Sustaining streetscape character: assessing the visual qualities of a dwellings style

Chris Tucker[1] and Michael J. Ostwald[1]

[1]University of Newcastle, School of Architecture & Built Environment, Newcastle, Australia

ABSTRACT: The visual amenity of streets within a city plays an important role in creating a sense of place and community for its citizens (Lynch 1960). Whether this amenity can be sustained or modified to provide a more sustainable urban pattern when undergoing change is the principle concern of a streetscape analysis conducted during the planning approval process (DIPNR 2004). While the geometric qualities of a development such as height, volume and thermal load might be accurately assessed, the visual effect of a development in relation to its context often relies on the subjective qualities of style and character (HullIV 1993). This paper outlines an interdisciplinary approach, utilising architectural knowledge and computer image segmentation, to compare the visual qualities of traditional and suburban dwellings. The study suggests that a contextual fit between dwellings of different styles might be possible where they share particular visual characteristics.

Conference theme: Digital
Keywords: Streetscape, visual analysis, architectural style

INTRODUCTION

The visual amenity of streets within a city plays an important role in creating a sense of place and community for its citizens (Lynch 1960). Whether this amenity can be sustained or modified to provide a more sustainable urban pattern when undergoing change is the principle concern of a streetscape analysis conducted during the planning approval process (DIPNR 2004). This visual analysis is regulated by a range of State Environmental Planning Policies (SEPPs), Development Control Plans (DCPs) and Local Environment Plans (LEPs) and failure to meet these requirements can result in lengthy and expensive design modifications, and sometimes appeals against rulings in the Land and Environment Courts.

Utilising architectural knowledge and computer imaging, a software program has been developed to compare the visual qualities of traditional and modern dwellings. The intention for developing such software is to provide those involved in the planning process with a visual measure that is comparable across a variety of urban conditions and geographic regions. Specifically the software provides a measure of the form and complexity of the vertical surface of the façade such that it might be used in concert with more established planar methods of urban analysis, including space syntax (Hillier 1996). The use of emerging computer visualisation within a field dominated by subjective and manually laboured techniques provides an objective visual basis for planning decisions made within the streetscape.

Stylistic elements, textures and other features at a fine scale are considered in the same way that more formal elements such as doors and windows are considered at a larger scale. When the urban façade of a dwelling is studied as a composition of elements at different scales, the built form might be considered as a textured surface defining the open space of the street (Hildebrand 1999). This surface that dominates the visual field may play a critical role in the way that abstract information is retrieved from the city, as discussed by Hillier and Hanson (Hillier 1984) as description retrieval. Visual correlations occurring between dwellings can inform how a proposed dwelling might 'fit' within a given context even though it might be of a different style to other dwellings within the street.

1 VISUAL COMPLEXITY WITHIN THE STREETSCAPE

Various scholars have independently concluded that the amount of perceived complexity within a dwellings facade is an important variable that determines whether or not a person might find it appealing (Berlyne 1974; Rapoport 1990; Imamoglu 2000; Stamps III 2003). The perceived number of elements within the facade, and particularly the "noticeable differences" (Rapoport 1990) or boundaries between them, provides a measure of visual complexity. Visual complexity relates to the rate at which usable information is made available to the viewer, or by the rate of change of the noticeable differences (Rapoport 1990). The way that the differences are gradually revealed determines the extent to which the surface of a space might feel monotonous, surprising or familiar.

Stamps states that while empirical work on architectural detail is sparse, it tends to support the hypothesis that "detail is an important part of preferences for buildings" (Stamps III 1999). Salingaros reflects that ornamentation "connects us to our environment" (Salingaros 2003b) and that successful buildings facades within an urban space feature a "continuous swath of high-density visual structure that the eye can follow in traversing their overall form, or focal points of intense detail and contrast arranged in the middle or at the corners of regions" (Salingaros 2003b). He has shown that ornament and decoration "subdivide building façades on many different scales" and that the most effective hierarchical scaling creates a fractal geometry (Moughtin 1999; Salingaros 1999b) which is independent of any associated scale. Hildebrand offers an interesting reflection on this when he maintains that successful architecture results from an abstract drive to impose patterns on surfaces that otherwise appear to be random acts of inhabitation (Hildebrand 1999). These patterns are then the physical attributes of buildings that help to identify visual regions of interest may make them appealing to us (Schira 2003). Capturing and analysing the texture of the vertical surfaces of the urban environment might then provide valuable information about how cities are inhabited. While the lack of computing power may have limited studies in the past, there are a number of current research projects that are using sophisticated methods to model the urban surface, and its form with a high degree of accuracy.

Other researchers comment that the elements within buildings of roughly the same size "couple strongly to become an element of the next-higher order in size", single elements then have a role in linking elements together to form elements of a larger scale (Salingaros 2000a). Jacobs (Jacobs 1961:p234) similarly points out that diversity in urban uses can become a problem when the size of elements is of a disproportionate size. For a harmonious or contextual fit a building should have regions bounded by edges within a "hierarchy of scales" with the same "definition and connections as the building's internal subdivisions" (Salingaros 1998). Salingaros (Salingaros 1999b) states that the buildings façade, pavement surfaces and other urban features such as trees and furniture can generate these regions. It is then the perception of these elements in terms of the organisation of form and the differentiations within the surface generates the "information field, which in turn determines the use of urban space" (Salingaros 1999b).

2 METHODS FOR ASSESSING VISUAL COMPLEXITY

Oku and Cooper have separately attempted to determine the fractal dimension (a measure of complexity across multiple scales) or character of streetscapes (Oku 1990; Cooper 2003). Salingaros and Crompton have discussed the question of the significance of detail at different scales within building facades and the success of associated urban spaces (Salingaros 2000a; Crompton 2001). While Stamps (Stamps III 1999) used a theory of visual septaves (detail that occurs at a seventh of the façade size) to show that decoration and trim within a façade were desirable attributes.

Another related technique places regular grids over images of building facades, either to recognise and count the boundaries between surfaces (Bovill 1996), or to allocate a value to a particular surface type and form a sequence (Krampen 1979). Generating this for the whole façade, both methods provide a measure of how boundaries might change throughout the image.

An alternative method uses the human eye to separate a residential facade into formal elements and groups of elements. The frequency of the elements can then be considered as a measure of visual diversity (Stamps III 1999; Malhis 2003; Stamps III 2003). In other studies dwellings were analysed using three scales of decomposition; overall massing, secondary massing, and differentiation of elements such as doorways and windows (Elsheshtawy 1997). Malhis and Elsheshtawy both similarly attempted to segment the residential facade into meaningful elements in order to provide an objective measure of their visual character. However all methods tend to rely on time-consuming, skilled, manual techniques throughout the segmentation process; a practical as well as s possible methodological problem.

2.1 Computer visualisation of the urban environment

Researchers have recently begun to consider and evaluate the volume and surfaces of urban space. Fisher-Gewirtzman and Teller considered a three dimensional viewpoint and the volume of visible space as a measure of spatial openness (Fisher-Gewirtzman 2003b). Fisher-Gewirtzman reflects however that considerable computational power is required to complete the calculations for an abstract 3D model of an urban area. The data they use for their studies is then restricted and diagrammatic, containing little of the detail we actually associate with a view of a street. Techniques using 2D laser scanners, digital photography and software processing is presently showing the most promise, with the surface of actual urban streets being accurately mapped (Frueh 2005). These methods however are being developed within computer visualisation and without any application to an analysis of the built environment.

2.2 The isovist

An analytical method derived from space syntax is the concept of an isovist; a set of points visible from another point in space (Batty 2001a). Fundamental to the operational use of the isovist is the belief that a person's perception of moving through an urban area is related to the shape of the associated open space and its geographic setting. While these techniques have shown to predict the movement of people within urban spaces (Carvalho 2004), the isovist analytical technique is largely restricted to planar arrangements (analysis of the plan of an urban area only) with no consideration of the elevational surface texture of that urban space (what you actually see). The concept of a façade isovist (Hillier 1996) which describes the planar area of urban space that a façade is visible from appears to be a measure which would be enhanced by an evaluation of the facade itself.

2.3 The use of a dwellings style within the planning process

An architectural style is a set of visual characteristics that a group of buildings might share (Apperly 1994:p16). These characteristics include the 'relationship of the parts of the building to each other and to the building as a whole', the use ornament and visible textures, and the scale of elements within the composition.

A requirement for the approval of a new dwelling within an existing streetscape is to define the existing character of the street (usually regulated through the DCP). This analysis typically involves the description of the different building styles and constitutive elements adjacent to the site, within the street and sometimes the locality. These streetscape elements are valued for a range of reasons including their ability to differentiate one place from another, define boundaries between spaces or help create a strong image of a particular area (Hull IV 1993). Whether the proposed dwelling enhances or reinforces the existing streetscape character will often relate to whether the dwelling is of a similar style, with replication of an existing style considered an acceptable and often desirable planning solution (Alexander 2003). However this raises significant issues, particularly in localities where the dominant character is generated from an older or traditional building stock. While there is often pressure on planning authorities to sustain the existing character of these places (Craglia 2004), contemporary building and design practices, and contemporary lifestyles require a different type of dwelling than those constructed fifty or so years ago. When a new building is proposed within a traditional streetscape, the planning issue becomes:

1. How to retain the visual character of the streetscape whilst using the forms and construction practices of a contemporary dwelling. For example a brick veneer house with a (double) garage facing the street is the most common type of new dwelling, however traditional dwellings rarely have these characteristics.
2. What are the significant visual qualities of traditional and contemporary dwellings, and how do these contribute to a dwellings style.

One of the methodological qualities of computer visualisation that makes it so useful for a comparative analysis is that the representational and symbolic meanings of a buildings style play no part. The organisation of the elements can be analysed without having to interpret their possible meaning at the beginning of the process.

3 A VISUAL STUDY OF RESIDENTIAL FACADES USING SCAPE

Digital images of dwellings considered as being the same architectural style were collected in groups. This database of images was then analysed using the developed software, named scape, to find where visual correlations might be found.
The software uses image segmentation and the Hough Transform to establish the visual boundaries within an image. By considering the geometry within the entire image, images are processed to differentiate and segment them based on the edges formed by colour, texture and intensity levels (Boldt 1989; Gonzalez 1992; Tucker 2004; Yang 2004). The histogram produced provides the number of boundaries of a specific pixel length within the image. A pixel within the image can then be given a size, allowing the length of a boundary to be expressed as a metric dimension; for example in the 640 x 480 pixel image shown in Figure 6 a single pixel is around 20mm in length. This scaling process also allows images of dwellings of different sizes to be compared with each other. The metric length of a boundary is then multiplied by the number of boundaries of that length found within the image, providing the total length of all boundaries a given length. This information is then displayed as a line graph, examples of which are shown in Figures 1, 2, 6, 9, 10, 11, 16, 17, 18, 19, 24 & 25. The use of the Hough Transform provides a longer boundary length to be formed from discontinuous boundaries within the image, for example the head of a door lining up with the head of a window will be graphed as a boundary of the cumulative length (Tucker 2005).

3.1 Modern terrace houses

If stylistically similar facades are processed and displayed on the same graph, similarities can be seen between the graphs. Figure 1 shows the scape analysis of a modern terrace house, the boundary lengths found within the image are graphed with those 400mm in length on left hand side and those up to 3200mm in length on the right hand side. The boundary length appears to diminish at a constant rate until around 1200mm where it flattens out. This general graph shape is also found in the analysis of the images shown in Figures 4 & 5, a characteristic clearly shown in Figure 2 that shows these graphs overlaid. The three dwellings are essentially the same design, sharing the same style and form, only some details and the extent of furniture and vegetation separate the images. It is the presence of these differences that produces the differences in the marked peaks and troughs within the graph. For example in Figure 2 at a length of around 1300mm one image produces a trough while another produces a peak. The troughs and peaks become pronounced when the boundary length increases to a dimension equivalent to the size of the formal elements within the façade, such as doors and windows. The fewer number of boundaries at these dimensions also exaggerates the differences between them. The relative location of peaks and troughs within the graph appears to be a significant feature of theses graphs and others, however at this stage of the study the importance of this in terms of the visual character of the dwelling has not been evaluated.

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Figure 1: Scape analysis of Figure3

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Figure 2: Scape analysis of Figure3, 4 & 5

Figure 3

Figure 4

Figure 5

Figure 6

Figure 7

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Figure 8: Scape analysis of Figures 6 & 7

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Figure 9: Scape analysis of Figures 3, 4, 5, 6 & 7

The analysis of the images shown in Figure 6 & 7 are shown in Figure 8. Again, for dwellings of essentially the same design the graphs show a similar shape. When the analysis of all five dwellings are overlaid (Figure9) it can be seen that the graphs of Figures 6 & 7 (Figure 8) are similar to the graphs of Figure3, 4 & 5 (Figure 2). However compared with Figure 9, Figure 8 contains more boundaries up to around 2000mm in length, a characteristic that represents the inclusion of a masonry element in these dwellings.

3.2 Traditional dwellings

The analysis of traditional dwellings that are of the same style but have a different design (changes in the form and detail) are shown below. Figure 10 shows that most boundaries are less that 2000mm in length, a characteristic of the Federation style where exterior forms are trimmed with detailed features. Figure 11 shows the comparison between Figures 12 & 13, and is interesting because the presence of the tree at the front of Figure 12 is seen to have little effect on the graph shape. This is because the huge boundary lengths created by the tree are relatively small (not shown in the graph) and the structural detail within the dwelling is still 'seen' through the tree. Figures 14 and 15 show Federation dwellings with more pronounced detailing, particularly around the entry and deck spaces. Their graphs shown in Figures 16 & 17 are of a similar shape but the peaks and troughs are the most pronounced of those shown so far. The graph is not as 'smooth' as those produced by modern buildings (for example Figure 2), whose surfaces typically lack detail and features. This architectural quality of the urban environment has been discussed by a number of researchers including Salingaros (Salingaros 1999b), Alexander (Alexander 1977) and Bovill (Bovill 1996), whose studies however were not able to use image segmentation to graph this visual characteristic in an objective and automated way.

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Figure 10: Scape analysis of Figure 12

Figure 11: Scape analysis of Figures 12 & 13

Figure 12

Figure 13

Figure 14

Figure 15

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Figure 16: Scape analysis of Figures 12, 13 & 14

Figure 17: Scape analysis of Figures 12, 13, 14 & 15

3.3 A comparison between traditional and modern dwellings

The analytical differences between dwellings of different styles are shown in the graphs below. Figure 19 shows the comparison between a modern terrace house and a Federation dwelling. Between the boundary lengths of 400mm and 3000mm, the total number of boundaries within the Federation dwelling is significantly more and more evenly spread over those lengths, a visual quality of traditional buildings discussed by Salingaros (Salingaros 1999b). Figure 24 includes the graph of a modern terrace with little surface detail, a characteristic of the dwelling that is shown in the graph up to a boundary length of 1000mm. Figure 25 includes the graph of a dwelling previously discussed (Figure 6), its boundary length distribution is more closely related to Figure 21 however formal and detail differences still differentiate the graphs.

QuickTime™ and a TIFF (Uncompressed) decompressor are needed to see this picture.

Figure 18: Scape analysis of Figure 20

QuickTime™ and a TIFF (Uncompressed) decompressor are needed to see this picture.

Figure 19: Scape analysis of Figure 21 (Figure 20 grey)

Figure 20

Figure 21

Figure 22

Figure 23

QuickTime™ and a TIFF (Uncompressed) decompressor are needed to see this picture.

Figure 24: Scape analysis of Figure 22 (others grey)

QuickTime™ and a TIFF (Uncompressed) decompressor are needed to see this picture.

Figure 25: Scape analysis of Figure 23 (others grey)

The study still has many more buildings to analyse and the software will continue to be developed to encompass other characteristics of the building façade such as colour, shadow and relative location of boundary lengths. The results presented in this paper however do show that the application of image processing techniques to interpret the visual characteristics of a buildings façade might reveal a useful visual structure.

4 DISCUSSION

Techniques for connecting the visual urban texture at the scale of the individual with the urban character of street patterns, building heights and opens spaces within the city, are difficult to find (Ratti 2004). However the use of computer visualisation in conjunction with other established methods, including traditional streetscape analysis and space syntax theory, could offer better models for the prediction of visual amenity within urban areas. Of particular interest is whether a contextual fit between dwellings of different styles is possible, given that they might share particular visual characteristics. From an architectural perspective, software correctly calibrated and authenticated through expert judgment that provided this type of analysis, would be very useful. The proposed introduction of a contemporary building within a traditional streetscape might then be shown to be visually appropriate, and removing a reliance of planners to use the style of a dwelling alone to determine its visual appropriateness (streetscape character).

Visibility analysis is a seemingly attractive way to understand urban spaces as it appears to allow “mathematical certainty to the experience of urban and building environments” (Turner 2003). However by concentrating on visual relationships rather than an “interpretation of direct perception” (Turner 2003) the analysis will always require a level of interpretation based on how the information has been collected and how it will be used. Different cultural, and social backgrounds will necessarily interpret visual information differently (Turner 2003). However one of the qualities visibility analysis that makes it so useful for a comparative analysis is that the representational and symbolic meanings of a buildings style play no part. The organisation of the elements can be analysed without having to interpret them at the beginning of the process. This is not to say that representational meanings are not important to the visual character of a dwelling, but that both methods might work in parallel to provide a more thorough study of the urban environment.

5 REFERENCES

Alexander, C., Ishikawa, S., Silverstein, M., Jacobson, M., Fiksdahl-King, I., Angel, S. (1977). *A pattern language: towns, buildings, construction*. New York, Oxford University Press.

Alexander, N., Stark, P. (2003). *Neighbourhood Characters - Multi- or Mono-Cultural. Planning with Diversity*: Adelaide 2003, Adelaide.

Apperly, R., Irving, R., Reynolds, P. (1994). *A pictorial guide to identifying Australian architecture: styles and terms from 1788 to the present*. Pymble, NSW, Angus & Robertson.

Batty, M. (2001a). "*Exploring isovist fields: space and shape in architectural and urban morphology*." Environment and Planning B, Planning and Design 28(1): 123-150.

Berlyne, D. (1974). *Studies in the New Experimental Aesthetics*. New York, Wiley.

Boldt, M., Weiss, R., Riseman, E. (1989). "*Token Based Extraction of Straight Lines*." IEEE Transactions on Systems. Man. and Cybernetics 19(6).

Bovill, C. G., A.E. Wiedemann, G. (1996). *Fractal geometry in architecture and design*. Boston, Birkhauser.

Carvalho, R., Batty, M. (2004). *Automatic Extraction of Hierarchical Urban Networks: A Micro-Spatial Approach*. Computational Science - ICCS 2004: 4th International Conference, Krakow, Poland, Springer-Verlag Heidelberg.

Cooper, J. (2003). "*Fractal assessment of street-level skylines: a possible means of assessing and comparing character*." Urban Morphology: Journal of the international seminar on urban form 7(2): 73-82.

Craglia, M., Leontidou, L., Nuvolati, G., Schweikart, J. (2004). "*Towards the development of quality of life indicators in the 'digital' city*." Environment and Planning B, Planning and Design 31: 51-64.

Crompton, A. (2001). "*The fractal nature of the everyday environment*." Environment and Planning B, Planning and Design 28(2): 243-254.

Elsheshtawy, Y. (1997). "*Urban complexity: toward the measurement of the physical complexity of street-scapes*." Journal of Architectural and Planning Research 14(4): 301-316.

Fisher-Gewirtzman, D., Wagner, I. (2003b). "*Spatial openess as a practical metric for evaluating built up environmnts*." Environment and Planning B, Planning and Design 20: 37-49.

Gonzalez, R., Woods, R. (1992). *Digital Image Processing*. Reading, Mass, Addison-Wesley.

Hildebrand, G. (1999). *Origins of Architectural Pleasure*. Berkeley CA, University of California Press.

Hillier, B. (1996). S*pace is the Machine*. Cambridge, Press Syndicate of the University of Cambridge.

Hillier, B., Hanson, J. (1984). *The social logic of space*. Cambridge, NY, Cambridge University Press.

Hull IV, R., Lam, M., Vigo, G. (1993). "*Place identity: symbols of self in the urban fabric*." Landscape and Urban Planning 28: 109-120.

Imamoglu, C. (2000). "*Complexity, Liking and Familiarity: Architecture and Non Architecture Turkish Students' assessments of Traditional and Modern House Facades*." Journal of Environmntal Psychology 20: 5-16.

Jacobs, J. (1961). *The death and Life of Great American Cities*.

Krampen, M. (1979). *Meaning in the Urban Environment*. London, Pion.

Malhis, S. (2003). *The multiplicity of built form manifestations: Situating the domestic form within interwoven syntactic and semiotic domains*. 4th International Space Syntax Symposium, London.

Moughtin, C., Taner, O., Tiesdell, S. (1999). *Urban Design: Ornament and Decoration*. Oxford, Architectural Press.

Oku, T. (1990). "*On visual complexity on the urban skyline*." Journal of Planning, Architecture and Environmental Engineering(412): 61-71.

Rapoport, A. (1990). *History and Precedent in Environmental Design*. New York, Plenum Press.

Ratti, C., Richens, P. (2004). "*Raster analysis of urban form*." Environment and Planning B, Planning and Design 31: 297-309.
Salingaros, N. (1998). "*A scientific basis for creating architectural forms*." Journal of Architectural and Planning Research 15: 283-293.
Salingaros, N. (1999b). "*Urban space and its information field*." Journal of Urban Design 4: 29-49.
Salingaros, N. (2000a). "*Complexity and Urban Coherence*." Journal of Urban Design 5: 291-316.
Salingaros, N. (2003b). "*The sensory value of ornament.*" Communication and Cognition 36.
Schira, G. (2003). "*Texture preference and global frequency magnitudes*." Environment and Planning B, Planning and Design 30: 297-318.
Stamps III, A. (1999). "*Architectural detail, Van der Laan septaves and pixel counts*." Design Studies 20: 83-97.
Stamps III, A. (2003). "*Advances in visual diversity and entropy*." Environment and Planning B, Planning and Design 2003 30: 449-463.
Tucker, C., Ostwald, M., Chalup, S. (2004). *A method for the visual analysis of streetscape character using digital imaging processing*. Proceedings of the 38th Annual Conference of the Architectural Science Association ANZAScA and the International Building Performance Simulation Association, Launceston, Tasmania, UTAS.
Tucker, C., Ostwald, M., Chalup, S., Marshall, J. (2005). *A method for the visual analysis of the streetscape*. Space Syntax 5th International Symposium, Delft, Netherlands, Delft University of Technology.
Turner, A. (2003). "*Analysing the visual dynamics of spatial morphology*." Environment and Planning B, Planning and Design 2003 30: 657-676.
Yang, G., Gillies, D. (2004). *Perceptual Grouping*. London, Department of Computing, Imperial College.