Improved Photographic Representation of Human Vision for Landscape Assessment

Shao YUHAN, Eckart LANGE and Kevin THWAITES

[1]Department of Landscape, The University of Sheffield, Western Bank,
Sheffield, S10 TN, UK
shaoyuhan7@hotmail.com

Abstract

Photographs have been used for many years in landscape assessment. Typically, these methods rely on standard image formats (e.g. 24 x 36 mm). The main objective of this study was to develop a photo based interview process that offers an improved representation of real human vision. The process is composed of two main steps: the first step is to produce photos that replicate real horizontal as well as vertical human vision. These panoramic photos are then used in the second step to interview participants in order to identify local characteristic elements of the study site in Yantai, China. The results revealed that an interview using 180˚ panoramic photos offers improved representation of human vision and helps to pinpoint and understand people's perceptions of their surrounding landscape.

1   Introduction

Using images in landscape study was introduced decades ago. LINTON (1968) used images to assess the quality of natural landscape as early as 1968. The use of photographs as proxies to simulate landscape has been further developed by various researchers since the 1970s (ZUBE et al. 1974, DUNN 1976, SHAFER & BRUSH 1977, NASSAUER 1983, ZUBE et al. 1987) and there have also been extensive empirical studies conducted using photo-realistic visualisation to represent the real environment in recent years e.g. (DANIEL & MEITNER 2001, LANGE 2001, WILLIAMS et al. 2007). In this research, photos or images have been extensively used to gather people's opinions on certain landscapes or to assess and compare between different landscapes. A high correlation between responses to photographs and landscapes has been found in the literature (SCHROEDER & DANIEL 1981, KAPLAN & KAPLAN 1989).

However, there are gaps in terms of the characteristics of human vision and the technologies used in landscape representation (DANAHY 2001). Hence, computer based landscape modeling techniques have been introduced as a tool for landscape planning in the last decade (WALZ et al. 2008). This includes the use of computerised interactive visual simulation to assess environments in the design and planning process (LANGE 1994). Using 3D visualisation techniques to gather sufficient information from participants' interviews has been applied and tested in various studies, and has been shown as an efficient but resource intensive approach (WISSEN et al. 2008, LANGE et al. 2008). These approaches focus more on modeling the complex structure of the landscape than replicating the real world experience.

There are still reality differences between 3D technology, photo and real world in landscape study (LANGE 2001). Therefore, photography remains as a convenient and cost effective medium to extract people's opinion and preference on local elements.

The objective of this study is to focus on developing a new way of using photos to replicate the real human vision in their surrounding environment in order to identify preferred or disliked elements.

2   Methodology

2.1   Human Vision vs. Photographs

Vision is composed of both foveal and peripheral modes and is a dynamic process in which people visually explore their surrounding environment. Most people rely on foveal vision to identify photographs or paintings (ANTROP 2007); it is the form of vision that allows one to focus on only one aspect of the object and ignore everything else around it. In contrast, there is peripheral vision, which takes into account everything around us. It is used to sense dynamic changes in the patterns of the environment. As the peripheral vision system provides the cerebellum with information used to judge the surroundings, it has been proven to be a significant component of our awareness of space (ERNST et al. 2000, WATANABE & MATSUOKA 1999). Therefore when identifying the spatial qualities of a landscape, the human eye uses a combination of peripheral vision, movement and motion parallax and binocular vision to decipher the entire visual landscape (HILGARD et al. 1975, LANG 1987, DANAHY 2001).

2.2   Use of Panoramic Photographs in Landscape Studies

The validity of photographs has been questioned (SCOTT 2002) in that the photographs fail to replicate the saliency and contextual validity of the onsite scene (STEWART & HULL 1996, HUANG 2009).

PALMER & HOFFMAN (2001) used 19 studies that explicitly tested the validity of photographic representations. As a result, they argued that a standard 35mm wide-angle lens only captured 60˚ of human vision, which is a limited field of view, and discussed that an angle of view with 120˚ or more will be better accepted. While ANTROP (2007) found that humans can focus on 40˚ to 46˚ angle of a view, the studies from ZUBE et al. (1974) and PALMER & HOFFMAN (2001) have concluded, that panoramic and wide-angle color photography may be valid landscape simulation media.

SEVENANT & ANTROP (2011) used panoramic and normal photos to find the best alternative to an onsite procedure. They have used photos with 39.6˚, 80˚ and 100˚ horizontal view angles with 27˚ vertical angle to represent 12 landscape vistas and used a statistical model to measure the validity of the different angled panoramic photos. As a result, they have concluded that wide-angle panoramic photos offer improved representation of the landscape.

2.3   Horizontal Vision Angle of Panoramic Photographs

HENSON (1993) identified two key characteristics of human vision: binocular vision and field of view (FOV). The 120˚ binocular vision angle is the angle in which both eyes are used together to focus without any eyeball or head movement, whereas the FOV (view angle of 180˚) entails eyeball or head movements. HENSON suggests that the approximate field of view of an individual human eye to be almost 180˚. With eyeball rotation of approximately 90˚, horizontal field has a maximum 270˚ (DC 1999). ZUBE et al. (1974) have found that compared with wide-angle horizontal photos; panoramic photos with 122˚ view angle have produced closer results to the field response. DANIEL & BOSTER (1976) tested the efficiency of 180˚ view angle of panoramic photos. NASSAUER (1983) further tested a wider panoramic photo angle based on the work of ZUBE et al. (1974), suggesting that 140˚ panoramic photos could help to capture participants' preferences and better simulate the field experience. In addition, various smaller vision angles have been compared in the scientific world (ROBINETT & HOLLOWAY 1992, PIANTANIDA et al. 1992).

There have also been arguments to support the use of 360˚ panoramic photos as they provide complete freedom of view (ENGLAR & CONSOLATI 1990). Although it seems the wider the photo angle, the better it will cover the true human vision, too wide a field of vision might cause vision sickness (KOLASINSKI 1995, STERN et al. 1990).

In this study three sets of wide angle panoramic photos are used (all panoramic photos have been taken with a 60˚ vertical angle):

- 120˚, the binocular vision. It needs to be tested whether the binocular angle or FOV angle could provide better results.
- 180˚, the field of view. This is what people see in real life with their peripheral view.
- 360˚ photos have been suggested in landscape studies (ENGLAR and CONSOLATI, 1990).

A common debate is that although 120˚ has been suggested to represent the human binocular vision angle (WELLS & VENTURINO 1990), it has been argued that the angle is almost 180˚ with side vision (KOLASINSKI 1995). Landscape visualisation research has mostly focused on the representation of FOV rather than the binocular vision. It is believed that the wider view better represents the field experience, as people tend to look around when they are physically at the study site (BISHOP & ROHRMANN 2003, DANIEL & MEITNER 2001).

2.4   Vertical Vision Angle of Panoramic Photographs

GIBSON (1979) and BARFIELD et al. (1995) indicated the vertical human FOV is approximately 135˚. A standard modern digital camera has a smaller vertical angle (60˚) than human vision (135˚). ULRICH (1981) pointed out that, when shooting distance is limited, panoramic photos would have the limitation of not capturing the full vertical view. Therefore a way to combine two panoramic photos vertically to represent human vision is introduced.

Not all photos need to be formed combining two panoramic photos together. If the distance between the site and the camera is long enough, one single panoramic photo will be sufficient to include most of the elements in the study site. For example: with a camera having 60˚ vertical capture angle positioned at a height of 1.6m, with 10 m distance between the

camera and the recorded scene, the maximum height the camera can record is approximately 14 m. Therefore within this range, if the objects in the scene are taller than 14m, a vertical combination of two panoramic photos would need to be used.

NASSAUER (1983) also pointed out that when the shooting distance is long enough, one panoramic photo would accurately simulate the in-field experience, such as standing at the coast and shooting the view towards the sea.

3   Case Study, Yantai, China

In a first step traditional 60˚ photos are compared with 180˚ panoramic photos. And then three wide angles are compared to determine the best panoramic photo angle. The photos were taken along the center of the street using a Nikon Coolpix P510 Digital Camera with zoom range from 24mm to 1000mm (35mm equivalent focal lengths). The camera was attached to a tripod at eye level.

It has been suggested that between 12 to 20 participants for one interview group is an appropriate size (GUEST et al. 2006, CRESWELL 1999, SANDELOWSKI 1995). Hence a sample size of 15 was chosen for each case study.

3.1   Comparison of Smaller Angle Photographs with Panoramic Photographs

The photos, which were taken along the center of the study street, including one 180˚ panoramic picture and a set of three 60˚ photos to try to cover the same 180˚ view. The sets of photos below were taken at the site of Penglai Pavilion in Yantai, China and shown to two groups of 15 participants at a local coffee shop (without direct observation of the study site) to pick landscape features using circles (15 participants for the panoramic photos and 15 for the 3 small FOV images), which are the elements which they think are unique at the study site. Questions are used throughout the interview process to further investigate participants' opinions on their selections. The interview process is recorded using a digital recording pen. The same sets of photos are then shown to another group of 15 participants at the study, i.e. at Penglai Pavilion.
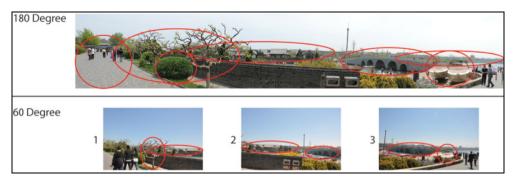

Fig. 1:   Selection of landscape features at Penglai Pavilion with different angles

Only elements that have been selected by more than 7 participants in each group are identified. People identified the following features most often:

- The pedestrian path.
- The pruned trees.
- The bridge and the historic architecture.

3.2   Horizontal Angle of Panoramic Photographs

After comparing the traditional 60˚ photos with wider 180˚ degrees wider-angle photos, which were commonly used and tested by various researchers, were compared between each other to see which angle would produce the best results when used in landscape study. The digital camera can be set to record two panoramic angles, 180˚ and 360. As well as the panoramic shooting mode, the camera has the ability to continue shooting one image until the selected range of 180˚ or 360˚ of horizontal view is covered, increasing the accuracy of the shooting angle. Because the purpose of using panoramic photos is to extract information from participants for the "surrounding environment", each set of photos need to cover the entire 360˚ to replicate the environment surrounding the participants. Therefore at each point three 120˚, two 180˚ and one 360˚ panoramic photos were produced to cover the entire surrounding site.

Three sets of photos were produced.

Fig. 2:   Panoramic Photos with Different Angles, Penglai Pavilion

Three photos of 120° (normal camera arc-degree) at each shooting point along the study site. Due to technical issues, it is impossible to measure a 120˚ panoramic angle when shooting the images, therefore the photo sets at each point are generated by taking a 360˚ panoramic photo using the camera settings and then split equally into three photos via a

third party software (e.g. Photoshop and Illustrator). As a result, each photo would represent a 120˚ view angle.

180° photos at each point along the study site. Taken as two 180° photos. For each photo the camera is placed at the center and rotated 180° to shoot the photo.

Photos at 360° at each point along the study site by rotating the camera.

Three groups of participants each with 15 participants (one group for each photo set) were chosen who agreed to take the interview in order to identify the unique landscape elements and highlight them in circles (Fig. 2). The interviews were carried out in a local coffee shop. Only elements that have been selected by more than 7 participants in each photo sets are shown. The same approach was pursued with participants on site.

The historical boundary wall and other historic buildings were most identified. For these historical memories deeply embedded and being viewed as the "symbol of the site". Plants and unique shaped streetlights were also selected due to their design characteristics.

3.3   Vertical Angle of Panoramic Photographs

After testing the horizontal angles, the vertical combination technique mentioned in Section 2.4 is then tested. Two panoramic photos were taken from the same point covering different heights. The two photos are combined to construct one photo that covers the entire vertical sight. The final combined photo is then shown to 15 participants in comparison with one of the normal panoramic photos.

Un-combined

Vertical Angle

Combined

Vertical Angle

Fig. 3:   Vertical Combination

The historical western building façade and Kelindun and Changhong Hotel were selected due to their physical appearance, historical means and local memory value.

4   Discussion

4.1   180˚ Horizontal Panoramic Photographs

During the interview all participants mentioned that they have difficulties combining the 60° photos into one image in their head. Also, when they saw similar or identical elements in different 60˚ pictures, they felt confused about whether to highlight the one they have already chosen in the other pictures. For example in Figure 1, the left of photo 2 and right of photo 3 have both captured similar elements, which caused confusion in the interview process. One could argue that with certain techniques, the three 60˚ photographs can be constructed without noticeable overlaps. However, this would still face the issue of lack of continuity from the photo set. When participants interpret the 60˚ photographs, they see them as three individual photos rather than one overall image. When trying to pick out the elements that they think best represent the region using 180˚, they are more focused on the element that can represent the whole environment rather than three individual photos when they see the 60˚ photo set. In addition, certain elements became hard to notice in narrow angle photos, e.g. the ancient architecture complex in photo 3 has never been picked but is commonly picked out on the 180˚ photograph.

Conversely, participants all find that 180˚ panoramic photos are easy to follow and helpful in regard to recalling memories from their past experiences. The view from the photo has been described as "nearly identical to what we see at the real site" by the onsite interview participants. This suggests that a wider angled photo would help in a photo based landscape interview process to improve results.

However, in wider-angle universe, there are differences between the 120° photo and the 360° photo set as well as between the 180° photo and 360° photo set.

The following feedback was received from the participants:

120˚ photos are considerably better than traditional photos and have been proven to show greater ability to present the site continuously. However, similar types of objects have been picked multiple times in different photos. This is due to the coverage of individual photos. It is not trivial for them to form all three pictures as a whole in their mind.

Participants agree that the 180° photos provides them with a great overview of the region and also gives them room to focus on particular elements. The information is very easy to absorb and the photos simulated real life appropriately. Because the number of photos presented is limited (only 2 photos), they find it is relatively easy to combine the photos' contents in their mind.

Compared with the 120° photo set the 360° photo is better. Participants feel more comfortable as they can see the entire environment in one photo rather than having to join them in their mind. However, 60 out of 90 participants (there are, in total, 6 groups of 15 participants) indicated that because the photo shows a "circle" in one dimension, the photo looks distorted to them and it is hard for them to think in a "round way", the onsite participants especially find it hard to match what they see in real world. Due to the high amount of information shown in one photo, participants tend to pay more attention to the big elements and ignore the small ones.

To conclude, the result clearly shows that the participants were most comfortable selecting unique landscape elements from the 180° photo set. Moreover, by comparing the common elements selected between onsite and offsite groups for each angle, it can be concluded that 180˚ photos has provided the least different results between the two scenarios. Hence supporting the idea that the elements chosen in the 180˚ photos are identical to the elements that would have been chosen by direct viewing of the environment.

4.2   Vertical Combination of Panoramic Photographs

When there are a considerable number of tall elements in the view, it would be best to take two 180˚ panoramic photos; one for capturing the bottom part, the other for the top part. The reason being, a normal panorama only provides a very limited view in an urban environment, and that one only gets the 'full picture' if two panoramas were combined in vertical direction. The participants were able to identify different features because the vertical combination has the ability to show more elements in better appearance. Without this approach participants only get a limited view. If the typical approach were used, participants in a study would not see everything. Key features could possibly be excluded.

5   Limitations

As discussed earlier the vertical shooting angle of the camera to mimic human vision and to provide a panoramic photo for the photo based interview process remains a major limitation. In a situation where the building's height is much higher than the shooting range the entire angle cannot be captured. For example, in New York Times Square, where the shooting distance is very limited and the buildings are extremely high, the vertical combination technique would not work. However, there is no technique available that could tackle such limitation effectively.

6   Conclusion

For an improved representation of the real world in landscape studies it is suggested to use panoramic photographs, with a wide horizontal angle as well as a wider vertical angle.

References

ANTROP, M. (2007), Perspectives on the Landscape: Backgrounds to Read and Understand the Landscape (Perspectieven op het landschap: achtergronden om landschappen te lezen en te begrijpen). Academia Press, Gent.

BARFIELD, W., BJORNESETH, O., HENDRIX, C., KACZMAREK, K. A. & LOTENS, W. (1995), Comparison of Human Sensory Capabilities with Technical Specifications of Virtual Environment Equipment. Presence: teleoperators and virtual environments, 4, 329-356.

BISHOP, I. D. & ROHRMANN, B. (2003), Subjective responses to simulated and real environments: a comparison. Landscape and Urban Planning, 65, 261-277.

COLLIER, J. (1967), Visual Anthropology: Photography as a Research Method. Holt, Rinehart & Winston, New York.

CRESWELL, J. W. (1999), Qualitative Inquiry and Research Design: Choosing Among Five Traditions Contemporary psychology. Sage, London.

DANAHY, J. W. (2001), Technology for dynamic viewing and peripheral vision in landscape visualization. Landscape and Urban Planning, 54, 127-138.

DANIEL, T. C. & BOSTER, R. S. (1976), Measuring landscape aesthetics: the scenic beauty estimation method. USDA Forest Service Research paper, RM-167. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Co.

DANIEL, T. C. & MEITNER, M. M. (2001), Representational Validity of Landscape Visualizations: The Effects of Graphical Realism on Perceived Scenic Beauty of Forest Vistas. Journal of Environmental Psychology, 21, 61-72.

DC, D. O. D. W. (1999), Military Standard: Human Engineering Design Criteria for Military Systems, Equipment and facilities. Lockheed Human Factors Engineering group.

DUNN, M. C. (1976), Landscape with Photographs: Testing the Preference Approach to Landscape Evaluation. Journal of Environmental Management, 4, 15-26.

ENGLAR, G. & CONSOLATI, J. (1990), Panorama Procedures for Design Communication. Representations: Journal of the Design Communications Association. Tucson.

ERNST, M. O., BANKS, M. S. & BÜLTHOFF, H. H. (2000), Touch can change visual slant perception. Nature Neuroscience, 3, 69-73.

GIBSON, J. J. (1979), The ecological approach to visual perception. Houghton Mifflin, Boston.

GILL, L., LANGE, E., MORGAN, E. & ROMANDO, D. (2013), An analysis of usage of different types of visualisation media within a collaborative planning workshop environment. Environment and Planning B: Planning and Design, 40, 742-754.

GUEST, G., BUNCE, A. & JOHNSON, L. (2006), How Many Interviews Are Enough?: An Experiment with Data Saturation and Variability. Field Methods, 18, 59-82.

HARPER, D. (2002), Talking about pictures: A case for photo elicitation. Visual Studies, 17, 13-26.

HENSON, D. B. (1993), Visual Fields. Oxford University Press, Oxford.

HILGARD, E. R., ATKINSON, R. C. & ATKINSON, R. L. (1975), Introduction to psychology. Harcourt Brace Jovanovich, New York.

HUANG, S.-C. L. (2009), The Validity of Visual Surrogates for Representing Waterscapes. Landscape Research, 34, 323-335.

HULL, R. B. & MCCARTHY, M. M. (1988), Change in the landscape. Landscape and Urban Planning, 15, 265-278.

KAPLAN, R. & KAPLAN, S. (1989), The Experience of Nature: A Psychological Perspective. Cambridge University Press, Cambridge.

KOLASINSKI, E. M. (1995), Simulator sickness in virtual environments (Technical Report 1027). U.S. Army Research Institute for the Behavioral and Social Sciences.

LANG, J. (1987), Creating Architectural Theory: The Role of the Behavioral Sciences in Environmental Design. Terian Journal of Architectural Education, 41, 60-61.

LANGE, E. (1994), Integration of computerized visual simulation and visual assessment in environmental planning. Landscape and Urban Planning, 30, 99-112.

LANGE, E. (2001), The limits of realism: perceptions of virtual landscapes. Landscape and Urban Planning, 54, 163-182.

LANGE, E., HEHL-LANGE, S. & BREWER, M. J. (2008), Scenario-visualization for the assessment of perceived green space qualities at the urban-rural fringe. Journal of Environmental Management, 89, 245-56.

LINTON, D. L. (1968), The assessment of scenery as a natural resource. Scottish Geographical Magazine, 84, 219-238.

NASSAUER, J. I. (1983), Framing the landscape in photographic simulation. Journal of Environmental Management, 17, 1-16.

PALMER, J. F. & HOFFMAN, R. E. (2001), Rating reliability and representation validity in scenic landscape assessments. Landscape and Urban Planning, 54, 149-161.

PIANTANIDA, T. P., BOMAN, D. K., LARIMER, J. O., GILLE, J. & REED, C. (1992), Studies of the field-of-view / resolution tradeoff in virtual reality. In: Proceedings of HumanVision, Visual Processing and Digital Display III, SPIE Proceedings 1666, 448-456.

PORTA, S. & RENNE, J. L. (2005), Linking urban design to sustainability: formal indicators of social urban sustainability field research in Perth, Western Australia. Urban Design International, 10, 51-64.

ROBINETT, W., HOLLOWAY, R. (1992), Implementation of flying, scaling and grabbing in virtual worlds. In Interactive 3D graphics: Proceedings of the 1992 symposium (I3D '92), 1992, 189-192.

RUSSELL, J. A. & LANIUS, U. F. (1984), Adaptation level and the affective appraisal of environments. Journal of Environmental Psychology, 4, 119-135.

SANDELOWSKI, M. (1995), Sample size in qualitative research. Research in Nursing & Health, 18.

SCHROEDER, H. & DANIEL, T. C. (1981), Progress in predicting the scenic beauty of forest landscapes. Forest Science, 27, 71-80.

SCOTT, A. (2002), Assessing Public Perception of Landscape: The LANDMAP experience. Landscape Research, 27, 271-295.

SEVENANT, M. & ANTROP, M. (2011), Landscape Representation Validity: A Comparison between On-site Observations and Photographs with Different Angles of View. Landscape Research, 36, 363-385.

SHAFER JR., E. L. & BRUSH, R. O. (1977), How to measure preferences for photographs of natural landscapes. Landscape Planning, 4(C), 237-256.

SHUTTLEWORTH, S. (1980), The use of photographs as an environment presentation medium in landscape studies. Journal of Environmental Management, 11, 61-76.

SMITH, E. L., BISHOP, I. D., WILLIAMS, K. J. H. & FORD, R. M. (2012), Scenario Chooser: An interactive approach to eliciting public landscape preferences. Landscape and Urban Planning, 106, 230-243.

STERN, R. M., HU, S., ANDERSON, R. B., LEIBOWITZ, H. W. & KOCH, K. L. (1990), The effects of fixation and restricted visual field on vection-induced motion sickness. Aviation, Space, and Environmental Medicine, 61, 712-715.

STEWART, W. P. & HULL, R. B. (1996), Capturing the moments: concerns of in-situ leisure research. Journal of Travel & Tourism Marketing, 5, 3-20.

ULRICH, R. S. (1981), Natural Versus Urban Scenes: Some Psychophysiological Effects. Environment and Behavior, 13, 523-556.

WALZ, A., GLOOR, C., BEBI, P., FISCHLIN, A., LANGE, E., NAGEL, K. & ALLGÖWER, B. (2008), Virtual Worlds − Real Decisions: Model- and Visualization-based Tools for Landscape Planning in Switzerland. Mountain Research and Development, 28, 122-127.

WATANABE, H. & MATSUOKA, K. (1999), Peripheral vision facilitates depth perception in the fovea. Perception, 28, 102.

WELLS, M. J. & VENTURINO, M. (1990), Performance and head movements using a helmet-mounted display with different sized fields-of-view. Optical Engineering 29, 870-877.

WILLIAMS, K. J. H., FORD, R. M., BISHOP, I. D., LOITERTON, D. & HICKEY, J. (2007), Realism and selectivity in data-driven visualisations: A process for developing viewer-oriented landscape surrogates. Landscape and Urban Planning, 81, 213-224.

WISSEN, U., SCHROTH, O., LANGE, E. & SCHMID, W. A. (2008), Approaches to integrating indicators into 3D landscape visualisations and their benefits for participative planning situations. Journal of Environmental Management, 89, 184-96.

ZUBE, E. H., PITT, D. G. & ANDERSON, T. W. (1974), Perception and measurement of scenic resources in the Southern Connecticut River Valley. Landscape Research, 1, 10-11.

ZUBE, E. H., SIMCOX, D. E. & LAW, C. S. (1987), Perceptual landscape simualtions: history and prospects. Landscape Journal, 6, 62-80.