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Analyzing how travelers choose scenic routes using route choice models

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ABSTRACT

Finding a scenic route between two locations is a common trip planning task, in particular for tourists and recreational travelers. For the automated computation of a scenic route in a trip planning system it is necessary to identify which attributes of a route and its surroundings are associated with attractive scenery. This study uses a route choice model, more specifically a Path Size Logit (PSL) model, to identify the relevant attributes and their relative importance. Three hypotheses are formulated and tested with three PSL models to understand the effects of different attributes on scenic route selection. The set of chosen scenic routes are based on various VGI (Volunteered Geographic Information) data that have been extracted for California as a study region. The results identify several variables of the surrounding environment as significant contributors to route scenery after controlling for road type.

1. Introduction

Online route planners have become part of our everyday lives. They allow users to find the optimal path between two locations based on a specific criterion such as travel time, travel distance, or complexity between the predefined locations in street networks (Su, Winters, Nunes, & Brauer, 2010). Recent approaches focused on the computation of optimized routes for tourists or recreational travelers (Hochmair, 2004; Hochmair & Navratil, 2008; Zhang, Kawasaki, & Kawai, 2008).

A shortest and in general single criterion optimal path is not what a tourist typically needs when planning a trip. That is, the computed path should not only be short or fast but at the same time satisfy other conflicting optimization criteria, such as passing through landscapes (Sun & Lee, 2004). Thus, the computation of a scenic route is inherently a multi-criteria problem. While there is undoubtedly a variation in how individual travelers judge the attractiveness of a given route, this research is based on the assumption that at least some criteria are commonly viewed as contributing to route scenery. Thus this paper examines which attributes are associated with scenic routes chosen by travelers. The presented approach includes obtaining a collection of selected routes, generating alternative routes, extracting attribute values of all routes and the surrounding environment, and analyzing how the attribute values of chosen routes differ from those of alternative routes. We formulate three hypotheses that relate predictor attributes to route attractiveness, which are then verified through statistical analysis. For the latter we start with a series of non-parametric tests to identify significant differences in attribute values between two related samples, i.e. the set of scenic and alternative routes. Then the combined effect of several variables on route scenery is determined through multiple regression. For this task we use the mathematical framework of route choice models, which are a special case of discrete choice models. Route choice models answer the question of how individuals select a route from a set of alternative routes. The results of these models indicate the significant attributes with their coefficients which can be used for the computation of scenic routes in automated route planning systems.

A route choice model in this context requires the following data:

- A set of selected scenic routes between origins and destinations.
- A set of alternative routes for the same origin–destination pairs.
- Attribute values related to all routes.
- A regression model to estimate the contribution of the individual attributes to route attractiveness.

The choice set for an individual traveler includes the selected scenic route and the alternative routes available to that traveler

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to choose from. Various Web-based data sources based on Volunteered Geographic Information (VGI) (Goodchild, 2007) provide relevant information that captures people's travel behavior, which will be used in this study to extract a set of traveled scenic routes. As an alternative in each choice set we use the fastest route since it is plausible that a traveler knew about the fastest route, e.g. from a GPS based car navigation system (Mainali, Mabu, Yu, Eto, & Hirasawa, 2011), at the time when planning the route. The route attributes are subdivided into those relating to the route itself, such as route geometry or travel time, and those relating to the surroundings of the route, i.e., landscape scenery. The attribute values are computed for all routes in the choice set, and different Path Size Logit (PSL) models are used to derive the coefficients and their levels of significance for these attributes, based on the following three general hypotheses:

- Landscape scenery is associated with the selection of a scenic route when controlled for travel on local roads (model 1).
- A richer set of landscape related variables is associated with the selection of a scenic route when omitting road type (model 2).
- The density of geo-tagged Panoramio photos is associated with the selection of a scenic route (model 3).

While previous work has already used route choice models to identify the significance of pre-defined scenic areas as a deciding factor in route choice (Ben-Akiva, Bergman, Daly, & Ramaswamy, 1984), this study goes further in depth by identifying which different facets of the route and the surrounding landscape contribute to route scenery.

The remainder of this paper is structured as follows. Section 2 reviews previous work on identifying attributes related to scenic routes and the computation of scenic routes. Section 3 describes our approach of extracting scenic routes from VGI data sources, followed by the computation of route characteristics in Section 4. Section 5 performs a paired samples test to identify differences in attribute values between the sets of fastest and chosen routes. Section 6 describes the used route choice models and presents the estimated model results. This is followed by conclusions in Section 7 which summarize the findings and novel contributions of the conducted research.

2. Literature review

Previous studies on scenic routes can be divided into those that demonstrate the significance of scenic attributes in route choice behavior in general, those that highlight the importance of specific attributes for perceiving a route as scenic, and those that introduce algorithms for computing scenic routes. Studies analyzing the individual effect of different route and environmental attributes on the perception of route scenery and route choice are sparse, which is therefore the research focus in this paper.

Ben-Akiva et al. (1984), Wu and Fleming (2012) describe studies where route scenery was found to contribute significantly to the utility function of a route choice model and to play an important role in route selection. Furthermore, Wu and Fleming (2012) conclude, based on an Internet survey of 396 respondents, that scenic view influences to some extent route choice decisions even for daily commutes to work. The main focus of these two studies was to examine route choice behavior but not the identification of attributes involved with the selection of a scenic route. Eby and Molnar (2002) examined the demographic characteristics of tourists who drove along scenic byways, revealing that the presence of choosing a scenic byway was more important to the traveler when the trip purpose was vacation, when the trip was long distance, and when the trip was planned well in advance. It was, however, not examined whether scenic byways are perceived more scenic than alternative routes, and which attributes exactly contribute to route scenery.

A few studies focus on quantifying the factors contributing to the scenic beauty of locations or routes. Bishop and Hulse (1994) assessed the scenic value of landscapes based on a viewer's evaluation of various panorama pictures and subsequent regression analysis, identifying visible foreground river and range of visible relief as key predictor variables for scenery. Hochmair (2010) found that the density of geo-tagged photos from Panoramio was higher along scenic routes (which were first extracted from the EveryTrail[3] website) than the density along corresponding fastest routes between the same origin and destination. The paper did, however not further discuss specific landscape features contributing to route scenery.

Various algorithms for the computation of scenic routes are presented in the literature, including a single objective shortest path methodology on a network with modified weights (Hochmair & Navratil, 2008), or the use of Internal Path Discovering (IPD) and Bellman-Ford algorithms with VGI data sources, such as geo-tagged photos of Panoramio and Flickr (Lu, Wang, Yang, Pang, & Zhang, 2010; Zheng et al., 2013). Byon, Abdulhai, and Shalaby (2010) used a multi criteria shortest path algorithm which considers scenic zones, slope and crime ratio in the cost function. Scenic views throughout the city were evaluated in paper surveys distributed to 29 travel agents in Toronto. A weighted linear combination method was then used to express the multi criteria planning problem as a single objective function that was to be minimized through the Dijkstra shortest path algorithm. Similar to Ben-Akiva et al. (1984) the scenic zones were not characterized by more refined scenic attributes. They varied only in their rated scenery based on the results obtained from the paper surveys. Hochmair and Navratil (2008) used a single objective shortest path algorithm to compute scenic routes where costs were reduced for edges running nearby scenic locations. Similar to other related studies this approach relied on the a priori knowledge of scenic locations, such as parks, lakes, or rivers, for route computations. Zhang et al. (2008) developed a planning system that, based on a Web search engine, automatically extracts touristic spots and scenic sight recommendations upon a user's region input. The user can then select from the recommended locations, and the system computes a route that runs nearby scenic sights that are identified through visibility analysis based on a Digital Elevation Model (DEM). Although the route planning system considers touristic and scenic spots, attributes of landscape scenery are not explicitly utilized. Further the DEM used for the visibility analysis does not account for the elevation of buildings. Zheng et al. (2013) used clustering of geo-tagged photos to identify scenic hot spots, followed by the compilation of a database of scenic roadways based on road segments that were visible from the scenic hot spots. The scenic route was then determined by solving a single criteria shortest path problem using the Bellman-Ford algorithm. Sun, Fan, Bakillah, and Zipf (2013) apply a spatial cluster method on geo-tagged Flickr images to identify prominent travel landmarks, between which the best travel routes are recommended. For the latter, the authors use a linear combination of the number of images and number of image contributors for a road, the number of points of interest (POI) in different POI categories along a road, and road length, to compute a recommendation index for a road segment. The recommendation index is then used as edge cost in the Dijkstra algorithm to determine a scenic route between two specified landmarks.

In summary, only few of the reviewed studies tackle the question of which criteria are involved in the selection of scenic routes.

[3] www.everytrail.com.