Interactive Spatial Planning on a GIS Network Model

Ko Ko Lwin and Yuji MURAYAMA

Abstract: A GIS network model was developed based on Graph Theory which is topological and mathematical representation of the nature such as roads, rivers and other interconnected line features. A GIS network model is very useful for transportation planning, market analysis, public facility management and other connectivity and accessibility studies. In this paper, we discuss the implementation of an interactive, web-based Geographical Information System (Web-GIS) to calculate eco-friendly walk scores based on the integration of Advanced Land Observing Satellite (ALOS) data and a GIS network model from Tsukuba City. We use our study to help local residents make spatial planning regarding neighborhood environmental quality assessment, how to find the shortest or greenest path to walk to help their physical health and how to choose an eco-friendly living space for potential home buyers.

Keywords: ALOS, A GIS network model, greenness score, greenest paths and Web-GIS

1. Introduction

Recently, GIS studies of urban green space areas have been increasing in number. For example, Mahon and Miller (2003) used GIS to identify green space areas with high ecological, recreational and aesthetic value to protect certain green space areas from development. Randall et al. (2003) presented a GIS-based decision support tool to model planning scenarios related to the creation of new green space areas as part of neighborhood greening strategies. Herbst and Herbst (2006) also described a GIS-based decision support tool to ascribe ecological and aesthetic value to green space sites for use in urban planning. Jim and Chen (2006) conducted a survey-based study on the use of different types of green spaces and peoples' willingness to pay for access to them. Their results provided the basis of a cost model for green space development. Zhang and Wang (2006) presented a study that used landscape metrics to quantify the spatial configuration of green spaces and performed GIS-based network analyses to assess the accessibility of many proposed green spaces enhancements. Ghaemi et al. (2009) implemented a web-based platform to support interactive environmental planning.

A GIS road network model plays critical role in urban planning, emergency preparedness, retail market analysis and market competition, public facility management and other planning and decision making process. A network is an interconnected set of points and lines that represent possible routes from one location to another. For geometric networks, this consists of edge features, junction features, and the connectivity between them. For network datasets, this consists of edge, junction, and turn elements and the connectivity between them. For example, an interconnected set of lines representing a city streets layer is a network. Road center lines are generally used in road network model and can be extracted from high spatial resolution satellite images or aerial photos. However, GIS data alone cannot solve any spatial problems, especially in environmental issues that include difficulties in determining where are the green spaces, how much forested areas, how much surface water areas, etc.

Because the GIS data represent the world in a graphical form (i.e., roads are represented as lines, homes are represented as polygons, bus stands are represented as points and so on). In this representation scheme, geographic means "geo" plus "graphic," and, therefore, we can easily construct a database for these graphics and manipulate them. Therefore, GIS is a powerful tool to solve spatial problems by means of graphical representations. In contrast, remote sensing technologies, frequently referred to as geoinformatics, use sensors and capture the world as real information. However, due to the nature of landscape complexity and the thousands of millions of pixels used to describe landscapes, it is difficult to construct a database that could be used to extract information from the pixels. By integrating the remote sensing GIS information, we will benefit spatial information users not only by enhancing their graphical processing, but also by enabling the processing of real-world information. Therefore, in

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this research, we used Advance Land Observing Satellite (ALOS) data to identify the green spaces, which we then integrated with other GIS data such as road networks, public facility locations and building footprints to calculate the "eco-friendly walk score" by providing GIS analytical functions for local residents' decision making. We used Tsukuba City as a case study.

2. Methodology

2.1 Building a GIS Network Model

GIS road network model (Figure 1) was built on combination of Zmap-TOWNII data and GSI Geographical Survey Institute data. Additional road centerlines were digitized manually based on aerial photos. Then, the road data was cleaned by the ArcInfo Clean function and built a network model.

Figure 1: Road network model

2.2 Compute Greenness Score

Following this, we added a 10-m buffer to both sides of the road and computed the greenness score based on the binary green image (Figure 2) for each road segment as follows:

Greenness Score = (Vegetated area in the 10-m buffered road/Road buffered area) * 100

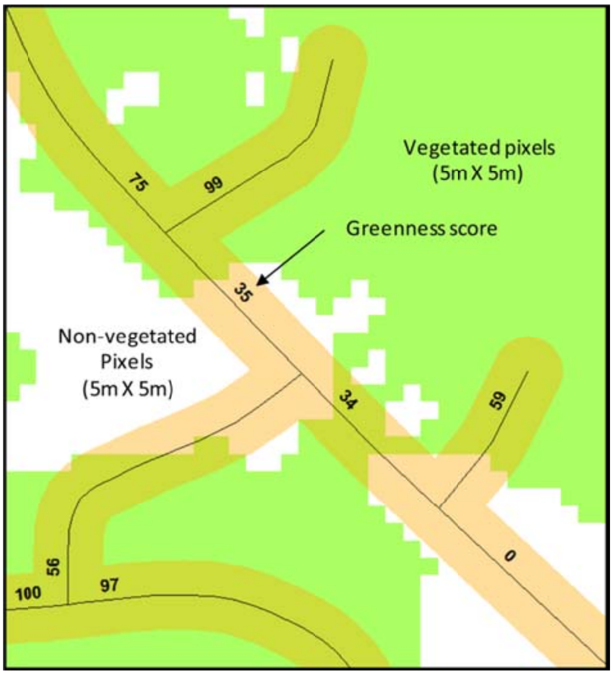

Figure 2: Calculation of the greenness score for each road segment based on the binary green image

2.3 Implementation of a Web GIS

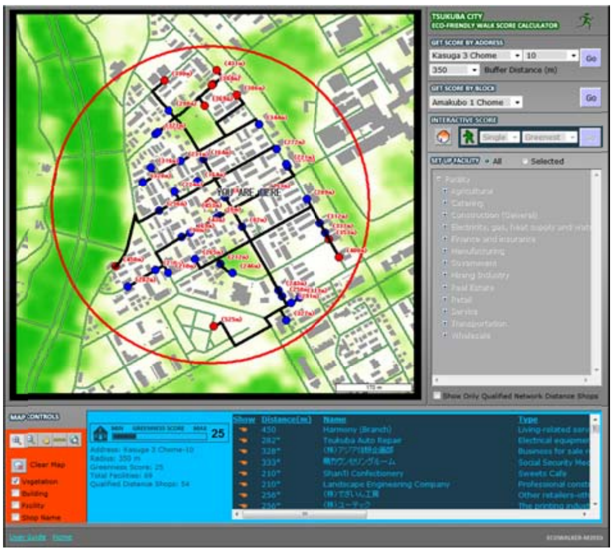

Figure 3: Graphical User Interface (GUI) http://land.geo.tsukuba.ac.jp/ecowalk

3. Results

We measured the greenness score by three modes named Get Score by Address, Get Score by Block and Interactive Score. Get Score by Address (Figure 4) is ideal for existing local residents to evaluate their neighbourhood environmental quality by giving their home address and search radius (the default search radius is 350 m).

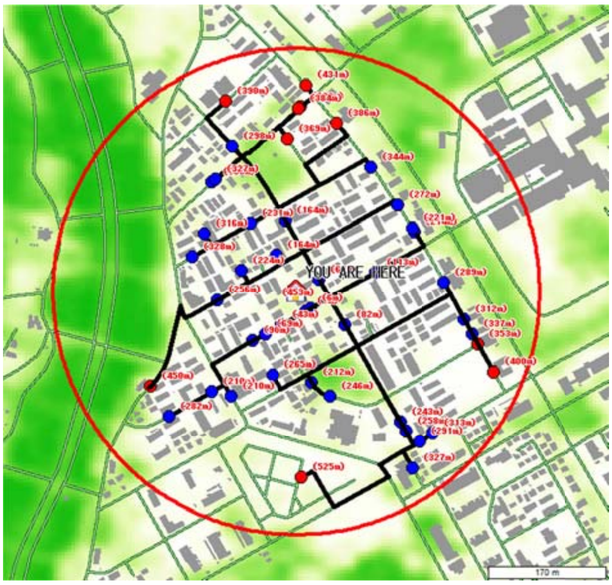

Figure 4: Get score by user-defined address and default search radius of 350 m

Figure 5: Network distances between home and available facilities

In the interactive score mode, users can find either the shortest or greenest walking path by specifying their start and end points. The shortest path (Figures 6 & 8) is ideal for shopping activities, and the greenest path (Figures 7 & 9) is ideal for walking activities. Moreover, users can locate multiple points for such activities. For example, one could start from home, go to the library, go to a shopping centre and then return to home. In this process, the greenness score is calculated based on averaging of the greenness score from each 10-m buffered route path. This measurement is ideal to help people who want to make outdoor recreation activities a part of their daily or weekend routines.

Figure 6: Shortest path analysis (Single route)

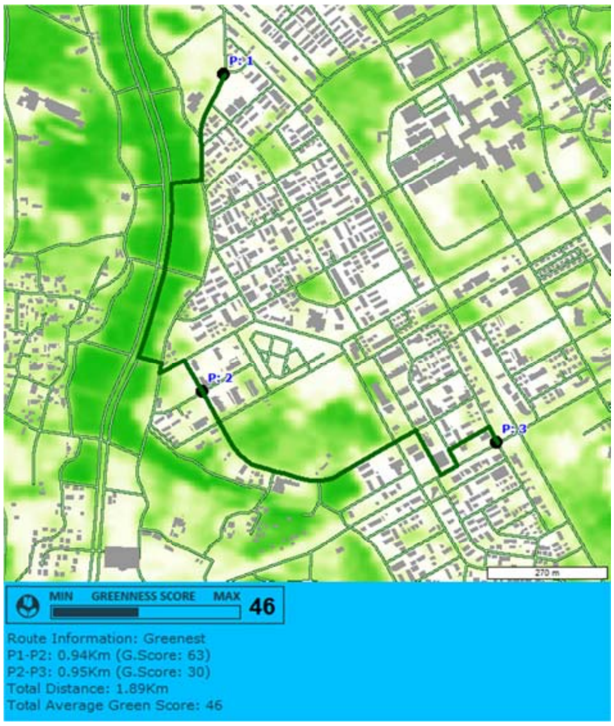

Figure 7: Greenest path analysis (Single route)

Figure 8: Shortest path analysis (Loop route) between user define points

Figure 9: Greenest path analysis (Loop route) between user define points

4. Conclusion

The increasing popularity of the Internet from online surfing to e-commerce has made it an integral part of society. This GIS network based interactive spatial decision making process is a much wider audience than traditional GIS. The general public can now directly access spatial information and see the analysis results through their web browsers without any installation of GIS software. The system itself is reusable and updatable.

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