Spatial Measurement of Urban Space Based on a 3D Building Environment Index

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Abstract

This study proposes a 3 dimensional (3D) building environment index (BEI), which integrates the visibility proportions of buildings, vegetation and sky within a 3D Viewsphere at a given urban district. Based on 19000 Goolge Street View images of Hong Kong Island and Singapore Downtown Core, we test the proposed index and demonstrate its effectiveness in describing the building environment and distinguishing the quality of urban space.

1.Introduction

The concept of building environment is one of the fundamental aspects versus livability. As it is simple and easy to communicate in planning practice, it has been widely used in urban planning and urban study, such as development control and discriminant analysis of urban space. Planners and researchers however found that measuring building environment is not as simple as it seems to be, but full of complexity. It becomes increasingly important to measure building environment from a 3D perspective, especially in the high density city such as Hong Kong, where 2D indices are limited in support of describing building density and landscape. In recent years there has been a paradigm shift from polygon boundary-based indicator, such as Plot Ratio and Site Coverage, to perception-based approach

such as Viewsphere Analyst (Teller, 2003;Fisher, 2003; Yang, Putra and Li, 2005).

Digital 3D building models and photographs of landscape are the two major types of data sources for the Viewsphere Analyst. However, 3D building models can't describe real vegetation and complex forms (Yang, 2005). The analysis of photographs is unreliable due to the unprofessional photographers (Chen, 2009), and the shortage of photographs largely limit the study area. To help standardize the measurement of urban space based on a perception-based approach, there is need to utilize a more reliable data source covering more urban areas.

2.Goal and Objective

This study aims to develop a 3D building environment index and demonstrate the feasibility of using Goolge Street View Image as data source for the building environment assessment at a city scale.

3.Methodology

Buildings, vegetation and sky together form the main characteristics of environment quality of urban space. This study proposes a 3D building environment index (BEI), which integrates the visibility proportions of buildings, vegetation and sky within a 3D Viewsphere at a given urban district. The BEI is:

BEI=*%Building:%Vegetation:%Sky*

We first obtain the panorama image from Google Street View service (figure 1). Then, we use classical edge detector and vegetation index approaches to identify buildings, vegetation and sky in an image (figure 2). Finally, we project the panorama image to a hemisphere as illustrated in figure 3, and calculate the proportions of buildings, vegetation and sky (BEI) according to the projection.

Figure 1: **A** panorama image obtained from the Google StreetView service

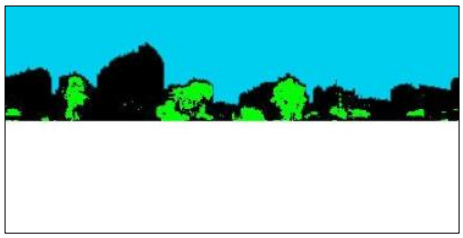

Figure 2: Identified buildings (black), vegetation (green) and sky (blue) from a panorama image

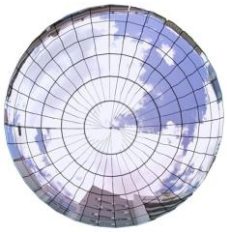

Figure 3: Projects the panorama image to hemisphere

Based on the BEI, since the sky and vegetation are positive factors for the environment, we define the Street Environment Index (SEI) as follows:

$$SEI=\frac{\sum_1^n(\%sky+\%vegetation-\%building)}{n}$$

where n is the number of observation points of each street.

4.Case study

This study analyzes 12000 observation points of Hong Kong Island streets and 7000 observation points of Singapore Downtown Core streets. We set observation points along a street with a distance interval of 20 meters. Figure 4 shows the BEI distribution pattern in a ternary diagram.

Compared with Singapore, BEI of Hong Kong Island shows significantly high ratio of building visibility and less vegetation landscape. It indicates people living in Singapore Downtown Core have a better visual perception of vegetation than people living in Hong Kong Island.

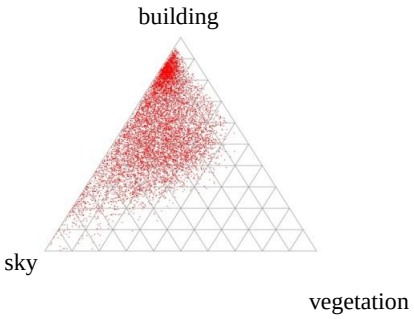

Figure 4.a: BEI of Hong Kong Island

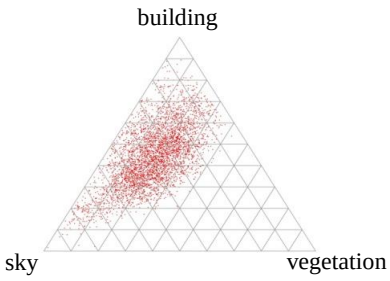

Figure 4.b: BEI of Singapore Downtown Core

Figure 5 presents the normalized SEI on Hong Kong Island streets. The high value of SEI means a better street environment with more sky and vegetation. As other perception-based approaches, the SEI avoids the zoning problem. In contrast with the traditional Plot Ratio method (Figure 6) that ignores the road network due to street block zoning, the SEI focuses on street space, which is crucial in people's daily lives, and it much more accords with the intuitive way of understanding the urban environment.

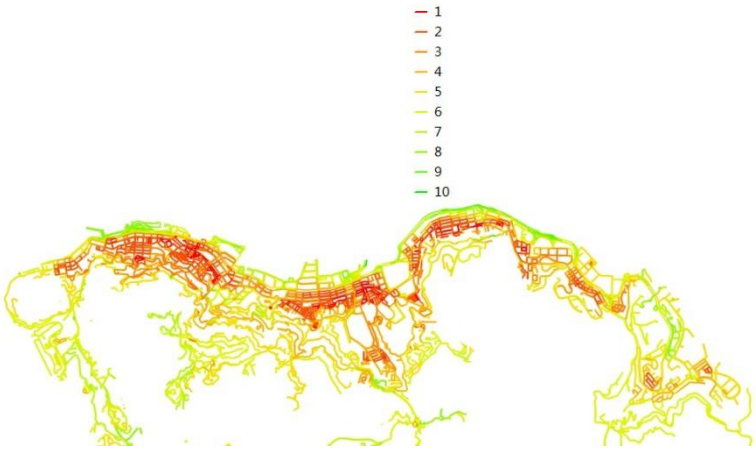

Figure 5: SEI of Hong Kong Island

Figure 6: Plot Ratio of Hong Kong Island based on street block

5. Conclusion

As shown above, this study proposes a 3D building environment index to reveal the different patterns of building environment at a city level, which contributes for the existing method. Furthermore, image data from Google Street View covering most of developed countries is a reliable data source to study the essential urban elements. Our study demonstrates the feasibility of assessing building environment by obtaining large-scale open source urban images. This research will further increase the usefulness of Goolge Street View data for urban researchers and planners who concern people' experiences in an urban environment.

References

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