Space Syntax Analysis of Kaunas: Some Methodological Aspects

Kęstutis Zaleckis*, Irina Matijošaitienė

Kaunas University of Technology, Faculty of Civil Engineering and Architecture, Studentu st. 48, LT-51367 Kaunas, Lithuania

* Corresponding author: kestutis.zaleckis@ktu.lt

Space syntax analysis is a well known method. Despite the fact of its wide usage some improvements could be offered. While preparing axial map of Kaunas it was noted that one single axial map cannot be used for evaluation of global and local integration if the correct results are expected. The possibility to use different maps for evaluation of global and local integration in Kaunas is discussed in the article. Additional arguments for usage of the concept of continuity lines are presented. The offer to not limit the axial map of the city to formal administrative border of the municipality is explained.

Keywords: *space syntax, axial maps, pedestrian routes, continuity lines, Kaunas, Lithuania.*

1. Introduction

City is a complex organism and as such it requires complex methods of investigation. Complex investigation should consider all levels of urban reality and its social, economic, cultural dimensions. Space syntax represents one of the complex methods for urban investigation (Hillier B., 2007) because it focusses not on the spatial characteristics itself but on the social uses of the space. In this way the method integrates spatial, social, economic, cultural dimensions. During the preparatory stage of investigation of Kaunas spatial structure and its influence on security of inhabitants the following important aspects were noted:

▪ Many contemporary cities function as complexes of autonomous subsystems from the point of view of transportation because of the separation of pedestrian and car traffic;

▪ Big number of single streets cannot be represented by one single axis because of the curved lines;

▪ Formal Borders of the city do not represent a real urban system.

▪ The following problems or discrepancy between the formal methodology of space syntax and real situation appear here:

▪ A single axial map for a city is created traditionally. Two important features are analyzed on the base of the map: global integration and local integration. It could be concluded that the first one is more focused on the public and private car transport. The second one, because of traditionally used distances or number of steps, is more focused on pedestrian connections. Global integration measures accessibility of all axes from all other axes of the system. Axes of public and private car transport are the most actual here. Pedestrian routes as used within the limited distances are not so important for the global integration. If the map is based on the register of the formal streets then many pedestrian axes are not considered too. When the local integration is measured on the base of distance or the number of conditional steps, some axes of transportation could be excluded as not accessible for the pedestrians, e.g. transport tunnels in the city, transit highways, etc. Significance of the above mentioned aspects and existence of at least two autonomous networks of transportation in the city could be illustrated by the presented results of investigation: 17 percent of travels in Kaunas are made by walking, 60 percent by public transport, and 23 percent by private cars (VĮ Transporto et al. 2007). It is logical to conclude that different types of travelling are used when going to different destinations, e.g. walking to local center of neighborhood, taking a bus or private car to the city center, taking a private car to suburban shopping mall, etc. Of course the bigger part of the axes for the global and local integration maps are the same, but quite significant number of mono-functional axes should be taken into consideration. The fact of existence of separated traffic networks could be illustrated by the notice of the existence of streets and roads as two different types of transit spaces in the modern city. The street could be described as a space that integrates pedestrians, traffic, various cultural and social activities. Creation of the streets as spaces suitable for street culture is one of the main aims of New Urbanism. Road as a transit space intended for cars appeared as the result of Modern urbanism and mono-functional zoning of a city. In wider context the fact of partially separated networks of transportation demonstrates

the fact of fragmentation of the contemporary cityscape at the all levels of its existence: appearance of white spots in the image of the city (Zaleckis 2002), loss of compositional integrity and a-local functional connections, caused by web technologies in the matterscape, increased amount of logical asymmetry in the cityscape (Zaleckis 2011), asymmetry, etc. In general it means that contemporary city functions as few quite autonomous sub-systems that are connected not in all points. In such a case creation of one axial map of the city is not correct. Significant influence of pedestrian connections on the essential qualities of urban structure was proved by investigations in Kaunas downtown area (Zaleckis et al, 2012).

▪ Formal administrative borders of the city do not reflect the real urban integration as it was mentioned above. In Kaunas case the number of bridges and highways outside the city borders (e.g. Vilnius-Klaipeda road, Via Baltica, southern bypass) in fact are functioning as a part of the inner urban network of the city. Appearance of the features of the peripheral city confirms that fact. At the same time the big suburban settlements as Garliava and Sargenai are functionally and compositionally integrated into the cityscape of Kaunas but formally they must be excluded from the axial map because they are outside of the administrative borders of municipality.

▪ In space syntax analysis the curved streets are shown as a number of direct axes. The above mentioned fact is true even for such obviously integral and the most straight long street of Kaunas as Savanoriai prospect. In many cases the cut of the street into separate axes do not correspond to reality as a big part of curved streets function as single units in the mentalscape or matterscape of Kaunas.

Proposals:

▪ The two different axial maps should be created for the analysis of global and local integration of the city. Map of the local integration should include spaces of the public and semi-public transit pedestrian spaces. At the same time axes that are not accessible for pedestrians and public transport should be excluded from this map.

▪ Axial map should not be limited to the formal administrative borders of the city; closely integrated suburban parts and roads should be included in the map;

▪ The aggregation of the segments of curved streets of the city should be respected in the axial maps. In fact it could be done by introduction of continuity lines. According to Figueiredo "…the notion of continuity is already embedded in the axial system" (Figueiredo et al. 2004) and the continuity lines represent the chosen movement roads with the higher percent of probability.

The aim of the article is to prove or reject the above mentioned proposals. Kaunas as one of the objects of investigation within the project is chosen as a laboratory for this task.

2. Methods

Space syntax method is used as the basic method in presented research. Two different axial maps of Kaunas are created. Various characteristics of the maps are compared between themselves and validated for the correspondence

to the observed facts of urban life of Kaunas. The final conclusion on the acceptance or rejection of the above mentioned proposals is made on the base of the research results. Mindwalk software was used for syntax analysis.

3. Results

The first question could be formulated as following: will the quantitative changes between the axial map without pedestrian routes and with pedestrian routes be significant enough to consider it? To receive the answer two axial maps of Kaunas were created. Axial map 1 with only formal streets included (Fig. 1). Axial map 2: the pedestrian routes were included and axes not accessible for pedestrians and public transport were excluded (Fig. 2). Area of the both maps covered suburban territories that are functionally and compositionally integrated into the city. Pedestrian axes embraced the following:

- Spaces of the courtyards of the modernistic districts in Silainiai, Kalnieciai, Eiguliai, Dainava;
- Pedestrian axes in the parks and city forests;
- Pedestrian bridges.

Fig. 1. *Axial map of Kaunas with only formal streets included*

Pedestrian axes in the courtyards of Old town and New town were not considered because of the ongoing process of restitution and tendency to close the private spaces for the pedestrian transit in these parts of the city. Axes excluded from the map 2:

- Via Baltica;
- Highway Vilnius-Klaipeda;
- Parts of the southern bypass.

There were identified 9607 axes in the first map (Fig. 1) and 10298 axes in the second map (Fig. 2.) The total number of axes in Kaunas has increased by 7 percent. If subtracted axes from the map 2 are taken into consideration then pedestrian axes can make up to 10 percent of all axes in the city. Having in mind a part of pedestrian journeys in Kaunas (17 percent) it is a significant change at the city level. Its significance for local integration is even higher because of the concentration of axes in few areas.

Fig. 2. Axial map of Kaunas with pedestrian axes included. Concentration areas of the pedestrian axes could be identified by the darker zones

Is the quantitative change reflected in quantitative qualities of axial map? Do these changes correspond to the observed processes in Kaunas?

Depth values of the both maps were compared in the beginning of quantitative analysis. Visually there were no significant changes at the city level but maximal depth of all system was increased from 67 to 70 when pedestrian axes were added. Having in mind relatively small number of added axes the change is quite big. In concentration areas the depth of the territory was increased by 5-7 points. The changes of the depth values reflect an observed specialized, disaggregated use of the public spaces of modernistic districts.

Local integration values were analyzed in the second step. Radius was measured by 3 conditional steps or changes of the direction of the paths. Significant changes were noted in the modernistic districts in the streets with a higher concentration of commercial and public buildings, e.g.: local integration value of Baltu prospect increased from 2.7556 to 3.21, Baltijos street – from 2.4173 to 3.17. At the same time control values of Baltu prospect decreased from 4.575 to 3.8528, Baltijos street – from 4.111 to 2.924. The similar changes could be seen in the all main streets of modernistic districts. Segment of Partizanu street and Siaures prospect (local integration 3.3005 without pedestrian axes and 3.9628 with pedestrian axes) appeared as clearly expressed local centers. The last change represent quite well in reality observed attractiveness of Siaures prospect for various commercial activities even if it is located at the border of the city. Interesting fact if analyzing the changes of control values: for Siaures prospect it increased from 6.6742 to 14.4861 with pedestrian axes added. If comparing situation with above analyzed streets in Silainiai (Baltu and Baltijos streets) the differences could be explained by configuration of pedestrian routes: courtyards in Silainiai are more closed and have limited connections to the streets surrounding blocks; in Kalnieciai, because of the original spatial design,

they are more oriented towards Siaurės prospect and other streets. Ukmerges street is a minor street in Kalnieciai where a few cafes, local community and recreation center with a pool and new shop are located. Its integration values increase from 1.4136 to 2.3473. In general, the identified changes quite well represent the real bigger attractiveness of the above mentioned streets as local linear centers or main streets of the neighborhoods and real use of the courtyards for pedestrian transit. As it could be seen in the Fig. 3, significant part of the new pedestrian axes is included into 5 percent of all axes with the highest local integration values. It demonstrates significance of the mentioned pedestrian routes for the local neighborhoods and could be proved by the intensive use of these routes while walking to neighborhood centers, shops, etc. It even was intended in the original design of the modernistic district, e.g. in Kalnieciai the shopping centers as Vitebskas (now IKI) or Kalnieciai were reachable by walking and practically without usage of transport roads. The same applies for the public spaces as Cecenijos square. The maximal local integration value in the city increased from 4.5512 to 4.5746 with pedestrian axes added. The lowest mark remains the same 0.333. The change of the local integration values of the main streets of the modernistic districts is exceeding the common change of the background. At the same time two important axes of Kaunas – Savanoriai and Veiveriu prospects remain the dominant axes of local and global integration in both maps. It coincides with in reality observed multi-functionality of these axes as the central places of the highest rank. If the theory of central places by Christaller is applied to the containment of the city then the above mentioned phenomenon could be explained in its terms: central places of the higher rank perform all functions of the central place of the lower rank and additional functions (Leslie 1984). Note not directly related to the topic of this article: may be the coincidence of high values of the global and local integration can help to identify the central places of the highest rank in the city? Of course such a statement requires a separate investigation.

Fig. 3. Local integration map with pedestrian axes (5 percent of the axes with the highest values are shown in black)

Fig. 4. Local integration map without pedestrian axes (5 percent of the axes with the highest values are shown in black)

In both cases (with and without pedestrian axes) the fast choice map remains the same. It corresponds to the local significance of the pedestrian axes and their little influence on city traffic.

There are around 1500 streets in Kaunas (VĮ Transporto *et. al.* 2007) and 9607 axes in the map. As it was mentioned above, even practically direct streets as Savanoriu prospect, according to the rules for axial map making, should be broken into few axes. The human perception plays a very important role when choosing a road for transformation and the big part of the curved streets are percepted and used as integral axes (Figueiredo et al. 2004). Because of this, the concept of continuity lines was introduced into the axial map. According to L. Figueiredo and the Mindwalk options the angle smaller than 35 degrees is not percept by us as a change of direction. Axes in Kaunas map were merged into continuity lines according to the above mentioned criterion. As a result the number of axes in the map was reduced twice: from 9607 to 4812. Examples of aggregated continuity

Fig. 5. Proposed continuity lines (shown in black)

lines: Savanoriai prospect, Vilnius street, Laisves avenue together with Gertrudos street, Siaurės prospect, highways around Kaunas, Karaliaus Mindaugo prospect, etc. It looks that the result reflects human perception of Kaunas more correctly, but the question till remains open: could be some additional arguments found for the usage of continuity lines in Kaunas map?

Global integration with and without continuity lines was calculated. The obvious differences could be noted between the Fig 6 and Fig. 7:

- There clear zones of integration could be seen in the map without continuity lines; single streets are highlighted in the map with continuity lines. In the first map some minor streets of the local significance are competing with the main streets of the city, e.g.: the value of global integration of Ausros street differs from Savanoriai prospect only by 0.033 points (0.4743-0.4413=0.033). It means that streets are practically of the same significance for the city. The difference is more realistic in the map with continuity lines: 1.7391-1.2994=0.4397.

- Integration values of the highways around Kaunas are much higher in the map with continuity lines: for Via Baltica it increased from 0.3803 to 1.9629, for the south roundabout from 0.4156 to 1.907, etc. These changes reflect few in reality observed processes. The first one: active usage of roundabouts not only by transit but by inner transport of the city too. The second one: higher integration values correlate with appearance of suburban shopping malls and other big commercial objects and new housing developments in Giraite, Sargenai, Kleboniskis, Ramuciai as elements of peripheral city.

- Global integration values in the map with continuity lines are falling down in the area around Vyduno avenue, New Town, Old Town significantly. It represents these relatively quiet (in the terms of traffic) urban pockets of the city more correctly.

- Without the continuity lines the most controlling axes in Kaunas are Veiveriai and Savanoriai prospects. In the map with continuity lines the roundabouts become important players here too. Control values of the above mentioned roundabouts are much higher in the second case. It corresponds well to the role of these axes as distribution lines of the city.

- Depth analysis of the global map reflects the significance of integrating roundabouts for creation of the shallow zones around the city. As it was mentioned above the present centers of the peripheral city confirm usage of these axes for global purposes of the city.

- Local integration values in the map with continuity lines are more correct: the real local axial centers or main streets as Zemaiciu street, Taikos prospect, Kalantos street, Raudondvario street and others have the significantly higher values of integration if compared to the surrounding contexts.

32
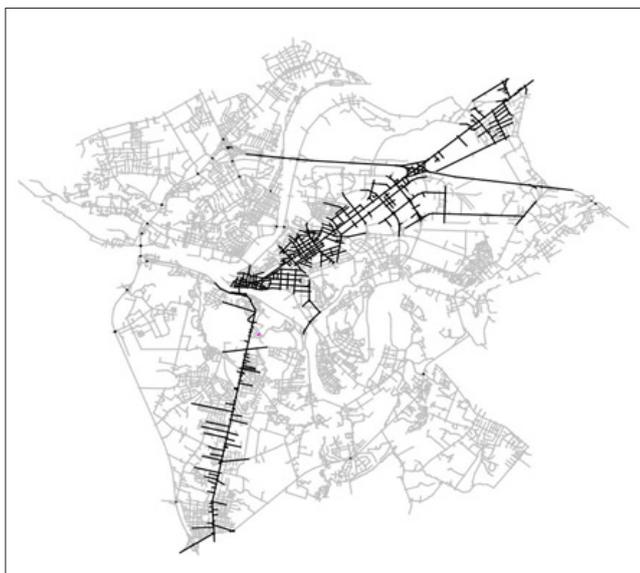
Fig. 6. Global integration map without continuity lines (5 percent of the axes with the highest values are shown in black, black dots mark two level crossings)

Fig. 7. Global integration map with continuity lines (5 percent of the axes with the highest values are shown in black, black dots mark two level crossings)

- When calculating the aggregation degree of the city with proposed continuity lines the results are following: the aggregation degree without pedestrian axes is equal 0.6832; the aggregation degree with pedestrian axes is equal 0.6292. In both cases it is quite high and according to the urban network toponomy by Figueiredo (Figueiredo et al. 2007) marks grid type of the city. The increased depth of some areas demonstrates movement towards less aggregated tree type of the urban network in the city. The tree type structure is peculiar for the deep spaces of semi-public courtyards of the modernistic districts. Important note: the lower aggregation degree is calculated for the map with the bigger number of axes. It would

be logical to predict the opposite situation because in the bigger number of axes the bigger number of continuity lines could be expected. In this case the lower aggregation degree reflects the quality of the spaces of modernistic districts in the city.

4. Discussion

The received results were validated by the correspondence to the various urban processes in Kaunas. Can we say that it will be true in all other cases? If speaking about two axial maps with and without pedestrian axes it can give the similar results in the city with quite significant amount of pedestrian axes that do not correspond to axes of transportation. E.g. big territories planned in modernistic manner give a strong argument for creation of two separate maps. New Urbanism (APA 2006) tends to integrate pedestrian and car transport. The case of usage of two maps would be obsolete. The same would be true for the analysis of the medieval or 19th century urbanism. In general we can conclude that offer to make two axial maps is the most actual for the cities that were touched significantly by Soviet modernistic urbanism. Despite the limited actuality various forms of walkable urbanism can call for the suggested improvement of space syntax analysis. The need to create special axial map with pedestrian axes could be very important for the analysis of relations between spatial structure and crimes too, as different parkways, courtyards and other deeper spaces can attract potential criminals.

The idea of continuity lines is offered by L. Figueiredo. Despite the strong supporting arguments it is not very often used in space syntax analysis. The analysis of Kaunas gives a strong support for the usage of this idea. Interesting note: combination of axial analysis with and without continuity lines may can help to identify the limits of integral corridors of New Urbanism. Such idea appeared when comparing two maps: single dominant axes are highlighted when continuity lines are modeled in the axial map; without the continuity lines the same integrating axes (e.g. Savanoriai or Veiveriai prospects) are shown as parts of the clear zones of high global integration.

5. Conclusions

For Kaunas and probably other contemporary cities with big enough percentage of pedestrian axes, it would be more correct to create two axial maps: one for global integration and one for local integration.

The map of the local integration should include axes of the public and semi-public pedestrian transit spaces. At the same time axes that are not accessible for pedestrians and public transport should be excluded from this map.

The map of the global integration should include all streets and roads used by the car transport.

The axial map should not be limited to the formal administrative borders of the city. It should include suburban areas that are functionally and compositionally closely related to the city. The role of the roundabouts around Kaunas proved this statement.

The integration of curved streets of the city should be respected in the axial maps. In fact it could be done by more active usage of continuity lines.

Suggested improvements in Kaunas case helped to do the following: to identify the main axes of global and local integration more precisely; to evaluate the depth of the map more correctly; to reflect the real street network in more accurate ways, etc. It was validated by the observed real processes of urban life.

Acknowledgment

References

American Planning Association. 2006. Planning and Urban Design Standards. John Wiley & Sons, Inc.

Figueiredo L., Amorim L. 2004. Continuity lines: aggregating axial lines to predict vehicular movement patterns. Proceedings of the Third Great Asian Streets Symposium, Singapore, National University of Singapore.

Figueiredo L., Amorim L. 2007. Decoding the Urban Grid or Why Cities are Neither Trees nor Perfect Grids. .Proceedings of the 6th International Space Syntax Symposium, İstanbul, 1–16.

Hillier B. 2007. Space is the machine: a Configurational Theory of Architecture. London: Space Syntax.

Leslie J. K. 1984. Central Place Theory (Scientific Geography Series). Thousand Oaks: Sage Publications.

VĮ Transporto ir kelių tyrimo institutas, VGTU Teritoriju planavimo mokslo institutas. 2007. Kauno miesto dviračių takų specialusis planas [Special plan for bicycle routes in Kaunas].

Zaleckis K. 2002. Kai kurie teoriniai ir praktiniai bendrai suvokiamo ir įsivaizduojamo miesto vaizdo nustatymo klausimai. Urbanistika ir architektūra = Town planning and Architecture, 26 (2), 96–106.

Zaleckis K. 2011. Globalizacijos atspindžiai miesto kūne: keletas įžvalgų. Logos : religijos, filosofijos, komparatyvistikos ir meno žurnalas, 66, 142–152.

Zaleckis, K., Matijošaitienė I. 2012. Hidden urban revolution in Kaunas downtown area: 1935-1988-2011. Eight International Space Syntax Symposium, January 3-6, 2012, Santiago de Chile, Chile : proceedings, Santiago de Chile, Pontificia Universidad Católica de Chile, 1–16.

Kęstutis ZALECKIS – professor at Kaunas University of Technology, Faculty of Civil Engineering and Architecture, Department of Architecture and Land Management.

Main research areas: Urban genotype and phenotype, military architecture, urban history.

Address: Kaunas University of Technology, Faculty of Civil Engineering and Architecture, Studentu g. 48, LT-51367, Kaunas, Lithuania.

Tel.:   +370 616 28902

E-mail: *kestutis.zaleckis@ktu.lt*

Irina MATIJOŠAITIENĖ – lecturer at Kaunas University of Technology, Faculty of Civil Engineering and Architecture, Department of Architecture and Land Management.

Main research areas: road and urban landscape, space syntax, Kansei engineering, hedonomics, ergonomics, statistics.

Address: Kaunas University of Technology, Faculty of Civil Engineering and Architecture, Studentu g. 48, LT-51367, Kaunas, Lithuania.

Tel.:   +370 606 88819

E-mail: *irina.matijosaitiene@ktu.lt*