Intrusiveness of Outdoor Advertising and Visual Information

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***Abstract*—*The placement of outdoor advertising is a crucial task where people identify those are as intrusive elements of the built environment. Thus, there is a need of finding, why outdoor advertisements are considered as intrusive elements. In this background, this research aims to examine an association between the level of intrusiveness (a negative visual quality) and the level of visual information. The methodology of this research includes Shannon's Information Theory based entropy values to measure the level of visual information and the level of intrusiveness is evaluated by conducting a perception survey. The result of the level of visual information is correlated with the road users' perception to see the association. The findings of the research are, the t-test result shows the outdoor advertising add visual information to the built environment and the correlation analysis depicts a positive correlation between the level of visual information and intrusiveness. Moreover, this research introduces a widely applicable methodology that proves the possibility of employing entropy to measure the visual information and permits advertisers and planners to objectively decide the placement or elimination of outdoor advertising.*

Keywords*—*Entropy, Perception, Intrusiveness, Outdoor advertising, Visual information

I. INTRODUCTION

The visual quality of the built environment makes imageability of the place as well as negative perception. Nasar (1990) studied two cities in United States to describe the positive and negative imageability of built environment. He used evaluative maps that were prepared based on the perceptions of residents and visitors regarding the areas they liked and disliked based on physical features. The findings revealed that the negative evaluations (dislike) were highly associated with chaotic signs and billboards than the appearance of buildings, industry, highways, utility poles/wires, parking, riverfront, railway, gas stations and buses. The majority of respondents preferred to improve the environment by reducing the prominence of signs and billboards. As per the research results, the authorities decided to remove over 40 billboards from highways. Likewise, the contemporary discourse related to outdoor advertising is also negatively perceived, while there is a doubt whether all outdoor advertisings are intrusive to the road users.

The places like Times Square in New York and Piccadilly Circus in London are produced by outdoor advertising. On the other hand, road users' negative perception of outdoor advertising due to the wrong location decisions would negatively impact on the city image, brand perception and ultimate outcome would be elimination of outdoor advertisements from the streetscape (Wilson and Till, 2011). The scholars have identified tourism (Taylor and Taylor, 1994) and transportation (Edquist et al. 2011) sectors are impacted by this visual intrusiveness. In this background, aim of this research is to explore the association between intrusiveness and level of visual information. The location specific understanding of the association of the level of visual information and the level of intrusiveness would be a valuable guidance for advertisers and city planners to make decisions. And this study can be grounded on Shannon Information Theory, which is limitedly used to assess the visual quality of the built environment.

This empirical investigation largely refers to the photograph based empirical data sources and the level of intrusiveness will be collected from road users by using a short questionnaire. The process has three phases, namely: find the level of intrusiveness by analysing the road users' perception; image processing with Photoshop and MATLAB Digital Image Processing platform to find the entropy or the level of visual information; *t-test* to statistically establish the impact of outdoor advertising on visual quality of streetscape; and correlation analysis to depict the association between the level of visual information and intrusiveness.

II. INTRUSIVENESS OF OUTDOOR ADVERTISING

People produce their positive or negative image of the city by drawing different information collectively. Haken and Portugali (2003) posit that the imageability of a city depends on the amount of external information that is represented by different urban elements. Outdoor advertisements along the streets have become widespread across the world today and have been adding information to the urban streetscape (Guerra and de Camargo Braga, 1998). Cronin (2008) explains that outdoor advertisementis also a key calculable element of the production of urban space.

Outdoor advertising can be classified into three main groups: signs on vehicles, signs at the point of sale, and signs away from the point of sale (Andreassend, 1985). However, this study does not consider the movable outdoor advertisements like signs on vehicles. Some outdoor advertising is now more sophisticated with sound effect, but, the research explores only the visual intrusiveness of outdoor advertising.

Intrusiveness is a negative perception, irritation or annoyance which evokes due to outdoor advertisements (Li et al. 2002). Kozyris (1975) mentions, since in the history the sellers tend to communicate the buyers what is on the market through different media, but potential excesses of outdoor advertising can conflict with the other space users' interests. In this view, Kozyris provides a clue to a relationship of a number of information and negative perceptions of the road users. He further explains intrusiveness occurs in a situation where people have not expressed any interest to receive a message from advertisements, but captive involuntarily. Moreover, the scholars indicate outdoor advertisements can be a cause of distracting the drivers and creating safety hazards (Bendak and Al-Saleh, 2010). While outdoor advertising has been criticising due to the intrusion of commercialism in the cities at the expenses of public order which embodies 'the common good' (Iveson, 2012), Raj et al. (2014) mention the information provided on outdoor advertising grabs public attention and creates a memorable impression. Thus, it can be argued that all the outdoor advertisements may not intrusive or the level of intrusiveness can be context specific. Taylor and Taylor (1994) mention the empirical analysis has some potential to resolve the anti-billboard and pro-billboard arguments. Further, they recommend the policy makers to consider the information contain in the billboards as a main factor of the analysis process.

Some scholars refer the excess amount of visual information as information complexity. Tucker, Ostwald, Chalup et al. (2005) indicate that the amount of information which is perceived within a streetscape, particularly the "noticeable differences" between forms of information, provides a measure of the visual complexity of that streetscape and it determines intrusiveness of the street. According to Nasar (1994), the environmental complexity comprised with visual richness, ornamentation, diversity, information rate and variety of information in an environment. When there is more richness or more variables in the environment, it is considered to be a complex environment (Gilboa and Rafeli, 2003). Drake (1991) emphasises the need of controlling the degree of sign complexity to achieve the desired character of specific streetscape. Presumably, the judgements of the amount of information which is generated by outdoor advertising is largely based on subjective judgements. In view of this gap, introduction of Shannon's Information Theory to advertising research would permit to initiate more objective analysis, particularly where the outdoor advertisements are perceived as a visual information.

III. MEASURING THE VISUAL INFORMATION OF THE STREETSCAPE

Wang and Shen (2011) mention information theory can be used to quantify the amount of information in scientific data sets and to measure the quality of visualization. A key measure of information is entropy. Spiekermann and Korunovska (2014) say higher information in a still image is well correlated with higher entropy. Shannon introduces the concept of entropy in the field of information theory by describing an analogous loss of data in information transmission systems (Wang and Shen, 2011). Shannon (1949) defines the entropy of a given system as weighted average of the probability of occurrence of all possible events in that system. In this theory, the meaning and the content of the message is disregarded when quantified the information, but consider only the probability. In the following equation, H represents the entropy, while p is the probability of the occurrence of a level of a factor, and the summation is over the levels of the factors. The entropy level is zero if every factor is the same, and entropy is maximised if each factor is different (Stamps 2002).

$$H_{factor} = -\sum_{i=1}^{nlevels} p_i \, log_2 \, p_i$$

Haken and Portugali (2003) apply this theory to the urban landscape with the aim of studying the city elements and its information level. That study reveals different urban elements in the city express different levels of information to the navigator. The city elements of which are identical or similar to each other, transmits very little information. On the other hand, when all objects are different from each other, information is high, but our cognitive ability to make use of this information is low.

Therefore, in this research study, visual entropy is selected as a more effective quantitative measure which evaluates the visual information.

IV. MEASURING THE INTRUSIVENESS OF OUTDOOR ADVERTISING

Nasar (1987) examines commercial scenes to find the signscape complexity by simulating the street with colour photographs. The set of photographs consisted with different level of complexity and different levels of contrasts. Three different representative groups had to rank-order the street scenes for coherence from most coherent to least coherent. The results show that judgement of coherence was lowest for the most contrasting signscape and higher for the moderate contrasting signscape. In terms of complexity, judgement of coherence was highest for the least complex signscape and lowest for the most complex sign scape.

Taylor and Taylor (1994) analysed the relationship between billboards and tourism in the state of Michigan using videotaped data. Their main analysis method is content analysis has done with a pre-developed coding scheme. The results revealed the information contains in a billboard (2.38) exceed the accepted advertising research standard (2.04 information clues), but a decision of eliminating them is far from clear-cut as the information is useful for tourism purpose.

Young and Mahfoud (2007) conducted a study by using a driving simulator to examine the effects of roadside advertising on drivers' attention and performance. Urban, rural and motorway are the three types of roads are taken for evaluation and the conditions of the routes are controlled and stimulated 'with and without billboards', placing the advertisements in semi-random locations and change the placement into road sides (right or left) and so forth. As a sample, 48 participants drove each of these routes and total number of crashes, drivers eye movements and driver's attention were recorded in the simulation space. At the end of the test, participants were asked questions related to the billboards' conditions. Three types of roads are comparatively analysed with ANOVA and *t*-test. The results indicate that the presence of billboards impacts drivers' performance as it influences to the driver's attention, thereby, leads to crashes. The eye fixations increased where a billboard presence. Moreover, the participants' recalling capacity of road signs appeared to be impacted by billboards depending on the road types as participants could recall billboards more than the road signs.

Portella (2007) examines the visual pollution in three historic cities due to the commercial signage, which are displayed in building facades and public spaces. The specific aims of the research are to find (i) user satisfaction with commercial street facades; (ii) user evaluation of order, colour variation, and complexity; (iii) user feelings of pleasure and interest level with respect to the appearance, and (iv) a number of commercial signs, and the percentage of building facade coverage of commercial streetscape. The colour photo stimulation is the method used. As scholars state that user preferences varies based on users' background and urban contexts (Coolican, 2004 cited in Portella, 2007), the photographs were shown to randomly selected professionals and lay people (361 sample) and recorded their perception by using a short questionnaire in order to compare among different preferences. A focus group discussion conducted in each case study to further understand the reasons of their preferences. The study reveals the users' preference is influenced by familiarity and symbolic meaning attributed to the buildings and users' perception is varied based on the urban context. However, the preference among distinct user groups (professional and lay people) not significantly different. Moreover, the user satisfaction has been influenced by the percentage of façade covered by the commercial signs than the number of commercial signs. To solve the issue, the author recommends to control the façade coverage by commercial signs, thereby to decrease the complexity and colour variation to compatible with a historic city. By concluding the article, author states the possibility of employing this concept to develop a general approach to control the commercial signs based on the contexts.

Accordingly, the available analysis methods are either technically sophisticated, expensive or based on people's perception. The literature review discloses the way of recording the visual quality of streetscape in a photographic survey, use of with and without advertising scenarios and the way of conducting a perception survey.

V. METHOD

A main data source of the research is photographic survey, which involve photograph capturing along High Level road, a main commercial spine of Colombo, Sri Lanka (Fig 1).). About 50 street scenes are captured by a handheld digital camera to obtain the serial view of the streetscape (Fig 2).

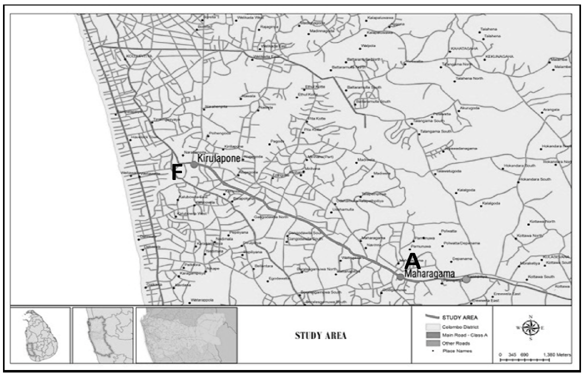


Fig 1: The case study area
Source: Authors

The road users' perception is also recorded by using a questionnaire survey to determine the level of intrusiveness. The road users are selected on-site as well as off-site. On-site road users are randomly selected to form a sample of 60 road users at the locations where photographs are captured. They are comprised with 60% of 35-45 age category, 56% are male and only 4% walking along this street segment for the first time. The main question asked from road users is, 'How do you evaluate the street scene with outdoor advertising?' under ten variables; interest, order, colourfulness, complexity and pleasing as positive expressions and boring, disorder, colourless/too much colourful, complex and unpleasing as negative expressions which are evaluated as per a Likert scale of 0-5 corresponding to 'extremely less', 'less', 'less moderate', 'moderate', 'high', and 'very high'.

The selected off-site users are predominantly professionals and drivers (sample is 20) and they have given "with and without billboards" photographs with a questionnaire to evaluate the street scenes (Fig 3). Nasar (1994) and Portella (2007) mention that evaluation of streetscapes by observing a photograph is very similar to the evaluation of the same streetscapes is observed on-site. The Likert scale results of perception survey is analysed with descriptive statistics. The result shows positive or negative values and negative values indicate the places of the road users perceive outdoor advertising is intrusive.

The image processing has done in two instances; processing of photographs with Photoshop software and processing with MATLAB Digital Image Processing platform.

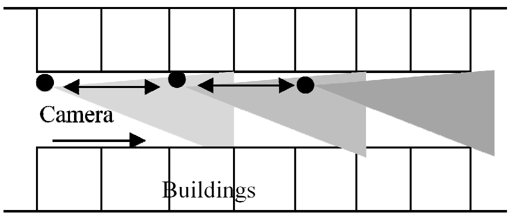


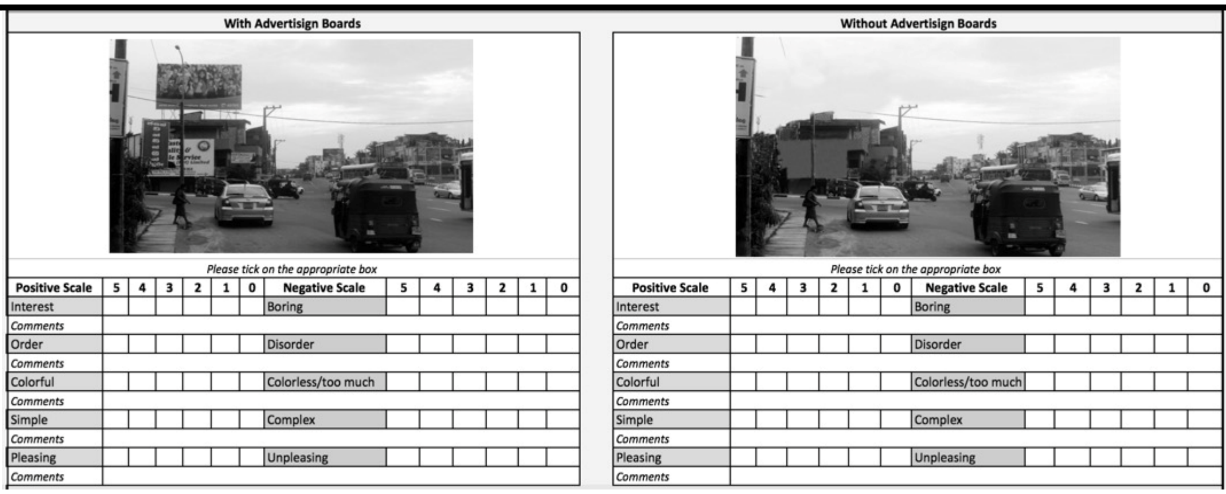
Fig.2: The method of photographing the streetscape as serial vision

All 50 street scenes are edited in Photoshop by deleting the outdoor advertisements to produce 'without outdoor advertising' scenario (Fig 3 and 4). Secondly, MATLAB Digital Image Processing platform is used to measure the information by employing entropy. MATLAB is considered as a sophisticated data analysis and visualization tool.

The pixels' order of images is estimated to derive visual entropy and it derives the degree of information richness. The visual entropy calculation process includes, reading an RGB image (the picture is read in RGB format pixel-by-pixel between 0 – 255), improving the contrast with the method of histogram equalization (probability of random variable p*i* can be estimated by using a histogram), and calculating the entropy value by developing an algorithm ($E = -sum (p_i * log2 (p_i))$) (Annexure 1: The key algorithm for entropy calculation). The process has run for 50 photographs of 'with outdoor advertising scenario' and 50 photographs of 'without advertising scenario' to find the level of impact. The two variables are then subjected to *t-test* by using SPSS to determine the difference of "with" and "without" outdoor advertising scenarios, which means the impact of outdoor advertising.

Fig 3: With outdoor advertising

Fig.4: Without outdoor advertising
Source: Authors



With Advertisign Boards

Please tick on the appropriate box

Positive Scale	5	4	3	2	1	0	Negative Scale	5	4	3	2	1	0
Interest							Boring						
Comments													
Order							Disorder						
Comments													
Colorful							Colorless/too much						
Comments													
Simple							Complex						
Comments													
Pleasing							Unpleasing						
Comments													

Without Advertisign Boards

Please tick on the appropriate box

Positive Scale	5	4	3	2	1	0	Negative Scale	5	4	3	2	1	0
Interest							Boring						
Comments													
Order							Disorder						
Comments													
Colorful							Colorless/too much						
Comments													
Simple							Complex						
Comments													
Pleasing							Unpleasing						
Comments													

Fig.5: Model of short questionnaire has given for off-site road users

Source: Authors

Finally, we analyse the two sets of data with *Bivariate CorrelationAnalysis* to find the association between road users' perception of outdoor advertising and the entropy values.

VI. RESULTS

According to the perception survey, the respondents perceived that the outdoor advertising along High Level Road add displeasing appearance (70%), more complexity (84%) and disorder (78%), although outdoor advertisements add colour (74%) and interest (64%) to the streetscape. The average road users', professionals' and drivers' perceptions has no significant variation.

When processed with MATLAB, the entropy values of the photographs of 'with outdoor advertisements' are higher or similar to the 'without advertisement photographs' (Fig 6). That means the information content of the street scenes 'with outdoor advertising' is higher. When run a *t-test* to find the overall difference of with and without advertising scenarios, the result proves that there is a significant difference (*t* 6.705, *p* .000). That means the level of visual information of this streetscape has been significantly impacted due to outdoor advertising.

When considering location specifically, the level of visual information is comparatively higher at the segments A, E and F which are functioning as major junctions along the commercial spine and have multiple storied buildings, colourful buildings, advertising signs and activities. The visual information is high along the segment E and F even without significant impact of outdoor advertising. The cause of this higher visual information are, high intensity of buildings and urban activities due to the closeness towards the Colombo City Centre.

Moreover, Paired Sample *t-test* is conducted to identify the impact of outdoor advertising in each segment (Table 1). Accordingly, segment B (*t* 6.023, *p* .004), segment D (*t* 5.532, *p* .003), segment E (*t* 4.002, *p* .001) and segment F (*t* 2.915, *p* .017), the most commercialised segments, have a significant impact from outdoor advertising. The level of visual information is high in segment A, but impact of outdoor advertising is low (*t* 2.632, *p* .058). Comparatively, Segment C is not impacted due to outdoor advertising (*t* 2.238, *p* .089) as the segment is not intensively developed compared to other segments.

At the same time, the variation of road users' perception and the level of visual information due to outdoor advertising along the streetscape denotes (Fig 7) the places with more entropy are the most intrusive areas. A substantial part of C, D, E and F segments have more entropy and road users consider intrusive compared to other segments. As same as Nasar's research finding, road users perceive a reason of the intrusiveness of outdoor advertising is that those are located in visually complex built environments.

Although the level of information in segment A (*Maharagama*) is high, road users do not consider that area has visually intrusive outdoor advertising. Comparatively the visual information of segment D low, but road users consider the outdoor advertising is visually intrusive as outdoor advertisements highlight beyond some important buildings and landmarks of the node. The physical characteristics of outdoor advertising such as size, proportion, colour, location and numbers of outdoor advertisements can create a displeasing, complex and disorderly environment, particularly where the visual information is comparatively high even without advertising, namely, segments E (*Nugegoda*) and F (*Kirulapana*).

Finally, the result of thecorrelation analysis confirms a positive correlation between level of intrusiveness and the level of visual information which is generated due to outdoor advertising (Table 2).

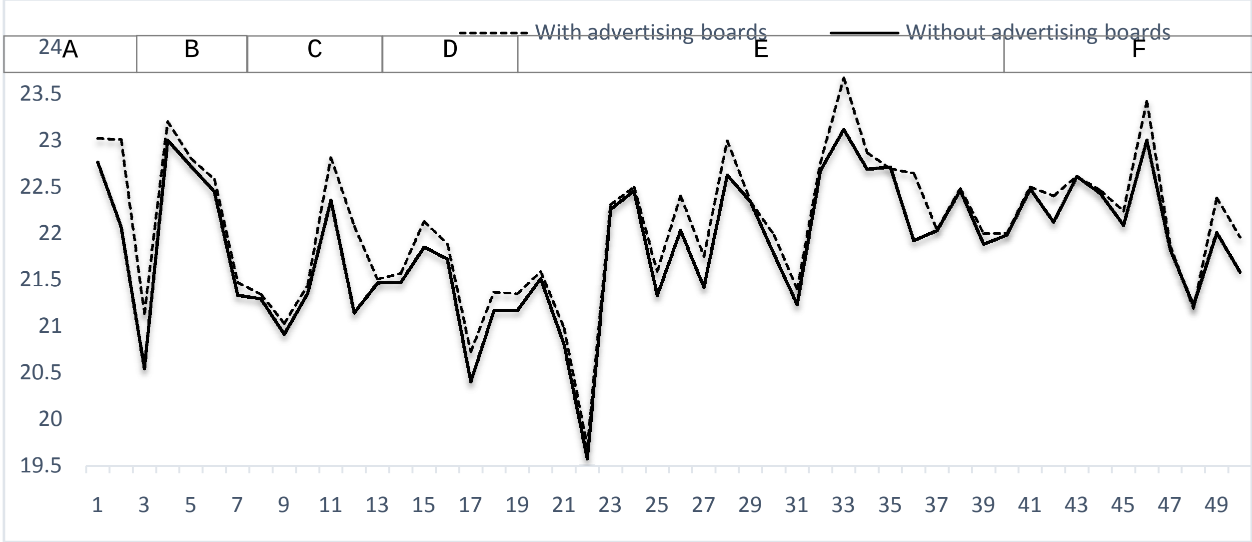


Fig.6: Fluctuation of entropy values of with and without outdoor advertising along High Level road

Source: Authors

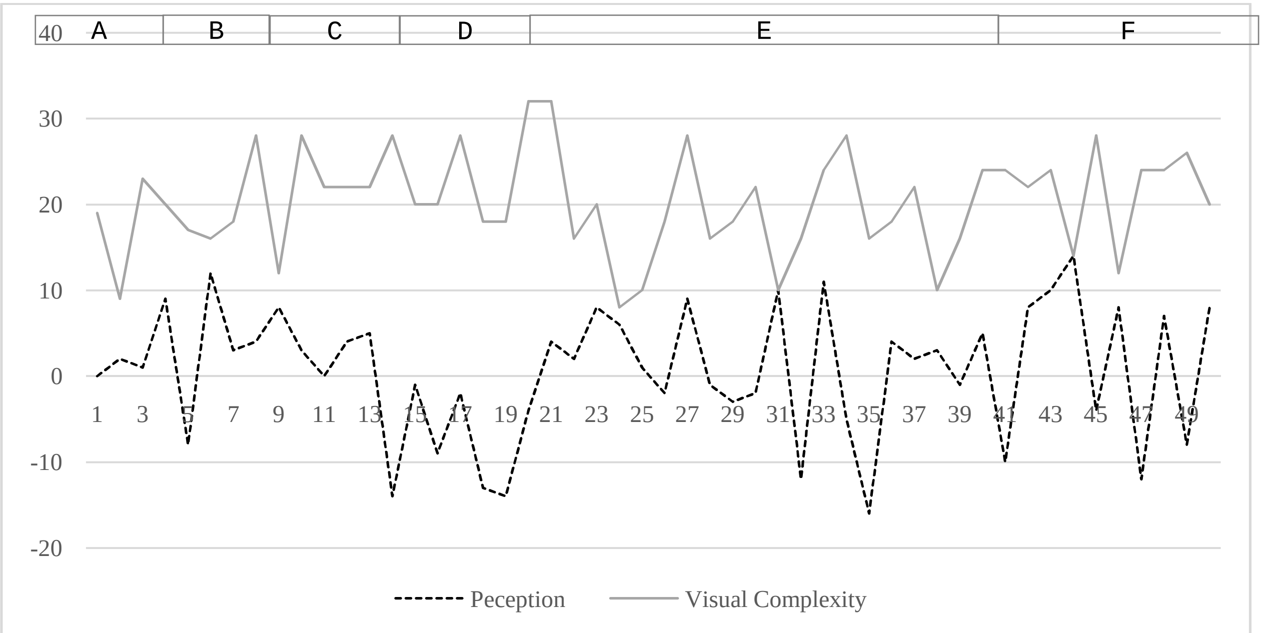


Fig.7: Variation of intrusiveness and the level of visual information of outdoor advertising along the streetscape (negative values indicate the intrusiveness)

Source: Authors

Table.1: Results of paired samples t-test to find the difference of entropy

Segments		Paired Differences							
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference: Lower	95% Confidence Interval of the Difference: Upper	t	df	Sig. (2-tailed)
Maharagama (A)	With Advertisement Scenario - Without Advertisement Scenario	.41134	.34879	.15598	-.02174	.84442	2.637	4	.058

Nawinna (B)	With Advertisement Scenario - Without Advertisement Scenario	.10130	.03761	.01682	.05460	.14800	6.023	4	.004
Vijerama (C)	With Advertisement Scenario - Without Advertisement Scenario	.35836	.35812	.16016	-.08631	.80303	2.238	4	.089
Delkanda (D)	With Advertisement Scenario - Without Advertisement Scenario	.18232	.08073	.03296	.09760	.26703	5.532	5	.003
Nugegoda (E)	With Advertisement Scenario - Without Advertisement Scenario	.18746	.20317	.04661	.08954	.28539	4.022	18	.001
Kirulapana (F)	With Advertisement Scenario - Without Advertisement Scenario	.16401	.17792	.05626	.03674	.29128	2.915	9	.017

Source: Authors

Table.2: Correlation of the level of visual information and intrusiveness

		Additional visual information due to outdoor advertising	Intrusiveness
Additional visual information is generated due to outdoor advertising	Pearson Correlation	1	.404**
	Sig. (2-tailed)		.004
	N	50	50
Intrusiveness	Pearson Correlation	.404**	1
	Sig. (2-tailed)	.004	
	N	50	50

**. Correlation is significant at the 0.01 level (2-tailed).
Source: Authors

VII. CONCLUSION

The prevailing, people's perception based research works highlight that outdoor advertising negatively impacts to the visual quality of the built environment. This research conceived the phenomenon step ahead and attempted to evaluate the association between intrusiveness to the outdoor advertising and the level of visual information of a streetscape by incorporating Shannon's Information Theory based method.

The methodology was developed by reviewing existing literature on similar research. The level of intrusiveness of the outdoor advertising was evaluated by conducting a perception survey. Both on-site and off-site road users, including professionals and drivers have responded to a short questionnaire which consisted ten variables to evaluate as per a Likert scale. All the responses were analysed with descriptive statistics to identify where and to what extent people consider outdoor advertisments are intrusive. The process of evaluating the level of visual information along the streetscape was; 1. collect visual data during a photographic survey; 2. process photographs with Photoshop to stimulate with and without advertising scenarios; 3. process both types of photographs with MATLAB to get entropy values; 4. find the entropy difference of with and without advertising scenarios to get the visual impact of outdoor adverting; 5. confirm the impact by analysing with t-test; and 6. visualise the pattern along the streetscape as a line graph. The final step of the methodology was, find the association of level of intrusiveness and the level of visual information by correlating the perception survey's results and entropy.

The findings of the research are twofold. Firstly, it confirms the association between level of intrusiveness and the level of visual information. That association is confirmed statistically and illustrated graphically by referring to specific locations of the streetscape. Secondly, this research derived widely applicable methodology. It confirms the possibility of incorporating Shannon's Information Theory based entropy to measure the visual information of the streetscape. This research used primary and inexpensive data sources that do not need sophisticated laboratories to do stimulations and analysis.

A limitation of this research is that it was not possible to determine the road users' acceptable level of the visual information as empirical work has done for a streetscape in Sri Lanka. Thus, further research on different contexts has to be done and it would be more appropriate to test in other colour spaces, such as CIELAB, which is designed to be very close to the normal human perception of colours.

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Annexure 1: The key algorithm for entropy calculation,

```
closeall;
clearall;
I= imread('1.jpg'); % reading the image
imshow(I);
size_I=size(I);
No_pixels = size_I (1,1)*size_I(1,2); % total number of
pixels
E_r=0;
E_g=0;
E_b=0;
Entropy_img = zeros(1,3);
rgbhistvalues = rgbhist(I);
p=rgbhistvalues ./No_pixels ;
fori=1:1:length(rgbhistvalues)
   %% Red Entropy
if p(i,1)~=0
E_r=-1*p(i,1)*log2(p(i,1));
else
E_r=0;
end
Entropy_img(1,1)=Entropy_img(1,1)+E_r;
   %% Green Entropy
if p(i,2)~=0
E_g=-1*p(i,2)*log2(p(i,2));
else
E_g =0;
end
Entropy_img(1,2)=Entropy_img(1,2)+E_g;

    %% Blue Entropy
if p(i,3)~=0
E_b=-1*p(i,3)*log2(p(i,3));
else
E_b=0;
end
Entropy_img(1,3)=Entropy_img(1,3)+E_b;
end

Total_Entropy = sum(Entropy_img); % Total Entropy
(By adding the three entropy values)

display(Entropy_img); % array containing the red, green
and blue entropy values
fprintf('The Entropy of the Red value %3.4f\n
',Entropy_img(1,1));
fprintf('The Entropy of the Green value %3.4f\n
',Entropy_img(1,2));
fprintf('The Entropy of the Blue value %3.4f\n
',Entropy_img(1,3));
fprintf('The Total Entropy of the image %3.4f\n
',Total_Entropy);
```

Code for Histogram of RGB values

```
function rgbhistvalues   = rgbhist(I)
%RGBHIST   Histogram of RGB values.

if (size(I, 3) ~= 3)
   error('rgbhist:numberOfSamples', 'Input image must be
RGB.')
end

nBins = 256;

rHist = imhist(I(:,:,1), nBins);
gHist = imhist(I(:,:,2), nBins);
bHist = imhist(I(:,:,3), nBins);


figure
subplot(3,1,1)
h(1) = stem(1:256, rHist);
set(h(1), 'color', [1 0 0]);
title('Red Histogram');
subplot(3,1,2)
h(2) = stem(1:256 + 1/3, gHist);
set(h(2), 'color', [0 1 0]);
title('Green Histogram');

subplot(3,1,3)
h(3) = stem(1:256 + 2/3, bHist);
set(h(3), 'color', [0 0 1]);
title('Blue Histogram');
 rgbhistvalues= [rHist gHist bHist];

end
```