

THE ONE- AND TWO-DIMENSIONAL ISOVISTS ANALYSES IN SPACE SYNTAX

7.1 INTRODUCTION

This contribution aims to show the spatial properties for indicating degrees of street life, safety and economical attractiveness in urban areas through analysing the one- and two-dimensional visibility analyses of the space syntax method. The space syntax method is able to calculate the spatial configuration of built environments and compare it with numerical socio-economic data. The most known method is to calculate how spatially integrated a street is in relation to all others in terms of direction change and degree of angular deviation. It is able to identify the streets' spatial features for vital shopping areas, crime distribution, various social classes' spatial preferences when choosing a dwelling area, and the spatial features of the location of various institutional buildings. The space syntax method's elements are based on visual sight lines. Examples from Delft and Alkmaar will be used for showing the correlations between the spatial analyses and socio-economic data.

7.2 THEORETICAL FRAMEWORK, METHODS AND TECHNIQUES

In the past three decades the space syntax method, developed by Bill Hillier and his colleagues at the University College London, have been applied to urban studies. This method

consists of calculating configurative spatial relationships of built environments' public spaces.

In urban analyses, according to Hillier, space syntax is three things. Firstly, it is a family of techniques for *analysing* cities as the networks of space formed by the placing, grouping and orientation of buildings. Secondly, it is a set of techniques for *observing* how these networks of space relate to functional patterns such as movement, land use, area differentiation, migration patterns and even social wellbeing and malaise. Thirdly, based on the empirical results from the two first things, space syntax has made it possible to make a set of *theories* about how urban space networks relate in general to the social, economic and cognitive factors which shape them and are affected by them. The techniques have been applied to a large number of cities in different parts of the world. In this way a substantial database now exists of cities, which have been studied at some level using space syntax (Hillier et al., 2007).

What space syntax measures is the two primary all-to-all (all street segments to all others) relations. On the one hand it measures the *to-movement*, or accessibility, potential, of each street segment with respect to all others. With other words, it measures the location potentials for various urban centres. On the other hand space syntax measures the *through-movement* potential of each street segment with respect to all pairs of others. To say it differently, it measures the spatial potentials for streets with the highest potential flow of movement. Each of these two types of relational pattern can be weighted by three different definitions of distance. The *metric* distance measures the city's street and road network as a system of shortest paths, while the *topological* distance calculate the city's street and road network as a system of fewest turns paths. Finally, the *geometrical* distance gives a picture of the city's street and road network as a system of least angle change paths. Each type of relation can be calculated at different radii from each street segment, defining radius again either in terms of shortest, fewest turns or least angle paths (Hillier and Iida, 2005: 557-558).

Hillier distinguishes between intrinsic and extrinsic properties of space. Extrinsic ones determine the way in which spatial units relate to one another. According to Hillier, spatial configuration has its own rules (Hillier, 1996: chapter 8). If one intends to understand settlements in terms of these laws they are regarded as sets of *spaces*. In this perspective primarily topological issues become relevant. Volumes, textures and size are not taken into consideration. When regarded in purely extrinsic terms, spaces are shape-free. It is just their inter-relational aspect or structure that counts here. Each space has one or more functions either for occupation or movement. Extrinsic properties of space concern built form and function (Marcus, 2000: 40).

While extrinsic properties of space concern invisible, structural relationships, intrinsic properties concern visible ones. They rely on things we can see, such as the shape, the size, the

volumes, and the objects placed in space, and the texture of physical objects or built masses (Hillier, 1999e: 1). They consist mostly in geometrical properties. Describing and illustrating the intrinsic properties of a built environment does not abstract from meaning and intentions external to it. First and foremost, a physical object's purpose is important at the time it was made. In later contexts it is mostly left out of consideration. In this respect, intrinsic properties of space account for the inter-relationship between built form and social meaning (Marcus, 2000: 40). In research traditions belonging to urban morphology and place phenomenology, the concepts of space relate to intrinsic properties of space. Namely, they consist of descriptions of building typologies, property patterns, building morphology, forms of squares, and the shapes of built volumes, windows, and doors.

As intrinsic properties of space are perceptible and describable rather easily, there exist several writings about them. A narrow street, an intimate square, a large massive building, and a star shaped junction – they can all illustrate how to describe these properties of space in a built environment. On the other hand, however, it is rather difficult to describe extrinsic properties of space. Concepts like 'here' and 'there' or 'inside' and 'outside' are used to refer to seemingly simple spatial relationships. But as soon as one tries to describe whole buildings or towns, our language seems unable to spell out complex spatial relationships. Therefore abstract models or maps are often used to present such complex systems of space.

Describing extrinsic properties of space requires considering the city as a set of spaces. In terms of how we name things, urban space is recognised to be mostly linear. Apart from squares, one disposes of several names for the routes between them. Examples are alleys, streets, roads, avenues, boulevards, highways, paths, pavements, subways, bridges, stairs, etc. All these kinds of urban spaces shape a grid or network – a potential pattern of movement. The urban grid is defined to be “the pattern of public space linking the buildings of a settlement, regardless of its degree of geometric regularity” (Hillier, 2001: 02.1). If one looks at city maps most tourist offices distribute to visitors, the street grid is the most detailed represented part. Important buildings and squares may be indicated, but not in such a detailed scale as a whole street grid. Therefore, the urban street grid can be represented as a set of axial sightlines.

For more than 20 years ago, most calculations of the spatial relationship between these axes were done manually. Later on, several software programs, such as Axman, Uba Pesh, Orange box, Axwoman, Mindwalk, Webmap at home, and Meanda have improved the possibilities to analyse the complex spatial relationships of the public spaces of whole cities. The Depthmap software is able to describe and visualise a built environment's spatial inequalities, make point depth analyses, isovists analyses, all-lines analyses, and to simulate and trace movement routes of computer-generated agents. The way these agents move is based on research in a present urban context (Turner, 2007).

7.3 SPACE SYNTAX' ELEMENTS

The Space Syntax method operates with the following three basic elements: convex space, isovist field and axial line. A *convex space* is defined as a space such that “all points within that space can be joined to all others without passing outside the boundary of the space” (Hillier 1988: 68). The panoptical view is essential in the definition of what a convex space is. It is mostly used for occupation of various functions and place-bound human activities such as standing and sitting. Convex maps are used for analysing buildings and the public spaces between a group of buildings in neighbourhoods or smaller villages. In the urban analyses, the point depth and the all-lines analyses have replaced the convex space analysis. An explanation might be the time consuming work to make the convex map. Moreover, no software improvement has been done since the 1990's for the convex space analysis.

An *isovist field* represents the panoptical view a person has from a given point in an urban space. It is used for orientation or way finding in the urban fabric. First it was done manually. Now one-point as well as all-points isovist analyses can be carried out with the Depthmap software.

An *axial line* represents the longest sight line one has in an urban space or street. It represents the way human beings moves in lines through the urban street and road network. During the last two decades the axial line has been the basic spatial element in the methodology and theoretical development of space syntax in urban studies.

The main thought behind these three basic spatial elements is that human beings move in lines, interacts in convex spaces and sees changeable panoptical views when moving around in the built environment.

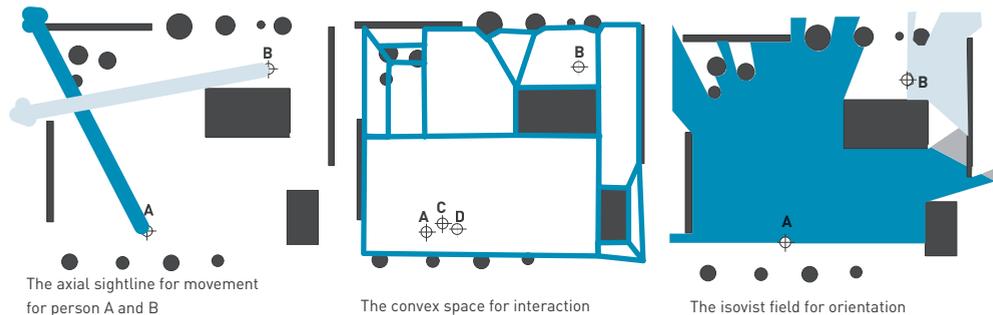


Figure 1
Example of axial lines, convex space and isovist field

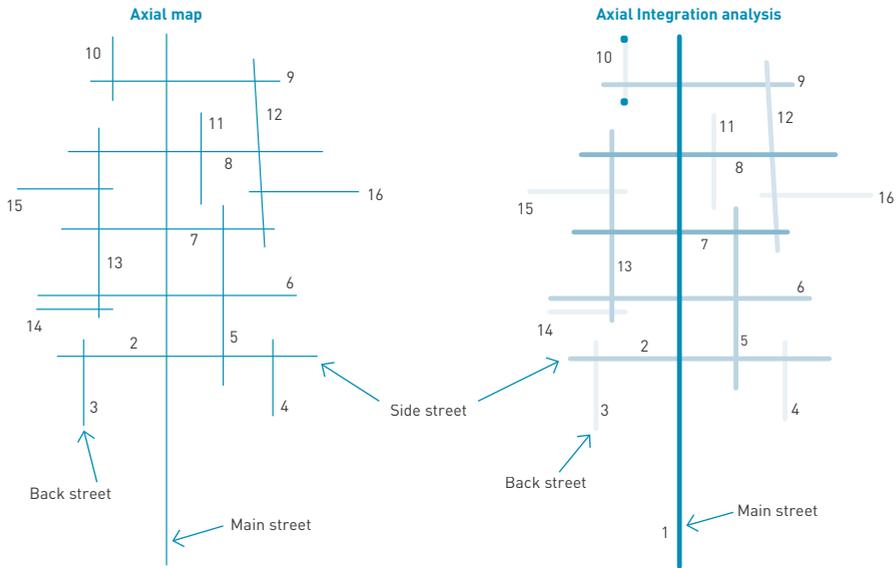
7.4 THE ONE-DIMENSIONAL VISIBILITY ANALYSES

The basis for the space syntax method in urban studies is the *axial map*. The street and road network in built environments is represented with the longest and fewest sight lines. Therefore, direction changes in terms of visibility are presented. The notion of *syntactic step* on an axial map is meant to represent a change of direction from one axial line to another. The number of syntactic steps from each axial line to all other axial lines measures a settlement's *topological depth*.

A *global integration analysis* implies the calculation of how spatially integrated a street axis is in terms of the total number of direction changes to all others in a town or city. The fewer direction changes to all other streets, the higher spatial integration values. Conversely, streets with many direction changes to all others tend to have low global integration values. Hence, they are spatial *segregated*.

This simple one-dimensional analysis makes it possible through the Depthmap software to analyse whole cities and large metropolitan areas. As research has shown, streets with the fewest direction changes to all other streets in a built environment tend to be the most vital shopping streets with the highest flow of human movement (Hillier et al., 1993, 1998). Conversely, streets with a very high number of direction changes tend to be affected by crime and anti-social behaviour or they tend to be gated communities (Hillier, 1996; López and Van Nes, 2007; Hillier and Shu, 2000; Hillier and Sahbaz, 2005).

Figure 2 shows a simple settlement consisting of a main street with some side streets and some smaller back streets. On the right side the town's street network is represented as a set of fewest axial sight lines. Each axis is represented as a public urban space, connected to other public urban spaces. One can thus calculate how each axis is inter-related to all other axes in this system. In other words, one calculates the *topological depth* of each axis in relation to all other axes. Each time one has to change direction one has taken a syntactic step. This basic calculation is also used in the convex space analyses as well as in the all-lines and all-points isovist analyses. Figure 2 shows how the degree of spatial integration of the back street (axis number 3) is calculated. Every time one changes direction from the street, one multiplies the number of direction change from the street number 3 with the number of streets that can be reached. The total depth from street number 3 to all other streets is 50. When comparing the total depth from back street 3 with the main street, the total depth is 28 (below in figure 2). On the left in figure 2, the formula for calculating spatial integration is shown. The formula is useful when comparing changes in integration when cities grow, or changes due to new road or street links.



Calculating axial integration:

Mean depth for each axle (MD):
 $MD = \text{sum depth}/k - 1$
 $k = \text{number of axes in a system}$
 $\text{sum depth} = \text{the topological depth from each axle to all others}$
 $D_k = \text{diamond value}$

Calculating the back street axe:

$(MD) = \text{sum depth}/k - 1 = 50/16 - 1 = 3.3$

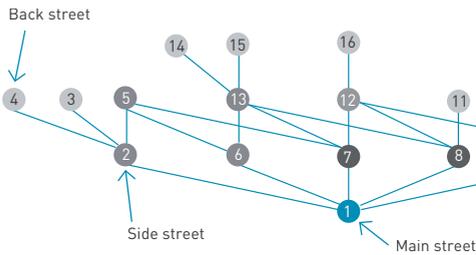
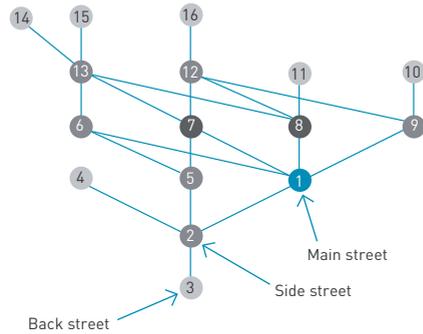
Real asymmetry (RA) = $2(MD - 1)/k - 2 = 2(3.3 - 1)/16 - 2 = 0.3333333333$

Real relative asymmetry (RRA) = $RA/D_k = 0.3333333333/0.086 = 3.87596899224806$

Integration value of the back street:
 $1/RRA = 1/3.87596899224806 = 0.258$

$5 \times 3 = 15$
 $4 \times 4 = 16$
 $3 \times 4 = 12$
 $2 \times 3 = 6$
 $1 \times 1 = 1$
 $0 \times 1 = 0$

 Sum Depth: 50



Depth: $3 \times 3 = 9$
 $2 \times 7 = 14$
 $1 \times 5 = 5$

 $0 \times 1 = 0$
 Sum depth = 28

Figure 2
 How spatial integration is calculated in a simple settlement



Figure 3
Global integration analyses of Delft

Figure 3 shows a *global integration* analysis of Delft. As can be seen in the figure, the modern shopping centre in *De Hoeven* area has the most integrated streets (coloured in black). It is the most accessible area in Delft in terms of the fewest direction changes from every street to all others. The second best integrated area is the newly established *Zuidpoort* shopping area at the edge of Delft centre. The most segregated streets (coloured in light grey) are in the *Tanthof* area and some of the post war housing areas.

The *local integration* analysis highlights the various local urban centres. It is done as follows: one calculates how integrated an axis is when changing the direction three times from it. The Depthmap software calculates this for every axis in the whole built environment. Figure 4 shows a local integration analysis of Delft. The various local shopping streets in Delft historic centre are highlighted in black. The highest locally integrated shopping street is the *Binnenwatersloot – Nieuwe Langedijk* connection.



Figure 4
Local integration analyses of Delft

During the last 10 years the angular relationship between the axial sight lines have been taken into account. This made it possible to highlight the main routes going through and between urban areas in cities through a pure calculation of spatial interrelationships. A city consists of a very small number of long streets that end up at another long street with an angle close to 180 degrees, and a very high number of short streets, ending up with an angle close to 90 degrees to another street.

This visibility property of a city's street and road network makes it possible for people to guide themselves from the edges towards the city centre with a few direction changes and small angular deviations. In particular in large complex cities, the angular analyses can show how the city's edges can reach the centre through the network of the main routes. The long lines have thus long visibility properties, and at the junctions one can see how the long lines continues with a small angular deviation to another long line.

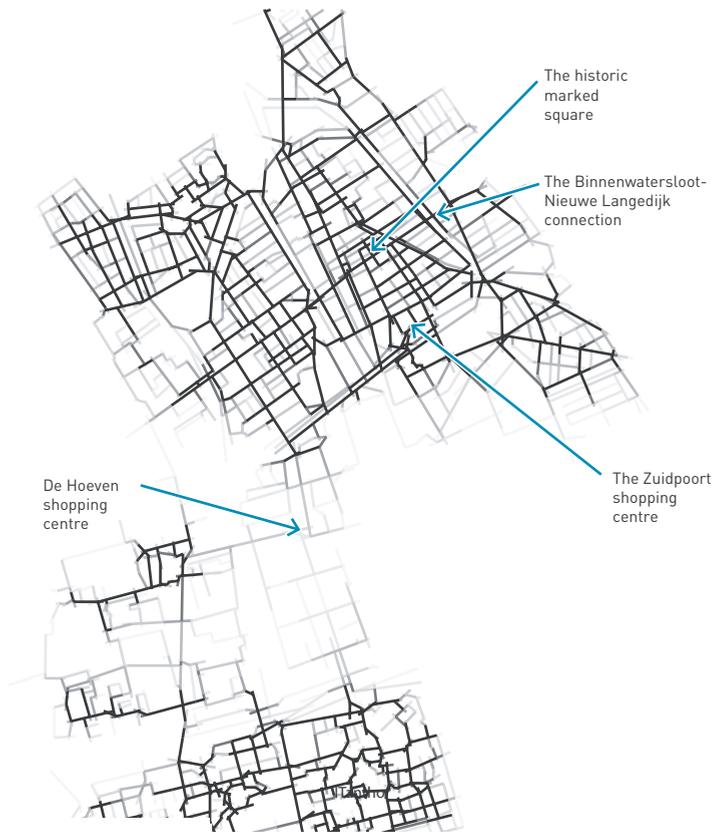


Figure 5
Local angular analyses of Delft with low metrical radius

The axial line is still the basis for the angular analyses. When processing the angular analyses in Depthmap, the software breaks up the axial lines at every junction. At every junction an angular weighting is made. The fewer direction changes in terms of angular deviation, the higher values of the street segments.

One of the critics of the space syntax method was the lack of *metrical* properties in the analyses (Ratti, 2004). Now it is incorporated into the calculations. As the results show, the geometrical and topological distances correspond with the pedestrian and vehicle flow rates and the location pattern of shops more than the metrical *distances*. However, when applying metrical *radiuses* in the angular and axial analyses, some striking results can be seen.

Figure 5 shows an angular integration of Delft with a low metrical radius. The various local vital shopping streets are highlighted. When increasing the metrical radius to a high value, the

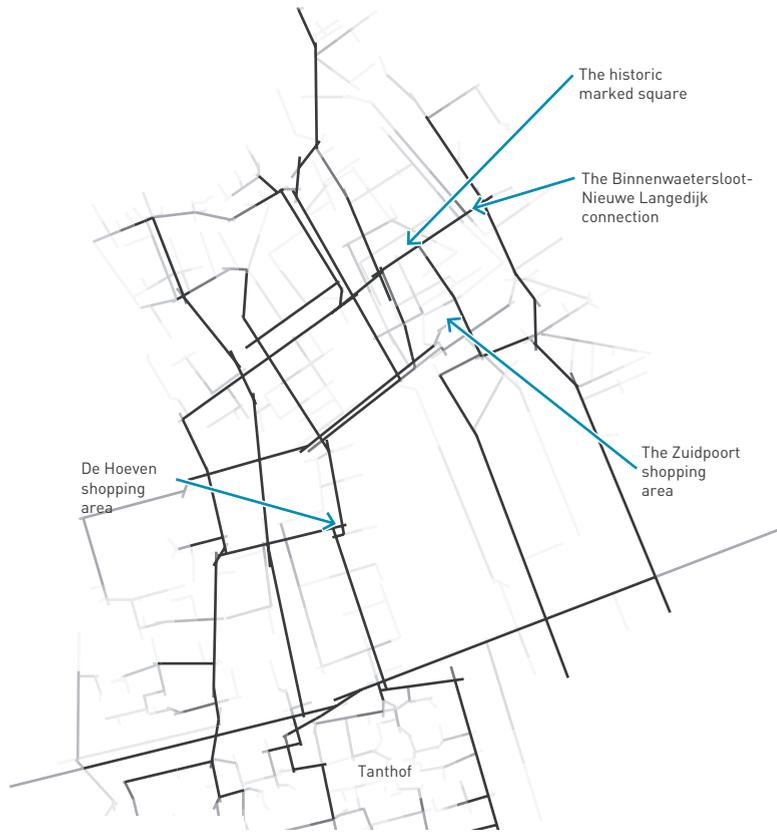


Figure 6
Local angular analyses of Delft with high metrical radius

main routes linking the various urban areas together are highlighted. Figure 6 shows a local angular analysis with a high metrical radius. Here the *Binnenwatersloot – Nieuwe Langedijk* axis has the highest values, and the main streets for car traffic are highlighted.

When comparing the results from figure 5 and 6, the following can be stated. In traditional urban areas the main routes and the local shopping areas are located adjacent or in the same street, where the street network has high values in both a high and low metrical radius. Seemingly, a condition for a vital shopping area is to have a dense inter-connected street network within a short metrical distance in order to catch the local customers. Moreover, it needs also to be located on or adjacent to the integrated segments of the main routes in order to catch the through travellers.

In post war urban areas, the most integrated areas with low metrical radiuses are not located in the same place as those within the high metrical radiuses. The effect is that inside the housing area there is only one local super market with the necessary food facilities located along street, with high integration values with a low metrical radius. Sometimes there are no shopping facilities at all in these areas. Car-based shopping centres tend to locate along streets with high integration values with a high metrical radius.

In Delft the post war urban areas have almost no shops inside their areas. The shopping centre *De Hoeven* serves most of the surrounding post war neighbourhoods. In Delft centre, the newly established *Zuidpoort* shopping centre is located adjacent to the fine-grained network of local shopping streets, while it is located along a highly integrated road with a large metrical radius.

While the traditional global and local integration analyses measures the *to-movement* potential, the angular analyses with metrical radiuses measures the *through movement* potential. Together these spatial measurements of the street and road network can show the degree of spatial inequalities on various scale levels. The results from research are useful in order to predict to some extent the socio-economic effect of proposed design interventions for future built environments, as well as understanding socio-economic activities based on the information of the physical form in excavated town or past built environments (van Nes, 2009).

The visibility component is essential for a human being's orientation in complex built environments. In a recent finished MSc thesis about the effects of the tsunami in Banda Aceh, a correlation was found between the spatial configuration from the axial analyses and the mortality rates. The more spatially broken up the street grid the lower integration values on the axes, the higher the mortality rates in the neighbourhood. The data about mortality rates was gathered from the local Red Cross based on neighbourhood levels. It was established from the interviews that people fled in the opposite direction of the tsunami. As claimed in the perception psychology literature, people cannot think rationally in the case of panic. The visual orientation plays a role in orientation when people are fleeing. Therefore, highly integrated neighbourhoods on various scale levels are indicators for way finding (Fakhrurrazi, 2010).

7.5 THE TWO-DIMENSIONAL VISIBILITY ANALYSES

On a neighbourhood level several tools exist for taking two-dimensional spatial aspects into account. The *isovists analyses* are useful for analysing the degree of visibility of the location of important urban artefacts (like towers), or the panoptical view of urban spaces when arriving in a place at the railway station, and how new urban interventions will increase or decrease existing isovists' views. Moreover, isovists analyses are useful in studies on how trees and vegetation can

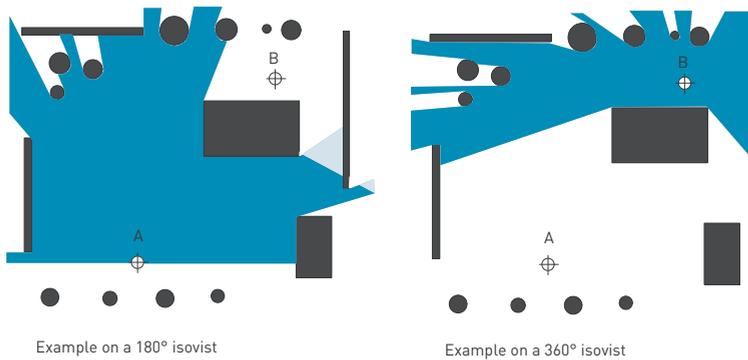


Figure 7
Example on a 180- and 360-degree isovist

block the degree of inter-visibility in parks. It can identify places attractive for junkies to operate, or places where there might be a risk of getting raped.

According to Benedikt, an isovist is: “the set of all points visible from a given vantage point in space and with respect to an environment” (Benedikt, 1979: 47). It visualises the panoptical view from the viewer from a particular standing point in a built environment. The panoptical view’s borders are defined by walls and free standing objects such as trees, bushes and statues located inside a built environment’s spaces. When moving around in built environments, the shape and size of the isovist change. It is thus possible to visualise the sequences of scenes or panoptical view arrows from particular points along the movement routes.

The applicability of isovists fields is manifold. As figure 7 shows, one can choose for a 180- or a 360-degree isovist field. The first one is what one sees when one for example enters a park, while the latter one shows what one can see when turning around right on the spot where one is standing.

Consider person A entering a place, as shown in figure 7. He or she is a visitor to this park and wants to have an overview over the area. Behind a building person B is standing. B is a junkie and needs a place where nobody can see him or her when operating. Person A and B can not see each other. Since person A is walking into the park, an isovist field of 180 degree is made. It visualises A’s direct view. Person B has to know that few people can see him or her. Therefore an isovist field of 360 degree is made from B’s position. The isovist field for person A is larger than person B, because person A is standing at a place in the park with a large overview. Person B is hidden behind a building, a fence and some trees which affects his or her isovist field. Drawing the isovist from a given point is a way of visualising the spatial possibilities on how children,

junkies and criminals can hide away from the social control of adults. Likewise, it visualises the spatial possibilities from where one can get a maximum view of an urban square.

The *point depth analyses* show the degree of visibility from every point of the public spaces of a neighbourhood. This method is useful to test out where the most visible and less visible areas are in urban squares and post-war housing areas with free standing buildings and the degree of visibility in urban parks. In particular it can describe the spatial properties in terms of inter-visibility in the unsafe spaces of parks and squares. The method is useful for testing out how the placement of trees and bushes can affect a park or a square's degree of inter-visibility.

As shown in the previous section, the isovist is a polygon, which contains the perceived visible area from a particular location. By using graph analyses, the software Depthmap is able to calculate the degree of integration of each point or isovist's root in relationship with the others in a built environment. All public spaces in a built environment are rasterised by a grid. One can choose how fine-grained the grid can be. The more fine-grained the grid is, the more time consuming the analyses is, however, the more exact the results will be.

Each point for the visibility analyses is taken from the centre of each cell's square. How integrated each point is in relationship to other points is calculated. The various integration calculations presented in earlier chapters can be used. Every time one moves from one cell in the grid to another, one takes a topological step. What the point depth analysis does, is to calculate how each cell relates to all other cells in the grid. Obstacles, like walls, fences, trees etc, contribute to increase the topological depth between various cells (Turner, 2007).

Figure 8 shows a point depth analysis of the same park used in the previous example. As can be seen from the figure, the large open space in the park is the most integrated one (coloured in black), while spaces behind buildings and trees are the most segregated ones (coloured in light grey).

When applying the point depth analyses with isovist properties on the public spaces in delft centre, the canals and the roads outside the centre are the most visible public spaces in Delft. Most of Delft's significant buildings, richly articulated in their architectural expressions, are located along these highly inter-visible spaces.

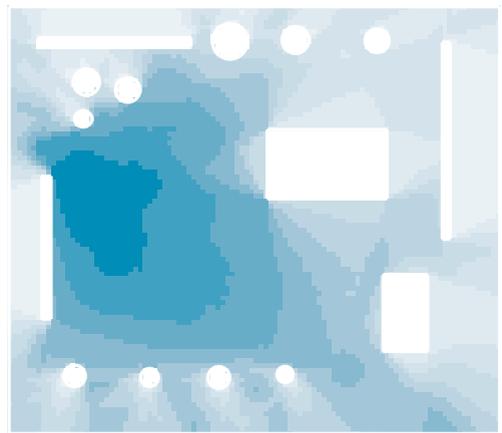


Figure 8
Point depth analyses of the park



Figure 9
Point depth analyses with isovist properties of Delft centre

While the point depth analyses shows how integrated each point is in a public space, the *all lines analyses* shows how integrated each sight line is in relationship to all other sight lines. The software Depthmap is able to make an all-line map of all the public spaces in a settlement. When preparing the basis map before processing, all obstacles and urban blocks are represented as polygons. All the publicly accessible spaces are represented as one space (Penn et al., 1997).

As research has shown, the degree of visibility of urban spaces affect the way users behave in these spaces. The higher the inter-visibility, the more it generates a mix of people of different social classes, genders, races and ages in public spaces. When comparing the results from the registration of human behaviour with the all lines analyses, the results comply with the dispersal of the integration values. The more spatially integrated the street is, the more people on streets and the more mix of women and men, age groups and ethnicity can be seen in these highly integrated areas. Conversely, the more spatially segregated the streets are, the fewer people on streets and the more the streets are dominated by unemployed immigrant men or groups of youngsters (Rueb and Van Nes, 2009).

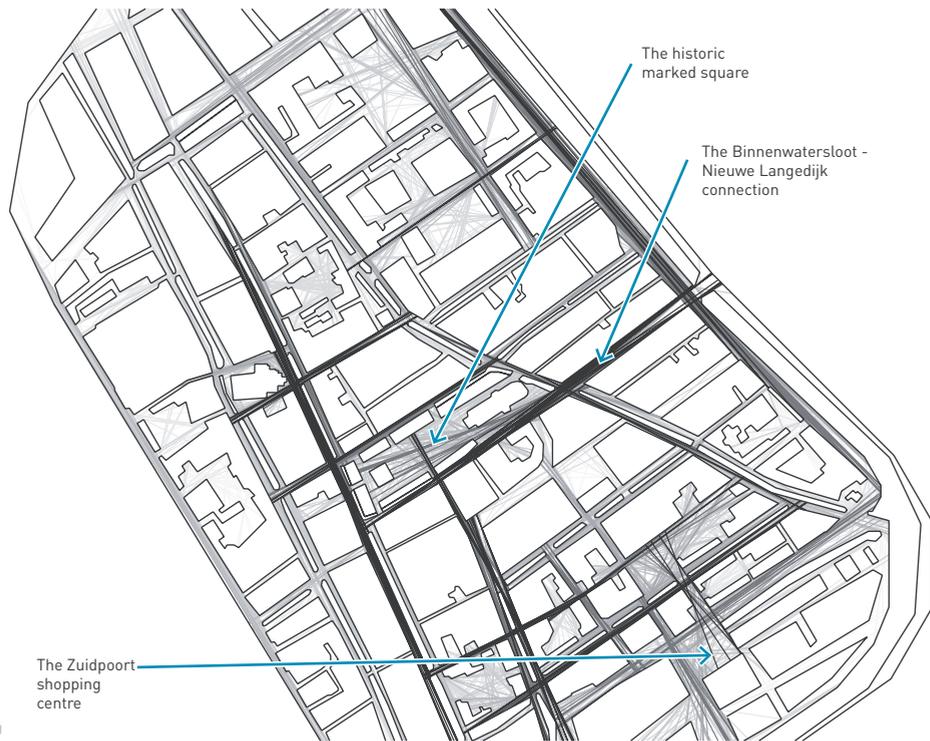


Figure 10
All lines analyses of Delft centre

Figure 10 shows an all lines analyses of Delft centre. In comparison with the point depth analyses, the most integrated lines are on the *Binnenwatersloot – Nieuwe Langedijk* axis, *Brabantse Turfmarkt*, and *Wijnhaven*. These streets are the most frequented streets and most individual shops are located along these streets. Modern urban housing areas are located along the most segregated spaces. While the point depth analysis shows visibility properties, all lines analysis shows accessibility properties. The first one influences the architecture of adjacent buildings, while the latter one affects the location of shops.

The recent developed *agent based modelling* in the Depthmap software is based on how people in fact orientate themselves through urban areas. Through empirical testing of how people orientate themselves through virtual environments with strange angles, correlations between the results from the all lines analyses and point depth analyses are found. The least angular deviation from one's direction plays a role in how people orientate themselves through built environments (Conroy, 2001). Therefore, this research's result can be useful in estimating how urban spaces will be frequented in the future as well as how they were frequented in the past.



Figure 11
Agent based modelling of Delft centre

Figure 11 shows the traces of 5000 people moving inside Delft centre's public spaces from the agent based modelling in Depthmap. When comparing the results with the various spatial analyses, the highest locally integrated main streets comply with the results from the agent based modelling.

The recently developed *micro scale urban analyses* tools are about the relationship of buildings or private spaces and their inter-relationship with street segments. More precisely it is about demonstrating how dwelling openings relate to the street network, the way building entrances constitute streets, the degree of topological depth from private space to public space, and inter-visibility of doors and windows between buildings.

Since no software development is current available for analysing micro scale spatial relationships, Microsoft excel and Statistical Package for the Social Sciences (SPSS) software are useful. In a study on space and crime in Gouda and Alkmaar, 1,168 street segments were registered



Figure 12
Degree of inter-visibility between buildings and streets in Alkmaar compared with the dispersal of burglaries

manually for the micro scale analyses part. All data were put into SPSS for comparison in order to run multi variable statistical comparisons between the various spatial parameters. As the results from the spatial analyses in Gouda and Alkmaar show, both micro and macro spatial variables are highly inter-dependent (López and Van Nes, 2007). The more segregated a street segment is, the lower the inter-visibility between doors, windows and streets is. In other words, the higher the spatial segregation of a street, the more the entrances are turned away from the street. Streets with low inter-visibility from windows and doors to streets tend to have high burglary rates (van Nes and Lopes, 2007).

Figure 12 shows the degree of inter-visibility between buildings and streets in Gouda's local area. The black coloured lines illustrate 100% visibility, the dark grey lines illustrate 80% visibility, the grey lines illustrate 60% visibility etc. The very light grey lines show 0% inter-visibility. Most intruded homes are entered from the streets or back paths with 0-20% inter-visibility.

The two-dimensional spatial measurements depend on the results from the one-dimensional analyses. Together they offer at least knowledge about the spatial conditions for different issues, such as vital street life, urban safety, vital shopping areas, social interactions and their interdependence. All seems to depend on various degrees of adjacency, permeability and inter-visibility taken into account on different scale levels. In particular results from research contribute to understandings on the socio-economic effects of one's design proposals when applying these tools in urban design.

7.6 THE THREE-DIMENSIONAL VISIBILITY ANALYSES

So far, two-dimensional isovist analyses have been applied in urban research and even in strategic planning and design. At present, software capable of analysing three-dimensional isovists have been developed by Van Bilsen and Stolk (2007). In the development of three dimensional measures, the first steps have been taken: spatial openness by Fisher-Gewirtzmann and Wagner (2003), sky opening by Teller (2003), real world measurements of the latter by Sarradin (2004) and more recently various measures in digital landscape models (DLMs) by Morello and Ratti (2009). However none of these can be considered a general three-dimensional approach. For example, DLMs cannot adequately represent cities when it comes to observer experience of inside spaces (roofed) and outside spaces (arches, bridges, etc.). Technology used for entertainment games is improving at an exponential rate. This technology is used to obtain large amounts of visibility information on acceptable timescales: full three-dimensional analyses have become feasible (van Bilsen, 2009, 2008).

The added value of three-dimensional analysis, compared to two-dimensional analysis, is summarised in the following (non exhaustive) list of points (van Bilsen, 2009):

- The vertical dimension (e.g. building height) is ignored in two-dimensional analyses;
- Walkable surfaces of cities differ in height, such as on hills and bridges;
- Incomplete landmark analysis in two-dimensional analyses, if any;
- Facade analysis, the inter-visibility between facades with regard to privacy, is possible in three-dimensional analyses;
- The possibility to relate to concepts relevant to urban design and planning like building density and incidence of sunlight, which are based on three dimensional measures;
- Comparison of perspectives with regard to safety (e.g. adult and child);

- A typology of space based on the full three-dimensional environment;
- A connection to cognitive pattern recognition, which occurs in three-dimensional analyses;
- Discrimination of lighting and cover conditions during night and day, bad and good weather, for navigation and safety.

However, due to a lack of research funding, it has never been applied systematically on various types of urban areas and correlated with socio-economic data. Seemingly, a three-dimensional isovist analyses can shed some light on to what extent building heights and building topography affect human perception and the social life between buildings.

7.7 CONCLUSIONS

The space syntax method can be applied on a wide scale level in research on built environments – from the organisation of furniture in a room up to the metropolis, making possible, in the first instance comparison of built environments with one another from a spatial point of view. Similarly, the method is a useful tool for comparison of the spatial changes in a before and after situation of structural urban changes in an area. However, while the method is a tool for explaining the physical spatial set up of buildings and cities, the interpretation of the results from the spatial analyses must be done in correlation with understanding of the societal processes and human behaviour.

Space syntax develops constantly. Its contribution to theories on built environments and methodology develop at the intersection of natural, social and technical sciences. So far, research projects range from anthropology or cognitive sciences to applied mathematics and informatics and touch upon philosophical issues. The evolution of space syntax asks for communication not just between various cultural contexts, but also likewise between different scientific domains.

As regards the development of scientific theories on the built environment, several credits have to be given to Space Syntax theory for applying it to research on the space and society relationship in built environments:

Firstly, the method has a high degree of testability. For it can be used in order to investigate various kinds of settlements belonging to different cultures. The choice of spaces as basic elements for explaining and comparing settlements allows for a rigorous comparison of settlements, independent of their cultural context (Hillier, 2001: 02.4). The space syntax method's context independence makes it applicable on all types of built environments, independent of types of societies, political structures and cultures. Therefore it is recognised to be a sustainable solid analyses and research method on built environments on various scale levels of a wide range of different cultures.

Secondly, the explanatory power of Space Syntax theory lies in the possibility to derive various effects from urban spatial changes. Configurative changes in the street grid are for example a sufficient condition for a change in according integration values. Likewise, a change in the integration values is a sufficient condition for a number of socio-economic changes. These functions are recognised to decide upon the locations of shops and the flow of pedestrian and vehicle movement. The theory thus allows for a high degree of predictability for future economically driven functional changes.

Thirdly, the theory's degree of falsifiability is of great interests. Taken in isolation the usage of laws of spatial combinatorics as meta-structures for the built environment is an application of an axiomatic method. In this respect Space Syntax theory is nothing but an *application* of mathematics to the built environment. In this way, this empirical theory is stated clearly, developed through 30 years of trial and error, conjectures and refutations. General statements gained through the application of the space syntax method on one type of built environment can be found in other types of built environments.

Fourthly, the method's whole key lies in a concise definition of space. It has contributed to operational and uniform research methods, which again has contributed to solid theories and generalisations on the relationship of society and space in urban studies.

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