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ScienceDirect

Transportation Research Procedia 10 (2015) 413 – 422

Transportation Research Procedia

www.elsevier.com/locate/procedia

18th Euro Working Group on Transportation, EWGT 2015, 14-16 July 2015, Delft, The Netherlands

Designing single origin-destination itineraries for several classes of cycle-tourists

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Abstract

This study concerns the optimal design of cycle tourist itineraries considering several classes of users. It builds upon a recent work which first introduced the problem of designing the most attractive itinerary for cycle tourists connecting a given origin to a given destination, subject to a budget and a time constraint. Starting from a network made of existing cycle-trails, gravel paths, and unsurfaced field roads, local administrators face the problem of selecting a budget-compliant set of edges to be reconditioned and turned into paved bike trails. Indeed, investing in enhancing cycle tourism infrastructures proved to be effective in fostering sustainable development but decision support tools are needed to support decision makers in optimizing scarce public resources spending. The key issue in this problem is the objective function, namely the route attractiveness. Each node and each edge of the network yields a reward each time it is traversed, related to the pleasure of cycling along it. Additional pleasure usually decreases when traversing the same edge or node one more time but it may still be positive. Therefore, the optimal route may contain cycles, which is a special feature of this problem. In previous studies attractiveness was computed on the basis of each point of interest located on the edges and at the nodes of the route, and the route maximizing total attractiveness was searched for. The focus was on the *generalist cycle tourist*, without thematic preferences. This study takes a more realistic view and proposes a model where different classes of cycle tourist are considered individually, each one with its own preferences, like the cultural oriented tourist, the gastronomic fan, or the one fond of wild life and nature. This new perspective yields a new network design problem in the field of vehicle routing problems with profits, generalizing the Orienteering Problem, that we call the *multi-commodity orienteering problem with network design* (MOP-ND): it consists of designing a set of itineraries, one for each user class, sharing the same origin and the same destination and potentially any edge of the network, so that each itinerary satisfies a maximum duration constraint and the cost of the whole infrastructure is budget compliant. The objective is to maximize the sum on all user classes of the attractiveness of the itinerary selected for that class. In this paper we provide a mathematical model for MOP-ND, test it on realistic data, and compare with the generalist model.

Peer-review under responsibility of Delft University of Technology

Keywords: Cyclo tourist network design ; multi-commodity orienteering problem ; vehicle routing with variable profits

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Peer-review under responsibility of Delft University of Technology
doi:10.1016/j.trpro.2015.09.091

1. Problem description

Cycle tourism is emerging as a sustainable strategy for promoting economic growth, able to redistribute to an entire region the incomes due to increased tourist flows. Visitors spend money into lodging, food, and local handicrafts, in addition to all services related to a holiday by bike such as technical assistance, luggage transportation, and guided tours. These are small scale business ventures that do not need big capital investments and may encourage young people not to leave their home in the countryside and contribute to local development. However, the governmental role is fundamental. As discussed in Cox (2012) where Belgium and the Netherlands are compared, local governments policies strongly influence the development of a cycle friendly attitude, affecting also the popularity of the bicycle as a mean of transport. Once a region enjoys few features that make it worth the visit, such as a strong cultural identity, a territory marked by historical sites, plus pleasant weather and beautiful nature, if it is well connected to the transportation network only the lack of adequate biking tracks impasses the development of local and international cycle-tourism. Indeed, cycle tourists don't look for big expensive facilities while they tend to appreciate unspoilt surroundings and getting in touch with local people according to a slow motion way of traveling. There is one feature, though, to which cycle tourists are sensitive, that is safety on the road. For this reason the best way to spur this business is to set up a network of dedicated tracks where bicycles are the only mean of transport allowed.

In this paper we focus on the Trebon region in South Boemia, Czech Republic, whose local administrators face the problem of wisely investing scarce public resources for the purpose of setting up a cycle-tourist network by reconditioning existing tracks or building brand new ones in a sustainable manner. Potential tracks include field and forest roads, gravel roads, dismissed rail tracks, as well as, in our case study, abandoned army trails. Decision support systems based on quantitative methods are necessary to provide decision makers with the best tools to make the right choices according to optimization criteria, so that the resulting network provides accessibility to the most attractive locations and allows several different itineraries able to meet distinct cycle-tourist expectations. Indeed, the application of optimization techniques to the field of recreational systems is flourishing (Shcherbina and Shembeleva (2014)), the most representative case being given by the many applications of the Orienteering Problem (OP) and its several variants in the family of routing problems with profits for the sake of tourist route planning (Vansteenwegen et al. (2011)). The majority of studies concerning the optimized planning of touristic itineraries concentrate on target selection and on the routing (Gavalas et al. (2014)), assuming that the infrastructure is given: for example Vansteenwegen and Van Oudheusden (2007) studies the problem of supporting the tourist in selecting his/her own preferred itinerary according to individual preferences, taking for granted that the tourist exploits the existing transit network to move around the city, while (Liang et al. (2013)) does not contemplate any infrastructure since activities take place outdoor. On the opposite, our focus is on the design of the network infrastructure, guided by the potential use that cycle tourists will make of the resulting network. While disregarded in the tourism framework, the topic of bicycle network design has been intensively tackled by transportation engineers looking for effective planning strategies to promote the use of bicycle as a mean of transport. Commonalities and differences can be highlighted between the methodologies adopted when planning leisure oriented or transportation oriented bicycle infrastructures.

In both cases, how to model the user preferences that guide the cyclist route choice is a challenging problem. Bicycle as a mean of transport is a central issue in sustainable transportation planning, and public agencies tend to invest in improving bicycle devoted infrastructures in order to induce modal shift from private car to multi-modal transportation systems made of a mix of public transit, bicycle, and walking, to reduce traffic congestion, curtail auto emissions in urban areas, and improve life quality and health conditions by physical activity Rybarczyk and Wu (2010). To meet these goals cycling in town must be safe and desirable, but how to make people actually change their habits and switch from car to bicycle is still highly debated. In fact, cyclist behavior and preferences have not so far been fully understood so to formulate consistent mode choice and route choice models and come up with reliable bicycle travel demand data associated with potential infrastructure improvements, able to forecast the impact of different measures aimed at promoting cycling. Supply-based models tend to evaluate infrastructures by quality indexes such as bicycle level of service (BLOS) or bicycle compatibility index (BCI) that address the safety of itineraries and how comfortable the roadway is, but several studies on risk perception show the limits of such measures and the need for more sophisticated tools to assess perceived risk Parkin et al. (2007). Indeed, increasing BLOS or BCI alone or reducing perceived risk will not necessarily induce bicycle traffic. A recent study in Wardman et al. (2007) showed that economic reward would play as much a role as a devoted segregated cycleway in making people cycling to work. Moreover, cultural