Space Syntax and/in Archaeology

The following paper has been written for the purpose of the „DAJ1 Odborná jazyková příprava pro DSP - Academic Writing in English", however its parts will be used in my doctoral thesis in a chapters focusing on introduction, methodology and state-of-the-art Space syntax method and applications.

The overall structure of this paper takes the form of several interconnected parts. In the first section the historical development of the Space Syntax method is presented. The introduction to the method will be explained in the second part and the basic theoretical framework will be presented together with terminology. The third part will give an overview of the most notable application of Space Syntax methods in historical studies with a focus on archaeology. The last section of this paper will serve as a conclusion of this text.

Historical background

The question of the relationship between human activity and the built environment was raised in the 19th century, in a time where theories of cultural evolution were formed. Through the years various explanations were put together. These explanations vary from environmental determinism to social evolution, from collective to individual responsibility. Despite the different attitude **most archaeological theories agree that the way people construct and organize and even furnish their living space, have reflection in the social, cultural and political or even symbolical structures** (CUTTING 2003: p. 3; STÖGER 2011: p. 41).

It was in the late 1970s when architects and urban morphologists Bill Hillier and Julienne Hanson set the foundation stone of Space Syntax (HILLIER & HANSON 1984). This new spatial analysis was based on the idea that human societies use and configure space and that social structure is expressed spatially. Space syntax theory is usually connected with structuralism, assuming that every anthropological activity bears a mental structure or pattern. A study of these patterns can then reveal the people folklore, concepts or cultural and social behaviour (STÖGER 2011: p. 41). Techniques of Space Syntax were developed mainly for the architects as a planning tool to improve design of the buildings and open spaces and to simulate the social effect of their design as well as understanding the relationship between spatial configuration and purposeful movement (CUTTING 2003: p. 1). However it was primarily developed for the design of new architecture and soon afterwards it was applied to historical sites as well (HILLIER ET AL. 1987; HANSON 1989a, 1989b; VAUGHAN & PENN 2006; VAUGHAN 2007).

Due to the limited computing capabilities of early computers, first analyses were focused only on small towns or individual buildings. Nowadays development of computer software and hardware make it possible to analyse larger metropolitan cities and even entire regions (CRAANE 2013: p. 21). However Space Syntax has been most frequently applied to British towns and larger metropolitan areas such as London, Paris or Tokyo, only a few studies were focused on larger regions or territory.

Theoretical background

Space Syntax analysis (SSA) is an overall name for a theoretical and analytical set of techniques to identify, compare and interpret patterns in the spatial configuration of space. It is a combination of tools which are able to quantitatively and qualitatively capture the space configuration and show important correlation with human movement and use of space.

According to Craane (2013: p. 21) there are three aspects to Space Syntax. First, it is a set of techniques for analysing cities as networks of space formed by the placing, grouping and orientation of buildings. Secondly, it is used for observing how these networks of space relate to functional patterns such as movement, land use, areal differentiation, migration patterns, and even social well-being and malaise. Finally, it is also a set of theories about how urban space networks in general relate to the social, economic and cognitive factors by which they are shaped and influenced.

Before going deeper in to the theory, it is necessary to clarify exactly what is meant by term space in the world of Space Syntax. Spaces here are understood as voids (empty places) between walls, fences and other impediments or obstructions that restrain (pedestrian) traffic and/or the visual field (KLARQVIST 1993). Every human settlement consists of private and public spaces. Hillier (1984) claims that: "public spaces are the results of the arrangements of buildings, and possibly other bounded areas such as gardens, parks and the like". These are publicly accessible and usually open to everyone.   Private places can be defined as an opposite of public spaces, as a place enclosed by walls and fences with specific access restrictions. Regarding to the above mentioned, primary object of Space Syntax analysis research is the configured complex of public and private spaces, which usually takes the form of building or urban plans (BAFNA 2003: p. 18).

Space syntax is focused mostly on external properties of spaces, as how they are connected to each other rather than what are their inner dimensions in meters. In Space syntax we usually speak about topological patterns. Topological features are more robust than documentation evidence (measuring error). They enable more objective analysis and comparison of settlements (BAFNA 2003: pp. 17–19). The main point of Space Syntax application is to analyse spatial configuration of public spaces and how they are related to private space. The way how these are connected influence the socio-economic activities.

The point of departure for space syntax is the assumption that human beings occupy a finite area of space. They have no other choice but to get control over this space and to move from one point to another in order to do anything. Moving through space and interacting with other people, or even just seeing ambient space from a point in it, all these action have a

natural and necessary spatial geometry: movement is essentially linear, interaction requires a convex space in which all points can see all others, and from any point in space we see a variably shaped, often spiky, visual field we call an isovist (Figure 1).

people move in lines   interact in convex spaces   see changing visual fields as they move around built environments
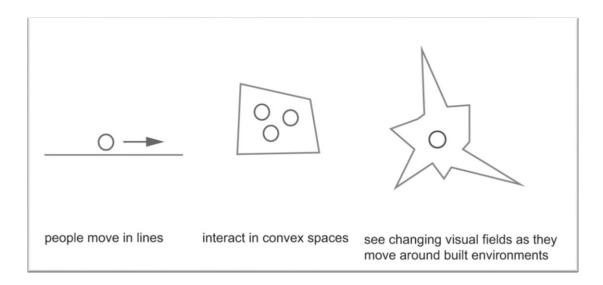
FIGURE 1 - SPACE IS NOT A BACKGROUND TO ACTIVITY, BUT AN INTRINSIC ASPECT OF IT (CRAANE 2013).

As explained earlier, Space Syntax measures how every public space is related to all other public spaces. The term public space represents open publicly accessible squares and streets or its segments. The streets are the most determining factor at the urban environment, they carry all the movement and provide a place for social interaction (RUDLIN & FALK 1999).

Most suitable method for the analysis of the street network is **axial line analysis**. In order to analyse the urban environment we need to create its abstracted image with focus on topology. In Space Syntax terminology it is called "axial map". The axial map of an area is drawn on the basis of open-space structure in a plan and it consists of the least set of straight lines-of-sights that pass through all the open spaces in an urban area (Vaughan & Hillier 2007: p. 215). It's a representation of urban space in term of longest and fewest lines it takes to pass through all the public spaces (GRIFFITHS 2005: p. 657). This simplified representation can be then translated into a graph in which a line is visualized as a node and intersections between lines are shown as links between nodes (Bafna 2003: p. 23), (Figure 2). However, thanks to development in software Depthmap (TURNER 2004a), the most usual way of presenting results of Axial map analysis is to colour axial lines according to calculated values from red to indigo via orange, yellow, green and blue (Figure 3).
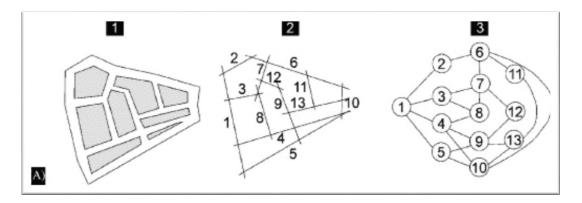
FIGURE 2 - 1) FICTIVE URBAN ENVIROMENT; 2) PRIMAL AXIAL MAP NETWORK3) CONECTIVITY GRAPH

Parameters usually included at graph are:

Integration: the number of steps it takes to get from one line to all other lines in the system. If this number is low, then the line is considered integrated, if this number is high the line is segregated. The most integrated lines correlate with high levels of movement (TURNER 2005: p. 59). In short, the less depth a space is from the complex as a whole, the more integrated it will be, and vice versa. This parameter can be also described as *to-movement* potential.

Choice: also referred to as through-movement of a line is calculated by counting the number of times that it appears on the shortest path routes between all possible pairs of origins and destinations in a system.

The integration as well as choice values reflect a part of the decision process that humans undergo before moving anywhere in a system. First, a human decides on an origin and a destination. This destination is the to-movement. More accessible destinations are more likely to feature as a destination and, as a result, are the most integrated, whereas the most inaccessible destinations are less likely to feature as such and are therefore the least integrated. Secondly, before a human can start moving he or she needs to select the streets (lines) that must be passed through to go from origin to destination, or the through-movement (CRAANE 2013).

Simply, before human move they have to know where. It's more likely that better accessible places (more integrated) will feature as destination over less accessible (less integrated) feature. When they know where the go human need to choice the route.

FIGURE 3 - AXIAL MAP ANALYSIS OF VIENNA CENTER.

Besides differentiation between to-movement and through-movement (integration and choice), it is necessary to notify the difference among **global and local** scale of both. Global values (high radii) correlate strongly with primary routes through an urban system, whereas local values (low radii) correlate strongly with secondary streets or a neighbourhood level. Therefore, the latter is particularly useful in calculating how local people use the space (to go to the local shops, school, or friends), whereas the former calculates how non-locals use the urban space (to travel through a town, or take the most logical straight route to their destination) (CRAANE 2013: p. 32).

Axial analysis is best suited to detect potential movement within the system, in a sense of which part is accessible better or which is more segregated. Degree of integration or segregation of some parts within a system often indicates some special social or economics reason. Analysis of axial map also offers the way how to investigate the degree of organization of the development at the city.

Original Space syntax graph was based on an algorithmic reduction of all the complete lines of sight which could be drawn in all of the public spaces in a town (TURNER 2004b; TURNER

ET AL. 2005), however creation of segments by dividing line of sights from junction to junction provides a higher correlation with movement patterns (HILLIER & IIDA 2005).

Another method from the SSA set can be used for further investigation of individual buildings or a building block is **convex space analysis.** This one is of interest to archaeologists because it is very useful in research of social use of domestic and small settlement spaces (CUTTING 2003: p. 3). Using this method we can quantitatively describe how the spaces are related together and formulate "configuration of space". However it's very complicated to interpret social activity based on micro-topology.
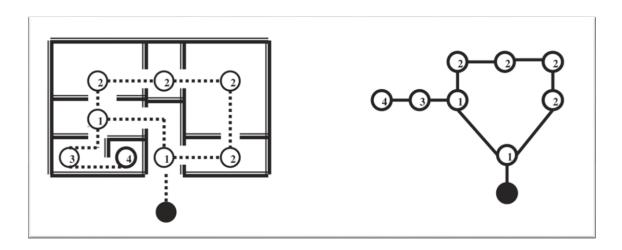

FIGURE 4 - THE GROUND PLAN OF THE BUILDING (LEFT), A CIRCLE MARKS EACH CONVEX SPACE AND DOTTED LINE SHOWN LINKAGE BETTWEEN THEM. JUSTIFIED GRAPH OF THE SAME BUILDING (RIGHT) (CUTTING 2003: P. 3)

The term convex analysis often refers to access analysis. This type of SSA is used especially for syntactical analysis of buildings to identify how spaces within a structure are arranged and related to each other. The resulting graph is a purely topological representation of the building (Figure 4). The graph alone can be used as a powerful representation for a first-hand qualitative understanding of the spatial structure. In a contrast to qualitative, quantitative approach requires numerical values to be calculated. This enabled the comparison of different spatial layouts and helps to investigate visible and invisible patterns (VAUGHAN & HILLIER 2007: p. 207).

Visibility graph analysis (VGA), based on a concept of isovist, which is a volume of space visible from certain location, or the visible field, has also potential for my study. VGA provides an attractive way to investigate and translate the environment system into a mathematical statement (Figure 5). This quantitative expression can be considered as the

experience of urban and building environments. It also provides a description of the space from inside point of view of the individuals, as they perceive it, interact with it, and move through it. VGA offers the way to determine what the perceptual qualities of a building might be, to categorize different urban types, or to examine how people can move or interact within the visible space (TURNER 2003: pp. 657–8).
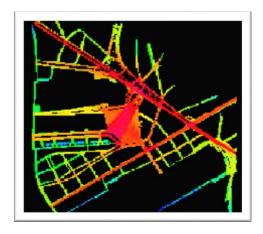

FIGURE 5 - VISIBILITY GRAPH ANALYSIS OF THE SITE OF THE URBAN ENTERTAINMENT CENTRE IN FRANKFURT

By way of summary, the main values as they have been discussed and the socio-economic aspect that they correlate with are set out in table pod (VAN NES, AKKELIES 2009; CRAANE 2013).

TABLE 1 THE MAIN SPACE SYNTAX VALUES SUMMARIZED.

Segment angular/ axial line measure	What does it measure?		High values correlate with	Low values correlate with
Global Integration	To-movement potential: Shows where the potential lies for economic activities such as shops and markets in a whole region or city	The degree of accessibility of a street to all other streets within an urban environment in terms of the total number of direction changes	The spatial potential for the main shopping street within an urban environment	Silent streets. Tend mostly to be dwelling areas or industrial areas located on the edges of a city.
Local Integration	To-movement potential: Shows where the potential lies for the various local centres in a city or a region	The degree of accessibility of a street to other streets within a set number of direction changes (usually three)	Discovering neighbourhood shopping streets	Quiet residential streets
Global Choice	Through-movement potential: the likelihood that people will pass through a particular street (segment) when they travel from any A to any B in a system	Highlights the main route network through the towns and cities	The main thoroughfares running through and between urban areas	Routes no-one takes to get across town
Local Choice	Through-movement potential: the likelihood that people will pass through a particular street (segment) when they travel from any A to any B in a system	Highlights the various vital pedestrian areas in towns and cities	The most vital local pedestrian streets	Routes no-one takes to get across a neighbourhood

Application of Space Syntax in historical studies

Traditional use of Space Syntax kit in architecture and urban planning includes pedestrian modelling, criminal mapping and navigation processes in a complex building and urban structures. These researches are based on the assumption that observed spatial structures and patterns, have significant impact on human activities and behaviour in a built environment and vice versa. (JIANG & CLARAMUNT 2002: p. 296).

In past decades a number of studies applied computer-based spatial analysis to the investigation of historic and prehistoric space, both domestic and ritual. In the field of archaeology, the whole landscape, rather than urban space or individual buildings has been the main subject of these investigations. Recent years showed significant increase of archaeologists' and historians interest in urban structures analysis. Several formal spatial analytical methods have begun to be developed for the study of human interaction, experience and socialization within the built environment. Focuses of these studies vary in matters of time, space and used techniques. Most of them prove the SSA as a suitable technique to identify invisible patterns and add a level of objectivity to research and place the hypothesis on to more solid ground.

These studies are mainly focused on the use of SSA in areas where the plan of the city is evident and therefore the places like Pompeii and Ostia were put in to question (ANTER & WEILGUNI 2003; LAURENCE, RAY 2007; VAN NES, AKKELIES 2009; STÖGER 2011; WEILGUNI 2011). A broad range of research questions were asked, from the investigation of the space arrangement in the apartment buildings through the relationship between streets and houses to the examination of the intensity of the movement through the cities with regard to the land-use.

Other research projects based on examination of the excavated sites were carried at Peloponnese peninsula, Crete, Cyprus and in ancient Mesopotamia (BRUSASCO 2004, 2007; LANG 2005; THALER 2005; FISHER 2006; WESTGATE 2007; PALIOU 2008; BINTLIFF 2010; PALIOU ET AL. 2011). Research shows that SSA can answer question of architectural changes in an urban layout, socio-economic trends in an ancient societies or even in combination with agent-base modelling approach, intra-site movement and visibility from public spaces.

With the new agency approach space syntax research gained a new way how to test the hypothesis and verify the results (PALIOU 2008). Another way how to investigate the results

is the integration of SSA in ethnological studies. Studies of the settlement layouts and its correlation with social and spatial forms (WIDLOK 1999), or examination of spatial structures of the Inuit snow houses (DAWSON 2002) together with investigation of Native American sites (FERGUSON 1996; SHAPIRO 2005), proved SSA to be useful.

Studies using SSA are not focused only on the excavated sites (HANSON 1989a; GRIFFITHS 2005; VAUGHAN & PENN 2006; VAUGHAN 2007). Craane's study of medieval towns shows that SSA can be used even in a transformed environment. Together with methods taken from urban historical geography (map regression) the author studies commercial spaces and medieval trade in Dutch cities (CRAANE 2009, 2013).

Even if the SSA studies usually investigate archaeological sites with complete plan, fragmentary nature of archaeological data won't be necessary the problem. In a number of cases, application of the archaeological prospection methods solved this problem sufficiently (BENECH 2007, 2010; SPENCE-MORROW 2009; GONDET & BENECH 2009). City layout obtained thanks to the prospection methods, especially geophysical, are well suitable for street network analysis.

Conclusion

Notwithstanding promising researches mentioned above, Space syntax has been neglected for a long time. While the concept is rather simple, basic ideas is hard to explain. SSA uses terms at choice integration or movement and these have other and sometimes different connotations outside space syntax world. Due to the lack of historical specificity, especially historical disciplines were sceptical to Space Syntax. However recent studies have shown that SS approach can be successfully applied from Anatolian town forts (KUBAT 1997), Roman towns (VAN NES, AKKELIES 2009; BENECH 2010; STÖGER 2011; KAISER 2011) to medieval cities (CRAANE 2009, 2013).

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