Smart Eco Path Finder for Mobile GIS Users

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Abstract: Along with advances in modern wireless communication, Internet technologies, and mobile computational devices, nowadays, GIS goes everywhere, desktop to laptop to netbook to smart phone. The increasing popularity of the Internet and user-friendly web based GIS applications such as Google Maps/Earth and Microsoft Bing Maps Platform have made GIS an integral part of life today for finding the nearest facilities, driving routes and so on. However, choosing an eco-friendly walking route is a big challenge for local residents because of the lack of GIS analytical functions and environmental data available online. Although analysis of route paths has been widely used in GIS applications, the integration of green factors with route path analysis is still lacking in the GIS arena. In this paper, we will present an integrated methodology for identifying an eco-path (eco-friendly walking routes) by providing web-based GIS analytical functions using Tsukuba City in Japan as a case study. This web-based program "Eco Smart Walker" enables mobile GIS users to find the eco-friendly walking route between their multistop trips using smart phone or netbook computer through Wi-Fi Internet access.

Keywords: Eco Smart Walker, route analysis, greenest and shortest path and multistop trips

1. Introduction

GIS provides theory and methods that have the potential to facilitate the development of spatial analytical functions and various GIS data models. Among them, GIS road network data model is important for solving the problems in urban areas such as transportation planning, retail market analysis, accessibility measurements, service allocation and more. There are several network models in GIS, such as river networks, utility networks and transportation networks or road networks. Understanding the road network patterns in urban areas is important for human mobility studies, because people are living and moving along the road networks. Network data model allows us to solve our daily solutions such as finding the shortest path between two locations, look for closet facilities within specific distance, and estimate drive time. Although many network models are conceptually simple but mathematically complex and require computational resources to model the problem.

On the other hand, neighbourhood environmental quality is an important factor that affects human health. Fortunately, neighbourhood environmental quality can be improved through proper urban management. Thus, epidemiological studies have explored the relationship between access to nature and health. For example, a study in Sweden by Grahn and Stigsdotter (2003) demonstrated that the more often one visits green areas, the less often one reports stress-related illness. One epidemiological study performed in the Netherlands (Maas, Verheij, Groenewegen, de Vries, & Spreeuwenberg, 2006) showed that residents of neighbourhoods with abundant green spaces tended, on average, to enjoy better general health. Another possible mechanism relating nature to health occurs during social interactions and social cohesion. Several studies conducted in Chicago suggest that green spaces, especially trees, may facilitate positive social interactions between neighbourhood residents (Kweon, Sullivan, &Wiley, 1998).

The quality of eco-friendly living places can be measured by an indicator of walkability index or score. Although most walk score calculations are based on distances between home and public facilities, an eco-friendly walk score calculation is based on green spaces (i.e., location of home or a walking route with green spaces). The higher the score, the better the environmental quality (i.e., Eco-friendly) for living or doing green exercise.

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In this paper, we used GIS road network model to find the greenest and shortest path for local residents spatial decision making while walking on the streets through Wi-Fi Internet access.

2. Overview

The GIS network can be constructed from various sources, such as river network can be extracted from contour map or digital elevation model (DEM) and road network can be constructed from aerial photos or high resolution satellite images (Figure 1). Road outline and center line data can be purchased from GIS data vendors. It is possible to represent one-way streets in the line theme feature based on digitized directions in a road network. Moreover, digitizing is based on target application and analysis, for example, walkability study with green space is required to digitize both sides of the main road since the green space may present each side of the road within 10 m buffered zone (Figure 2).

Figure 1: On screen digitizing on high resolution aerial photos.

Figure 2: 10 m buffered along the road

GIS network model is widely used in transportation planning, market analysis and accessibility studies. Accessibility is a measure of the spatial distribution of activities around a point, adjusted for the ability and desire of people to overcome spatial separation (Handy and Niemeier, 1997).

To identify green spaces, we used Advanced Land Observing Satellite (ALOS). ALOS has an optical sensor named Advanced Visible and Near Infrared Radiometer type 2 (AVNIR-2) with better spatial resolution (10m at nadir) and composed with four multi spectral bands (i.e. three bands in visible and one band in near-infrared). The Normalized Difference Vegetation Index (NDVI) (NDVI = (NIR-RED)/(NIR+RED)) was computed using a visible Read band (RED, Band 3: 0.61~0.69µm) and Near-Infrared band (NIR, Band 4: 0.76~0.89µm) acquired in vegetation growing season.

After that, this NDVI intensity image was converted into binary green image (1 for vegetated area and 0 for non-vegetated area). The main purpose of this conversion is to identify the vegetated areas rather than green intensity which varies season to season and this binary green image will also reduce the data size and computational time. This is especially suitable for Web-GIS where the some network and computational resources are limited. Vegetated areas include trees, bushes and grass lands, paddy fields and non-vegetated area includes buildings, car parking lots, bare lands, rivers and lakes.

We set up the greenness score attribute field as a weighted factor to compute the shortest or greenest route between the points. The shortest route was computed based on road distance, and the greenest route was computed based on road distance and the greenness score which value is between 0 and 100. 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 3) for each road segment as follows:

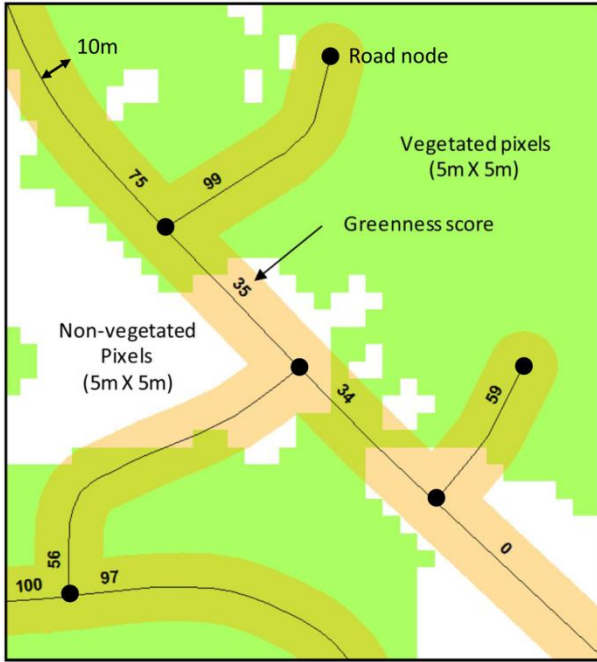Greenness Score = (Vegetated area in the 10-m buffered road/Road buffered area) * 100

Figure 3: Calculation of greenness score for each road segment (Lwin and Murayama, 2011)

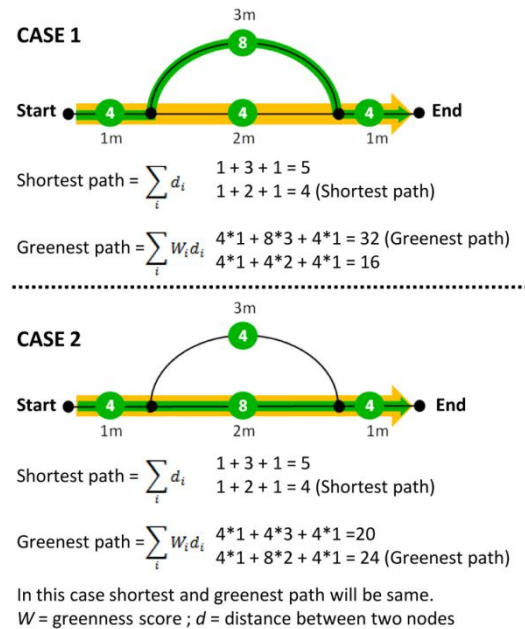Calculation of shortest and greenest path is based on weighted greenest score attribute field (Figure 4).

Figure 4: Calculation of shortest and greenest path (Lwin and Murayama, 2011)

3. How It Works

Graphical User Interface
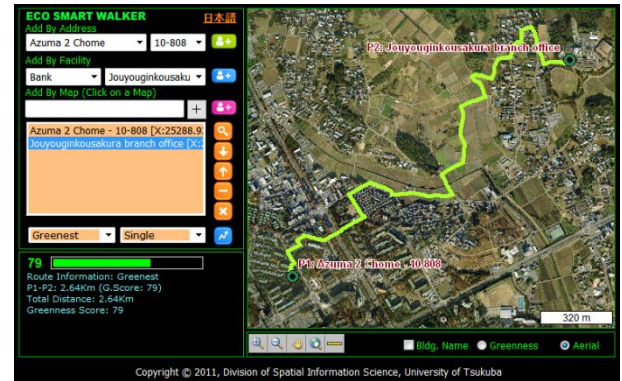

Figure 5: Graphical User Interface of Eco Smart Walker

URL:
http://land.geo.tsukuba.ac.jp/ecowalker/
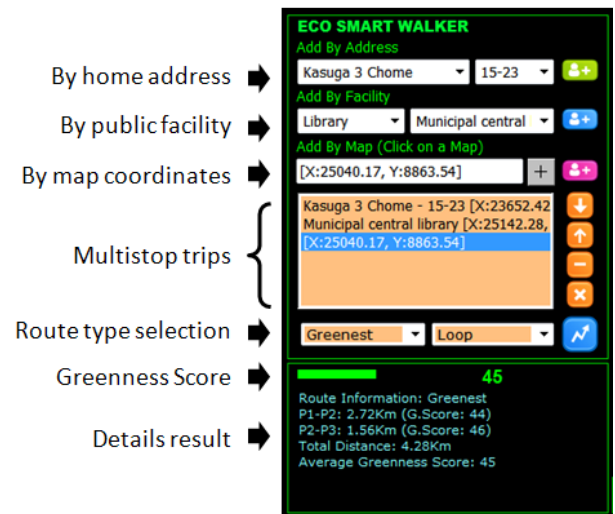URL: http://land.geo.tsukuba.ac.jp/ecowalkscore/

Figure 6: Multistop trips planning by adding address or public facility or map coordinates

Under the Eco Smart Walker, users enable to plan multistop trips by adding home address or public facility or map coordinates. Users can also arrange trip order and route types such as greenest or shortest path and single or loop trip. Eco Smart Walker is ideal for green exercise takers to find the greenest path while they are walking on the street through Wi-Fi Internet access.

Figure 7: Eco Smart Walker on NetWalker (Sharp PC-T1) and iPad2 (Apple)

4. Conclusion

The main purpose of this paper was to introduce a web-based interactive Eco path finder "Eco Smart Walker" for local residents of Tsukuba City to help with their eco-based spatial decision making. Our work will help them make neighbourhood environmental quality assessments, find the shortest or greenest path to walk to improve their physical health and choose places to live with green spaces to improve their health and welfare.

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