Environmental Perception: Image Based Analysis of People's Impression of Places

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Abstract

Public places cast an impression on the user or visitor of the place. However, there exists a substantial gap in analyzing and understanding this impression scientifically. Human beings take crucial decisions based on this environmental perception which in turn has ramifications upon feelings and emotions. This directly or indirectly impacts on image building, financial and well-being aspects. This research is built on image-based qualitative analysis and on the feedback derived from selected locations of IIT Kharagpur campus in India using empirical eye tracking methods. The objective of the present study is to demonstrate the gap that exists between individual’s visual perception and the visual aesthetic of the urban environment. The experiments executed in this study have generated heat maps for attractiveness, organization, novelty and smartness; which share lots of common aspects. It was noted that given the nature of the heat maps, there are certain pivotal elements, which dictate the aesthetic impression of the observer. Text is one of the elements, which garners attention as it engages the observer in a conscious thought process. Further, the definition of smartness given to the participants has corroborated the findings of this experiment.
1. INTRODUCTION

As India ushers into the smart age, the government did not fall behind on commissioning the smartening of the cities. In the first phase, 100 cities have been selected from all the states of India for implementing smart initiatives. Smart cities and villages are complex systems with a culmination of various parameters. Smart city features are not just restricted to domains of mobile phones and internet services but the smart dwellings and enhanced living enclosures. In a larger context, it relates to Internet of Things concept (Rathore et al., 2016 and Saber et al., 2017). While existing emphasis on smartness revolves around technology, communication, governance and sustainability, often the aspect of visual perception is completely ignored. Vision being the most dominant of all the senses put together for human beings, our perception of the environment is crucial for human cognition and behavior towards it (Barbara and Eugenio, 2015). Visual perception is also deeply connected with aesthetic evaluation. In the growing buzz of smart cities and smart places, where one can find the ‘smartness’ in the aesthetic paradigm of our cities, is urbanscape. Undeniably, the aesthetics shape our environmental behavior, and culture (Dominic et al., 2015). It also affects our feelings, emotions and decision making to some extent. Making cities smarter, making human lives smarter is not only about infusing and imposing technology, but also about human visual perception towards the new paradigm of context to the existing, which affects the environment they interact with affecting their daily lives (Gibbs, 2000; Betsill and Bulkeley, 2006; Rydin et al., 2012).

In the past, studies pertaining to detailed characterization of urban environment in terms of visual perception and aesthetics is however missing. Hence, this present research aims to study this gap that exists between visual perception relating to individual internal smartness and the visual aesthetic of urban environment. An urban environment whether smart or not, is a source for infinite stimuli. These stimuli affect people’s perception, and thus percolates to various actions in their daily lives (Mosavynezhad and Jafari, 2015). The research envisages on methodological approach towards to physical parameters, sieved through visual parameters which finally affects the perceptual impression. That in turn serves the basic function towards aesthetic evaluation. This conceptual framework needed to be validated by analyzing each of the parameters mentioned. The research employs an experimental setup to back up this theoretical argument. Empirical study has been based on Eye-tracking mechanism (Piga et al., 2011; Piga and Eugenio, 2013), to establish relationship between these parameters. Set of willing participants have engaged in the experiment to unearth the process by which immediate visual perceptions lay foundation for linking aesthetics, urbanscape and behavioral constraints. Emphasis has been on studying the perception mechanisms that warrant a reaction from the observer. These reactions are parameter based and these reactions give essential clues
to the relationship of aesthetic evaluation, visual perception and environments physical parameters. This research also brings out an important facet relating to culture or community specificity. Given that the perceptions are not universal, for a country like India, with such diverse populous, the need to integrate cognitive processes with the development of the framework is also realized. Hence, demonstration of this variability in a flexible yet robust framework has essentially been the target of the study.

1.1. Visual perception and Aesthetic impression

This paper gives useful insight to how visual perception plays an important function relating to change of physical parameters in the urban environment on one hand, and on the other, the reactions evoked or impressions created towards the environment. Various environmental initiatives, including smart cities, often lack this perception centric paradigm due to lack of proper methodology. There has been an endeavor to mitigate this existing gap through this paper. Visual perception is the capability to (Perovic and Folic, 2012; Basu and Ghosh, 2016) understand and interpret our environment or surroundings. It is both a conscious and subconscious meaning-making process which is a result of the external visual stimuli and our own knowledge accumulated since the time of birth (Greenwald et al., 1995; Ghosh et al., 2013 and Ghosh et al., 2015). Aesthetic impression is related to an individual’s evaluation of the surrounding environment. It is directly related to the visual perception as the ‘evaluation’ goes parallel with registering of the visual stimuli and the process of turning the stimuli into a meaningful experience (Winters, 1986; Arnold and Carlson, 2007).

Urban is a place-based characteristic that incorporates elements of population density, social and economic organization, and the transformation of natural environment into a built environment (Weeks, 2008). The built environment which consists of man-made elements such as buildings, furniture, hoardings, landscape, etc. is a source for plethora of visual stimuli. Undeniably the visual perception shapes our behaviour, and, in fact, in most cases our behaviour can be viewed as a direct response to the environmental stimuli of which the visual component is dominant. People create an urban place and then are influenced by the place that has been created (Weeks, 2010). This influence of the urban place can manifest in our responses, that is, in our emotions, behaviour, and our decision making process. This means that the aesthetics which are part of the urban place impact us greatly. People not only see the physical environment of buildings and react to what they see but they also have memory images of the environment and their behaviour is strongly affected by this images (Gary, 1979). Hence, the smartness of an urban place, in turn, of an entire City, is not only through technology, communication, sustainability, etc., but also through visual
parameters which influence our aesthetic evaluation. Thus, there is a requirement for emphasis on the study of visual parameters as to how they influence our aesthetic impression and in turn how they influence human behavior (Emily, 2003).

1.2. The smart city Paradigm

As India moves into the high growth phase, the government did not fall back on launching the ‘smart cities’ project (Smart Cities Mission, 2017). This includes combining the development with high technology into governance, sustainability, etc. However, given the aesthetics have a great impact on our decision making process, no effort has been made to integrate the aesthetic paradigm into the developmental process. The statement from the government for the 100 Indian smart cities is “........the objective is to promote cities that provide core infrastructure and give a decent quality of life to its citizens, a clean and sustainable environment and application of ‘Smart’ Solutions. The focus is on sustainable and inclusive development and the idea is to look at compact areas, create a replicable model which will act like a lighthouse to other aspiring cities.” The features for the smart cities would be mixed use development, housing and inclusiveness, walkable localities, preserving and developing open spaces, variety of transport options, citizen-friendly governance, smart solutions to infrastructure, and to create an identity based on main economic activity, local cuisine, sports, culture, furniture, hosiery, etc. No reference has been made to visual parameters and aesthetics in the smart cities (Smart Cities Mission, 2017).

Many studies have proved that the interdependence of visual perception, aesthetic impression and stimulus from the urban environment (Ulrich, 1983), but, the issue now at hand is to incorporate this theoretical framework into the development policies. The purpose of this paper is to raise this very particular issue. Including aesthetics on papers and policies cannot be mere shallow terms without objectivity. It is possible to analyze visual parameters as to how they influence the aesthetic impression. This analysis is intended to form a basis for quantifying aesthetic aspects of the urban environment based on experimental evidence. To achieve this the onus is on supporting the already existing theoretical framework with a Visual Performance Survey (VPS) experiment. This experiment is designed to evaluate and colligate key elements of the visual stimuli provided by selected images with the rating provided by the persons who have participated in the experiment.

2. METHODOLOGY

The present study is set up in three parts: (a) Setting up the experiment and the experimental framework, (b) carrying out the experiments and collecting the data and
opinions of the subjects, and, (c) analyzing the gathered data and checking in what way and to how much extent it corroborates with the existing theoretical framework and studies.

2.1. Experimental Framework

For the sake of objectivity, the experiment is designed to analyze few basic parameters that form a part of the whole ‘aesthetic impression’. These basic parameters are Attractiveness, Organization, Novelty and Smartness (Ernawati, 2013). These parameters, for the sake of this experiment, are defined as follows in basic terms.

Attractiveness is the unmediated impression of how likable and good a setting or the image of that setting appears to an individual. Organization is described as how systemic the spaces and its elements are, which extends to how easily understandable the (built) environment is. Novelty, as told to the subjects of the experiment, is the degree of uniqueness they attribute to the scene or setting. In simple terms, novelty extends to more uniquely recognizable elements of the scene. Integrating the above, for the sake of easy comprehension, smartness is defined. A ‘smart’ urban environment should be attractive, unique to the purpose, and organized among other aspects. However, for the case of visual-perception study, these three factors are more dominant.

The purpose of the experiment is to understand how people’s urban impression is influenced based on characteristics of the place. The characteristic locations used in this study are as shown in Figures 1 and 2. The experiment is itself crafted in a simple fashion. The individuals who participate in the experiment are shown a set of two images of two familiar places. The set of images is shown four times. Each time the set is shown, the urban settings shown should be individually rated, on 0 to 5 scale. In each set both the images are displayed on the screen for 10 seconds each. After displaying the set for the first time, the images are to be individually rated for attractiveness. The second time for organization, third for novelty and finally the fourth time for smartness.
2.1.1. The Experimental Set up

The two images used are those of two built settings within the Indian Institute of Technology (IIT) Kharagpur campus. One is the Technology Students Gymkhana (Figure 1) and the other is of the Tech Market (Figure 2). All the people participating in the experiment are familiar with both the places. The Gymkhana is a recently constructed building, which is the major activity center for the student life in the campus. The Tech market is a relatively old structure, which is the most prominent place for shopping within the campus. The images are taken such that buildings dominate the most part, but the streetscape is also present to give a sense of space,
scale, location, etc. These two locations are selected keeping in view of the importance of these locations for students, very high relevance to smart aspect, urban form-congregational and activity oriented. The most important aspect of this process is ‘eye-tracking’. Before the set of images is shown, the individuals are told that they are required to give a score to the images for one of the above four parameters. And, while they are viewing the images, the eye tracker records the eye path and also notes which areas in the images catch the attention, i.e., a heat map is generated. The eye tracking device is positioned in front of the test subjects while they view the images on a display. This device is an infra-red tracker, which tracks and records the eye moments and also duration of gaze. In addition, to attune to an individual’s eye movements, calibration of the tracker is done for every person undergoing the experiment.

2.1.2 Eye Tracking Experiment

As discussed in the previous section, the eye-tracking is central to the whole experiment. But, the onus is on how the experiment is framed. This can be done by adding detail as to how the experiment is executed. As the person sits for the experiment, he or she is asked to view the images and give a rating at the end. The experiment starts with showing the set of two images for rating them based on attractiveness. The person sitting in front of the display is asked to view the set for the first time, each of the two images for ten seconds, and rate them individually for attractiveness only. The same is repeated for the other three parameters. The presumption is that when the person knows what he or she is going to rate the settings (or the images of the settings) for, they consciously or unconsciously view certain elements in those scenes so as to judge them. Further, when a person is asked to rate for attractiveness, it is desired to know what elements are being viewed the most and how long. Same is the case with organization, novelty and smartness. Obviously, the rating they give at the end is based on what they see and how they see it and for how long. These heat maps not only have how long an individual observes a particular area on the display, but also gives a path diagram of the eye movement on the display. In addition, all these heat maps can be superimposed to get a heat map of an ‘average’ person.

2.1.3 Procedure for analysis

Once the heat maps are generated, they are carefully examined to see if there are any considerable commonalities in a particular category or not. Also, the ratings given would be pitted against the heat maps to find out based on what the judgement is being made. In addition to this, the average of the heat maps of both the images will be compared with the aggregate of the ratings given to the images for each category.
For instance, where organization is concerned, the average heat map of both the images will be generated to see what aspects of the settings are being observed while being rated for organization. Also, heat maps of individuals can be separately analyzed with the scores they give to get a better understanding of how to proceed with the analysis. The average score for organization for both the Figures 1 and 2 will reveal which of the two settings was perceived to be more organized, and by extension, comparing the average of heat maps for organization of both the images against the scores can give further insights into the understanding.

3. OBSERVATIONS AND FINDINGS

The images of the aggregate heat maps, i.e., the one which is the combination of all the heat maps generated by the participants of the experiment are shown in the following discussions. The number of individuals from whom the data for this experiment is collected are 40. Hence, the analysis for the each of the parameters is not standalone, but it is in comparison to the other parameters. In addition, as a whole the major emphasis will be on how the first three parameters i.e., attractiveness, organization and novelty relate to the smartness paradigm as it is defined. Also, the major emphasis will be on the average of heat maps and not on individual heat maps of a single person since deriving generalizations from a set of 40 individuals is not possible. However, individual heat maps have been looked at by the experimenter and the weightage contributed to the study is included. The following discussion deals with the attractive, organization, novelty and smartness heat maps of the two cases studied.

3.1. Attractiveness heat maps of Gymkhana and Tech Market

This section discusses and compares the attractive heat maps of the two cases studied, namely Gymkhana and Tech Market. Figures 3 and 4, shows the attractive heat map of the Gymkhana and Tech Market locations considered in this study. The figure demonstrates that the maximum burn through is observed in the large glazed area present at the top of the building and also at the text presented (see places on the building façade). Some amount of attention or eye gaze has been captured by the street elements such as the lighting post railing and such. What is interesting to note is that the road and the part of the street below the building plinth have captured very little or no attention. The attention garnered by the glazing could be attributed thusly: the reflective black glazing could have generated a sense of depth or the bright framing of the arches in contrast with the dark skin may have gained fixations or both.
In the context of TechMarket; as seen in the case study of Gymkhana, the attention is grabbed by the text in various places on the streetscape as shown in the Figure 4. However, the most burn through is over the central foliage. Undoubtedly, this particular foliage occupies major area in the center of the screen and the green color in contrast with the buildings in the background works in its favor in resting the viewers gaze.
3.2. Organization heat maps of Gymkhana and Tech Market

This section describes and compares the organization heat maps of the two cases studied, namely Gymkhana and Tech Market. The organization heat map of the Gymkhana (Figure 5) is more or less similar to the attractiveness heat map of the same. The difference between the two is that one can see the burns happening over a wider span, and also spilling on to the road and the boundary railing separating the road and the building premises. This horizontal burn through can be observed over the railing and the row of columns scene in the building.

Fig. 5. Organization heat map of Gymkhana

Fig. 6. Organization heat map of Tech Market
Following the lines of the Gymkhana heat map, the Tech market heat map (Figure 6) for organization is similar to its attractiveness heat map. In this heat map, it not only shows the central foliage which has the maximum burn through, some other elements such as text and shop doors have a red burn through. Also, the burn through is over a wider span.

3.3. Novelty heat maps of Gymkhana and Tech Market

In this section, we analyze and compare the novelty heat maps of the two cases studied namely Gymkhana and Tech Market. Figure 7 shows the novelty heat map of Gymkhana. In this particular heat map the maximum burn-through is on the glazed area framed between the arches on the top of the building and also on the area which is in between the two large circular red columns on the right of the building. Also, the text has captured the viewer's gaze considerably. Very minimal or no burn through is observed below the plinth of the building.

Fig. 7. Novelty heat map of Gymkhana

Fig. 8. Novelty heat map of TechMarket
Figure 8 shows the novelty heat map of Tech Market. The Novelty heat map for this particular built environment shows maximum burn through over the central foliage and some amount of burn through over the areas with large text. Some amount of minimal burn through, seen in blue, is spread over the entire image except the periphery.

3.4. Smartness heat maps of Gymkhana and Tech Market

This section discusses and compares the smartness heat maps of the two cases studied, namely Gymkhana and Tech Market. Figures 9 and 10, show the smartness heat maps of the Gymkhana and TechMarket locations considered in this study. Among the four different heat maps for the aforementioned parameters, the ‘Smartness’ heat maps for both Gymkhana and the Tech Market are more complex compared to the rest. They are complex in the sense that the spread of the burn areas is more and the burn-through areas in red are more in number. The burn-through areas in red are the glazed portion on the top, street lights, text and the area framed by the two big circular columns on the right. Further, the road, the railing, and the row of columns have gathered considerable gaze from the people who participated in the experiment.

Fig. 9. Smartness heat map of Gymkhana
4. INFERENCES AND KEY FINDINGS

To understand the heat maps is to understand the link between the physical and visual characteristics of spaces or elements. This process is nothing but the understanding the process of stimuli and response: why does a person look at something for long? How does it affect his or her judgement? And, in what way? As discussed earlier, given the lack of numbers, individual analysis for each heat map or the eye path is not possible. As mentioned in the observations, the heat maps of attractiveness, organization, and novelty share lots of common aspects. One important thing here, as discussed in previous sections, is that the person undergoing the experiment is given a description of each of the four parameters before he or she analyses the images of the settings to give a rating. This definition is intended to have an impact on the participant so that the heat maps generated are more objective and easy to analyze. The following are the major inferences and the key findings from this study:

- From the heat maps of the gymkhana, it can be easily made out that the large glazing framed by the arches caught the most attention followed by the text on the building facade. This holds true for all four of the heat maps. In the second heat map for gymkhana, which is for organization, the burn-through has
slightly increased in area when compared to the heat maps of attractiveness and novelty. And, the difference in the heat maps of attractiveness and novelty for the gymkhana is negligible given the small sampling. Hence, we may infer that while what is unique in the setting of the Gymkhana is also the attractive part, one tends to give attention to surrounding or ancillary elements or spaces when one judges in terms of organization (as it is clearly seen that the front railing and the circulation area in front of the gymkhana have gathered some burn through while it was not evident for the same in the other two heat maps). Clearly, we may observe that what is unique or attractive may not necessarily mean it is well organized or vice versa.

- Further, as we can see from the smartness heat map, both the streetlights and other elements have considerable burn through over them. This aspect makes the smartness heat map of the Gymkhana a combination of the previous three heat maps. Hence, the same parallels can be drawn in the case of the Tech market as well. The smartness heat map for this building has a greater spread of maximum burn through (in red) when compared to its other three heat maps. Also, upon observing the overall burn-through, it can be seen that all aspects that have garnered attention in the first three heat maps combined, have done so in the smartness heat map as well. Hence, in this case it is safe to assume that the smartness heat map of Tech Market is at least the combination of the heat maps of the first three parameters.

- As the participants were given the definition that the ‘smartness’ is a combination of the first three parameters (attractiveness, organization, and novelty) and more. The heat maps generated corroborate with this definition. Hence, it is concluded that the participants were consciously or unconsciously searching for the elements which make the urban setting attractive, organized and novel while they were judging for smartness.

- Given the nature of the heat maps, there are certain pivotal elements, which dictate the aesthetic impression of the observer. Text is an element, which garners attention as it engages the observer in a conscious thought process. Further, the definition of smartness given to the participants has corroborated the findings of this experiment.

5. CONCLUSION

The impact of visual and aesthetic parameters is much influenced by the socio-cultural background of the viewer. Where there is much that cannot be generalized or quantified universally, there can be a few prime parameters, which can be found to be common. It is the understanding of these commonalities that can usher in future research in visual semantics, which is not only backed by theory alone, but also by
experiments and controlled observations. Though the study in this field and allied fields is in its nascent stage, further research must develop rapidly for it is required for the fulfillment of this techno-modern wholesome society. The stimuli that our surroundings present have the greatest possible impact upon us, and, the visual component of that stimuli is quite enormous. This presents a very less studied field contrasted with the great impact such a study can bring to our society.

The study elaborated is in this paper is one of its kind in linking the theoretical framework to the experimental results in this particular field. This limited scope is partly due to the limitations of manpower and resources. If such a study were to be carried out in large scale with many more participants and researchers, more sound theories can be framed and verified. Also, given the advancement in technology, many types of devices are now available to study and understand the human behaviour, and there are numerous possibilities to dwell deeper, as one cannot deny the fact that the eye tracker, which is a very basic device in its own right, has provided for a sound and interesting experiment.

The prime objective of this research was to understand and link the relation between aesthetic impression and visual stimuli one’s environment provides. The medium used to make the study simpler is the use of images. In this regard, the basic definitions set out before the experiment and the procedures have held up through the process of the experiment. To add to this, that the results were positive and corroborative provides for a great deal of satisfaction.

The future direction of the research leads to detailed analysis various dimensions of image based eye tracking methodology. Also, different user groups could be surveyed in order to find differences in perception and associated causes. Public places are subject to multiple users, stakeholders and varied usage through the day or days. Hence a sequential study in future would reap useful findings in relation to holistic place perception. The newer urban development & place making as well as revitalization projects can adhere to the methodology adopted in the paper for its prudent analysis and subsequent design interventions. This would lead to a logical and holistic place making with consideration of its environmental perception. And hence create a better built environment in the world to live in.

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REFERENCES


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