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MONITORING INTELLIGIBILITY CHANGES OF KAUNAS INTERWAR MODERNISM BUILDINGS

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Abstract. The research based on the project "Heritage in Depopulated European Areas" (HerInDep), started in April 2023 and examines the transformation of Interwar (the years between the end of the First World War and the beginning of the Second World War) architecture and its influence on the social and urban development of Kaunas, Lithuania. Kaunas, particularly its central region, holds a significant concentration of Interwar modernist architecture, which has endured substantial urban changes during the Soviet era and pressures from business developments post-1990. In 2023, Kaunas' modernist architecture was nominated to the UNESCO World Heritage list under "Modernist Kaunas: Architecture of Optimism, 1919-1939," reflecting its transformation into Lithuania's provisional capital. Approximately 80% of these heritage properties have distinct characteristics meriting legal protection. The idea of the article is to propose and validate a methodology for assessing the legibility of immovable cultural heritage in an urban environment. Such a methodology could be used not only to understand better the importance of cultural heritage in creating urban landscape identity but also to monitor changes in legibility due to various transformations of the urban fabric, even in the absence of destroyed or otherwise physically affected heritage properties. The paper focuses on the presentation of the space syntax or mathematical graph-based intelligibility model which, because of its simulative natures offers predictive possibilities while pointing out further possibilities of its use for monitoring purposes.
Keywords: intelligibility, space syntax, interwar modernism buildings, heritage, sociological survey

Introduction

The research of the project Heritage in Depopulated European Areas (HerInDep) analyses the transformations of Interwar architecture and their impact on the social and urban development of Kaunas city.

From 1919 to 1939, when Kaunas became Lithuania's provisional capital, many modern architectural buildings were built in Kaunas, the temporary capital of Lithuania. In early 1919, the Council of State, Cabinet of Ministers and other institutions were located here. Diplomatic missions of various countries were also established in Kaunas. Most of them were located on V. Putvinskio Street (USA, Sweden, France, Czechoslovakia, Hungary), others were located on Laisvės (Liberty) Avenue (Austria, Netherlands, Russia), Kęstučio Street (Latvia, Great Britain). Most of the objects that represent it, including the buildings of the Central Post Office (architect F. Vizbaras), the Milk Centre (architect V. Landsbergis-Žemkalnis), the Palace of the Vytautas the Great Museum (architects V. Dubeneckis and K. Reisonas), etc.) were built in Kaunas' New Town [1]. New districts of K. Donelaičio, Kęstučio, V. Putvinskio, Maironio and other streets of the central part of Kaunas, and Žaliakalnis (Green Hill) were formed [2].

The greatest diversity and concentration of Interwar architecture is found in the central part of Kaunas, which suffered a major urban transformation during the Soviet period and has been under pressure from business development since 1990. The population of Kaunas has been fluctuating over the last three decades, with a decrease of 29.8% between 1996 and 2019, and only in recent years has the situation slightly changed. These demographic processes have directly impacted the gradual deterioration of building functions and public spaces. This is particularly the case in areas with a large number of cultural heritage sites and important historical artefacts. Within the scope of the project, the research is carried out in the historically and culturally significant territory of Kaunas city - Naujamiestis (New Town), representing modernist architecture, and Old Town, as an inseparably perceived structural part of the centre of Kaunas. The central part of Kaunas has more than 1500 buildings reflecting Interwar modernism that have survived to the present day. In twenty years (1919-1939), the city's territory expanded sevenfold, and its population increased eightfold, from 18,000 to 154,000 inhabitants [1, 2].

The research area has a protected street network, which was formed in different periods: in the Old Town there is a medieval street network, in the New Town there is a predominantly classical street layout, and in the southern part of New Town, there is a twentieth century street layout. The research area has a natural border made by the Nemunas River and slopes of the river valley with a limited number of entrance axes from the other parts of the city.

In 2023, Kaunas's modernist buildings were nominated to the UNESCO World Heritage list as "Modernist Kaunas: Architecture of Optimism, 1919-1939". This property testifies to the rapid urbanisation that transformed the provincial town of Kaunas into a modern city that became Lithuania's provisional capital between the First and Second World Wars [3]. Most cultural heritage buildings built during the Interwar period are listed in the Lithuanian Register of Cultural Properties of the Republic of Lithuania [1] and have been granted legal protection. Around 80% of these properties have identified individual values, which are defined by the distinctive characteristics of the buildings, such as the volume of the building, including height, roof shape and materiality; the architectural design and decorative elements of the facades; the layout of the floor plans and the location of the load-bearing walls; the artistic and technical elements of the interiors; the construction and the value of the built environment.

The main objective of the article is to present the model for monitoring intelligibility changes in Kaunas Interwar modernism buildings. Such a model would expand traditional monitoring of changes in cultural immovable heritage which, at least in Lithuania, is focussed on the identification of valuable features of the objects themselves, e.g. elements of décor, architectural composition, volume, etc. The proposed model would allow observation and evaluation of how the importance of the heritage objects is decreased, increased or remains unchanged while their urban spatial environment is changing. The concept of intelligibility itself, as it will be clarified in more detail later, is based on the idea of legibility (intelligibility) or imageability by Lynch as "...the apparent clarity ... of the cityscape" and his statement that "legibility is crucial in the city setting" [4], We argue that if applied to immovable cultural heritage, this concept would allow for monitoring changes of its activeness in a perceived cityscape thus increasing the complexity of cultural heritage monitoring. The tasks of the research were oriented to a description of the study area and heritage sites, legibility and intelligibility research, mathematical graph models for the investigated area, building graph model, validation of the selected heritage objects based on sociological survey and open data.

Methods

Observation was used to investigate and interpret locally significant examples of depopulation. The observations provide data on how cultural heritage signs, events and strategies are implemented, celebrated and appropriated by different actors.

The assessment of the current state of heritage objects and areas was carried out by analysing the physical condition, cultural value, and functional use of selected objects, which allows a better understanding of the survival of real cultural heritage objects, as well as how the changing functions of heritage objects affect the recognition and significance of heritage objects.

Urban legibility studies were carried out to investigate how changes in heritage assets affect the visual identity of the city. These studies were based on simulation modelling. Simulation modelling allows the prediction of both past and future loss of people in an area and its impact on heritage legibility. This was an integral part of the project. The research analysed statistical and other data such as online images, maps, records, number of visitors to the sites, etc.

The sociological survey of residents of the central part of Kaunas City was carried out to validate the results of urban legibility studies.

Investigated heritage objects

Eighteen Interwar modernist buildings (Table 1) were selected for intelligibility research and sociological survey. The criteria for selecting the buildings are the following: they were built in the Interwar period, they are included in the Register of Cultural Property of the Republic of Lithuania, their valuable properties have been identified, they are located in different quarters of Kaunas New Town and they are built in the inner part of the quarters or along the main streets of the

TABLE 1

List of investigated heritage objects [created by author's]

No	Title of the object	Address	Year of construction, Architectural style	Author
1.	Building complex house of the artist Antanas Žmuidzinavičius	V. Putvinskio str. 64	1928, Modernism	Architect Vytautas Landsbergis-Žemkalnis
2.	Kaunas Central Post House	Laisvės ave. 102	1932, Modernism	Architect Feliksas Vizbaras
3.	The Dairy Centre Palace	Laisvės ave. 55	1931-1934, Modernism	Architect Vytautas Landsbergis-Žemkalnis
4.	Church of St. Michael the Archangel, Garrison Church	Nepriklausomybės sq. 14	1890-1895, Neo-byzantine	Engineer Konstantinas Limarenka
5.	Church of the Resurrection of Christ	Žemaičių str. 31	1934-1940, Modernism	Architect Karolis Reisonas
6.	Lithuanian American Joint Stock Company Building (Amlitas)	Kęstučio str. 72	1923, Functionalism / Modernism	Architect Vladimiras Dubeneckis
7.	The House of the Engineer Viktoras Rėklaitis	V. Putvinskio str. 33	1933, Modernism	Engineer Klaudijus Dušauskas-Duž
8.	Professor Augustinas Janulaitis' House	Kęstučio str. 48B	1931-1932, Modernism	Architect Arnas Funkas
9.	The Vatican Nunciature (now Artists House)	V. Putvinskio str. 56	1930, Modernism	Architect Vytautas Landsbergis-Žemkalnis
10.	The House of the Lawyer Petras Leonas	K. Donelaičio str. 77	1924, Modernism	Engineer Edmundas Frykas
11.	The Jewish Gymnasium (now Juozas Naujalis Music Gymnasium)	Kęstučio str. 85	1930-1931, Functionalism / Modernism	Architect Boruch Kling
12.	The House of the Lithuanian Diplomat Petras Mačiulis	K. Donelaičio str. 57	1935-1936, Modernism	Architect Vytautas Landsbergis-Žemkalnis
13.	The Tercijonai House	V. Putvinskio str. 72	1936, Modernism	Architect Bronius Elsbergas
14.	The House of Architect Grigorijus Gumeniukas	Kęstučio str. 19	1935, Modernism	Engineer-Architect Grigorijus Gumeniukas
15.	The House of Aleksandra Radzvickienė	Laisvės ave. 2	1939, Modernism	Architect Karolis Reisonas
16.	The House of Stefania Montvilaitė-O'Rourke	K. Donelaičio str. 51	1937, Modernism	Architect Arnas Funkas
17.	The House of Stasys and Jadvyga Montvilas	K. Donelaičio str. 55	1939, Modernism	Architect Arnas Funkas
18.	The House	Laisvės ave. 5	1933, Modernism	Not identified

New Town.

Kaunas visitor estimation data acquisition

The site BestTime.app was discovered during the investigation of data sources, although they do not state this in their documentation it is apparent that they use [5] estimation of popular times [6]. As Google itself does not provide an API to gather this data, a demo page of BestTime.app was used to generate the web page with the required data [7]. This way we acquired the required data with one HTML save, instead of scraping it with a browser simulator in a scraping-resistant Google environment.

Data mining of the saved HTML was undertaken by utilising the BeautifulSoup library in Python language. Inconveniently hourly popularity estimates were not stored as values and had to be derived from embedded SVG in the same HTML code. SVG (scalable vector graphics) is an open-source format for vector graphics supported natively by all major web browsers. Values were taken from the path object of the SVG, which was composed of 23 curves. Conveniently y coordinate of 24 endpoints of curves was proportional to the hourly popularity of the place. Only the endpoints of curves were used, because other points did not carry any useful information, they were only for aesthetic reasons.

To be useful as a GIS database, this data was missing GPS coordinates, therefore, to acquire coordinates using the street address, the Nominatim service was used to reverse-geocode database entries. The Nominatim uses an OpenStreetMap database assembled by volunteers.

Legibility and Intelligibility

The interrelated terms "legibility" and "intelligibility" are used in research on architecture and urbanism as interrelated terms. Lynch [4] described the legibility defining it as "...the apparent clarity ... of the cityscape" and stating that "legibility is crucial in the city setting, ... (and it) might be called imageability; that quality in a physical object which gives it a high probability of evoking a strong image in any given observer". Thus, relating it to such elements of the image of a city as paths, nodes, districts and landmarks.

Environmental psychology analyses how we perceive the spatial environment, what makes our perception easier and what environment we prefer if such possibility exists – it is summarised on the concept of the preferred environment by Environmental psychology. Kaplan, while describing informational factors essential for the satisfaction of two basic information needs – understanding and exploration, creates a so-called preference matrix of a landscape which contains the following features: legibility, complexity, coherence and mysteriousness. According to him, a combination of the above-mentioned four creates patterns, which affect understanding and preference of an environment. Legibility is defined as "how easy would it be to find your way around the environment depicted, to figure out where you are at any given moment or to find your way back to any given point in the environment" [8]. Coherence shows "how easy is it to organise and structure the scene how well a scene hangs together" [8]. Complexity is "how much the scene contains elements of different kinds" [8]. Mysteriousness shows "how much does a scene promise more if you could walk into it" [8]. The other environmental psychologists [9] stated that higher complexity can "...affect the legibility of the landscape as a consequence of offering too much information". The following indicators of complexity, which could be seen as affecting legibility are mentioned: density, diversity, spatial organisation, variation and contrast, etc. On the other side, if we speak about the perception of the image of a city or its mental map then we can assume that perception of at least complexity and coherence is based on it while legibility should be considered as the basic feature or property of environment which makes possible to create its mental map. Gordon Cullen [10], while formulating the concept of serial vision on urban spaces, states that townscape could not be perceived directly. Thus, pointing out the importance of the city image as a complex urban map for human-environment interaction and evaluation of the importance of the elements of a cityscape for its perception and significant role of legibility or intelligibility.

John Peponis and Jean Wineman [11] in the chapter "Spatial Structure of Environment and Behavior" in the Handbook of Environmental Psychology use the term "intelligibility" to analyse cognitive aspects of urban and architectural environments. Based on earlier sources „...intelligibility indexes the degree to which the number of immediate connections a line has is a reliable guide to the importance of that line in the system as a whole (namely, it is a correlation between axial connectivity and axial global integration). A strong correlation, or "high intelligibility", implies that the whole can be read from the parts [32]. It is important to point out that this intelligibility is modelled based on the theory and models of Space Syntax as one of the simulative descriptive models of the architectural environment which employs mathematical graph as the main tool to calculate various centralities of the graph nodes, which could be related to certain aspects of human behaviour. Based on the Peponis' definition we will see the intelligibility as an index of legibility as a more complex feature of a landscape.

The presented research aims to propose and validate the methodology for the evaluation of the intelligibility of immovable cultural heritage in urban settings. Such methodology could be used not only for a better understanding of the importance of cultural heritage for the creation of identity of urban landscape but also for monitoring intelligibility changes because of various transformations of urban fabric even without the destruction or other physical impact on heritage objects. The article focuses on the presentation of the model itself while pointing out further possibilities for its usage for monitoring purposes.

Mathematical graph models for the investigated area

So, if applied to the objects of immovable cultural heritage, intelligibility can mean that they are seen as visually active, accessible, easy to find, and often seen even without specific intention in an urban fabric or, in terms of Lynch [4], form participate in an image making as significant elements forming nodes, paths, districts, landmarks or edges.

Because of the complexity of human behaviour and cognitive functions, it could be stated that intelligibility or the possibility of understanding any urban structure is related/defined by motivation, attention, prior knowledge, processing speed, emotional state, social and cultural contexts, etc. At least some of the above-presented aspects affecting intelligibility could be modelled based on spatial configurations as the most available type of data:

- Attention could be related directly to spatial structure, the possibility of seeing heritage objects because of better visibility or allocation besides spaces which attract more people. Such probabilities depend on the visibility of urban spaces and the different reachability of city areas.
- Processing speed could be related to movement speed directly, based on the observation that we perceive more details and receive more detailed information about the surrounding environment while walking. The

walkability of urban structures and pedestrian flows could be addressed in simulative modelling as it will be discussed later as well.

- Prior knowledge could be related to the shared collective city image, city map or personal experience. Attention and orientation to pedestrian movement modelling, if related to the elements of the image of a city, could be seen as an important component of such analysis.

Architectural urban configurations, movement and concentration of people could be analysed in many ways including observation in situ or sociological survey. However, in the presented research, it was addressed based on simulative modelling which is used in many research fields for analysis and a better understanding of complex systems. There are in essence three groups of simulative models: cellular automata which, if applied in urban simulation, describes immovable cells (e.g., buildings, land plots, etc.) and a set of rules - how one cell reacts to changes in the other neighbouring cells; agent-based modelling which constructs simulation out of stable environment and moving agents (e.g., people) which interact with both environment and each other ; and mathematical graph-based network analysis which is applied in the presented research. The last one, based on previous experience of the research group and because it requires the least amount of initial information (e.g., no behaviour models of agents or properties of cells) was chosen for intelligibility modelling because of the following reasons:

- Mathematical graph models are based on urban layout, see the city as a network of objects/spaces and are used to simulate human behaviour in a city. Space Syntax is one of such models [12]. Similar models are used for modelling complex systems in many fields.
- Mathematical graph models are tested and validated based on empirical data in many situations. They allow us to model the movement of people, concentration of human activities, accessibility of places, visibility of spaces, etc.
- Simulative models not only allow us to investigate present, past and future situations but enable us to analyse the present situation with very high precision, achievement of which based on in situ investigations, would require an enormous amount of time.

The mathematical graph is made of nodes and links which connect them. Even if such a model looks very simple from the first point of view, it is successfully applied in many fields of science where a system as a network of interacting elements needs to be modelled, e.g.: the human brain, universe, etc. The essence of the mathematical operations is a calculation of the importance or centrality of the nodes for the movement of people, e.g.: each node of the graph which might represent part of visual space, visual axis or segment of street is considered as an origin and destination of calculations of distances and movement. Most often calculations are conducted from every node to the rest of the nodes, and the results make a background for calculations of the centralities of nodes. In more advanced graphs only part of the nodes could be used as destinations or origins, e.g., only nodes representing spaces except for living houses could be used as origins and only nodes representing spaces besides shops could be used as destinations, etc.

Traditional Space Syntax theory uses three types of graphs:

- Axial graph where each node is represented by the longest visual axe of real urban space, e.g., street. The crossroads represent links between the nodes. Such graphs mostly are used inside buildings or while investigating relatively small urban structures where visibility is an important factor for navigation.
- Segment graph nodes are constructed out of straight segments of central lines of streets while turns of intersections of segments at the ends are represented by links. Such graphs could be used for the investigation of urban structures of various sizes – from small to very large.
- Visual graph is constructed out of the cells of tessellated visual space. The possibility to see one cell from another one is considered as a graph link. Such graphs are used when visual relations of architectural space should be investigated with high precision.

Each of the above-mentioned graph types has its own strengths and weaknesses. Each of them could be used for the identification of probable elements of city image and evaluation of the role of heritage objects in it. Yet, the first and essential question is whether the simulative model is working well in the investigated area.

The validation of all three types of graphs is based on the idea of movement economy by Hillier. It states the following: "The theory of the movement economy, built on the notion of natural movement, proposes that evolving space organisation in settlements first generates the distribution pattern of busier and quieter movement pattern flows, which then influence land use choices, and these, in turn, generate multiplier effects on movement with further feedback on land use choices and the local grid as it adapts itself to more intensive development" [12]. Based on this, we can assume that the concentration of the object of interest of city users should correlate with certain calculated centralities of the

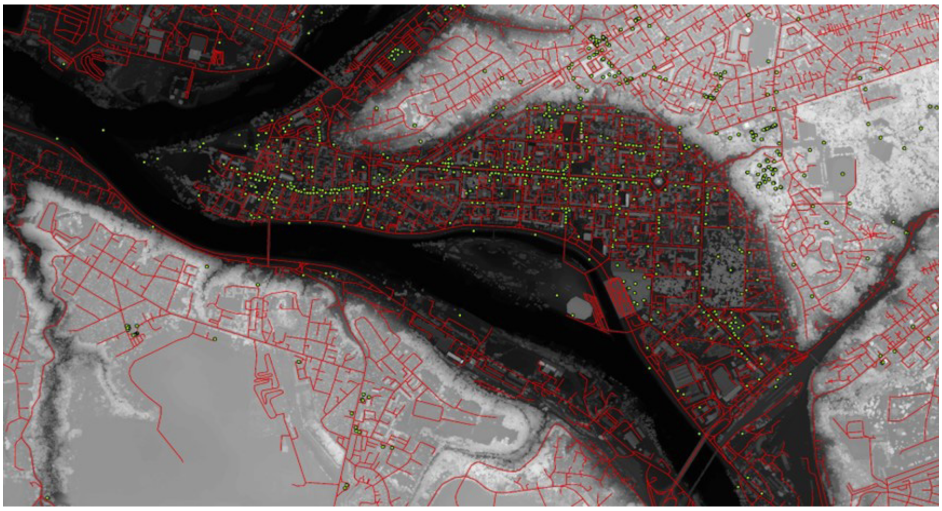

Fig. 1. The streets of the investigated area (marked by red lines) and allocation of (POIS) marked by red dots)

TABLE 2

Pearson correlations between density of POIS within 50 and 30 meters and Space Syntax indexes. Green colour marks strong, yellow colour – moderate correlations. ** mark 0.01 significance level of the correlations

	Ch3	Ch5	Ch7	Chn	Con	InRn	InR3	InR5	InR7	NC3	NC5	NC7	TDn	TD3	TD5	TD7
pois50	.625**	.601**	.589**	.634**	.613**	.257**	.355**	.293**	.261**	.420**	.236**	.148**	-.189**	.395**	.198**	.085**
pois30	.657**	.634**	.627**	.682**	.644**	.246**	.353**	.286**	.254**	.410**	.230**	.147**	-.177**	.383**	.193**	.086**

Space Syntax models. Centralities of all three types of graphs of the Kaunas Downtown area were checked for correlations with the density of so-called POIS (Figure 1) or points of interest based on the Open Street Map (OSM) data.

It is important to point out that the investigated area has a natural border made by the Nemunas River and slopes of the river valley with a limited number of entrance axes from the other parts of the city. That allows us to investigate the area autonomously without considering the rest of the city, especially while speaking about pedestrian movement.

The first tested model was based on an axial graph. The model was used to calculate the following basic centralities:

- Connectivity (Con in Table 2) or number of links each node has – it corresponds to the number of crossroads on each visual axe.
- Choice or betweenness centrality which represents the main probable transit routes within the area with four different radiuses: 3 turns of crossroad passed, 5, 7 and n (Ch3, Ch5, CH7, Chn in Table 2).
- Total depth or sum of the shortest topological distances counted in the number of nodes crossed from each node to the rest of the nodes within specified radiuses (TD3, TD5, TD7, TDn in Table 2). The lower the number, the better reachability the node has within the network.
- Node count of the density of nodes (axes) within specified radiuses (NC in Table 2).
- Integration or normalised Total Depth by comparison of it to statistically probable dispersion of the centrality values to Normal Dispersion (InRn, InR3, InR5, InR7 in Table 2).

Space Syntax results were intersected with POIS within two radiuses – 30 and 50 meters. Distances for intersection were selected as the most actual for visual perception based on the concept of visual graph based on the visibility of urban spaces.

In essence, the model works quite well, especially while modelling pedestrian flows within the area, which demonstrate strong significant correlations with POIS densities. Despite this, the correlations between POIS and Integration are moderate and weak, showing the limitations of the model in pointing out the most reachable and attractive areas successfully. The resolution of the model, caused by the length of a bigger part of the axes could be indicated as another weakness in the presented research as any building besides a street should be considered of the same importance for the further intelligibility model based on available data. Besides the previously-mentioned weaknesses, the axial graph (Figure 2) uses just topological distances for identifications of radiuses measured in the number of turns – it can possibly help to understand why integration results, which show the most reachable areas in the investigated area, are not working so well.

The segment graph, as it was mentioned earlier, differs from the axial one in two essential ways: a) nodes of the graph are constructed not from the longest possible straight axes but from straight street segments formed by intersections and turns of streets; b) it allows usage of various type of distance measurement, including metric radiuses, which could be more precise if compared to the axial graph.

If Space Syntax indicators of the segment graph are intersected with POIS density within a radius of 400 meters, then both Pearson and Spearman's correlations demonstrate very similar results.

In the case of segment graph analysis, Space Syntax indicators are intersected with POIS within 400 meters. Such radius represents a 5-minute walkable distance as a kind of minimal resolution not on visual connections but on movement lines-based segment graphs (Figure 3).

In both cases, choice or transit flows within the investigated

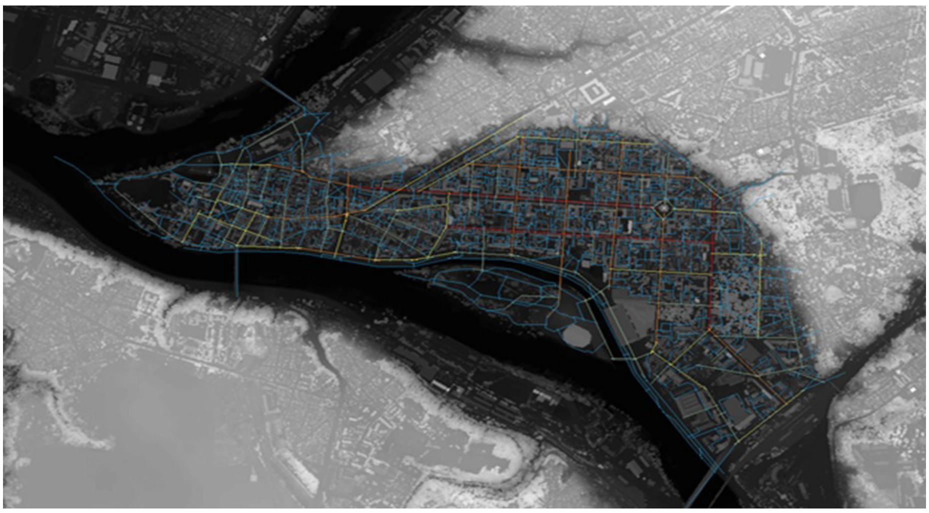

Fig. 2. Axial graph: Choice with radius n. Red colour shows high and blue – low numerical values

Fig. 3. Segment graph: Integration with a radius of 800 meters. Red colour shows high, blue – low numerical values

area (Ch with radius in meters marked in Tables 3 and 4) demonstrate significant but weak correlations. Integration in segment analysis ('In' with radius in meters marked in Tables 3 and 4) considers both the closeness of a segment to the rest of the network and the density of the network around it. It demonstrates significant strong and moderate correlations. The total depth of pure closeness without evaluation of the density of the network shows both positive and negative moderate and strong correlations, especially in the shorter radiuses. In this case, interesting regularity could be observed: TDn or less reachable areas demonstrate a negative correlation with POIS density, and it looks logical. When the radius is decreased (e.g., TD400) correlations are positively strong. It means that the street network around the most reachable areas in a city becomes more complicated and denser, which can reflect the natural phenomena of organic densification in the historical area of the city. So-called Metric reach or Total Metric Length within a radius 800 meters (MR800) shows the densest zones of the street network and confirms the previous insight based on TD400 while demonstrating significant positive strong correlations.

It is hard to say if the segment graph in the case of Kaunas works better than the Axial Graph but each of them works well on specific indicators. If you think about the level of precision needed for the intelligibility modelling of heritage buildings, the resolution of the segment graph is better. Still, there are a lot of different buildings allocated besides many of the street segments.

The third, and the most precise graph suitable for urban analysis and employed by Space Syntax is Visual Graph. During the construction of the graph, all spaces between buildings were tessellated while using a 10-meter step. Cells of the open spaces were connected if they were intervisible between themselves. The intersection of POIS with the visual graph was conducted at a 100-meter radius. Having in mind the social function of urban spaces it is a distance at which a medium size person would be seen as a 1.1 vertical angular degree size object, which could be still perceived as an autonomous single element on a visual field [13].

Statistical analysis of the results revealed significant moderate both positive and negative correlations between POIS density and:

- Connectivity (Conn in Table 5, Figure 4) or simply the sum of visible cells from the cell for which the calculation is conducted so the bigger number means bigger visual space.
- Isovist Occlusivity (IsOcl in Table 5) or length of the invisible perimeter of the visual field from the point of its observation. It is considered that higher occlusivity produces less visually predictable environments.

TABLE 3

Pearson correlations between POIS density and Space Syntax indicators of the segment graph

	Ch1200	Ch2400	Ch400	Ch800	Cnn	In1200	In2400	In400	In800	Inn	MR800	TD1200	TD2400	TD400	TD800	TDn
POIS	.159**	.132**	.270**	.204**	.126**	.476**	.463**	.432**	.527**	.327**	.663**	.502**	.147**	.741**	.669**	-.327**

TABLE 4

Spearman's rho between POIS density and Space Syntax indicators of the segment graph.
Green colour marks strong, yellow colour – moderate correlations. ** mark 0.01 significance level of the correlations

	Ch1200	Ch2400	Ch400	Ch800	Cnn	In1200	In2400	In400	In800	Inn	MR800	TD1200	TD2400	TD400	TD800	TDn
POIS	.069**	0.023	.195**	.115**	-0.01	.488**	.454**	.445**	.541**	.324**	.646**	.468**	.116**	.752**	.677**	-.324**

TABLE 5

Spearman's rho between POIS density and Space Syntax indicators of the visual graph.
Yellow colour marks moderate correlations. ** mark 0.01 significance level of the correlations

	Conn	IsOcl	IsPerim	PFM	PSM	ThrVis	VMD	ViEntr	VisInt
POIS	-.267**	-.223**	-.224**	-.269**	-.269**	-.215**	-.241**	-.300**	.241**

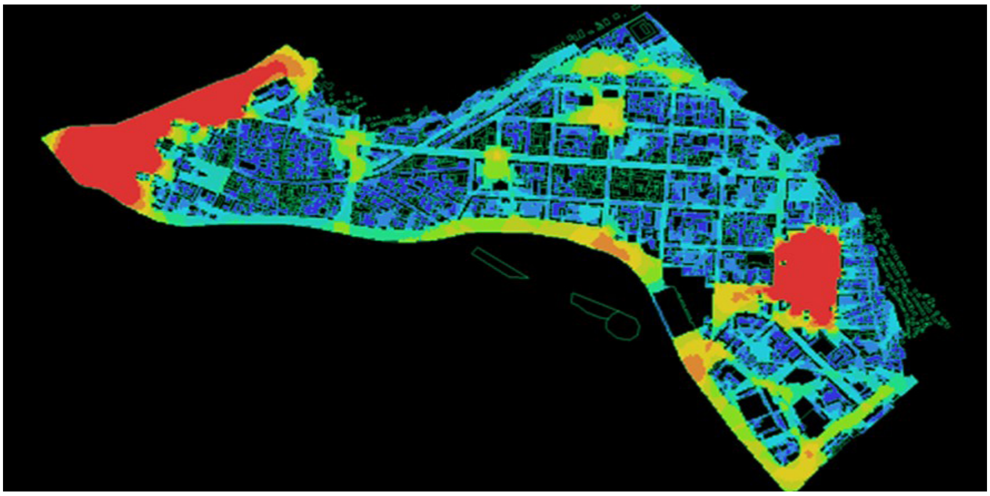

Fig. 4. Visual graph: Connectivity within radius 200. Red colour shows high, blue – low numerical values

- Isovist Perimeter (IsPerim in Table 5). The longer perimeter of the visually perceived spaces offers more visual information for an observer.
- Point First Moment (PFM in Table 5) or elongation/ skewness of a visual space. Higher mathematical value means that visual space is perceived as a kind of urban corridor.
- Point Second Moment (PSM in Table 5) or diversity of radiuses of the visual field – a bigger number means that space offers a higher variety of short, medium and long perspectives and could be considered more interesting for an observer.
- Through Vision (ThrVis in Table 5) or the sum of times when the calculated cell appears on the visual connection between pairs of other cells. A higher value means that space is more exhibited and visible from all sides.
- Mean Depth (VMD in Table 5) is simply a sum of distances counted in the number of turns/changes in direction while moving from the calculated cell to all the other cells in the investigated area. Smaller value shows more reachable space.
- Visual Entropy (ViEntr in Table 5) – an indicator which shows the probability that the calculated point of space could be discovered by accident or unintentionally while moving in a city. A bigger value means that part of the space is more hidden.
- Visual Integration (Vi Int in Table 5) or normalized value of Mean Depth where a bigger number means better reachability of a space spot.

The model demonstrated just medium significance despite the higher precision of the graph if compared with the segment and axial ones. Possible better results could be achieved if graph creation rules were more complex, e.g.: a) two cells could be connected not only when intervisible, but when there is a possibility to move from one to another; b) when different types of border are considered as solid and intervisible; c) high transport intensity streets are removed from the graph as not accessible for pedestrians; d) big open spaces in parks removed as they offer completely different environment for perception in comparison to urban fabric; etc. Because of the lower values of the correlations, there is no possibility to model the movement of people directly and a little problematic. No clear optimal rules for the creation of links between the nodes of the graph, which would require a separate investigation, the visual graph at the moment was found as not the ideal background for the intelligibility of cultural heritage buildings modelling. At the same time, weaker correlations do not mean that the visual graph model is less suitable for the modelling of urban processes. In this case, simply the different data if used for validation can give better results as the visual graph in essence models visual perception of spaces but allocation of POIS is more suitable for modelling the movement and reachability in a city.

Building graph

All three types of city graphs simulate city functioning quite well as was demonstrated in the previous chapter and, in essence, could be used for modelling the intelligibility of urban structure. The problem arises when the exact task to conduct modelling at the level of single buildings is formulated: axial and segment graphs demonstrate too high resolution, visual graphs calculated with Depthmap [14], do not allow to simulate the movement of people and its resolution is too precise. An ideal solution in this situation would be a graph with buildings as nodes, which would allow us to simulate both the movement and concentration of people. Such a model, based on the same mathematical graph approach, was offered by Sevtsuk and Mekonnen [15]. It uses buildings as graph nodes, allows the addition of various weights to each building thus reflecting its unique properties as volume, perimeter, 3D perimeter, etc., and still incorporates street networks as the backbone of the model. Each building as a node is connected to the closest street segment thus reflecting entrance to a building. An example

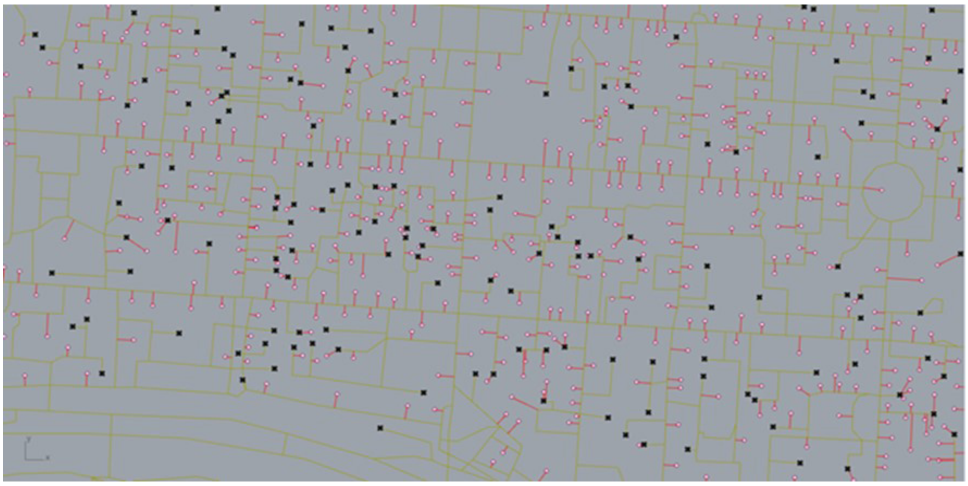

Fig. 5. Part of the building graph of the investigated area in Kaunas created while using the Urban Network Analysis Toolbox (UNAT) [16]. Yellow lines represent segments of streets, white round dots - buildings as graph nodes, red lines - connections between buildings and streets, and black crosses - dead ends of street segments

of such a graph is presented in Figure 5. Creation of one entrance per one building could be seen as a limitation in dense historical urban fabric, but each model represents a simplified view of the real situation, and the most important question is as follows: if it is effective enough?

UNAT offers the possibility of calculating five graph centralities

The first one is Reach Centrality, and it is calculated for each node of the graph as a sum of the weights of the nodes reachable from it within a specified radius [17].

The second is Gravity Centrality, which is counted for each node as a sum weight of each node reachable within a specified radius divided by the exponential function of distance to that node [17]. A higher gravity value means that more buildings with bigger weights (e.g.: 3D perimeter or volume) are located closer to a specific point. It demonstrates the most reachable and densely built-up zones of a city thus pointing out potential centres with higher diversity and concentration of functions. If compared to the Reach Centrality, Gravity is more sensible to distances of movement between buildings. In essence, the indicator is similar to the earlier mentioned integration of segment graph in Depthmap which considers both distances and density of reachable nodes.

The third type of centrality is Betweenness which is called Choice in Space Syntax and Depthmap. It is calculated based on a node as a sum of the shortest journeys between all pairs of potential origins and destinations as the starting and ending buildings for a journey within a specified radius, which cross the counted node, divided by the total number of potential node-pairs/journeys and multiplied by a weight of a destination [17]. As a result, betweenness demonstrates the potential transit flows simply normalised by the total number of journeys within the radius. The usage of the weights means that buildings with high value generate bigger flows towards themself in the simulative model.

The fourth indicator is Closeness, and it is calculated for each node by dividing one by the sum of distances from it to all the other nodes multiplied by the weights of those nodes [18]. It could be stated that bigger closeness means that the total sum of distances to the other buildings within the radius from the calculated building is bigger and the building is located in a more distant position on the network. In Space Syntax, it is called Total Depth.

The fifth centrality is called Straightness, which is calculated as a sum of ratios between the real shortest distance from the calculated node to the other node within a specified radius and a straight line of so-called "crow fly" distance multiplied by the weight of the node to which distance is measured [17]. In the presented research it is proposed to multiply the Straightness and Height of a building to evaluate its visual legibility as even the 3D perimeter of the building does not necessarily reflect its height, e.g.: lower but with a bigger area building can have the same 3D perimeter as higher but with smaller area one.

The sixth centrality calculated is called Redundancy. It is based on the idea that people tend to choose alternative routes for movement within certain limits of route elongation acceptable for them. "Redundancy Index computes the ratio of the sum of the lengths of redundant segments to the sum of the lengths of shortest path segments per each ... pair (of street segments within specified radius). If there are multiple

TABLE 6

Spearman's rho between POIS density and centralities of the building graph. Yellow colour marks moderate correlations. ** mark 0.01 significance level of the correlations. Nv means not weighted graph, 3dw means buildings-nodes weighted by 3D perimeter

	POIS	Reach nv	Closeness nv	Gravity nv	Betweennes nv	Straightnes nv	Norm_Gravity nw	Norm_Betwennes nw	Norm_Reach nw	Norm_Closeness nw	Norm_Straightnesnw	Reach_3dw	Closeness 3dw	Gravity_3dw	Betweennes 3dw	Straightnes 3dw	Norm_Straightnes 3dw	Norm_Gravity 3dw	Norm_Betweennes 3dw	Norm_Reach 3dw	Norm_Closeness 3dw	Reduncdancy index	Redundancy index norm	Legibility nw	Legibility 3dw
POIS	1.000	.660**	-.607**	.633**	.228**	.625**	.130**	0.038	.660**	.203**	.190**	.741**	-.666**	.782**	.274**	.715**	.246**	.440**	.070**	.663**	.494**	.502**	-.499**	.537**	.585**

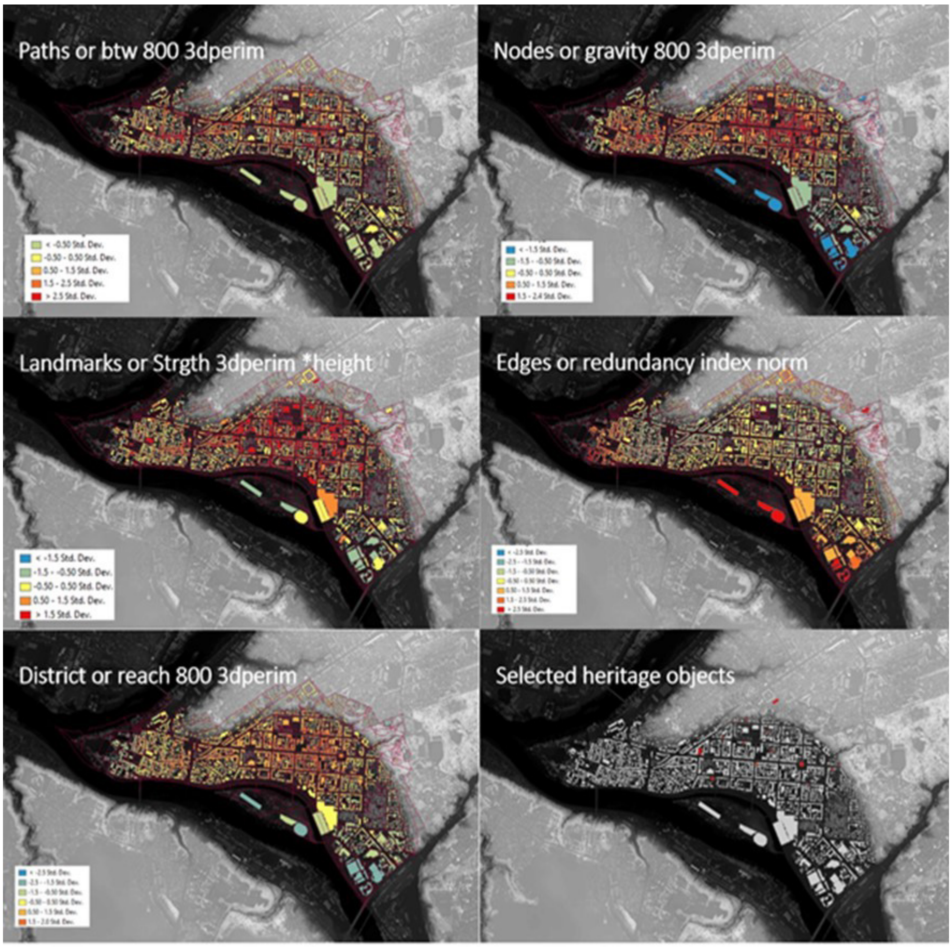

Fig. 6. Results of intelligibility modelling based on graph centrality calculations and structure of the mental city image by Lynch [4] and location of heritage objects

destinations for the same origin, we average these multiple values. Many urbanists have argued that having more path options to Destinations is a positive quality of the built environment enabling travellers more choices" [17].
The first five centrality indexes are normalised in the following way: Reach by dividing it by a sum of the weights of the nodes; Gravity by dividing it by the Reach; Betweenness by dividing it by the Reach; Straightness by dividing it by the Reach [18]. In the presented research it was proposed to normalise Redundancy by dividing it by Reach. In this way, we eliminate street network density parameters and identify and make the result dependent clearly on the morphology of the street network.
Even if the previously presented Space Syntax graph were simulating aspects of the city functioning quite well and we can expect the same from the building graph, its validation should be conducted. For this purpose, the results of calculations of centralities were intersected with a density of POIS within the same radius as in the segment graph – 200 meters. The obtained correlations are presented in Table 6. Straightness multiplied by the height of a building is marked as legibility there. In essence, it could be pointed out that now normalised values with buildings weighted by 3D perimeter demonstrate stronger correlations between POIS and legibility, redundancy index, straightness, closeness, and reach. Weighted betweenness demonstrates the strongest close to moderate correlation if compared to the non-weighted and normalised versions. Based on the presented validation results and suitable resolution of the model for building-focused analysis, it was decided to use the building graph for further intelligibility modelling.

Intelligibility modelling

According to Lynch [4], the mental image of a city is constructed in our memory from the following elements:

- Paths as the main connecting elements experienced and formed while moving through a city. Lynch mentions that paths should be identifiable and continuous in addition to their directional quality because of their functional necessity. It is logical to predict that streets with the higher betweenness centrality of choice values in the graph model have a bigger chance to function as paths of the image.
- Edges create a boundary between areas or districts with different characters. Quite often natural elements in a city such as rivers or slopes can function as edges too. In terms of graph centralities, depending on available calculated indicators, zones with the least transit flows (low betweenness centrality), the most peripheric or hard reachable (high closeness centrality) and similar indicators could be associated with edges. Large roads with intensive car traffic can form edges for pedestrians as well.
- Districts are a group of urban spaces that have common characteristic features which could be experienced by an observer. According to Lynch [4], it could be texture, space configurations, form details, building types, activities, etc. Not all of those properties could be modelled in graphs, some of them could be addressed in visual graphs while others in segment or axial graphs. In our case, while looking at the possibilities offered by UNAT, reach centrality could be associated with a district as, if local radius is used, it identifies urban zones with different densities and configurations of street network.

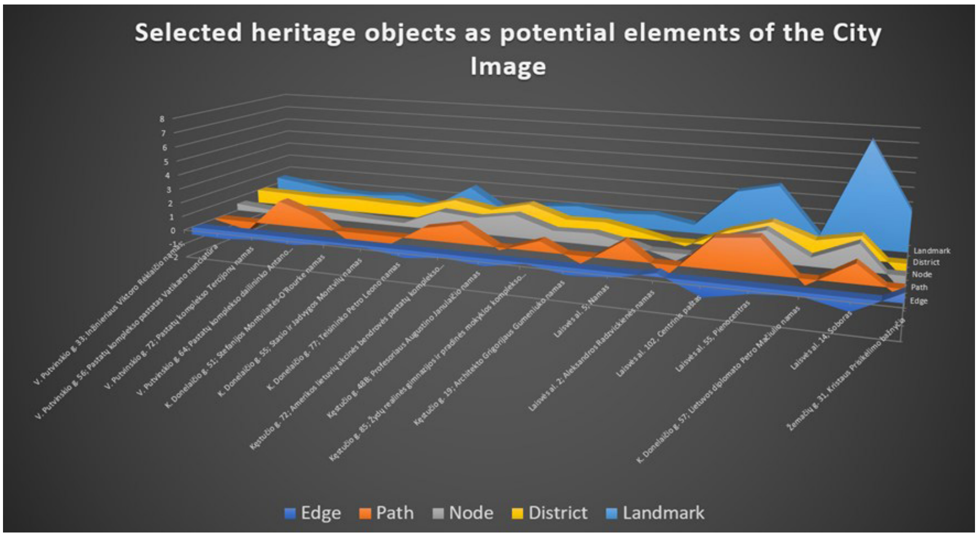

Fig. 7. The scatter plot of normalised graph centralities represents the potential of the selected heritage objects to become elements of the city image

- Nodes are the points or concentrated areas where the observer can enter. According to Lynch [4], nodes can be related to intersections or junctions between paths, but they may be larger than that. A node could be seen as the centre of a district so exhibiting gravity centrality, which identifies the most attractive, well reachable, attracting potentially the biggest number of users, could be seen as graph centrality useful for node identification.
- Landmarks are references like nodes but in comparison to them the observer doesn't enter within landmarks. According to Lynch [4], these elements are unique and memorable in a city context because of the figure-background contrast. Straightness centrality, as it was explained earlier, helps to identify buildings-nodes that appear more often on the straight axes of movement. If weighted by the height of a building, they can help to identify at least part of the potential landmarks as visual dominants of a cityscape.

Based on the presented argumentation for possible connections between the elements of the city image and the graph centralities and while looking at the strongest correlations, the following exact indicators were chosen for modelling:

- Paths – betweenness centrality within a radius of 800 meters weighted by the 3D perimeter of a building (Btw 800 3dperim in Figure 6).
- Nodes – gravity centrality within a radius of 800 meters weighted by the 3D perimeter of a building (Gravity 800 3dperim in Figure 6).
- Landmarks – straightness within a radius of 800 meters weighted by the 3D perimeter and multiplied by the height of buildings (Strgth 3dperim *height in Figure 6).
- Edges –Redundancy normalised within a radius of 800 meters (redundancy index norm in Figure 6).
- Districts – Reach normalised within a radius of 800 meters (Reach 800 3dperim normalised in Figure 6).

The numerical scales of the results of calculations were normalised by dividing them by standard deviation. In this way, bigger standard deviations (both positive and negative) easily identify the most exceptional and unique values of centrality, e.g.: if the value is between 1 and 2 then it represents 13.6 percent of the most unique values if it is above 2-2.1 percent, etc. The higher standard deviation could be related to a higher probability of a building performing a role or being a part of the modelled element of a city image because of its differentiation from a background of urban fabric. While looking at the maps it could be concluded that they demonstrate quite clear, visually recognisable pattern: paths as the main pedestrian streets with nodes concentrated around them at certain points; edges as the zones with offered more opportunities for alternative routes together with reach differentiation, identify three historically different zones and potential districts: the Old Town with its medieval street network; the part of New Town with the most clearly expressed and preserved classicistic street layout; the southern part of New Town with more organic and in the twentieth century deformed layout. The least clear picture is presented by the modelling of the Landmarks as it presents quite a large number of the buildings. Two ways to improve the results could be chosen in the future: increase the value of the standard deviation or search for additional indicators and possibly employ both quantitative and qualitative techniques. But even in the present situation the landmark modelling decreases the number of potential candidates and works quite well in the Old Town where it identifies the main churches and Town Hall. Figure 6 represents the results of all five indicators.

Numerical values are normalised while dividing by standard deviation. Bigger normalised values (red) show a higher probability of the building becoming an element of the city image. In the heritage map, green colour shows Interwar Modernism buildings, and red colour – other heritage objects. The results presented in Figure 6 could be interpreted in the form of a scheme of a city image but for the investigation of the intelligibility and validation of the model, the other path was chosen: different heritage objects, which, according to the expertise of the authors of this research, might perform a different role in the city image of the central part of Kaunas were selected (Figure 6) and the values of centralities, normalised by standard deviation were compared between themself in the first stage of validation (Figure 7). The bigger absolute value of the centrality after normalisation demonstrated the bigger potential possibility for the building marked by it to play a role of the corresponding element of the city image. The clear differentiation of the selected objects could be observed:

- Functionally, symbolically and visually dominating objects such as Soboras, Central Post office or Church of Resurrection could be named as potential landmarks.
- Bigger buildings located both beside the main pedestrian street and in zones of higher multifunctionality could be seen as potential elements of the nodes.
- Soboras and Central Post office, besides their important role as landmarks, could be seen as an element of the edges which mark the transition from the Old Town to

TABLE 7

Spearman's rho between graph centralities and both POIS density and visitors count density in Google maps. Yellow colour marks moderate correlations. ** mark 0.01 significance level of the correlations. Nv means not weighted graph, 3dw means buildings-nodes weighted bey 3d perimeter

	Reach_3dw	Closeness 3dw	Gravity_3dw	Betweenness 3dw	Straightnes 3dw	Redundancy index norm	Legibility 3dw
POIS	0.741**	-0.666**	0.782**	0.274**	0.715**	-0.499**	0.585**
VISITORS	0.791**	-0.777**	0.762**	0.098**	0.720**	-0.437**	0.573**

the New Town central and southern parts.

- The rest of the buildings could be seen as the formants of the districts with possible differentiated roles within blocks and local streetscapes.

In conclusion to this part of the research, it could be stated that the results of the modelling meet experts' opinion, so the most important final part of validation will be presented by the sociological survey. Before the final validation, one more question should be asked: which group of users the constructed model of the potential elements of the mental city of Kaunas central area represents? Local inhabitants, tourists or both? Maybe different indicators, different weights, or different destinations of journeys should be used if different groups of city users are considered. In the created model all buildings-nodes were seen as both origins and destinations for the calculations. Is such a model correct regarding both tourists and locals? While answering these questions, various hypotheses could be made, e.g.: a tourist might move merely between certain objects and from certain locations like hotels, parking lots or public transport stops; local inhabitants might move from their dwelling to certain, objects such as shops, schools, public transport stops, etc., which are more important for them. Creation and testing of those assumptions would be worth separate research publications. However, before surveying local inhabitants it would be wise to get at least some clarity and get insights if those groups can have a very different mental city image of the investigated area. To receive the answer, information about the most often visited places by tourists in Kaunas centre was obtained based on the methodology described earlier. Correlations between the used centralities and the density of the visits were calculated and compared with the earlier tested correlations with POIS. The results of the comparison are presented in Table 7. The most significant difference could be seen in correlations with betweenness centrality (Betweenness 3dw in Table 7): if compared with the initial model it decreases from nearly moderate to very weak. It might be explained by the assumption that tourists are not restrained by everyday routine and discover cities not following the most rational and short paths of movement in opposition to local inhabitants. At the same time, the relatively weak correlations between POIS and Betweenness could be better understood because POIS includes objects important for both tourists and local inhabitants. The other correlations have quite similar numerical values, and it might show two things:

- The investigated area is quite compact and homogeneous thus not leaving a lot of space for different interpretations of the mental maps by the different types of users.
- The initial model addresses both groups of users and presents some kind of "mean" city image or intelligibility. More clarity will be obtained after sociological survey-based validations of the model are presented, but, in any case, the presented research should be seen as a pilot attempt to create a methodology for intelligibility analysis.

Validation of the selected 18 heritage objects as the elements of the city image based on a sociological survey

To test the recognisability and legibility of the elements of the image of the city, selected heritage objects (Figure 8) were used (see the list of the objects in Table 1), the importance of which was determined through sociological surveys and open databases.

The residents' survey

The survey was focused on the target group - residents of the central part of Kaunas City (Kaunas Center Eldership), and it was conducted online using the Google Forms tool, which complies with the General Data Protection Regulation - GDPR. The random sampling was performed. 59 respondents submitted their answers.

The first block of questions was related to various aspects of the socioeconomic data that not only describe the profile of the survey's respondents but also, in the literature, are considered to be the predictors of the sense of the place. The respondent's gender – some studies claim that gender does not affect the sense of the place significantly [19, 20]. Other researchers claim that women tend to establish closer social relationships and thus, they also feel stronger place attachment [21, 22]. The majority of this survey respondents were women (74, 6%). The respondent's age influences both the sense of the place and the scale of the most important places. For example, children feel most strongly attached to the smallest scale nearest territories, when they grow up, it starts to vary depending on the individual's mobility [22]. While ageing, people's mobility decreases again, and the nearest territories regain their importance [23]. This survey was carried out only for the adults (18+ years). 36 % of all the respondents were between 46 and 65 years old, 34 % were between 31 and 45, 22% were between 18 and 30, 3 % were older than 65 and 5% did not reveal their age. Respondent's education and occupation – some researchers [20] claim that more educated people are geographically more mobile, thus, they feel less attached to a certain place. Other researchers [22] conversely believe that more educated people are more proud and attached to their dwelling places. Regarding education, 88 % of the survey respondents claimed that they have a higher-university education. The rest said to have secondary education (3 %), upper school education (3 %), vocational education (3 %) and higher non-university

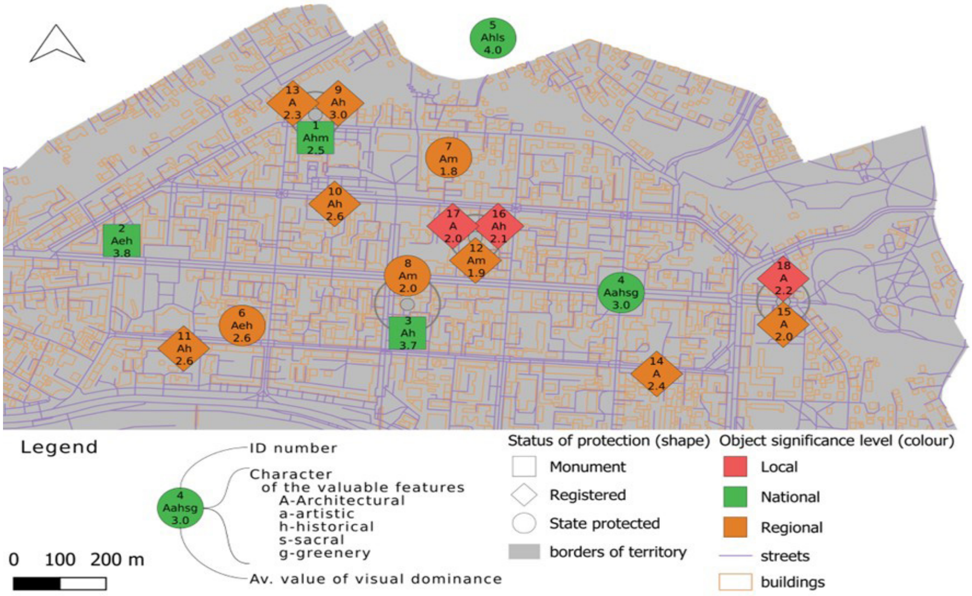

Fig. 8. Location and status of investigated heritage objects (for identification of ID number look at Table 1)

TABLE 8

The scale of Sense of the Place (SoP) based on Axford and Hockings [30]; Shamai [31]; and the percentage of the respondents' choice regarding their feelings towards the entire Kaunas city and its central part

Scale	Item	Explanation	SoP for entire Kaunas	SoP for Central Part of Kaunas
7	I am ready to give up even a part of my personal privileges if this is necessary for the welfare of the place	sacrifice and commitment	3%	2%
6	I could dedicate my strength and resources for the benefit of the place	involvement and active participation	19%	25%
5	I identify with the goals lifestyle and values of the local community	loyalty and dedication	10%	7%
4	I am emotionally attached to this place	emotional attachment special place	41%	32%
3	I always feel that I belong to this place	sense of community, belonging	15%	7%
2	I do not feel I am local	knowledge of place, situation, no attachment	5%	14%
1	I feel nothing for this place	neutral state, no feelings	2%	7%
0	I don't want to live here	negative feelings	0%	2%
Not able to evaluate			5%	4%

education (2 %). The respondents' occupations were the following: 81 % were employed, 8% worked while studying, 5 % retired, 3 % were on maternity leave and the remaining 2% were high school students. Place of birth – literature [24, 25, 26] indicates that people born in a particular place possess stronger positive feelings about it, they comprehend the place more fully and deeply. More than half of the survey respondents (64,4%) were born in Kaunas, but just 15% were born in the area of research interest, i.e. in the central part of Kaunas. Time of residence – is one of the best predictors of the positive sense of the place [19, 24, 27, 28, 29], because the longer people live in a certain place, the more attached to it they feel. The average time of the respondents' residence in Kaunas was 34,5 years (the value ranged from 2 years to 65 years). Meanwhile, the average time of residence in Kaunas city centre was 20,5 years (the value ranged from 1 to 63 years).

In the next section, the sense of the place (SoP) was evaluated for the entire Kaunas city and the central part of the city (New Town and Old Town). Based on the existing sense of the place scales [30; 29], eight statements were submitted in the survey (see Table 8). They varied from the highest level of sense of the place (7 points) down to the lowest level (0 points). The respondents had to choose one of the most suitable statements for the entire Kaunas city and one for the central part of the city (New Town and Old Town).

While talking about the sense of place, most respondents chose that they feel emotionally attached to Kaunas city (41%) and the majority also have this feeling for the central part of Kaunas (32%). Even though, on average, the sense of the place score was slightly higher (4,27 points) for Kaunas than for the central part of it (3,98), residents feel that they belong to these places and are attached.

Results of both the first and the second sections confirmed that respondents of the survey are not only familiar with the place but know it pretty well and also have a strong attachment to it. Thus, they are suitable for the evaluation of the different heritage objects existing in the territory.

In the previous sections intelligibility modelling was used to evaluate the potential of the selected heritage

Fig. 9. Church of the Resurrection of Christ [photo 1: kvr.kpd.lt, photo 2: I. Povilaitienė]

Fig. 10. Jewish Gymnasium [photo 1: kvr.kpd.lt, photo 2: I. Povilaitienė]

Fig. 11. House of Engineer Viktoras Rėklaitis [photo 1: kvr.kpd.lt, photo 2: I. Povilaitienė]

objects to become elements of the city image (Figure 9). The sociological survey was one of the ways to validate the results of intelligibility modelling. Therefore, the respondents of the survey were asked to evaluate the same 18 selected heritage objects (Figure 8) in terms of their relationship to the surrounding environment. They rated objects on a scale from 1 to 4, where the numerical values mean: 1 - the object does not stand out in the environment; 2 - the object is a local accent (slightly, but stands out); 3- the object is a landmark (stands out in the quarter, it is possible to orientate on the spot); 4 - the object is a clear landmark of the city (main, predominant, dominant). The respondents could also indicate that they are not able to evaluate. The average values of the evaluation are provided in Table 8, column "Av. value of visual dominance".

While comparing the results, it is noticeable, that the heritage objects, that were predicted to become landmarks in the intelligibility modelling, were also rated highest as the most prominent landmarks of the entire city by the residents of Kaunas.

It also confirms the insight from the intelligibility modelling that bigger buildings located both beside the main pedestrian street and in zones of higher multifunctionality could be seen as potential elements of the nodes, as in the sociological survey they were rated (Figure 10) as standing out of the surroundings and helping to orient within the block (i.e. Lithuanian American Joint Stock Company Building Complex Studio, Jewish Gymnasium (now Juozas Naujalis Music Gymnasium) or Lawyer Petras Leonas' house).

Finally, the survey also confirms that the rest of the buildings could be seen as the formants of the districts with possible differentiated roles within blocks and local streetscapes as in the sociological survey the rest of the heritage objects were rated as local accents (e.g., House of Engineer Viktoras Rėklaitis (see Figure 11), House of Lithuanian Diplomat Petras Mačiulis or House of Professor Augustinas Janulaitis).

Conclusions

1. The territory of the research - the central part of Kaunas city (Old Town and New Town) - was chosen with the case study identified in the HerInDep project application, which is characterised by the transformations of Interwar Lithuanian architecture and their impact on the social and urban development of the city. The largest variety and concentration of Interwar architecture is found in the central part of Kaunas (New Town), which underwent a major urban transformation during the Soviet period and has been under pressure from business

development since 1990.

2. The modern internet has its own Genius Loci, which in part is producing and sharing open data. Wide acceptance of this idea allowed this research to acquire useful datasets from public and open sources that represented human behaviour. Although data is shared voluntarily it is made public in a way that is not suitable for data analysis in some cases; nevertheless, this obstacle can sometimes be overcome by using data scraping and mining techniques.
3. It could be concluded, based on the investigation of Kaunas' case, that the proposed intelligibility model, which is constructed on the simulation of the behaviour of people in the mathematical graph of buildings, performs quite well and allows analysis and comparison of intelligibility of individual buildings quite well.
4. The presented model reflects the potential of buildings to perform a specific role in the Mental City Image in the present situation but because of its simulative nature, it could be used for the prediction of changes in the intelligibility if urban configuration is changed or new development happens. Therefore, the model could be used as a monitoring tool which, in contrast with the existing heritage monitoring practices focused on physical and functional changes, allows monitoring of changes in the role of heritage objects in perceived cityscape.
5. The possibility to apply a simulative model to the past situation opens the possibility of comparing the present and future intelligibility of the actual buildings with its previous situation, which, if needed, could be used as a benchmark for evaluating the ongoing changes.
6. The limitations of the proposed model should be pointed out:

- It is validated only in the situation of Kaunas so before application to other situations its validations would be necessary.
- The building graph has certain limitations such as one entrance per building, connections of the buildings-nodes to the nearest street segment-nodes based on the shortest distance, but not real connections, etc. In Kaunas' case the last problem was addressed and solved by correcting the graph manually, but, if the investigated area would be bigger – the other solutions should be found. The influence of the potential possibility to model more than one entrance per building on the modelling results should be investigated in the future.
- It still remains unclear if intelligibility from the perspectives of different users could and should be addressed in the model. Some insights were given in the text, but it requires further research.

7. It remains unclear if the proposed building-graph-made model is the best or the only solution for intelligibility modelling. In the case of Kaunas, it worked quite well and offered resolutions suitable for the task. In the other situations with different sizes of territories, while addressing possible different detail levels of intelligibility and if past situations with limited available data would be used, it would be useful to test the other types of graphs.
8. The sociological survey conducted to assess the visual dominance of selected heritage objects in the surrounding environment corresponds to the findings of the intelligibility modelling, indicating a positive relationship between the predicted potential of heritage objects and perceived visual significance by residents, thereby validating the usage of the intelligibility modelling for the revealing the differentiate roles of heritage objects in the entire urban fabric.

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Kopsavilkums

Pētījums balstīts uz projektu "*Heritage in Depopulated European Areas*", kas tika uzsākts 2023. gada aprīlī. Tas aplūko starpkaru perioda (laikposma starp Pirmā un Otrā pasaules kara beigām un sākumu) arhitektūras pārmaiņas un tās ietekmi uz Kauņas (Lietuva) sociālo un pilsētbūvniecisko attīstību.
Kauņā, īpaši tās centrālajā daļā, atrodas ievērojama starpkaru modernisma arhitektūras koncentrācija, kas ir piedzīvojusi būtiskas pilsētas pārmaiņas Padomju Savienības laikā, kā arī spiedienu no komercdarbības attīstības pēc 1990. gada. 2023. gadā Kauņas modernisma arhitektūra tika nominēta iekļaušanai UNESCO Pasaules mantojuma sarakstā ar nosaukumu "Modernistiskā Kauņa: optimisma arhitektūra, 1919–1939", atspoguļojot tās pārvēršanos par Lietuvas pagaidu galvaspilsētu. Aptuveni 80 % no šiem kultūras mantojuma objektiem piemīt unikālas īpašības, kas ir juridiskās aizsardzības vērtas.
Raksta mērķis ir piedāvāt un pamatot metodoloģiju nekustamā kultūras mantojuma salasāmības (*legibility*) novērtēšanai pilsētvidē. Konkrēto pētījuma metodoloģiju varētu izmantot ne tikai, lai labāk izprastu kultūras mantojuma nozīmi pilsētas ainavas identitātes veidošanā, bet arī, lai uzraudzītu salasāmības izmaiņas dažādu pilsētvides transformāciju rezultātā, pat gadījumos, kad mantojuma objekti nav fiziski bojāti vai iznīcināti.