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# Demo Abstract: Extracting Eco-Feedback Information from Automatic Activity Tracking to Promote Energy-Efficient Individual Mobility Behavior

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**Abstract** Nowadays, most people own a smartphone which is well suited to constantly record the movement of its user. One use of the gathered mobility data is to provide users with feedback and suggestions for personal behavior change. Such eco-feedback on mobility patterns may stimulate users to adopt more energy-efficient mobility choices. In this paper, we present a methodology to extract mobility patterns from users' trajectories, compute alternative transport options, and aggregate and present them in an intuitive way. The resulting eco-feedback helps people understand their mobility choices and explore sustainable alternatives.

**Keywords** Mobility · Tracking · Trajectory Analysis · Eco-feedback · Sustainability

## 1 Introduction

Several smartphone apps perform automatic mobility tracking, with increasing accuracy both in path recognition as well as in the identification of transport modes. Prototypical apps that assess and influence individual mobility behavior recently came into the focus of researchers [4,6]. In these apps, users frequently see a very condensed summary of their mobility (e.g., total $CO_2$ emissions) or all the individual routes they travel, and do not get a complete yet simple understanding of their *mobility patterns*. Getting the right *eco-feedback* [5], and making users aware of their mobility patterns and the consequences they entail, is acknowledged as a necessary – though not sufficient – condition towards more sustainable mobility (cf. [4]).

We argue that eco-feedback can be improved by taking into account peculiarities of individual mobility and propose a two-step approach where we first identify users' *individual mobility patterns* (i.e., a user's "systematic mobility") and then compute meaningful and sustainable *travel alternatives* (a user's "potential for change"). We deployed this approach in the Swiss-based *GoEco!* project [2], which uses a gamified smartphone app to influence the mobility behavior of 213 volunteer users over the course of 4.5 months (cf. [1]).

## 2 Mobility Patterns and Ecological Alternatives

In our approach, eco-feedback consists of *mobility features* (weekly averages of traveled distance, produced $CO_2$, etc.; they are computed from the raw tracking data and corresponding $CO_2$ emission factors) and of *systematically traveled routes* and their possible *alternatives*. Systematic routes are of particular interest, as a behavioral change in these situations would be repeated over time and thus has a large potential to reduce energy consumption. To compute these, we aggregate routes into *loops* starting and ending at the user's home location, which is motivated by the fact that travel alternatives must respect the availability of transport modes (e.g., it is implausible for someone who drove to work by car to go home by bike, as the car even-

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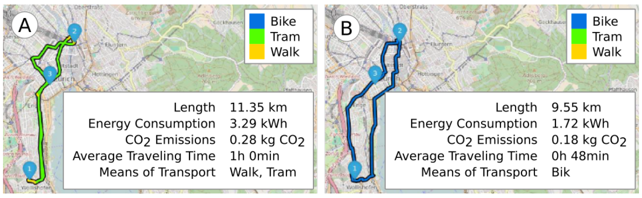


**Fig. 1** Original and alternative systematic loop as shown in the eco-feedback report.

tually needs to be at home). Within the set of identified loops, we look for loops visiting a sequence (or subsequence) of points of interest (POIs) in the same order. If the same sequence is visited at least three times within 6 weeks, we consider it a systematic loop.

The assessment of one's potential for change is based on the computation of an optimal travel behavior, which we determine by minimizing the $CO_2$ production of potential trips. Given a systematic loop, we identify different itineraries and modal choices that pass by all the POIs visited in the original loop while reducing the overall ecological impact. This search for alternatives consists of routing between individual POIs using different modes of transport (thus building a graph of mobility options) and is restricted by the following rules: 1) Modes of transport not available to a user at a certain location may not be used and vehicles must end up at their starting location. 2) The alternative duration may not be more than $\lambda$ times as long, where $\lambda = 2$ for trips up to 22 mins, and decreases to 1.3 for trips of 2 h or longer. 3) The $CO_2$ emissions must decrease by at least 5% (simply to filter out tracking inaccuracies).

## 3 Results and Discussion

Eco-feedback is presented to each user in a brief report, which contains systematic loops and their alternatives as in Figure 1. Ⓐ shows the original systematic loop, while Ⓑ shows the suggested alternative (in this case, riding the bicycle). Table 1 shows some global results obtained when computing alternatives for all 213 users of the *GoEco!* project. Although affected by the approximations necessarily involved in real data collection, these results provide a scale of potential energy savings. The table shows the average number of systematic loops and how many times each loop was repeated within a single tracking phase (6 weeks). It also presents several mobility features, averaged over all users, and compares them with what could be achieved by using the best alternative for every route.

The eco-feedback generated using our approach is mostly of educational nature, however, it can be used as a base for incentives (e.g., in *GoEco!* it impacts game elements), thus making the suggestions more effective [7].

**Table 1** Analysis of the mobility patterns and potentials for change averaged over all users.

| | Original | Alternatives |
|---|---|---|
| Avg. syst. loops per user | 3.98 | |
| Avg. syst. loops repetitions | 4.86 | |
| Weekly distances | 388.9 km | 338.6 km |
| Weekly energy consumption | 258.2 kWh | 193.6 kWh |
| Weekly $CO_2$ emissions | 50.0 kg | 37.1 kg |
| Use of car | 56.8 % | 45.3 % |
| Use of public transport | 31.3 % | 36.7 % |
| Use of bicycle | 4.0 % | 5.3 % |
| Use of walking | 3.3 % | 4.1 % |

Future research should consider privacy issues, additional data sources, such as personal calendars, in-app questionnaires or weather data, and improve on the immediacy of eco-feedback [3]. The prompt recognition of a starting journey and the real-time suggestion of an alternative could greatly enhance its effectiveness.

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