

## #92.

### Segment analysis as space-syntactic ‘archaeology’ and the configurational stratification of historic built environments:

three research scenarios

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#### ABSTRACT

*Although it is now routine to produce segment graphs from road-centre lines, they are, in principle, derivative of axial models. There is a conceptual difficulty, however, in this derivation since the individual segment cannot be easily represented as an ‘embodied diagram’ in Conroy Dalton’s sense. In this paper I start by explaining why the abstraction of the segment has serious implications for the space syntax proposition that an intrinsic connection exists between the physical city of buildings and the social city of human action, prompting questions about what a segment actually is. I argue that while the axial line represents a highly synchronic syntactic description that is undifferentiated along its extension, the granularity of the segments represents a more diachronically enriched description. If the axial line embodies continuity in the smooth flow of movement from the past to the future, the segment expresses greater temporal depth, embodying mutability and contingency. The particular quality of segment analysis to represent urban movement potential at a given network (‘metric’) distance is a source of interpretative ambiguity since any given segment may be implicated at multiple resolutions of description. This quality of segment analysis transforms the axial map into a complex of interfaces identified contingently as the configurational expression of historical spatial cultures. In the second section of this paper I explain what I mean by space syntax archaeology. In the final section I offer examples from three ongoing research projects that engage with the theoretical arguments made in this paper.*

#### KEYWORDS

axial analysis, segment analysis, historical research, scale, resolution

## 1 INTRODUCTION

Segment graphs break up axial lines to create segments at each road junction. As fine-grain representations of urban space they offer space syntax researchers greater analytical range and precision. Although it is now routine to produce segment graphs from road-centre lines, they are, from a theoretical perspective, derivative of axial models (Turner 2007; Hillier and Iida 2005, 480). While the axial model remains fundamental to space syntax theory the conceptual status of the axial line is also considerably clearer than that of the segment. This implies difficulties in making the translation from axial to segment mode that have only been partially addressed in the literature, and then usually to present the segment as an unproblematic refinement of the axial line (Turner 2005). Yet this move represses innovations in the space syntax theory of society and space made explicit by segment representations – for example that of distance concepts (Hillier and Iida 2005). It is also oddly uncurious about the ways in which the segment has been deployed in space syntax research *de facto* to highlight the temporal descriptions that are surely intrinsic to spatial configuration (Griffiths 2012).

In this paper I start from the observation that, unlike the axial line, the segment tends to be regarded as an artifact of the road network that is of relatively little interest as element in its own right. I explain that one reason for this is that the segment does not straightforwardly constitute what for Conroy Dalton (2005) is an ‘embodied diagram’ describing a domain of spatial-cognitive possibility. This contrasts with the way in which axial lines and many other foundational space syntax notations clearly describe the operational space of the human body (Grosz). I argue that the conceptual deficit tends to prioritize the segment as an analytic unit of over its status as a configurational description of social space (that is implicit in its derivation from the axial line). This has serious implications for the space syntax proposition of a fundamental connection between the physical city of buildings and the social city of human action. Hillier and Hanson are consistently unequivocal that the realization of this connection involves the of “embodiment” and “re-embodiment” of syntactic descriptions through social action in space-time (Hillier and Hanson 1984, 45; Hillier 2012, 29-30); so what kind of kind of description is embodied in the segment? My argument here is it has something to do with the time-of-space; because once it is acknowledged that the axial line can be partitioned then it points to an historical process of partition or extension, and resolutions beneath or above which partitions and extension are *not* represented because they do not constitute a field (one could say a *scale*) of social action.

At issue here is whether temporality is regarded as *extrinsic* or *intrinsic* to spatial description. To present the argument in artificially binary terms: if the axial line represents a synchronic syntactic description that is undifferentiated along its extension, the granularity of the

segmented line might offer a differentiated, more diachronically enriched description. If the axial line embodies continuity in the predictable flow of movement from the past to the future (uniform cognitive agents in Newtonian time), the segment embodies mutability and contingency in this relation (historical body-subjects in morphogenetic time). While extrinsic description identifies temporality as a universalizing and linearizing function of spatial laws (t1, t2, t3) and privileges the observer position at a fixed scale, the intrinsic description identifies it in the specific and non-linear intersections of spatial morphology and historical events, and privileges no particular scale of analysis over any other. Indeed I will suggest that one of the qualities of the segment is its relationality within, between and across any scales of analysis that were, are or might be socially practised or *performed*. It should be noted that the concept of morphogenetic time is Hillier's own. Hillier and Leaman (1974) use it to express their critique of physicalist models of environmental function against the contingent 'might' of historical time in which it is clear that the relationship between environments and societies is best understood in terms of the structure of possibilities – rather than the realization of purposes and intention, whether divine or designed (or both). From this perspective the idea of movement as a Newtonian constant is difficult to maintain

## 2 THE SEGMENT IN SPACE SYNTAX THEORY

### 2.1 The embodied segment?

In 2007 Alasdair Turner announced the deprecation of the axial line in his symposium paper subtitled 'An Investigation into the linkage of the local to regional continuum'. In the paper's abstract Turner states "this study models the entire road network at the regional scale, by dispensing with axial lines entirely and moving to a road-centre line model of the UK, the Ordnance Survey's Integrated Transport Network (ITN) layer." As the author of *Depthmap* software Turner was well placed to assert the timeliness of this move. In his release of *Depthmap 4* (2004) Turner had included his own implementation of angular segment analysis, building particularly on the work of Sheep Dalton (2003) and Shinichi Iida and Bill Hillier (Hillier and Iida 2005). Segment analysis had originally been developed to address the limitation intrinsic to the axial model which meant it could not differentiate analytically between different sections of an axial line. Route 'choice' (betweenness), for example, could not be meaningfully computed on this basis. It also coincided with a sense that, for all its strengths and versatility, the axial model had begun to acquire something of an 'analogue feel' in a research environment dominated by GIS-based analysis of urban systems using road-centre line data.

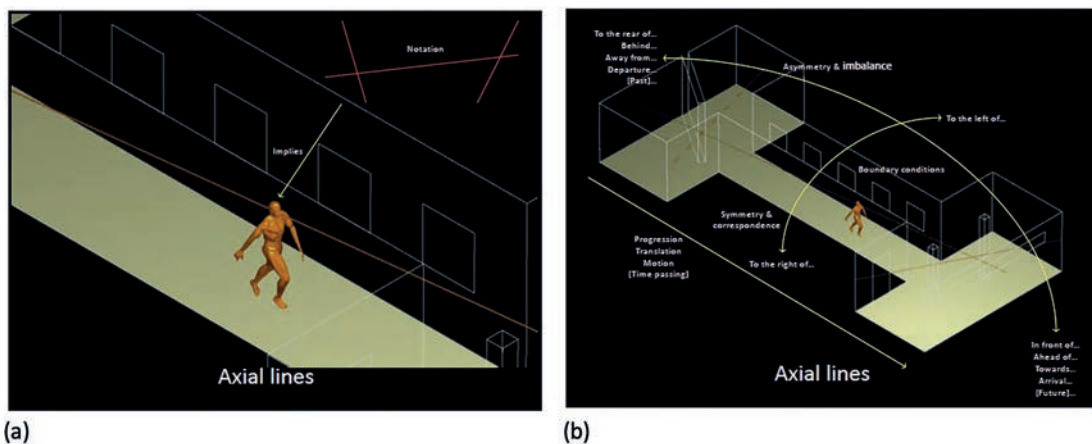
Key to the segment innovation was breaking the axial line at road intersections and using a simplified ('tulip') algorithm that weights the connection between segment nodes by the angular deviation on the principle that the greater the deviation the greater the cost, such that the obliquely connected axial lines of the axial integration core would still be represented as close in graph terms. The ability to construct space syntax models on the basis of road-centre line data (axial lines 'in disguise', as Turner (2005) put it) opened the door for space syntax researchers to develop large, multi-scale analyses of urban and regional networks, realize the potential of choice analysis, and to fully integrate urban space syntax into GIS platforms, with all the facilities for data linkage and analytical sophistication that entails. And while road-centre line data may require some 'cleaning up' for the purpose of space syntax analysis, this does not compare with the research cost in producing axial maps of large urban systems by hand. Although the axial line would continue to have its advocates (including this author) both on conceptual grounds and in specific research applications, it had largely been superseded for space syntax analysis of cities and urban systems.

The transition to segment-based urban modelling in space syntax has been a 'good thing' for the field and transformative of the kind of built environment research it can engage in, especially on an interdisciplinary basis. But the hegemony of the segment has served to amplify the fact that its conceptual status is somewhat ill-defined. As previously stated, this is because the segment model is in principle a derivative of the axial model which remains anterior in a theoretical sense (Hillier and Iida 2005, 29). The inevitable by-passing of the axial phase anticipated by Turner (2007) has obscured this genealogy. Perhaps it does not matter for many applied scenarios that a segment map generated from road-centre line data has become disassociated from the axial line. An unanticipated consequence however, is that production of the segment graph effectively dispenses with the role of the researcher in producing the representation from first principles, as a consequence rendering it as a rather abstract as a representation.

This process of abstracting the segment has three aspects. To grasp the first requires recalling that the original axial line was not, in fact, regarded primarily as a form of embodied notation by Hillier and Hanson (1984). Rather than explicitly constituting a line of sight as was subsequently claimed (with justification, see below), the original axial line was simply a phase in settlement analysis. It was produced on tracing paper using a ruler and pencil to create a line that would 'just about' get through the vertices of buildings to the nearest building frontage. In this respect the axial line was embodied by the researcher's own physical engagement with the map in, thinking about lines of movement and sight through an act of 'mapping', rather than by a definite conceptualization of the line itself (Griffiths and Vaughan 2020). It is significant in this

light to reflect on how the analogue production of the axial map as a research practice that continues to be relevant has no equivalent in segment mode. The segment map is simply not drawable without some kind of underlying trace of axiality. Who has ever drawn a segment?

The second aspect of abstracting the segment in many ways follows from the first and highlights the status of the representation itself. This is Ruth Conroy Dalton's conceptualization of space syntax notation as 'embodied diagrams' (Conroy Dalton, 2005). Conroy Dalton's work on navigation and wayfinding emerged in parallel with Turner and Penn's interest in a 'bottom-up' syntax that produced, for example, agent-based modelling functionality in Depthmap (Conroy Dalton 2003, Turner and Penn 2002). Both Turner and Conroy-Dalton shared an interest in the psychologist Gibson's idea of affordance as a way of understanding perceptual immersiveness in the world as a possibility for action (Baggs, Chomero et al 2019). The contribution of psychology in space syntax has sometimes seemed questionable in a field that has largely emphasized the social over the psychological quality of spatial cognition. Even so the influence of psychology was important in the context of developing research in wayfinding and navigation strategies.



**Figure 1:** Conroy Dalton's illustration of the axial line as an embodied diagram.  
Source and copyright: images created by Ruth Conroy Dalton for Conroy Dalton (2005)

Conroy Dalton's notion of the embodied diagram was a necessary and important piece of conceptualization that drew on the philosophical perspectives well as research in spatial cognition to make the case space syntax notation as representations of environmental embodiment, for example that axial lines combined lines of sight and movement. Conroy Dalton went further however, in arguing that space syntax notations did more than represent the embodiment of the built environment to embody sources of social meaning. Figure 1 shows how Conroy Dalton expressed the axial line not just in terms of bodily orientation and movement temporality but in broader social terms 'departure and arrival', 'past and future'. This conception underwrites the space syntax conceptualization of virtual community as the

relational structure of space that creates the pre-conditions for sociality; rather than particular instances of sociality (i.e. encounter). The embodied diagram encourages thinking about, for example, how such elementary notations might describe recurrent journeys through space (i.e. departure-arrival...) rather than specific ones. In other words, it suggests how co-presence might be constructed in time as well as in space.

Dalton's notion of the axial line as an embodied diagram proposes the axial-line map as a minimal embodied field that represents the possibility of sociality between human bodies in inhabited space. In the segment paradigm of space syntax research no equivalent exists. The 'embodied segment' doesn't intuitively make much sense because what description does it embody that does not assume an axial extension? In fact, as Conroy Dalton presents it the embodied diagram is also rather abstracted from real-world settlement space – indeed it is illustrated in the interior of a schematic building and appears rather constrained – the world beyond the boundary being a blank space. I will return to this in section 3.

The third and final aspect of the abstraction of the segment has to do with the attention given to retrofitting segment analysis as mode of syntactic description to the cognitive theorization of urban spatial networks that had developed around the axial line. Interest in the axial line intensified as empirical research employing computational analysis made apparent how the analysis of grid inequalities represented by the axial line map correlated with observed patterns of movement. The theory of natural movement (Hillier 1996; Hillier, Penn et al 1997) directed theoretical attention towards the qualities of the axial line as a special kind of representation of human movement potentials. From the early 2000s a succession of publications explored the axial line from the perspective of embodied spatial cognition. The focus was strongly on the cognitive rather than embodied element because cognitive models promised a generalizable validation of why axial maps worked to accurately predict levels of movement and social activity in urban areas.

In Alan Penn's 2003 article 'Space Syntax And Spatial Cognition: Or Why the Axial Line?' Penn argues that the axiality of the city describes the shape of a generic cognitive space that explains the link between urban configurations and human activity. Penn (2003) and Hillier (2003) both reference work in neuroscience led by John O'Keefe that proposes some kind of 'grid-maps in the brain' associated with the hippocampus (O'Keefe & Nadel, L. 1978). This is consistent with an allocentric (rather than ego-centric) definition of human wayfinding behaviour that corresponds closely with the space syntax theory of spatial configuration that describes local position through its extrinsic, non-local relations. Hillier (2012) goes further in incorporating the

experiments using segment analysis into the post-axial syntactical theory of spatial configuration – particularly with regard to geometry (a point that will be followed up in the next section). Its overriding concern, similar to Penn's is with proposing of the "generic cognitive city" that prioritizes "mental interaction with the spatial world" (p29).

In an earlier paper the cognitivist perspective on the axial line was refined for segment mode by Hillier and Iida (2005) in which the experiments with natural movement data were re-run for the key laboratory case studies in London neighbourhoods. Hillier and Iida show how three different 'distance concepts' in segment analysis (topological, angular and metric) correlate differently with levels of movement, with simple metric proximity the least significant. Given the street network is unchanged they argue the network embeds the psychological preferences for movement structured with clear local-global linear intelligibility. One important conclusion of this paper was that "axial graphs in their present form are in most circumstances a perfectly good approximation of the impact of spatial configuration on movement", indeed the axial correlation was stronger in several cases (p.488).

These papers by Hillier and Penn and colleagues have made pivotal contributions to the development of space syntax theory. My intention here is to draw attention to what the cognitive focus represses, particularly in the translation from axial to segment mode. This has to do with the space syntax conceptualization of movement as a Newtonian constant, or as it has been argued elsewhere 'that which does not need to be explained' (Griffiths 2011). While this Newtonian insight is powerful in removing the need to explain intentionality and thereby enabling the theory of natural movement, it assumes a highly synchronic framing of movement in an area of urban space at a fixed scale and prioritizes the statistical aggregate; assuming that movement beyond the  $r_2$  refers either to outliers or lies beyond the reach of spatial morphological explanation. Where angular-weighted segments achieve similar results it is because they succeed in emulating the axial line in achieving synchronic descriptions in a similarly privileged frame of analysis. The theme of the time-space description of segments is developed in Section 2.3. Before then it is worth considering why acknowledging the temporality intrinsic to the elementary modalities of segment analysis reveals this cognitive-synchronic framing as in some respects contrived and awkward to maintain.

One of the most prominent features of GIS-enabled segment analysis is the multiplicity of descriptions it offers: not just three ways of conceiving distance but also the possibility of constructing these at different resolutions or catchments that are typically metrically defined (x metres) but may also be topological or angular reaching. Even if one goes no further than the

most commonly used syntactic measures of choice (NACH) and integration (NAIN) this offers a wide range of descriptions. Space syntax researchers are now familiar with the listing of 'metric radii' (400m, 800m, 1500m, 2000m, 5000m, *nm*). In urban design applications these are loosely associated with various modes of localized and larger scale movement that are more or less valid in a pragmatic sense but theoretically such approximations cannot easily be accommodated into the 'generic cognitive city'. These multiple scalar descriptions threaten not only de-centre the privileged axial categories of *local* and *global* they also deprive the observer, who themselves becomes situated in a given complex of scalar relations to the object of study. Statistical techniques like principal component analysis can identify clusters of similar metric radii that may identify significantly differentiated scales of analysis relevant to specific case-studies but this method and similar are unlikely to identify authoritative radii on a more generalized basis that can respond to the many different ways in which space is embodied and re-embodied in social practice.

In other words the matrix of distance concepts and variable scalar radii of segment analysis do not appear to lend themselves to any universalist, generic cognitive definition. Rather they draw on an historical understanding of how: a) bodies enact spatial descriptions with distinct distance and scalar attributes, b) the temporality intrinsic to spatial-morphological concepts of distance and scale (i.e. the-time-of-space) affords such enaction; (c) the time-space descriptions of spatial morphological relations express different scales and modalities of possible movement at any given time but also through time – given the distinctive temporality of built environments and (d) how marginal movement patterns may enact different scalar-distance trajectories rather than being simply statistically atypical.

By 'historical understanding' I am not suggesting a resort to social history – though this certainly has its role. Rather I am talking about *historical understanding of spatial morphology* of the kind proposed by Julienne Hanson in her PhD study (1989). I am suggesting that the multiplicity of descriptions raised by segment modelling in space syntax suggest how the generic-cognitive city has to be balanced by the a similar understanding of the historical-material one that is intelligible to human bodies. Achieving this balance has a lot to do with understanding the relationship between the graph and the geometric form but it is more than this because it claims that only by understanding how actual bodies enact {morphic languages} in the historical world can the ambiguities of myriad configurational descriptions at the generic-cognitive level be at least partially resolved through accounts of any given social situation or event.



At times the cognitive reduction in space syntax theory calls to mind what Doreen Massey (2005, 36) means by the ‘prison house of synchrony’. She is referring to the danger of repressing the plurality of historical-diachronic trajectories through which we understand the relationship of society and space in preference for a synchronic generic model in which time is only ever  $t_1$ ,  $t_2$  etc. In such a *sociological* model people become risk becoming placeholders in a system aimed simply reproducing itself, rather than active agents in social reproduction in a morphogenetic sense – i.e. as an expression of their being-in time (Griffiths 2011). As Hillier and Penn acknowledged the concept of a generic cognitive city theorized in configurational terms needed to be congruent with intuitive intelligibility of people found in material built environments, given that the range of geometric expressions of the generic city could not be assumed to be isomorphic with the topological one.

The concept of the generic cognitive city does not seem equipped to account for the ways in which the built environment structures movement historically. Yes, bodies can be regarded as agents with universalizable cognitive capacities (or parameters as they might be in a computer simulation) but this cannot occlude acknowledging their identities as *bodies* coming to sociality in the historical-material (artefactual) world *for which a pre-social world never existed*. This time-space situatedness makes demands on them not simply to reproduce social information but to embody it in the world as they experience it – a process which may extend to the erosion and manipulation of morphic descriptions. This principle is acknowledged, for example, in recent research examining how ‘natural’ movement patterns in an urban environment might be experienced by ‘non-normal’ (e.g. mobility impaired) bodies (Koch and Legeby 2022). Such work raises questions not just at the level of the inevitable normativity of design knowledge but also for the generic cognitive model. It also draws attention to how the body resists universalization because it is always situated in the historical-material world and orientated towards it.

The environmental phenomenologist and critical advocate of space syntax David Seamon might agree. In the tradition of Merleau-Ponty Seamon argues that body-subject is a “special kind of subject” and anything but mechanistic (Seamon 1979). For Seamon body-subject inhabits the world through an ongoing process of corporeal learning. Seamon’s rich lexicon of ‘lifeworld geography’ often draws on metaphors from dance (also familiar to readers of Jane Jacobs) such as ‘body ballet’ and ‘time-space choreographies’ to explain how body-subject comes to know the world, both in relation to itself and to other people (Seamon 1979). Crucially this phenomenological view of embodiment does not seek to isolate any cognitive mechanism, certainly none any that could sustain a mind-body dualism, so much as to understand bodily

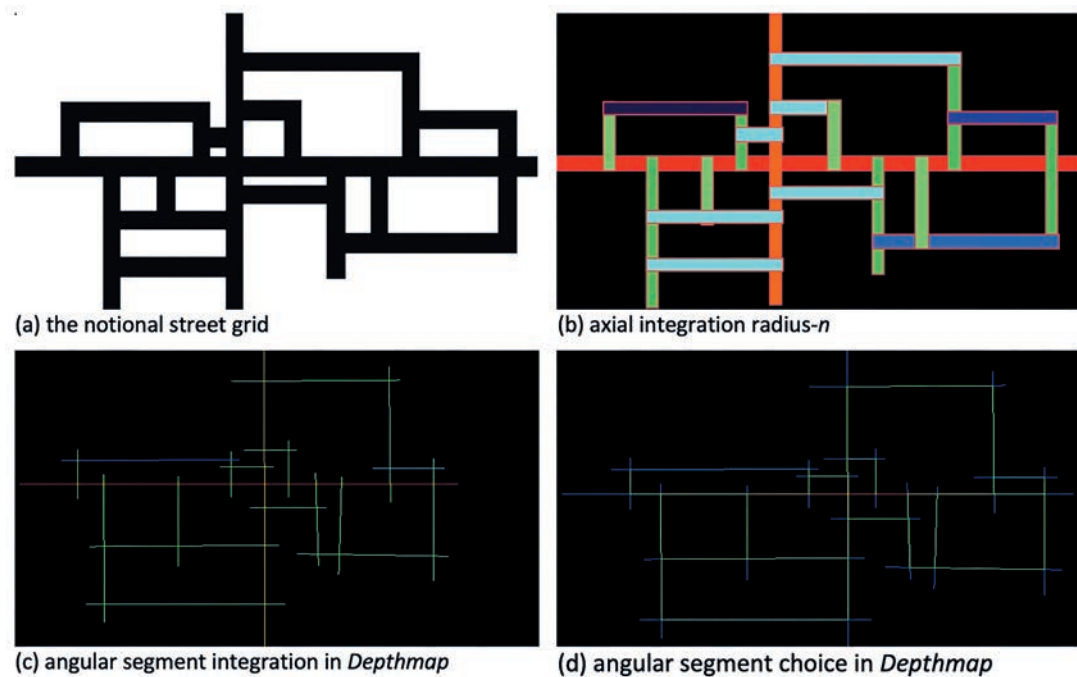
immersion in the world as an emergent phenomenon shaped by temporalized practices that include the routines and rituals of familiarity

## 2.2 The geometry of segments

In his 1999 paper the 'hidden geometry of deformed grids' Bill Hillier argues that "cities seem to be intuitable and constructable as geometries but to work as graphs. Intuition appears to stand on one side, that of geometry, functionality on the other, that of graphs" (Hillier, 1999, 23). If configuration gives rise to dynamic urban processes such as natural movement (the grid as its own attractor) and the function of the movement economy (differentiating the distributions of socio-economic activity by accessibility) it does not in itself account for the geometric shape of space that is recognizable as cities. In this statement Hillier outlines the problem of understanding the nature of the relationship between the form of the historical-material built environment that is intelligible to people, and its topological structure which may, in principle, be preserved, even in built forms that may not look very much like actual cities.

To address this apparent paradox Hillier uses a partitioning model to metricize topological relations (see also Hillier 1996, pp.285-313). This enables him to demonstrate how the "translation" of axial maps of actual cities into graphs of spatial configuration preserves key aspects of the geometric properties of urban structure that render them intuitively intelligible as real-world built environments to (real-world) people. For Hillier the possibility of this translation hinges on the graph internalizing the non-local geometry of the "structure of connectivities" that characterizes the distribution of axial line lengths (i.e. many short and relatively few longer lines) and the angles of incidence between axial lines, that distinguish global movement routes (obtuse angles) from more localized circulation (approximate right angles) in cities. The (line) graph of the (axial) map then is more than just abstract graph measures it carries with it pervasive descriptions of the historical-material world in which social life emerges.

Hillier's argument is important for its emphatic statement of the importance of the axial line to the proposition of space syntax theory: that an intrinsic connection exists between the physical city of buildings and the social city of human activity. The crux of this connection is linearity as the organizational principle of urban space because of its effects on human movement – but also because the plasticity of the line graph with regards to its geometrical expression is constrained by the global 'shape of linearity' that makes a collection of axial lines intuitively recognizable as the street network of actual cities. Hillier reflects on how "Geometry has been used to tame the wild, disorderly, world of graphs to make them work lawfully and to access them to intuition" (p181).



**Figure 2:** Translating Hillier's notional street grid from axial to segment analysis mode  
Source and copyright: 2a & 2b (Hillier, 1999); 2c and 2d, derived by the author from Hillier's original

But perhaps one aspect of segment analysis is to reveal geometry as not so tame, or at the least to suggest how the historical-material built environment internalizes the configurational distance modalities and scalar descriptions that sustain various emergent trajectories of embodied social possibility.

Even in the schematic network that Hillier (1999) uses to illustrate his arguments about how configuration internalizes geometric order the transition to segment analysis is telling. Figures 2a and b are Hillier's; Figures 2c and d reproduce the network as a segment analysis for integration (c) and (d) choice. Whereas segment integration closely resembles the axial representation along the longest horizontal line, choice analysis concentrates movement potential at the central segments, decreasing from centre to edge along the principal axis. One might say that whereas Figure 2c emphasises the strongly synchronizing agency of all-point to all-point movement, the differentiation of segments in Figure 2d reveals the granularity that implies a temporalizing agency through which the continuity of the line is interrupted.

Figure 2d may resonate with those familiar with Hillier's arguments around pervasive centrality and his concept of the 'spatial seed' of urban centres (Hillier 2009; K01:6). Hillier's example of Streatham identifies the spatial seed as highly central at relatively local metric radii of choice (400m) –showing how successively higher radii add high-choice segments up to 2000m. Hillier concludes that "It also seems highly likely that centres grow from low to high radius, though this

remains to be tested on historical material” (K01:12). Hillier acknowledges there is an historical process here that requires further research but more than this it implies that the process is not only one to be understood in configurational (graph) terms – but also in geometric (historical-material) terms. If this is true is not credible to think this historical process does not only corresponds to distinctive graph descriptions of segments but also highlights localized patterns of geometric differentiation associated with different epochs that may become increasingly marginal as graph centrality extends across higher scales? This is speculative but it rings true that the granularity of graph descriptions is likely to have its analogue in emergent geometric arrangements of real world space. This, of course, is likely to be repressed when spatial morphological description prioritizes a given scale of urban-morphological analysis over others. The scalar relativity of segment analysis however, reveals such prioritization as an artifice of a particular research objective. Historically speaking geometric order is seen to be more ambiguous and less stable than it may superficially appear.

This matters in terms of how space syntax elements are said to be embodied. For Hillier as for most in the field of space syntax the concept of intuition falls heavily on the ‘graph’ side of the equation. That is, it assumes generalized human agents retrieving relational (non-local) descriptions of social organization through a cognitive process of information extraction (Hillier and Iida 2005, 476 *passim*). Description retrieval in this sense is referred to as a “mechanism”, “through which we extract abstract information from concrete events and reembody it in real time” (Hillier 2012, p.29). For Hillier intuition means access to the graph of a city’s generic structure.

Yet if intuition is all about spatial cognition and information extraction, this seems to assume a rather reductionist view of what it means to be embodied, rendering the body itself as little more than the generic ‘mechanism’ for recovering and reproducing descriptions. Hanson (2012, p.91) implies as much in arguing that regarding space syntax as a method for extracting social information from space is “too crude and exploitative approach to any phenomena that may be under investigation”. Hanson’s observation suggests the need to balance the cognitivist conception of intuition with a phenomenological one open to the material qualities of spatial morphology that embody particular histories and situations.

One implication of this proposition is the need to reconsider how far the historical-material form of space (i.e. its geometric order) may, over time, become a site of social action that modifies, deconstructs or otherwise complicates the kind of configurational descriptions that can be abstracted in the forms of graphs. Penn (2003b) approaches integration in the axial map

as being intrinsically invested with the temporality of movement. Demonstrating the intrinsic temporality of the axial map is important but in the cognitive city it limited to the sense of efficient route choice. It follows that the axial model remains a robust predictor of movement in this sense because it is the most synchronic of descriptions such that movement is, in a sense, knowable and 'all at once' within a restricted temporal framing that does not correspond to the temporality of built environments but of a particular observer perspective. Yet in the arc of built environment temporality (as opposed to the temporality of a given movement) different configurational descriptions can emerge, become visible and significant as they become embodied in social practice. Decoding such descriptions would require a more nuanced conceptualization of the human body as rather less of a cognitive mechanism and rather more of a social subject participating in a contingent rather than determined history.

While Hillier 2012 marks a development in the space syntax theory of the relationship between configuration and geometric order in the theory of the cognitive city, it does not propose that any further theorization of the role of the human body is necessary in segment mode – this is not Hillier's purpose. Yet if it has been understood that angular-segment analysis retains the axial representation of relative straightness - particularly in the foreground network – this does not seem enough to address the question of what the segment embodies as a discrete element – being neither a line of movement or a line of sight. One could fairly argue that the segment introduces a new relational dynamism; in other words it embodies a relation to adjacent segments in a refinement of Conroy Dalton's embodied diagram of the axial line. This seems credible but, as has been explained, the relationality of the segment is particularly sensitive to descriptions of distance and scale (resolution) that cannot be known at the level of the discrete segment element. It therefore seems possible that the segment embodies a contingent relationality; embodying a temporal orientation of past and future, much as Conroy-Dalton's diagram does – but in historical time what this past and future looks like cannot be known with any certainty. Or to look at it another way; the synchronic description of a segment in an extant configuration intersects with its diachronic description which cannot give any priority to a specific scalar description of the many contingent descriptions it may play a part in constituting.

### **2.3 The segment as time-space description**

Once the principle of breaking up the axial line is admitted, why only at road junctions; why not also at the granularity of the alleyway, the footpath, the ginnel? Of course it depends on what kind of research is being undertaken but it makes the point that at the multiple scales at which spatial description affords social action for humans the segment mode introduces new questions of description and with ambiguity; because a given element can construct multiple

descriptions of situation. The diversity of description along a given axis may indeed be important and quantifiable through measures of Shannon entropy.<sup>1</sup> These scales and descriptions are not configurational abstractions but arise through historical processes and their relevance to urban practices (past, present and future) and may only be visible when we have the historical understanding to decode them. A representation of the embodied segment would respond to its particular openness to historically contingent forms of relationality.

In her PhD thesis Hanson (1989, 396) uses an elementary axial model to explore the London's urban grid as a "source of historic memory" noting that an urban grid can conserve principles of form and structure over time through the accumulation of "syntactic events". Hanson invokes the relationship between the contingent events of social history and the capacity of the urban grid to absorb and adapt to such events as affecting urban space but without destabilizing the fundamental 'deep' structure of the city. One might think that the segment model promises greater sensitivity and even reflexivity in exploring the relationship of configuration and form historically. Historical research can help reveal the different time-space descriptions (varying in scale and resolution) that signified patterns of social activity in the past, and how these descriptions have fared with the continuity, adaptation or decline of the social practices they were associated with. Terminologically it might help to distinguish between scale as a quality of analysis (400m, 800m etc) and resolution as the level of description appropriate to express the mores of a particular spatial culture from the street corner to the urban region. This involves recognizing that if it is desirable for pragmatic reasons to give priority to a particular scale of analysis for urban modelling (typically the most global possible), the analysis of a human event or situation from a built environment perspective is not going to be satisfied by description at just one or two scales of analysis but is likely to require considering within, across and between multiple scales. This is true not only of space but also of time because patterns of movement, encounter and co-presence are equally temporal qualities with the potential to occupy space differentially and selectively; bringing the past into the present and future, while anchoring the present and the future in the patterns of the past.

### **3 SEGMENT ANALYSIS AS SYNTACTIC ARCHAEOLOGY: THREE WORKED EXAMPLES**

The concept of syntactic archaeology seems appropriate to the research practice of using space syntax, particularly in segment analysis mode, to disentangle the interpenetrating layers of time-space description in the built environment. It implies a dialogue between the formal analysis of maps and plan and a concern to represent patterns of socio-spatial affordance below the level of the macro 'social syntax', such as may help identify and represent characteristic

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<sup>1</sup> With thanks to Dr Kimon Krenz for suggesting this; see Section 4a for a possible case study

situational, social-group or otherwise defined spatial-cultural practices associated with a given time and place. Such research practices have in fact been employed by space syntax researchers (particularly on historical topics) without being explicitly theorized – for example by Psarra 2018 see also Griffiths and Vaughan 2020). In this work one concern is to explore the scalar characteristics of configurational analysis in conjunction with source material denoting specific time-space routines and place choreographies (to use Seamon’s terms) that help to identify the *social* affordances and signification of embedded configurational descriptions.

It is commonplace in archaeology and landscape studies to think in terms of stratification, layers and palimpsests etc. But, as has already been discussed, diachronic description does not equate to synchronic slices of the time series. Syntactic archaeology is as likely to draw on a single graph as on many, and the layers of description (strata) it identifies are interpenetrating, rather than discrete because the same geometric-material elements are likely to appear in different configurational descriptions expressing different qualities of the urban (or rural) landscape at different (or the same) times. This points to a key research practice of syntactic archaeology which involves the relationship between the graph and the mapped representation of the form of the built environment. In space syntax studies of buildings it is usual to represent the graph of convex spaces on the building plan before they are taken into the justified graph. Early space syntax studies of urban areas used to do the same but the analysis of large urban regions has made this kind of representation practically difficult. Yet an important part of unlocking the potential of segment analysis to describe the interface between historical resolutions of everyday life depends on using the space syntax representation in dialogue with contemporary and historical maps in order to excavate signifying scalar qualities beneath the global, which may be less obvious or considered of less interest in purely graph terms. We might expect segment analysis at smaller metric radii, for example, to reveal the historic ‘seeds’ of subsequently urbanized villages, while regional through routes might part of the deep structure of the road network or much more recent interventions (Griffiths, Jones et al 2010). Such a hypothesis proposes a relationship between historicity and configurational scaling. Apparently Informal reference to axial and segment ‘maps’ rather than ‘graphs’ is legitimate in this context because it reflects the ambition of space syntax graphs to represent the intuitively recognizable shape of habitable space – rather than be an exercise in graph analytics *per se*. Of course in segment mode such a dialogue must also be a source of ambiguity of description because the choice of representation is not axiomatic but involves a sensitivity to the different configurational descriptions that characterize the time-of-space.

The final three sections of paper are intended to illustrate key aspects of syntactical archaeology. All three relate to ongoing research projects. They rely on visual and textual explanation of the basic research premise rather than detailed quantitative analysis which (in the first two examples) will be the focus of subsequent publications. In their different ways all explore qualities of time-space description of spatial morphology that identify the enduring (or otherwise) qualities of historical road networks under conditions of urban and regional development.

### 3.1 Scalar stratification of historical roads in the English county of Devon

In this section I offer an elementary but revealing example how segment analysis enables the researcher to tease out and differentiate the scales that express contrasting temporalities of historical road networks. Figure 3 (a-f) shows a sequence of visualizations of the English county of Devon. Devon is a largely rural county with a large number of villages. Figure (3a), from a road atlas, shows the vehicular main routes in 1930 focused on historic roads - which is not to say they had not been modified for motor traffic. Figure (b) shows a contemporary transport layer in Open Street Map where the M5 motorway is visible in the west coming into the city of Exeter. Figure (c) shows the network used to create the open source Space Syntax Open Mapping tool.<sup>2</sup> This is not comprehensive but extends to most minor rural roads that carry vehicular traffic. The other three images (e-f) represent the street network at the street network at three scales of metric choice 2k, 10k and 100k.

Given the visual prominence of major through routes on the road atlas and transport layer I was interested to examine the relationship between configurational and geometric visibility of major roads at the regional scale of the county. Focusing particularly on the connections between the urban centres in the north and south of the county (Figure 3c) using historic maps from Edina Digimap<sup>3</sup> in QGIS to trace the line of the historic routes against the contemporary road networks. What is remarkable is how major roads, such as the A361 and A377 (in general but see also Figures 4 & 5) are invisible at choice 2k, becoming more visible as part of the county road network (choice 10k) and only clearly distinguished as routes connecting urban areas (choice 100k). The contrast with the M5 is clear. Although partially built on the line of a historic route the geometric form of the contemporary motorway is distinguished at all scales as a sequence of long, linear segments. Configurationally speaking, at choice 2k the motorway is less complex. Unlike the historic through routes that go through or proximate to villages, circulate

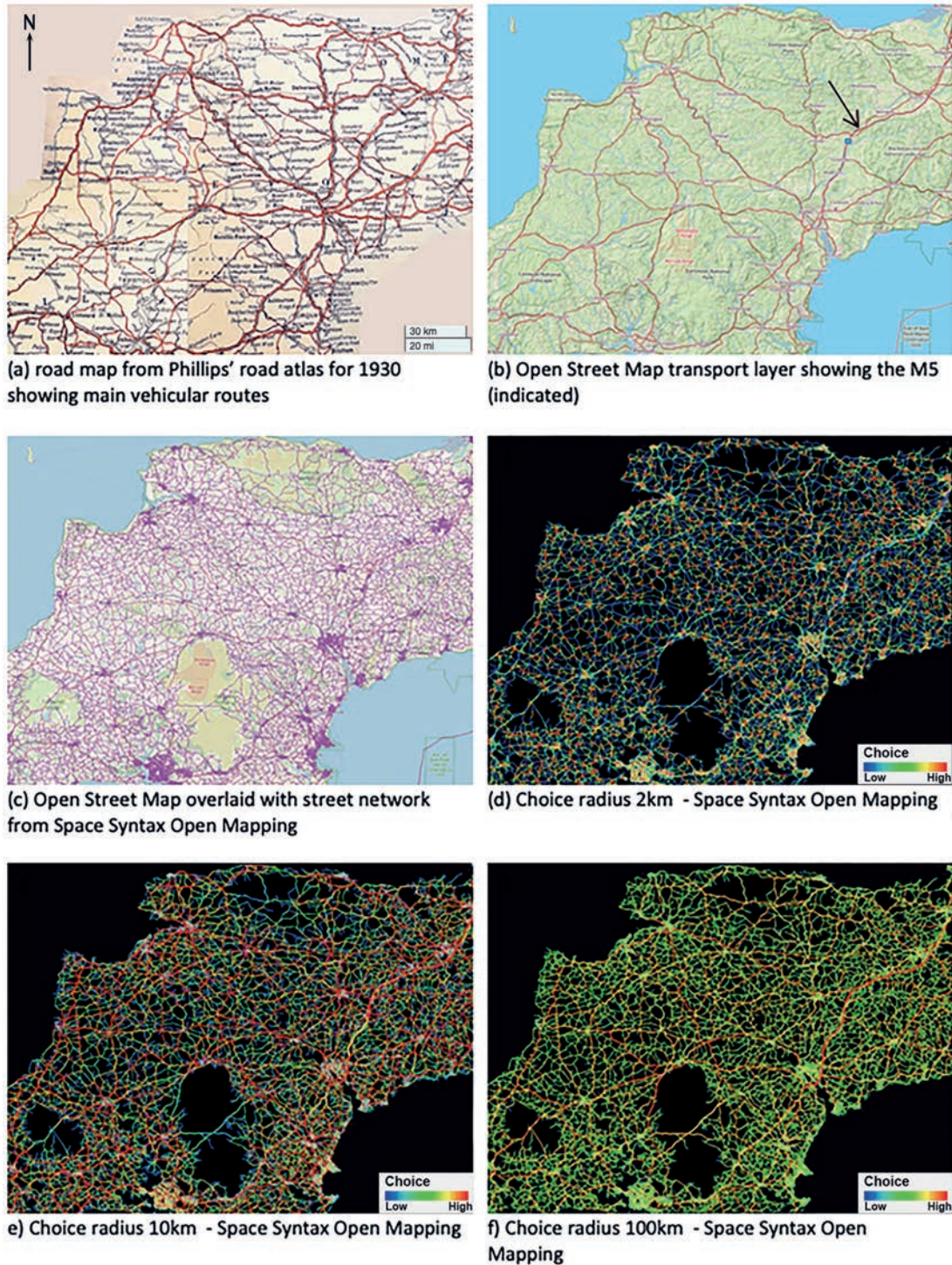
<sup>2</sup> Space Syntax Open Mapping <https://spacesyntax-openmapping.netlify.app/#6/55.603/-3.252>, accessed 16.2.2024

<sup>3</sup> Edina Historic Digimap <https://digimap.edina.ac.uk/historic> accessed 16.2.2024





between local areas and connect cities, the motorway is inaccessible to relatively local scales of movement but is strongly articulated at the 100k scale. This preliminary investigation suggests how the diversity of spatial-morphological descriptions in the older routes is bound up with the complexity of the historical-material, or geometric embedding of these roads in the 'deep history' of the landscape. By contrast the pronounced geometric form of the motorway reveals its character as a later, planned, intervention in this landscape, a quality enhanced by its relative disconnection from local settlements.



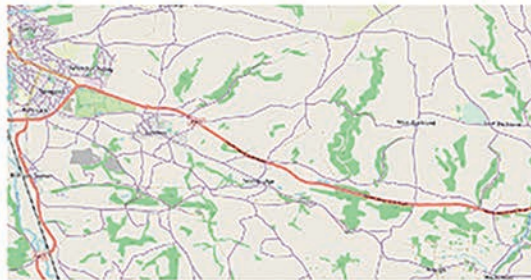
**Figure 3:** Scalar descriptions of the road network of the county of Devon, UK, using segment analysis  
 Sources and copyrights: Phillips *Road Atlas* 1930; Open Street Map <https://www.openstreetmap.org/> ;  
 Space Syntax Open Mapping <https://spacesyntax-openmapping.netlify.app> ©Space Syntax Limited.

Figures 4 & 5 (a-e) continue the analysis through an examination of close-up of sections of two historical roads in Devon, the A361 and the A377 as they leave the northern coastal town of Barnstable and head south-east and south respectively. Both roads follow or shadow pre-

vehicular routes on the 1900 Ordnance Survey map but the stretch of the A361 in Figure 4 is a relatively new section which bypasses various villages and has the stronger geometric definition even at 2k choice (Figure 4d), whereas the section of the A377 more closely follows that on the 1900 map and is hard to pick out with the naked eye even when zoomed in. Both settlements (but especially the A377 along its length) either cut through or are directly connected to local settlements, which conceals their identities as through routes at lower radii. A comparison of Figures 5&6 (d) at 10k choice suggests the importance of both roads to travel around the county but even here the A377 appears as part of a circuitous web of local roads, whereas the A361 is more obviously revealed as a conduit for through movement at the 10k scale. At 100k the A377 recedes into the background. Interestingly the analysis in Figure (e) picks out an alternative north-south route to the west that concatenates minor roads and does not stand out in either historic or contemporary road atlases. It would be interesting to know more about this orientation, which may possibly identify a through route of historical interest but more likely is an artifact of the irrelevance of this larger scale of analysis to understanding the embedding of the more local county roads.



(a) Route of the A361, c.1900 (indicated) Ordnance Survey



(b) Section of the A361 in Open Street Map overlaid with road network from Space Syntax Open Mapping



(c) Choice radius 2km - Space Syntax Open Mapping, overlaid on 1900 Ordnance Survey



(d) Choice radius 10km - Space Syntax Open Mapping, overlaid on 1900 Ordnance Survey



(e) Choice radius 100km - Space Syntax Open Mapping, overlaid on 1900 Ordnance Survey

**Figure 4:** Zoomed-in scalar descriptions of the A361 road, Devon, UK, using segment analysis  
 Sources and copyrights: Ordnance Survey, Crown Copyright, Edina Digimap <https://digimap.edina.ac.uk/>;  
 Phillips Road Atlas 1930; Open Street Map <https://www.openstreetmap.org/>; Space Syntax Open Mapping  
<https://spacesyntax-openmapping.netlify.app> ©Space Syntax Limited.



(a) Route of the A377, c.1900 (indicated) Ordnance Survey



(b) Section of the A377 in Open Street Map overlaid with road network from Space Syntax Open Mapping



(c) Choice radius 2km - Space Syntax Open Mapping, overlaid on 1900 Ordnance Survey



(d) Choice radius 10km - Space Syntax Open Mapping, overlaid on 1900 Ordnance Survey



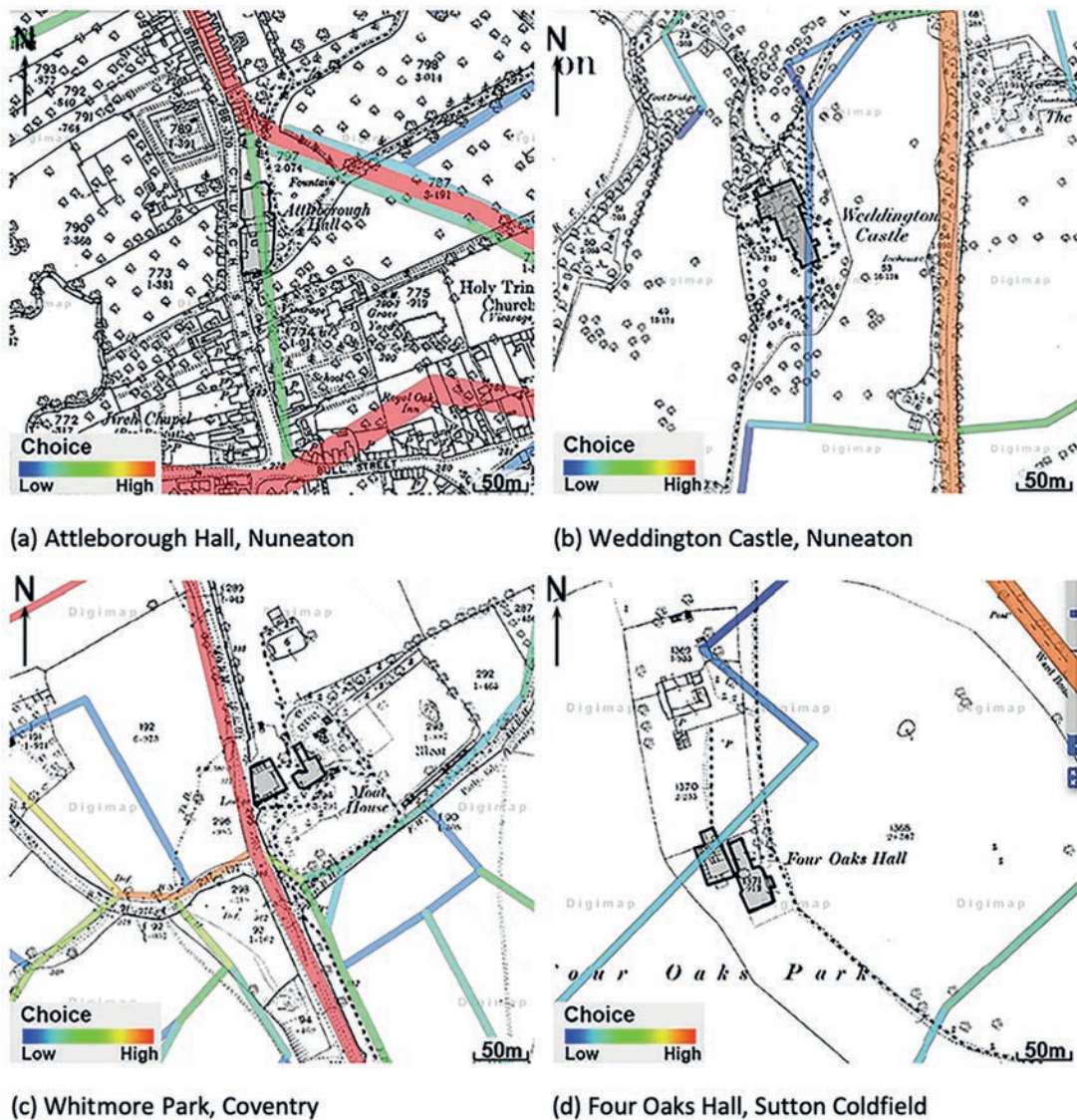
(e) Choice radius 100km - Space Syntax Open Mapping, overlaid on 1900 Ordnance Survey

**Figure 5:** Zoomed-in scalar descriptions of the A377 road, Devon, UK, using segment analysis  
 Sources and copyrights: Ordnance Survey, Crown Copyright, Edina Digimap <https://digimap.edina.ac.uk/>;  
 Phillips Road Atlas 1930; Open Street Map <https://www.openstreetmap.org/>; Space Syntax Open Mapping  
<https://spacesyntax-openmapping.netlify.app> ©Space Syntax Limited.

### **3.2 Excavating the spatial morphology of historical events: the sites of four demolished country houses in the English county of Warwickshire**

In this example I show how the temporal sensitivity of segment analysis using the choice measure makes it a good method to interrogate Hanson's proposition of conservation by spatial morphology. These examples are drawn from ongoing research exploring the legacy of the spatial-morphological embedding of demolished country houses in areas that were subsequently urbanized (Griffiths 2024). Each of the separate cases in Figure 6 shows the site of a country house in Warwickshire that had been demolished in the period 1890-1940, with the contemporary road network from the Space Syntax Open Mapping tool overlaid. What is immediately notable in each case is how the highest choice route coincides with the oldest routes through the area that were extant when the houses were still standing in their grounds.

The partial exception is Figure 6(a) where the historic route is still visible to the north of the hall. This case is interesting because the high choice route that runs to the east of the hall is a more recent intervention that bypasses the historic village centre and connects to the east-west route to the south. The effect of the bypass is that the site of the old hall is far less utilized by through traffic than would have been the case historically. In Weddington (b) the historic route runs to the east of the site of the old house which maintains its connection along the alignment of several historical footpaths. In this way both Attleborough (a) and Weddington (b) maintain a village character (confirmed by site visits) that is now enjoyed by post-war suburban housing. The situation in site (c) Whitmore Park is different – the major through route serving to cut off the site of the historic house behind suburban housing. In site (d) the historic road is at some distance from the site of the demolished house and the late-nineteenth century roads have not been laid along the alignment of the old Four Oaks Hall. All four examples illustrate how the arc of spatial-morphological history intersects with epochs of social history, in this case the displacing of the culture of the country house with post-war suburban housing.



**Figure 6:** Historic sites of four demolished county houses in the county of Warwickshire, UK overlaid with the contemporary road network using segment analysis to show choice radius-10k  
 Sources and copyrights: Lost Heritage database <http://www.lostheritage.org.uk/>; Ordnance Survey, Crown Copyright, Edina Digimap <https://digimap.edina.ac.uk/>; Space Syntax Open Mapping <https://spacesyntax-openmapping.netlify.app> ©Space Syntax Limited.

### 3.3 Embodying the segment: an account of a walk out from the city of Sheffield in 1831

The third and final example does not make direct recourse to a space syntax representation (although many have been consulted). Rather it reflects on an account of a walk made from the centre of Sheffield into its rural hinterland in 1831 as an embodied text. In this case the syntactic concepts of axial and segment description help in decoding the articulation of narrative figures that express the experience of rapid industrial-urbanization on the urban

periphery, evoking a strong sense of temporal co-presence with different phases in the growth of the contemporary city.

A sense of how the concept of historical spatial morphology might assist in the interpretation of an historical text can be conveyed through a consideration of a passage from an article featured in the series of 'Walks in the Neighbourhood of Sheffield' which appeared sporadically in the *Sheffield Independent, and Yorkshire and Derbyshire Advertiser* from 1830 to 1831. In the spirit of Rousseau, the anonymous author leaves Sheffield behind him and goes in search of the bucolic Derbyshire village of Bradfield and an Arcadian imaginary populated by fauns and naiads. Perhaps unsurprisingly, he finds that such creatures are scarce in rivers punctuated at regular intervals by water wheels. The various stages of his journey suggest how the contiguous road that led north from Sheffield into the country during this period was constituted at different modalities of scale:

Many persons here scarcely know more of Bradfield, than enables them to say that it is a little town somewhere amongst the hills, and therefore I will prick out this little journey, step by step, so that you will have small pains hereafter to follow my route. First of all, the pedestrian leaves town by the north-west.— This is the course of the valley of the Don, but for a mile, streets and houses shut in the river, and are even high and close enough together to screen the grounds which rise beyond it. Further on, we arrive at Shales-moor. The preservation of names, after their meaning and application have become lost or changed by time, is the joy of the historian, whether he be the chronicler of a village or an empire. Shales-moor is covered with buildings, noble manufactories are prominent amongst them, and in the very midst stands a new stone-built Christian church.— Yet the assertion is not without warranty for its truth, that on other moors, those wild birds now live, which the busy encroaching foot of man, some sixty years ago, drove from this place, their own proper manor. Emerging from parallel walls of bricks, the Infirmary, which only, of all erections belonging to the town, merits the name of a public building, greets the eye of the benevolent walker as he turns to the left, and on the right the river is now discovered, nobly crowned and guarded by the lofty Old Park Wood. Another mile, and we part with the Don, at the little manufacturing village of Owlerton. Here a small stream flows into it from the west, and in this direction we bend our way. This is the Loxley, one of the many meandering waters, rising in the high wild country beyond Bradfield which is sometimes called the region of the English Apennines, and joining the tide of the Don, in its course to the German ocean.<sup>4</sup>

Despite the author's highly stylised writing three different articulations of linearity can be identified in the text. Firstly, the author describes how he picked his way "step by step" through a sequence of different places: Sheffield, Shalesmoor, The Infirmary and Owlerton, before reaching the River Loxley. These places occur successively along a road which describes a sequence of segments when represented on an axial map. In naming each place and describing its particularity, the author acknowledges their distinct identities. In doing so he characterises

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<sup>4</sup> *The Sheffield Independent and Yorkshire & Derbyshire Advertiser*, 18/6/1831.



his journey in terms of how each place distinguishes the road at that point rather than in terms of how the identity of road characterises the places along it



(a) Plan of Sheffield in the early 19C



(b) Plan of Sheffield 1838 – included in White's Directory



(c) Plan of Sheffield to accompany the handbook for the meeting of the British Association – 1910

**Figure 7:** Historical maps showing area to the Northwest of Sheffield with Shalesmoor (a road) indicated  
Sources and copyrights in all cases: Sheffield Local Studies Library; Sheffield City Council

This suggests how the author's walk out of Sheffield to the north can be characterised topologically as concatenative movement along road segments that 'hold the line' between relatively local and urban modalities of scale. Secondly, the Shalesmoor locale on Sheffield's northern periphery, with its "noble manufactories", provides an opportunity for the author to pause and ruminate on social change. Here he 'slips' entirely within the most locally constituted modality of scale where the outwardly orientated, linear trajectory of his journey dissolves into a mosaic of convexities and movement loses its directionality. The author is overcome by proximity both to a range of nearby buildings but also to Shalesmoor as a persistence in time: its 'new' stone church and departed birds. Thirdly, as the author follows the rivers Don and Loxley via Owlerton towards the Arcadian village of Bradfield the privileged modality of scale shifts again, this time towards an increasingly linearised time-space synchrony which evokes the relative 'straightness' of Sheffield's access roads when realised at the most linear, one might say, globalizing scale: "another mile", he declares, "and we part with the Don". Once past Owlerton the realms of town and country are sufficiently differentiated for the author to become immersed in the rural, with which Sheffield as a whole is now implicitly contrasted. However, his immersion also assumes a linear trajectory as the author follows the line of his imagination from the "wild country" of the "English Apennines" and eventually to the ocean. In summary, the author's journey as he describes it could be characterized in terms of the constitution of the line at different modalities of scale involving the 'unpacking' of various locales between, within and eventually across these scales. This interpretation of the author's journey suggests how, through sensitivity to temporalized descriptions of spatial morphology it can be acknowledged that a text does not simply determine the space but the space is also articulated in the text.

#### **4 CONCLUSIONS**

If nothing else my intention in this paper has been to encourage reflection on what a segment actually is in the spirit of the early conceptual work on axial lines, especially in the context of the space syntax of spatial cognition and more recent efforts to establish the continued validity of this theory as underlying the segment paradigm of urban analysis. The basic argument has been that segments embody a temporalizing contingency of spatial relation, whether with regard to the extension of the line, the deformation of the line and/or with the scale-granularity of its description. The notion of syntactic archaeology starts from the premise that multiplicity of descriptions proposed by the segment analysis of historic built environments requires both a renewed emphasis on the importance of bringing the syntactic graph (spatial morphology) into critical dialogue with the geometric qualities of urban morphology and an insistence on teasing out the historical trajectories of spatial affordance through an exploration of the spatial

practices that have emerged, adapted, continued and declined in any given area, rather than relying exclusively or complacently on *a priori* analytical categories. Over the long and complex temporal arcs of built environment materiality these may guide us to consider instances where the generic cognitive city has been unexpectedly plastic in the light of contingent historical events.

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