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Building an Arithmetic Model to Assess Visual Consistency in Townscape

Dheyaa Hussein, Peter Armstrong

***Abstract*—**The phenomenon of visual disorder is prominent in contemporary townscapes. This paper provides a theoretical framework for the assessment of 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, explores the relationships between them and highlights their significance. The paper uses arithmetic methods from outside the domain of urban design to enable the establishment of an objective approach of assessment which considers subjective indicators including users' preferences. These methods involve the standard of deviation, colour distance and the distance between points. The paper identifies urban space as a key representative of the visual parameters of townscape. It focuses on its two components, geometry and colour in the evaluation of the visual consistency of townscape. Accordingly, this article proposes four measurements. The first quantifies 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 visual surroundings of urban space through assessing the location of their vertices. The last two measurements calculate the visual similarity in both vertices and colour in townscape by the calculation of their variation using methods including standard of deviation and colour difference. The proposed quantitative assessment is based on users' preferences towards these measurements. 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 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.

I. 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 cultural landscape seen from outdoors.

The paper attempts to tackle contemporary issues related to visual consistency of townscape, arising from two main urban challenges. First is the visual deterioration of the townscape. Contemporary townscape has failed to keep pace with the vast scale of modern urban development and the use of new construction methods because of 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 an aesthetic framework and current subjective assessment methodologies of townscape. These challenges require the establishment of an objective evaluation of visual qualities of townscape.

Dheyaa Hussein, Ph.D. candidate, Faculty of Architecture, Design and Planning, The University of Sydney, Australia (e-mail: dhus4848@uni.sydney.edu.au)

II. Parameters of Visual Consistency in Townscape

Visual consistency in townscape attributes to different parameters. These parameters vary based on perception and methods of its interpretation including phenomenology which signifies the pure experience of the environment and structuralism which focuses on understanding elements of culture regarding their relationships to larger structure. Accordingly, parameters of visual consistency in townscape are classified into objects, aspects and relationships.

A. Objects

It is essential to distinguish between two approaches to the description of visual objects in townscape; the first approach describes the possible objects of sensation, whereas the second describes the objects of perception. The aim of the first approach is to define all visible objects. On the other hand, the second approach refers to objects that are perceived [1]. The paper deals with the possible objects of sensation, in an attempt to list all visual elements available to the urban designer, as their perception may vary from an individual to another.

Visual objects in townscape are categorised into site and objects on the site. The natural qualities of the site contribute to the character of towns. Rome, for instance, is clearly affected by the hills on which it is built. The morphology of site, size and shape, have a substantial impact on townscape [2].

Objects on the site are visually classified into four groups: buildings, other outdoor elements, spaces and human activities. The visual characteristics of buildings are represented through their facades, which provide various types of experience to the viewers and a strong impact on the evaluation of the image of townscape [3]. A façade is a combination of walls, openings, including windows and doors, and elements attached to walls, including columns, parapets, cornices, balconies, advertising signs within buildings and other objects [4].

In addition to buildings, townscape contains other outdoor elements, which are sometimes called "urban furniture and vegetation". These elements possess the same visual attributes as buildings [1].

Urban space is the most significant of all built objects of townscape. It is created by the coming together of all the visual objects in space. What we perceive as urban space may be considered as a void that is defined by elements placed on a site [1]. Spaces in the city are vital objects of a sensation 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 [5]. The quality of space is determined by the quality of objects that bound or exist in it and the relationships between them [2].

Human activities of people going about their daily affairs bring life to the urban scene [6]. They are considered as an essential part of townscape and are required to be understood. These activities are largely affected by the characteristics of space [7].

B. Aspects

Perception of objects depends on their visual aspects, which distinguish elements from their context. These aspects are formal and locational. Formal aspects refer to general characters that provide an object with its appearance. These aspects are shape, size, colour, texture, material, detail and ornament.

The other type of identified visual aspect is location. Ching [8] affirms that the position of an object is visually significant. Relationships between objects depend on their positions in relation to each other. The location of an element can be determined by its three-dimensional distance from a particular point or axis within space.

C. Relationships

Visual consistency in townscape involves a group of relationships that are concerned with the level of consistency between objects in a townscape [6]. These relationships are the most significant in the visual perception of townscape. They depend on the aspects of objects and their number. These relationships are scale, enclosure, redundancy and harmony. Harmony is a principal relationship, which enfolds subordinate relationships, including symmetry, continuity, rhythm, variety and contrast.

Scale represents the agreement in size between humans and other objects in townscape. It makes buildings appear in either a correct or an incorrect size [9]. Enclosure is defined as the degree by which urban space is defined by buildings, trees and other surrounding elements. A key principle of enclosure concerns with the proportional relationships between objects and the users of the public space. It depends on the relationship between the height of the urban space and its width [10]. Redundancy relies on the number of objects and refers to their plenitude. It can attract users and enhance the visual richness of townscape [11].

Visual harmony is a fundamental relationship in the achievement of visual consistency in townscape. It involves several subordinate relationships, which depend on both visual aspects, formal and locational, 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 duplicating elements with all their formal characteristics [8]. These elements would be at the same distance from a virtual centre or axis in space, which means that they have the same locational aspect. Continuity in townscape is achieved by constancy in the visual aspects of elements. This constancy is applied to all formal aspects, and the only difference will then be in the spatial location. Continuity may overcome an unpleasant contradiction in the built environment and enhance order [12]. Rhythm is another mean to produce consistency, through the relationship between objects that have a group of similar characteristics and gradual change in a formal aspect as well as location. Rhythm helps to create order among elements [8]. Variety results from a change in the visual aspects of components. Complexity includes variations within an order. Order is essential to distinct differences that are significant for perception. It is the changes in stimuli that matter more than stimuli themselves [11]. Variety can boost the visual quality of townscape [13]. It is created by allowing, at least, one common formal aspect shared between elements. Contrast results from either total 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 result in a symmetrical contrast [8]. Contrast plays a vital role in drawing the attention of recipients and achieving a visual richness in townscape [14].

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 locational, and the number of objects. The parameters of visual consistency in townscape are summarised in (Fig. 1).

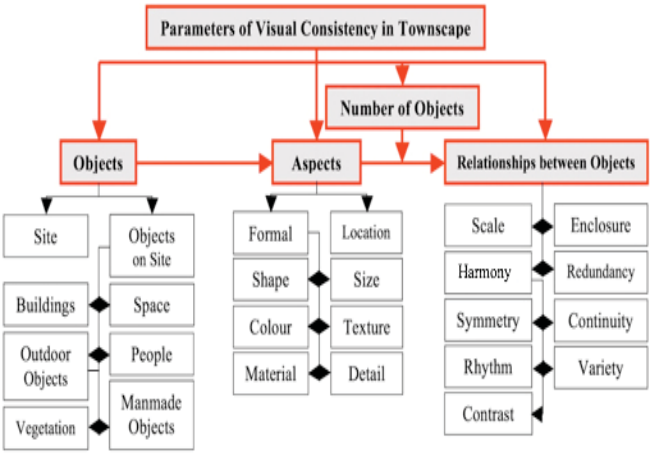


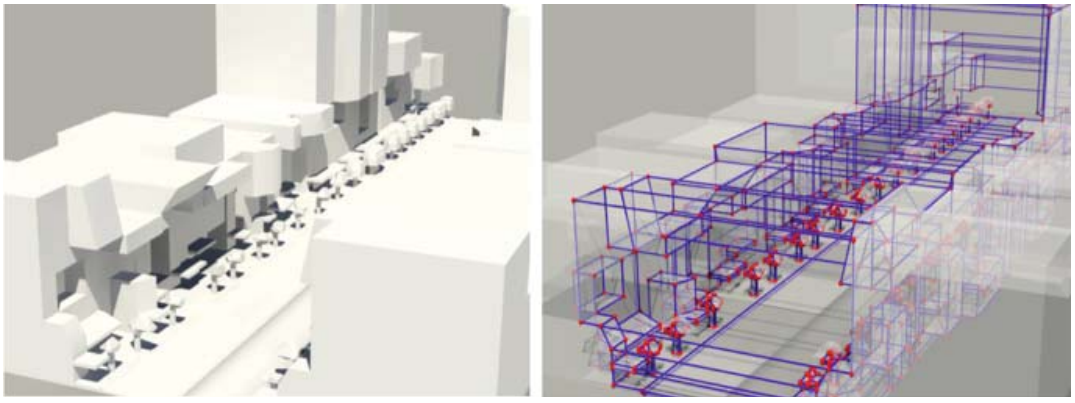
Fig. 1 Parameters of visual consistency in townscape

III. Townscape Defined by 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 understanding of connections between its parameters. The main objective of the research in urban design is to determine which element of the urban system is the most significant in the visual assessment. Hence, a better explanation will be provided to the way an urban setting responds to changes and a better prediction of the effect of different planning policies. The presented concept of 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.

Townscape is the container of urban space, which is the core three-dimensional extension of the built environment. It refers to all kinds of space defined by buildings and other visual objects in the city [15]. 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 organising the space. This hypothesis is not to deny the importance of the other parameters including visual objects and their aspects and relationships, but to clarify that they all occur within a spatial framework. Hence, urban space is the principal purpose and the most useful to study and assess built environments [11]. The advantage of thinking regarding 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. A total urban system could be examined as a network of open space that is formed by buildings and other objects within townscape.

Visual objects of townscape collectively form urban space and influence public activity on different scales. Spaces within the city should be considered as an overall structure [16]. The paper proposes a new method to visually evaluate townscape based on the quality of its urban space (Fig. 2). All visual parameters of townscape, including objects, their aspects and relationships between them, can be represented by a single object, which is urban space. Hence, a clearer framework is to be provided to evaluate townscape by the analysis of one representative element. Urban space, in turn, can be represented by two characteristics. The first is geometry, which is the three-dimensional structure of urban space that characterises visual objects in townscape, their aspects, except colour, and the relationships between them. The second is colour.



(a) Virtual townscape (b) Contained urban space

Fig. 2 Townscape defined by urban space

IV. Geometry of Urban Space

The geometry of urban space is its three-dimensional structure. It represents all parameters of visual consistency in townscape including objects, their aspects and relationships, except colour. This structure is characterised by vertices. Vertices are points connected by line segments to mathematically represent three-dimensional surfaces of objects (Fig. 3). The number and location of these vertices control all parameters associated with visual consistency in townscape except colour. The paper suggests a technique to measure the geometry of urban space based on the values of its vertices. The value of each vertex depends on its vertical and horizontal locations to a particular reference (Fig. 5). This method considers all relationships that affect visual consistency in townscape. Scale, as a primary relationship, depends on architectural detail in terms of the correlation with the human body, which bring the size of objects to a level that makes them perceptually plausible for users. Details are the three-dimensional composition of objects. They are represented by vertices. More details within a townscape mean more vertices. Therefore, blind facades with fewer details and, thus, fewer vertices will have less geometric values than

detailed facades as geometry is essentially the sum of the values of its vertices. Vertices within the cone of vision are more vital to viewers than those outside the cone of vision. 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. Accordingly, the value of vertices in the proposed model is affected by the location in relation to the cone of vision of a viewer (Fig. 6). Vertices within the cone of vision will have twice the value of others outside it. Therefore, the proposed visual analysis may differ according to the observer's distance from the examined townscape.

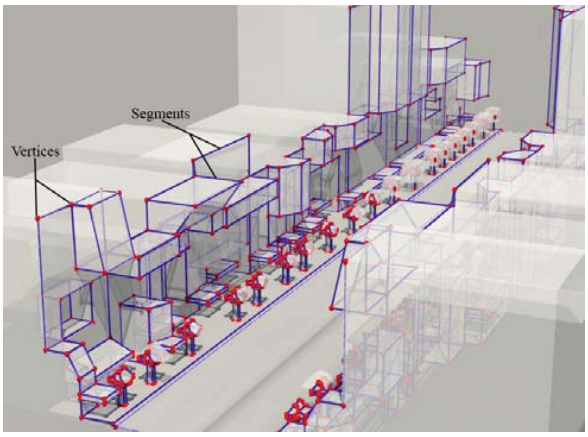


Fig. 3 The geometric structure of townscape

Enclosure is another important relationship that affects visual consistency in townscape. It depends on two factors; these are urban space ratio and continuity on the vertical surface that surrounds the urban space. Urban space ratio refers to the proportion of a vertical object to the width of its urban space. The paper measures the vertical and horizontal distance of the highest visible vertices of a townscape to a centre within the ground of the urban space. These vertices will be allocated values according to their distance to the optimal space ratio (Fig. 4), which is to be determined by measuring preferences towards urban settings with different space ratio.

The continuity in the surroundings of urban space affects the vitality of the city. It is mainly concerned with the juxtaposition of facades. Buildings should be treated as parts of a whole scene. In less dense areas of the city, structures are perceived more as individual units than as a complete facade. Buildings designed as a group will be observed as one entity that forms an urban space. The spatial enclosure is weakened when there are many gaps between neighbouring objects. However, an area with no proper physical enclosure may also be attractive. The merits of such a space do not rely principally on its visual characters, but more on the human activities which it generates [16]. A townscape with more voids has fewer vertices to be measured and, therefore, less overall geometric value.

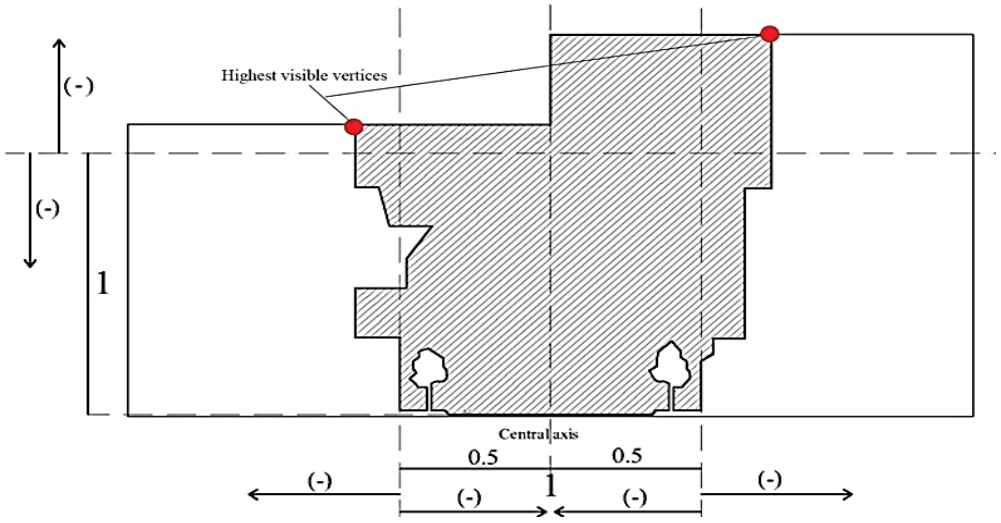


Fig. 4 Effect on the value of vertices, assuming that the optimal space ratio is 1:1

Redundancy, as one of the relationships of visual consistency in townscape, is also considered by the proposed technique. It depends on the number of objects and consequently the number of vertices. As the proposed approach measures the geometry of urban space by summing the value of the vertices, more objects mean more vertices and, therefore, more geometric value.

Harmony is an essential relationship of the visual consistency in townscape. It relies on the degree of similarity in the visual aspects of objects in townscape. Thus, it depends on the similarity in the location of vertices in a townscape.

The paper proposes a method to measure consistency of vertices in townscape using a statistical method, namely standard deviation (SD). It is used to quantify the amount of variation or dispersion of a set of data values. In this method, each data point will represent the location of a visible vertex in the townscape. In this method, the mean of the population data set is the median of the horizontal position (x) and vertical location (y) of all visible vertices in a townscape. The data difference is determined using the method of measuring the distance between two points. The measuring reference of the location of any vertex is the midpoint of the line between the perpendicular surface of the measured vertex and the facing surface on the ground of the urban space.

Because colour is not characterised by vertices, colour consistency in townscape needs to be assessed separately.

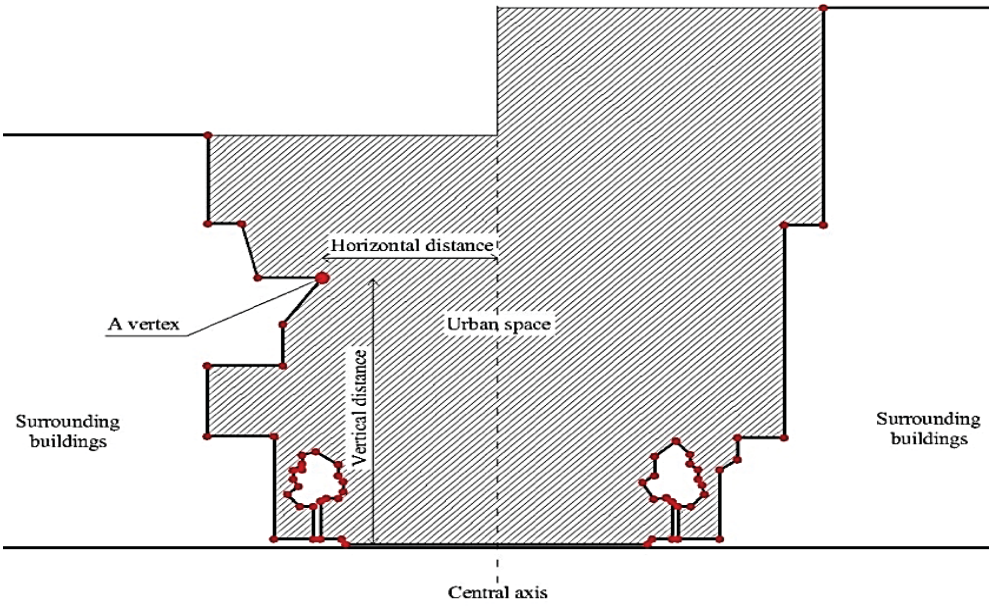


Fig. 5 The location of vertices

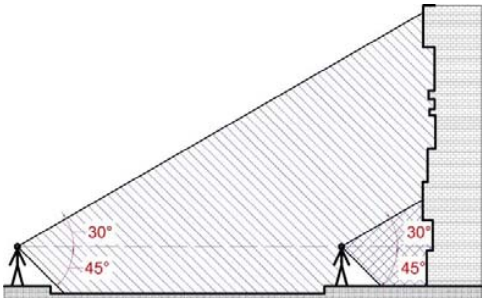


Fig. 6 Change in the visual attention according to distance from objects

V. Colour in Urban Space

Besides 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 through the triggering of different emotions. Colour varies in terms of both the texture of the surface and the light condition in which it is seen. Colour perception may change in different environmental conditions and diverse material finishes. The achievement of colour consistency 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 [17]. Most colour studies ignore the impact of context on the perception of colour and little is known about the assessment of preferences towards colour in townscape. It may be influenced by gender, age, culture, experience and other individual factors [18]. Architects and urban designers usually rely on talent, common sense, personal and professional taste and experience in dealing with colour design [19].

Various attempts have introduced some rules for colour consistency. Itten [20] offers a geometric model of representation of colour consistency in a twelve hue colour circle. The geometric illustration of colour in this model is representational and abstract. The model has limitations that hinder its utilisation in a townscape. It does not consider the wide range of colour values that lie between pure colours and their specific location on the colour circle. It also does not justify the consistency in a combination of more than six colours and does not take into account the colour context, including the number and area of other colours in a scene. Consistency is not absolute, and colour combinations are not either harmonious or otherwise. Each composition may achieve a particular degree of consistency. A decision

regarding colour consistency can be subjective and does not follow universal rules.

The paper proposes an approach to assess colour consistency in townscape using the method of standard deviation (SD). In this assessment, each data point will stand for a colour in a townscape. The data difference, in this measurement, is determined using a method called colour distance.

The method of colour distance measures the change or distance between two colours and allows quantified examination of a colour quality that formerly could only be described with adjectives. It relies on the Euclidean measurement and has been introduced by the international commission on illumination (CIE) as a distance metric (ΔE) or "Delta E" [21].

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 non-uniformities, which are the outcome of the unequal sensitivity of the eye towards different colours [22]. The formula has adequately resolved the perceptual uniformity issue [23].

In applying the equation of the standard deviation, the mean of the population dataset is represented by the average of the three colour values (L*a*b*). The amount of difference in the same equation is determined using the method of colour difference (CIEDE2000).

In the proposed method of measuring colour consistency in townscape, each input date will represent a colour of each visible polygon in a townscape. A polygon is a plane figure that is bounded by a chain of line segments which connect vertices (Fig. 7).

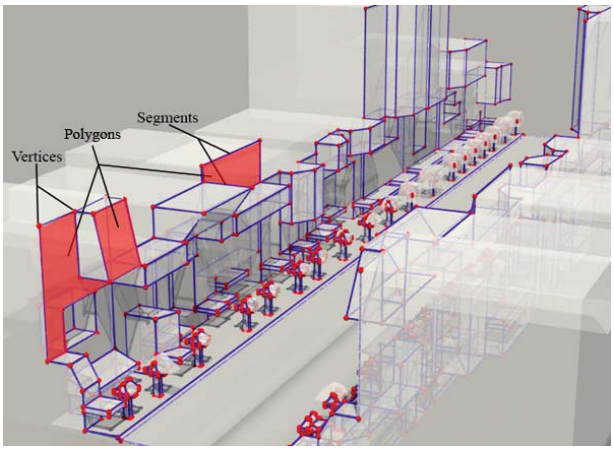


Fig. 7 Polygons in a virtual townscape

VI. Visual Preferences towards Townscape

The visual evaluation of a townscape is mainly influenced by the perception of its users [24], [25]. Urban residents may be united in their reaction, approval or aversion, towards a familiar built environment based on its undergoing visual transformations [26]. The collection and analysis of opinions enable the gauging of aesthetic preferences through the employment of objective techniques. The public has discernment with respect to the built environment. Investigations have shown that individuals care about their townscape and possess a strong preferential view [27]. 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.

The literature suggests 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 [28]. This practice can lead to visual dissonance that the uninvolved public has to bear [29]. It is in the culture of designers to favour visually innovative and distinctive solutions. This expert-led design process 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 [27].

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 analyse and improve a proposed development.

The measurement of visual consistency in both geometry and colour will be based on preferences of users towards examined townscape.

VII. Conclusions

In response to the inadequacy of traditional methods of townscape visual evaluation, this paper suggests a new method for a better description of the visual quality of townscape. It focuses on urban space as a representative of the parameters of visual consistency in townscape.

This paper provides a theoretical framework (Fig. 8) and hypothesises an alternative method based on an arithmetic assessment of townscape physical parameters and the visual perception of its users. It proposes a model to objectively evaluate townscape through both quantitative and qualitative

data. In the context of this theoretical structure, the model uses the quantitative indicators to measure urban space ratio, the number of visible vertices of townscape and variation in the position of these vertices and the colour of visible polygons. The significance of each of these indicators is measured based on users' preferences. This model permits the incorporation of differing user preferences, and addresses social, cultural and climatic factors which vary from location to other. This model is, therefore, capable of delivering an equation to predict user response towards any townscape regarding its visual consistency. The result is a flexible approach to effectively represent visual requirements of townscape users and eliminate the likelihood to encounter unguided planning decisions.

This paper paves the way for the establishment of online application which predicts public response towards townscape development to assist planners in their decision regarding visual consistency in townscape.

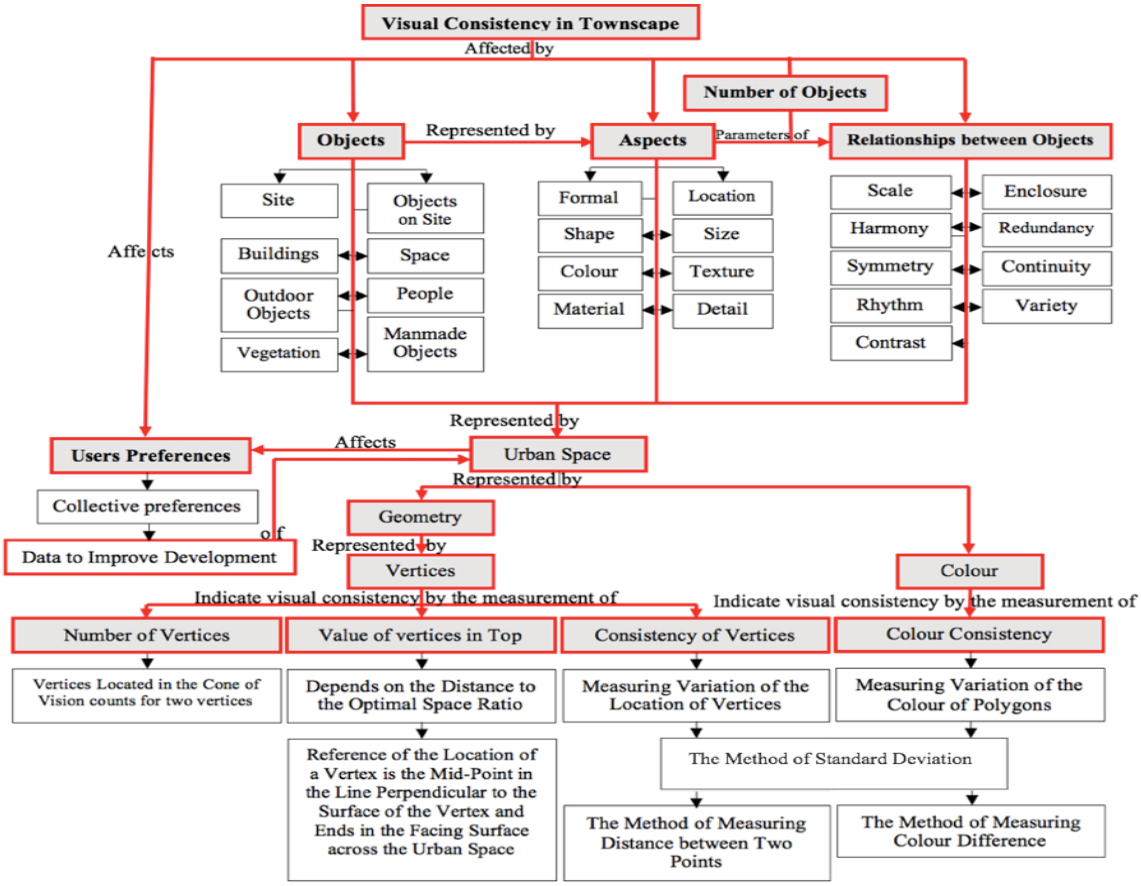


Fig. 8 Theoretical framework

REFERENCES

[1] N. Taylor, "The elements of townscape and the art of urban design," *Journal of Urban Design,* vol. 4, pp. 195-209, 1999.
[2] P. Thiel, "A sequence-experience notation: for architectural and urban spaces," *The Town Planning Review,* vol. 32, pp. 33-52, 1961.
[3] 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.
[4] 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.
[5] B. Zevi, *Architecture as Space: How to Look at Architecture*, Rev. ed. New York Horizon Press, 1974.
[6] G. Burke, "Townscape," in *Townscape*, P. Hall, Ed., 1st ed England: Pelicans Books Ltd, 1976.
[7] 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.
[8] F. Ching, *Architecture: Form, Space & Order*. New York: Van Nostrand Reinhold Co., 1996.
[9] 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.
[10] M. Larice and E. Macdonald, *The urban design reader*, 2nd ed. London and New York: Routledge, 2013.
[11] A. Rapoport, *Human Aspects of Urban Form: Towards a Man-Environment Approach to Urban Form and Design*. U.K.: Pergamon Press Ltd., 1977.
[12] M. William, *Perception and Lighting as Formgivers for Architecture*. New York: McGraw-Hill Book Co., 1977.
[13] I. Bentley, A. Alcock, P. Murrain, S. McGlynn, and G. Smith, *Responsive Environments: A Manual for Designers* London Architectural Press, 1985.
[14] R. Venturi, *Complexity and Contradiction in Architecture*. London: The Architecture Press Ltd., 1966.
[15] R. Krier, *Urban Space*. London: Academy Editions, 1979.
[16] P. Spreiregen, *Urban Design – The Architecture of Town and Cities*. New York: McGraw-Hill Co., 1965.

[17] 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.
[18] E. Cubukcu and I. Kahraman, "Hue, saturation, lightness, and building exterior preference: An empirical study in Turkey comparing architects' and nonarchitects' evaluative and cognitive judgements," *Journal of Color Research & Application,* vol. 33, pp. 395 - 405, 2008.
[19] P. Green-Armytage, "The value of knowledge for colour design," *Color Research & Application,* vol. 31, pp. 253-269, August 2006.
[20] J. Itten, *The Art of Color: The Subjective Experience and Objective Rationale of Color*. New York: Van Nostrand Reinhold Company, 1973.
[21] A. Valberg, *Light Vision Color*. England: John Wiley & Sons Ltd., 2005.
[22] B. Fraser, C. Murphy, and F. Bunting, *Real World Color Management*, 2nd ed. U.S.A.: Peachpit Press, 2005.
[23] 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 (Wiley),* vol. 30, pp. 21-30, 2005.
[24] H. Sanoff, *Visual Research Methods in Design*. New York: Van Nostrand Reinhold Co., 1991.
[25] J. L. Nasar, *The evaluative image of the city*. Thousand Oaks, California Sage Publications, 1998.
[26] I. Bentley, *Urban transformations: power, people and urban design*. London; New York Routledge, 1999.
[27] M. Gjerde, "Visual Aesthetic Perception and Judgement of Urban Streetscapes," in *18th CIB World Building Congress*, Salford, United Kingdom, 2010, pp. 12-22.
[28] N. J. Habraken, "Cultivating the field, about an attitude when making architecture," *Places,* vol. 9, pp. 8–21, 1994.
[29] M. Carmona, T. Heath, T. Oc, and S. Tiesdell, *Public places, urban spaces: the dimensions of urban design*, 2nd ed. Amsterdam; Boston: Routledge, 2010.