Efficiency of Choice Set Generation Methods for Bicycle Routes

Katrín Halldórsdóttir *

Department of Transport,

Technical University of Denmark, Kgs. Lyngby, Denmark

Nadine Rieser-Schüssler

Institute for Transport Planning and Systems,

Swiss Federal Institute of Technology Zurich, Zurich, Swiss

Kay W. Axhausen

Institute for Transport Planning and Systems,

Swiss Federal Institute of Technology Zurich, Zurich, Swiss

Otto Anker Nielsen

Department of Transport,

Technical University of Denmark, Kgs. Lyngby, Denmark

Carlo Giacomo Prato

Department of Transport,

Technical University of Denmark, Kgs. Lyngby, Denmark

***** Email: katha@transport.dtu.dk

1 Background

With a growing interest in sustainable transport systems, the interest has increased on encouraging more cycling. To encourage cycling, it is important to identify which network attributes influence cyclists route choice and evaluate the trade-offs among these attributes. To analyse travel behaviour, observed choices and alternatives composing the choice set of each cyclist are necessary. However, generating the alternative choice sets can prove challenging. This paper analyses the efficiency of various choice set generation methods for bicycle routes in order to contribute to our understanding of choice generation for highly detailed networks.

There is a substantial amount of literature that studies cyclists' route choices. Most studies have been based on stated preference (SP) data (see, e.g., [1,2]). Although SP data have a lot of benefits there are some disadvantages, e.g. the challenge to, without bias,

predefine what cyclists consider when choosing a route. There have been few revealed preference (RP) studies reported in the literature (see, e.g., [1,2]). One disadvantage with RP data is that generating alternative routes can prove difficult.

The benefit of collecting travelling information with GPS loggers, compared to self-reported RP data, is more accurate geographic locations and routes. Also, the GPS traces give more reliable information on times and prevent trip underreporting, and it is possible to collect information on many trips by the same person without reporting fatigue. GPS data require nevertheless extensive post-processing and in some cases mode imputation. They also require a very detailed digital network to map the routes accurately, which can lead to high computation times during choice set generation, as well as issues with behavioural realism that might produce inconsistent estimates.

There have been some studies on bicycle route choice set generation reported in the literature, whereof few studies focussed on route choice models for bicyclist estimated from GPS observations. Menghini et al. [3] successfully applied a Breadth First Search on Link Elimination (BFS-LE) approach. Broach et al. [4] tested three different choice set generation methods, i.e. K-shortest paths, simulated shortest paths, and route labelling. None of these methods proved to be satisfactory and a modified route labelling method was proposed instead.

2 Objective

This paper focuses on choice set generation for bicycle routes. When generating the choice set the scale of the detailed network creates problems. The generated set should include relevant and heterogeneous routes which different cyclists would consider choosing. Including all physical routes is unrealistic.

The purpose of this work was to generate choice sets with relevant routes, including routes with relevant characteristics, i.e. scenic routes and dedicated cycle lanes. In total, two route set generation approaches were applied, i.e. a doubly stochastic generation function and the BFS-LE method. The paper analyses the methods in relation to their efficiency to generate bicycle route choice sets and also to see how they compare.

3 Data

The dataset used in the paper includes approximately 800 bicycle trips, traced by GPS, carried out by 184 persons living in the Greater Copenhagen Area in Denmark. In addition, travel diaries were collected from a sample of the participants, collecting information on their travel on a selected day, which were used for validation of the post-processing.

Schüssler and Axhausen [5,6,7] describe in detail the extensive post-processing procedures used. To obtain a more detailed network, various sources were compiled together. This resulted in a very detailed network, with attributes that we considered imported for bicycle route choice, e.g. road type, bicycle-paths and land-use. The network comprises of 110,924 nodes and 138,885 links for the study area.

4 Methodology

In total, two route set generation methods are examined with regards to their strengths to generate bicycle route choice sets. First, a doubly stochastic generation function [8] is applied, assuming that travellers perceive path costs with error and also that they have different perceptions. Advantages of this method are its computational efficiency in large networks and the inherent heterogeneity of the generated alternatives.

Finally, the BFS-LE procedure [9] is applied. This method combines a BFS with topologically equivalent network reduction. The procedure concentrates on generating the route set, which afterwards can be reduced to the individual choice set. Its advantage is, while ensuring a significant level of route variety, a high computational efficiency in a high-resolution network. So far only single attribute cost functions have been applied in the link elimination, while various extended cost functions are tested in this study.

5 Results

The paper reports on the efficiency of the two methods. The coverage measures of the algorithms are analysed by comparing the results according to different overlap thresholds. Also, the structure and the quality of the derived route sets is analysed. Since, the choice set generation methods were computed on a high-resolution network it is important to evaluate the computational time of the algorithms. The number of unique routes and the consistency index are also examined.

When analysing the efficiency of the methods, the focus is on the stochasticity of the doubly stochastic generation function and the applicability of the BFS-LE. The BFS-LE method can use similar cost functions as the doubly stochastic generation function, without the stochastic effects. Thus, it is interesting to see how this algorithm performs when using a multi-component cost function.

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