Extraction of Landmarks using Building-Attribute Data for Pedestrian-Navigation Service

Jiyoung Kim
ICEE, Seoul National University
1 Gwanakro,
Seoul, South Korea
soodaq@snu.ac.kr

Jung Ok Kim
ICEE, Seoul National University
1 Gwanakro,
Seoul, South Korea
geostar1@snu.ac.kr

Abstract

Recently, interest in the Pedestrian Navigation Service (PNS) has increased due to the diffusion of smartphone technologies, the improvement of location-determination technology, and its efficiency regarding the use of landmarks in the route guidance for pedestrians that is due to the pedestrian-movement characteristics and the path-finding success rate. Accordingly, the research studies on landmark extraction have been progressed. The preceding research studies, however, are limited because only the difference between the buildings was considered, and the visual attention of the maps in the PNS display was not considered. This study addresses this problem by defining the building attributes as local and global variables. The local variables reflect the saliency of the buildings by representing the inter-building differences, and the global variables reflect the visual attention by representing the inherent building characteristics. Also, this study considers the network connectivity and solves the overlapping problem of the landmark candidate groups with the use of the network Voronoi diagram. To extract the landmarks, the building-attribute data were defined based on the preceding research studies. Next, choice points for the pedestrians in the pedestrian-network data were selected, and the landmark-candidate groups were determined at each choice point. The building-attribute data were calculated using the extracted landmark-candidate groups, and lastly, the landmarks were extracted using the principal component analysis (PCA). The proposed method was applied to a part of Gwanak-gu, Seoul, South Korea, and the extracted landmarks were evaluated through a comparison with the labels and landmarks that are used by portal sites such as NAVER and DAUM. In conclusion, from among the 219 NAVER and DAUM landmarks, 132 landmarks (60.3%) were extracted using the proposed method, and it was confirmed that 228 landmarks, for which there are no labels, or the NAVER and DAUM landmarks were helpful in the determining of a directional change in the local-level path finding.

Keywords: Pedestrian Navigation Service, Landmark, ISOVIST, Network Voronoi Diagram, Principal Component Analysis.

1 Introduction

Recently, the interest in the Pedestrian Navigation Service (PNS) has increased due to the diffusion of smartphone technologies, the improvement of location-determination technology, and its efficiency regarding the use of landmarks in the route guidance for pedestrians that is due to the pedestrian-movement characteristics and the path-finding success rate (Elias, 2003). The studies of Elias (2003) and Rho et al. (2011), however, are hampered by the following limitations: 1) The incorporation of the assumption that landmarks are relative concepts, and the building that has the largest difference between itself and the neighboring buildings was extracted as a landmark. 2) The defining of the local landmarks in consideration of the difference between a building and its neighboring buildings.

Therefore, the authors sought to extract landmarks to help in the understanding of both the global and local paths that are found in the device-screen area.

2 Extraction of the Landmarks for Pedestrians

2.1 Method

In this study, the landmarks were extracted from the existing maps as a fundamental research procedure for landmark-based path-finding in the PNS. The process for the extraction of the landmarks that is proposed in this study consists of the defining of the building-attribute data, the estimation of the candidate landmarks, and the extraction of landmarks using the principal component analysis (PCA), as shown in Figure 1.

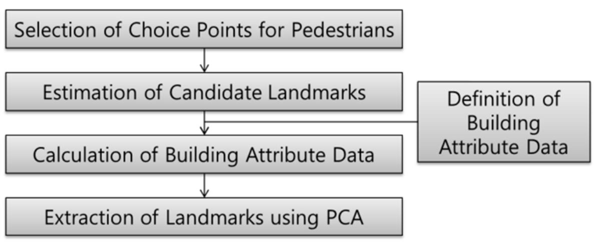


Figure 1. Process of the landmark extraction for pedestrians

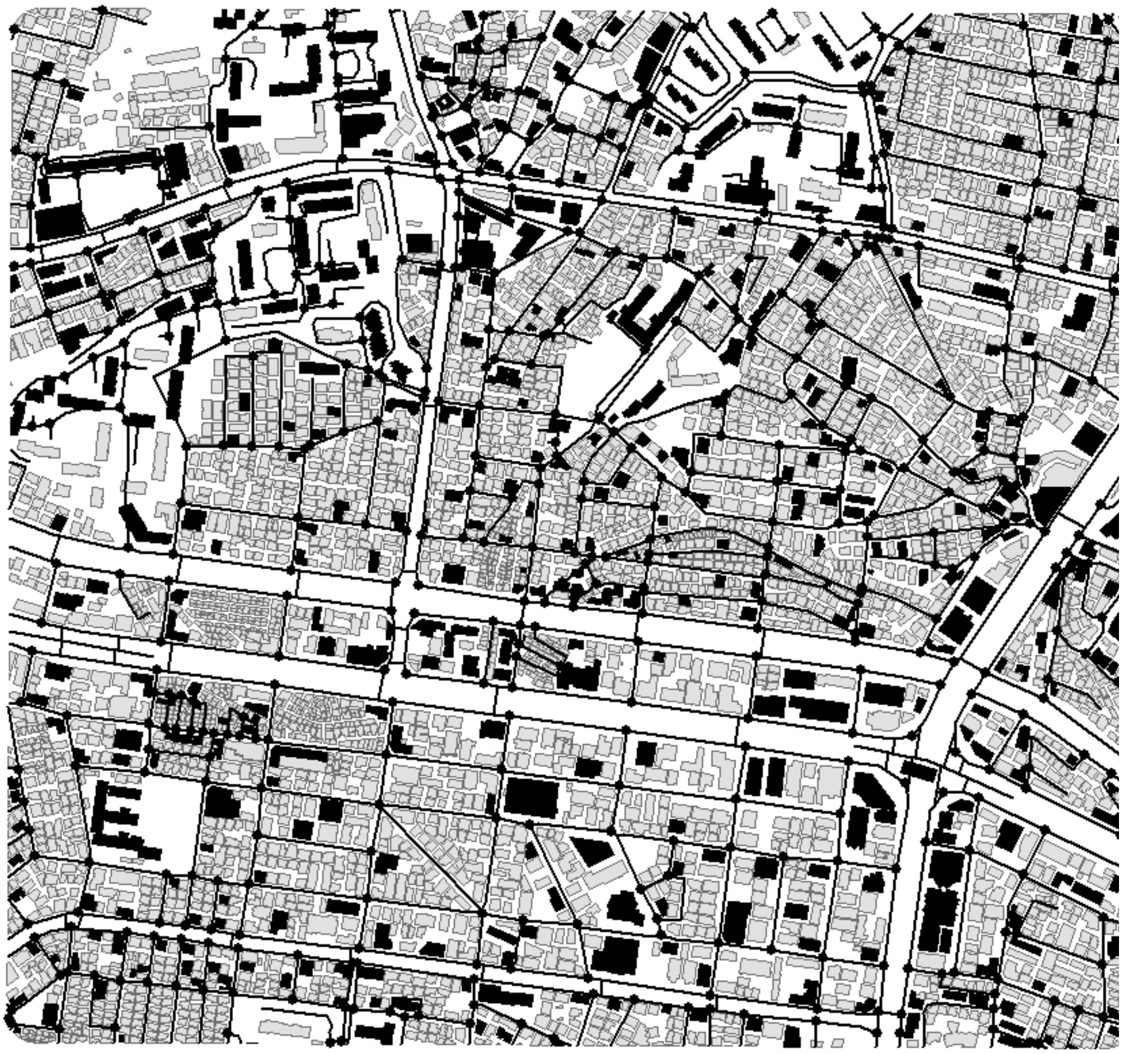
Firstly, the building-attribute data (Table 1) were divided into geometric and semantic attributes in consideration of the visual attention of the maps in the PNS display, the saliency of the buildings, and from the preceding research studies, and this was followed by the subdivision of the local and global data. The local variables reflect the building saliency by

Table 1. Definition of building-attribute data

Class		Name	Definition	Expression
Geometric Attribute	Local variables	df_AREA	Difference between the median values of the building area	The absolute value of the difference between the standard value of the area of the building in the landmark-candidate groups and the median value
		df_HEIGHT	Difference between the median values of the building height	The absolute value of the difference between the standard value of the height of a building in the landmark-candidate groups and the median value
		df_LONG	Difference between the median values of the building distance	The absolute value of the difference between the standard value of the distance of the major axis of the minimum rectangle in the landmark-candidate groups and the median value
		df_SHORT	Difference between the median values of the building width	The absolute value of the difference between the standard value of the distance of the minor axis of the minimum rectangle in the landmark-candidate groups and the median value
		df_ANGLE	Difference between the median value of the building azimuth	The absolute value of the difference between the standard value of the azimuth of the major axis of the minimum rectangle in the landmark-candidate groups and the median value
		df_VERTEX	Difference between the median of the number of the building vertex	The absolute value of the difference between the standard value of the number of the building vertices in the landmark-candidate groups and the median value
	Global variables	ab_AREA	Area of the building	The standard value of the area of the building polygon in the test area
		ab_HEIGHT	Height of the building	The standard value of the height of the building polygon in the test area
		ab_LONG	Distance of the building	The standard value of the distance of the major axis of the minimum rectangle in the test area
		ab_SHORT	Width of the building	The standard value of the distance of the minor axis of the minimum rectangle in the test area
		ab_VERTEX	The number of the building vertex	The standard value of the number of building vertices in the test area
Semantic Attribute	Local variables	a_TC	The number of the same building type	$a_{TC} = \frac{TC_{\max} - TC}{TC_{\max} - TC_{\min}} = \frac{n-T}{n-1}$ Here, TC: the number of the same building type, $TC_{\max}$: the maximum TC of the landmark-candidate group, $TC_{\min}$: the minimum TC of the landmark-candidate group, n: the number of the landmark-candidate group
	Global variables	st_POICo	The POI number of the building	The standard value of the POI number that is matched in the building polygon in the test area

representing the difference between the buildings, and the global variables reflect the visual attention by representing the inherent characteristics of the buildings. Secondly, the choice points are the nodes that the pedestrians use to change the direction, and these points are the selected intersection points of more than three links, and especially more than two links, in the surrounding crossings. Thirdly, to estimate the candidate landmarks, ISOVIST polygons were used so that the visibility areas could be generated in each choice point using the ISOVIST algorithm (Davis & Benedikt, 1979), and network Voronoi diagrams (Okabe et al., 2008) were generated in each choice point. It was then possible to extract the data from the buildings that are within the visibility of the pedestrians when they are walking. The building-attribute data that were defined earlier were calculated from a building layer of the existing map, the Korean Address Base Map of South Korea. Lastly, the PCA was used to extract the landmarks in consideration of both the local and global variables, and the landmarks were extracted with the use of the two principal components that explain that the value of the total PCA variance is large.

Figure 2. All landmarks extracted by the proposed method in test area.



2.2 Test and Results

The proposed method was applied in a part of Gwanak-gu, Seoul, South Korea.

For the evaluation accuracy, the extracted landmarks (Figure 2) and buildings were compared with the labels that are displayed and used for the pedestrian path-finding in NAVER and DAUM, the famous portal sites of ROK. Consequently, 132 buildings (60.3 %) from among the 219 labels in the NAVER and DAUM sites were extracted using the proposed method. Further, it was confirmed that 228 landmarks, for which there are no labels, or landmarks that are in the NAVER and DAUM sites were helpful in the determining of the direction changes in the path-finding of the local level.

3 Conclusion

A method for the extraction of landmarks from the existing maps for a user-invented PNS is proposed in the present paper. The preceding research studies are limited because only the difference between the buildings is considered, while the visual attention of the maps in the PNS display were not considered. Therefore, this study addresses this problem by defining the building attributes as either local variables or global variables. Also, this study considers the network connectivity and solves the overlapping problem of the landmark candidates by using the network Voronoi diagram.

As a result of the application of the proposed method in the existing ROK map, it was confirmed that the landmarks and the visual attention of the maps in the PNS display were extracted in consideration of the saliency of the buildings.

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