be suitable.
- Use either the 'Isovist measures' or the 'Space Syntax measures' drop down menus to select the fields to be reviewed. The requested field should subsequently become visible as a coloured fill on the drawing.
- Wait… The analysis runs in real time and rapidly develops from a stochastic sampling process to give a statistically stable field of values. The time required to complete varies relative to complexity of field measure chosen and computer device power.
- Review the local and global cycles counts, visible in the primary menu at the top left of the Isovist_App window, to help assess when a field analysis is 'complete'. Local isovist measures will display a % complete figure, and global space syntax measures can be considered stable after after circa 250 global cycles.[9]
- To display numeric values at locations in the field, select the 'show field point values' option from the isovist analysis menu. Move the cursor to any location in the field and the numeric value for that field at that location should appear beside the cursor. Click and drag the cursor, and a selection box will appear, with the average field value within that box displayed. Remember that the numeric values are dependent on the drawing unit scale previously set.
- To fine tune the colour visualisation of each field result, use the 'upper limit' and 'lower limit' sliders in the field analysis menu. Numerous alternative field colour schema can also be chosen from the tab immediately below these two sliders.
- To switch between viewing the measure results as a 2d 'field' or 3d 'landscape', select from these two options below the colour schema options tab. In the landscape form a 3d view will appear, with peaks and troughs through the representation space reflecting result magnitudes.
- To completely reinitialise the field analysis, press the 'reset' button at the foot of the field analysis menu. The existing field results will be wiped and a new analysis started.



Top left: The Path Analysis menu (expanded view).
Bottom left: A path analysis of Mies' Barcelona Pavilion with charts revealed and labelled.
Right: The Field Analysis menu (expanded view).

[9] See McElhinney, (2024)

3.3 View and export results

3.3.1 Export point isovist data

To export numeric metric data based on specific user selected isovist locations and geometries:

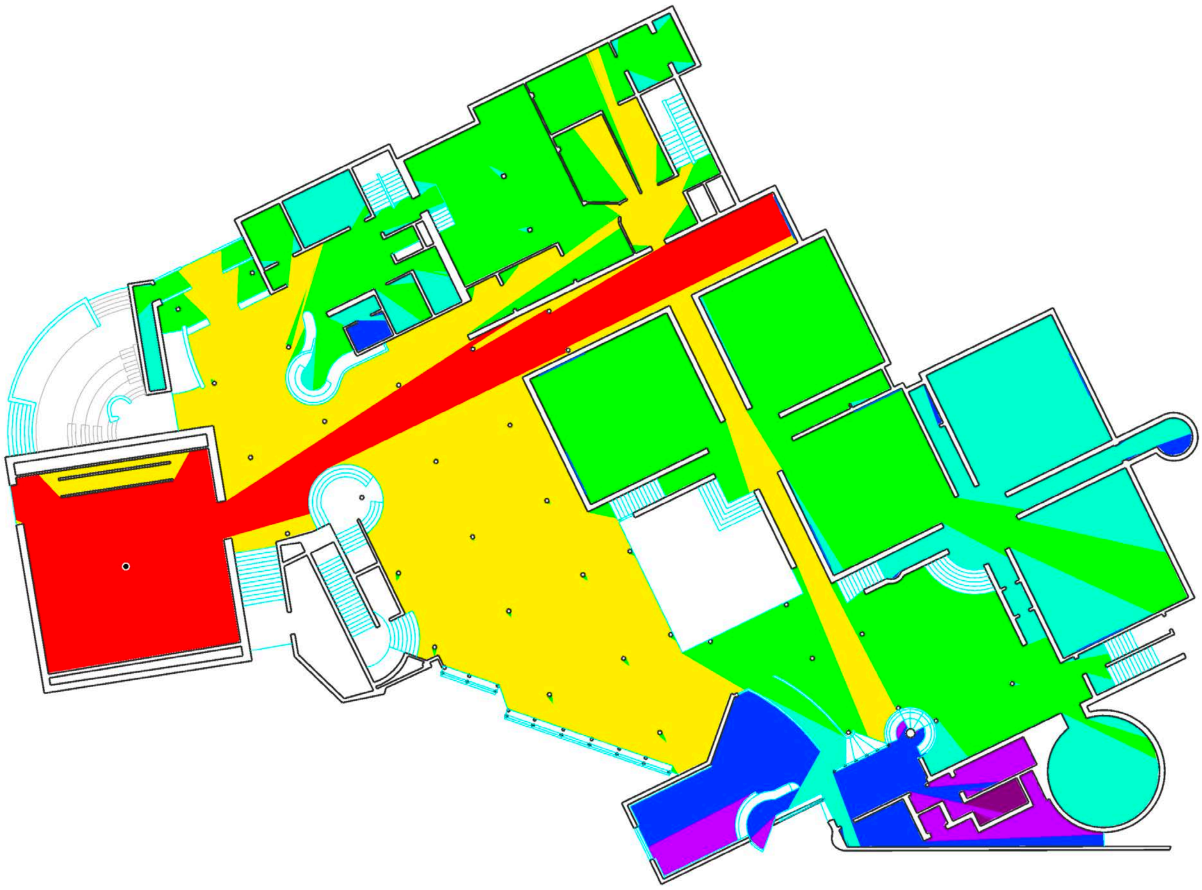
- Set up the desired point isovists on the screen using the isovist analysis menu options.
- Select 'Import/Export' from the primary menu at the top left of the screen, and then 'Export data'. A file dialogue box should subsequently open to allow a file to be named and saved.
- On pressing 'Ok' in the file dialogue, the software will export a CSV data file, with coordinates for all point isovists within the analysis areas and a numeric value for every isovist metric. Remember that the numeric values are dependent on the drawing unit scale previously set.
- The resulting data file can be opened and reviewed in Microsoft Excel. If the original import drawing file was a .dxf or .dwg format with geo locational data, then the export data coordinates should preserve this information for aligned import into GIS interfaces.

3.3.2 View and export visual step depth data

To export numeric visual step values based on specific user selected viewpoints:

- Import and set up a drawing for field analysis as normal.
- Open the 'Field Analysis menu'.
- Chose the 'Visual Depths to Location' option from the 'Space Syntax measures' drop down box.
- Use the cursor to select locations from which to measure the visual step depths. Wait… a series of coloured visual step geometries should appear sequentially on the screen. Repeat for all desired locations.
- Select 'Import/Export' from the primary menu at the top left of the screen, and then 'Export data'. A file dialogue box should subsequently open to allow a file to be named and saved.
- On pressing 'Ok' in the file dialogue, the software will export a CSV data file, with coordinate fields for all selected locations, and numeric values for visual depths from these to all coordinates within the analysis area.
- The resulting data file can be opened and reviewed in Microsoft Excel. If the original import drawing file was a .dxf or .dwg format with geo locational data, then the export data coordinates should preserve this information for aligned import into GIS interfaces.

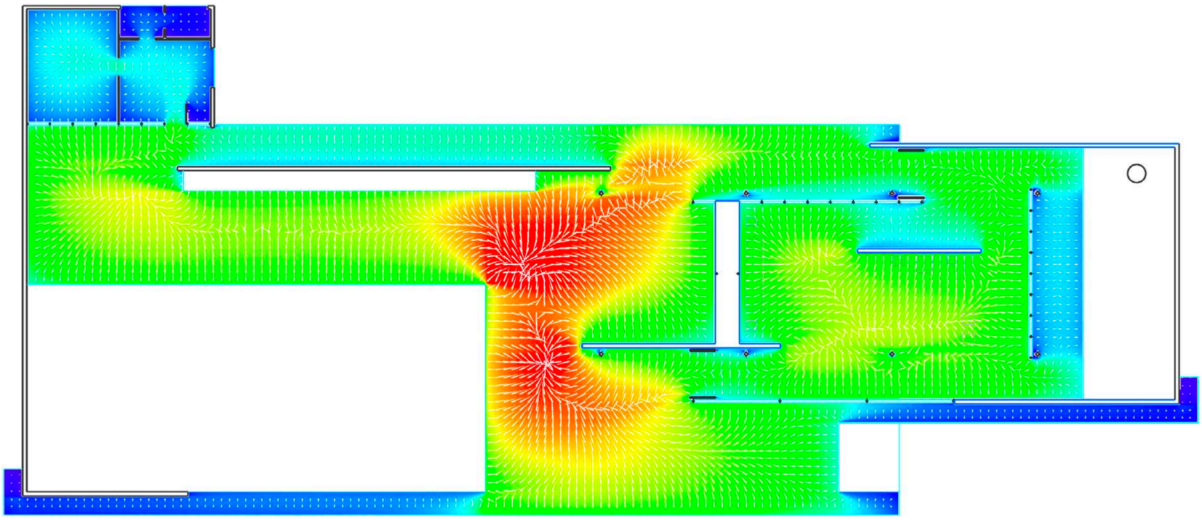
Below: A visual depth analysis of Hollein's Monchengladbach Museum.
Right: Flow vectors overlaid upon an average radial field in Mies' Barcelona Pavilion.



3.3.3 Export numeric field data from all locations

To export a data file containing numeric analysis field data:

- Import and set up a drawing for field analysis as normal.
- Open the 'Field Analysis menu', and run the analysis in the advanced mode if all measures are required.
- Select a field analysis for display on screen from either the 'Isovist' or 'Space Syntax' measures options. Wait… for the data representation to reach a stable condition.
- Think about how much data you want to deal with. Our fields are very dense, with hundreds of thousands of points. You may prefer a decimated field; in which case select the 'downsample data export' option in the fields menu.
- Select 'Import/Export' from the primary menu at the top left of the screen, and then 'Export data'. A file dialogue box should subsequently open to allow a file to be named and saved.
- On pressing 'Ok' in the file dialogue, the software will export a CSV data file, with fields for all point coordinates within the analysis area, and every value, for every scan measure, at each point. The full data export resolution is set at the same resolution as the scan itself, and so can be large.
- Wait… The export can take time due to the volume of information involved. Once export has commenced, normal scan analysis will resume; export occurring in parallel as a background function. Whilst export continues, the 'exit' button in the user menu will be greyed out.
- The resulting data file can be opened and reviewed in Microsoft Excel. If the original import drawing file was a .dxf or .dwg format with geo locational data, then the export data coordinates should preserve this information for aligned import into GIS interfaces.



3.3.4 Overlay annotations upon an isovist field

A series of drawing overlays can be calculated and displayed over the isovist fields. To draw these:

- Import and set up a drawing for field analysis as normal.
- Open the 'Field Analysis menu', and run the analysis in the advanced mode if all measures are required.
- Select a field analysis for display on screen from either the 'Isovist' or 'Space Syntax' measures options. Wait… for the data representation to reach a stable condition.
- Select the 'toggle overlays' option and switch the required overlay type on or off:
  - Select 'overlay flow vectors' to draw a series of vector lines that indicate the direction and magnitude of the field results at locations throughout the space.
  - Select 'overlay spatial partitions' to display an estimated set of Peponis' E- and S-Partitions[10] based on the analysis space and isovist types.
  - Select 'overlay persistent thresholds' to reveal experientially key thresholds in the analysis space.
  - Select 'overlay sample locations' to view all stochastic sample points assessed so far in the field
  - Select 'overlay plan annotations' to switch the drawing annotations layer on and off

[10] See Peponis et. al. (1997)

3.3.5 Export vector drawings of isovist geometries

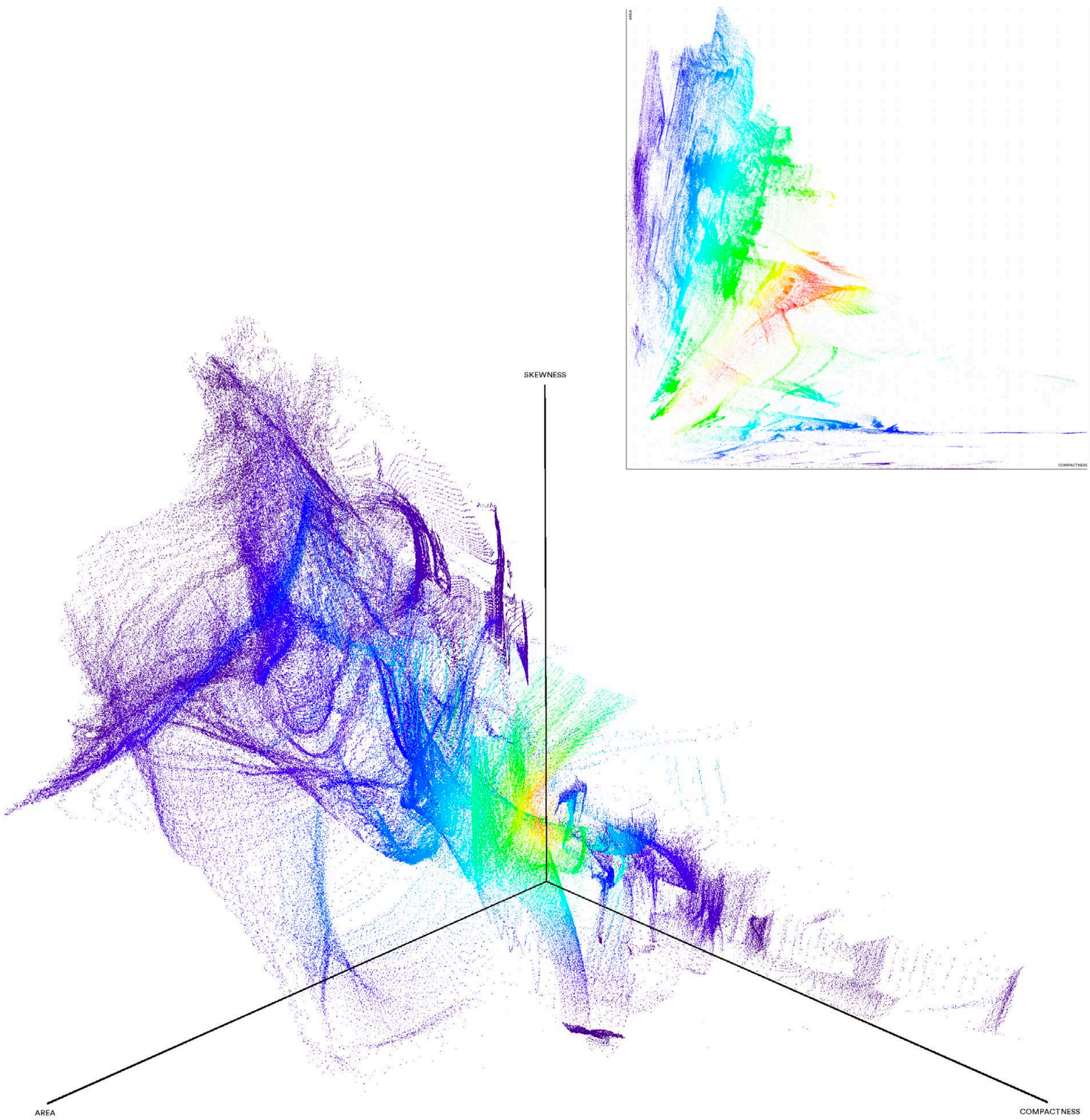
To export and edit vector shapes based on specific user determined isovist geometries:

- Set up the desired isovists on the screen using the isovist analysis menu options.
- Zoom in or out to show the extents of what you wish to export.
- Select 'Import/Export' from the primary menu at the top left of the screen, and then 'Export image file'. A file dialogue box should subsequently open to allow a file to be named and saved.
- On pressing 'Ok' in the file dialogue, a pdf file will be exported of the current viewport view.
- The resulting file will include any visible drawing lines and isovist geometries as vector information, which can be easily opened and edited further using Adobe Illustrator.

3.3.6 Export high resolution images

To export a high resolution image of a field or chart:

- Set up the desired image on the screen using the various analysis menu options.
- Select 'Import/Export' from the primary menu at the top left of the screen, and then 'Export image file'. A file dialogue box should subsequently open to allow a file to be named and saved.
- On pressing 'Ok' in the file dialogue, a high resolution pdf file will be exported of either the live field or the current viewport view.



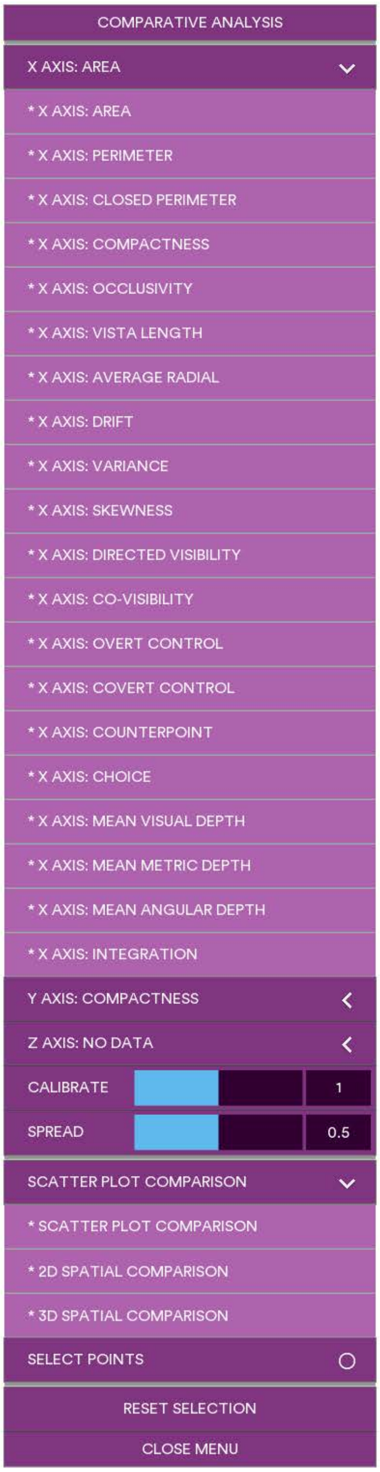
3.4 Run advanced analysis

3.4.1 Numerically compare two or more fields

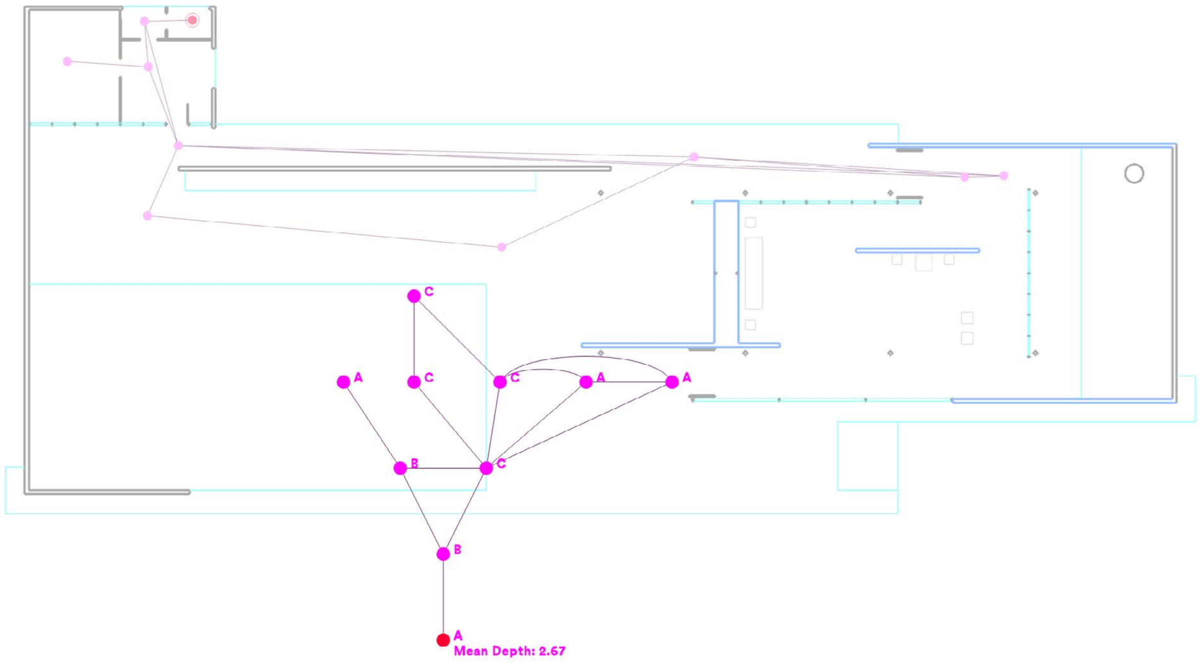
The comparative analysis menu accesses the most advanced analysis tool set within the Isovist_App and provides a novel form of spatial data interrogation. It is probable that there is some consistency between common discrete quantitative structures within comparative point clouds of key isovist measures, and common discrete spatial typologies or elements. Such a set of relations, if rigorously defined, could form a novel syntax for the description of architectural space.

To conduct a comparative analysis:

- Import and set up a drawing for field analysis as normal.
- Open the 'Field Analysis menu', and run the analysis in the advanced mode if all measures are required.
- Select a field analysis for display on screen from either the 'Isovist' or 'Space Syntax' measures options. Wait... for the data representation to reach a stable condition.
- As the spatial analysis fields start to become coherent, open the 'Comparative analysis' menu.
- Select the required fields for comparison by clicking on the X-axis, Y-axis and if necessary Z-axis options. A dynamically updating scatter plot chart should appear.
- The analysis plots the normalised spatial measures of the user axis selections against one another, forming a point cloud in either two or three dimensions. Over time the structures seen will vary less as the analysis results stabilise. They can be zoomed into using the mouse scroll, and spun around in the case of the 3d visualisation, by clicking and dragging.
- In the 2 dimension chart a line of best fit and values for r and r_squared will be calculated.
- To vary the colouration of points in the chart, use the two available sliders, 'Calibrate' and 'Spread'. The default colouration of comparative chart and spatial representations grades from a 1:1 ratio of compared values (red) to a very high or very low ratio (blue). The fall-off and the median of colouration can be varied to assist in identifying spatial patterns of consistent correlation.
- To highlight regions of data points, either on the chart, or in 2d field view, click on the 'select points' option in the comparative menu, and then click and drag with the cursor around the desired selection on screen. Doing so should highlight the selected points in magenta.
- To switch between visualisation of the comparative data in chart form, 2d spatial field form, and 3d spatial landscape form, select from the drop down immediately below the calibration sliders.
- To clear a highlighted set of points, press the 'reset selection' button at the foot of the comparative analysis menu.



Left (main): A 3d comparative point cloud of isovist measures in Mies' Barcelona Pavilion.
Left (inset): A 2d comparative point cloud of isovist measures in Mies' Barcelona Pavilion.
Right: The Comparative Analysis menu (expanded view).



3.4.2 Draw a 'visual graph diagram' for a space

The Isovist_App can be used to draw isovist justified graph diagrams to summarise the visual and spatial relations within a plan. These diagrams are very similar to basic space syntax justified graph diagrams, with the difference being the former's linkages are based on isovist shape and inter-visibility rather than convex spaces.

To draw an isovist justified graph:

- Set up a drawing and open the isovist analysis menu as normal.
- Open the 'draw spatial graph' sub menu and select 'add/remove graph nodes'.
- Using the cursor, click at the desired 'root' location of the graph. Doing so adds a node, which just appear on screen in both localised and justified forms.
- Move the cursor and add more nodes as required. Each time nodes have a visual linkage, an edge will appear and the justified graph will grow. If an unconnected node is added, a new j-graph will be started.
- Hovering the cursor over a node and pressing delete will remove that node; clicking on a node will set that node as the root, and re-configure the j-graph accordingly.
- The j-graph will be labelled with node type, and the mean depth of the root node in each iteration.
- To collapse co-visible nodes (i.e. represent them with one single node, and simplify the j-graph accordingly) the 'collapse co-visible nodes' option can be toggled on and off.
- Exporting an image file whilst the isovist justified graph is viewable will produce an editable vector pdf.

3.4.3 Find a 'minimal set' for a space

The Isovist_App can be used to estimate the minimal connected series of locations required to give complete visual coverage of a space. Known as the 'minimal set', the resulting set of nodes and edges is a precursor to a true spatial graph.

To find a minimal set:

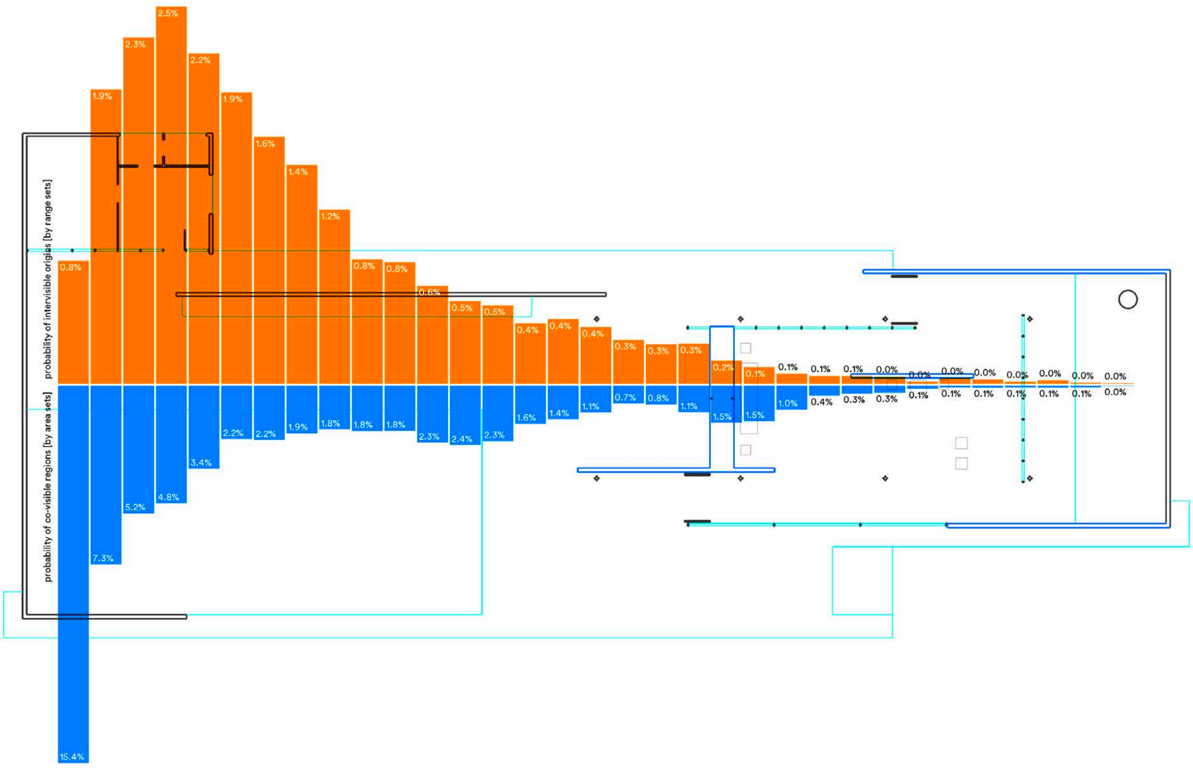
- Set up a drawing and open the isovist analysis menu as normal.
- Select the 'find a minimal set' option at the foot of the menu
- Using the cursor, click at the desired 'root' location of the minimal set. Doing so defines an origin for the estimation process to begin from.
- Wait… the process of estimating a minimal set should be visible on screen as a sequence that gradually generates nodes (rings) and edges (lines). The nodes are scaled relative to importance in the minimal set.
- Clicking again in an alternate location will restart the estimation from the new root point.
- To increase or decrease the accuracy of the estimation, edit the slider provided. Increasing accuracy slows the estimation process.
- To hide the minimal set results, toggle the 'find a minimal set' option off again.

3.4.4 Generate a 'spatial co-visibility' profile

The Isovist_App can also be used to generate a spatial co-visibility profile; a histogram that represents the likelihood of locations to either see one another or to share regions of co-visibility. This is unique for every building, but demonstrates some similarity between different building configurations. It takes the form of two sets of histogram bars for user defined sets of separation.

To generate an co-visibility profile:

- Set up a drawing and open the isovist analysis menu as normal.
- Select the 'show/hide co-visibility histogram' from the 'toggle isovist overlays' options. A set of orange and blue bars should appear on screen, annotated with percentage values. These will vary and settle over time.
- The orange bars illustrate the percentage of locations which are inter-visible (i.e. can see one another), for each user defined range set. The blue bars represent the percentage of locations which have co-visible isovist regions (i.e. a degree of isovist overlap), for each user defined area set.
- To change the number of sets of range and area, drag the slider provided, and the histogram should recalculate immediately



Above: The co-visibility profile histogram for Mies' Barcelona Pavilion.
Right: A fragment of visual graph for Mies' Barcelona Pavilion in justified and true form.

3.4.5 Generate isovist rose diagrams

An isovist 'rose' diagram is a little like a weather map wind diagram. It segments the total isovist view at any given point into sub-division 'bins' and displays the relative quanta of isovist metric that originates from that sub division. The latter produces a diagrammatic representation of space that is very different from the actual isovist itself, essentially showing where the weighting of a particular experiential quality comes from at any given point.

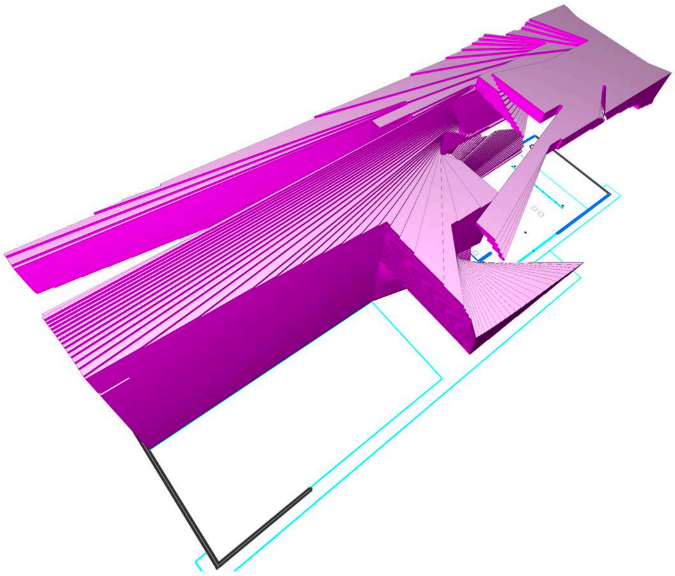
To generate isovist rose diagrams:

- Set up a drawing and open the isovist analysis menu as normal.
- Select an isovist space type to display on screen, and then toggle on the 'show measure rose' option that appears in the isovist analysis menu. A magenta diagram should appear at the cursor position, on top of the usual isovist geometry.
- The metric that the isovist rose displays can chosen from the drop down menu provided.
- To vary the parameters of the isovist rose, the options of 'F.O. View', 'Increment' and 'Scale' can be used to change the bin overlap angles, bin angular size, and the scale of the rose diagram.

3.4.6 Generate and export an Minkowski model

A Minkowski model is a layered representation of all isovists along a single path. The Isovist_App produces these in realtime and can export them as 3d geometries. To generate a Minkowski model:

- Set up a drawing import and conduct a path analysis as normal.
- Once the path is defined, switch on the 'Show Minkowski model' option.
- A magenta 3d Minkowski model should appear on the screen. Click and drag to rotate this as desired.
- To vary the height or number of slices in the Minkowski model, use the two sliders provided in the path analysis menu and the model should update in real time.
- To export the model, select 'Import/Export' from the primary menu at the top left of the screen, and then 'Export data'. A file dialogue box should subsequently open to allow a file to be named and saved.
- On pressing 'Ok' in the file dialogue, the software will export a PLY model file. This is able to be opened in numerous 3d modelling packages, including 3d print softwares.



3.4.7 Generate agent trails and visibility fields

Isovist agents can be added singularly by the user, but can also be added automatically en-masse to a space to generate agent exploration trails. To do so:

- Set up a drawing and open the isovist analysis menu as normal.
- Select 'Isovist Agents' from the dropdown at the top of the Isovist analysis menu.
- Switch on the required isovist spatial types for analysis (i.e. Accessible, Visible, Reflected or Spectral) in the isovist analysis menu.
- Set any preferred isovist parameters (i.e. sweep, direction, or rims) in the isovist analysis menu.
- Select 'show/hide massed agent trials' from the 'isovist agent overlays' option. A series of developing trail lines should subsequently appear on screen.
- To increase or decrease the numbers of agents released, edit the slider provided.
- To view a field of the intensity of space seen by the agent explorations, select the 'show/hide massed agent visibility' from the 'isovist agent overlays' option. A gradually changing spectra field should subsequently appear on screen.

3.4.8 Set start and end points for agent exploration

To vary the start and end locations for agents added automatically to explore a space:

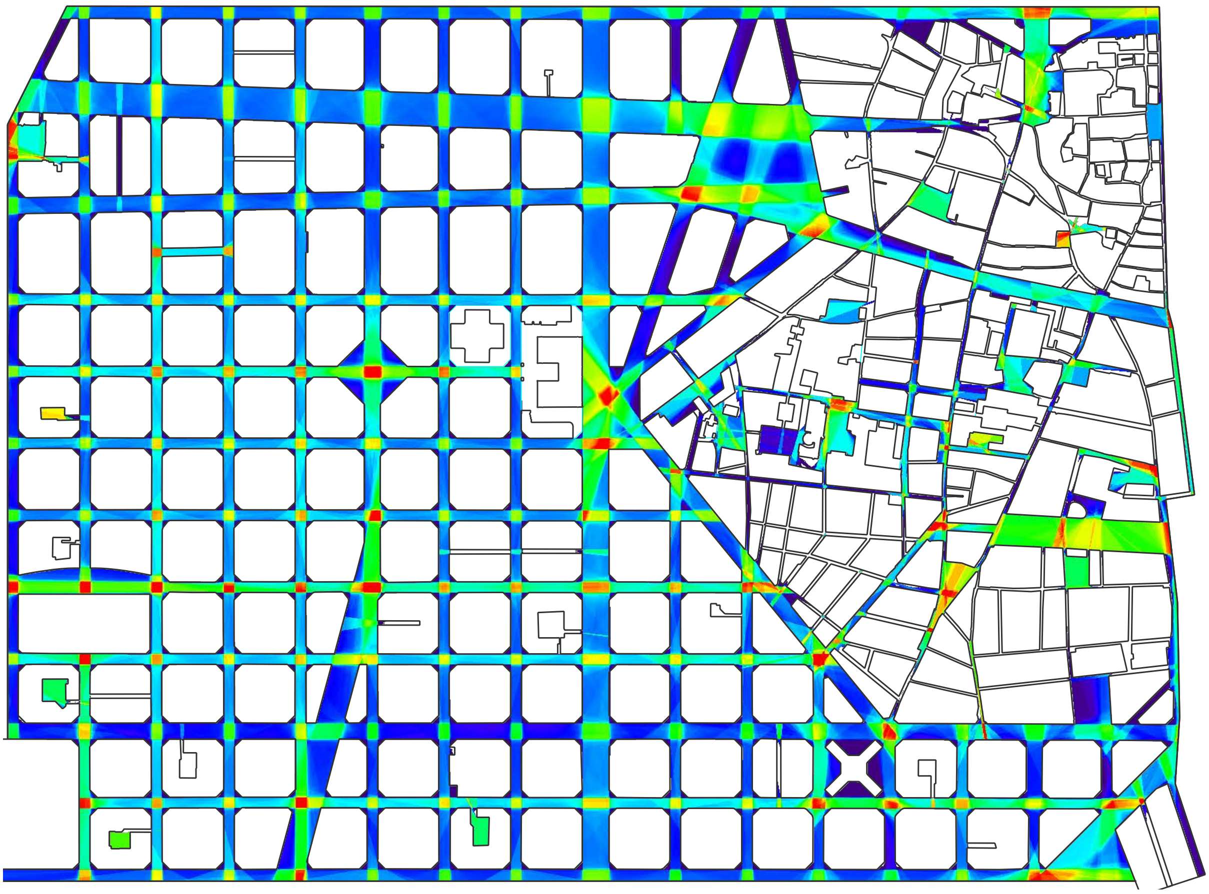
- Set the Isovist_App to generate massed agent trails.
- Change the 'release single agent' dropdown option to either 'set massed agent start points' or 'set massed agent end points'
- To add new start or end points, click on the screen with the cursor; to remove points, hover the cursor over an existing point and click.
- The sensitivity of agent detection of an end location can be increased by using the slider provided.
- Agent exploration should restart with each change made.

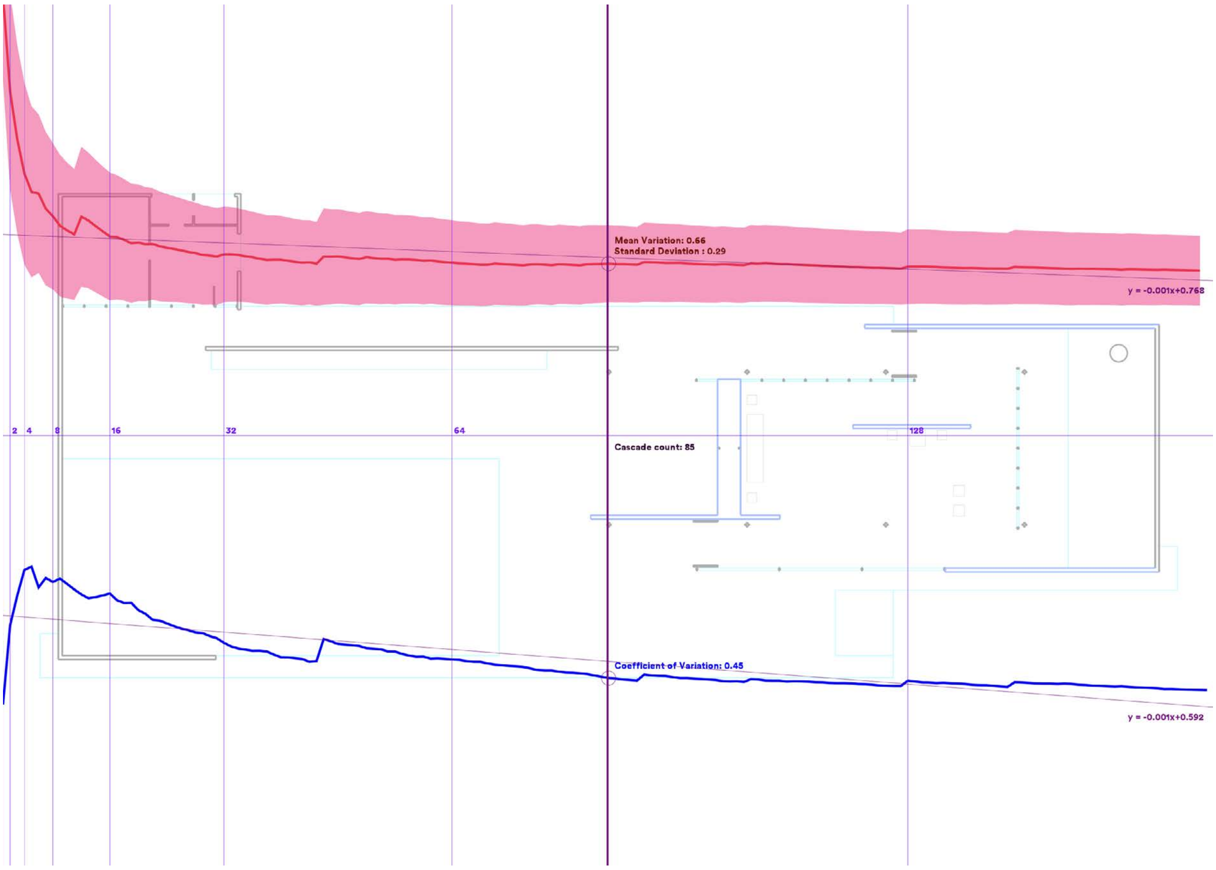
3.4.9 Calculate an optimal route through a field

Once an isovist field analysis is stable, it can be used to derive optimal routes through the space, either maximising or minimising exposure to the respective field measures. To do so:

- Import and set up a drawing for field analysis as normal.
- Open the 'Field Analysis menu', and run the analysis in the advanced mode.
- Select a field analysis for display on screen from either the 'Isovist' or 'Space Syntax' measures options. Wait… for the data representation to reach a stable condition.
- Select the 'Show optimal path' option below the field threshold sliders.
- Next select either 'seek shortest path', 'seek high values', 'seek low values' or 'seek least change' from the dropdown option that appears below the optimal path toggle.
- Use the cursor to click at the path origin location in the analysis field.
- Wait… after a short calculation period, moving the cursor will draw the route from the path origin to the cursor position that best optimises the chosen parameters for the field displayed.
- Changing the 'affinity' slider varies the degree of compliance between the parameter set and metric distance when calculating the path route.
- Further clicks with the cursor will define new origin locations and restart the optimisation calculations.

Left: A 3d Minkowski model of a route through Mies' Barcelona Pavilion.
Below: An Overt Control field in Barcelona's grid plan





Above: 'Spatial wobble' plots for Mies' Barcelona Pavilion

3.4.10 Review 'spatial wobble' characteristics

The mean depth and integration fields generated by the Isovist_App calculate on a continual temporal basis, beginning as broad estimates and iteratively converging upon an accurate result. The latter is stable in all plans by circa 250 global cycles. Underlying this convergence, every plan has a unique residual variation that is a product of the spatial morphology of that plan.

By measuring the mean residual variation across the whole of a plan we can identify characteristics that are related to qualities of complexity and entropy within the spatial configuration. The Isovist_app does this automatically, and displays the mean residual variation, the standard deviation of variation, and the coefficient of variation for each plan. These can be viewed in the main menu, in the 'Spatial Wobble' readout box.

The development of the above characteristics over time can also be viewed as a line chart. To review the latter:

- Import and set up a drawing for field analysis as normal.
- Open the 'Field Analysis menu', and run the analysis in the advanced mode.
- Watch the 'Spatial wobble' values in the main menu.
- When you wish to review the line chart of these values over time, select 'show/hide wobble plots' from the main menu viewport options. A pair of chart plots should appear on screen. Move the cursor over these to view values at any given point on the plots.
- To export the data of these plots, select 'Import/Export' from the primary menu at the top left of the screen, and then 'Export data'. A file dialogue box should subsequently open to allow a file to be named and saved.
- On pressing 'Ok' in the file dialogue, the software will export a CSV data file with values for each iteration of the field variation over time.

4 How the calculations work

4.1 The computation methods

As a result of its underlying algorithms, the Isovist_App does not necessarily define a moment when a field is 'completed'. Instead it iterates continually, with results rapidly attaining visual and statistical stability.[11] The adoption of a temporal process of development of calculation allows for the measurement of a novel value of 'spatial wobble' that can be used to quantify properties of complexity within a plan (see also section 3.4.10).[12]

All of the fields produced by the Isovist_App adopt a default representation that grades from the highest value in red, through orange, yellow and green, to the lowest value in blue-purple. Users can view calculation progress in real time, allowing for consideration of field results whilst they attain a consistent state. The latter, not entirely incidentally, makes watching the Isovist_App in action both enjoyable and educational too.

4.1.1 Isovist Geometry Calculation

All isovist geometries within the software are calculated in real-time using an implementation of Bungui et al's triangular expansion algorithm.[13] The approach reduces computation to O(nh) linear run-time for the worst case (where h identifies number of holes in a polygon, or in isovist terms, occlusive objects), and in practical use often less than linear time. It requires O(n) space, yet retains useful aspects of Benedikt's traditional radial sweep method,[14] including ready generation of reflective geometries.

4.1.2 Local Isovist Scanning

All local isovist metrics are calculated via the above algorithm. For every analysis point in the subject area, a single isovist is calculated. From that isovist, a series of geometric values are extracted and used to derive the metric results. Results are then assigned back to that location to be visualised in field form. Over time every point in the subject plan is sampled, with CPU parallelisation used to accelerate the process.

4.1.3 Stochastic Isovist Overlap

Directed Visibility, Overt & Covert Control and Counterpoint are calculated by continually deriving point isovists at stochastically selected locations within the subject area. Geometric information is extracted from each isovist and recorded to all points within its perimeter. As the stochastic sampling repeats, information within regions of common isovist overlap is concatenated, rapidly creating an increasingly accurate and stable field.[15]

4.1.4 Mean Aggregate Isovist Cascade Analysis

The 'global' Space Syntax-type measures, Mean Metric Depth, Mean Visual Depth, Mean Angular Depth and Integration (HH) are all calculated using a novel 'mean aggregate isovist cascade' analysis algorithm. The algorithm, with some relation to a 'jump flood fill' algorithm, propagates an information cascade from a single origin point to all other points in the subject plan.[16] It does so by starting from a single isovist in space, seeding new isovists from its occlusive edges, and recursively expanding until all space is covered.[17] At each step in the cascade, the visual depth, the metric depth, and the angular bearing of each point 'seen' is assessed. The outcome is recorded at the point in question, and also affects the information that is passed on to the next level of the cascade. One complete isovist cascade, covering all points in the plan, can thus be viewed as a field of relative 'to location' point depth values (i.e. Visual, Metric or Angular) and provides a single 'global cycle'.

With the conclusion of each new isovist cascade, the values recorded are concatenated with all past values to provide means. A new origin is then stochastically selected and a new isovist cascade initiated. As the cycles iterate, the mean values produced refine, rapidly producing high definition global mean depth fields.

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[11] A first discussion of the method can be found in Psarra, S and McElhinney, S. (2014) 'Just around the corner from where you are: Probabilistic isovist fields, inference and embodied projection', The Journal of Space Syntax, v5: pp. 109-132

[12] McElhinney (2024)

[13] Bungui et al (2014)

[14] See Benedikt (1979) for discussion of the generation of an isovist from radial tests

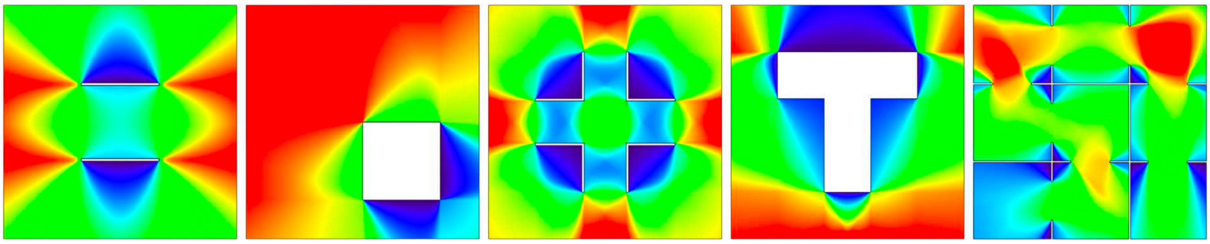
[15] A development of the method set out in Psarra and McElhinney (2014)

[16] For jump flooding, see Rong, G and Tan, T. (2006) 'Jump Flooding in GPU with Applications to Voronoi Diagram and Distance Transform', *The Proceedings of ACM Symposium on Interactive 3D Graphics and Games (i3D 2006)*, pp. 109--116, pp. 228;

[17] McElhinney (2024)

4.2 Isovist Measure Definitions

4.2.1 Area



Area (Av) expresses the area of all space visible from a subject point in the plan.[18] In visibility graph terminology, it represents the number of other subject points that said location is directly 'connected' to, called 'Connectivity'.[19] Isovist_App Area has been shown to correlate to DepthMap's Connectivity.

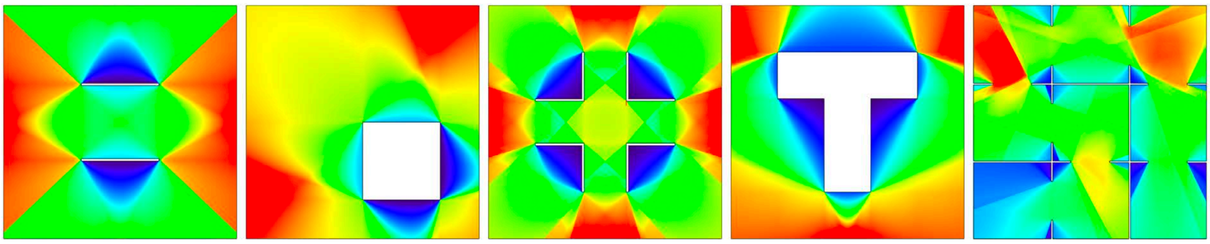
To determine Area at point 'V', the Isovist_App simply extracts the geometric area value from the polygon of the isovist calculated at V. The outcome is an absolute value in units.

In notation form the calculation for Area is expressed as:

$$A_v = \sum_{i=1}^{n} \frac{1}{2} \left| (x_{i-1} \cdot y_i) - (x_i \cdot y_{i-1}) \right|$$

Where x_i, y_i is the vector from V to each vertex of the isovist polygon, and n the total number of vertexes of the isovist.

4.2.2i Perimeter



Perimeter (Pv) expresses the length of the edge of all space visible from a location. In isovist terminology, it represents the geometric isovist perimeter at said location.[20]

To determine Perimeter at point 'V', the Isovist_App simply extracts the geometric perimeter value from the polygon of the isovist calculated at V. The outcome is an absolute value of length.

In notation form the calculation for Perimeter is expressed as:

$$P_v = \sum_{i=1}^{n} \sqrt{(x_i - x_{i-1})^2 + (y_i - y_{i-1})^2}$$

Where x_i, y_i is the coordinate of each vertex of the isovist polygon, and n the total number of vertexes of the isovist.

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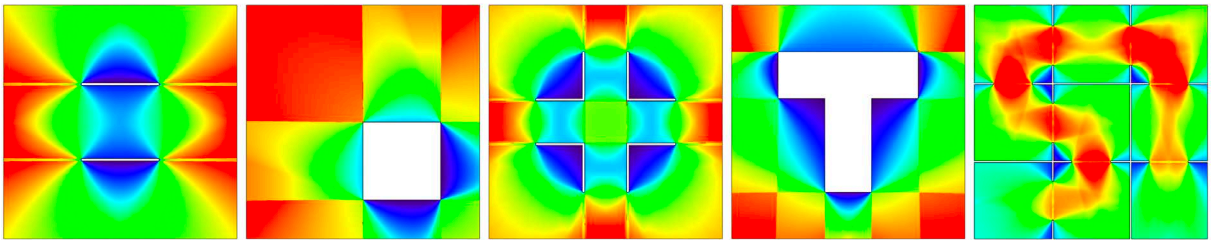
[18] See Benedikt (1979)

[19] See Turner, (2001b)

[20] See Benedikt (1979)

4.2.2ii Closed Perimeter



Closed Perimeter (Uv) expresses the length of the closed edges (i.e. solid walls) of all space visible from a location. In isovist terminology, it represents the non occluded perimeter at said location.

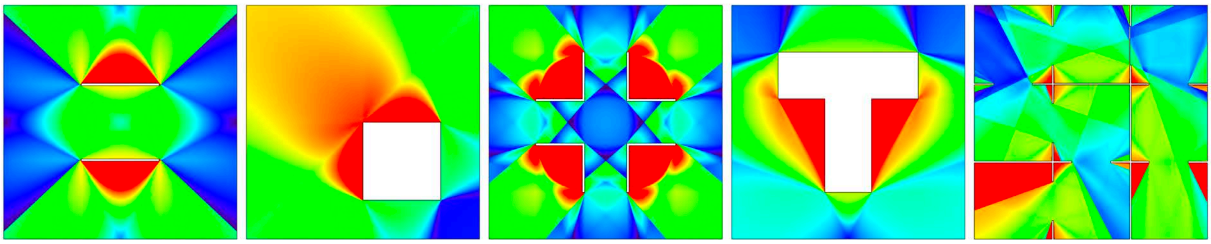
To determine Closed Perimeter at point 'V', the Isovist_App calculates the total length of all occlusive edges of the polygon of the isovist calculated at V. It then subtracts that sum from the value of Perimeter (Pv). The outcome is an absolute value of length.

In notation form the calculation for Closed Perimeter is expressed as:

$$U_v = P_v - \sum_{i.occ=1}^{n} E_{i.occ}$$

Where $E_{i.occ}$ is length of each occlusive edge, n the total number of occlusive edges of the isovist, and Pv, perimeter.

4.2.3 Compactness



Compactness (Cv) expresses the shape property (relative to a circle) of all space visible from a location. In an isovist field, compactness identifies the regions of plan in which an observer's spatial experience is contiguously consistent. Such regions identify and correlate to meaningful instances of Peponis' S- and E-partitions;[21] identifying opportunities for the emergence of new surfaces in the visual field as a result of movement.

To determine Compactness at point 'V', the Isovist_App calculates a form of the isoperimetric quotient of the isovist calculated at V. The outcome is a relative value between 0 and 1.

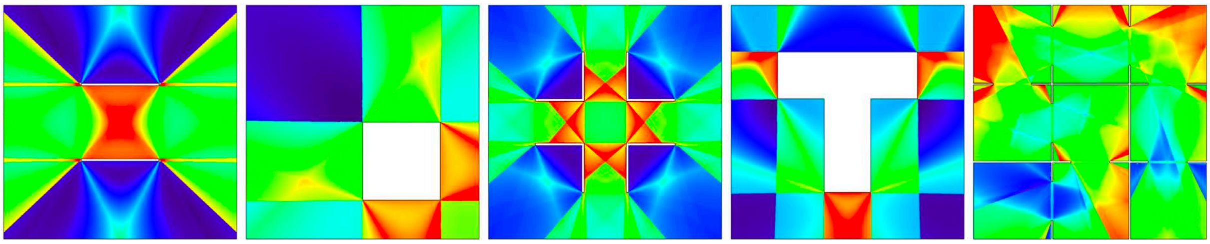
In notation form the calculation for Compactness is expressed as:

$$C_v = \frac{4.\Pi \, . \, A_v}{P_v^2}$$

Where 'Av' is the area value; and 'Pv' the perimeter value.

[21] See Peponis, J; Wineman, J; Rashid, M; Hong Kim, S; Bafna, S. (1997) 'On the description of shape and spatial configuration inside buildings: convex partitions and their local properties'; *Environment and Planning B.* v24: pp. 761-781

4.2.4 Occlusivity



Occlusivity (Ov) expresses the proportion of edges of an isovist that are not physically defined. It represents how previously unseen space may be revealed during movement.[22] Occlusivity fields show moments of dramatic visual change as a user passes between spaces. A forest or hypostyle hall has high Occlusivity; a convex room has none; flat surfaces tend to extend occlusive edges into space.

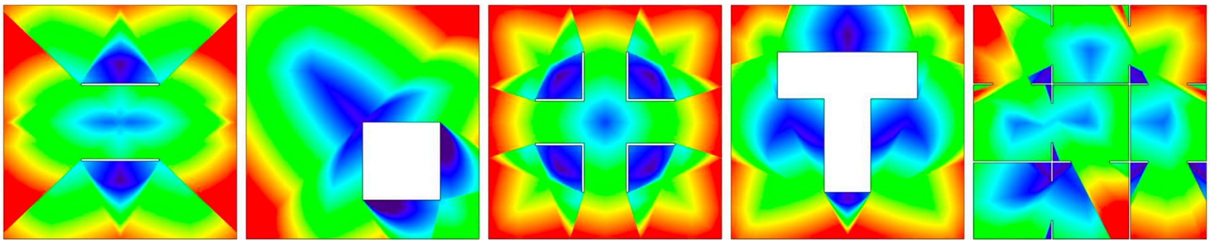
To determine occlusivity at point 'V', the Isovist_App calculates the total length of all occlusive edges of the polygon of the isovist calculated at V. The final total is divided by the value of the perimeter length, 'Pv'. The outcome is a relative value between 0 and 1.

In notation form the calculation for Occlusivity is expressed as:

$$O_v = \frac{1}{P_v} \cdot \sum_{i.occ=1}^{n} E_{i.occ}$$

Where $E_{i.occ}$ is length of each occlusive edge, n the total number of occlusive edges of the isovist, and Pv, perimeter.

4.2.5 Vista Length



Vista Length (Hv) expresses the longest single view available at each location. In isovist terminology, it records the longest radial of the isovist at a location. Vista Length values identify regions of high axial view.

To determine Vista Length at point 'V', the Isovist_App calculates the distances between each vertex of the polygon of the isovist, and the origin point of the isovist calculated at V. The highest distance is recorded. The outcome is an absolute value of length.

In notation form the calculation for Vista Length is expressed as:

$$H_v = \max \left| H_v, L_i \right|$$

Where 'Li' is the length from each isovist vertex point to point V.

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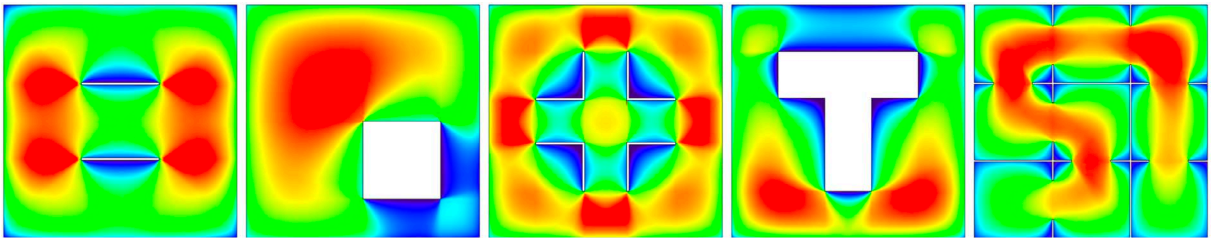
[22] See Benedikt (1979); also Gibson (1979)

4.2.6 Average Radial



Average Radial (Qv) expresses the mean view length of all space visible from a location. In visibility graph terminology, it relates to the 'through vision' at a location.[23] In isovist terminology, it represents the mean radial length at a location.

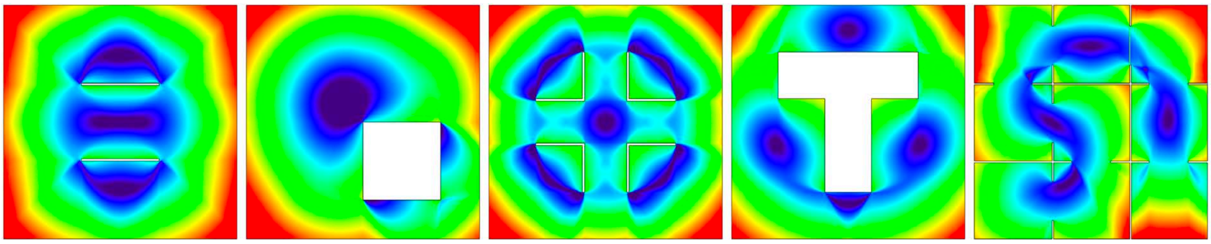
To determine Average Radial at point 'V', the Isovist_App calculates the average distance between each edge of the polygon of the isovist, and the origin point of the isovist calculated at V. It subsequently finds the mean average of all such values, as weighted by the angle subtended by each edge. The outcome is an absolute value of length.

In notation form the calculation for Average Radial is expressed as:

$$Q_v = \frac{1}{\theta} \cdot \sum_{i=1}^{n} \alpha \cdot \sqrt{\frac{\left|\left(x_{i-1} \cdot y_i\right) - \left(x_i \cdot y_{i-1}\right)\right|}{2.\alpha}}$$

Where x_i, y_i is the vector from V to each vertex of the isovist polygon, n the total number of vertexes of the isovist, alpha the angle subtended by the edge and theta the total sweep of the isovist.

4.2.7 Drift



Drift (Dv) expresses the distance from a subject point to the centre of gravity of its isovist.[24] In an isovist field, drift identifies the inherent 'flow' within a series of spaces, or the 'pull' or 'push' one might feel from the volume of space itself. To move along contours low in Drift is to be in the centre of one's isovist, and so be visible from all directions. High Drift identifies regions from which space can be surveyed with a minimum of head turning.

To determine Drift at point 'V', the Isovist_App finds the centroid point 'M' for the polygon of the isovist calculated at V. It then measures the distance from M to V. The outcome is an absolute value of length.

In notation form the calculation for Drift is expressed as:

$$D_v = \sqrt{\left(x_m - x_v\right)^2 + \left(y_m - y_v\right)^2}$$

Where X_m,Y_m describe the coordinates of 'M' and ' X_v,Y_v the coordinates of 'V'

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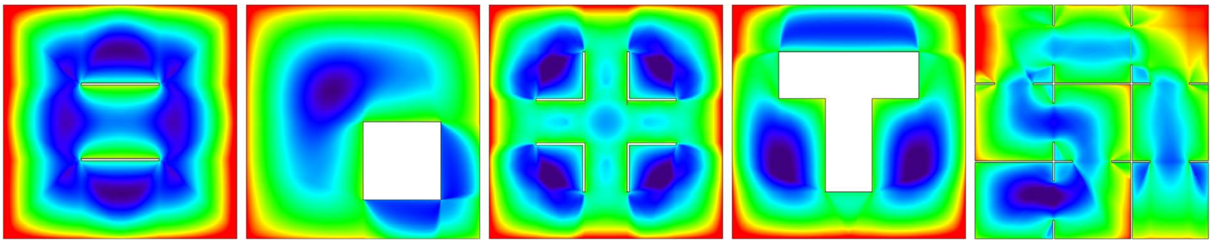
[23] See Turner, A. (2007). 'To move through space: lines of vision and movement', *Proceedings, 6th International Space Syntax Symposium,* İstanbul

[24] See Dalton, R and Dalton, N. (2001) 'OmniVista:an application for isovist field and path analysis' *3rd International Space Syntax Symposium*, Atlanta, Georgia

4.2.8 Variance



Variance (Tv) expresses the mean of the square of deviation between all radial lengths and average radial length of an isovist.[25] In visibility graph terminology, it represents the point second moment for a location. Variance indicates both the complexity and eccentricity of an isovist. It takes other measures to sort out which.

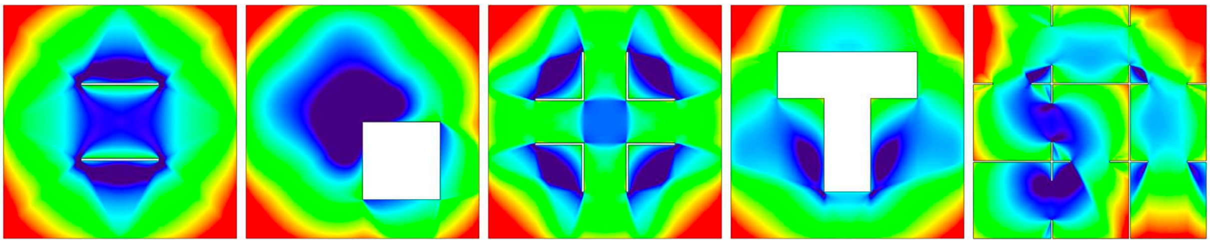
To determine Variance at point 'V', the Isovist_App calculates the average distance between each edge of the polygon of the isovist, and the origin point of the isovist calculated at V. It then finds the square of the difference between the latter and Average Radial (Qv). It subsequently calculates the mean of all such values, as weighted by the arc angle associated to each edge. The final outcome is square rooted.

In notation form the calculation for Variance is expressed as:

$$T_v = \sqrt{\frac{1}{\theta} \cdot \sum_{i=1}^{n} \alpha \,.\, (L_i - Q_v)^2}$$

Where L_i is is average length to each edge of the isovist polygon, Q_v the average radial value, n the total number of edges of the isovist, alpha the angle subtended by each edge, and theta the total sweep of the isovist.

4.2.9 Skewness



Skewness (Sv) expresses the mean of the cube of deviation between all radial lengths and average radial length of an isovist.[26] In visibility graph terminology, it represents the point third moment for a location. Caves have positive Skewness; space near columns, trees or outside corners, have negative Skewness.

To determine Skewness, the Isovist_App calculates the average distance between each edge of the polygon of the isovist, and the origin point of the isovist calculated at V. It then finds the cube of the difference between the latter and Average Radial (Qv). It subsequently calculates the mean of all such values, as weighted by the arc angle associated to each edge. The final outcome is cube rooted.

In notation form the calculation for Skewness is expressed as:

$$S_v = \sqrt[3]{\left[\frac{1}{\theta} \cdot \sum_{i=1}^{n} \alpha \,.\, (L_i - Q_v)^3\right]}$$

Where L_i is is average length to each edge of the isovist polygon, Q_v the average radial value, n the total number of edges of the isovist, alpha the angle subtended by each edge, and theta the total sweep of the isovist.

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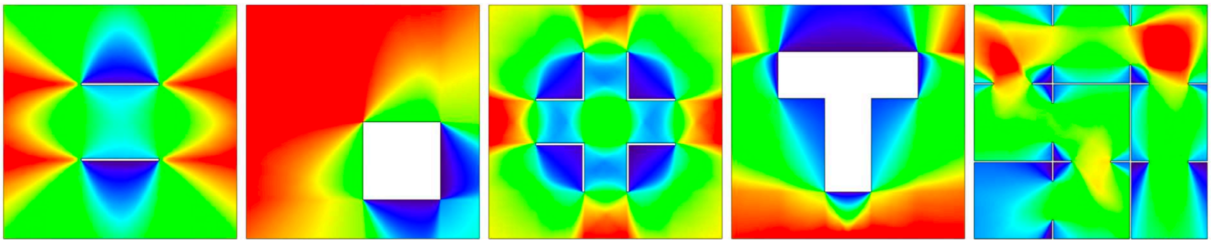
[25] See Benedikt (1979)

[26] Ibid

4.3 Space Syntax Measure Definitions

4.3.1 Directed Visibility



Directed Visibility (Wv) expresses how often any given subject point is seen from a defined sample region. In isovist terminology, it represents how often a space falls within an isovist generated from within said region. Isovist_App visibility correlates to Area and Connectivity when the space being viewed exactly matches the sample region; but varies significantly, introducing a degree of direction once the sample region is restricted.

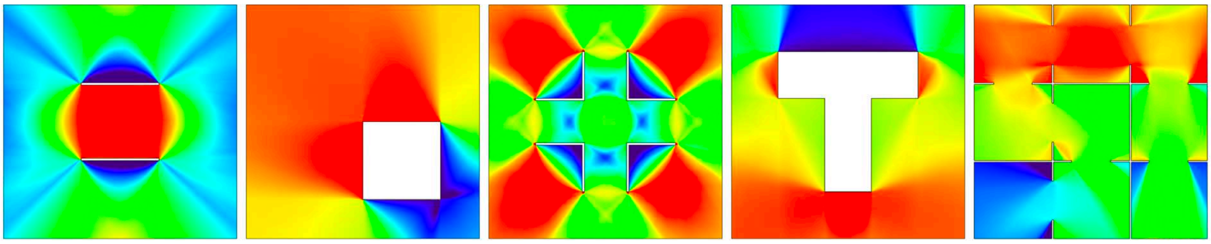
To determine Directed Visibility, the Isovist_App generates isovists at stochastically selected locations in the sample region. It then records any point 'V' that falls within them. The resulting 'score' at V is divided by the number of isovists generated overall to give a mean value. The result is a relative value between 0 and 1.

In notation form the calculation for Directed Visibility is expressed as:

$$W_v = \frac{1}{n} \cdot \sum_{i=1}^{n} H_i$$

Where 'Hi' is either 0 or 1 depending on whether point V falls within a sample isovist; and 'n' the total number of isovist samples.

4.3.2 Co-visibility



Co-Visibility (Rv) accounts for the average area visible within one visual step from a location.[27] In isovist terms, co-visibility represents the mean area of isovist generated from all points encompassed by the isovist at point 'V'; or, more simply, the mean area of all isovists that point 'V' is seen within.

Co-visibility indicates the degree to which an individual at a location is engaged in a reciprocity of 'seeing and being seen'. A location that is high in co-visibility both sees, and is seen alongside, a large number of other locations. A location that is low in co-visibility both sees, and is seen with, fewer other locations.

To calculate Co-visibility, the isovist_app generates isovists at stochastically selected locations in the sample region. It then records the sum of their areas at any point 'V' that falls within them. The result is divided by the number of isovists generated overall to give a mean value. The outcome is an absolute value of area.

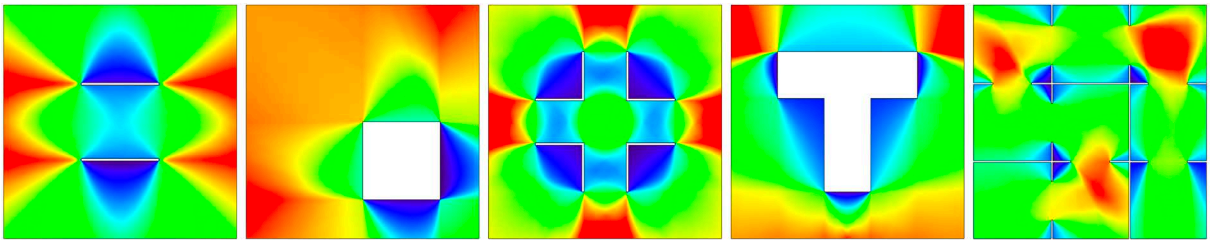
In notation form the calculation for Co-visibility is expressed as:

$$R_v = \frac{1}{n} \cdot \sum_{i=1}^{n} A_i$$

Where 'Ai' is the area of any isovist that point V falls within; 'Av' the area at point V; and 'n' the total number of isovist samples.

[27] Psarra and McElhinney, 2014

4.3.3 Overt Control



Overt Control (Xv) expresses the visual 'linking' dominance of any location; the options each space offers for its immediate neighbours as a junction, or where movement may provide access to multiple restricted visual fields.[28] It increases as an isovist encompasses regions of space that have smaller, more isolated isovists than itself; i.e. when a location can 'see' regions of space that in turn 'see' relatively less more separate space than it. A prime example of an overt control location would be the centre of Bentham's panopticon, surrounded by cells.

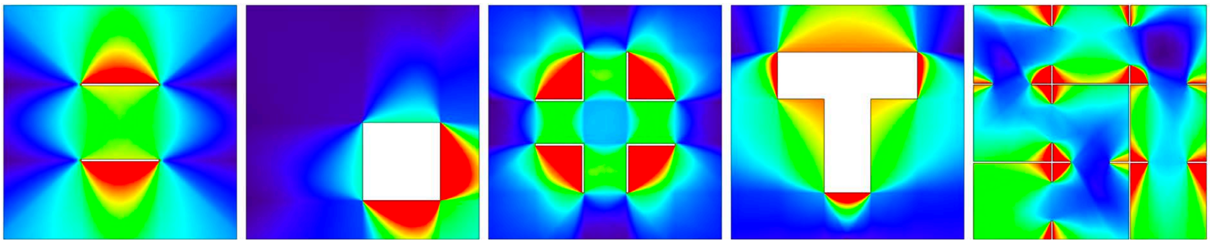
To calculate control, the Isovist_App generates isovists at stochastically selected locations in the sample region. It records the sum of the reciprocal of their areas at any point 'V' that falls within them. The result is divided by the number of isovists generated to give a mean. The result is a relative value between 0 and 1.

In notation form the calculation for overt control is expressed as:

$$X_v = \frac{1}{n} \cdot \sum_{i=1}^{n} \frac{1}{A_i}$$

Where 'Ai' is the area of any isovist that point V falls within; and 'n' the total number of isovist samples.

4.3.4 Covert Control



Covert Control (Yv) expresses the potential for any location to visually oversee others whilst avoiding scrutiny itself. In isovist terms, Covert Control is the ratio of the average area visible within one visual step of a given location (co-visibility) against the amount said location is seen (or directed visibility). It is akin to the inverse of Controllability, the potential for any location to be visually controlled in an 'overlooking' manner.[29]

Covert Control increases when a location can 'see' regions of space that in turn 'see' relatively more, better connected space than it. Locations that are high in covert control offer ready visual connection to large areas but are themselves fairly concealed, making them useful for surreptitious oversight by a king-pin mafioso figure.

To calculate covert control, we divide co-visibility by directed visibility. The outcome is a relative value from 0 – infinity. In notation form the calculation for covert control is expressed as:

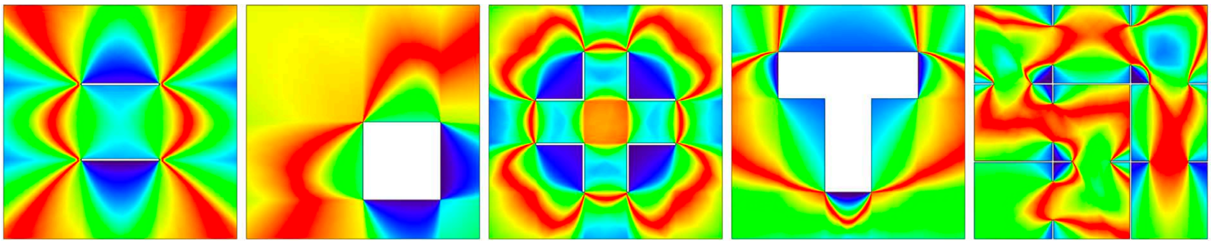
$$Y_v = \frac{1}{n \cdot W_v} \cdot \sum_{i=1}^{n} A_i$$

Where 'Ai' is the area of any isovist that point V falls within; 'Wv' the directed visibility at point V; and 'n' the total number of isovist samples

[28] Hillier and Hanson (1984)

[29] See Turner, (2001b)

4.3.5 Counterpoint



Counterpoint (Bv) expresses the degree of balance between what is seen at any given location and what could potentially be seen via movement. In isovist terms, Counterpoint records how much the area that a given location 'sees' (directed visibility), matches the average area visible within one visual step (co-visibility).

A location of high counterpoint is seen by locations that have similar sized visual fields to itself. A location of low counterpoint is seen by locations that have different sized visual fields to itself. Counterpoint therefore reveals the potential for movement to preserve or vary the size of the visual field. It is highest in entirely convex spaces, and can also reveal moments of balance and variation as an occupant moves through a threshold.

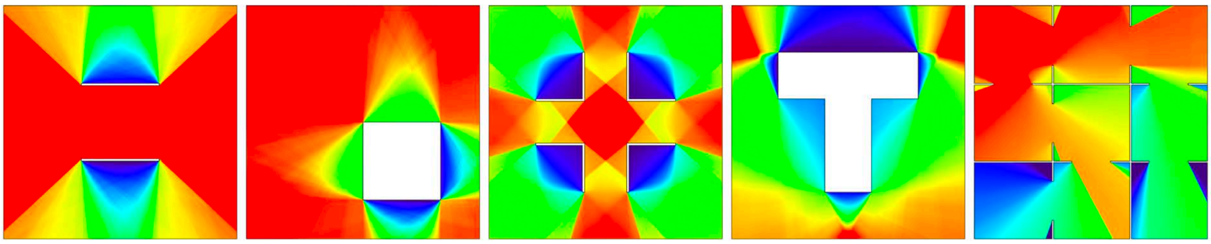
To determine counterpoint, the Isovist_App divides the value for directed visibility with the value for co-visibility. The outcome is then used to create a normalised relative value between 0 and 1.

In notation form the calculation for counterpoint is expressed as:

$$Y_v = \left[1 + \left| 1 - \frac{n \,.\, W_v}{\sum_{i=1}^{n} A_i} \right| \right]^{-1}$$

Where 'Ai' is the area of any isovist that point V falls within; 'Wv' the directed visibility at point V; and 'n' the total number of isovist samples

4.3.6 Choice



Choice (Zv) expresses the how likely it is for any location to be seen on all shortest routes from all spaces to all other spaces.[30] In graph terminology, it relates to 'Betweeness Centrality'.[31] In isovist terminology, choice represents how often a location falls within isovists generated by random walks through space.

To determine choice, the Isovist_App generates all isovists along the shortest path between two points at stochastically selected locations in the sample region. It then records any point 'V' that falls within each isovist generated. The resulting 'score' at V is divided by the number of isovists generated overall to give a mean value. The result is a relative value between 0 and 1.

In notation form the calculation for choice is expressed as:

$$Z_v = \frac{1}{n} \,.\, \sum_{i=1}^{n} B_i$$

Where 'Bi' is either 0 or 1 depending on whether point V falls within a sample isovist chain; and 'n' the total number of isovist samples.

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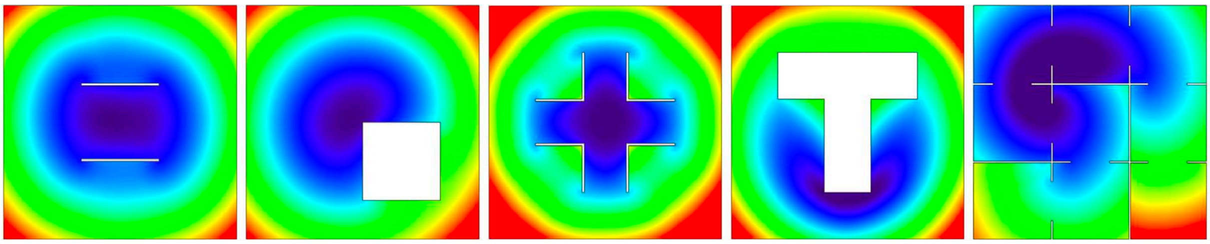
[30] Hillier, B., Burdett, R., Peponis, J., Penn, A. (1987)

[31] Freeman, L. (1977)

4.3.7 Metric Depth and Mean Metric Depth

The *metric depth to location* at any point 'V' in plan is the shortest metric path distance from said point to a single universal sample location.



The *mean metric depth* (MMD) at any point 'V' in plan is the average metric distance from the point to all locations.[32] In an isovist field form it illuminates metric centrality within a configuration.

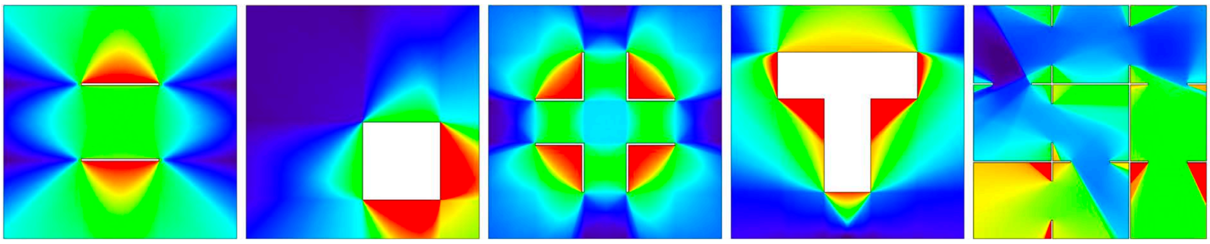
The Isovist_App determines mean metric depth by averaging all shortest path lengths calculated from point 'V' to all successive stochastic global sample locations. In notation form the calculation for mean metric depth is expressed as:

$$MMD_v = \frac{1}{n} \cdot \sum_{i=1}^{n} F_i$$

Where 'Fi' is the shortest path distance from location V to a global sample location; and 'n' the total number of global sample locations.

4.3.8 Visual Depth and Mean Visual Depth

The *visual depth to location* at any point 'V' in plan is the least number of 'visual steps' from said point to a single universal sample location. A 'visual step' is taken whenever a path passes across the threshold of all space visible from the start of the previous visible step (i.e. the isovist perimeter at that origin location).



The *mean visual depth* (MVD) at any point 'V' in plan is the average total of visual steps from the point to all locations.[33] In scan form it illuminates visual centrality within a configuration.

The Isovist_App determines mean visual depth by averaging all visual step depths calculated from point 'V' to all successive stochastic global sample locations. In notation form the calculation 1for mean visual depth is expressed as:

$$MVD_v = \frac{1}{n} \cdot \sum_{i=1}^{n} G_i$$

Where 'Gi' is the least number of visual steps from location V to a global sample location; and 'n' the total number of global sample locations.

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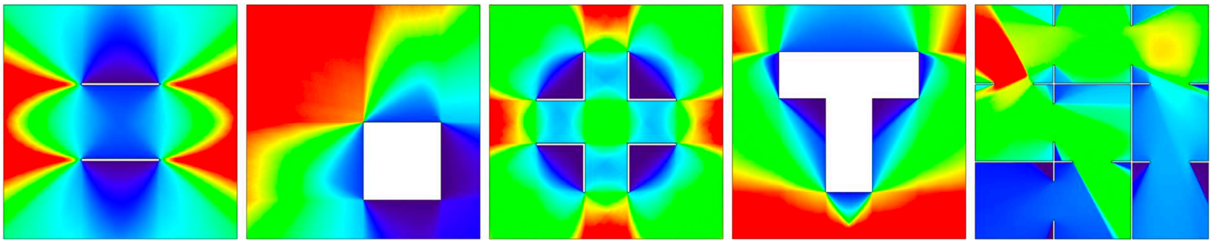
[32] See Hillier, B. (2009), 'Spatial sustainability in cities: organic patterns and sustainable forms.' *Koch, D. and Marcus, L. and Steen, J., (eds.) Proceedings of the 7th International Space Syntax Symposium*. pp. k01.3-4

[33] Hillier, B. (1996, 2007) pp.268

4.3.9 Integration (HH)

Integration (HH) is a normalised version of Mean Visual Depth.[34] It standardises for plan size based on a user-set unit scale and results in values between the range 0-infinity, allowing for comparison between different plan configurations. A high value represents strongly integrated space, and a low value indicates segregated space.



The Isovist_App determines Integration (HH) by normalising mean visual depth at point 'V' in plan using Hiller and Hanson's 'd-value'. The method is the inverse of that used to find 'real relative asymmetry'.[35] In notation form the calculation for Integration (HH) is expressed as:

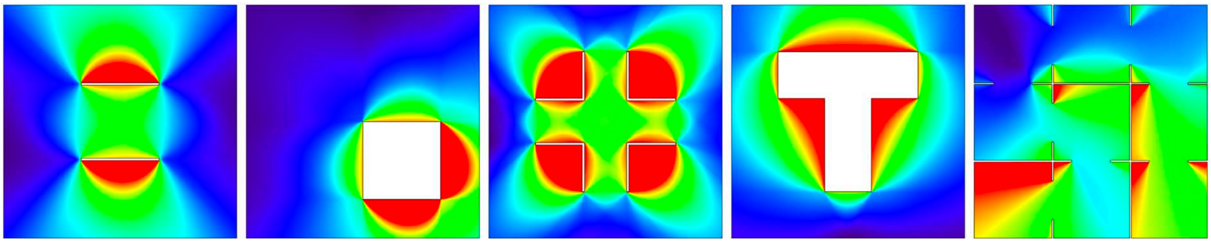
$$dValue = \frac{2.\left\{k.\left[\log 2\left(\frac{k+2}{3}\right)-1\right]+1\right\}}{(k-1)(k-2)}$$

$$IntegrationHH_v = \frac{dValue.(k-2)}{2.(MVD_v-1)}$$

Where 'k' is the total number of units of subject area as defined by the user's scale settings

4.3.10 Angular Depth and Mean Angular Depth

The *angular depth to location* at any point 'V' in plan is the lowest angular variation in heading accumulated along any path from said point to a single universal sample location.



The *mean angular depth* (MAD) at any point 'V' in plan is the average of all lowest angular depths from said point to all locations in the plan.[36] In isovist field form it illuminates angular centrality within a plan configuration.

The Isovist_App determines mean angular depth by averaging all lowest angular depths calculated from point 'V' to all successive stochastic global sample locations. In notation form the calculation for mean angular depth is expressed as:

$$MAD_v = \frac{1}{n}.\sum_{i=1}^{n} U_i$$

Where 'Ui' is the lowest angular depth from location V to a global sample location; and 'n' the total number of global sample locations.

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[34] First defined in Hillier and Hanson (1984)

[35] See Teklenburg et al. (1993) for a thorough discussion of Integration normalisation methods

[36] See Dalton, R. (2003) 'The Secret Is To Follow Your Nose Route Path Selection and Angularity', *Environment and Behavior.* v35: pp. 107 - 131 for a discussion of the relevance of angular integration in spatial exploration

5 Crashes, bugs and other horrors

At present there are no known critical bugs with the live release. There may be more minor ones lurking. If a problem is encountered, please check our downloads page, as, occasionally, downloading the most recent update of the software may solve your issue.

If the problem is with the most recent version and is significant or persistent, it would be useful to know of it for future development purposes. Please report it, here. Positive feedback is of course always welcome as well…

5.1 Change log

v_2.4.9 [01_02_24]
– Extension of licence to September 2024
– Addition of spatial wobble metrics of mean variation, standard deviation variation, and coefficient of variation, and live plots of wobble characteristics
– Addition of time-to-contact array overlay
– Addition of motor containment metric
– Fix to point isovist positioning to allow floating point precision

v_2.4.8 [23_06_22]
– Minor bug fix to export of isovist point data csv file
– Fix to occasional bug in depth search algorithm when linkers enabled

v_2.4.7 [01_05_22]
– Minor bug fixes
– Extension of licence to 01/09/2022

v_2.4.6 [01_02_22]
– Re-enabled Minkowski models
– Re-enabled Threshold finder
– Resolution of crash on intel gpu chips (finally!!)
– Extension of licence to 01/05/2022
– Resolution of performance issues and minor bugs
– Press X and then use numbers 1, 3, 6, 9 & 0 for a hidden treat

v_2.4.5 [01_11_21]
– Complete rework of core calculation engines for local and visual depth measures
– Accelerated performance for complex urban footprints
– Accuracy of local measures increased
– Memory improvements on loading and closing drawing tabs
– Resolution of minor bugs generally

v_2.4.3 [06_04_21]
– Addition of isovist measure roses
– Control field renamed Overt Control and unitised
– Addition of Closed Perimeter, Co-visibility, Covert Control, and Counterpoint fields
– Removal of Curvature and Controllability fields
– Improvement of loading costs for lower memory GPU sets
– Resolution of minor bugs generally

v_2.4.2 [01_02_21]
– Licence extended until April 2021

v_2.4.1 [29_11_20]
– Licence extended until Feb 2021
– Resolution of minor bugs on comparison chart switching

v_2.4.0 [23_10_20]
– Major version release
– Complete re-write of core calculation algorithms
– Layer support added for dxf dwg import
– Resolution of numerous minor bugs on field tab switching etc
– Improvement of GUI operation and appearance

v_2.3.9 [01_08_20]
– General fixes in line with User Guide re-write
– Version extended to 01/12/2020

v_2.3.8 [23_06_20]
– Internal horizon added to isovist generation
– Choice measure enabled across multiple floors
– Edits to occlusivity calculation to improve fidelity
– Addition of local spatial curvature measure
– General bug fixes
– Version extended until 01/09/2020

v_2.3.7 [14_03_20]
– Version extended to August 2020
– General bug fixes

v_2.3.6 [02_02_20]
– 'Contact us' option enabled
– 'Choice' measure enabled
– Point isovist location import and data export enabled
– Fix to bugs on isovist agent trails and heat maps
– Delete button allows removal of point isovists
– Fix to bugs on Metric and Angular depth searches in some plans
– Improvements to absolute value overlay
– General bug fixes

v_2.3.5 [14_12_19]
– Minkowski model calculations and exports enabled
– Fix to bugs on Path analysis calculations
– General bug fixes

v_2.3.4 [15_11_19]
– Massed agent trails enabled
– Massed agent visibility enabled
– Fix to depth to point requests
– General bug fixes

v_2.3.3 [19_10_19]
– Redesign of window mode control bar
– Fix to linkers bug on visual depth calculations
– Fix to data export (x,y) coordinate values
– Improvement of partitions calculations
– Fix to flux calculations

v_2.3.2 [01_10_19]
– Major rework of calculation engine to replace openCl with openGl basis
– Addition of basic/advanced field calculation option
– Refinement of drift, variance and skewness definitions/calculations
– Addition of point isovist data dialogue option
– Reduction of runtime memory overheads
– Refinement of absolute value overlays to match scale information
– Code structure tidy up

v_2.3.1 [01_08_19]
– Licence extended until 01/10/19

v_2.3.0 [01_07_19]
– Licence extended until 01/10/19- Improvements to menu sizing on high resolution screens
– Improvements to startup reliability on PC
– Improvements to graphics memory use on PC
– Fix to crash on comparative analysis mode on PC
– Improvements to calculations of spatial partitions overlay
– Improvements to image export functions
– Multiple path chart value overlays enabled
– Debugging .txt file record enabled
– Visibility renamed to directed visibility
– Integration and mean visual depth overlay and chart values re-enabled

v_2.2.6 [01_06_19]
– Occasional crash on import fixed
– Licence extended until 01/08/19

v_2.2.5 [24_04_19]
– Threading memory use improvements
– Optimal path overlays enabled
– Minimal set searching enabled
– Drift field vectors amended to reflect true drift headings
– Fix to occasional error on dwg and dxf block imports
– Fix to crash on super high resolution screens
– Fix to partition calculation error
– Fix to display of 3D mean visual depth and integration fields

v_2.2.4 [25_03_19]
– Dxf and Dwg block import now supported
– Fix to absolute value overlay errors
– Licence extended to 01/05/2019

v_2.2.3 [18_03_19]
– Dxf and Dwg import support
– Optimised plan drawing functions
– Fix to rare isovist geometry errors

v_2.2.2 [11_02_19]
– Improved import and flood sampling processes
– Optimised integration and step depth calculations
– Addition of record and export of step depths
– Fix to occasional crash on plan load and resampling
– Fix to rare isovist geometry errors

v_2.2.1 [03_02_19]
– Fix for crashes on import and tab switching when isovists are displayed
– Fix for step depth crossover between tabs when switching tabs
– Fix for crash of scan progress /scan blackout on tab switching
– Fix for y-axis inversion of CSV data
– Fix for isovist geometry errors due to infinite line segments in some plans
– Fix for spectrum in zero value regions in mean metric depth and mean angular depth scans

v_2.2.0 [21_12_18]
– Major reworking of all plan import and optimisation processes
– Integration, Mean Visual Depth, and Visual Depth to location analysis algorithms rewritten to operate via geometric isovist methods
– Accuracy and definition of Angular depth algorithms increased
– Inter-visibility analysis via histogram overlay now included

v_2.1.10 [07_11_18]
– RRA calculation inverted to align integration values with DepthMap
– Integration D-value related to drawing scale bar to allow cross plan comparisons
– User mouse scroll sensitivity option added to set menu
– Ability to select and drag copy linkers added using control button

v_2.1.9 [22_10_18]
– version licence extended until 01/01/19
– added 3d field 'landscape' representations in plan space
– added undo delete option to line drawing tools
– aligned isovist heading to path direction on path analysis
– improved legibility of absolute values overlay
– prevented escape button causing app shut-down
– fixed depth to location error on tab switching
– improved allocation of spatial linker tools
– improved plan resampling fidelity
– improved csv export stability on PC
– improved isovist file save stability on PC

v_2.1.8 [06_09_18]
– version licence extended until 01/11/18
– fixed occasional bug on global field calculation on MacBook Air models

v_2.1.7 [17_07_18]
– scan edge expanded from plan import edge
– scan edge removed from scan field results
– plan import fixed to allow group names in upper or lower case
– maximum number of plan linkers increased to 128
– comparison charts click-drag spin enabled
– minor bug on spatial comparisons display resolved
– absolute point data values enabled as overlay option
– calculation enabled on iris generation intel gpu chip sets
– resolution of visibility, control and controllability calculations improved
– stability when switching between tabs on PC improved
– stability of export and save functions on PC improved
– minor memory efficiency improvements

v_2.1.6 [30_06_18]
– image export updated to provide high resolution and vector line pdfs
– pc stability increased
– crash on micro sampling resolved
– minor calculation speed improvements

v_2.1.5 [28_05_18]
– drawing menu containing plan edit tools added
– scan setup tools relocated to drawing menu
– user defined scale added to drawing menu
– loading blinker set to fade
– heading arrows included for isovists with a sweep of less than 180 degrees
– circular horizon added to visibility scans
– scan region selection optimised
– scan resolution set to require scan region re-selection by user
– integration HH slider set to logarithmic scale
– angular step depth maximal value range increased
– local and global scan functions optimised
– sweep and heading bug fixed for isovist scans with a sweep of less than 180 degrees
– escape button crash fixed
– occasional save crash bugs reduced

v_2.1.4 [15_05_18]
– regional isovist calculation tool added
– angular depth and angular mean depth added
– control and controllability measures improved
– zoom inversion fixed
– pan tool added
– file naming dialogue added

v_2.1.3 [04_05_18]
– control and controllability measures now included
– spectrum fade out at minima option added
– occasional rare isovist calculation errors debugged

v_2.1.2 [30_04_18]
– isovist visibility scanning now included
– integration (HH) now included
– plan segment downsampling improved
– user added segments now affect scan base choice
– user menu rearranged and rationalised
– error on link propagation fixed
– error on link restoring from second tab fixed
– error on .isovist file load fixed
– hang error on exit fixed

v_2.1.1 [13_04_18]
– option to turn off plan added
– tiff export at full analysis resolution enabled
– spatial links improved
– tab switching improved
– underlying search data structures refined to improve efficiency and speed

v_2.1.0 [30_03_18]
– path analysis chart tools added
– variance, skew and average radial measures added
– occlusion measure redefined to increase accuracy
– scans updated to include restricted and directed isovist settings
– grayscale and colour invert settings included for scans
– scan radial resolution setting added
– 'persistent threshold' calculation and overlay added
– isovist radial display option included
– isovist agents provided with 'body' visibility
– changes to .isovist file format

v_2.0.9 [05_03_18]
– occlusivity and compactness measures refined to improve fidelity in urban figure grounds
– edit to scan region selection to improve selection in urban figure grounds
– fix to scatter plot setup to account for high value spreads
– fix to minor spectrum slider update error

v_2.0.8 [25_02_18]
– major revision to allow multiple scans to be opened simultaneously
– major revision to include .isovist and .isospect file formats to allow scan or spectrum saving
– threading of file open/close processes
– fix to PC file extension errors to include default formats of .tiff, .csv, etc
– inclusion of 3d scatter charts in comparisons analysis
– fix to some long plan segment recalculations on scan resolution resizing

v_2.0.7 [19_01_18]
– addition of 'annotations' overlay layer to plan import and display
– improvement of import optimisation functions
– review and improvement of reflection geometry calculations

v_2.0.6 [14_01_18]
– mouse selection of step depth to location calculations enabled
– visual step depth to location max-min and averages implemented

v_2.0.5 [09_01_18]
– comparison charts re-enabled (whoops, sorry)

v_2.0.4 [07_01_18]
– inclusion of all solid walls within scan when visible space is activated
– refinement of 'viewed depth' calculations
– some optimisation of scan calculations on mac version
– debugging of mouse zoom input

v_2.0.3 [28_12_17]
– implementation of isovist horizons within scan measures
– implementation of ‘viewed depth’ and ‘view depth’ as sub-category of visibility global measures
– minor variation to lower end of blue/black spectrum

v_2.0.2 [20_12_17]
– implementation of user defined resolution settings
– optimisation of import plans to suit defined resolution
– inclusion of refined spectrum thresholding
– fix to allow reset of scan on selection of visible/reflected space draw settings

v_2.0.1 [09_12_17]
– inclusion of ‘visibility’ global depth measures to scan analysis
– solution to bug that caused a crash on detection of mal-formed segments in an imported plan
– inclusion of full screen/window switching based on user feedback
– inclusion of summary visual depth statistics based on user feedback
– minor change to spectrum mix; darker tone at blue end

v_2.0.0 [01_12_17]
– major upgrade release
– adoption of OpenCl standard methods for all scan analysis
– inclusion of ‘accessibility’ global depth measures to scan analysis
– revision, review and restructure of all user interface issues
– reworking of all import processes to improve reliability
– reworking of numeric export standards to align to DepthMap
– expansion of scan spectrum options

v_1.0.3 [02_10_17]
– revision of field spectrums to include low values as fade to black

v_1.0.2 [31_07_17]
– revision of import options to simplify import process

v_1.0.1 [12_07_17]
– fix to exports to correct errors in data formatting and values
– fix to isovist calculations to improve fidelity of geometries relative to small line fragments

v_1.0.0 [06_07_17]
– initial public release

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