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Accurate transport mode detection in Smartphone-based mobility tracking for sustainable mobility

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Abstract

Due to the current diffusion of Smartphones and the always increasing quality and availability of sensors, travel data collected by Smartphones have become a fundamental source of information about mobility choices and transport usage.[1] The little effort required to users in the data collection process, makes automatic Smartphone-based mobility tracking a preferable solution compared to traditional, very time consuming, travel surveys. In the field of sustainable mobility, the data thus recorded are of great interest as they allow assessing citizens' mobility. Also, fully automatic tracking is, indeed, a necessary requirement for large scale interventions aimed at data collection and monitoring, as confirmed also in two recent field experiments (GoEco![2] and Bellidea[3]) we have carried out in Ticino and Zurich areas. These projects focused on the use of persuasive Smartphone apps to induce citizens to more sustainable mobility choices, by exploiting gamification techniques, social interactions and tangible prizes. It clearly appeared that, on one hand, users tend to leave the project if it requires too big an effort in data collection; on the other hand, any interaction with the user could influence her behaviour.

Currently, depending on the quality of the device, automatic location tracking can be very accurate. It has already been implemented in several tracking apps freely available on the market (e.g., fitness apps). However, most of these apps cannot accurately identify all transport modes that are relevant for a correct quantification of the ecological impact of mobility patterns. For instance, the commercial app Moves®,[4] used as tracker by both GoEco! and Bellidea apps, can only distinguish between foot, bike and motorized transport. Therefore, the general framework of the persuasive GoEco! and Bellidea apps, has been to collect pre-processed position data using Moves® app and, then, infer from these data, by a purposely developed algorithm, a more refined classification of the transport mode, including car, bus and train besides foot and bike. We have assessed the performance of different classification approaches based on the data collected in the GoEco! project (around 200 users tracked for at least two weeks) and in an internal testing phase of Bellidea (around 15 users tracked for four weeks). Results have shown that learning different classifiers for each user improves the classification accuracy as it allows learning user-specific routines. On the other side, matching the trajectories recorded by Moves® with the transport network has no relevant effects,

probably due to the inaccuracies in the segmentation of the recorded location data performed by Moves®. Moves®, in fact, does not provide the original GPS coordinates of all the tracked positions, but aggregates them into trajectory segments called activities. This feature is quite common in commercial apps.

In GoEco!, training data for the classifier were collected by asking users to confirm the correctness of all identified transport modes and to manually modify them when the classification was wrong. Having identified a relevant cause of dropout from GoEco! in the conspicuous effort required by this validation procedure, in Bellidea the number of validations requested has been reduced: validation of all recorded activities was only asked in a first *warm up* phase of about two weeks; after that, validation was requested only for the activities with low classification confidence, that is, those for which the probabilities of the two most probable transport modes where too close. Thresholds on the number of validations initially required and on the acceptable classification confidence have been set by measuring the effects of these two parameters based on the data collected along GoEco! and Bellidea projects. Due to the limited number of validated data for each user, a single classifier, common to all users, was created. Besides reducing the number of validations required to achieve a reasonable accuracy, this approach makes the classifier more robust to cheating, compared to having different classifiers for each user. To limit the negative effects of a common classifier on classification performances, a user identifier was passed as input to the classification algorithm to allow for a certain degree of specialization. Overall, we managed to obtain an accuracy of 87% asking the validation of the first 80 activities in the *warm up* phase and of about 15% of the activities during ordinary monitoring. The precision varies between 73% and 93% across transport modes, whereas the recall is between 58% and 97%.

This work has shown that, although a classification accuracy acceptable for smartphone applications can be achieved, there are good margins of improvement, especially concerning the number of validations required and the classification accuracy of public transport modes. The accuracy that could be achieved is limited also by the lack of low level sensor data, such as accelerometer and gyroscope measurements, which have proven to be effective in distinguishing between different motorized transport modes.[5] Also, the sometimes low quality of the GPS measures and, more often, the inaccurate segmentation of the recorded positions performed by Moves®, represent a limit to the classification performance. Future research will be devoted to the improvement of such segmentation either starting from Moves® records, or directly from low level sensor data.

References:

[1] Harding, C., et al. On the user experience and performance of smartphone apps as personalized travel survey instruments: Results from an experiment in toronto. In 11th International Conference on Transport Survey Methods (ISCTSC), Estérel, Québec, 2017.

[2]Bucher, D., et al. Exploiting fitness apps for sustainable mobility–Challenges deploying the GoEco! app. ICT for Sustainability (ICT4S), 2016.

[3]Cellina, F., et al. Outcomes of a smart city living lab prompting low-carbon mobility patterns by a mobile app. In: Proceedings of the 18th Swiss Transport Research Conference STRC 2018, Ascona, May 16-18, 2018.

[4]moves-app.com

[5]Wang, S., et al. Accelerometer based transportation mode recognition on mobile phones. In Wearable Computing Systems (APWCS), 2010 Asia-Pacific Conf on, pp. 44-46, IEEE.