Sustaining residential social space: a visual and spatial analysis of the nearly urban

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ABSTRACT: Residential development within heritage conservation areas is regulated by Development Control Plans (DCP), which provide guidelines about the shape and form that new houses, alterations and additions should take (DIPNR 2004). By understanding that 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) they attempt to sustain, through regulation, an urban pattern that has become valued by the community.

This paper, being the third in a series of papers delivered at Anzasca conferences, will build on an established interdisciplinary approach, utilising architectural knowledge and computer imaging to evaluate the visual character of detached housing within a heritage conservation area. The visual environment is assessed using computer software developed to locate the visual boundaries within a view or elevation. Aerial views of the streets and houses are also analysed using the established image segmentation methods, extending the spatial assessment of a streetscape beyond the purely visual information derived from walking through it.

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

INTRODUCTION

How new buildings relate to existing urban settings has become an important point of debate in architectural, planning and public policy forums (Groat 1988). In difference to new buildings within the natural landscape, or those that are visually removed from the public space of the street, buildings that infill urban and suburban streets visually relate to nearby buildings and become part of the existing streetscape. In a legislative or policy sense the definition of streetscape, as described in the Environmental Planning and Assessment Act is: the character of a locality defined by the "spatial arrangement and visual appearance of built and landscape features when viewed from the street" (Env. Planning Act 1979). For parties in dispute over the effect of proposed building works within a streetscape, this definition becomes a critical and potentially costly factor (VicD.I. 2001; DIPNR 2004). Such policies and practices signal the importance of determining some measure or dimension that could be used for describing or defining the visual character of a streetscape. Only by defining these processes more clearly can creative solutions be found for new buildings in areas with a well-established street character (RAIA 2004).

1. VISUAL CHARACTER OF THE STREETSCAPE

1.1. Qualitative measures

While planning diagrams concentrate on the functional and formal requirements of the built landscape, little attention is given to obtaining information about the visual character of the urban environment. Aside from issues purely concerned with visual character, knowing the shape and materials of the built environment might inform urban sustainability issues such as space and energy consumption. Fisher-Gewirtzman, Burt and Tzamir (Fisher-Gewirtzman 2003a) adds that "quantitative parameters" such as: the penetration of natural light, wind intensity and density measurements, need to be related to other physical and psychological "qualitative parameters" such as texture, privacy, colour, and nostalgia. Quantitative measures such as the height of a proposed building and other density measures can be determined quickly and accurately. However, measuring the qualitative aspects of the built environment, such as visual character, are open to the interpretation of the individual. Because they are difficult to measure they can be overlooked, resulting in changes that disassociate residents from their "place based communities" (Hull IV 1993). In cases where the character of a street or locality requires improvement, the challenge is to identify the physical attributes of the preferred character while developing the broader infrastructure and amenity within the locality (Townsend 2001).

1.2. Analysing visual character

Establishing the existing visual character of a streetscape involves a two-step process. The first might be considered as a visual reading of the elements within the streetscape, a process that by its description might allow an objective analysis and a measurable outcome. The second stage involves a decision about the importance of the patterns of

elements in relation to others (VicD.I. 2001; Alexander 2003; DIPNR 2004). This second stage of the process may remain a subjective analysis; the emphasis that each local government authority places on the importance of visual character will change, as will the meanings that each individual takes from a given scene. However, for buildings to be approved, planning authorities must assess these qualitative aspects of existing urban areas such that decisions can be made about proposed changes. It is this first stage that our research is concerned with, and in particular how the visual properties of a streetscape might be interpreted without first having to interpret its 'style'.

When new buildings are proposed in heritage conservation areas, development is regulated by Development Control Plans (DCP) that provide guidelines about the shape and form that new houses, alterations and additions should take (DIPNR 2004). By understanding that 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) they attempt to sustain, through regulation, an urban pattern that has become valued by the community. This paper will build on an established interdisciplinary approach utilising architectural knowledge and computer imaging to evaluate the success of regulation in sustaining the visual character of detached housing within a heritage conservation area.

1.3. Representing the visual surfaces of urban areas within computer models

Planning authorities use maps of land-use and density, studies of traffic movement, landscape details, topography, and other physical characteristics of the urban environment to understand the impact of a new development (Batty 2000a). Computer models have been implemented within the planning process to provide flexibility in the way that proposed buildings might be visualised, and alternatives be compared (Dodge 1998). Some models are essentially a visual interface for complex and interrelated social and regulatory data, and are not intended to depict a visual reality (Batty 2001b). They use the visual interface of the city map to manage the complexity and more quickly establish trends and patterns within the data. Torrens (Torrens 2000) believes however that there is a need to develop realistic three dimensional models of spatial complexity that begin to represent the surfaces of urban space. Models of this type would then allow the visual qualities of streetscapes to be reasonably represented. Models that represent buildings as prismatic shapes with little or no surface characteristics may be useful at the scale of the city, but convey little information about how it might actually feel to walk down a street (Bishop 2003). While some recent software, such as Canoma and Photomodeler, can take advantage of the regular shape of urban structures and construct 3D models from just a few images, the use of aerial photographs of the same scene taken from different positions has been the main source of data for 3D models (Batty 2000a). An aerial photograph of a building presents the surface of the elevation as a near vertical surface, with roof overhangs and similar structures sometimes preventing accurate information being obtained at all (Batty 2000b). The draping of prismatic forms derived from aerial photography with textures generated from ground based images can represent complex façade details quickly, and can overcome some of the problems with purely aerial based representation. Using complex processing techniques to locate matching points in space, common building forms can be accurately represented; those that are more unique are still difficult to accurately represent using these techniques. While the photographic coverage of the urban terrain is increasing, information about the elevation of surfaces in urban space lacks sufficient content or resolution to allow a detailed visual analysis (Bishop 2003). Automated and sophisticated laser mapping techniques, discussed by Freuh, Jain, and Zakhor, (Frueh 2005) for example, will eventually provide detailed information about the existing visual character of streets. Although how this information might be used for the analysis of visual character is the primary concern of this research project.

1.4. Surfaces of the streetscape

Urban open spaces are usually defined by the volume of empty space separated by the built surfaces. Teller (Teller 2003) reflects on this stating that the form of a space is characterised by the relationship of "filled elements" that are within it. Salingaros (Salingaros 1999b) similarly states that it is the information within the surrounding surfaces of the open space that is perceived, and is of greater importance than an analysis of a plan that is not perceived at all. While Hillier (Hillier 1984:p1) rejects this based on a building's purpose, which he states is to transform space. The importance of visual perception to inform a building's purpose has been discussed by Lynch (1960:p4) and Venturi (1966:p19 in some detail. Differentiations in the surface of the open space caused by colour, texture and ornamentation are considered significant subdivisions within the surface of the streetscape even when their effect on its form may be minimal (Moughtin 1999; Salingaros 1999b). Surfaces of the open space that are orientated perpendicular to movement create a local spatial boundary (Salingaros 1999b); a spatial type that Alexander calls "positive space", which is a fundamental property of coherent urban spaces. Theil, Harrison and Alden (Theil 1986) state that the visual boundaries within the surface of a space define its degree of enclosure in a more significant way than simply determining how large it is. Research undertaken by Al-Homoud, and Natheer (2000) supports this by finding that vertical objects 'determine our perception of spatial enclosures' more than horizontal elements within urban spaces do.

1.5. Texture of the streetscape

Texture is a property of all surfaces and is one of the characteristics used to identify visual regions bound by edges within an object. Depending on the scale of the visual information, both symmetry and simplicity can be accounted for in terms of analysis of texture (Schira 2003). It can be described as the 'structural arrangement of a surface and the relationship that one arrangement has with others surrounding it' (Schira 2003).

So does replicating a Federation house within a streetscape dominated by federation houses provide a satisfactory outcome for the visual character of the street? This is a debate with wide ranging views, but from a planning perspective, replication of an existing style is considered an acceptable and often desirable solution (Alexander 2003). Architects might disagree with the premise of this planning solution (RAIA 2004), but to satisfy the

requirements of the planning process, the visual qualities of contemporary buildings must be understood, and they must be understood in relation to the existing visual context.

Craglia, Leontidou, Nuvolati and Schweikart (Craglia 2004) reflect on the "reinvention of tradition as one of the strategies to enhance visibility" based on the market driven by the "urban tourist", as opposed to the more traditional resident. These sometimes conflicting requirement of the city have drawn a distinction between the modernist tendency to regulate space based on zoning to a post-modern approach where "fragmentation, urban mosaics and the colourfulness of cultural difference" (Craglia 2004) are encouraged. Craglia et al. point out that this "recognition of differences has resulted in a cultural shift in urban studies with the city analysed as a work of art, a representation, and a text, that take different meanings for the various actors in it'. Urban planning ideas originally proposed by Sitte (1945), Lynch (1960), Jacobs (1961) and Alexander et al. (1977) are now being discussed from a commercial point of view (Craglia 2004).

However, Hildebrand (Hildebrand 1999) offers a reflection on this; he maintains that successful architecture results from an abstract drive to impose patterns on surfaces, that otherwise appear to be random acts of inhabitation. These patterns are the physical attributes of buildings, and help to identify visual regions of interest, that subsequently make them appealing or not (Schira 2003). Salingaros (Salingaros 1999b) comments that contemporary building materials and methods used to replicate traditional façade styles might 'minimize the information field' and subsequently not provide the visual field associated with the traditional building. This is an important issue and expands the discussion of streetscape character beyond purely the formal attributes of buildings.

1.6. The significance of detail within the façade of buildings

Many researchers have shown that the character of a building often depends on the detail within its façade (Stamps III 1999). For instance, Brolin (Brolin 2000) suggests that the visual texture 'composed primarily of small scale details' is the most critical factor to consider when locating a new building within an existing built context. Methods used in architecture to determine scale within a building include massing, where the largest scale is usually defined by an outline of the building itself (Salingaros 2000b). Elements within the façade such as openings, detail, trim and the material itself will then successively identify smaller scales.

Symmetry is a condition of massing and is manifested through the recurrence of shapes in a regular way, and can help connect elements forming a single element at a greater scale (Salingaros 2000b). Once formed, this arrangement can be thought of as modular, repeated through the 'economy of thought and action' (Salingaros 2001)
Bentley (Bentley 1987) suggests that 'richness' can be created through details within the walls that incorporate patterns of material and colour. Moughtin et al. (Moughtin 1999:p25) suggests that decoration, ornamentation and articulation within a building's façade is the 'means by which a variety of visual experiences are introduced to the viewer'. Hull et al. ((Hull IV 1993) found that decorative style or other distinguishing physical characteristics were highly valued by the residents of houses, and were perhaps highly valued because they distinguished one place from another.

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 (2003b) reflects that ornamentation 'connects us to our environment'. Also, that successful building 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.

The location of larger details within the façade such as doors and windows are important elements within the urban fabric as they offer the opportunity for natural surveillance of the urban space, reducing the likelihood of crime (Newman 1972:p80). Whether actual surveillance takes place may be difficult to determine, but the capacity for buildings to provide the opportunity is an important aspect of 'natural surveillance' (Newman 1972).

1.7. Streetscape as text

Venturi, Scott Brown, and Izenour (Venturi 1977) argued for the 'symbolism of the ugly and ordinary in architecture… for the decorated shed with a rhetorical front and conventional behind'. Harries (Harries 1997) reflects on this suggesting that this is not so much a demand for decoration but 'a refusal of what is experienced as the muteness of modern architecture, with a longing for architecture as text, for buildings carrying messages that can be read in some sense…". The 'text' in this sense is not something that is fixed to the external surface of a building, but is essentially carried by its form (Harries 1997). Boyd (Boyd 1968) criticised the addition of 'features' to a suburban house as a concealment of its basic structure, however as Fiske (Fiske 1987) points out it may be that "the 'features' typically express a critique of dominant structures and dominant meanings". Reflecting on this, and considering the social relationship a house has with the street, perhaps the most appropriate 'feature' for critique becomes the deeply covered entry space typically found at the front of a 'bungalow' cottage (Purser 2003). Its openness to the street, allows 'introductions to be made and visitors… received in an informal manner without the obligation to introduce the visitor into the house' (Drew 1992) i. From this space the owner can observe the public space of the street and, from the perspective of a passer-by, become part of the streetscape. It invites the public to share symbolic possession of the space through active or passive surveillance, however it remains privately controlled (Watson 1994). This relationship suggests that the owner of the house has some obligation to allow visual access for the public, and in

return, the owner has a right to view the public, and exert their influence over that common space (Fiske 1987). Talen (Talen 2005) states that this conversation at the level of the streetscape is important for social interaction and 'good urban form'.

1.8. Visual segmentation of the streetscape

Stamps (Stamps III 2003) developed an alternative parsing technique which involved the counting of defined elements within a building's façade. By sequencing elements such as a 'square window' within an abstract computer drawn streetscape, he was able to determine a value for the entropy of any given arrangement. He then used the image of the streetscape to derive human responses of desirability, and together with the calculation of visual diversity was able to link visual diversity with desirability.

Stamps (Stamps III 1999) used a theory of visual septaves originally developed by Van der Laan to determine how the number of elements within the façade change at regular scales of one seventh. This is based on the assumption that it is easier for the mind to comprehend groups of similarly sized elements than a group of elements with no shape similarity. This concept can be extended beyond an analysis of a single dwelling and incorporate nearby dwellings. For instance a new building within an existing streetscape may appear to more parts of the streetscape if the size of some of its elements match those of the existing context. Such a premise reinforces research conducted by Groat (1988), wherein twenty-five images of urban scenes were compiled that showed a variety of infill situations, ranging from those that appeared to reflect the immediate context, to those that were very different. Through an interview process that involved residents, and people directly involved in the planning process, she showed that design strategies that embodied a 'high degree of replication, especially in aspects of the façade design', (Groat 1988) were consistently preferred over other design strategies such as site organisation and massing. This is supported by other researchers (Moughtin 1999; Brolin 2000) who state that details within the façade are a critical part of contextual design. However, Groat's study also showed that designs that had some form of façade replication together with a strategy for site organisation and massing were the most preferred.

1.9. Visually assessing the character of a streetscape

Ellefsen (Ellefsen 1991) states that planning authorities have a need for specific and objective information about the character of urban buildings and their settings when they undertake studies of the local environment. Understanding that the visual characteristics of streetscapes effect social life within the street has been recognised as an important way of revitalizing urban areas that are socially dysfunctional (Healy 2004). However, methods that clearly articulate how the physical character or aesthetics of a streetscape might be evaluated and then compared with another are difficult to find. Lillis, and Pourmoradian (Lillis 2001) found that techniques currently used for streetscape analysis did not establish the basic information required by planning authorities and community groups for informed decision making about changes to the streetscape. They proposed a "toolkit" that relied on a checklist of commonly found elements within the streetscape. An individual would use the checklist to record the visual aspects of the street, but how this information would be used by a designer to develop a new design is difficult to understand. As Stamps (Stamps III 2003) reflects, those verbal and notated descriptions will eventually become 'physical materials in physical space'.

So while this information might enable the development of a database of elements within the streetscape, by not visually recording the information within the street (using photography); the database would retain a subjectivity based on the expertise of the assessor; while the checklist could never be so comprehensive to actually record the varied and intricate relationship between elements within the streetscape (Tucker Ostwald Chalup Marshall 2005). A photograph only records a two dimensional frame of a part of the streetscape, but it has the benefit of recording the complex relationships of visual elements in a detailed way (Tucker 2004). If this visual field is analysed using algorithms that segment the image in a way that identifies the visual boundaries within the image (Tucker Ostwald 2005), then the elements are recorded without having to first identify and catalogue them. Also whatever the visual qualities of the streetscape may be, they need to be considered as part of its visual complexity and must necessarily be recorded (Alexander 2003; DIPNR 2004). Without using photography it is difficult, cumbersome and intrusive to describe the visual nature of an element in sufficient detail for it to actually be useful. For instance the size of a window might be described in a statement, but its detail (as a unit and placement within the wall), its relation to other elements, material qualities and degree of weathering (which all effect the visual field) are best recorded using photography.

Visibility analysis supported by computer algorithms makes it useful for a comparative analysis because the representational and symbolic meanings attributed to a building play no part. The organisation of the elements can be analysed without having to interpret them at the beginning of the process, and any part of any streetscape can be assessed using the same processes. This is not to say that representational meanings are not important to the visual character of a streetscape, but that an interpretation of these elements might follow such a visual analysis. Venturi (Venturi 1966) and Rapoport (Rapoport 1990) refer to this complexity of meaning as a visual ambiguity, a juxtaposition of the physical reality of an image and what it 'appears' to be. The associational qualities that may exist within an element, and their relation to each other, reveal the multiplicity of meanings that can be elicited from a streetscape. Rapoport however argues that analysing the patterns that elements form within a streetscape—as opposed to attempting to understand the meaning that they might have for different individuals—can provide a more useful and sustained analysis (Rapoport 1990).

2. DISCUSSION

2.1. Assessing the visual properties of streetscape images

Computer software has been developed that utilises architectural knowledge and computer imaging to analyse images of the streetscape. The images and description below shows the different ways that the image is analysed to reveal some of its visual properties. Figures 1 – 9 are analysis of the image shown in Figure 4.

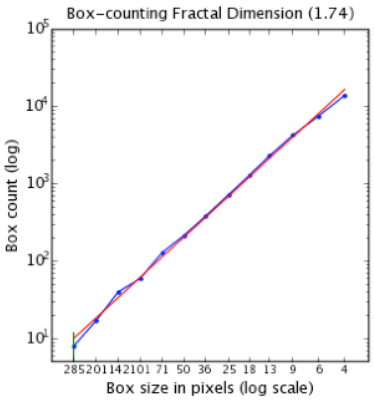

Figure 1 Fractal calculation

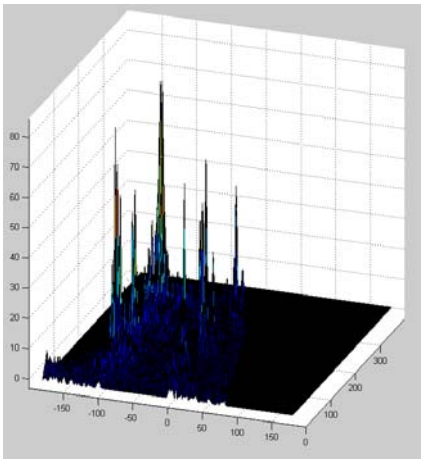

Figure 2 3D Hough accumulator array

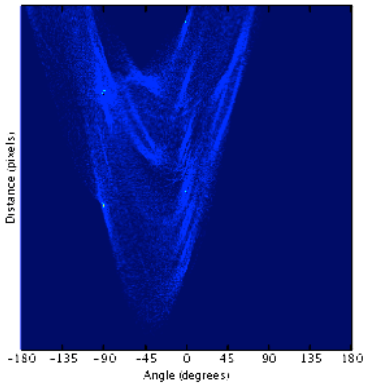

Figure 3 2D Hough accumulator array

2.2. Fractal dimension calculation using an automated box counting method

Figure 1 shows a calculation of the fractal dimension using the box counting method. The automated technique develops the work undertaken by Bovill and Weidemann (Bovill 1996) and uses methods developed by Fouroutan, Dutilleul and Smith (Foroutan-pour 1999) to determine the best approximation for the fractal dimension. Salingaros West (Salingaros 1999a) has discussed the relationship between a higher fractal dimension and successful urban spaces.

Figure 4 Original image

Figure 5 Edge detection

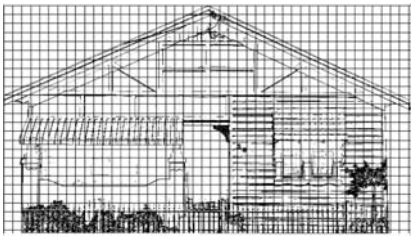

Figure 6 Box counting

Figure 7 Hough, 80 lines

Figure 8 Hough, 40 lines

Figure 9 Hough, 11 lines

2.3. Horizontality and verticality assessed using the Hough transform

Figure 4 shows a contributory house within the Hamilton South conservation area in Newcastle. The front elevation has been analysed using the Hough Transform; an algorithm that detects the likely direction of a line that any pixel in the image might be part of. Such an examination of all possible lines in an image generates a diagram (Fig 2 & 3) called the accumulator array, which shows the angle and distance of all pixels within detected lines from a predetermined origin. Lines with the greatest number of edge pixels within them appear as points with varying heights (Fig2). This processing provides a 'map' of the image that can be compared with other image maps to find where similarities and differences between images occur. Software is being developed to find these overlaps between multiple images and cluster them into groups that share this particular visual characteristic.

Figures 7, 8 and 9 show the inverse Hough transform that shows the dominant lines detected within the image back over the image itself. Figure 7 shows the 80 top lines, Figure 8 the top 40 lines, and Figure 9 the top 11 lines ii. Determining whether an image of the streetscape exhibits more horizontal or vertical lines can be related to feelings of privacy (verticality) or publicity (horizontality) (Al-Homoud 2000). Figures 10 &13 show neighbouring houses that would have been constructed at the same time, and in the same way, but have undergone different methods of alteration. The differences in horizontal and vertical elements are shown clearly with the hough transform analysis shown in Figures 11, 12, 14 & 15. Using this method the detail within the façade is emphasised over the formal structure.

Figure 10 Original image

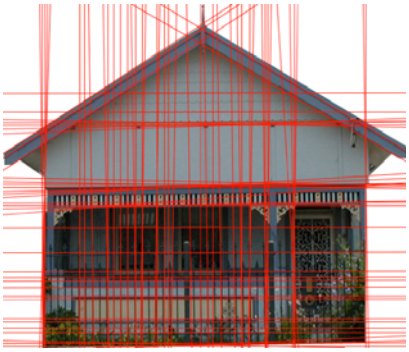

Figure 11 Hough, 80 lines

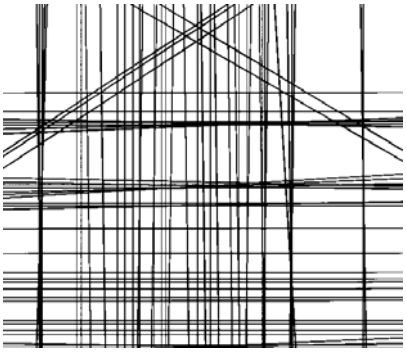

Figure 12 Hough, 80 lines

Figure 13 Original image

Figure 14 Hough, 80 lines

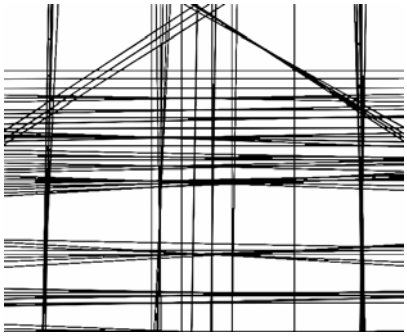

Figure 15 Hough, 80 lines

2.4. Colour segmentation based on user selected classification

Grouping colours within the image that represent a particular characteristic provides information about the distribution of a particular characteristic. For instance Fig 16 shows an aerial view of the Hamilton South Conservation Area (HSCA marked with black outline). The HSCA has reasonable planning controls but does not differentiate between areas within the conservation area that might have a different visual character. The visual character does appear to gradually change when assessing the streetscape, however by analysing the aerial map using colour segmentation differences become clear. Fig 17 shows an analysis that distinguishes between the colours of road (25%), terracotta rooves (17%), metal rooves (15%), tree's (19%) and lawn (24%) and provides data on the number of pixels that have that colour characteristic. The analysis shows in Fig 18 that the naming of a suburb has a marked effect on the style of dwelling that was constructed in the area – the black outline showing the suburb boundaries. Metal rooves (+ timber walls) dominate in the suburb of Merewether compared with the terracotta rooves (+ masonry walls) of houses in Hamilton.

Figure 16 Conservation area

Figure 17 Colour segmentation

Figure 18 Suburb layout

The software allows any image to be segmented by colour classification. Through the image on the screen, one can establish a classifier, such as road, and then click on parts of the image that correspond to that classification. The software then sorts every pixel in the image into the different classifications that have been made.

2.5. Future work

The different methods of visual analysis outlined in this paper are being brought together as a single platform. The analysis of an image will provide a data file whose characteristics can be grouped with other data files, allowing visually similar (and dissimilar) images to be recognised. For proposed changes to the streetscape, the analysis of style and formal characteristics of an existing area might also include an analysis of their visual characteristics.

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i When Murcutt cut this space away from the bungalow house he 'straightened it out and discarded the unwanted core of the house' (Drew 1992), he also removed its physical nature, and its function. The palette of materials changed from masonry and weatherboards, to metal and glass shutters. Its function as an entry, and as a social space within the public realm of the street, was given over to the private spaces of the house.

ii Pixels within horizontal and vertical lines are given priority over angled lines, this is a variable within the software interface.