

Assessing urban character: the use of fractal analysis of street edges

Jon Cooper

Joint Centre for Urban Design, School of the Built Environment, Oxford Brookes University, Oxford, OX3 0BP, UK. E-mail: jcooper@brookes.ac.uk

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Abstract. *Fractal analysis can provide a synthetic measurement of place complexity and thereby allow a numerical characterization of places. A fractal analysis of street edges is provided, linking the calculation of fractal dimension to the presence of the physical features making up a street edge. A technique for calculating street edge fractal dimensions is presented and speculation on the use of fractal analysis in comparing the character of differing places is made.*

Key Words: street edge, fractal dimension, character, complexity, urban design

The definition and delivery of local character and distinctiveness of place continue to be issues that challenge those who both study and create the built environment. Designers and conservationists tend to use well documented morphological methods for decoding place – plot measurement, block dimensions, recording of façade details etc – in an attempt to then re-code it for possible new building or infill development that will ‘reflect’ or ‘respect’ the existing character of a place whilst avoiding ‘pastiche’. The use of the two ‘r’ words is in itself a problem as they are both open to wide definition and interpretation. A typical problem of decoding place, especially older places, is how to record the irregularity or complexity that these places have that is an inherent part of their underlying character.

One method that may aid in the recording of place complexity, which might help facilitate the quick comparison of character between places and that could potentially allow the underlying characteristic irregularity of a place to be measured – helping to quantify the ‘r’ words – is the calculation of fractal dimension.

The use of fractal dimension in describing

and analysing urban structures has already been carried out by a number of authors. For example, Cooper (2000, 2003), Hagerhall *et al.* (2004), Heath *et al.* (2000) and Oku (1990) have employed fractal analysis to characterize the complexity of urban and natural skylines. Cooper (2000), Mizuno and Kakei (1990) and Rodin and Rodina (2000) have examined the fractal characteristics of urban street networks. Several authors have investigated the potential of fractal dimension in relation to urban structure and planning, such as Batty (1995), Batty and Longley (1994a, b), and Frankhauser (1994). In the field of urban design Cooper (2000) and Robertson (1992, 1995) have investigated fractal dimension in relation to urban design qualities and urban character. With regard to landscape evaluation, Li (2000), Ricotta (2000) and Schmidt (2000) have investigated the use of fractals in the evaluation of landscape features in terms of habitat and species distribution patterns. Concerning landscape design, authors such as Brodie (1996) have explored the use of fractal patterns as design inspiration. In the field of architecture, Bechoefer and Bovill (1995) and

Bovill (1996) have examined the use of fractal dimension both in evaluating buildings and as potential design generators, and Jencks (1995) has explored the role of fractals in architecture as the inspiration for a new creative design theory and approach.

Taking its cue from these authors, particularly Batty and Longley's (1994b) work on urban boundaries – where fractal dimension was used to characterize the irregularity of certain urban boundaries – this exploratory and experimental paper examines the fractal characteristics of a series of lines representing the indentation of building façades and gaps along a series of streets. Its main aim is to show how the calculation of fractal dimension might be carried out for a series of street edges and how the resultant numerical measurement can be related to the presence of certain morphological features that, in combination, affect the character of a place. Differences between and along a selection of streets are quantified using fractal dimension as an illustration of how changes in physical character can be collapsed and recorded in a single number that might subsequently allow quick comparison to be made between places. The intention is to assess the potential of using the ruler measurement method of calculating fractal dimension in gauging the character/complexity of indentation in a street edge as an aspect of street character.

The paper first presents a brief description of fractal concepts and outlines the notion of fractal dimension, followed by details of the method used to assess street edges. It then presents the resultant fractal values, and derives some conclusions in terms of the relationship between fractal dimension and street age and type. Using correlation tests and multiple regression analysis it examines the mean fractal dimension calculated for each street in terms of the presence of certain physical characteristics, such as plot sizes, building structure and levels of detachment. Levels of variation in fractal dimension within each street are presented in relation to physical changes that incorporate the regularity and degree of repetition of features characterizing the case street, and final commentary is given

on the implications of the findings.

Fractal geometry

Modern geometry is dominated by the concept of things as one, two or three dimensional – Euclidean geometry. The line has one dimension: length. The plane has two dimensions: length and width. The cube has three dimensions: length, width and height. This is suitable for describing objects or shapes that are completely regular, but Mandelbrot (1977) argues that much of the 'natural' world, and it is argued here much of urban development, cannot be adequately described using the concepts of Euclidean geometry. It should be noted that this discussion applies to the 3D material world. In terms of mathematics the notion of fractal geometry has introduced the possibility of ranges of fractional dimensions in the n dimensions of the mathematical world.

Mandelbrot (1977) derived the term 'fractal' from the Latin verb *frangere* (to break) and the adjective *fractus* (irregular and fragmented), and used the term to describe shapes or objects that demonstrate repeating patterns when examined at increasingly smaller scales – that demonstrate scale invariance. It is this quality of scale invariance that is quantified by the concept of fractal dimension.

Types of fractal

It is useful to make a distinction between two types of fractal objects: mathematically constructed fractals and natural fractals. Mathematical fractals are mathematical constructs. They are objects formed by the repetition of a simple geometric instruction: a Koch curve, for example, as shown in Figure 1.

More important to this paper are the second group, the 'natural' fractals. Examples of this kind include the structure of dust, smoke, foam, snow flakes, cobwebs, trees, mountains, lakes, islands, clouds, coastlines and, at the largest scales, galaxies, clusters and super clusters (Koch 1993, p.643).

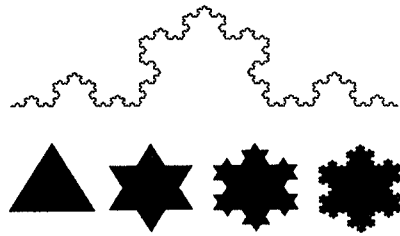


Figure 1. The Koch curve. This curve is generated by adding to a base triangle a triangle one-third the size of the original to the centre of each side and repeating the action. The result is an increasingly long boundary that stays within the confines of a circle that can be drawn around the original object. An infinitely long line defines a finite area.

A cauliflower or a tree displays similar characteristics to those of a natural fractal object. The whole cauliflower head displays irregularity in Euclidean terms but is made up of smaller, similar versions of itself. These individual florets are themselves made up of smaller similar, versions. Natural fractal objects display a degree of randomness in their details that sets them apart from the mathematical constructs.

Similarity over scales is one of the key characteristics of fractal geometry: in an object or pattern that demonstrates natural fractal characteristics the degree of roughness or irregularity looks the same when the image is magnified, although the actual details may differ. In mathematical fractals, this similarity can be repeated over an infinite number of scales, while in natural fractals, including a variety of elements of urban structure, it is repeated over a limited number of scales.

Fractal dimension

What both types of fractal object have in common is the notion of fractal dimension. The concept of fractal dimension enables the degree of irregularity of a shape or object to be calculated and represented as a number. This number (D) lies between the Euclidean dimensions of 1, 2, or 3. For example, the fractal dimension of an irregular line, such as

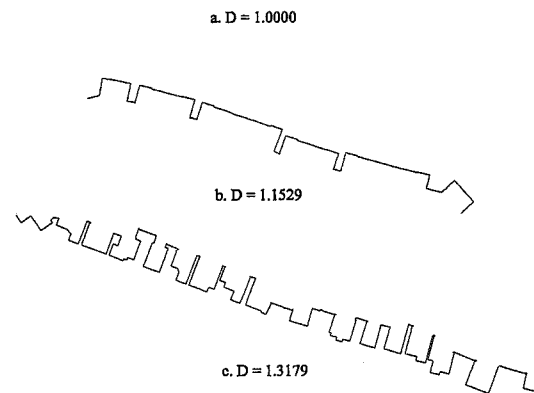


Figure 2. Fractal dimension in relation to line 'roughness'. Line 'a' is a straight line with a single dimension (length) and is therefore labelled as $D = 1$. Line 'b' has a greater degree of 'roughness' and has a correspondingly higher D value at 1.1529 – it is not a simple straight line. Line 'c' exhibits a still further degree of irregularity and has a D value of just over 1.3. These examples show how a numerical value (D) can be used to quantify the degree of irregularity in a line.

a coastline, would lie somewhere between 1 and 2: it is not a simple straight line, that would be one-dimensional, but nor is it a full plane which would have two dimensions. It lies somewhere between the two. Fractal dimension can be represented as non-integer numbers, while Euclidean dimensions are integers. Essentially, fractal dimension is a measure of how well a particular object fills the space in which it is drawn. For example, using the concept of theoretical mathematical fractals it is possible to imagine an infinitely long line drawn in a finite space. The line is infinitely folded and irregular on diminishing scales. Its length can be infinite as it increases through irregularity: it increases its density within its given space. Figure 2 illustrates the concept in relation to a simple straight line in comparison to two traced street edges and shows how increased 'roughness' of line can be represented numerically (D). Again it should be noted that this definition of fractality applies to the material 3D world and not to the worlds of mathematics.

Mandelbrot's work on coastline measure-

ment followed from earlier work on national boundaries by Lewis F. Richardson (1961). Richardson experimented in measuring the west coast of Britain and the Spanish-Portuguese land boundary and noticed that his results depended on the scale of the maps being used. In some instances there were discrepancies of up to 20 per cent in the total lengths. It was this discovery by Richardson that subsequently led Mandelbrot to develop the concept of fractal dimension. Mandelbrot (1977) argues that the length of a coastline becomes infinite, with increasing detail detected as the measurement scale reduces. This is the key to understanding fractal dimension: it is this relationship between measured length and measurement scale that is the basis of calculating fractal dimension.

Methods of calculation

A number of methods could be used to characterize the fractal dimension of irregular or rugged lines. All seek to establish a relationship between measured size (length, surface or volume) and scale, by evaluating how length, surface, or volume increases with measurement using smaller and smaller scales. The method employed here is the 'structured walk' or 'ruler' method, where the distance used for each 'step' (the 'detail' of the walk) is related to the scale used.

In its simplest form the structured walk method employs a set of dividers or rulers set at a number of predetermined stride lengths (s) to allow measurement at various scales. The rulers are then walked along the subject line at each of the predetermined settings and the subsequent total lengths (N) are recorded.

To compare the results of measurement at different scales and subsequently to calculate the fractal dimension, the measurements are entered into a double logarithmic graph as the log of s (the stride size) against the log of N , where N is the resultant lengths. This helps to remove the difficulty of reading length-versus-settings relationships when the settings used may vary from several hundred units to just a few. These log/log diagrams are referred to as

Richardson plots, after Richardson (1961).

When points on a log/log diagram fall on a straight line, a power-law relationship exists between the two sets of data (Peitgen *et al.*, 1992, p. 192). This allows the exponent of that power law to be read off as the slope of that straight line (d). To arrive at the value of d we can employ the equation $y = dx + b$, which is the description of a straight line on an x, y diagram, where b is the intercept point of the straight line on the y axis and d is the gradient of the line. So $d = (y_2 - y_1) / (x_2 - x_1)$ for any pair of points, for example (x_1, y_1) and (x_2, y_2) on a line, which can be calculated easily by picking two points on the line and their co-ordinates and subjecting them to the equation. The value of d is in effect the gradient of the line. This value d is essential in calculating the fractal dimension of the subject in question.

The fractal dimension is D , which is equal to $1 + d$. This gives a direct measurement of the roughness of the fractal object by adding d to the topological dimension 1. Effectively we know that the subject, in the case of the coastline or street edge trace, is some kind of line, so its base dimension must be 1. We also know that it has roughness: it is not a smooth line. So to get the overall effect we add an indication of its roughness to its base dimension: hence we add d to its base dimension of 1. Strictly speaking this method gives the ruler dimension, which is written D_r .

A number of cautions have to be observed when calculating fractal dimension in this manner. The resultant fractal dimension is related to observations made over a certain range of scales and relates only to those scales. In terms of urban form and design, this makes the selection of a useful and useable measurement scale paramount in achieving meaningful results when evaluating different characteristics. For example, it would be of little value to evaluate the façade of a building at scales ranging from 50 metres to microns. It would probably be more pertinent to use scales from perhaps 10m down to perhaps 0.001m. This would pick up most of the relevant detail from gaps between buildings, building width, and the indentation of bay

windows, down to the textures of brickwork. Any evaluation of D must be undertaken at scales that are meaningful in relation to the particular subject.

In practice it is unlikely that a single fractal dimension calculation accurately captures the character of a façade measured over such a large range, as different regions of a subject will often have different fractal properties – commonly referred to as multi-fractality. Batty and Longley (1994a), for example, have observed this multi-fractality in the urban boundary of Cardiff.

Method for assessing street edges

This section develops and assesses an experimental technique for using the ruler-measurement method of calculating fractal dimension (D_r) to investigate the characteristics of the edges along a series of streets. For the purposes of this paper the street edge is defined as the line formed by the buildings bounding the street. It does not, at this stage, take into account the presence of vegetation or changes in terrain – although this is currently being worked on in relation to a fractal analysis of views along streets.

The sets of lines shown in Figures 4 to 8 and used throughout this paper are traced, using 1:2000 plan outlines of the case study streets' building frontages. They are extracted from the digitized Ordnance Survey of Oxford (Ordnance Survey, 1998) and saved as black and white negative images prior to measurement to produce D_r values using proprietary software Benoit 1.3 (Trusoft, 2004) that is specially designed for the analysis of fractals (Hagerhall *et al.*, 2004). The lines shown are not all continuous. Obviously, in reality frontage outlines are broken lines, as the buildings, particularly detached ones, have spaces between them. In order to use the D_r method to measure façade indentation, the lines had to be made continuous. To make a single line for each side of the street the original plans showing only the buildings were extracted using the layering system of AutoCAD 14 (see Figure 3 as an example).

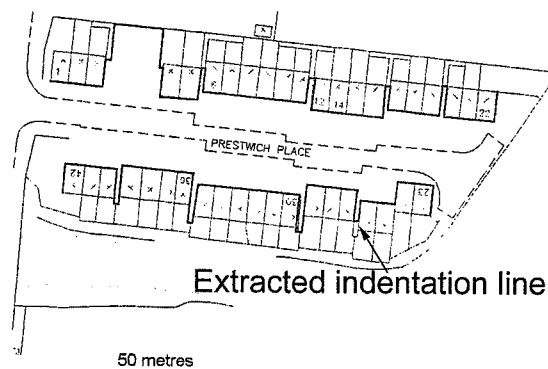


Figure 3. Prestwich Place: building outline (source: Ordnance Survey, 1998).

Where gaps occurred, including side roads, a new straight line was drawn to connect the existing building lines, using the back of the shallowest building as the reference point.

This was carried out in order to measure the degree of indentation along the case streets as a combination of indentation on the individual façades and the gaps between the buildings, all of which register, visually, as an obliquely viewed pattern, on progressing along a street. Although the line connection decision seems somewhat arbitrary, field observations confirmed that the resultant continuous line retains the visibly broken nature of the original building/gap pattern whilst also allowing measurements using D_r .

A total of 25 streets in Oxford, England were examined, representing 50 traced street edges (2 per street). Prior to measurement using Benoit 1.3, questions of suitable measurement parameters arose and a number of problems were identified. Previous studies suggest that fractal dimensions are calculated in relation to the upper and lower size limits (l) of the subject. This is automatically done in Benoit 1.3 where the largest 'ruler' size is $l \times 0.25$ and the subsequent 'ruler' sizes reduce by a coefficient of 1.3. However, the lengths of the case study streets vary, although they average approximately 150m, and some are curved. This presents an immediate problem in terms of selecting the measurement parameters. Two methods appeared to be feasible. First, use the default values of trace length (l) multiplied by 0.25 to calculate the largest grid size. This would have the advan-

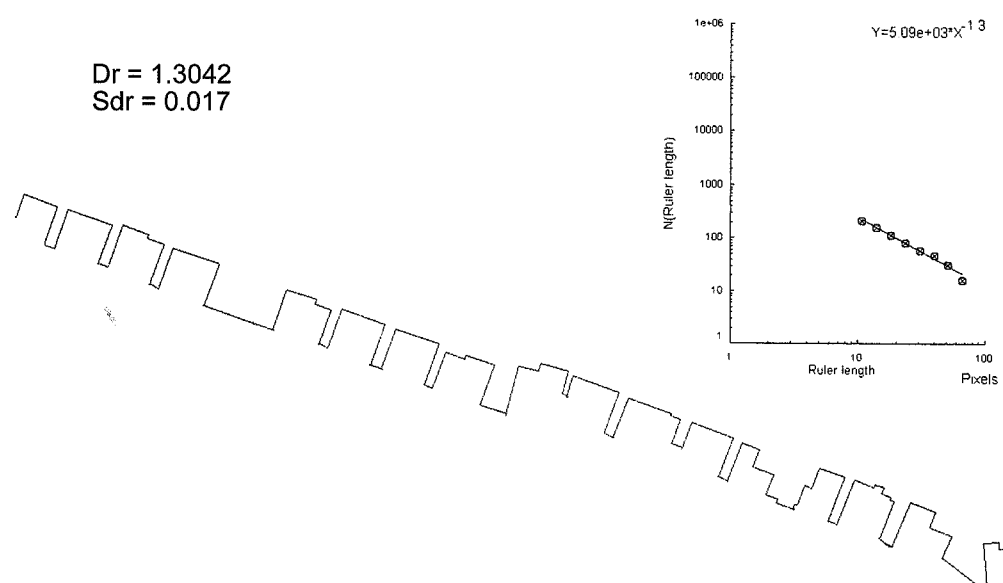


Figure 4. Richardson plot for Hurst Rise Road West with a Dr value of 1.3042 and Sdr of 0.017.

tage of allowing the resultant Dr values to be fully relevant to each trace. The disadvantage would be in the difficulty of then comparing traces of differing length. Secondly, select standard maximum and minimum grid sizes to be applied to all traces. The advantage of this method would lie in being able to compare traces over a common range, but the results may be distorted if the range used was either too large or too small in comparison with the subject trace.

After carrying out a series of correlation tests with data extracted using both methods, the technique of using standard stride sizes provided the highest r values when compared to a second set of non-fractal data and the closest visual match with apparent line complexity. It was therefore decided to use a standard range of strides based on the sizes of the smallest case street.

Benoit 1.3 operates by measuring the lengths of the subject lines at a variety of scales using a set of 'rulers' that uniformly decrease in size. The software measures scanned digital images in pixels that can be scaled and converted to metric dimensions. All traced lines were measured with the largest ruler set at 68 pixels, with a reduction coefficient of 1.3, and a total of 8 ruler sizes. Following the practice set when examining

skylines (Cooper, 2000, 2003), the smallest ruler size was restricted – in this case to 10 pixels – to avoid distortion caused by thickness of the traced line. As the lines were all traced at scale, it is possible to convert the pixel size into metres, and so the smallest ruler size used represents approximately 2.0m while the largest grid represents 14m. This does not conform strictly to the earlier suggested range of 10m to 0.01m, but proved to be the best fit with the physical data being examined in this paper and returned the lowest standard deviation of residuals in relation to the accuracy of the fractal dimensions calculated. In this instance the fractal dimension is relevant between these dimensions and each pixel represents approximately 0.2m.

Street edge Dr values

Prior to considering the measured Dr values produced using the selected parameters, the standard deviation of residuals (Sdr) for the Richardson plots used in the calculation were examined. The range of Sdr values in these cases is considered small enough to allow the Dr presented on the Richardson plot to be used as the main indicator of fractal dimension in all the cases, with the highest Sdr being only

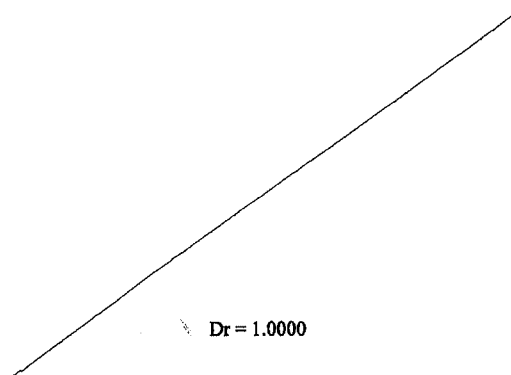


Figure 5. Argyle Street.

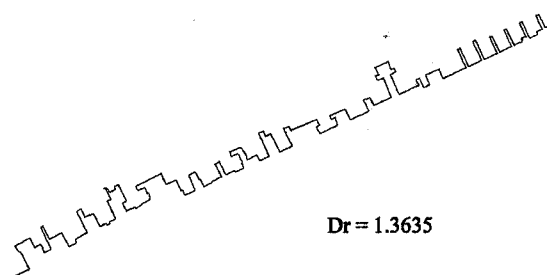


Figure 6. Davnant Road.

0.017, for Hurst Rise Road West with a Dr value of 1.3042 (Figure 4).

Of the 25 streets examined, the smallest Dr value was 1.0000 (Figure 5) for the south-western side of Argyle Street (showing a straight façade), while the largest was 1.3635 (Figure 6) for the northern edge of Davnant Road.

The remainder of this section focuses on the pairs of traces that make up each individual street, comprising a trace for each side of the street, as illustrated in Figures 7 and 8. For each case two measures are examined: first, the mean Dr value for each pair of lines; and secondly, the levels of homogeneity within the sets of lines. The second measurement is included to indicate the potential multi-fractal nature of each street by using the coefficient of variation (V) to measure the degree of uniformity within each street set. Hannigan (1990, p. 171) writes that where it is desirable to compare relative levels of homogeneity in cases where groups might have differing means, it is relevant to look at the size of the standard deviation relative to the mean. A relative variability can be obtained by dividing the

standard deviation by the mean to produce the coefficient of variation (V). To aid comparison this can be multiplied by 100 to convert to a percentage. These figures are subsequently compared with the age and type of each street and to the presence of certain physical characteristics of the case streets to highlight possible correlations between Dr and non-fractal variables.

Dr in relation to age and street type

An examination of the whole set of Dr values in relation to street age and street type reveals no apparent relationship between street edge Dr and street age, but there does appear to be a relationship between street type and Dr, suggesting that the Dr values are related to the 'grain' or 'texture' of the street edge. The edges with finer grain, such as those for streets with predominantly detached properties, have higher fractal dimensions than terraced streets with a coarser grain. For example, Figures 7 and 8 show the lines for Newton Road and Davnant Road: the former is a terraced street, and the latter contains mainly detached structures. These examples are shown pictorially in Figures 9 and 10.

This is confirmed if the streets are identified by type, in terms of the degree to which their structures are detached (type 1 = continuous terraced houses; type 2 = terraced houses in groups; type 3 = terraced houses in groups and semi-detached houses; type 4 = semi-detached houses; type 5 = detached houses plus semi-detached houses) and then compared to their mean Dr value, as shown in Figure 11.

Figure 11 shows a strong positive correlation between the degree of detachment and Dr value. The higher the Dr value, the higher the degree of detachment; there is a pattern of rising values in relation to the increasing fragmentation of the building line as the building units become more separate, although there is a degree of overlap between cases which may be caused by the averaging of the Dr values from the two traces of each street that would hide 'within-street' differences.

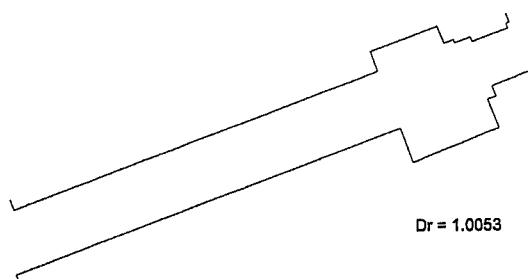


Figure 7. Newton Road: a late-Victorian terraced street with a uniform building line.

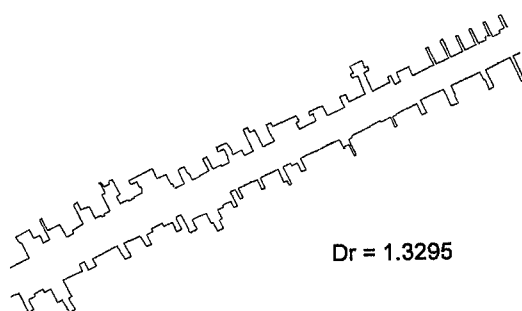


Figure 8. Davnant Road: a street of individual detached and semi-detached houses set within gardens, built c. 1950.

Although Figure 11 shows an overall trend, it is rather crude, and the use of street type is a somewhat artificial measure, as it does not tell the full story in terms of what the Dr value is indicating as a measurement. The character of a street is a function of many variables in combination and, in terms of the street edge, it seems self-evident that the size of the buildings, the regularity and repetitiveness of the building units and the numbers of gaps between the buildings making up the street edge have a great influence on the street's character and are likely to be reflected in the Dr value that can be calculated for that street edge.

Mean Dr and physical characteristics

To more accurately identify the degree to which these qualities are represented by the Dr value, and thereby gauge the potential usefulness of using Dr in character assessment, the



Figure 9. Newton Road: a late-Victorian terraced street with a uniform building line (mean Dr = 1.0053).

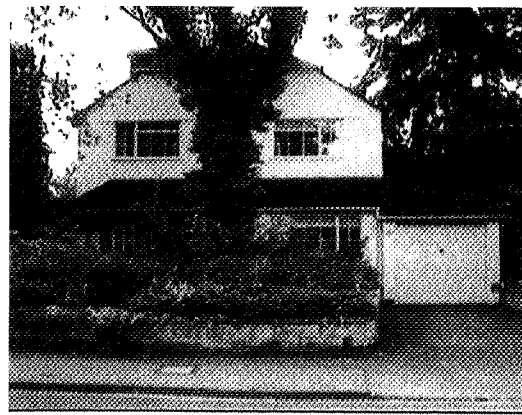


Figure 10. Davnant Road (mean Dr = 1.3295).

Dr values were subjected to a series of correlation tests and multiple regression analysis: first, in comparison with mean building size (the widths of each structure, as they face the street, were measured for each trace and the mean building size was calculated for each street); and secondly, the number of gaps on the street edges (the numbers of gaps between buildings, as they face the street, were counted for each set of traces). To arrive at an indication of the regularity – or homogeneity – of building sizes, it was decided to calculate

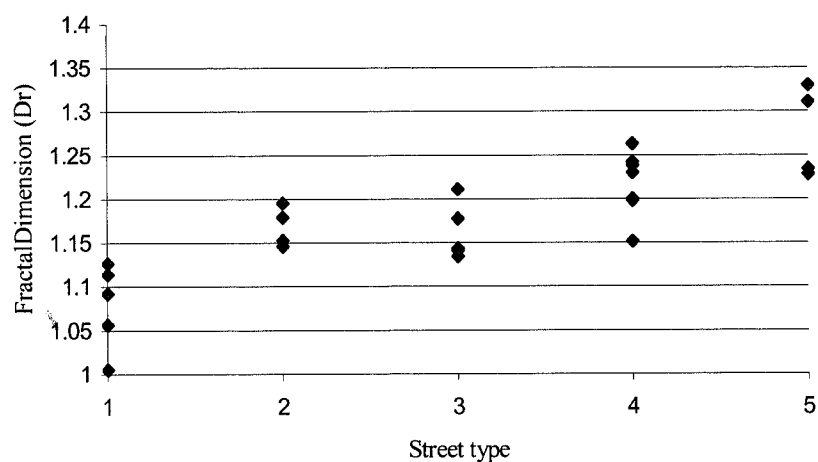


Figure 11. Street type and fractal dimension (Dr).

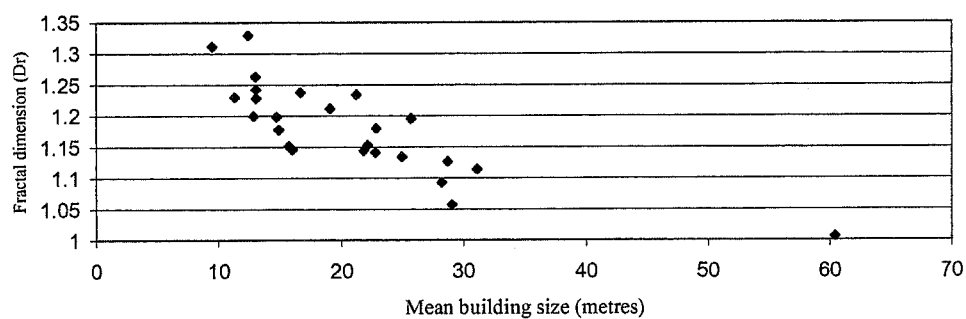


Figure 12. Mean Dr and mean building size.

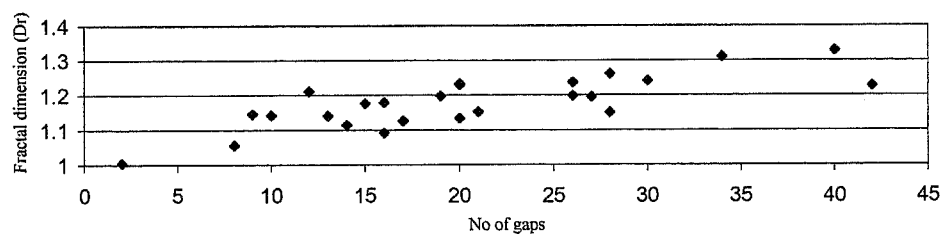


Figure 13. Mean Dr and number of gaps.

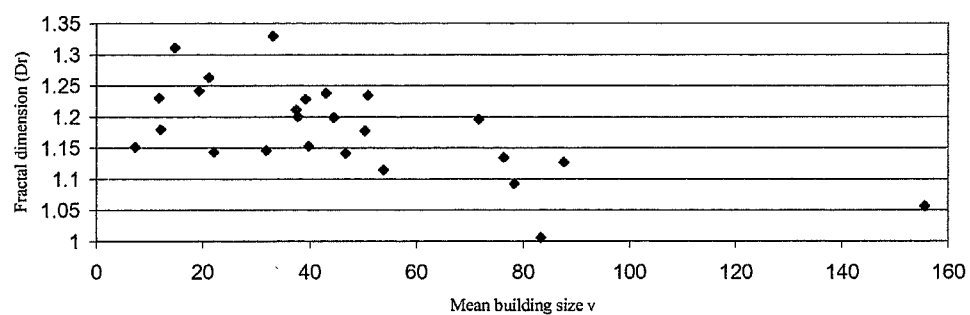


Figure 14. Mean Dr and mean building size V .

Table 1. Regression analysis

Models - added variables	Cumulative adjusted r^2	Adjusted r^2 difference	X coefficient	Standard error of coefficient
<i>a</i>				
Number of gaps	0.619		0.0059	0.0009
Constant 1.0585				
Std error of Y estimate 0.0466				
<i>b</i>				
Number of gaps			0.0047	0.0009
Building size V	0.725	0.107	-0.0008	0.0002
Constant 1.1204				
Std error of Y estimate 0.0405				

the building size coefficient of variation (V) for each set of traces. The resultant correlations are shown in Figures 12 to 14.

Mean building size (Figure 12) and mean building size V (Figure 14) both show a negative correlation with the Dr values, showing that as the average building size rises the fractal dimension falls, and as the regularity or homogeneity of the building size rises the fractal dimension falls. The number of gaps (Figure 13) shows a positive correlation with Dr , illustrating that as the number of gaps increases – as an indication of the level of detachment along the street – so does the fractal dimension. In terms of the strength of the correlation individually, mean building size and the numbers of gaps have relatively strong r^2 values of 0.6508 and 0.6197 respectively. Building size V has an r^2 of only 0.3947 but warrants an analysis of

its effect in combination with the other two variables.

A series of multiple regressions using the three variables in various combinations was carried out. The result of combining all three variables produced an adjusted r^2 of 0.80. However, further examination suggested that there was a significant overlap between the independent variables of mean building size and number of gaps, leading to possible distortions to the resultant r^2 values caused by co-linearity of the data. The combination of variables felt to have minimal overlap and that produced the highest r^2 value with Dr was number of gaps and the building size V , which produced an adjusted r^2 of 0.725 (Table 1). As the sample size was relatively small ($n = 25$), the

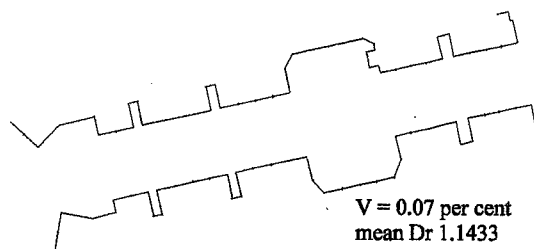


Figure 15. Chatham Road: a street of 1930s local authority houses constructed in short terraces or as pairs of semi-detached houses.

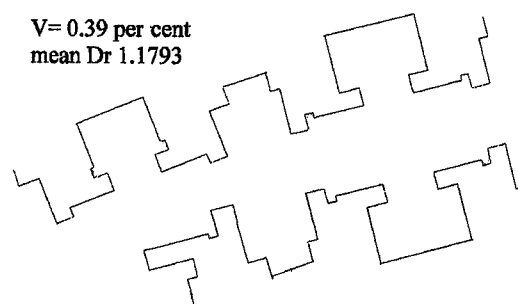
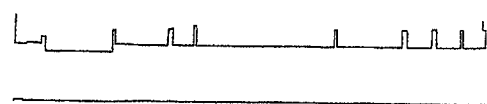


Figure 16. Park Close: constructed c. 1970s as a series of detached 3- or 4-storey blocks of apartments surrounded and separated by areas of open grass.



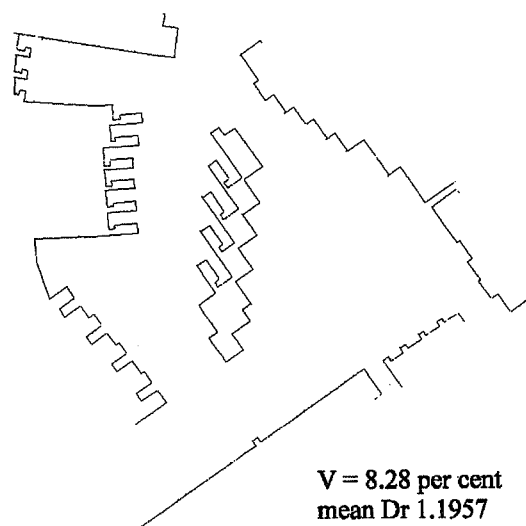
V = 7.81 per cent
Mean Dr 1.0564

Figure 17. Argyle Street: a late-Victorian street of terraced houses with a uniform building line.

adjusted r^2 is used rather than r^2 because it is calculated in relation to the sample size and number of variables, and is therefore deemed to give a more accurate indication of the strength of the correlation. In relation to Dr this suggests that almost 73 per cent of changes in Dr can be explained by changes in two variables. The variables of gap frequency and building size regularity in combination are significant in terms of the fractal dimension.

It seems from this analysis that the fractal dimension – represented in this case as mean Dr values between 14 and 2 metres – is providing a combined measurement of the size, range and regularity of indentations along a length of street frontage. Further evidence of Dr value highlighting differences in indentation grain can be found when examining the traces for differences within the street sets. The coefficient of variation for each set of traces highlights the degree of difference between the lines within each pair. They range from the almost identical and symmetrical (Figure 15, Chatham Road, and Figure 16, Park Close, with V values of 0.07 per cent and 0.39 per cent respectively) to the obviously varied (Figure 17, Argyle Street and Figure 18, Warberg Crescent that have V values of 7.81 per cent and 8.28 per cent respectively).

There seems to be some limited evidence, provided by both multiple regression analysis and visual examination of the lines, to support the claim that the fractal dimension derived using these techniques can provide a measure of street edge complexity. The correlation between Dr value and the independent variables of gap frequency and building-size coefficient of variation are of sufficient magnitude to be significant.



V = 8.28 per cent
mean Dr 1.1957

Figure 18. Warberg Crescent: a mixed street containing semi-detached houses, apartment blocks and maisonettes, constructed c. 1970s.

Conclusions

This paper has developed, and applied, a method of calculating a Dr value for the built edges of a street in plan, compared mean edge indentation Dr with street age and type, and tried to explain differences in Dr values in relation to variation in physical structure. The implications are that fractal dimension gives an indication of the structural grain of the case streets by reflecting both the frequency of indentation and regularity of the built structures. So, as with examinations of skylines (Cooper, 2000, 2003), the fractal dimension of street edges represents a composite, measurement of several variables – gap frequency, building structural type, building size and the regularity of repetition.

Although the fractal dimension calculated here is restricted to the range 14 to 2 metres and so will not detect façade detail below that point, from the investigation carried out and methods used, it has been found that the fractal dimensions of urban street edges range from 1.0 to 1.36. A street with low Dr is likely to contain:

- extensive runs of connected, continuous, terraced structures;
- uniform building sizes;

- buildings with large frontages;
- buildings with relatively flat façades, with little use of protruding bays or bows.

Streets with high D_r will be characterized by:

- a relatively high number of detached, or semi-detached houses;
- a variety of building frontage sizes, but predominantly narrow units;
- buildings with extensive use of bow-window and bay-window projections;
- a low level of repetition in terms of building size.

It seems from these descriptions that the fractal dimension of built street edges is recording the level of variety in building type and size: low D_r equals low variety and high homogeneity; higher D_r equates to higher levels of variety. This presents the possibility of using fractal dimension to compare the combined characteristics of different streets by identifying their fractal signature and allowing the degree to which new development should 'respect' or 'reflect' the character of a particular place to be numerically specified. The measured fractal signature of an existing street could be used as a reference point against which new development is compared or the existing signature could be used to generate a new pattern – this would have the underlying characteristics of the old but would not produce a pastiche. To develop these ideas further the role of vegetation combined with built form in defining the fractal characteristics of street edges is currently being investigated.

This examination of street edges reinforces the potential of using fractal dimension as a way of 'quantifying the qualitative' in terms of urban character that holds the further possibility of creating new and innovative development with a measurable and composite reference to the past. However, it should be recognized that the use of fractal dimension in describing street forms does not tell the whole story, and further work is required to develop its practical use as a tool to be employed alongside other recognized morphological techniques for assessing character.

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The waters of Rome

The waters of Rome is an occasional on-line publication of refereed articles investigating the history of water and its infrastructure in the city of Rome.

It is published by the project 'Aquae Urbis Romae: the waters of the city of Rome', based at the Institute for Advanced Technology in the Humanities, University of Virginia, USA. The project is an interactive cartographic history of the relationship between hydrology and hydraulics and their impact on the urban development of Rome from 753 BC to the present. *Aquae Urbis Romae* examines the intersection between natural hydrological features, including springs, rain, streams, marshes and the River Tiber, and hydraulic infrastructure elements, including aqueducts, fountains, sewers, bridges, conduits etc that together create a single integrated water infrastructure for the city. The

project director is Katherine W. Rinne.

The most recent publication by *The waters of Rome* is 'Restoring the ancient water supply system in Renaissance Rome: the Popes, the civic administration and the Acqua Vergine', by David Karmon (Department of Art History, Pennsylvania State University). It is available at: www.iath.virginia.edu/waters/article.html

Further submissions are invited. Papers that investigate water and water infrastructure within a social, cultural, technological or administrative context are particularly welcome. The language of publication is English; contributions in other languages are welcome if the author is also able to provide a publishable English translation. Prospective contributors should contact the project at:

www.iath.virginia.edu/waters/comment.html

Urban morphology at the Inaugural Nordic Geographers' Meeting, Lund, Sweden, 10-14 May 2005

The urban morphology sessions at the Inaugural Nordic Geographers' Meeting had their deserved success despite many late cancellations of expected speakers. A small kernel of ISUF members presented their recent work to a similar size group of interested people belonging to other geographical disciplines. A positive outcome was that time was not a problem and passionate

discussions took place on the main topics presented, allowing everyone to share their insights on the conceptual richness contained within morphological theory. Three major topics covered were: first, interpretation in Reykjavik of the concept of housing from the Caniggian tradition; secondly, the concept of *event* as a key to interdisciplinary morphological constructions

based on a process-oriented approach; and thirdly, the original theory of *townscape valuation cycles* from the industrial era applied to Leck and Stockholm.

The concept of housing in the evolution of Reykjavik, focusing on the contemporary urban landscape, was developed from the concept of leading type as described by Gianfranco Caniggia. A very interesting approach concerning the notion of leading type used as an analytical tool in understanding the evolution of the contemporary city was presented. This work showed that the distribution of new emerging leading types, created in different time periods, is the main reason for the urban landscape of Reykjavik appearing as a collage. The use of GIS techniques enabled a painstaking identification of the evolution of the urban landscape both in time and space and introduced a systematic depiction of the richness of contemporary cities and the difficulty of reading them as a continuous process.

The second paper discussed a theoretical approach to the morphological trio of form, scale and history, by introducing the concept of *event*. This notion is based on the understanding of the relationships between *physical objects* of the city and the sum of *transformation actions* recognized in history. This work uses the modern approach to history described as a process-oriented questioning, instead of the description of facts and places as *things* over a given period of time. It seeks to answer relevant questions about interdisciplinary constructions that were left unanswered by M.R.G. Conzen. In what ways can fields such as archaeology, history, architecture, planning and sociology enrich urban morphology? And in what

ways can urban morphology enrich these fields?

Finally, in a heuristic approach, the model of a *valuation cycle theory* was described and tested in the analysis of industrial townscapes. Case studies of the Altstadt in Leck and Gamla Stan in Stockholm were concerned with assessment of the pre-industrial townscape of these urban cores and allowed the identification of almost two synchronic cycles in these cities since the beginning of the industrial era. An interesting question was posed concerning a possible third cycle that is gradually taking place. As a corollary, tradition viewed in terms of conservation of heritage prompts the use of historical and morphological knowledge in order to define a new development cycle for these cities. The adaptation of this kind of historical design in many places even outside historical districts may lead to a pseudo-historical townscape. Thus, the simulation of history not only presents a contradiction to historical originality, but may also be the reason for turning away from history as a result of mistreatment of former rules of composition.

For those who could not attend this first Nordic Geographers' Meeting, set in the charming yellow and blue landscapes of southern Sweden, it is hoped that the themes discussed in this brief report highlight the enthusiasm for the morphological, philosophical and historical dialectics of city shapes that the participants encountered there.

Eduardo Camacho-Hübner, Laboratoire de systèmes d'information géographique, Ecole Polytechnique Fédérale de Lausanne, 1015 Lausanne, Switzerland. E-mail: Eduardo.camacho-huebner@epfl.ch

Planning Perspectives

The July 2005 issue of the journal *Planning Perspectives* contains papers of considerable interest to urban morphologists. Liora Bigon writes on 'Sanitation and street layout in early colonial Lagos: British and indigenous conceptions, 1851-1900', exploring the contrast between colonial control and the reality of the 'considerable freedom of expression' afforded to Lagos at this period.

Elizabeth Darling studies Elizabeth Denby (1894-1965), a UK housing expert, in 'The star of the profession she invented for herself: a brief biography of Elizabeth Denby, housing consultant'. Denby was particularly influential in the inter-war period, and her concerns included housing design

and layout, and the facilities provided.

Thomas Hall and Sonja Vidén write about 'The Million Homes Programme: a review of the great Swedish planning project'. Sweden suffered a post-war housing shortage, and this massive programme (1965-74) attempted to remedy this. The authors examine the planning, design, and subsequent fate of these housing blocks.

Stephen Ward reviews 'Consortium Developments Ltd and the failure of 'new country towns' in Mrs Thatcher's Britain'. He explains the politics behind the failure of the company's private development proposals despite the dominant Thatcherite ideology.