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EXPLORATION OF URBAN HERITAGE IN THE HISTORIC CORE OF LONDON: A SPATIAL NETWORK APPROACH

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ABSTRACT

Heritage is a key cultural, social and economic asset for cities. Ideas of urban conservation have evolved from monument restorations to Historic Urban Landscape (HUL). HUL emphasises connecting urban heritage to its city, but it lacks a platform for providing a direct connection. Spatial networks in space syntax theory translate non-discursive dynamic urban contexts to numerical and comparable systems. This paper argues that spatial networks can provide an effective platform for studying urban heritage in a closer link with all other aspects of the city. It takes the historic core in London as a case study. By using the techniques of spatial network modelling, the research investigates how the spatial characteristics match the heritage characteristics in the historic core. Heritage networks in this research are a device that aggregates the heritage data on the spatial model and presents it in a numerical, connected system. Furthermore, high heritage-weighted clusters are defined through a statistical analysis of the heritage networks. The research shows that these clusters have different spatial and potential movement patterns. With the spatial network approach, heritage conservation can be integrated with other planning and urban design tasks and can provide a more robust evidence for an enhanced urban conservation initiative. The approach employed in this paper is developed and tested for London. However, this methodology can be applied to any other city in the world, wherever urban heritage is an important element of urban planning and design.

KEYWORDS

Space Syntax, Urban Conservation, Spatial Networks, Heritage Networks, the Historic Core in London.

1. INTRODUCTION

Urban heritage is a cultural, social and economic asset for cities and plays an essential role in the overall sustainable development of the human environment (Historic England 2008; Rojas 2016; Taylor 2016; UNESCO 2011a). Ideas of urban conservation have evolved from monument restorations in the 1960s to Historic Urban Landscape (HUL) in the 21st century (Bandarin and Van Oers 2014, 2012; UNESCO 2016). HUL recognizes the dynamic nature of cities and integrates urban conservation within a wider urban context, considering the spatial organization and connection, the natural features and settings, and the social, cultural and economic values of historic areas (UNESCO 2011a, 2011b). In the UK, Historic England introduced the term 'historic environment' in 2000, integrating urban heritage with its context that incorporates social, cultural and natural issues (Rodwell 2008). The transformation of ideas in urban conservation reflects a trend of connecting

urban heritage to its city. However, there is a gap in current HUL for urban conservation: it lacks an effective approach to link urban heritage to its city directly.

Urban morphology focuses on the contextual urban fabric and the interrelation between components instead of individual monuments, so it is considered as a powerful tool in urban conservation (Bandarin and Van Oers 2014; Bianca 2014). Aldo Rossi (1982) believes that the material form of a city is an intrinsic aspect of its social and cultural reality. Bill Hillier develops this further into a space syntax theory, in which spatial networks, created by segment or axial maps, reflect the city as a social-spatial artefact and allow for statistical comparisons between different cities or different parts of the city. Integration and choice values of spatial networks indicate patterns of 'natural movement', capturing movement to destination, or 'to-movement', and movement through the network, or 'through-movement' (Hillier, 1989; Hillier and Vaughan 2007). Spatial networks also reflect the centrality of the city as a dynamic process, in which historic cores may or may not lose centrality depending on how the city grows around them (Hillier, 1999). Therefore, the use of configurational analysis of spatial networks not only reflects spatial configurations of a city, but also indicates the social logic and movement patterns generated or influenced by spatial structures (Hillier 2007; Hillier and Hanson 1989). This paper argues that spatial networks can provide a strong platform to effectively link urban heritage to other aspects of its city and thus fill the gap in the current HUL approach to urban conservation.

This research aims to employ a spatial network approach to analyse urban heritage within its urban context and to explore it as an interconnected system, thereby integrating urban heritage with other planning issues and providing evidence for better planning and decision making with regards to urban conservation. The spatial network approach consists of two types of analyses: a configurational analysis of the spatial networks (segment/axial models) within the larger context of the city, and an analysis of heritage networks by linking heritage data to a segment model.

This study's overarching research question contains three main parts:

(1) Can the spatial network approach be used as an effective method for linking urban heritage to its city and analysing urban heritage within its urban context?
(2) In which ways the spatial network approach assists us to build heritage networks to explore urban heritage as a connected system and identify heritage clusters?
(3) What spatial and potential movement patterns can be recognised in heritage clusters within the heritage network?

2. DATASETS AND METHODS

Methodology in this research consists of three stages: heritage data collecting and mapping, spatial network analysis and heritage network analysis. In the first stage, heritage data are extracted from the heritage list and mapped in QGIS to build heritage maps and find heritage characteristics. In the second stage, spatial networks in space syntax theory are used to find the spatial characteristics of the historic core and to analyse heritage within its urban context. In the third stage, heritage data are integrated with the spatial model to build heritage networks. High heritage-weighted clusters are defined and their patterns are compared.

(1) Heritage data collecting and mapping

List details are looked up on the Historic England website by using the list entry number of each listed heritage, including listed buildings, scheduled monuments, historic parks and gardens, world heritage sites and nature conservation sites. The heritage data (e.g. built year, grade, etc.) are obtained for each listed heritage and mapped in QGIS, then heritage characteristics are found.

(2) Spatial network analysis

Spatial networks of the city – segment maps of integration and choice – allow us to see the spatial configurations of the city in a numerical way. Segment maps also reflect the city as a dual system with foreground and background networks and indicate movement patterns (Hillier 2008, 2010).

Integration values indicate to-movement and choice values indicate through-movement (Hillier and Hanson 1989; Hillier and Vaughan 2007). Therefore, spatial networks of the city provide a platform for linking urban heritage to its city and for analysing heritage within its urban context.

Normalized Angular Choice (NACH) and Normalized Angular Integration (NAIN) are independent from the size of cities and have immense advantages (Hillier et al. 2012), 'making it easier to expose the inner structure of urban form and making it possible to compare street configurations in different cities and in different locations within a city' (Al_Sayed 2018: 78). NACH and NAIN are calculated using the following formulas (Hillier et al. 2012):

$$NACH\_r = \log (ACH\_r + 1) / \log (ATD\_r + 3)$$
$$NAIN\_r = ANC\_r \,\hat{}\, 1.2 / ATD\_r$$

In these equations, the ACH is angular choice, the ATD is angular total depth and the ANC is angular node count. This research uses the NACH and NAIN segment maps of 10km London at R800m, R3000m and Rn as spatial networks of the city, to analyse spatial characteristics of the historic cores, heritage within its urban context and the relationship between the top high NAIN and NACH segment lines and heritage.

(3) Heritage network analysis

All heritage data are linked to the segment model to build networks of heritage age layers, density and weight (Figure 1). The network of heritage age layers presents the number of different heritage age layers in each segment line, reflecting the city as a layered process through history (Table 1). The network of heritage density presents the number of all heritage linked to each segment line (Table 2).

Figure 1: Linking heritage data to the segment model. Source: The author.

Segment reference	Roman London	The Middle Age	Tudor	C17	C18	C19	C20	Heritage age layers
4370	0	0	0	1	0	1	2	3
4385	0	0	0	0	0	2	0	1

Table 1: Examples of heritage age layers. Source: The author.

Segment reference	Listed buildings			Scheduled monuments	World heritage site	Historic parks and gardens			Nature conservation site	Heritage density
	GI	GII*	GII			GI	GII*	GII		
4370	2	0	1	0	0	1	0	0	0	4
4385	0	0	1	0	0	0	1	0	0	2

Table 2: Examples of heritage density. Source: The author.

Listed buildings account for the majority of urban heritage, but they have three grades of heritage importance: 'Grade I (GI) buildings are of exceptional interest and only 2.5% of listed buildings are GI; Grade II* (GII*) buildings are particular important buildings of more than special interest and 5.8% of listed buildings are GII*; Grade II (GII) buildings are of special interest that account for over 90% of listed buildings.' (Historic England, n.d). Due to such a huge difference between GI and GII, heritage density cannot represent heritage importance. Historic parks and gardens also have three grades as listed buildings. To address this problem, a method of heritage weighting is introduced. While further research is needed to define the weight more objectively, a method of weighting is adopted for this research after testing various combination, which gives a weighting of 1.8 to the most prominent elements of heritage (GI heritage and world heritage sites), a weighting of 0.2 to GII heritage and a weighting of 1 to the rest (Table 3).

Heritage Type	Listed Buildings			Scheduled Monuments	World Heritage Sites	Historic Parks and Gardens			Nature Conservation Sites
	GI	GII*	GII			GI	GII*	GII	
No Weight	1	1	1	1	1	1	1	1	1
Weight	1.8	1	0.2	1	1.8	1.8	1	0.2	1

Table 3: Proposed weights for various heritage listing grades. Source: The author.

In the network of heritage weight, the value of each segment is a combing consideration of heritage density (HD) and weight (W):

$$\text{Heritage weight} = \Sigma\, HD * W$$

For example, the segment line 4370 has a heritage weight of:

Heritage weight = 2*1.8+0*1+1*0.2+0*1+0*1.8+1*1.8+0*1+0*0.2+0*1=5.6 (Table 4).

Segment reference	Listed buildings			Scheduled monuments	World heritage site	Historic parks and gardens			Nature conservation site	Heritage weight
	GI	GII*	GII			GI	GII*	GII		
4370	2	0	1	0	0	1	0	0	0	5.6
4385	0	0	1	0	0	0	1	0	0	1.2

Table 4: Examples of heritage weight. Source: The author.

Thus, heritage data is integrated with spatial model in each segment line (Table 5).

Segment reference	NAIN R800m	NAIN R3000m	NAIN Rn	NACH R800m	NACH R3000m	NACH Rn	Heritage age layers	Heritage density	Heritage weight
4370	1.499	1.670	1.607	0.982	0.952	0.944	3	4	5.6
4385	1.481	1.657	1.661	0.834	0.721	0.561	1	2	1.2

Table 5: Examples of combing spatial data and heritage data. Source: The author.

After heritage networks are built, top high heritage-weighted segment lines are picked from the network of heritage weight to form heritage clusters. Spatial and movement patterns of these clusters are compared, which links heritage clusters to their urban context and provides a foundation for integrating heritage with wider planning issues.

(4) Case study

All above-mentioned methods of heritage data collecting and mapping, spatial network analysis and heritage network analysis are applied in the case study of the historic core in London. The research area is within the Roman London walls, which has been the historic core of London from the 2nd

century (Figure 2). The site is chosen for the research case as it has plenty of urban heritage and reflect the history of London from its origin and record the layering process of the city (Ross and Clark 2008; Whitfield 2017). The research focuses on all listed heritage within the research area and in its immediate surroundings. Listed heritage in the historic cores includes: listed buildings, scheduled monuments, registered parks and gardens and world heritage sites. River Thames, as a nature conservation site, is also included in this research.

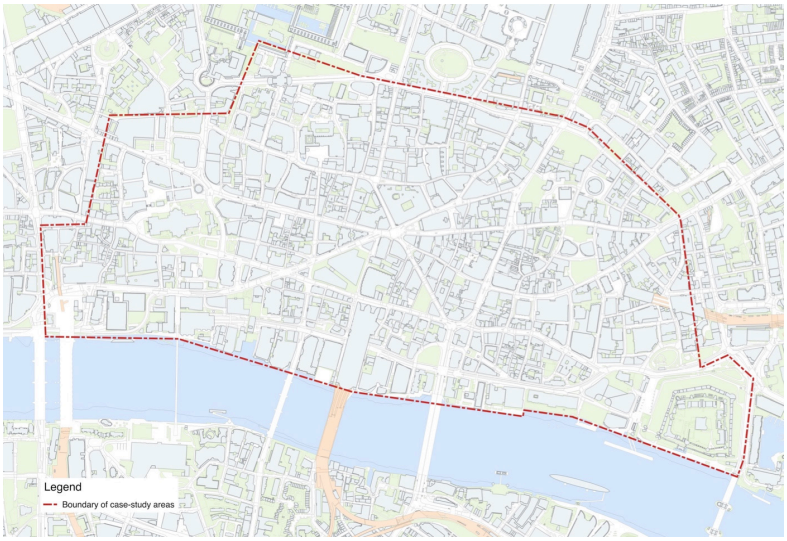


Figure 2: The research area of case study. Source: The author.

(6) Limitations

Minor errors are inevitable in the process of linking heritage data to segment lines, due to the large number of heritage and segment lines and the complexity of the segment model. However, this does not affect the overall pattern of heritage networks. Since heritage importance cannot be represented simply by heritage density, heritage weight is introduced into the research and different weight values are assigned. These weight values are defined according to the heritage grades from Historic England. Through testing, these weight values are the most suitable ones to present heritage importance of segment lines in the network, but further studies are needed to define them more objectively.

3. RESULTS

(1) Heritage characteristics

From heritage data mapping and analysis, there are 449 listed heritage elements within the historic core and in its immediate surroundings, including 396 listed buildings in Grade I, II* and II, 50 scheduled monuments, one word heritage site (the Tower of London), one historic park (the Barbican), and one Nature conservation site (the River Thames) (Figure 3). Listed buildings account for 88.2% of the all listed heritage, and scheduled monuments account for 11.1%. The heritage age covers the period from Roman London (43-410AD) to the 20th century, which represents 2000 years of cultural continuity in this area (Figure 4). The 19th century heritage is the largest heritage age group. Most of the scheduled monuments are dated from Roman London, while many listed buildings are from the 17th century. Most of the scheduled monuments are Roman London walls. Monuments also contains other Roman public places, such as Roman amphitheatres and Roman waterfronts. The second major type is Livery hall. Other types, like the Monument of Great Fire and the London Greyfriars are also included.

In the analysis of land use data, it shows that for Grade I listed buildings, the largest group is churches and the second is livery halls. They account for about 60% and 10% respectively in land uses. Land uses of Grade II* listed buildings is different. The largest group is offices, following by livery halls and catering. They account for about 23%, 16% and 16% respectively. As heritage is a social-cultural process (Smith 2006), tangible heritage always links to intangible heritage. For example, livery halls

represent the long history of trade in the historic core. Listed buildings and monuments include livery halls of the Great Twelve Livery Companies from the 13th century, like the Goldsmiths and Drapers. Roman baths, the Custom House and waterfronts indicate the close relationship between the city and the River Thames from Roman London. The natural environmental character forms part of the city's characteristics and heritage. The Monument of Great fire is standing at the exact place where the fire began, telling the past story of the city.

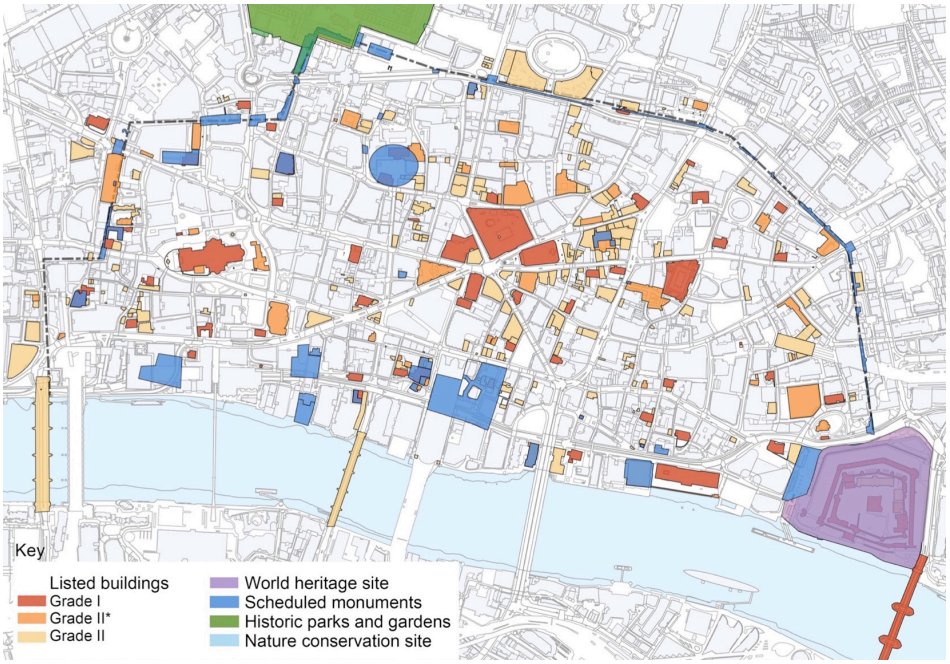


Figure 3: Heritage types. Source: The author.

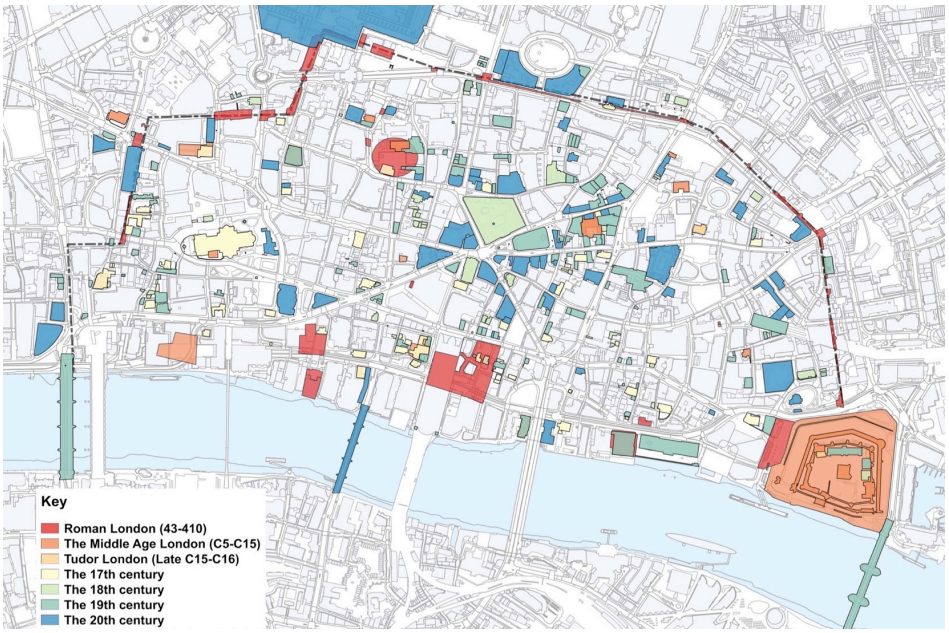


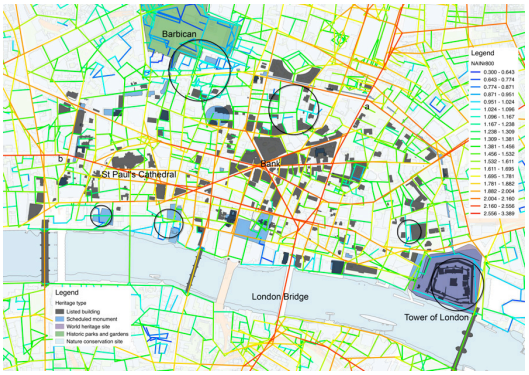
Figure 4: Heritage age. Source: The author.

Urban heritage in this historic core covers a wide heritage age-range, from Roman London to the 20th century, mixed with contemporary building. It shows the city as a layered and dynamic process, as mentioned in the 'recommendation on HUL' (UNESCO 2011a). This historic core has a unique heritage, including the Roman and medieval London walls, the extensive presence of churches and livery halls, as well as large Victorian and Edwardian financial buildings. These characteristics reveal that this area is the city's core and a trading centre of London since the Roman age.

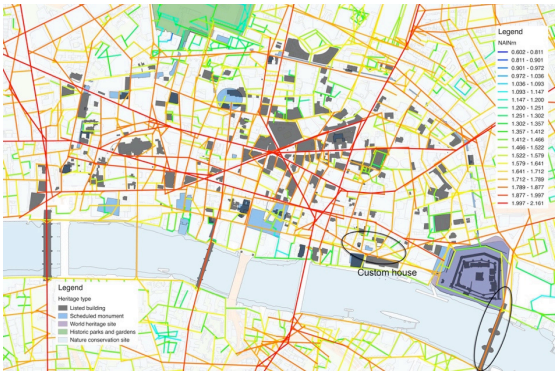
(2) Spatial characteristics

Spatial networks in this historic core has a unique spatial culture. The spatial structure in this historic core is generative for movement and co-presence, which matches the heritage characteristics, reflecting the historic core as a trading centre throughout a long history. It has a 'two-step logic', so little space in this spatial structure has deep depth or get segregated (Hillier 2007; Hanson 1989).

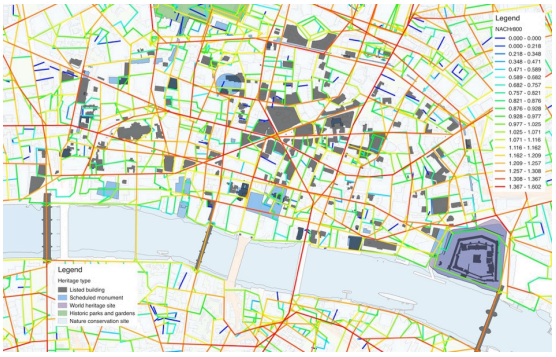
In Figure 5, all heritage in the NAIN segment maps shows that, from the local (R800m) to global (Rn) measurements, more and more heritage is located in high integration areas. NACH segment maps show that, from the local (R800m) to global (Rn) measurements, less heritage is directly linked to high choice value segment lines. The main street connecting St Paul's cathedral and Bank and the main street along the London Bridge have top 5% high NAIN and NACH at all three measurements (R800m, R3000m and Rn). The extensive presence of churches and livery halls is a heritage characteristic of this historic core. They have different spatial characteristics responding to their heritage characteristics. Most churches are linked directly or through open space to the top 5% high NAIN and NACH lines. In contrast, most livery halls are not. This supports Hillier's argument that churches' catchment areas are spatial and Livery halls stand for transpatial solidarities (Hillier 1989).



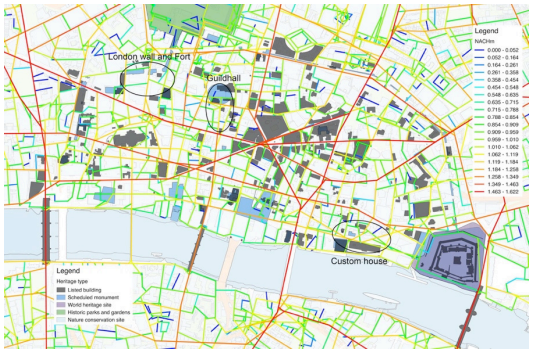
NAIN at R800m



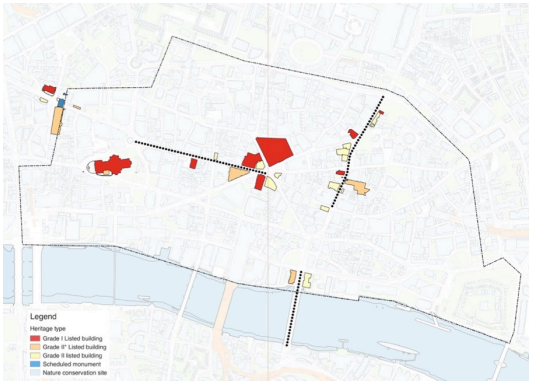
NAIN at Rn



NACH at R800m



NACH at Rn



Heritage linked to the top 5% high NAIN and NACH segment lines at R800m, R3000m and Rn.

Figure 5: Sptial networks and urban heritage. Source: The author.

(3) Heritage networks and clusters

Urban heritage is the layering accumulation of human cultures through space and time, which records the growing of a city. This research categorised heritage into seven time periods, including Roman London (43-410), the Middle Age (C5-C15), Tudor (Late C15-C16), the 17th century, the 18th century, the 19th century and the 20th century. Linking heritage age data to the segment model, Figure 6 represents a network of heritage age layers. It shows how heritage from different time periods is distributed in the current spatial network of the historic core. Each segment line has the number of different heritage age layers. The red line with the highest value of seven means it is linked to heritage built in all seven time periods.

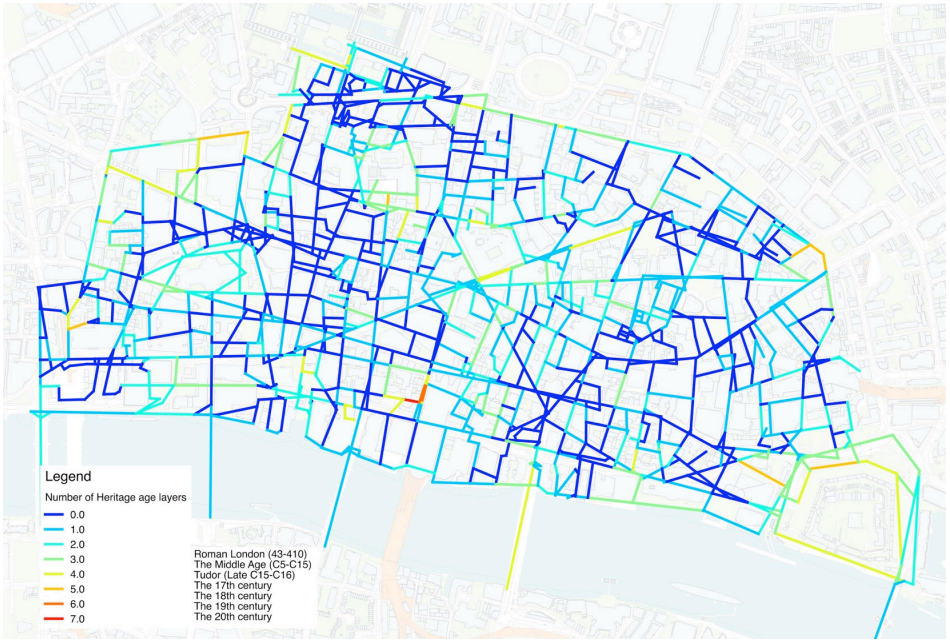


Figure 6: The network of heritage age layers. Source: The author.

By linking all mapped heritage to the segment map, the network of heritage density shows the number of heritage that each segment line has (Figure 7).

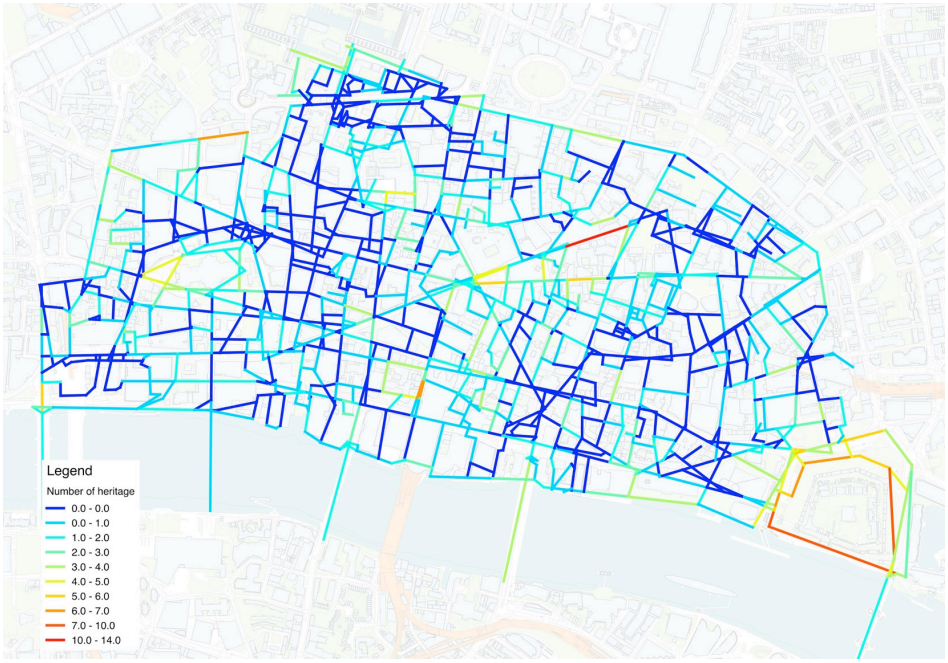


Figure 7: The network of heritage density. Source: The author.

As afore-mentioned in the methodology chapter, a weighting is given to different heritage in Table 3. Figure 8 is the heritage network defined by heritage weight.

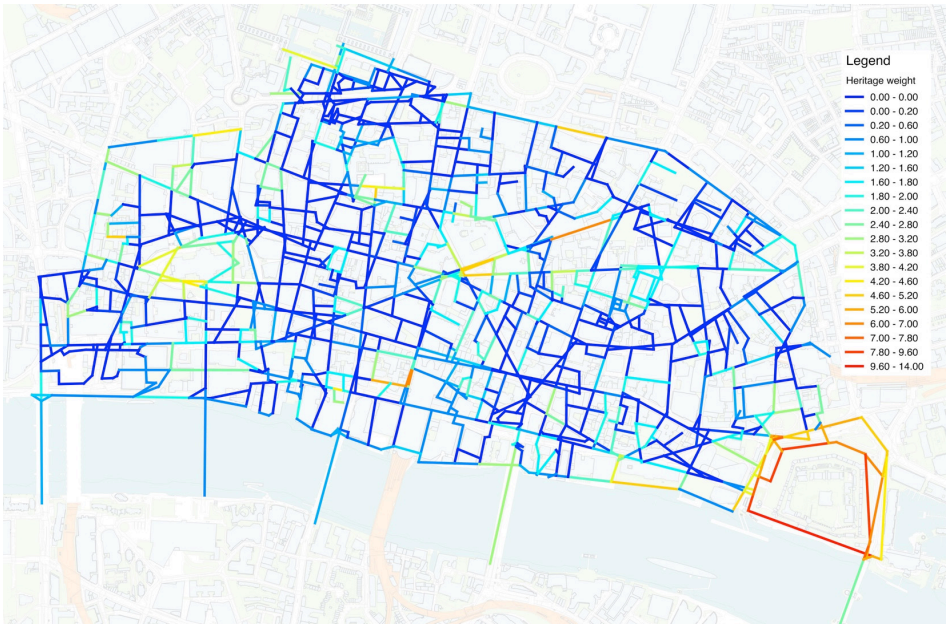


Figure 8: The network of heritage weight. Source: The author.

The top 5% high heritage-weighted segment lines are picked, and the 100m catchment analysis of these top high heritage-weighted segment lines forms segment line clusters within the network. Urban heritage linked to these segment lines forms ten heritage clusters in this historic core (Figure 9).

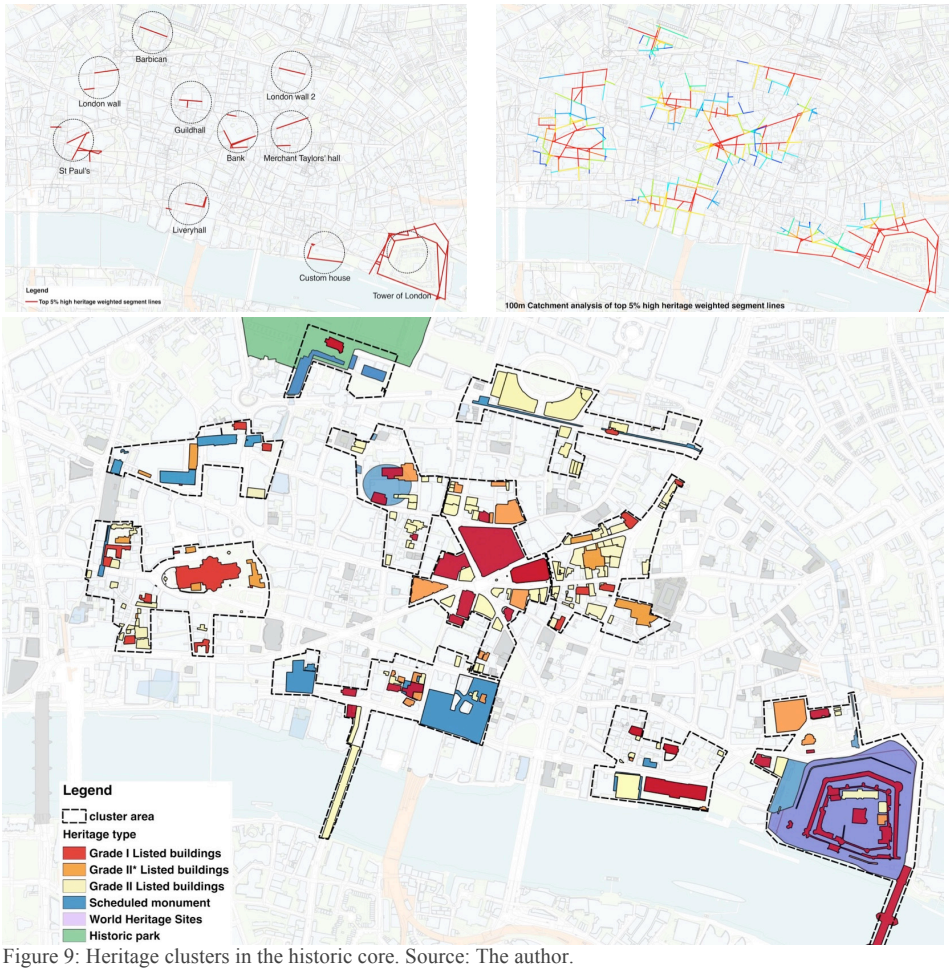
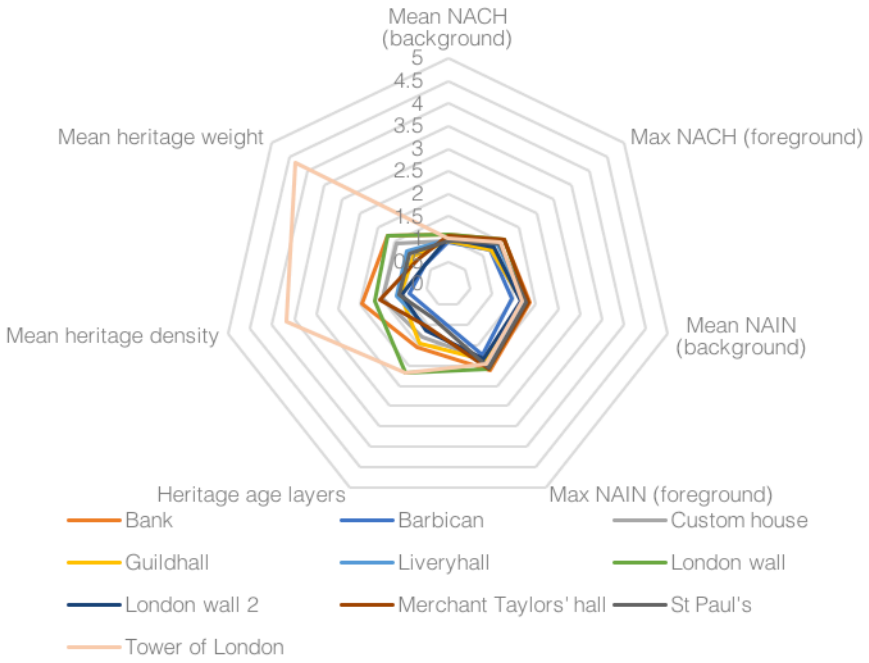
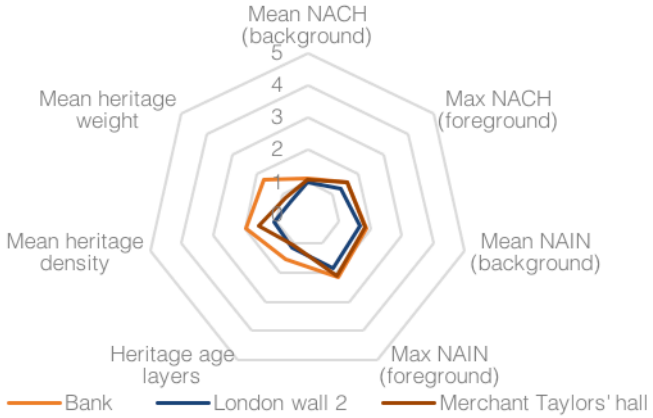


Figure 9: Heritage clusters in the historic core. Source: The author.

In comparison to conservation areas, heritage clusters provide a new way of thinking about urban heritage through a network. These clusters are formed from the highest heritage-weighted segment lines and also pick up the urban heritage, streets and urban spaces that are closely linked to these lines in the spatial network. This provides a complementary way of defining conservation areas. These clusters also incorporate urban data from the spatial model, which reveals that heritage clusters have different spatial and potential movement patterns, even if they are in the same conservation area (Figure 10).



Radar model of the ten heritage clusters.



Radar model of three heritage clusters within one conservation area in the historic core.
Figure 10: Spatial and heritage patterns of heritage clusters. Source: The author.

The different spatial, movement and heritage patterns of these important heritage clusters provide an evidence for developing better conservation plans. Clusters with high NACH/NAIN and heritage weight values (e.g. Bank, London Wall and Tower of London), need special considerations in traffic planning to mitigate heavy movement pressure. Clusters with the max NACH (at Rn) values above

1.5[1] are linked to the global structure of the city (e.g. Bank and Merchant Taylors' Hall), so their global economic role needs to be considered when choosing land uses.

4. CONCLUSIONS

Through a series of analyses, this research provides key findings regarding heritage characteristics, spatial characteristics, heritage networks and heritage clusters. Urban heritage in the historic core covers a wide range of time periods, from Roman London to the 20th century, mixed with contemporary building. Its unique heritage characteristics (e.g. the surviving London walls and the numerous churches and livery halls) reveal the longstanding role of it as London's core and trading centre. The spatial network of the historic core is organic and generative for co-presence and movement. The historic core does not lose its centrality when London grows. These spatial characteristics also reveal this area's role as London's core and trading centre, which matches its heritage characteristics. Heritage clusters are formed from high heritage-weighted segment lines and incorporate other urban data in the spatial model. There are ten heritage clusters in the historic core. Bank, London Wall and Merchant Taylors' Hall have a max NACH above 1.5, which means they are linked to the global structure of the city's network. Bank, London Wall and Tower of London have high values both in max NACH and heritage weight, while Barbican has low values in heritage weight and NACH/NAIN. Heritage clusters with low NAIN and NACH values need connections to other heritage clusters or changes in their ground-floor land uses to avoid segregation.

From the museological preservation of monuments to the conservation of historic areas and now the Historic Urban Landscape (HUL) approach, urban conservation has placed more and more emphasis on connecting urban heritage to its city. This research has introduced a new spatial network approach to link urban heritage to its city as well as explore urban heritage as an interconnected system.

The spatial network approach takes spatial networks from space syntax theory as a platform to connect urban heritage to its city. Spatial networks translate non-discursive dynamic urban contexts to numerical and comparable systems. By using spatial networks, the research identified the spatial characteristics of the historic core. It found that the spatial characteristics match the heritage characteristics, which indicates that the social logic underlying the spatial and heritage forms in the historic core has not been undermined by the city's growth. As Karimi (2000) states, a 'spatial spirit' controls the utility of the historic core. The consistent logic under space and heritage in a historic core is also a spatial spirit that needs conservation. Movement patterns in the urban context of heritage is also found by using spatial networks. These findings respond to the research question one.

The spatial network approach also links heritage data to the segment model to build heritage networks. This integrates heritage data with a spatial model and presents heritage data in a numerical connected system. By using this method, this research built networks of heritage age layers, heritage density and heritage weight. The network of heritage age layers reflects the layering process of the city. The network of heritage density presents the number of heritage elements linked to each segment lines in the network. The network of heritage weight considers heritage density and weight together, presenting heritage importance for each segment line. Heritage networks also allow for statistical comparisons of different historic cores. Heritage clusters are formed from high heritage-weighted segment lines in heritage networks and incorporate other urban data in the spatial model, so that spatial, movement and heritage patterns can be recognised in these clusters. Different patterns of heritage clusters provide evidence for developing better conservation planning and design. These findings provide answers to the second and third research questions.

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[1] 'Experience so far suggests that 1.5 identifies a dominant global structure, and 1.4 extends this to how it is related to more local organisation' (Hillier et al. 2012: 180).

The 1994 Nara Document, the current HUL approach and the national and local policy related to the historic core all emphasise the importance of understanding the character of the local urban context. The spatial network approach is an effective tool to reveal spatial characteristics of the urban context of heritage. More significantly, with the spatial network approach, heritage conservation can be integrated with other planning and urban design tasks and can provide a more robust evidence for an enhanced urban conservation initiative. This is in line with the present-day ideas in urban conservation and fills the gap in the current HUL approach. This approach also builds a bridge between the heritage discipline and space syntax. Further research can be conducted to integrate more urban data into heritage networks and to compare different cities in the world. The approach employed in this research has been developed and tested for London. However, this methodology can be applied to any other city where urban heritage is an important element of urban planning and design.

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