ISBN 978-93-84422-62-2
Proceedings of 2016 2nd International Conference on Architecture, Structure and Civil Engineering (ICASCE'16)
London (UK), March 26-27, 2016

Visual Consistency in Townscape: Developing an Arithmetic Evaluation Based on Visual Parameters and Users' Preferences

Dheyaa Hussein[1] and Peter Armstrong[2]

[1]Ph.D. Candidate in the Faculty of Architecture, Design and Planning at the University of Sydney, Australia
[2]Senior Lecturer and Coordinator of M.Arch Urban Architecture Studio in the Faculty of Architecture, Design and Planning at the University of Sydney, Australia

Abstract: *The phenomenon of visual disorder is prominent in contemporary townscapes. This paper provides a theoretical framework for the construction of an arithmetic tool to assess visual consistency in townscape in order to achieve more favourable outcomes for users. In this paper, visual consistency refers to the amount of similarity between adjacent components of townscape.*

The paper investigates Parameters which relate to visual consistency in townscape and explores the relationships between them. The paper uses arithmetic methods from outside the domain of urban design to enable the establishment of an objective method of assessment which considers subjective indicators related to the visual perception of users. These methods include the population standard deviation, colour distance, victor length and multiple nonlinear regression.

The paper identifies urban space as a key representative of visual parameters of townscape. It focuses on its geometry in the evaluation of visual consistency of townscape. Accordingly, this article proposes four indicators of visual consistency. The first concerns with the number of vertices, which are points in the three-dimensional space that are connected by lines to represent the appearance of elements. The second evaluates the urban space ratio through assessing the location of its visible vertices. The last two indicators involve the consistency in both vertices' position and colour in townscape by the calculation of their variation using methods including standard of deviation, victor length and colour difference. The proposed quantitative assessment is based on users' preferences towards all these four indicators as well as the position of observers while they are moving through townscape. The paper offers a theoretical basis for a practical tool which can alter the current understanding of architectural form and its application in urban space. This tool is currently under development.

The proposed method underpins expert's subjective assessment and permits the establishment of a unified framework which adds to creativity by the achievement of a higher level of consistency and satisfaction among the citizens of evolving townscapes.

Keywords: *Townscape, Urban Design, Visual Assessment, Visual Consistency*.

1. Introduction

Townscape represents everything in the city that the eye can see and that the other senses can interact with. It is the spatial arrangement and visual appearance of natural and manmade components of the built environment seen from outdoors.

The paper attempts to tackle contemporary issue of visual disorder of townscape, arising from two urban challenges. First is the visual deterioration of the townscape. Contemporary townscape has failed to keep pace with the vast scale of modern development and the use of new methods of construction due to the rapid increase in population and rise in the number of motor vehicles. Second is the lack of a reliable visual assessment of townscape consistency, which links to the absence of a solid framework to control townscape through the current subjective methods of assessing townscape. These challenges require the establishment of an objective evaluation of qualities related to visual consistency in townscape.

2. Visual Parameters of Townscape

Visual consistency in townscape is attributed to different compositional parameters. These parameters vary based on perception and methods of its interpretation including structuralism and phenomenology. The first appears in the explanation of the relationships between objects while the second takes place in the perception of objects and their aspects. The perception of visual consistency in townscape is achieved by the observation of its objects and their aspects as phenomena and the relationships between them as a complete structure.

2.1. Objects

Visual objects in townscape are categorized into site and objects on the site. Aspects of the site contribute to the quality of towns. Rome, for instance, is noticeably affected by the hills on which it is built. The morphology of site, has a substantial impact on townscape [1]. Objects on the site are visually organized into four groups: buildings, other outdoor elements and humans. The visual characteristics of buildings are represented by their facades, which provide different types of perceptual experience to the viewers and a significant impact on the evaluation of townscape [2]. A façade is a combination of walls, openings, including windows and doors, and elements attached to walls, comprising columns, parapets, cornices, balconies, advertising signs within buildings and other objects [3]. In addition to buildings, townscape includes other outdoor objects, which are sometimes known as “urban furniture and vegetation”. These elements possess the same visual attributes and similar impact as buildings [4]. Human activities in the city bring life to the urban scene [5]. They represent a substantial part of townscape and are largely affected by the characteristics of space [6].

2.2. Aspects

Perception of objects depends on their visual aspects, which distinguish elements from their context. These aspects are formal and positional. Formal aspects relate to characters that provide an object its appearance. These aspects are shape, size, colour, texture, material, detail and ornament. The positon of objects plays an important role in forming relationships between objects [7]. The location of an element can be determined by its three-dimensional distance from a particular point or axis within space.

2.3. Relationships

Visual consistency in townscape involves a group of relationships. These relationships are the most significant in the visual perception of townscape. They rely on the aspects of objects and their number. These relationships are scale, enclosure, redundancy and harmony. Harmony is a principal relationship, which enfolds other relationships, including symmetry, continuity, rhythm, variety and contrast. Scale represents the agreement in size between objects in townscape and humans. It makes buildings appear in either a right or an incorrect size [8]. Enclosure is the degree by which urban space is defined by buildings and other surrounding objects. A key principle of enclosure concerns with the proportional relationships between elements and users of the public space. It depends on the the height of the urban space and its width [9]. Redundancy relies on the number of objects and refers to their plenitude. It can attract users and enhance the visual richness of townscape [10].

Visual harmony is a fundamental relationship in the achievement of visual consistency in townscape. It involves several relationships, which depend on both visual aspects, formal and positional, of objects and their number. The paper objectively classifies these relationships, based on the number of shared aspects between objects, into symmetry, continuity, rhythm, variety and contrast. Symmetry occurs as a result of cloning elements with all their formal characteristics [7]. These elements are at the same distance from a virtual centre in space, which means that they have the same position from that centre. Continuity in townscape is achieved by constancy in the visual aspects of objects. This constancy is applied to all formal aspects, and the only change will then be in the spatial location. Continuity may overcome unpleasant contradictions in the environment and enhance order [11]. Rhythm is another method to enhance consistency, through having similar characteristics between a group of elements and gradual alteration in a formal aspect as well as position. Ching [7] confirms that rhythm assists in the creation of order among visual components. Variety results from a change in the visual aspects of parts. Complexity relates to variations within an order which is crucial to boost differences that are significant for perception. It is the changes in stimuli that matter more than stimuli themselves [10]. Variety can boost the visual quality of townscape [12]. It is created by allowing at least one common formal aspect shared between visual components. Contrast results from either complete difference to all the visual aspects of elements or similarity in all aspects with the exception of a few, including colour and texture, which may lead to a symmetrical contrast [7]. Contrast plays a vital role in the visual attraction of recipients and achieving a visual richness in townscape [13]. Both continuity and contrast are important in the perception of townscape. However, it is the balance between that matter the most (Fig. 1) and providing a method to determine its preferred level is required.

Visual consistency in townscape depends on different parameters; these are objects, their visual aspects and the relationships between them. Relationships are the most significant in the perception of townscape. These relationships depend on the visual aspects, formal and positional, and the number of objects.

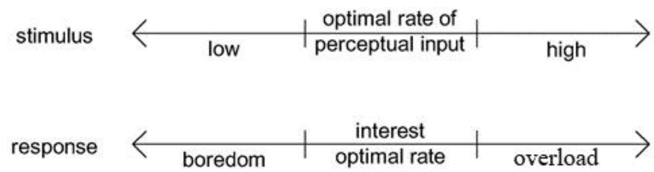

Fig. 1 The optimal rate of perceptual input

Reference: [10]

2.4. Urban Space

Cities have a complex visual system of interrelated objects through which a single change can cause repercussions in their visual context. An attempt to analyse the visual consistency in townscape requires a solid comprehension of the connections between its parameters. The main objective of the research in urban design is to determine the most significant element in its visual assessment. Hence, a better description will be provided to the way an urban setting responds to changes and a better prediction to the impact of different planning policies. The current concept regarding the parameters of the visual consistency in townscape is unlikely to be reliable; it is complicated and depends on multiple variables that involve many factors; visual objects, their aspects and relationships. Therefore, a clearer framework and a comprehensive representation of the characteristics associated with the visual consistency in townscape is required.

Urban space is the most significant part of townscape. It is created by the coming together of all visual objects in space. What is perceive as urban space may be considered as a void that is defined by elements placed on a site [4]. Spaces in the city are vital objects of since whenever people are in the outdoor environment of a city, they are in and moving through spaces of one sort or another. Thus, as architecture has been described as the art of making internal spaces, urban design can be defined as the art of creating urban spaces [14]. The quality of urban space is defined by the quality of objects that bound or exist in it and the relationships between them [1]. Townscape is the container of urban space, which is the core three-dimensional extension of the built environment. Cities may contain the same visual components. However, it is the underlying principles and relationships of their spaces that differ. The quality of the components of townscape defines the quality of its urban space, and vice versa. Hence, urban space represents a substantial indicator in the visual analysis of townscape. Design and planning at multiple scales, from the landscape of a region to the arrangement of a room, are the tasks of organizing the space. This is not to deny the importance of the other parameters including visual objects, their aspects and relationships, but to make clear that they all occur within a spatial framework. Therefore, urban space is the key object and the most effective to study and evaluate built environments [10]. The advantage of thinking in terms of urban space is that space indicates a large number of visual factors, which are collectively more distinctive and valuable than when they are considered alone.

The paper proposes a method to visually evaluate townscape based on the quality of its urban space which, in turn, can be represented by its geometry, which is the three-dimensional structure of urban space that characterises visual objects in townscape, their aspects and the relationships between them. This structure is formed by vertices which are points connected by line segments to mathematically represent three-dimensional surfaces of objects. The number, position (Fig. 2) and colour of these vertices control all parameters associated with visual consistency in townscape. The number of vertices represents the level of details, human scale, continuity and redundancy. The position of the highest visible vertices of a townscape to the eye level of recipients (Fig. 2) indicates the enclosure in townscape. The similarity between the location of visible vertices in townscape indicates the level of harmony in its geometry.

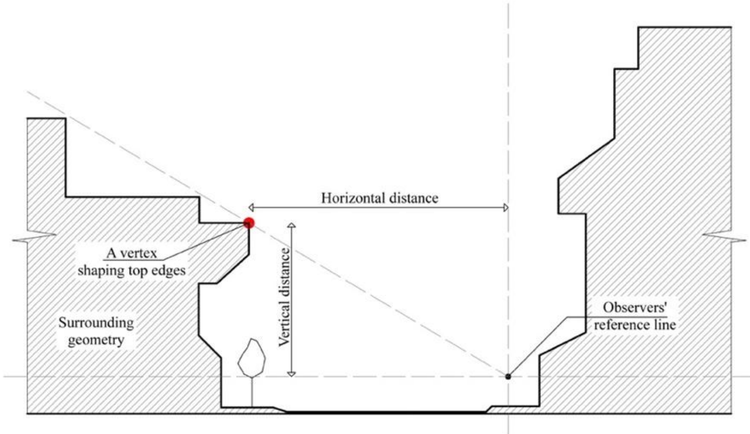

Fig. 2 The location of vertices

Colour is a principal factor in the visual perception of urban space and therefore it is a crucial element in its visual analysis. It can change the spatial perception of townscape and can affect the quality of design. The achievement of colour harmony in townscape is a primary goal in the pursuit of visual consistency. Colour consistency in townscape depends on the interrelationship of background and objects in terms of area, hue and other qualities of the colour of adjacent objects. Therefore, the visual evaluation of townscape should consider the colours of the entire scene in relation to each other [15]. Architects and urban designers usually rely on talent, common sense, personal and professional taste and experience in dealing with colour design [16]. The level of similarity or differences between the colour of visible vertices of the total townscape indicates the level of harmony of colour in townscape.

3. Visual Preferences of Urban Space

The visual evaluation of a townscape is mainly influenced by the perception of its users [17, 18]. Urban residents may be united in their reaction, approval or aversion, towards a built environment [19]. The collection and analysis of opinions enable the gauging of aesthetic preferences through the employment of objective techniques. The public has discernment in respect to the built environment. Investigations have shown that individuals care about their townscape and possess a strong preferential view [20]. As inhabitants of a particular locality are likely to have similar underlying visual preferences, it should be possible for places to change in the direction of obtaining preferable qualities.

It is suggested that designers have noticeably different preferences to the general public. High-profile designers are those with work featuring unique sculptural qualities and not those who have followed contextual principles. It appears that economic prerogatives and professional attitudes which influence the shape of contemporary cities have not always been sympathetic to the requisites of visual consistency in the built environment [21]. This practice can lead to visual dissonance that the uninvolved public has to bear [22]. It is in the culture of designers to favour visually innovative and distinctive solutions. This expert-led design processes raises the question of what are the chances that change will lead to visual admiration if the opinions of the vast majority of people are not considered? The recognition of the impact of the contemporary development of townscape has led many local authorities to attempt to control design as part of the planning approval process. The first consideration of the authority is to comply with standards, regardless of the surrounding setting. Once that condition is satisfied, the relationship with the context is further probed, asking the question: “will this project fit here? Perhaps the more appropriate questions might be: what are the visual characteristics that this setting demands?" Experts usually provide opinions about townscape, but it is doubtful that they speak for all citizens? Thus, it is crucial to consider the visual preferences of the broad range of users when developing a particular townscape [20].

It is imperative to assess the preferences of the users of a townscape that is under development. These users have a consensus about what they favour or dislike. Thus, data from user preferences of existing or virtual townscape will help to understand the impact of parameters of visual consistency in townscape and, thus, to analyse and improve a proposed development.

4. Proposed Arithmetic Approach

The assessment of visual consistency in townscape depends on four measurements to determine the sum of its vertices, space ratio, consistency of vertices and colour. The result of townscape visual evaluation can differ based on the location of the observer. Thus, a virtual line which represents observers' path and eyes' level during travel through a townscape is the reference for all four visual assessments. This line is identified as observers' reference line.

The first measurement detects the number of vertices which are visible from the observers' reference line. Visible vertices within the cone of observers' vision are more significant than those located outside it. Within a suitable distance, the whole composition of a building is of interest to an observer. However, on approaching this building, the projection of the cone on the building will become smaller. Thus, attention will move from the large composition of the whole building towards its small details (Fig. 3).

According to Spreiregen [23], the normal range of human vision is about (75o) vertically and (130o) horizontally. This range measures around (30o) up, (45o) down, and (65o) to each side. In order to reflect the locational significance of vertices in relation to the typical cone of observers' vision, vertices located inside the cone of vision, which starts from observers' reference line, will be allocated double the value of those outside. Thus, if a visible vertex angled between (30o) up and (-45o) down, it will score two points. Otherwise, the vertex will score only one point. The result value will be the sum of the scores of all vertices which are visible from observers' reference line as in (1).

$$\text{Sum of vertices} = \sum_{i=1}^{n} v_i \qquad (1)$$

Where (v) is a visible vertex = 2 if the vertex is within the cone of vision and 1 otherwise.

n: number of visible vertices

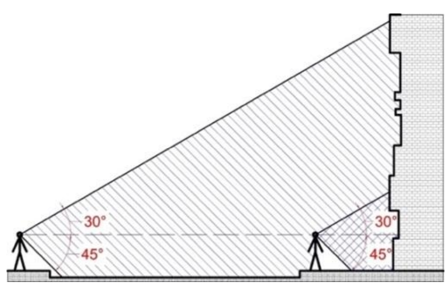

Fig. 3 Change in the visual attention according to distance from objects

The second measurement calculates the urban space ratio of townscape. Urban space ratio refers to the proportion between the height of the vertical borders of urban space and its width. Hence, the space ratio is formed by vertices which shape the top visible edges of townscape. The space ratio of each of these vertices is its vertical distance to the observers' reference line divided by the horizontal distance between them (Fig. 2). The space ratio of a selected townscape is the average space ratio of their vertices as shown in (2).

$$\text{space ratio} = \left(\sum_{i=1}^{n} tvi/tho\right)/n \qquad (2)$$

Where n = number of visible vertices shape top edges

tvi: vertical distance between a visible vertex, that shapes the top edges, and observers' reference line tho: horizontal distance between a visible vertex, that shapes the top edges, and observers' reference line

The third measurement determines the consistency of vertices' position in townscape. The paper employs a statistical method, namely population standard deviation to quantify consistency between vertices. This method is traditionally used to determine the amount of variation or dispersion of a set of data values. A standard deviation close to zero indicates that the data points are very close to the mean while a higher standard deviation indicates that the data points are spread out over a wider range of values. In the calculation of population standard of deviation, each data point represents the position of a visible vertex as in (3). The location of a vertex is its distance to the observers' reference line. This distance is represented by the length of vector which is measured using the Pythagorean formula (4).

$$\mathrm{s} = \sqrt{1/\mathrm{n} \sum_{\mathrm{i}=1}^{\mathrm{n}} (\mathrm{l_i} - \mathrm{m})} \tag{3}$$

where s: population standard deviation

n: number of visible vertices

m: the mean length of vectors

l: vector length of a vertex, which can be measured using formula (4).

$$\mathrm{l} = \sqrt{\mathrm{x}^2 + \mathrm{y}^2} \tag{4}$$

where x: horizontal distance between a vertex and observers' reference line

y: vertical distance between a vertex and observers' reference line

The last measurement calculates the consistency in the colour of visible vertices. The same statistical method, population standard deviation, will be used. However, colour value is typically represented by three indicators including red, green and blue (RGB) and other types of indicators. This system of representation makes it impossible to determine the difference between each colour value and the mean using a traditional subtraction method. However, colour difference can be measured using a method called colour distance. It amounts the difference between two colours and allows quantified examination of a colour quality that formerly could only be described with adjectives. It relies on a euclidean measurement and has been introduced by the international commission on illumination (CIE) as a distance metric (ΔE) or "Delta E" [24]. Various studies have proposed several delta E (ΔE) values. However, perceptual non-uniformities in the underlying CIELAB colour space have led to the refinement of the definition of delta E (ΔE) over the years. This refinement has resulted in the formula of the year (2000) known as CIEDE2000. This formula takes into account perceptual non-uniformities, which are the outcome of the unequal sensitivity of the eye towards different colours [25]. The detailed calculations involved in this formula are mentioned in equations (5 - 15) [26].

$$\Delta E_{00}^* = \sqrt{(\Delta L'/k_L S_L)^2 + (\Delta C'/k_C S_C)^2 + (\Delta H'/k_H S_H)^2 + R_T\,(\Delta C'/k_C S_C)\,(\Delta H'/k_H S_H)} \tag{5}$$

$$\Delta L' = L_2^* - L_1^* \tag{6}$$

$$\bar{L} = (L_1^* + L_2^*)/2\,, \qquad \bar{C} = (C_1^* + C_2^*)/2 \tag{7}$$

$$a_1' = a_1^* + (a_1^*/2)\left(1 - \sqrt{\bar{C}^7/(\bar{C}^7 + 25^7)}\right), \quad a_2' = a_2^* + (a_2^*/2)\left(1 - \sqrt{\bar{C}^7/(\bar{C}^7 + 25^7)}\right) \tag{8}$$

$$\bar{C}' = (C_1' + C_2')/2 \textit{ and } \Delta C' = C_2' - C_1' \quad \textit{where } C_1' = \sqrt{{a_1'}^2 + {b_1^*}^2}\,, \quad C_2' = \sqrt{{a_2'}^2 + {b_2^*}^2} \tag{9}$$

$$h_1' = \operatorname{atan} 2(b_1^*, a_1') \quad mod\ 360^o\,, \qquad h_2' = \operatorname{atan} 2(b_2^*, a_2') \quad mod\ 360^o \tag{10}$$

$$\Delta h' = \begin{cases} h_2' - h_1' & |h_1' - h_2'| \le 180^o \\ h_2' - h_1' + 360^o & |h_1' - h_2'| > 180^o, h_2' \le h_1' \\ h_2' - h_1' - 360^o & |h_1' - h_2'| > 180^o, h_2' > h_1' \end{cases} \tag{11}$$

$$\Delta H' = 2\left(\sqrt{C_1'\,C_2'}\right)\sin(\Delta h'/2)\,, \qquad \bar{H}' = \begin{cases} (h_1' + h_2' + 360^o)/2 & |h_1' - h_2'| > 180^o \\ (h_1' + h_2')/2 & |h_1' - h_2'| \le 180^o \end{cases} \tag{12}$$

$$T = 1 - 0.17\ \cos(\bar{H}' - 30^o) + 0.24\ \cos(2\bar{H}') + 0.32\ \cos(3\bar{H}' + 6^o) - 0.20\ \cos(4\bar{H}' - 63^o) \tag{13}$$

$$S_L = 1 + \left(0.015\,(\bar{L} - 50)^2/\sqrt{20 + (\bar{L} - 50)^2}\right), \quad S_C = 1 + 0.045\bar{C}'\,, \quad S_H = 1 + 0.015\bar{C}'T \tag{14}$$

$$R_T = -2\sqrt{\bar{C}'^7/(\bar{C}'^7 + 25^7)}\ \sin[60^o\,.\exp(-\,[(\bar{H}' - 275^o)/25^o]^2)] \tag{15}$$

The values resulted from these four measurements will not be beneficial without the consideration of their impact on the visual perception of users. Thus, a group of virtual townscapes will be designed to contain different values of the four indicators: sum of vertices, space ratio, consistency of vertices and colour consistency. These townscapes will be ranked by users through the implementation of the pairwise comparison method. In this method, a user will be asked to choose his/her preference for each pair of choices. This approach makes the experiment easily administrated because subjects only focus on two of alternatives and on a criterion each time instead of facing all multi-attributes for many objects at once [27]. It provides a good quality of discrimination and is easier to be used by subjects than rating tasks. Errors resulting from subjects assessing preference could be lower with this method [28]. Results from this experiment will be a value for each of these townscapes based on their ranks. As the value of each townscape and its four measurements becomes known, the impact of each factor of visual consistency on users' perception can be determine using the statistical method of multiple nonlinear regression. The method of multiple regression calculates the significance of parameters, which provides a comprehension of how these parameters are required to be adjusted to achieve the desired users' experience. It establishes a relationship model that includes independent variables which significantly affect dependent outputs [29]. It institutes the correlation between the parameters of visual consistency and the perceptions of individuals of alternative townscapes. The results of the trials are used to build a mathematical model to predict the likely individual response to any arbitrary townscape. To verify this approach, this model is used to assess and rank another group of townscape based on their visual consistency. The theoretical framework is demonstrated in (Fig. 4). These townscapes are further ranked by the same group of users to evaluate the agreement between the two methods of ranking. The result is an equation to predict significance of any townscape Based on user's preferences towards parameters of visual consistency in townscape.

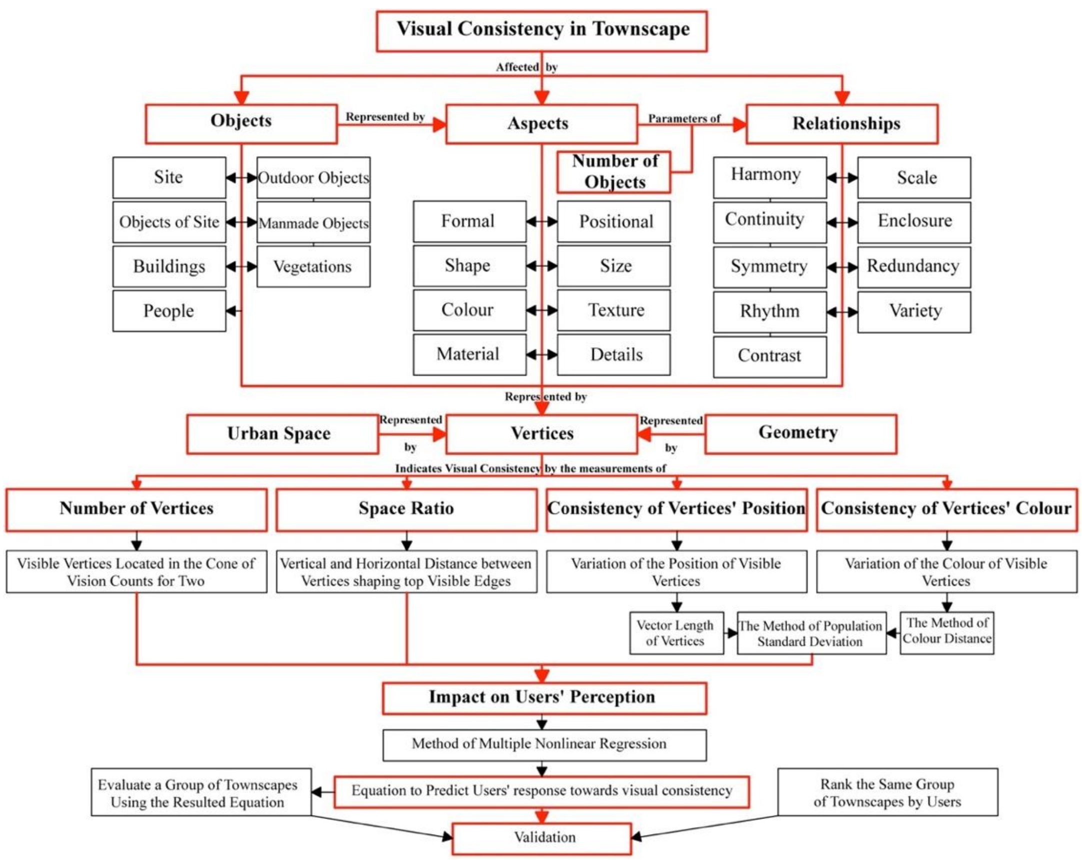

Fig. 4 Theoretical framework

5. Conclusions

In response to the inadequacy of traditional methods of townscape visual evaluation, this paper hypothesises an alternative method based on an arithmetic assessment of townscape physical parameters and the visual perception of its users. The paper proposes a model to objectively evaluate townscape through two types of data.

The first is quantitative; it relates to urban space ratio, the number of visible vertices of townscape and variation in both position and colour of these vertices. The second is subjective and deals with observers' response to the quantitative data. The model measures the significance of each of the quantitative indicators based on users' preference and builds an equation to predict their response towards any townscape. The result is a flexible arithmetical method to effectively represent visual requirements of townscape users and eliminate the likelihood to encounter unguided individual judgements by decision makers. This paper paves the way for the construction of online application which predicts public response towards townscape development to assist planners in their design decision regarding visual consistency in townscape.

6. References

[1] P. Thiel, "A sequence-experience notation: for architectural and urban spaces," The Town Planning Review, vol. 32, pp. 33-52, 1961.

http://dx.doi.org/10.3828/tpr.32.1.53n454100g514634

[2] A. Askari and K. Dola, "Influence of Building Façade Visual Elements on Its Historical Image: Case of Kuala Lumpur City, Malaysia," Journal of Design and Built Environment, vol. 5, pp. 49-59, 2009.

[3] H. Al-Alwan and D. Hussein, "Visual Richness of Townscape: Analytical Study in Rashed Street-Rusafa," Journal of the Association of Arab Universities, vol. 19, pp. 87-107, 2012.

[4] N. Taylor, "The elements of townscape and the art of urban design," Journal of Urban Design, vol. 4, pp. 195-209, 1999.

http://dx.doi.org/10.1080/13574809908724446

[5] G. Burke, "Townscape," in Townscape, P. Hall, Ed., 1st ed England: Pelicans Books Ltd, 1976.

[6] L. Kacha, N. Matsumoto, A. Mansouri, and A. Cavalcante, "Predicting Perceived Complexity Using Local Contrast Statistics and Fractal Information," Courrier du Savoir, vol. 16, pp. 89-97, 2013.

[7] F. Ching, Architecture: Form, Space & Order. New York: Van Nostrand Reinhold Co., 1996.

[8] N. Crowe, Nature and the idea of a man-made world: an investigation into the evolutionary roots of form and order in the built environment Cambridge, Massachusetts: MIT Press, 1995.

[9] M. Larice and E. Macdonald, The urban design reader, 2nd ed. London and New York: Routledge, 2013.

[10] A. Rapoport, Human Aspects of Urban Form: Towards a Man-Environment Approach to Urban Form and Design. U.K.: Pergamon Press Ltd., 1977.

[11] M. William, Perception and Lighting As Formgivers for Architecture. New York: McGraw-Hill Book Co., 1977.

[12] I. Bentley, A. Alcock, P. Murrain, S. McGlynn, and G. Smith, Responsive Environments: A Manual for Designers London Architectural Press, 1985.

[13] R. Venturi, Complexity and Contradiction in Architecture. London: The Architecture Press Ltd., 1966.

[14] B. Zevi, Architecture As Space: How to Look at Architecture, Rev. ed. New York Horizon Press, 1974.

[15] Y. Kinoshita, E. W. Cooper, Y. Hoshino, and K. Kamei, "Kansei and colour harmony models for townscape evaluation," Journal of Systems and Control Engineering, vol. 220, pp. 725-734, 2006.

http://dx.doi.org/10.1243/09596518jsce149

[16] P. Green-Armytage, "The value of knowledge for colour design," Color Research & Application, vol. 31, pp. 253-269, August 2006.

http://dx.doi.org/10.1002/col.20222

[17] H. Sanoff, Visual Research Methods in Design. New York: Van Nostrand Reinhold Co., 1991.

[18] J. L. Nasar, The evaluative image of the city. Thousand Oaks, California Sage Publications, 1998.

[19] I. Bentley, Urban transformations: power, people and urban design. London; New York Routledge, 1999.

[20] M. Gjerde, "Visual Aesthetic Perception and Judgement of Urban Streetscapes," in 18th CIB World Building Congress, Salford, United Kingdom, 2010, pp. 12-22.

[21] N. J. Habraken, "Cultivating the field, about an attitude when making architecture," Places, vol. 9, pp. 8–21, 1994.

[22] M. Carmona, T. Heath, T. Oc, and S. Tiesdell, Public places, urban spaces: the dimensions of urban design, 2nd ed. Amsterdam; Boston: Routledge, 2010.

[23] P. Spreiregen, Urban Design – The Architecture of Town and Cities. New York: McGraw-Hill Co., 1965.

[24] A. Valberg, Light Vision Color. England: John Wiley & Sons Ltd., 2005.

[25] B. Fraser, C. Murphy, and F. Bunting, Real World Color Management, 2nd ed. U.S.A.: Peachpit Press, 2005.

[26] G. Sharma, W. Wu, and E. N. Dalal, "The CIEDE2000 Color-Difference Formula: Implementation Notes, Supplementary Test Data, and Mathematical Observations," COLOR research and application, vol. 30, 2005.

[27] J.-F. Petiot and B. Yannou, "How to comprehend and assess product semantics - A proposal for an integrated methodology," presented at the International Conference on Engineering Design, ICED 03 sTOCKHOLM, 2003.

[28] A. Dagher, J.-F. Petiot, and H. Guyon, "Elicitation and modeling of customers' preferences in industrial design: a compparative study on vehicle front end," in IDETC/CIE, Brooklyn, U.S.A., 2008.

[29] H.-Y. Chen and H.-C. Chang, "Consumers' perception-oriented product form design using multiple regression analysis and backpropagation neural network," Artificial Intelligence for Engineering Design, Analysis and Manufacturing, pp. 1-14, 2015.