Workshop and Lecture:

GENERATIVE SYNTAX IN ARCHITECTURE AND URBAN DESIGN

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What to expect
What to expect
What to expect
What to expect
What to expect
### Day 1

- General Introduction
- Initial Design
- Analysis of Design
- Designing Bubblediagram
- Grasshopper Plugins:
  - Syntactic
  - SpiderWeb

### Day 2

- Generative Design Approaches
Workshop resources
http://www.gbl.tuwien.ac.at/Archiv/digital.html?name=AAG2014

Generative Syntax in Architecture and Urban Design by Richard Schaffranek (Vienna University of Technology), Pirouze Nourian (TU Delft)

Abstract: There are a few theories that describe and explain the role of spatial arrangement on the social interactions of people in built environments, best known of which is called Space Syntax. The term syntax, taken from linguistics, here refers to the (spatial) structure of the whole, as opposed to morphology, which looks at the qualities of individual items. Using these theories, we can analyze existing spatial configurations and in a way measure their socio-spatial performance. However, theories and methods for systematically generating spatial arrangements of certain properties are rare or not put into practice. Combining analytic theories (mostly based on graph theory) with the generation of geometry is at the core of the workshop. In this workshop, we will introduce computational methodologies that can help in generating spaces with known syntactic properties. Three toolkits and methodologies will be introduced: SpiderWeb, Syntactic and Configurational.

Workshop Files:
Grasshopper Plugins (preview):
- Syntactic
- SpiderWeb

Grasshopper Examples:
- Syntactic
- SpiderWeb

Presentation:
- Presentation

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- Dept. AE+I/Design Informatics
- Dept. OTB/GIS technology
- Dept. Urbanism/Urban Design

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PO Box 5043, 2600 GA Delft,
The Netherlands
The Academic Interchange should provide and support the following functions:

- meeting place/s for members of the university and neighboring university technology park, international guests, business community and local dignitaries, alumni, friends and sponsors of the university;

- informal and formal meeting space/s and spaces for, ‘working lunches’/dinners, receptions and press conferences;

- rooms for workshops, alumni fairs and professional training courses;

- graduation ceremony receptions and small exhibitions;

- chamber music/small musical performances;

- ‘incubator’ for internationalization efforts of the university;

- residential accommodation for the short- and medium-term stay of guest researchers/lecturers;

- business center for meetings to introduce scientists and the business community;

- overall, a socializing/mixing place for people from different backgrounds;

- to make university life more active and personal by extending activities and outreach into evening and weekends.

List of rooms & functions:

- faculty club - a catered restaurant/bar for faculty members and international researchers (sits 60) – doubles as canteen for house guests; bar should be usable even outside restaurant hours

- apartments for guest researchers (10 double rooms; 3 family suites (two bedroom, kitchen, living room)

- meeting and conference rooms (3 rooms of 20 people; 1 of 100 people (multifunctional for exhibitions, reception, chamber concerts))

- business hub (with hot-desking, printers etc. for 20 people; plus smaller meeting rooms for at least 5 groups of 2-6 people per group)

- administrative offices (10 for 2-3 people each)

- reception area

- visitor information center (for non-university visitors)

- The overall target area is 3000m2 and this has been calculated assuming ca. 23% (700m2) circulation and ancillary functions.

Site boundary:

- The site is 30 * 40 meters and can be accesses from a long and a short side.
Design as Spatial Configuration

Configuration: the particular way, in which spaces are linked to each other in a building or a built environment

Spatial Configuration is an Intellectual Activity!

- Any meaningful set has something more than all of its items.
- A certain configuration ‘reflects and affects’ social interactions within a built environment.
- **Main Question:** How do we design a plan to embody a spatial configuration?
- **Remember** there is no such a thing as an automated design process!!!
A Spectrum of Privacy to Community

Can you make an ordered list of spaces as to their intended privacy/community level? Something like: entrance-toilet-living-kitchen-bedrooms-bathroom

How would you connect them to one another to achieve this (as in a bubble diagram)?

You can distinguish between (wanted/unwanted) spatial connectivity and adjacency links.

You would probably avoid connecting a kitchen to a bathroom but you might put them next to each other for technical reasons, practically it will be good for them to share a wall, so that pipes can be brought to both efficiently. Right?
A Syntactic Design Process

How to design a plan with a particular spatial configuration?

- An abstract graph may correspond to many concrete plan layouts!
- A spatial configuration can be analyzed in terms of its social implications
- Configurations are in-between the abstract domain of functions and the concrete domain of forms
A Syntactic Design Process

How to design a plan with a particular spatial configuration?

More specifically:

An Interactive Process

Abstract → Design Process → Concrete

Function

Configuration

Form

- Bubble Diagram (Graph)
- Topological Embedding (Map)
- Plan Diagrams (Bubble Packing)

Configurational Analysis
SYNTACTIC
(Space Syntax for Generative Design)

- real-time Space Syntax analyses for parametric design
- interactive bubble diagram
- automated graph drawing algorithms
- enumeration of plan configuration topologies
- measuring the socio-spatial performance

www.grasshopper3d.com/group/space-syntax
https://sites.google.com/site/pirouznourian/syntactic-design
Graph Representation

Which Spaces (Points/Axial-Lines) are connected to which others?
Graph Formation Tools in Action

A node-link graph builder + a force-directed graph drawing algorithm
Interactive Bubble Diagrams

- The force-directed algorithm makes a neat drawing and lets the designer focus purely on syntactic issues.
- Changing the configuration or the required spatial sizes the diagram updates accordingly.
Real-Time Space Syntax Analysis

For letting the users know what are the social/spatial implications of their configurative ideas.
Augmented Bubble Diagrams

For letting the users know what are the social/spatial implications of their configurative ideas.
Justified Graphs

Justified graphs show the configuration from different points of views topologically: user chooses a point of view.
TWO INDICATORS OF PRIVACY AND COMMUNITY

- Integration (Close-ness Centrality)
- Choice (Between-ness Centrality)

Integration (Hillier and Hanson, 1984) is a measure of centrality that indicates how likely it is for a space to be private or communal. The more integrated a space, the shallower it is to all other nodes in a configuration. Intuitively shows how likely it is for people to move to a space. Integration is calculated by computing the total depth of a node when the depths of all other nodes are projected on it.

Choice (Originally introduced as Betweenness by Freeman (Freeman, 1977)) Choice or Betweenness is a measure of centrality for nodes within a configuration as to its role in shortest paths. Intuitively shows how likely it is for people to move through a space. That literally tells how many times a node happens to be in the shortest paths between all other nodes. It can also be computed for the links connecting the nodes in a similar way.

Now, can you re-look at your designed configuration and see if it matches your intentions in terms of privacy/community levels?
A SYNTACTIC DESIGN PROCESS

Graph to Map to Plan (after March & Steadman):
How many alternatives are out there?

A Single Graph
representing spatial interlinks

A Single Topological Embedding
describing how such relations can be put on a plane surface, given an outer face

Several Triangulations
suggesting extra adjacencies between spaces, not seen in the initial graph

A Single Dual Graph For Each Triangulation
suggesting a cell configuration that admits the connectivity graph plus extra adjacencies

Several ST-directed Triangulations Corresponding With the Fittest Dual Graph
showing different ways in which rectangular cells can be put together according to the adjacencies

A Single Dimensionless Rectangular Dual Corresponding to Each ST-Directed Triangulation
proposing a way rooms can be adjacent to each other to admit the primary spatial connections and secondary spatial adjacencies

Several Dimensioned Rectangular Duals Corresponding to Each Dimensionless Dual Graph
presenting a way rooms of required sizes can be put together according to the chosen cell configuration, given ranges of acceptable sizes

Phase 0: 1 alt.  
Phase 1: 1 alt.  
Phase 2: n alt.  
Phase 3: m alt.  
Phase 4: o alt.

design space expanding from one ‘graph-ic’ possibility to, one planar topologic possibility to $n \times m \times o$ geometric possibilities
The Generative Process

Tutte Convex Drawing

Triangulation

Dual Graph
Proposing Configurative Ideas

The sketchpad made by the NEWS Graph component
An Untangled Diagram: A Unique Convex Topology

A unique planar representation of the configurative inputs
The Generative Tools in Action

From a planar topology to a set of geometric duals

bounded to the number of triangulations

IndexOfTriangulation 0
Finding Possible Geometric Matches

From a planar topology to a set of geometric duals

Triangulations and Dual Graphs
1. A triangulation of a convex drawing gives rise to a dual graph
2. When triangulating a convex graph drawing, we are introducing new adjacencies
3. A dual graph eventually becomes a rectangular dual, which is a “dimensionless”
How many triangulations per face?

The complexity behind architectural plan layout!

\[
\text{Catalan Number} = \frac{1}{(n+1)} \binom{2n}{n}
\]

Images by courtesy of Muzaffer Saracevic, et al., IMPLEMENTATION OF THE CONVEX POLYGON TRIANGULATION ALGORITHM
Possibilities

Introducing one more link may reduce the possibilities many times this number!
A Catalogue of Possibilities

A limited number of possibilities, for a class of rectangular dissections: for example, the 18 admissible triangulations and dual graphs of a convex embedding.
Dimensioning a Rectangular Diagram

visual graphs
design algorithm

MATRJOSCHKA
set building footprint and entrance
place vertical circulation and atria

number of floors
distance map
compute average distance to entrance
close to entrance fare from entrance

desired choice is a relative value;
a low value (i.e. family suite); the building more often than a room with a high "desired choice" value to "desired choice";
import list and sort it descending according to their "choiceBetweenPoints" value;

family suites 102 0 0,1
... ... ...
family suites 102 0 0,1
business hub 127 0,8 0,2
meeting and conference rooms 317 0,8 0,8
meeting and conference rooms 63 0,8 0,5
meeting and conference rooms 63 0,8 0,5
meeting and conference rooms 63 0,8 0,5
visitor information center 127 1 1
reception area 102 1,1 1
faculty club 317 1,2 1

function m² desired choice view

... repeat until all functions are allocated;
second function; second function -> smallest remaining space on two floors; room is larger than i.e. 100m² it occupies points occupied by the first function; if a
allocate functions based on the values of allocation heuristic:
the fitness of the solution is the difference between those lists (less difference > better fitness);
difference between those lists (less difference > better fitness);
difference > better fitness);

the minimal circulation
randomly add different circulation to difference > better fitness);

... rarely often
shortest path, between two points?
development of i.e. 1.2 times the length of the shortest path or a path with a maximum deviation of i.e. 1.2 times the length of the shortest path, between two points?

How often is an edge of a graph part of the choiceBetweenPoints:
calculate "choiceBetweenPoints";

... rarely often

generate circulation and room geometries;
the placed functions > circulation graph compute all possible circulation between

the minimal and maximal spanning tree to ensure a working circulation, compute

the placed functions > circulation graph
SpiderWeb
http://www.gbl.tuwien.ac.at/Archiv/digital.html?name=SpiderWeb
Urban distance
SpiderWeb Example
http://www.gbl.tuwien.ac.at/_docs/GrasshopperScriptum/GrasshopperScriptum.html?filter=SpiderWeb
Further applications

SpiderWeb Examples
http://www.gbl.tuwien.ac.at/Archiv/digital.html?name=SpiderWeb

Flattest Path connecting Points

Drainage Pattern

3D - Random Structures
Metaheuristic Solvers

Parallel Planing

Syntactic SpiderWeb Plugin

7

Field to Space

Visual Graphs

Visual Graphs

MATRJOSCHKA

design algorithm

set building footprint and entrance

number of floors

define roomheight and maximum

reception area

place vertical circulation and atria

business hub

meeting and conference room

meeting room

faculty club

meeting and conference room

ground floor 1:200

design algorithm

vertical circulation

vertical circulation

vertical circulation

function m² desired choice view

administrative office

business hub

meeting and conference rooms

visitor information center

faculty club

meeting and conference room

vertical circulation

vertical circulation

vertical circulation

ground floor 1:200

design algorithm

vertical circulation

vertical circulation

vertical circulation

function m² desired choice view
Visual Graphs Introduction
http://www.gbl.tuwien.ac.at/_docs/GrasshopperScriptum/GrasshopperScriptum.html?filter=SpiderWeb

Mean Shortest Path

Visible Area
Isovists
Visual Graphs Introduction
Benedikt M L, 1979, To take hold of space: isovists and isovist fields"Environment and Planning B 6 47 - 65

Figure 3 Three isovists in D, as created by E. - Benedikt M L, 1979,‘To take hold of space: isovists and isovist fields’‘Environment and Planning B”, p.50
Isovists
Visual Graphs Introduction
VGA - Barcelona Pavilion

Visual Graphs Introduction
Turner, A; Doxa, M; O’Sullivan, D; Penn, A; (2001) From isovists to visibility graphs: a methodology for the analysis of architectural space. ENVIRON PLANN B, 28 (1) 103 - 121.
Justified Graph

Visual Graphs Introduction

Justified Graph
Visual Graphs Introduction
Justified Graph

Visual Graphs Introduction

Justified Graph
Visual Graphs Introduction
Justified Graph
Visual Graphs Introduction
### Total Depth

**Visual Graphs Introduction**


\[
\sum_{j \in V} d_{ij}.
\]
Local Changes have Global Impact

Visual Graphs Introduction


\[ \sum_{j \in V} d_{ij} \]
Mean Shortest Path (steps) - Two Sample Points

Visual Graphs Introduction

Turner, A; Doxa, M; O’Sullivan, D; Penn, A; (2001) From isovists to visibility graphs: a methodology for the analysis of architectural space. ENVIRONMENT PLANN B, 28 (1) 103 - 121.

\[ \bar{L}_i = \frac{1}{|V|} \sum_{j} v_j \in V d_{ij}. \]
Mean Shortest Path (steps)
Visual Graphs Introduction
Turner, A; Doxa, M; O’Sullivan, D; Penn, A; (2001) From isovists to visibility graphs: a methodology for the analysis of architectural space. ENVIRON PLANN B, 26 (1) 103 - 121.
1. Create grid representation of the spatial configuration and calculate the visual graph

2. Get properties of the visual graph

3. Calculate the total depth from each graph vertex. Careful do not use “find all” option on the visual graph since it is very dense (many edges)!

4. Display
Day 1

General Introduction

Initial Design

Analysis of Design

Designing Bubblediagram

Grasshopper Plugins:
  - Syntactic
  - SpiderWeb

Day 2

Generative Designs

Discussion
Syntactic SpiderWeb Plugin
Visual Graphs
Metaheuristic Solvers
Parallel Planing

Field to Space
design algorithm

set building footprint and entrance

Metaheuristic Solvers
Parallel Planing
Visual Graphs
Syntactic SpiderWeb Plugin

number of floors
define roomheight and maximum

reception area
place vertical circulation and atria

business hub
meeting and conference room
meeting room
faculty club
meeting and conference room
visitor information center

> distance map
close to entrance fare from entrance

meeting and conference room
administrative office

> minimal circulation
randomly add different circulation to

difference > better fitness);
difference between those lists (less differ-
the fitness of the solution is the difference between those lists (less differ-

1st autogenerative step:
interpret generate geometry by hand

meeting rooms 38 0,7 0,5
family suites 102 0 0,1
… … … ..
business hub 127 0,8 0,2
meeting and conference rooms 317 0,8 0,8
meeting and conference rooms 63 0,8 0,5
meeting and conference rooms 63 0,8 0,5
meeting and conference rooms 63 0,8 0,5
visitor information center 127 1 1
reception area 102 1,1 1

function m² desired choice view

... repeat until all functions are allocated;
second function;
room is larger than i.e. 100m² it occupies
points occupied by the first function; if a
first function -> smallest value; erase all
the distance map:
allocate functions based on the values of
allocation heuristic:

desired choice is a relative value;
shortest path between all functions within
should (i.e. faculty club) be part of the
a room with a high “desired choice” value
to “desired choice”;
import list and sort it descending according
order function descending according to their “choiceBetweenPoints” value;

meeting and conference room
meeting room
double room
faculty club
meeting room

vertical circulation
going through circulation
vertical circulation and evaluate

deviation of i.e. 1.2 times the length of the
shortest path, between two points?
How often is an edge of a graph part of the
choiceBetweenPoints:
calculate “choiceBetweenPoints”;
generate circulation and room geometry;
the minimal and maximal spanning tree
compute all possible circulation between

shortest path, between two points?
shortest path or a path with a maximum

How often is an edge of a graph part of the
choiceBetweenPoints:
calculate “choiceBetweenPoints”;
generate circulation and room geometry;
the minimal and maximal spanning tree
compute all possible circulation between

meeting and conference room
meeting room
double room
faculty club
meeting room
Labyrinth Runner - Metaheuristic Solvers
Please play: http://www.gbl.tuwien.ac.at/Archiv/digital.html?name=Labyrinth_Runner
http://www.gbl.tuwien.ac.at/Archiv/digital.html?name=Inventing_Circulation_Patterns_using_Available_Metaheuristic_Solvers
Matroshka - Methaheuristic Solvers
Competition entry: Design Form the Insight Out - Envisioning a Scientific Interchange

designing form the inside out 1144
Basic Spatial Generation
Matroschka - Design Algorithm

set building footprint and entrance

define roomheight and maximum number of floors

place vertical circulation and atria
Simple Distance Analysis
Matroschka - Design Algorithm

place vertical circulation and atria
compute average distance to entrance
> distance map

close to entrance   fare from entrance
import list and sort it descending according to “desired choice”;
a room with a high “desired choice” value should (i.e. faculty club) be part of the shortest path between all functions within the building more often then a room with a low value (i.e. family suite);
“desired choice” is a relative value;

<table>
<thead>
<tr>
<th>function</th>
<th>m²</th>
<th>desired choice</th>
<th>view</th>
</tr>
</thead>
<tbody>
<tr>
<td>faculty club</td>
<td>317</td>
<td>1.2</td>
<td>1</td>
</tr>
<tr>
<td>reception area</td>
<td>102</td>
<td>1.1</td>
<td>1</td>
</tr>
<tr>
<td>visitor information center</td>
<td>127</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>meeting and conference rooms</td>
<td>63</td>
<td>0.8</td>
<td>0.5</td>
</tr>
<tr>
<td>meeting and conference rooms</td>
<td>63</td>
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<tr>
<td>business hub</td>
<td>127</td>
<td>0.8</td>
<td>0.2</td>
</tr>
<tr>
<td>meeting rooms</td>
<td>38</td>
<td>0.7</td>
<td>0.5</td>
</tr>
<tr>
<td>family suites</td>
<td>102</td>
<td>0</td>
<td>0.1</td>
</tr>
<tr>
<td>family suites</td>
<td>102</td>
<td>0</td>
<td>0.1</td>
</tr>
</tbody>
</table>

allocation heuristic:
allocate functions based on the values of the distance map:

first function -> smallest value; erase all points occupied by the first function; if a room is larger than i.e. 100m² it occupies space on two floors;

second function -> smallest remaining value; erase all points occupied by the second function;

... repeat until all functions are allocated;
compute all possible circulation between the placed functions > circulation graph

calculate “choiceBetweenPoints”;
choiceBetweenPoints:
How often is an edge of a graph part of the shortest path or a path with a maximum deviation of i.e. 1.2 times the length of the shortest path, between two points?

rarely often
1. Generative Step
Matroschka - Design Algorithm

1st autogenerative step:
order function descending according to their "choiceBetweenPoints" value;
compare this list with the imported list;
the fitness of the solution is the difference between those lists (less difference > better fitness);
reposition staircase and atria;

import list and sort it descending according to "desired choice";
a room with a high "desired choice" value should (i.e. faculty club) be part of the shortest path between all functions within the building more often than a room with a low value (i.e. family suite);
"desired choice" is a relative value;

allocation heuristic:
allocate functions based on the values of the distance map:
first function -> smallest value; erase all points occupied by the first function; if a room is larger than i.e. 100m² it occupies space on two floors;
second function -> smallest remaining value; erase all points occupied by the second function;
... repeat until all functions are allocated;

calculate "choiceBetweenPoints";
choiceBetweenPoints:
How often is an edge of a graph part of the shortest path or a path with a maximum deviation of i.e. 1.2 times the length of the shortest path, between two points?

rarely	only

compute all possible circulation between the placed functions > circulation graph
compute all possible circulation between the placed functions > circulation graph

to ensure a working circulation, compute the minimal and maximal spanning tree > minimal circulation
2nd autogenerative step:

order function descending according to their “choiceBetweenPoints” value; compare this list with the imported list; the fitness of the solution is the difference between those lists (less difference > better fitness);
randomly add different circulation to the minimal circulation

calculate “choiceBetweenPoints”;
choiceBetweenPoints:
How often is an edge of a graph part of the shortest path or a path with a maximum deviation of i.e. 1.2 times the length of the shortest path, between two points?

rarely...often
generate circulation and room geometrie;
with and height of the circulation is influenced by the value of “choice between points”;
the amount of solid / transparent wall is influenced based on the view value of the function (> see imported list)
MATRJOSCHKA

Redrawn by Hand
Matroschka - Design Algorithm

designing form the inside out 1144

section long-long 1:200

section cross-cross 1:200

first floor 1:200
second floor 1:200
third floor 1:200
fourth floor 1:200

path reception - double room - reception 1:200

Visual Graphs & Metaheuristic Solvers

Circularity Measurement (p. 53) or Isoperimetric Quotient (Q)
Visual Graphs & Metaheuristic Solvers
Benedikt M L, 1979, To take hold of space: isovists and isovist fields"Environment and Planning B 6 47 - 65

Circularity: 0.9758

For a circle this the circularity / isoperimetric quotient should be 1. As the plugin works based on a discreet space partition there is a slight error.

\[ Q = \frac{4\pi A}{L^2} \]
FOV Shape and Circularity Measurement
Visual Graphs & Metaheuristic Solvers
Benedikt M L, 1979, To take hold of space: isovists and isovist fields”Environment and Planning B 6 47 - 65
Resulting minimized geometric mean
Visual Graphs & Metaheuristic Solvers
1. Input area and grid size of the analysis grid

2. Genepools to control the position and rotation of the walls

3. Create walls

4. Create visual graph

5. Compute circularity measurement

6. Compute the geometric mean of the given solution. (fitness)

7. Use Galapagos to minimize the fitness

Grasshopper Example
Visual Graphs & Metaheuristic Solvers
Metaheuristic Solvers

Field to Space

Parallel Planning

Syntactic

SpiderWeb Plugin

Visual Graphs

Metaheuristic Solvers

set building footprint and entrance
distance map
compute average distance to entrance
shortest path between all functions within
function m² desired choice view
... repeat until all functions are allocated;
second function;
value; erase all points occupied by the
space on two floors;
room is larger than i.e. 100m² it occupies
points occupied by the first function; if a
first function -> smallest value; erase all
the distance map:
allocate functions based on the values of
allocation heuristic:
the minimal circulation
randomly add different circulation to
difference > better fitness);
difference between those lists (less
difference of solution is the
list;
compare this list with the imported
to their "choiceBetweenPoints" value;
order function descending according
2nd autogenerative step:
"desired choice" is a relative value;
a low value (i.e. family suite);
the building more often then a room with
a room with a high "desired choice" value
to "desired choice";
import list and sort it descending according
meeting rooms 38 0,7 0,5
family suites 102 0 0,1
… … … ..
family suites 102 0 0,1
business hub 127 0,8 0,2
meeting and conference rooms 317 0,8 0,8
meeting and conference rooms 63 0,8 0,5
reception area 102 1,1 1
faculty club 317 1,2 1
function (> see imported list)
influenced based on the view value of the
the amount of solid / transparent wall is
enforced by the value of "choice between
with and height of the circulation is influ-
generate circulation and room geometrie;
mal circulation;
randomly add different circulation to the mini-
the placed functions > circulation graph
compute all possible circulation between
developers...
From Graph to Field to Space

a continuous approach to spatial configuration!

Say each space is defined in simplest form as a node, then in the absence of external influences it becomes a circle or hemisphere then...
From Graph to Field to Space

ISOSURFACE:
a scalar field of values is evaluated at every point of a 3D grid; then layers of the field can be found as ‘iso-surfaces’. An isosurface is the border between those points whose attribute values are above the iso value and the ones below.

Raster3D methods are based on OTB_3DGIS.DLL
https://sites.google.com/site/pirouznourian/otb_3dgis

- voxel representation of big spatial data
- converting 3D vector data to 3D raster data and vice versa
- using voxel representation in spatial analysis
- voxel operations for spatial planning
From Graph to Field to Space

What does (might) it all have to do with architecture?

Imagine a 3D configuration composed of nodes and links (vertices and edges) as in the top picture. We can think of a field around this configuration, which looks in 2D like the slice shown at the bottom. Controlling the field we can create the boundaries of spaces as isosurfaces!

From Inside Out!? Try it out! bubble diagram-to-field-to-space!?
Metaheuristic Solvers

Syntactic Visual Graphs

MATRJOSCHKA set building footprint and entrance

number of floors define roomheight and maximum place vertical circulation and atria meeting and conference room

meeting room faculty club

meeting and conference room

visitor information center

> distance map compute avreage distance to entrance close to entrance fare from entrance

meeting room administrative office

meeting and conference room ground floor 1:200

interpret generate geometrie by hand

administrative office

business hub

meeting and conference rooms 38 0,7 0,5

family suites 102 0 0,1

... ... ...

family suites 102 0 0,1

business hub 127 0,8 0,2

meeting and conference rooms 317 0,8 0,8

meeting and conference rooms 63 0,8 0,5

visitor information center 127 1 1

reception area 102 1,1 1

faculty club 317 1,2 1

... repeat until all functions are allocated;

vertical circulation

how often is an edge of a graph part of the shortest path, between two points?

deviation of i.e. 1.2 times the length of the shortest path or a path with a maximum

choiceBetweenPoints: calculate "choiceBetweenPoints";

the amount of solid / transparent wall is influenced based on the view value of the function (> see imported list)

influenced based on the view value of the function (> see imported list)

influenced based on the view value of the function (> see imported list)

...
Parallell Planing
Process 1: Spatial Configuration e.g.: “Gründerzeit“ Building in Vienna
Parallel Planning
Process 1: Spatial Abstraction
Parallel Planing
Process 2: Wanted Spatial Configuration eg. Flats

Parallel Planing
Matching Process 2 > Process 1
Parallel Planing
Figure 5. Modal algorithm (dotted lines show symmetry axes). (a) (b) Two possible mappings for a roof-like shape (one reflectional symmetry); (c) (d) two of four possible mappings for a rectangle (two reflectional symmetries); (e) rectangle skewed by small perspective distortion; (f) two skewed shapes whose modes are too dissimilar to match.
Graph Representation
Parallel Planning
http://www.gbl.tuwien.ac.at/_docs/GrasshopperScriptum/GrasshopperScriptum.html?filter=Graph%20Re
Different Graphs?
Parallel Planning
Graph Drawing by Eigenvectors
Parallel Planning

Pirouze Nourian, Richard Schaffranek
www.tudelft.nl, www.gbl.tuwien.ac.at
Generative Syntax in Architecture and Urban Design
AAG 2014
(a) Graphs X, Y.  
(b) Projections of graphs X and Y into 2D eigenvector subspace.

Inexact Graph Matching
Parallel Planing
Further Readings

**Space Syntax**
- Hillier B., 1999, “The hidden geometry of deformed grids: or, why space syntax works, when it looks as though it shouldn’t” Environment and Planning B: Planning and Design 26; p 179

**Graph Analysis**

**Visual Graphs**
- Turner, A; Doxa, M; O’Sullivan, D; Penn, A; (2001) From isovists to visibility graphs: a methodology for the analysis of architectural space. ENVIRON PLANN B, 28 (1) 103 - 121.
- Benedikt M L, 1979,"To take hold of space: isovists and isovist fields"Environment and Planning B 6 47 - 65

**Generative Design**

**Spectral Graphs**

**Graph Drawing**
- Tutte, W. T., 1963. How to draw a graph. s.l., s.n.
**Pirouz Nourian** is PhD researcher and instructor of computational design at TU Delft since 2010. In addition to his regular studios at TU Delft in courses like High-rise Buildings and XXL buildings, he has taught computational urban design in international workshops in Delft (eCAADe Urban Datascope 2013), Istanbul (Tarlabası Datascope 2013), Tehran (master class on high-rise design 2012), Lisbon (Measuring Urbanity 2012), Delft (HYPERBODY master class of computational design 2011). His main research interests are graph-theoretical design, spatial analysis, and configuration of street networks, density distributions and land-use allocation patterns. Released tool suites for computational design: SYNTACTIC & CONFIGURBANIST

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**Richard Schaffranek** is doctoral candidate and instructor of computational design / planning at Vienna UT since 2010. He has been teaching design studios at the TU Vienna with a focus on the application of algorithmic tools in planning. Together with three colleges, he contributed to the curriculum of the TU Vienna through introducing an algorithmic planning and analysing "Module" (a package of four courses for the diploma students in architecture). He is responsible for the development of a plugin for Grasshopper, “SpiderWeb”, enabling graph-based algorithms, which was presented for the first time in a workshop at AAG2012. His current focus is on statistical methods as a tool in generative design methods.

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Workshop presenters