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SPACE SYNTAX

—STRATEGIC URBAN DESIGN

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How we plan and design cities comes from how we understand them. Space Syntax is a new method for the scientific modelling of cities, which has led to a new, scientific theory of the city. If we accept the theory, it changes our understanding of cities, and tells us we should plan and design them in a new way – a *space-led* way.

So what do we mean by a scientific theory of the city and why is this important for the practice of urban design?

As forms, cities are very large collections of buildings held together by a complex network of space. Functionally, they are - even more complex - networks of activity, movement and interaction. A theory of the city must explain how the two networks interact, that is how the form of the city relates to the way it functions. Only then can urban designers act with the scientific rigour that their endeavours deserve, supported by a modelling technology that can accurately forecast how design proposals are going to function.

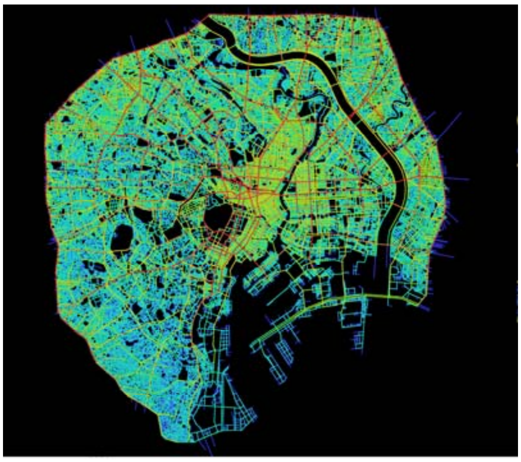
Most attempts to model cities have tried to approach the problem function-first. They represent the city as a set of areas, or *discrete zones*, and try to measure and predict the amount of interaction between each pair of zones as a function of the amount of activity in each, set against the distance they are apart. This approach has its foundation in the planetary model of Isaac Newton, and its fundamental concept is, by analogy with gravity, the *attraction* that zones have for each other.

In such a function-first approach, the spatial form of the city is seen as in some sense the product of these zone to zone interactions, and so remains at best indistinct and remote from the levels at which we intervene in the city. In a fundamentally different way, Space Syntax reverses things and looks first at the precise nature of the physical city by modelling, in the first instance, the network of space – streets, roads, boulevards, alleys, and so on – that is the biggest thing in the city and in effect holds it all together.

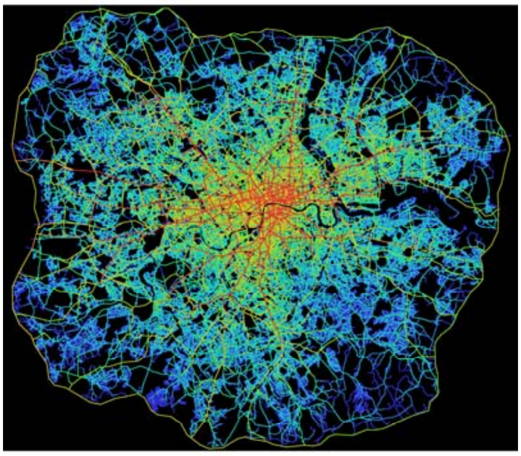
At first sight the typical urban network looks so complex and disorderly as to defy description. But if we look more closely, and start measuring and counting, we find remarkable consistencies across all kinds and sizes of cities. For example, by representing the network as its least line map – the fewest and longest straight lines that cover the network and make all connections – we find that all cities at all scales are made up of a very small number of long lines and a very large number of short lines – a fractal, or scale-free, property. The long lines then tend to end by connecting to other long lines by nearly straight angles (between about 5 and 30 degrees), while short lines end and intersect by near right angles. The result is a dual network, made up of a foreground network emphasising route continuity set into a more localised background network.

We can throw more light on this dual network by analysing it with Space Syntax spatial modelling technology. Space Syntax measures are *configurational*, rather that *attraction*-based, in that they calculate relationships between each space in a system and all others. In the main forms of syntactic analysis we use for cities, the spatial element is the street segment between junctions, and the key measures are of two kinds of movement potential: *to-movement* potential, or how easy is it *to* get to a segment from all others (measured by mathematical 'closeness' normalised as syntactic *integration*); and *through-movement* potential, or how likely are you to pass *through* as space on routes between all other pairs of segments (measured by mathematical *betweenness* and called *choice* in Space Syntax). The measures are applied to each segment at different *radii* from that segment that is for different scales of movement from the most local to the most global, and use three different concepts of distance: shortest path distance, fewest turns distance and least angle change distance. This yields a large array of measures which describe the *configuration* of the network.

Once we have these measures, we find more remarkable consistencies among cities. For example, we find that cities have unexpectedly similar underlying structures. We can bring these to light by simply colouring the street segments from red for high potential movement through to blue for low. For example, if we apply the *to-movement measure* without radius restriction and with the *least angle change* distance measure, we find most cities exhibit a *deformed wheel* pattern, with a *hub* of lines at the core, strong *spokes* linking centre to edge in all directions, and a strong *rim* of lines. We see this pattern in both metropolitan London and Tokyo, with the difference that Tokyo has multiple rims – a difference that reflects real differences in the functional structures of London and Tokyo. If we apply the *through-movement* measure with the same radius and distance conditions, we find a *network* structure which again seems powerfully related to the functional structure of the two cities.



Tokyo



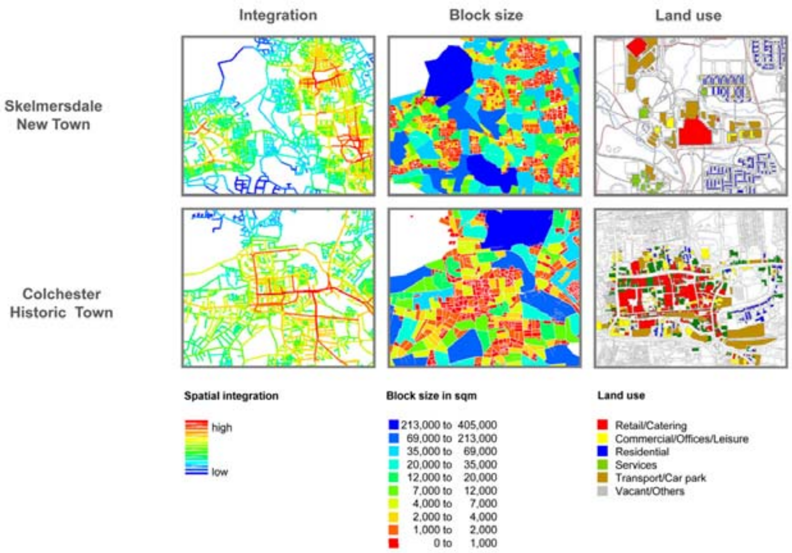
London

Least angle closeness (integration) in the segment map

Why this similarity of spatial and functional structures is found follows from the next discovery about cities brought to light by configurational analysis: that in and of itself, the configurational values that make up the structures we have brought to light are the most powerful single factor in determining real movement flows, both vehicular and pedestrian, along each segment. Somewhere between 50% and 80% of the differences between movement flows on a segment, are due to the configurational position of that segment in the network. We call the proportion of movement which is due to the network configuration, as opposed to the proximity of attractors and generators of movement, *natural movement.*

The discovery of natural movement should not be a great surprise, because the measures are after all of movement potentials. However if we examine the pattern of flows more carefully in relation to spatial configuration, we find that measures using the *least angle change* definition of distance are a little more powerful than those using the fewest turns definition, and much more powerful than the shortest path definition. The only possible interpretation of this is that people use least angle mental representation, not metric distance representations, in working out routes. The reason this most fundamental of urban form-function relations has not been known before, in spite of decades of traffic models, is that it has always assumed that shortest path models should be assumed, and these, we now know, conceal the relation.

Once the grid-movement relation is understood, however, the basic dynamics of the city as a form-function system come into view. Because the network structure shapes flows, it also shapes land use patterns, in that movement-seeking land uses seek locations that the grid has already made movement-rich, while others, often including residences, migrate to less-movement rich parts of the network. Economic values follow this process. With feedback and multiplier effects – once one shop appears, others follow - this is the fundamental *city creating process* by which cities evolves from collections of buildings to living cities, with busy and quiet zones, often in close juxtaposition, and with differentiation of areas according to the detail of how they are embedded in the larger scale grid.



Syntactic patterns of two towns

This leads us to a new definition of the spatial form of cities. Cities in general – not just ‘organic’ ones - self-evolve functionally as well as spatially *into a foreground network of linked centres at all scales*, from a few shops and a café through to whole sub-cities, *set into a background network of largely residential space*. The two networks have different geometric and metric properties. The foreground network has longer lines, nearly straight connections and route continuity, the background network shorter lines, right angle connections and more local grid-like structures. Through this process, cities acquire *pervasive centrality* in that centrality functions diffuse throughout the network. The pattern is far more complex than envisaged in theories of polycentrality. Pervasive centrality is *spatially sustainable* because it means that wherever you are you are close to a small centre and not far from a much larger one.

We can now see how economic and social forces put their different imprints on the city. The foreground structure, the network of linked centres, has emerged to maximise grid-induced movement, driven by micro-economic activity. Micro-economic activity takes a universal spatial form and this type of foreground pattern is a near-universal in self-organised cities. The residential background network is configured to restrain and structure movement in the image of a particular culture, and so tends to be culturally idiosyncratic, often expressed through a different geometry which makes the cities look spatially different. We call the first the *generative* use of space since it aims to generate co-presence and make new things happen, and the second *conservative* since it aims to use space to reinforce existing features of society. In effect, the dual structure has arisen through different effects of the same laws governing the emergence of grid structure and its functional effects.

So we have a form-function theory of the city which is *multi-scale* in that it works as well for the local micro-structure as it does for the global macro-structure of the city. The model can then be used for more detailed research by using the segment model as a frame for all kinds of urban data by simply adding data to the model segment by segment: movement flows, land uses, densities, demographic information, land and rental values and so on. We then have a tool for asking spatial questions of the city, of the form: is there a spatial dimension to this or that urban problem – to social malaise, to migration patterns, crime distributions, to the success of areas – all these are areas we have investigated using Space Syntax.

But it is in planning and urban design that the *multi-scale* capability of the model is most significant, because most urban phenomena function in some sense across scales. For example, movement passing along a street will be shaped by how it is embedded in both the global as well as the local network, local centres will occur and grow to the degree that that are embedded in a local metric system and a more global least angle system, while public squares are affected in their functioning not only by how the space is defined by the surrounding buildings, but also by how it is spatially embedded in the larger scale network of space.

It is the multi-scale capability of the model, in combination with its ability to synthesize the whole range of urban factors on the basis of the common language of space that makes the model so powerful and a tool for planning and design. The technique of application is, for any proposed intervention, to build a model of the site and its context, usually the whole city these days, test the model against existing movement flows and land use patterns, then use the verified model to test out designs by inserted them into the model and re-running the analysis, and suggest new design ideas from the analysis. This is what was done on such highly successful *spatial re-engineering* projects as Trafalgar Square and the Millennium Bridge in London.

But because of its ability to synthesise complex patterns of urban data on the basis of a functionally intelligent analysis of spatial networks, Space Syntax is increasing being used as a master-planning tool, not only at the scale of the urban area and the larger context, as at the Elephant and Castle in London, but also at the scale of the city and its region. For example, Space Syntax Limited was the lead partner in master-planning the future development of Jeddah in Saudi Arabia. There were three major problems with the rapidly growing city; how to reverse the isolation and decline of the historic centre as growth had shifted the centre of gravity of the city eastwards; how to re-integrate into the city the patchwork of unplanned settlements which now constitute islands of deprivation in the growing city; and how to develop large sites near the city centre, including the old airport site, in such a way as to support these aims.

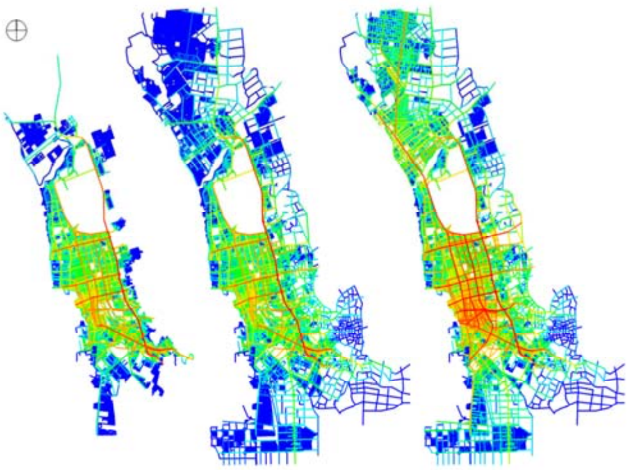
Space Syntax first created a model of the whole city which confirmed the isolation of the centre and the unplanned settlements. But then, by adding to the model all the developments planned to expand the city, it showed that the problem of the isolation of the centre would become worse if these developments were to take place. We then used Space Syntax simulation in relation to land use and density modelling to find ways to re-model space in the unplanned settlements around the centre in order to turn the current isolating effects these settlements had on the centre into generative effects, using the multi-dimensional capability of the model to minimise the cost and disruptive negatives resulting from this.

Analysis also showed that all the unplanned areas had strong internal structures, but lacked connection to the larger scale network of the city. Again syntactic experimentation found way to re-integrate these internal structures into the larger scale system so as to de-segregate the areas while augmenting rather than undermining their existing dynamics. Space Syntax was also able to show how to develop the waterfront and airport sites in such a way as to overcome the isolation of the nearly historic centre.

By building all of these proposed developments into the model it was then possible to show that the centre of gravity of the city would be shifted back towards the historical centre – an emergent global effect from a large number of local planning and design decisions. In this way it could be shown that with Space Syntax modelling it was possible to design a long term process of global urban change through a consistent pattern of local micro-changes.

Space Syntax is then a new space-based and evidence-based way of bringing architecture, urban design, planning and transport planning together in what people are beginning to call "strategic urban design", meaning urban design that works across scales, from the micro to the macro. The modelling technique can be used to integrate different factors into spatial design in a rigorous way. But most of all, it allows us to design in such a way as to go with the flow of the city creating processes which are the real sources of the life of cities.

Millennium Bridge (London)



Spatial Model of Jeddah (Saudi Arabia)

*Japanese translation is on the printed copy.