Space Syntax Toolkit for QGIS

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Quick Start Guide

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Overview

The "Space Syntax Toolkit" is a QGIS plug-in for spatial network and statistical analysis. It provides a front-end for the depthmapX software within QGIS, offering user-friendly space syntax analysis workflows in a GIS environment. It is primarily aimed at supporting the standard space syntax methodology, and enhancing it with standard GIS data, analysis and visualisation features. Nevertheless, the added functionality is of general benefit to QGIS users by introducing tools for exploratory spatial data analysis. Currently the Space Syntax Toolkit consists of two modules: "Graph analysis" and "Attributes explorer".

This Quick Start Guide describes the installation, functionality and basic usage of the toolkit. It does not explain the theory and methods of space syntax, nor the standard features and operation of QGIS. Please refer to the respective literature and documentation for information on these essential aspects.

Installation

The plug-in can be downloaded from the following web site:

https://github.com/SpaceGroupUCL/qgisSpaceSyntaxToolkit/tree/master/downloads

The "esstools.zip" file must be unzipped and the "esstools" folder copied into the QGIS plug-ins directory, which is:

Windows – C:\Users\{username}\.qgis2\python\plugins

Mac OSX and Linux – {Home}\.qgis2\python\plugins

This is a hidden folder and you must make hidden files and folders visible in your system before hand.

Note: In the next release the plugin will be available directly via the Plugins Manager like all other plugins.

After you start QGIS, the Space Syntax Toolkit plug-in is available in the plugins manager. Start it by going to the menu "Plugins > Manage and Install plugins…", select the "Installed" plugins tab, and scroll to check the box next to the "Space Syntax Toolkit" entry. This activates the plug-in and it will remain so for future sessions.

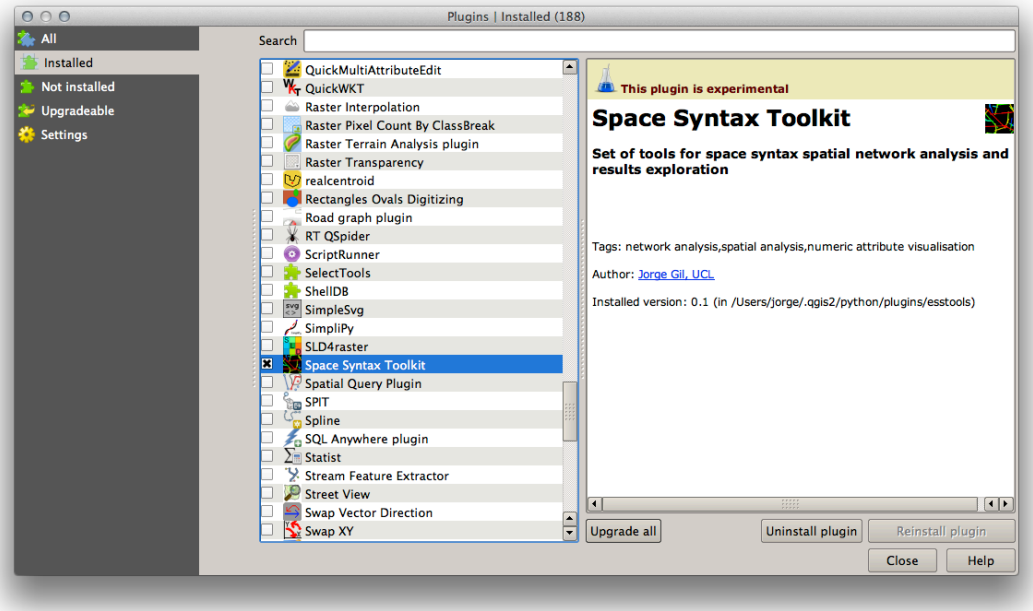

Fig. 1 – Plugins manager, with the "Space Syntax Toolkit" selected

After activating the plug-in, close the Plugins Manager. There is now a "Space Syntax Toolkit" menu entry in the Plugins menu, and two new buttons in the Plugins toolbar. These allow you to run the different modules.

 – Graph Analysis

 – Attributes Explorer

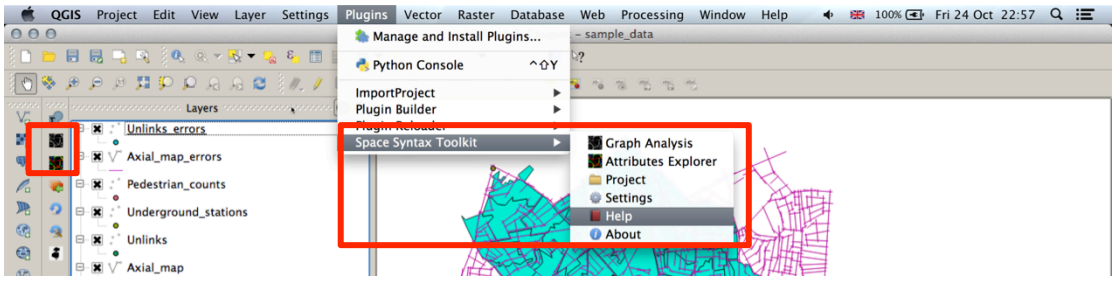

Fig. 2 – Plugins menu with the "Space Syntax Toolkit", and toolbar buttons.

Additional requisites

The following additional software and Python packages are required to use the full features of the toolkit. If any of these is missing, you will still be able to use the software, but with the limitations listed below.

- depthmapXnet – this software must be installed and running to perform a space syntax network analysis using the "depthmapX remote" tab in the Graph Analysis module. The package can be obtained here: http://archtech.gr/varoudis/depthmapX/?dir=depthmapXnet
- python igraph – this Python package is required to identify "islands" during the axial map verification process. If the package is missing the verification needs to be done in the "manual" way: running an analysis and seeing if the node count value is constant. The package can be obtained here: http://igraph.org/python/

- pyqtgraph – this Python package is required to display interactive charts in the Attributes Explorer "Charts" tab. If the package is missing the charts are not displayed. The package can be obtained here: http://www.pyqtgraph.org/
- Python 2.7 – to install any of the additional Python packages you must have Pyhton 2.7 installed. It usually comes pre-installed in Mac OS X systems. Otherwise you can obtain Python here: https://www.python.org/downloads/

The installation of each of these packages depends on the platform that you are using. Please refer to the individual package documentation.

Sample data

The Space Syntax Toolkit's Github page has a sample data set available for download, with which to use the plugin straight away. The sample data is used throughout this Quick Start Guide and allows testing all the toolkit's features.

https://github.com/SpaceGroupUCL/qgisSpaceSyntaxToolkit/tree/master/data

The sample data comes in two data formats: a folder with Shape files, and a Spatialite personal geodatabase file. You can use either format, or even try both, because the toolkit performs differently depending on the data format being used. With the data comes a QGIS project file – sample_data.qgs – that loads all the relevant layers.

General notes on data

The Space Syntax Toolkit has been developed to work with all the vector data formats available in QGIS, and it can use as input any vector layer loaded in a QGIS map window. It also supports the native data formats of QGIS, namely Shape files, Spatialite personal geodatabase, and PostGIS database. Each of these data formats has unique characteristics that might be more appropriate for different users, and the toolkit takes advantage of those to optimize performance in various operations. Each user should become familiar with the pros and cons of each format, and choose the most suitable.

Shape file

Shape file is the most common file based GIS format. It consists of a collection of files, storing the geometry, attribute data, metadata, coordinate system, spatial index, etc. A lot of existing data sets are distributed and shared in this format.

- Pros: uses the standard file and folder approach for storage that every user is familiar with.
- Cons: easy to lose components of the "file" when moving things around; limited to 10 characters in attribute names; limited to 2GB in the dbf (attributes) file; leads to huge folders with many files; depends fully on the QGIS API for querying and analysis.
- For more info: https://en.wikipedia.org/wiki/Shapefile

Spatialite

Spatialite is a spatial extension to the SQLite personal database, i.e. a self-contained database in a single file on disk. The Spatialite drivers are installed with QGIS and it supports it natively. Has similar functionality to PostGIS, with embedded SQL, many spatial analysis functions and spatial indices. The toolkit makes use of these embedded functions whenever possible.

- Pros: all the data is stored in a single file, the easiest to store, backup and share; the embedded SQL and functions allow powerful data queries and analysis; the embedded functions are many times faster than QGIS equivalents; has no restrictions to table and attribute names.
- Cons: requires some familiarity with database principles to manage the stored information, although QGIS offers user-friendly data manager interfaces; the database can quickly grow to have many tables; the SQLite SQL standard has some limitations; only supports vector data.
- For more info: https://en.wikipedia.org/wiki/SpatiaLite

PostGIS

Note: Currently there is no write support for PostGIS, nor does the toolkit make use of its SQL engine for faster operation. This will be introduced in a future version.

PostGIS is a spatial extension to the PostgreSQL database, the most robust and powerful open source relational database system. It is a server-based system, widely used in enterprise and web scenarios, allowing remote and concurrent access by multiple users. It can also be installed locally for personal use.

- Pros: no data size limit; full SQL support; rich analysis functions; extremely fast operations; supports vector and raster data; has "schemes" that help keep the database organised; possible to have multiple users collaborating on same database.
- Cons: requires installation of server and/or client platform; for personal use it requires knowledge of database systems and management; data sharing easiest using shape files, when others don't have access to the server.
- For more info: https://en.wikipedia.org/wiki/PostGIS

Graph Analysis

The "Graph analysis" module supports the verification and analysis of the space syntax network model. This model consists of an axial map layer, representing the public open space network, and an unlinks layer, indicating bridges and tunnels where there is no level crossing between lines. The module offers a verification tool to check the geometric and topological integrity of each layer, helping to correct problems before running the analysis. The axial and segment analysis is performed in depthmapXnet, via a direct link from QGIS, which receives back and prepares the results once the calculations are completed.

Preparation

The first thing to do is to indicate in the Map and Unlinks tab which layers should be used in the analysis. If there is no axial map or unlinks layer, either add an existing layer to the project, or create a new layer and draw the map/unlinks on it. The OpenLayers plugin is very useful for creating new axial maps because it loads layers with cartography and aerial imagery from OpenStreetMap, Google, Bing and other providers onto the canvas. Please refer to the QGIS documentation for details on these operations.

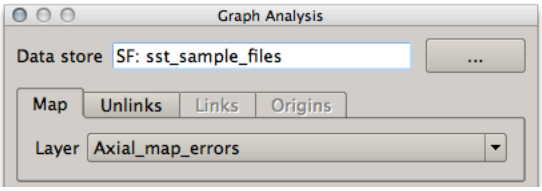

Fig. 3 – "Graph analysis" data store, map and unlinks setup fields.

The "Data Store" field indicates where the analysis results are saved and the data type (SF: shape file; SL: spatialite). By default this is the same location as the input files, but it can be changed to another location. This setting is saved with the QGIS project and recovered when the project is opened. Refer to the information in "General notes on data" to help decide which data type to use.

Verifying the axial map

The verification of the axial map checks for geometry and topology mistakes. Clicking on the "Verify" button in the "Verify layer" tab starts the verification, and when the process concludes, any problems found will be listed in the report. These may include:

- Small line – lines with a length below the minimum (default: > 1 m)
- Polyline – lines made up of more than two nodes
- Coinciding points – lines with two points coinciding
- Duplicate geometry – two lines with identical geometry
- Short line – line whose endpoint is close to another line without intersecting it (default: > 1 m)
- Orphan – line that is not intersecting any other line
- Island – group of lines that are disconnected from the main map (only verified if the igraph package is present, see Additional requisites)

The problems listed in the report can be filtered by selecting a type of problem in the "Problems" drop-down menu. The number in brackets indicates the total number of occurrences of a problem.

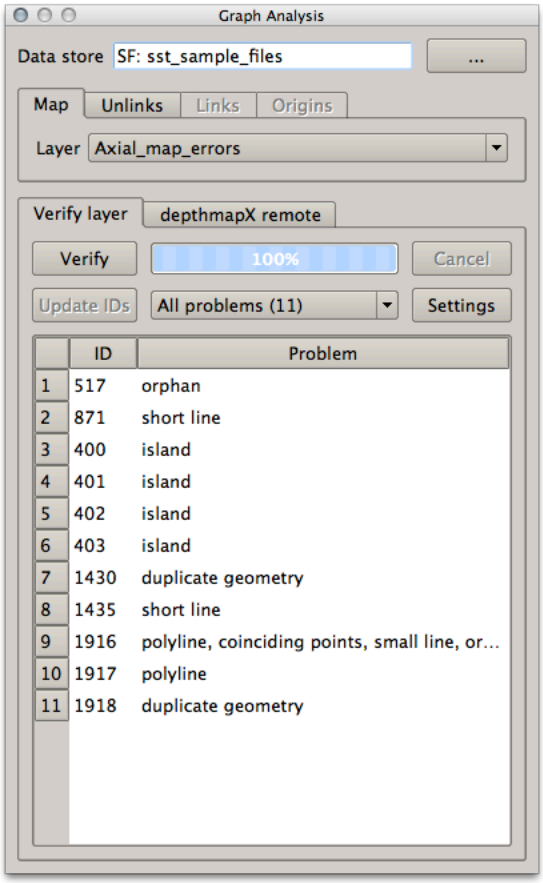

Fig. 4 – Axial map verification report.

Clicking on an entry in the problems report automatically selects and zooms into the corresponding line or group of lines. Once located, the user can switch the layer editing mode and modify or remove the line(s). The lines are identified by their unique ID, this is either an existing attribute called “ref”, “id”, “pk”, “sid”, or it is the internal feature id of QGIS.

The “Settings” button gives access to the distance thresholds of the verification process.

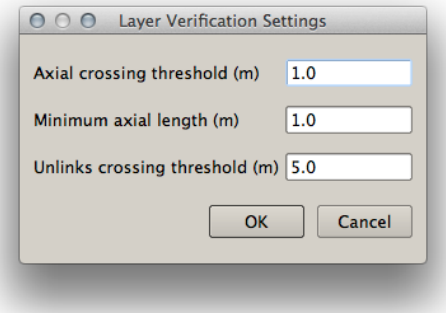

Fig. 5 – Layer verification settings, with default values.

When verifying the axial map, if an unlinks layer is selected, the unlinks are taken into account and can reveal topological problems due to unlink disconnections. This unlinks layer must also be verified (see next section) and corrected for the axial map verification results to be completely correct.

Notes:

The verification process is faster if the data is in a geodatabase because it makes use of optimised SQL queries. This can be important when working with very large maps.

The verification process is meant for axial maps only. It does not identify any possible problems in segment maps or road centre line maps, for example.

Verifying the unlinks

An unlink can be any feature that identifies an intersection between two axial lines, that are to be disconnected. It can be a point near the intersection, or a line or polygon intersecting the two relevant axial lines. The verification of the unlinks requires that an axial map is selected in the “Map” tab, and both files must be in the same data format. The unlinks verification checks for topological and line id problems in relation to the axial lines layer:

- Multiple lines – unlinks intersecting more than two axial lines
- Single line – unlinks intersecting only one axial line
- No lines – isolated unlinks not intersecting any lines
- Same line id – unlinks with the same line id attributes
- Unmatched line id – unlinks with the line id attributes not matching the currently intersected axial lines

The unlinks’ problem selection, filtering and editing process is identical to that for axial maps.

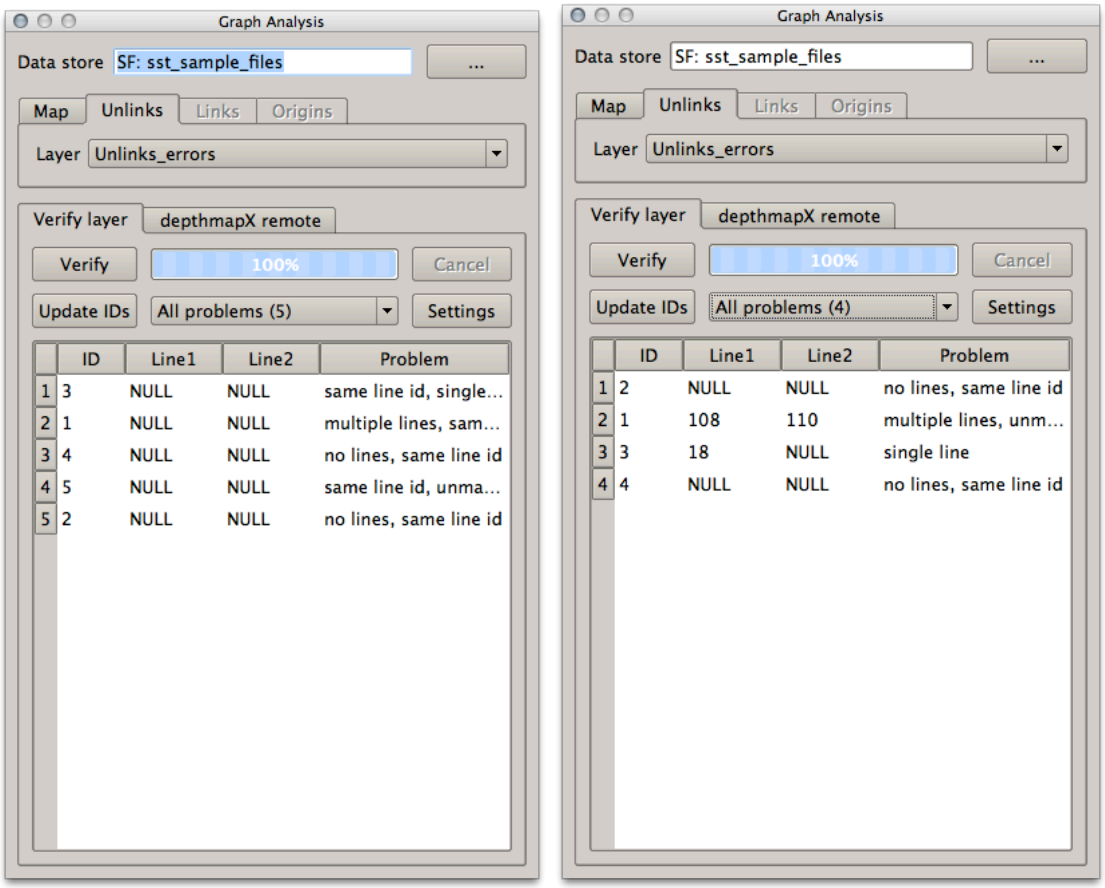

Fig. 6 – Unlinks verification reports, without line ids (left), after updating line ids (right)

The first time the unlinks verification runs, it checks if two attributes “line1” and “line2” are present, with the id of the lines to be unlinked. If these attributes are missing, the problems report will include all unlinks and the user should click “Update IDs” to assign the id of the lines at the intersection identified by each unlink. This id update is only triggered by the user to prevent an automatic change to line ids after the axial map has been edited, while the unlinks not. In this case, any unlinks with unmatched id will be signalled and can be confirmed by the user if it’s in the correct position. Only then should the ids be updated.

DepthmapX remote analysis

The remote tab controls the graph analysis of the selected map and unlinks layers in depthmapXnet, which must be installed and running before starting an analysis. The analysis settings in this panel emulate what one would find in depthmapX, but in a more compact layout (Fig. 7). One can choose between axial (topological) and segment (angular) analysis, set the radius distance, and select the attribute to use for the weight. Additional “advanced” analysis settings are available by clicking the “Settings” button. The tool automatically suggests an output table name for the results, which can be edited by the user. By default, the axial analysis results are added to the axial map layer, and the segment analysis results create a new layer with the “_segment” suffix. Clicking “Calculate” sends the data and parameters to depthmapXnet for analysis, and both QGIS and depthmapXnet must be kept running throughout. The analysis can be cancelled midway using the “Cancel” button.

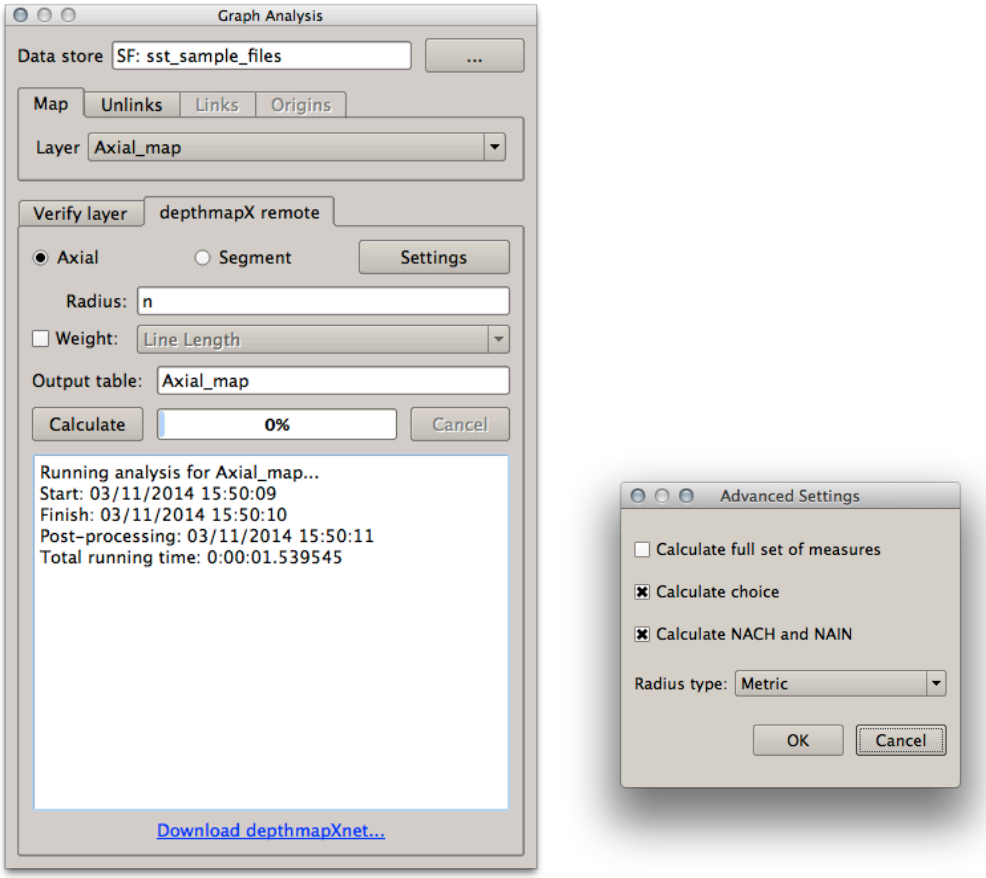

Fig. 7 – Axial and segment analysis control panel, for remotely running depthmapX analyses, showing "Advanced Settings" (right) for changing the default analysis parameters.

Once the analysis is completed, a report shows the duration of the various stages. The post-processing stage takes place on the QGIS side at the end, where the results are filtered and calculated according to the user's selections and the attributes renamed to be compatible with the current data store type. The results layer is added to the legend of the current map, and the new attributes can be seen by opening the attribute table. However, the best way to explore the results, is to use the "Attributes Explorer" tool.

Attributes Explorer

The "Attributes explorer" module supports the visual and statistical exploration of analysis results. The aim is to emulate the interactive nature of Depthmap when exploring analysis results. It provides the quick analysis of individual quantitative attributes of a selected layer, displaying the values on the map using simplified symbology, displaying essential descriptive statistics, and plotting basic interactive charts (histogram and scatter plot). To start the exploration the user just needs to select a layer from the drop-down menu, and click on one of the numeric attributes in the list.

Notes:

Do not select a layer with your custom symbology before saving the style, if you want to keep this. The tool changes the layer's symbology as soon as an attribute gets selected.

To produce maps with a black background, as is typical of Deptmap and other space syntax software, change the canvas background colour by going to "Project > Project Properties… > General > General Settings". This setting is saved with the QGIS project.

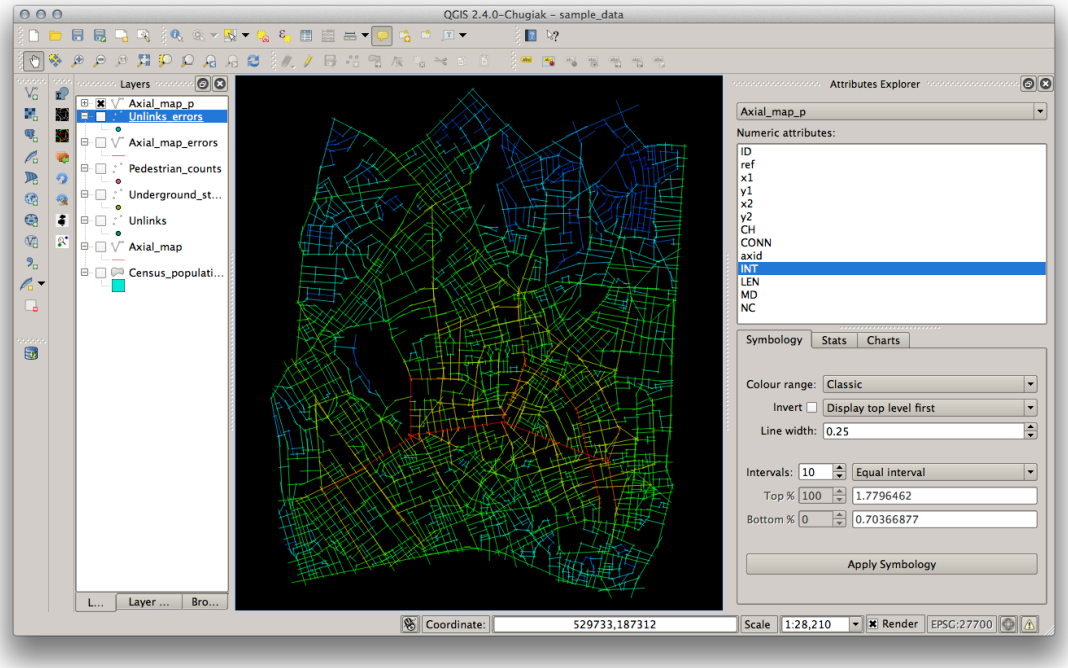

Fig. 8 – QGIS window with the "Attributes Explorer" panel open on the right.

Attribute symbology

The attribute symbology tab supports the display and production of maps that are standard within the space syntax community. The default style is applied as soon as an attribute is selected in the "Numeric attributes" list. The user can change the colour and data range settings to create a custom symbology that is more appropriate to the specific attribute. To see the result the user needs to click "Apply Symbology". This also stores the settings on the QGIS project and these become the style for that attribute, allowing the flipping between different attributes while retaining the custom styles.

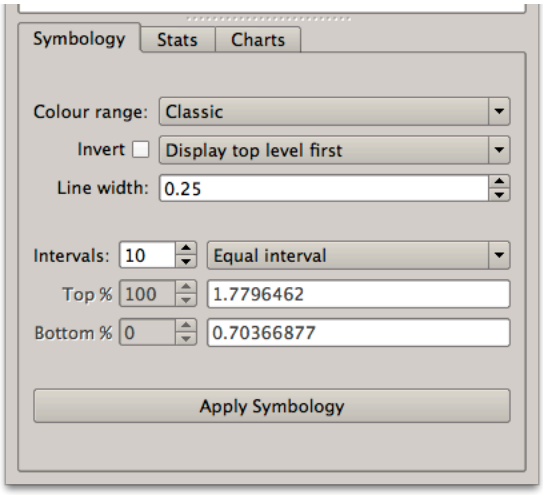

Fig. 9 – Attribute symbology settings tab.

The colour settings include:

- Colour range – select between classic, red-blue, greyscale and monochrome (Figure 10). The greyscale and monochrome colour ranges use back or white lines depending on the background colour.

- Invert – Inverts the range, assigning the red, black or thick line to the bottom values
- Display order – Ensures that the top or bottom values are displayed first in the map, the default being the red lines on top of all the others
- Line width – Sets the line width, which is constant in all styles except monochrome, where this value represents the maximum width

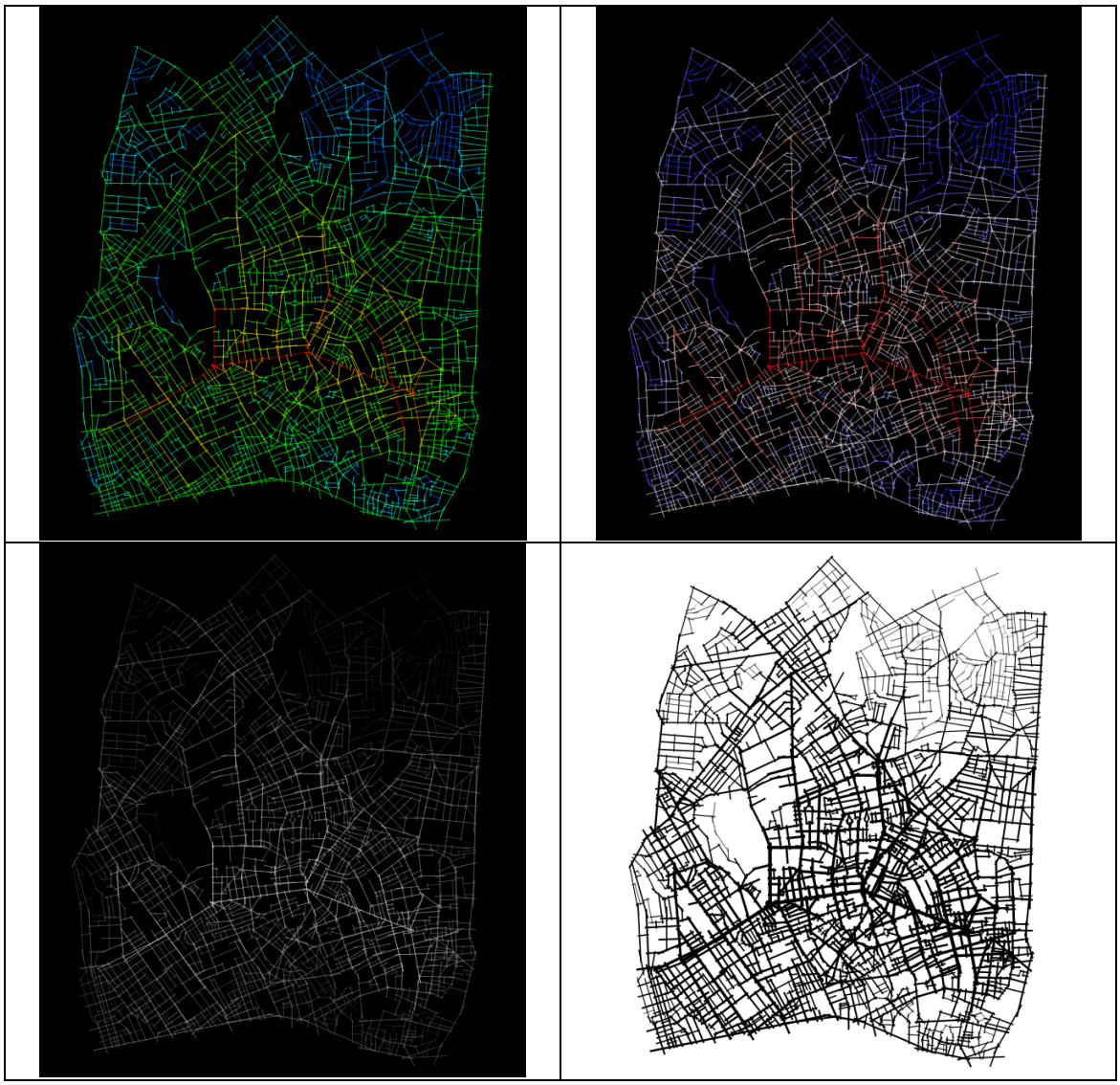

Fig. 10 – The different colour range settings: classic (top left), red-blue (top right), greyscale (bottom left) and monochrome (bottom right) with varying line width. The greyscale and monochrome colour ranges automatically use black or white lines depending on the background colour.

The data range settings include:

- Interval number – sets the number of intervals in the colour range (maximum is 1024)
- Interval type – selects the colour range interval distribution, between equal range, quantiles, natural breaks (slow) and custom. The custom range unlocks the limits controls.
- Custom interval limits – the interval limits are by default the maximum (top) and minimum (bottom) values. With custom intervals the user can change the size of the top and bottom range, using a percentage or the absolute value. The other intervals in between are automatically calculated using equal ranges distribution. This setting is equivalent to the slider controls in the “Colour Range” settings of Depthmap.

Note: The symbology applied to a layer can be further edited in the QGIS symbology dialog. These changes, however, will be overridden by the "Attributes Explorer" module. The user should store final display settings in a QGIS layer style file for later retrieval, or tweak the final display after finishing with the module.

Attribute statistics

The statistics tab displays a table with descriptive statistics of the attribute values, and of the selection of features on the map. These statistics give an indication of the overall distribution of values in the data, and can be helpful in deciding the most appropriate symbology settings.

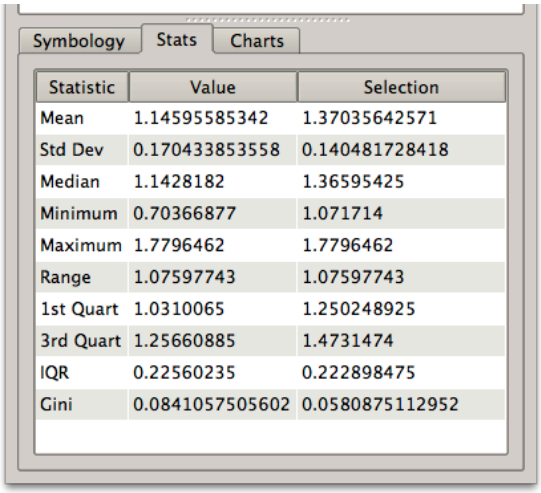

Fig. 11 – Descriptive statistics of the selected attribute values, with the statistics for the data of the selection on the map.

Attribute charts

The charts tab shows basic interactive charts (histogram and scatter plot) of the currently selected attribute, which can be zoomed in and panned. They display in red the data of the selected features, but they do not support the selection of data bars or points directly. For the scatter plot, the Y axis (dependent variable) is set in the appropriate drop down menu (Figure 12 right)

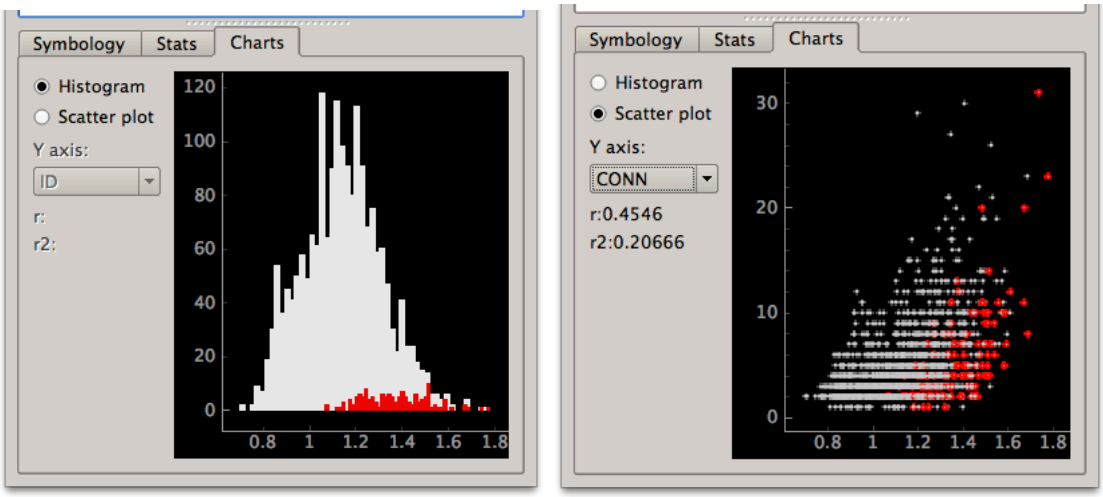

Fig. 12 – Histogram (left) and scatter plot (right) of the selected attribute values. In red are the data points corresponding to the selected features on the map.

Note: Currently, the charts are only available if the pyqtgraph package is installed.