AGRAPH,
Software for Drawing and Calculating Space Syntax Graphs

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Abstract
AGRAPH is a PC-application for drawing Space Syntax graphs and for doing Space Syntax calculations. AGRAPH is made for drawing graphs on the basis of imported background images such as floor plan drawings. By a "snap to grid"-option and "click-and-drag"-commands justified graphs are easily made. AGRAPH calculates the basic Space Syntax parameters of the graph-nodes but has also the option of excluding selected nodes from the calculation. AGRAPH has several colouring modes. One is the "custom mode" that is useful for coding nodes by colour. Another is the mode for colouring nodes according to the Space Syntax parameters Relative Asymmetry or Control Value. By the export-command the graph-image can be stored in formats appropriate for further editing and publishing. The tables containing the Space Syntax parameters of the nodes in the graph can be opened in common software such as EXCEL for further analysis. The program structure of the AGRAPH is designed for further development. At the time of writing this paper, several additions are being developed.

1. Introduction

AGRAPH is developed for being applied to a PhD-study at the Oslo School of Architecture and Design. In this study a PC-application was needed for doing Space Syntax analysis of a large number of apartments. There exist a number of software applications for Space Syntax analysis, ranging from tools for simple analysis of connectivity to advanced visual field analysis. Nevertheless, when in this PhD-study looking for software capable of handling both the Space Syntax calculations (giving easily accessible output data) and the intended drawing and editing of graphs, appropriate software for the PC was not found. It was then decided to develop software for the actual task. The outcome of this is AGRAPH. This paper explains the basic features of the software and describes briefly how it is used.

In the fields of graph-theory and combinatorics, which are the mathematical basis for Space Syntax calculations, the elements of the graphs are usually described as vertexes and edges.[1] In this paper, which is on Space Syntax analysis and not on mathematics, the more literal terms nodes and connections are preferred.

2. The AGRAPH Application in General

AGRAPH is developed in C# using VisualStudio.NET. The compiled .EXE file runs on PCs operated by WINDOWS. AGRAPH works on files of a format named .AGX. This file contains all information of the graph. From the graph-image drawn on the PC-screen, AGRAPH generates a "connectivity matrix" (listing whether nodes are connected or not) and an "internal distance matrix" (listing the shortest distance between the nodes in the graph)[2]. By simple calculations on these matrixes, the Space Syntax parameters of the nodes are determined.

3. The Space Syntax Parameters

AGRAPH calculates the parameters Control Value (CV), Total Depth (TD), Mean Depth (MD), Relative Asymmetry (RA) and the integration value (i).[3]

Control Value
The Control Values (CV) are found by letting each node give the total value of 1 equally distributed to its connected nodes. The Control Value of node n, CV(n), is the total value received by node n during this operation.

Total Depth
Total Depth of a node n, TD(n), is the total of the shortest distances from node n to the other nodes in the systems, i.e. TD(n) is the total of line n (or column n) in the distance matrix.

Mean Depth
Mean Depth for a node n is the average depth (or average shortest distance) from node n to all the other nodes. If k is the total number of nodes in the system, then MD(n)=TD(n)/(k-1).

Relative Asymmetry
The Relative Asymmetry (RA) describes the integration of a node by a value between (or equal to) 0 and 1, where a low value describes high integration. RA is calculated by the formula RA=2*(MD-1)/(k-2).[4]

Integration Value
A parameter that (contrary to RA) describes integration by a high number when a node is highly integrated is the "integration value" (i). The integration value is found by inverting the RA, i=1/RA.[5]

4. Drawing and Justifying the Graph

Unless the spatial structure to be analysed is very simple, a convenient way of drawing the graph is to use an appropriate background image. Such a background-image is imported into AGRAPH as a file of .TIF or .JPG format. In the case of studying apartments this background image would be the floor plan drawing. By setting the "snap to grid" to "off", nodes and connections are easily drawn on the background image. Especially when drawing larger systems it is useful to name the nodes before removing the background image and before justifying the graph. (Naming of nodes is done by "right click" on node and then using the "set node name"-option.) By turning on the "snap to grid", justified graphs are made by simple "click and drag". The nodes are automatically numbered from 0 and upwards in the order they are drawn.[6] The results of the calculation are listed according to node number. As it might be preferred to have the nodes listed in a given order, the numbering of the nodes can be edited after drawing. Having the node numbers visible in the centre of each node is an option that can be turned on/off. The name of the node is placed beside the node on the graph-image and can be edited as text at any stage. The file-name automatically appears at the down left of the graph. (See Figure 2) The graphs-image can be exported in formats such as .JPG or .BITMAP for printing or for further analysis.

5. The Colouring Modes

There are several modes for colouring the nodes. The simplest is to keep the default colour (light grey) and to identify the nodes by name only. One alternative is to use the "custom colour"-mode for coding the nodes by colour. When intending to compare many graphs or to study graphs consisting of a large number of nodes, such coding by colour simplifies the further analysis.

Similar to the well known coloured graphics used for presenting the integration values of axial line analysis, AGRAPH has the option of colouring the nodes according to the integration or to the control value of the individual nodes. When using "Colour by Control Value" or "Colour by RA, relative", the total scale of colour is set to range between the minimum and the maximum value occurring in the graph. Using "Colour by RA, absolute" the range of colour spans from the value RA=0 (red) to RA=1 (dark blue/purple), and the nodes are coloured according to their RA-value within this scale. When applying "Colour by RA" for comparing different graphs, the "Colouring by RA, absolute" is useful. If analysing only one graph the "RA-relative" is better as this gives a larger range of colour and thereby a more differentiated information. In addition to being useful for analysing given architectural spaces, these "colouring by calculation"-modes are helpful for visualising the effects of making changes to a system by deleting or adding nodes and connections.

When nodes are coloured by "custom colour", this information is stored in the .AGX file. This means that different "colour by calculation" can by applied without loosing a previous custom colouring such as nodes coloured by function.

6. The Calculation

For each calculation AGRAPH generates three output files. These are tables in the .HTML-format that are stored in the same file-catalogue as the .AGX file. The file "--summary.HTML" lists the CV, MD, RA and the 1/RA for all nodes of the graph. The files "--connections.HTML" and "--distances.HTML" contain respectively the connectivity matrix and the matrix of the internal distances between nodes. In most cases the summary file is the only information needed for further Space Syntax analysis. All these output files can be opened in common software such as EXCEL for further editing or analysis.

In Space Syntax analysis there are often cases where all of the existing spaces are not included in the calculation. The "calculation without exterior" is a well known such case. Depending on the actual study, it might be relevant to exclude other spaces. AGRAPH has the option of "deactivate node" which excludes the selected nodes from the calculation.

7. Further Development of AGRAPH

AGRAPH now works well as the tool searched for in the on-going PD-study. However, for a wider range of use, some additions to the software would be useful. Some improvements are being developed at the time of writing this paper and several more are planned.

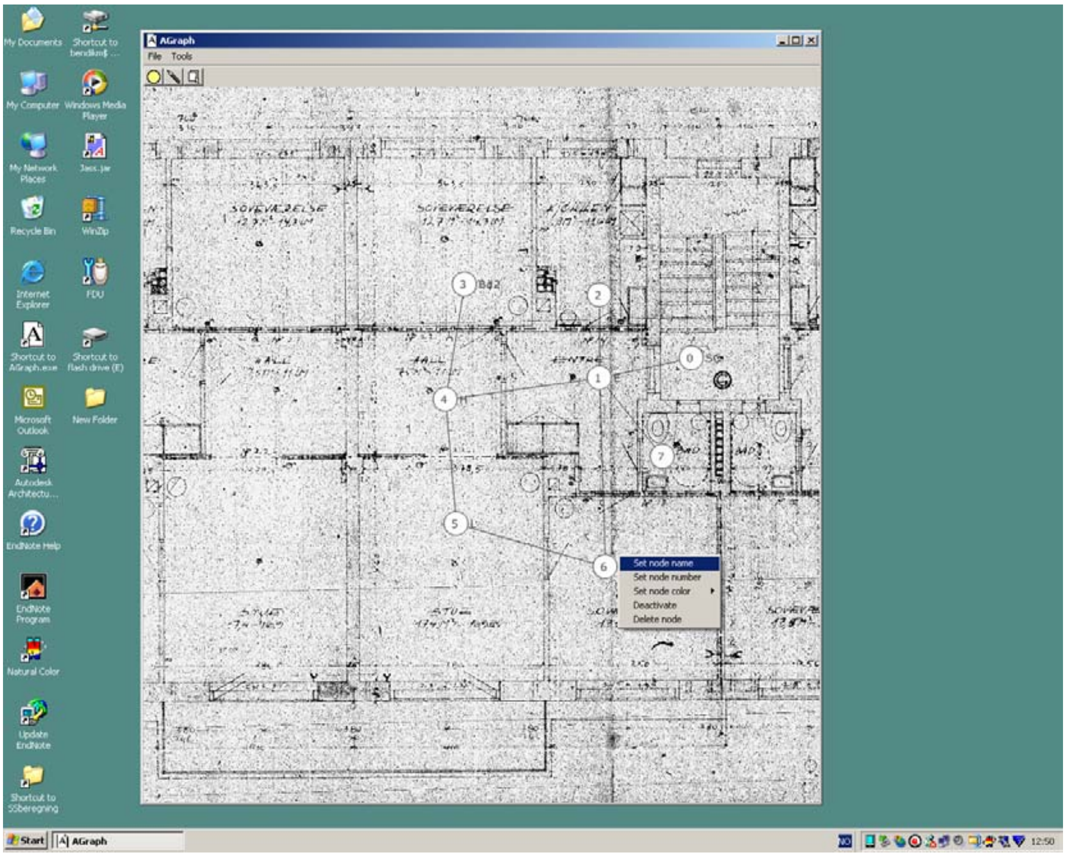

Figure 1. Opening AGRAPH. Choosing Background Image.
Drawing nodes and connections. Naming the nodes.

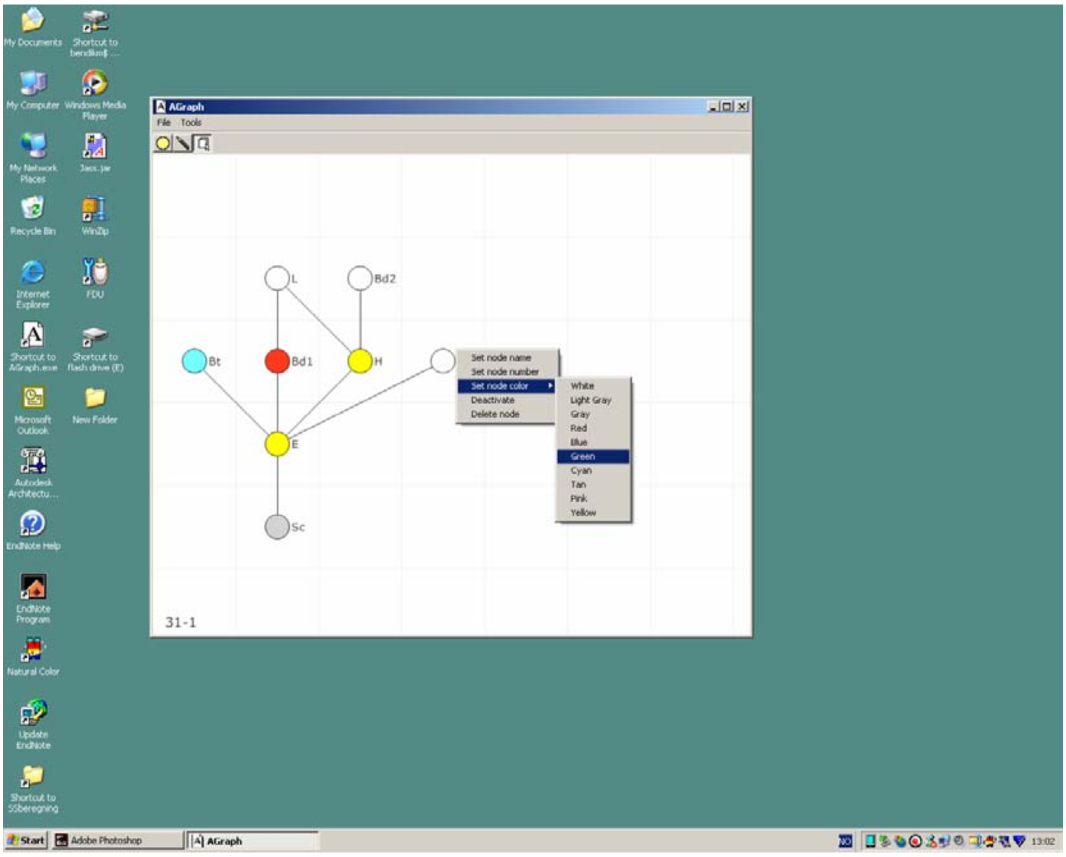

Figure 2. Clearing the background. Justifying the graph. Colouring the nodes.

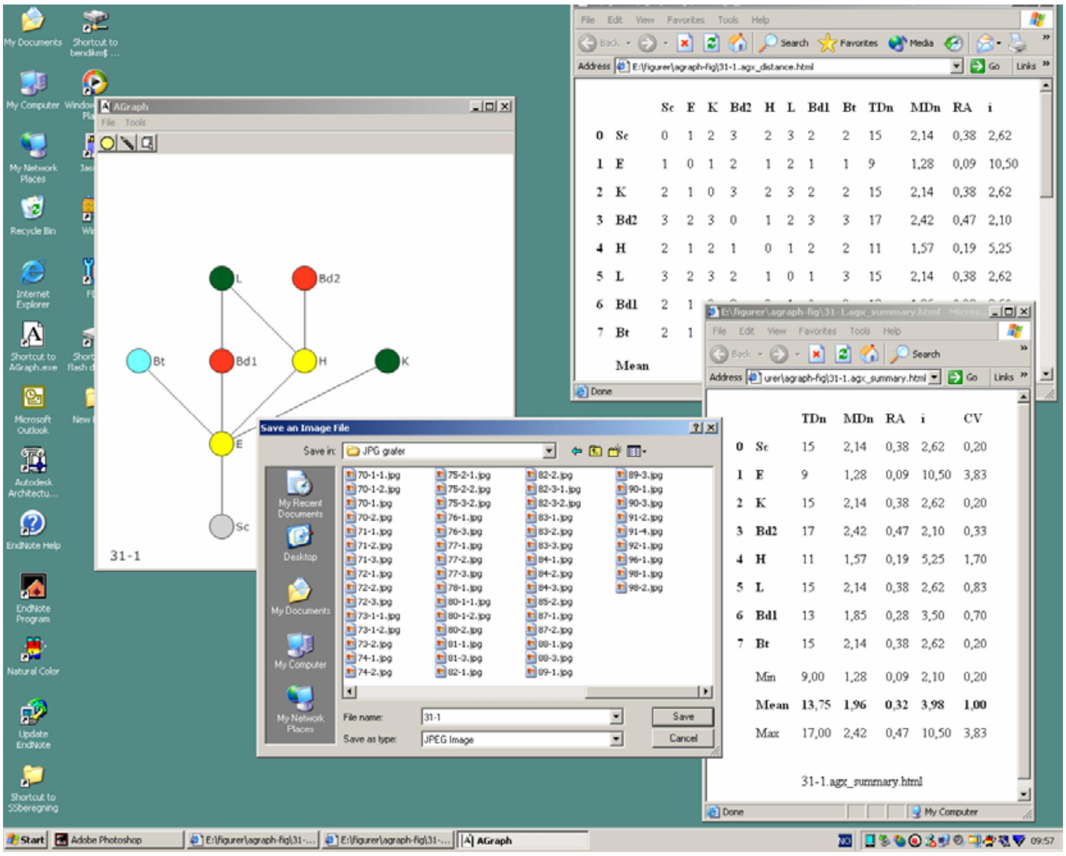

Figure 3. Doing the calculation. Saving the graph in an image-format.

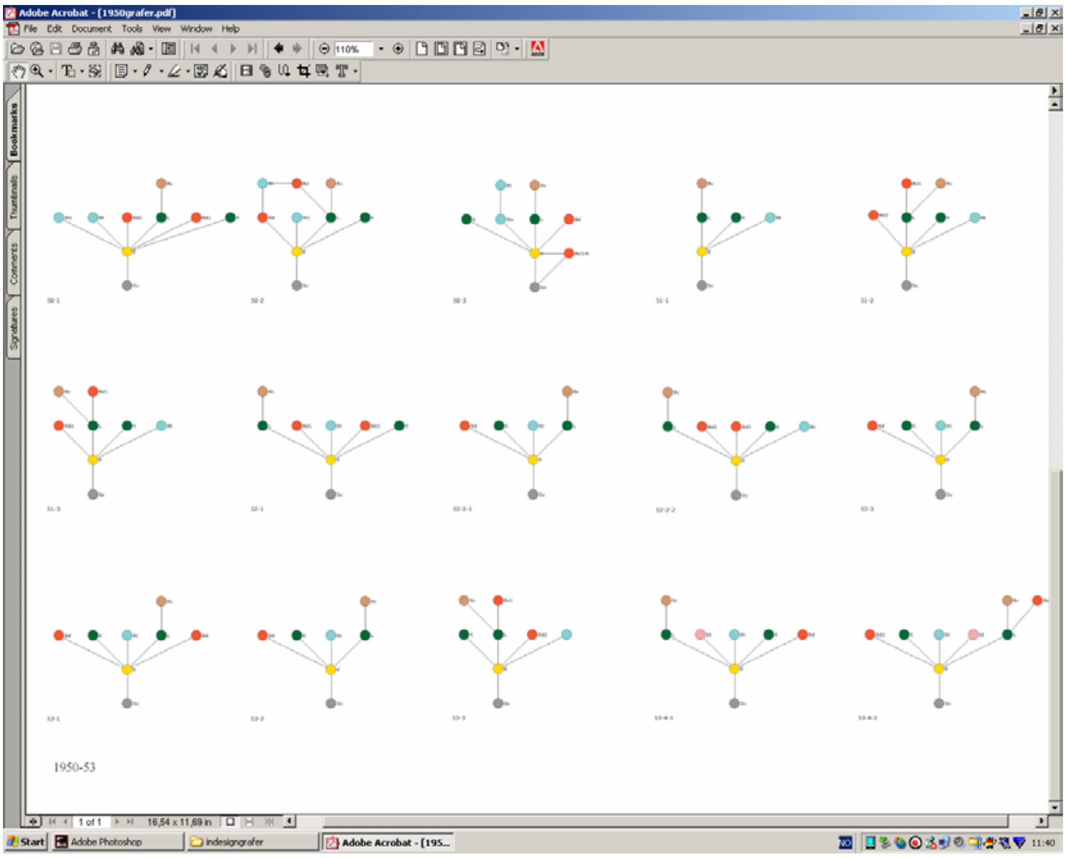

Figure 4. Some AGRAPH-images edited for presentation, an example.

Notes:

[1]For more on the mathematics of graphs, see for instance Tucker (2002).

[2] Distance not as "metric distance", but as "Space Syntax distance" (i.e. number of "space-steps").

[3] For more on the basics of Space Syntax calculations, see:
Hillier, 1996, p.33, p.88-.
Hiller and Hanson, 1984, p. 92-123,p. 147-155.
Hanson, 1998, p. 22-31.
Those who are reading a Scandinavian language might also see Klarqvist (1991).

[4] The RA-value is defined to be 0 when a node is as integrated as possible. The most integrated position possible is the root of a pure "bush"-graph. As all distances from such a root are 1, the MD is 1. By this RA=0 when MD=1. The RA might therefore be of the form RA= a*(MD-1). Contrary, RA is defined to be 1 when a node is as segregated as possible. The most segregated positions possible are the end nodes in a pure linear sequence. For a linear sequence of k nodes the MD for the end nodes is half the number of nodes in the line, MD=k/2. By this: RA=1 when MD=k/2. This implies 1=a*(k/2-1) which gives a=2/(k-2). By this RA=2*(MD-1)/(k-2).

[5] This is the integration value of RA. Integration might be defined as the inverse of other asymmetry parameters than the RA. The most usual is to invert the RRA, the Real Relative Asymmetry, as described by Hillier and Hanson, 1984, p.111-113.

[6] By this the highest node number is one less than the total number of nodes in the graph.

References:

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Tucker, A., 2002, *Applied Combinatorics*, New York, John Wiley & Sons.