Axial Maps and Visibility Graph Analysis

A comparison of their methodology and use in models of urban pedestrian movement

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1 Abstract
Axial Maps and Visibility Graph Analysis (VGA) are compared as techniques for the representation and analysis of urban spatial structure. Methodological issues such as reliability and comparability when using each technique in an urban setting are evaluated on a study area in central London. A sample of pedestrian movement counts on individual pavements is used to test the correlation of graph measures from the Axial Map and VGA with observed flows. The results show a significantly higher correlation between VGA-visibility and pedestrian movement than between any axial graph measure and movement. Implications for the direction of future research are discussed.

Keywords
pedestrian movement, visibility graph analysis, axial map, representation, urban morphology, spatial analysis

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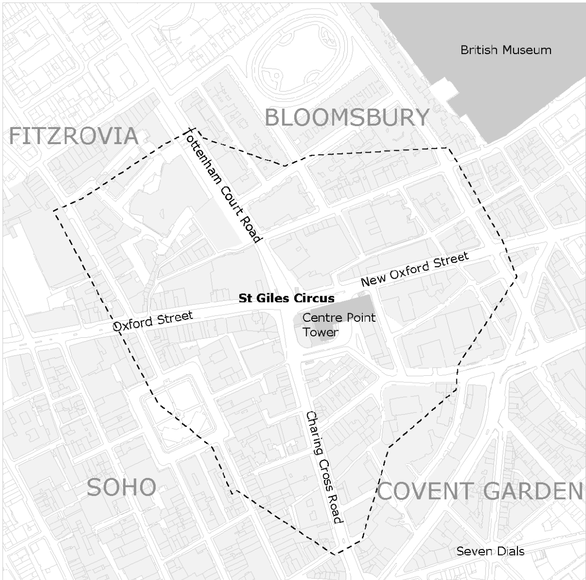
2 Introduction

This article compares two techniques for the representation and analysis of urban spatial structure and tests their relationship with observed pedestrian movement patterns. The techniques tested are Visibility Graph Analysis and the space syntax Axial Map. Their relationship to pedestrian movement is tested through regression models. Various analytic graph measures calculated with each technique and are used as the independent spatial variable. Empirical data from a sample of pedestrian movement on individual pavements in the area of St Giles Circus, London is used as the dependent variable.

The only previously published comparative test of axial analysis and Visibility Graph Analysis in models of pedestrian movement is from a study of a department store (Turner and Penn 1999). The results showed a higher correlation between graph measures of mean depth and pedestrian movement when calculated with a VGA representation than with axial lines. This paper tests the use of both techniques as correlates of pedestrian movement in an urban setting. After outlining the theoretical background to the use of these techniques, methodological issues that have been problematic with each technique are discussed.

2.1 Does urban spatial structure influence pedestrian movement?

Both the techniques tested in this paper are designed to help investigate whether the morphology of the built environment itself influences pedestrian movement. This research question belongs to that area of social science investigating the relationship between society and its spatial structure.



	Mean	Median	Std. Dev.	Std. Error	Min	Max
Mean Weekday flow per hour	321	162	427	46.538	0	1766
Mean Saturday flow per hour	342	137	503	54.91	0	2183

Figure 1: Study area

Table 1: Average Pedestrian flows in the study area

Hillier suggests a distinction between research programmes into the effects society has on space and those that look at the effects that space has back onto society (Hillier 1985; Hillier 1999). The first strand of research inquires into the way in which society creates spatial structures for its own reproduction. Research of this kind seeks to answer questions about the mechanisms and rules by which buildings and cities are created for social needs.

The second kind of research looks into the often-unintended social consequences that these spatial structures then have back onto society. Once a spatial structure such as an urban area has been created, it seems to offer unexpected social potentials and problems. The way that people use an area depends not on what planners or architects might have expected but on these potentials offered by the spatial structure itself. What are the laws that govern the use of spatial structure that we find, however it was created and for whatever original purpose? This is the starting point for a research programme that attempts to isolate the independent role of spatial structure onto the functioning of society[1]. One important way in which the environment might be shown to influence social activities is in the determination of pedestrian movement patterns. This is why it is of theoretical interest as well as practical use to develop models of this relationship. The two techniques discussed in this paper will be evaluated for use in such models.

3 Case study of pedestrian movement

Before testing the efficacy of alternative measures of urban spatial structure in a model of movement determination, we first present the evidence of pedestrian movement that the model will seek to explain. Observations are used from a study of the area around St Giles Circus in Central London, shown in Figure 1. St Giles' Circus is a strategically important junction that joins areas of Bloomsbury, Fitzrovia, Soho and Covent Garden. The junction is crucial to the flow of traffic and pedestrians between these areas of London and is also an important public transport interchange facility with 15 bus routes and Tottenham Court

1 This treatment of space as an independent variable has not been a focus for the mainstream of social theory historically (Ponsard 1983; Giddens 1995) despite some interesting theoretical modelling of spatial patterns as emergent part of social processes by theorists like Schelling (Schelling 1978).

Figure 2: Observation gates for pedestrian movement counts

Figure 3: Average Movement on each Pavement

Road Underground Station (which handles more than 100,000 people per day). Oxford Street, which enters the Circus from the West, is one of the most important retail streets in the world.

3.1 Methodology for measuring Pedestrian Flow

In order to measure the differences in pedestrian flows on pavements in the area, observation counts were undertaken at 84 locations, shown in Figure 2. The number of passing pedestrians was sampled for 5 minute periods within every hour from 08:00 to 20:00 on Saturday 18/03/00 and Tuesday 21/03/00. Table 1 below shows the differences in all day average pedestrian flows per hour between the observed pavements. Within this relatively small study area, there is a large variation in the number of pedestrians using each pavement. Movement on weekdays ranges from an average of 0 people per hour on some pavements to 1766 people per hour on others and at the weekends from 0 to 2183 per hour.

3.2 Spatial Differences in Pedestrian Flows

The pedestrian movement observations have been linked to pavement polygons that represent the pavement area on which each count was taken. These are held within a spatial database using a Geographic Information System (GIS). The pavement areas are shown in grey on Figure 2. This linking of data within a spatial database allows us to represent the results of the survey in maps to see the spatial pattern of movement. The pattern of average pedestrian movement can be seen in Figure 3 . The colour scale used is a spectral range where red denotes the highest movement down to blue for the lowest.

The first striking characteristic of the pattern of movement is the high difference between main streets and side streets within close proximity. On a Saturday there are about 3,625 people per hour walking down Oxford Street, which implies a total of approximately 43,500 moving people during the daylight hours observed (8am to 8pm). Tottenham Court Road has a total of 36,850 people passing in daylight hours at the block nearest St Giles' Circus on a Saturday. Some smaller side streets have almost no movement.

Another important characteristic is the notable difference in flow between sides of streets. This is particularly marked on the Tottenham Court Road-Charing Cross Road route. On average, the movement on the Western side is double that on the Eastern side of this route.

One important consideration in the difference in pedestrian movement is the lack of a pavement on the eastern side of Charing Cross Road adjacent to centre point tower. There is no formal footpath, but there is a narrow kerb (of approximately 40cm in width) located next to the 'Swimming Pool', as can be seen in Figure 4 below.

This break in the space available to pedestrians walking on the North South route through the area leads to a strong imbalance in the number of pedestrians on each side of the road. This can be seen in Figure 5: The average number of pedestrians on each block on each side of the Tottenham Court Road- Charing Cross Road route overleaf, which plots the average number of pedestrians on each side of the Tottenham Ct Rd/ Charing Cross Rd route by block. The number of pedestrians is higher on the Western side for all the street blocks in the observation area, but the block adjacent to Centre Point shows a much stronger imbalance, with movement almost 8 times higher on weekdays and 12 times higher on Saturday.

3.3 Tests of the influence of pavement width on pedestrian flow

Before evaluating the more sophisticated measures of spatial structure, the empirical findings from this study suggest that the very local spatial variable of pavement width can be significant in determining movement patterns. This simple variable needs to be considered further. It seems reasonable and obvious to assume that crowding on pavements can lead to pedestrian movement congestion, which would reduce observed pedestrian flows much like a traffic jam reduces the flow of cars. This itself would constitute a spatial influence on pedestrian movement.

This issue can be tested by looking at the relationship between the number of moving pedestrians and the width of the pavements to accommodate them within the study area[2]. As can be seen in Figure 6, this is a positive relationship (each dot in the scatter is a pavement). However there are some significant outliers. Some streets have wider pavements than would be expected for the level of movement on them. St Giles' High Street is an interesting example of this. The narrow kerb next to the 'Swimming Pool' under Centre Point tower is the one point (the most upper-left point in the scatter) that has significantly less pavement than would be expected for the level of movement.

These differences in the relationship between width and flow can be seen as a measure of the crowding of the pavement. Their spatial pattern is shown in Figure 7 below. As might be expected, the most heavily used pavements on Oxford Street and on the Western side of Tottenham Court Road and Charing Cross Road show much higher levels of crowding than the back streets. However, the

Figure 4: The narrow kerb next to the 'Swimming Pool' under Centre Point

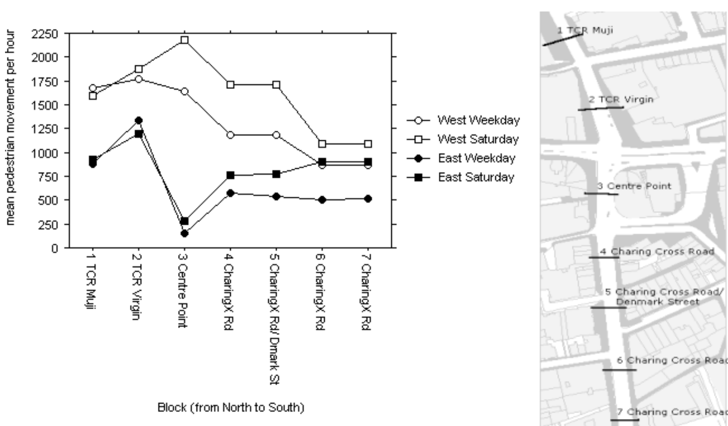


Figure 5: The average number of pedestrians on each block on each side of the Tottenham Court Road- Charing Cross Road route

2 The more crowded pavements are below the regression line in Figure 6, whilst the less crowded are above the regression line.

highest level of movement per available width is shown on the tiny pavement that borders the 'Swimming Pool' on the Eastern side of Charing Cross road underneath Centre Point (pictured in Figure 4). This has significantly higher levels of crowding than any other route.

The findings of the pedestrian movement study showed that the paucity of pavement space for pedestrians on the Eastern side of Charing Cross road outside centre point significantly disrupts the pattern of pedestrian movement in the wider area. However, despite the lack of a proper footpath on the Eastern side of the road and the obvious danger that this creates for pedestrians trying to walk there, there is still a constant flow of pedestrians who use this route as it falls along their desire line. These pedestrians are not being deterred from using this side of the street but they are being forced to walk out into the road because of the extreme deficit in useable pavement space for them. If two pedestrians attempt to use this route at the same time, at least one of them must walk in the road.

Three major characteristics of the empirical data on pedestrian movement have been identified that are of interest in the for the development of movement models:

- Pedestrian movement varies greatly from street to street within a small geographic area;
- there can be notable differences in movement from block to block and especially from one side of the street to another;
- the simple variable of available pavement width is significant and requires consideration;
- pavements with high levels of movement and crowding seem to be those on strategic 'desire lines' for movement.

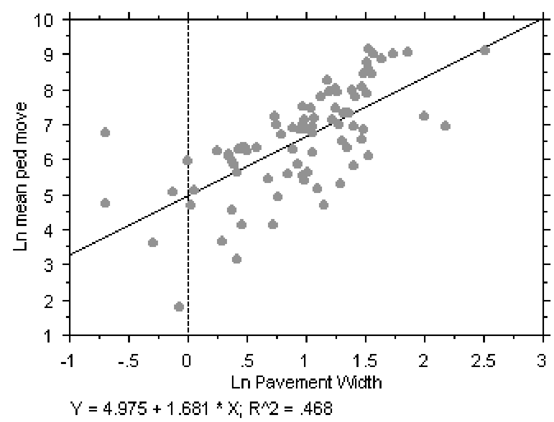


Figure 6: Relationship between pavement width and average number of passing pedestrians

4 Measurements of urban spatial structure

Having outlined the evidence of a case study on pedestrian flows, we now can investigate whether there is a relationship between urban spatial structure and these use patterns. To do this we will use measures of urban spatial structure and a model of the relationship to movement that can be tested with observed data. Model definition is a matter of trial and error learning, as Krugman suggested;

> "you make a set of clearly untrue simplifications to get the system down to something you can handle; those simplifications are dictated partly by guesses about what is important, partly by the modelling techniques available. And the end result, if the model is a good one, is an improved insight into why the vastly more complex real system behaves the way it does."(Krugman 1995, p71)

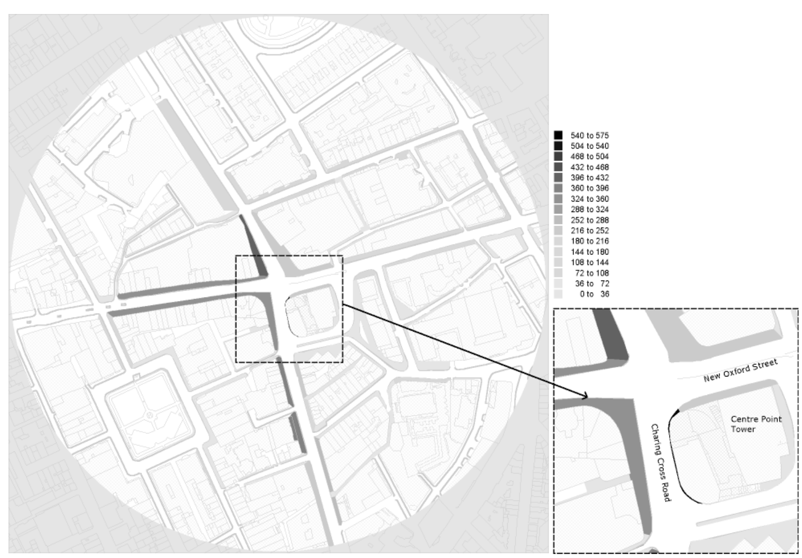


Figure 7: Pedestrian flow per m of available pavement width

The modelling approach adopted in this article is a regression model using some independent measure of spatial structure to correlate against the dependent variable of observed pedestrian movement flows. If there is a significant statistical relationship between the independent spatial variable and the dependent variable of pedestrian movement, then we have a model of a process that requires some theoretical explanation.

The issue in debate is what the best independent representation and measure of spatial structure is. Although any measure of the environment is a simplification, that simplification must describe the environment in some way that is susceptible to analysis. This makes it possible to use some measure of spatial characteristics that can be tested against pedestrian movement. The measure can be judged on how objective, reproducible and universally applicable it is and how well it predicts pedestrian movement.

4.1 The Axial Map

An axial map is a representation of the continuous structure of open space. The idea of a 'fewest line' axial maps was presented in the introduction of Hillier and Hanson's 'Social Logic of Space' as some minimal set of the fewest and longest lines of sight that cover some set of the "fattest convex spaces" in terms of their area perimeter ratio (Hillier and Hanson 1984, page 17). No particular social meaning was attributed to the axial map in Hillier and Hanson's work, rather it was suggested as a method for reducing the complex continuous spatial network of cities into a set of component parts that could be subjected to analysis.

The most widely applied method of axial analysis is the hand drawn 'fewest line' map. No algorithm has been developed to create this set of fewest axial lines in an automatic way that would be repeatable by independent researchers. If the idea of axial lines is to link all maximal convex spaces, it a mathematically impossible problem to reduce this to a repeatable procedure with an identical result. As deBerg et al. demonstrated, a unique set of convex polygons cannot be computed with only this minimal rule set (deBerg, van Krefeld et al. 1997).

This problem in defining the methodology for creating axial maps unambiguously means that some interpretative drawing by a person is required in order to split up an open space network into convex spaces and then more interpretation is required to link these spaces with axial lines. This interpretative role for the person drawing the map raises the problem of reliability. There will be some error margin involved in any human drawn process. Unfortunately there is no published data on what the error margin involved in a sample of 'trained' people drawing the same axial map to any particular specification is. There is also no standard control procedure for differences in drawing style that has been tested to ensure the comparability and reliability of maps. This prevents any researchers using the technique from knowing how comparable their maps are with anyone else's, or how much of their result was influenced by their own methodology in drawing the map. Therefore the fewest line axial map cannot provide researchers with reliable and comparable results in terms of basic scientific methodology.

An interesting alternative concept for an axial map is the 'all line' axial map. The idea of an all line map is to represent the longest lines of sight between any two intervisible building vertices. This can be calculated automatically and software for all line axial map generation called "Spacebox" was created by Nick 'Sheep' Dalton at the Bartlett in 1990 (Hillier and Penn 1992). This measure has been applied in a limited number of building cases (Penn, Desyllas et al. 1999). This technique has the limitation that the sampling of lines of sight is entirely dependent on the complexity of the polygons used in processing. This means that any graph based on the all line map is 'weighted' towards areas that have complicated facades or polygons. If curves are introduced the problem is increased because a standard graphics package may render a curve with many hundreds of vertices. However, a large area with relatively few complex polygons will have very few lines. The authors are not aware of any published studies on the relationship between a so called all line axial map and urban pedestrian movement flows, so the implications of these theoretical limitations have not yet been tested in empirical cases.

Once the representation of morphology has been created, measures of spatial characteristics can be analysed. Hillier et al. have used the axial representation of space to calculate analytic graph measures, where each axial line represents a node in the graph and each intersection between lines represents a vertex.[3] Graph measures are used with the simplifying assumption that the weighting of origins and destinations can be ignored in dense cities because there are so many complex potential origin-destination pairs. Hillier's theory of natural movement is that the routes prioritised for pedestrian movement in such circumstances will be dependent on the morphological characteristics of the streets themselves. This is the theoretical basis for the use of measures of route simplicity in models of movement patterns:

> If we define an urban street network as a system of lines linking some set of origins and destinations, and to the extent that movement can occur from all origins to all destinations, then movement along the lines making up the network will be substantially determined by extrinsic measures of those lines.[4] (Hillier 1998)

4.1.1 Methodology for Axial Analysis of the St Giles Circus Study Area

The axial map used for the St Giles Circus study is the map of London within the North and South Circular roads. A number of studies of movement with this map have been published by Hillier (Hillier 1996) and the map has been updated by researchers in the Unit for Architectural Studies, the Space Syntax Laboratory and the Virtual Reality Centre at UCL. The version of the map used in this study was last revised for the VR Centre Regent Street Project on 23.09.1999. Integration value data was calculated for this project using the "Ovation" software of the Space Syntax Laboratory. The axial map of the area is shown in below.

Figure 8: Axial Map of the study area (Connectivity)

Once the axial map representation has been created there is a methodological issue of how to link the measures of visibility and accessibility to individual counts of pedestrian movement. Most published studies linking axial maps to pedestrian movement have taken the mean value of a number of movement counts along the entire length of an axial line. Although this correlation may be of interest to test the average characteristics of axial lines, is not an adequate test of the influence axial measures have on pedestrian movement on pavements. This is because this relationship must be investigated at the spatial resolution of individual pedestrian movement flows in order to avoid committing the 'ecological fallacy' of

3 These measures have been described at length elsewhere (Hillier and Hanson 1984).

4 A clearer formulation of the theory might be "to the extent that origins and destinations are equally distributed throughout the system and movement does occur from all origins to all destinations" as it is only to the extent that such a simplifying assumption is valid that the model will predict movement.

imputing lower level relationships from aggregate data (Lee 1973). It also obscures significant differences in movement along a line such as those on each side of the street and from block to block outlined above in the St Giles study area. In this study the movement observations taken on individual pavements were linked to the axial lines passing them. The fact that axial lines cannot be sampled on individual pavements has led to a ratio of 1 unique spatial value to every 4.1 observation locations.

4.1.2 Empirical results

Using an axial analysis of urban spatial structure, the stronger correlates of pedestrian movement in the study area were the more local spatial variables, especially connectivity of the axial lines. Global integration was the worst correlate, with r^2=.238 (Figure 9), local integration correlated to r^2=.422 (Figure 10) and connectivity of axial lines correlated to r^2=.429, $p<.0001$ (Figure 11).

Connectivity is also the strongest correlate of pedestrian crowding (movement per m of available pavement width). The correlation is worse than that with direct movement counts but it is still a statistically significant positive correlation.

Axial measures have a very poor correlation to pavement width owing to the fact that this technique produces identical values along each street and for each side of the street, regardless of changing pavement conditions (see Figure 13 below). The relationship is nonetheless positive and statistically significant (p=.0004).

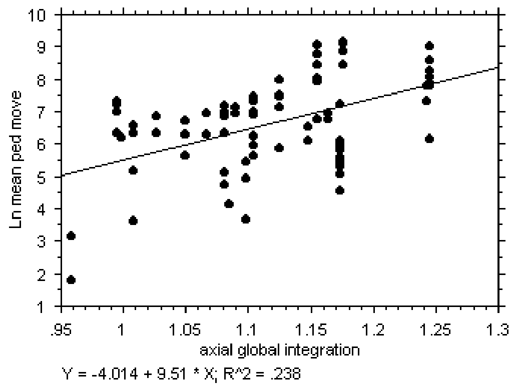
With all axial measures there is a banding in the correlations. This is a result of only having one spatial value per axial line but significant differences along the line and from each side of the street. The banding shows that there is a significant and measurable variance in pedestrian movement along the length of axial lines and any use of average movement counts along the line would mask this.

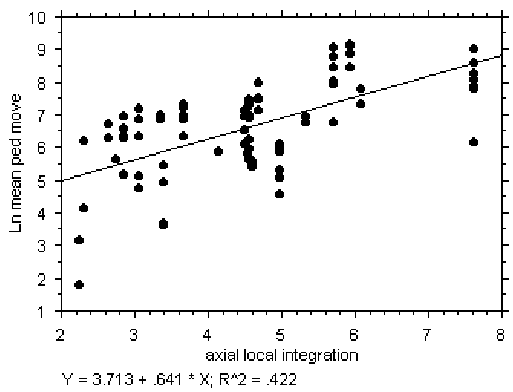
4.2 Visibility Graph Analysis

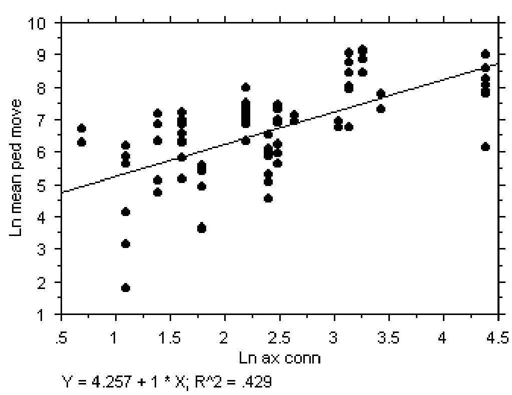
Visibility graphs analyse the extent to which any point in a spatial network is visible from any other. Where points are not directly visible, graph measures of a matrix of points can be calculated to test how many intervening points are needed for one point to see others. Visibility Graphs were first used by Braaksma in a study of airports to identify the visual and spatial relationship between various facilities that a passenger must find (Braaksma and Cook 1980). They have recently been the subject of interest in geocomputation (deBerg, van Krefeld et al. 1997) and in architectural analysis (Turner, Doxa et al. 1999; Turner and Penn 1999). Published research testing the relationship of VGA to pedestrian movement has been exclusively on studies within buildings, such as the Tate Gallery (Batty, Conroy et al. 1998; Turner and Penn 1999). Turner and Penn published findings on the extent to which the occupancy of gallery rooms by visitors could be explained by a combination of their area and mean depth within the visibility graph, finding that these two factors predicted to rsq=.634.

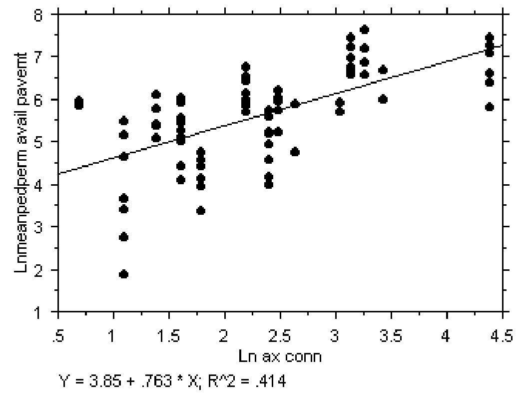
Whereas axial maps have often been used to calculate mean depth measures, the very low mean depths of visibility graphs make any depth analysis subject to extreme edge effect which has to be controlled. Depth measures are applicable in spatial analysis when some criteria for defining a bounded system can be made.[5] In building interiors, this is often simple because they are usefully thought of as (literally) bounded spatial systems. Measures of mean depth

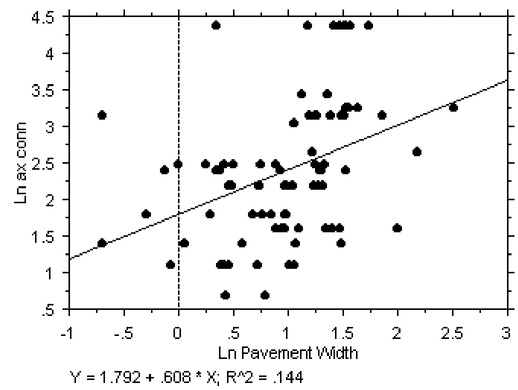
5 Depth calculations within a limited number of steps in a graph analysis can be accurately calculated if a much larger system is processed than the real study area. However, the depth of all points from the edge must be systematically calculated and those areas that fall within a set number of steps from the edge must be removed from study as their values will be incorrect.











INSERT Figure 9: Correlation between axial global integration and Ln pedestrian movement

INSERT Figure 10: Correlation between axial local integration and ln pedestrian movement

INSERT Figure 11: Correlation between Ln axial connectivity and ln pedestrian movement.

INSERT Figure 12: Relationship between axial connectivity and crowding.

INSERT Figure 13: Correlation between Pavement Width and Axial Connectivity

always create an 'edge effect' and that is the whole point: the interesting thing about them is the way that they define what is central and what is edge. As Turner and Penn noted, the problem of edge effect is even more obvious in urban systems if a small area is analysed with Visibility Graph Analysis because mean depths are so much lower (Turner and Penn 1999). One way to overcome this is to analyse a whole urban system (where some objective definition of the 'edge' of a city is adopted). The other way to overcome the limits of edge effect is to use local measures that are not dependent on any relations to the entire graph, such as the visual connectivity of a point (which is essentially its visibility) or the clustering co-efficient (Turner, Doxa et al. 1999).

4.2.1 Methodology

Visibility Graphs were calculated using the 'Fathom' visibility graph analysis software created by 'Intelligent Space' of London, UK. This program implements the automated spatial sampling technique used in VGA of generating a regular grid of points within the entire study area. Automated sampling resolves the issue of reliability that was discussed with the axial map methodology, which makes the whole analysis methodology a lot more open to scrutiny.

As has been noted, the very low mean depths of visibility graphs make measures of integration unusable without analysing the entire city. Therefore only the local measure of point connectivity (or visibility) was tested. Even for the calculation of the so-called 'local' measure of visibility, a much larger area of the city had to be processed, extending far beyond the study area on long streets such as Oxford Street as far as would be visible from any point in the study area. This was in order to ensure that values for visibility within the study area were correct. Figure 14 below shows the visibility of all pedestrian spaces in the study area calculated with Visibility Graph Analysis. This same analysis could be applied to any urban or building situation. The differences between movement, axial analysis and VGA are shown in Figure 15.

4.2.2 results

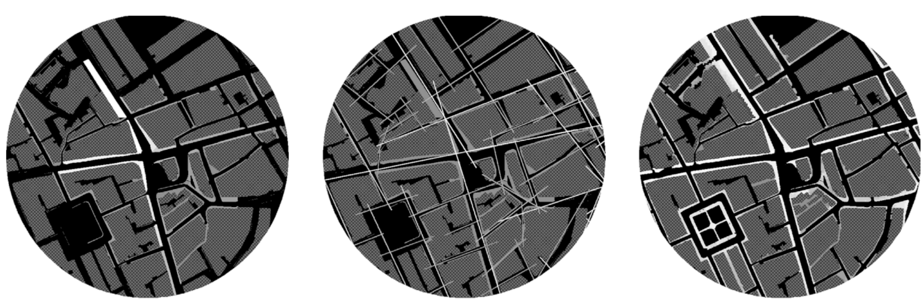
The correlation between movement and visibility of pedestrian space using VGA is significantly better than that with measures of space syntax axial lines. The best correlate with VGA is r^2=.625, which can be seen in Figure 17 below. This compares to the best relationship with axial lines (using connectivity) of r^2=.429.

One of the methodological issues when using VGA is the effect of changing the parameter of sampling grid resolution. Two different resolutions were tested in this analysis and the relationship to pedestrian movement did improve with a higher grid resolution. For ln average movement, the mean visibility of points on a pavement predicts to r^2=.456 when a grid of 5 metres is used. When the grid resolution is increased to 3m the correlation rises to r^2=.625. For both cases p=<.0001.

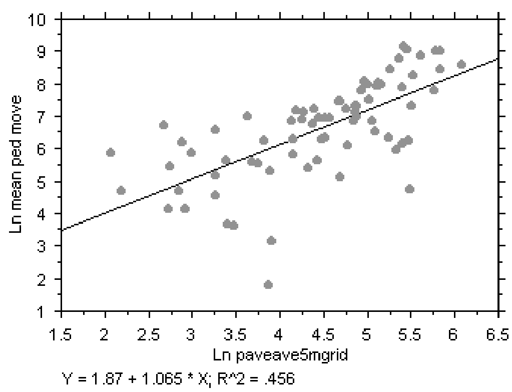
4.2.2.1 'Gate' Visibility and Movement: Although increases to the resolution of the grid increased the performance of visibility as a predictor of movement, the correlation was not improved by taking visibility only in a restricted area around the gate where movement was counted. For Average visibility within a buffer of 3m radius around the gate, the correlation was only to r^2=.425, as can be seen in Figure 18 below.

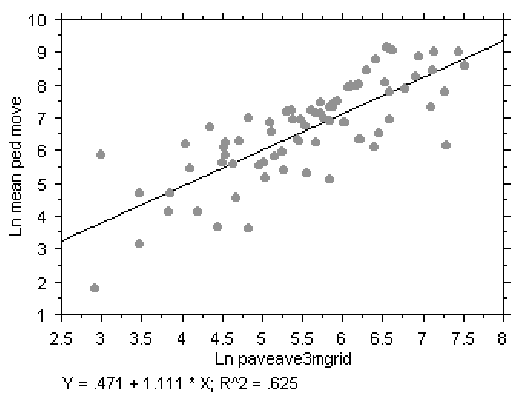
Figure 14: Visibility of pedestrian space in the study area calculated with VGA (colour scale)

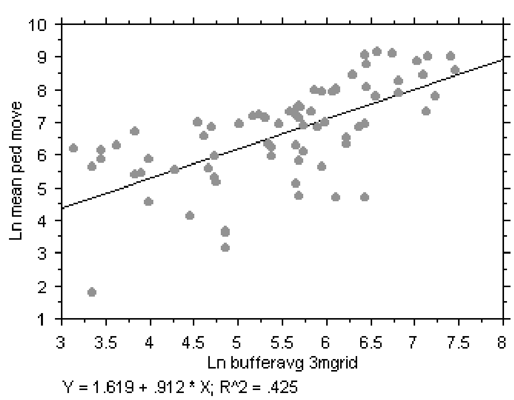
Figure 15: Comparison of pedestrian movement, axial connectivity and VGA visibility in the study area

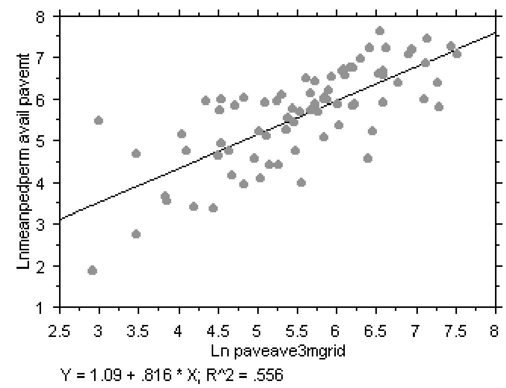


(a) pedestrian movement flows **(b) axial connectivity** **(c) VGA visibility**









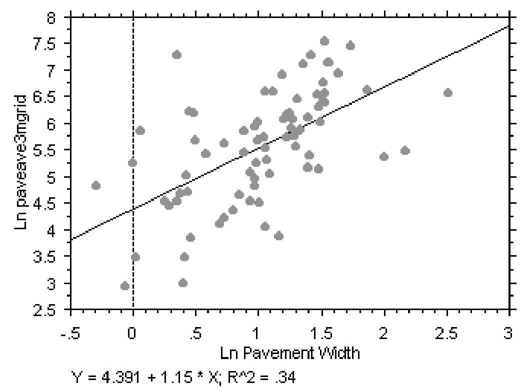


Figure 16: Correlation between Ln mean Visibility (5m grid) per pavement and Ln mean pedestrian movement

Figure 17: Correlation between Ln mean Visibility (3m grid) per pavement and Ln mean pedestrian movement

Figure 18: Correlation between Ln mean Visibility (3m grid) per gate buffer and Ln mean pedestrian movement

Figure 19: Correlation between Ln mean Visibility (3m grid) and Ln mean pedestrian movement per m of available pavement

Figure 20: Correlation between Pavement Width and Visibility

4.2.2.2 movement per m of available pavement width: The correlation between visibility and pedestrian movement per m of available pavement width is also better with VGA than with any axial measures. Whereas the best axial correlate of Ln Movement per M available width was connectivity (r^2=.414) the correlation of visibility from VGA was r^2=.556, as can be seen in Figure 19 below.

Pavement width also has an influence on visibility, as can be seen by the correlation of the two in Figure 20 below. In this sense the measure of visibility captures the differences from pavement widths and the correlation between visibility and movement is therefore reduced when movement is controlled for pavement width.

5 Discussion

We have shown that pedestrian movement varies significantly from street block to street block and on different sides of the street. Although the simple measure of pavement width can be used to explain some of this variance, measures of urban spatial structure have been found to correlate much better. Of the two kinds of representation technique used to measure urban spatial structure, the Visibility Graph Analysis measure of visibility for pavements performed significantly better than any of the axial map measures did. The strongest correlate of movement was visibility of pedestrian space (measured as the mean connectivity of VGA seed points spaced on pavements with a 3m grid).

The results of this paper raise interesting questions for further research. Why does the localised measure of visibility correlate so well with movement? This finding is especially interesting as it has been suggested by the theory of natural movement that location within a wider framework of the surrounding city should be more important in determining movement. Perhaps because greater visual reach into surrounding streets is used as a heuristic by pedestrians seeking to travel on more direct routes. Or perhaps we will find that when large enough Visibility Graphs can be constructed to calculate more global graph measures that these do indeed predict better than visibility alone. These findings can be tested by independent researchers on different cases because we now have a technique to measure urban morphology that is objective and universally applicable. The more powerful correlations shown in this paper suggest that the testing will bring very interesting results.

6 Conclusions

In this comparative study, Visibility Graph Analysis produced a better correlation with pedestrian movement than the axial map representation of space. This was also found in both of the other previously published comparative studies. This raises an issue for the direction of future research. There is a tradition in the space syntax research field of 'mapping it both ways'. In case studies of pedestrian movement, this approach is essentially to experiment with numerous tweaks of the representation of space to see which produces the better correlation with movement. This study has sought to develop an approach that can contribute to a more general test of each representation technique. The real research work is to move on from finding the representation that correlates best in your own particular study of pedestrian movement to the one that correlates best for all the data of all the studies that have been done. Finding the answer to this requires a wider program of dispassionate comparative testing of the various techniques for representing space.

Such a research program requires collaboration between large numbers of people distributed around the world. This means that each technique to be tested must be controllable for reliability and capable of comparable use. There are still important open questions about reliability with axial map use that limit this technique's use for such a program at present. VGA offers researchers one example of a more universally applicable and open methodology. We can look forward to the emergence of other techniques.

A research programme is not defined by the methods it uses to nor by the theories that it generates. Neither techniques nor theories should be things that we sign up to in order to belong to a research community, because they must be the subject of vigorous debate. This should lead to methodological progress, whereby criteria for preference can be set and the less successful techniques are abandoned in favour of the ones deemed 'better'. This means that the both the techniques used to generate results and the theories used to explain them are also by their nature transient.

The non-transient part of our research programme is not the set of techniques nor the theories but rather it is but the problems that these answers are seeking to address. As Karl Popper noted; "We are not students of some subject matter but students of problems. And problems may cut right across the borders of any subject matter or discipline" (Popper 1992).

Both Visibility Graph Analysis and Axial Maps are mere tools in the research programme that investigates the role of spatial configuration as an independent variable in social systems. This research programme is bigger than just a set of techniques and it crosses conventional subject boundaries. It is concerned with philosophical problems such as how can we measure the spatial structure of our built environment? What is the role of configuration in movement, co-presence and higher order social phenomena? What is the nature of the relationship between social organisation and spatial configuration? These philosophical problems, unlike the techniques and theories built to tackle them, are not transient.

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