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Automatic data collection for detecting travel behavior: the IPET platform

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Abstract

The purpose of this paper is to analyze a mobile system developed both for collecting daily trips and activities information and for promoting sustainable means of transport. Use of a technological device is a first step towards implementing tools that allow more accurate activity and travel data to be collected compared to traditional methods and communication with individuals for persuading them to choose environmentally friendly modes of transport. Nowadays such systems are essential in transport research for designing Voluntary Travel Behavior Change programs [1]. This work presents the outcome of two pilot tests conducted using the IPET platform (Individual Persuasive Eco-Travel Technology [2]), developed for managing a Personalized campaign to promote sustainable means of transport. The two tests, each conducted on a small appropriate sample, had different goals. The first was to test the App and modify/improve it on the basis of users' suggestions, before large-scale implementation; the second to assess the efficacy of the platform in terms of data collection and travel behavior change. Test results showed that the platform is easy to use and could be effective, once implemented further, for collecting and analyzing large amounts of data on mobility.

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1. Introduction

Although transportation systems are in continuous evolution, as society itself evolves, the problems and

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externalities associated with vehicular traffic remain unchanged, because of poor, often ineffective, interventions. Any measures proposed should be in line with the times, availing of the latest technology used in our daily lives (computers, smartphones, tablets, mobile apps, Internet, *etc*.).

One of the most advanced techniques, in transportation research relative to Voluntary Travel Behavioral Change (VTBC) programs [3], is "persuasive technology" [4], that aims to enhance the culture of sustainable mobility. Literally, persuasive technology refers to technological systems and frameworks designed to aid individuals' cognitive processes, attitudes and behavior, steering them towards a more informed choice of sustainable means of transport among the available options.

Very often information provided through traditional VTBC programs, in particular concerning choice of travel mode, is systematically ignored. One of the causes is related to the nature of the information, how it is communicated and the content. Often the information is inaccessible, unclear or too detailed and thus difficult to comprehend and also unmanageable because of overload or unreliable information not adequately supported [5]. In order to be effective, information needs to be useful, usable and used and readily acquired [5] as well as timely if it is to trigger changes in travel patterns. Personalized information presented in a suitable format can be more effective if repeated constantly, as repetition tends to reinforce the message, though it may be tedious. At the same time, the more individually tailored the information, the more likely people are to reflect on the consequences of their choice. Persuasive technology, with the support of mobile technology, allows one to deliver information that satisfies all the above requisites. The real novelty of technology, compared to traditional media such as radio and television, is its interactivity. It has three main advantages: a high level of personalization in data collection, the provision of real-time customized information and automation of the entire procedure for large-scale implementation. Some interesting applications for smartphones have been developed recently in the transportation sphere (Ubigreen Transportation Display [6], Quantified Traveller [7], MatkaHupi [8], Peacox [9], SuperHub [10], IPET [2], TrafficO_2 [11]).

The aim of this work is to provide a contribution to transportation research on behavior change supported by persuasive technology. The work comprised two phases: a pilot test to analyze the IPET computer platform, conducted on an appropriately intercepted sample so as to identify potential issues that the analyst, the creator of the platform with a profound knowledge of the subject, would not have been able to detect with a randomly chosen sample. This first test, for assessing the platform features, formed the preparatory work for the second pilot test, conducted on a different sample, which, unlike the first, aimed to test the efficacy of the platform in terms of travel behavior change, the real objective of the platform development.

The paper is organized as follows. Section 2 presents the application and the two pilot tests (sub-sections 2.1 and 2.2 respectively). Section 3 concludes and presents future research.

Nomenclature

IPET	Individual Persuasive Eco-Travel Technology
PTP	Personalised Travel Plan
QT	Quantified Traveller
VTBC	Voluntary Travel Behaviour Change

2. Application

The IPET computer platform tested in this work was designed for the large-scale implementation of a VTBC program for promoting sustainable travel alternatives. Following to the letter the seven principles of persuasion [4], the platform executes the entire process of data collection, analysis, processing and information provision in a VTBC program automatically and continuously. With the IPET it is possible to monitor and analyze car-drivers' actual travel behavior (surveillance), to identify possible personal sustainable travel alternatives (tailoring), to provide a simple and well-presented Personalized Travel Plan (PTP) (reduction and tunneling), complete with quantitative feedback based on the observed travel behavior, and to suggest a personalized sustainable alternative (tailoring and suggestion). All the information sent to the user is specifically customized on the basis of his/her travel/activity diary considering socioeconomic and attitudinal characteristics and needs (tailoring). Moreover, the PTP facilitates the complex process of choosing the means of transport (reduction), providing the user with all the necessary information for making a more informed choice (behavior control). Users can also monitor their own behavior (self-monitoring), through a

personal web page. After delivering the PTP, persuasive messages of incitement and reinforcement are transmitted (trigger), with text and images, whose content depends on the particular travel behavior chosen. This guides car-drivers along a path (tunneling), represented by the monitoring period, during which they feel fully supported by the technology that, in response to their behavior, approves or disapproves (conditioning), steering them towards the recommended behavior. In particular, persuasive messages are sent as soon as the user clicks on the transport mode he/she intends to use, confirming or disapproving of his/her choice. In this way the message intends to change the choice selected but not yet made. Fig. 1 shows the flowchart of the platform.

2.1. First pilot test

The first pilot test was conducted in the Metropolitan City of Cagliari in February 2014. The aim was to evaluate the platform features and the methodology used, with a view to improving the VTBC program as a whole and the persuasion tools. The sample chosen met specific requirements so as to make the test more reliable: young adults with a high level of education, as they were considered to be more familiar with mobile technology and thus able to analyze the platform critically and constructively, who were also car-drivers and could objectively assess the Personalized Travel Plan (PTP). The test lasted 6 days and comprised three steps: recruitment, program implementation and the final questionnaire that brought to light problems associated with IPET usage, form and content of PTP, sustainable alternative proposed, types of feedback provided, persuasive effects of reinforcing messages and their form and content, and web page.

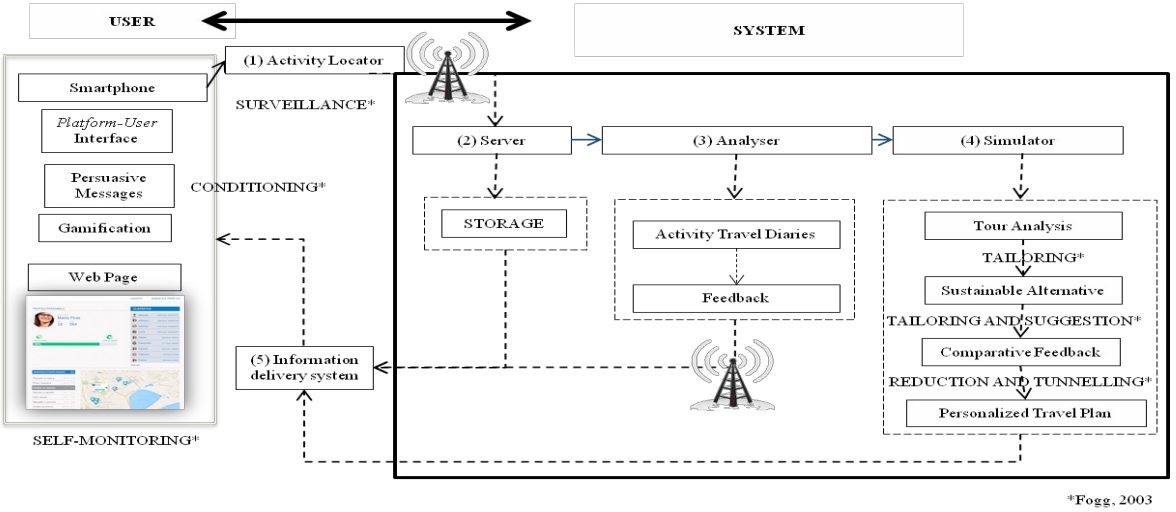

Figure 1. IPET platform functioning

A sample of ten workers (60% males and 40% females) was selected. The average age was 33 years. All participants had a master degree, driving license and owned a car. Regarding household characteristics, the sample was distributed as follows: 1-2 people (60%), 3-4 (30%), 5 (10%).

The aim of the test was to improve the tools of the platform prior to its use on a large scale. The test results showed that the general commitment required by the program was considered acceptable. Technical problems detected concerned rapid battery consumption (due to GPS use) and occasional crashes that required relaunching the application. The information provided with the PTP was found to be clear, easy to understand and was appreciated by most of the participants. Among the several feedbacks provided in the PTP, users indicated the most important to be travel time, followed by travel costs, CO_2 emissions and calories burned. Participants judged the persuasive messaging positively, preferring the messages containing both text and cartoon images. So, this test provided positive confirmation of the platform except for software performance that was improved by a team of programming experts. Before conducting the second test, the app was equipped with a gamification system that exploits competition to engage people in certain activities, stimulating commitment and competitiveness, so as to influence and persuade

them to behave in a given way, through a points and rewards system [12]. Points are assigned by comparing travel behavior observed before and after delivery of the PTP, rewarding the use of sustainable means of transport (public transport, car sharing, bike, walking, *etc.*) and penalizing private car use.

Users can visualize in every instant on their web page, the evaluation of their travel behavior through the "completion bar". As the user earns points, so the distances travelled by car diminish and the bar progressively turns green (Fig. 2).

Figure 2. Indicator bar of the user's sustainability level

2.2. Second pilot test

The second pilot test was conducted on a sample of post-graduate students at the Engineering Faculty in Cagliari. This choice was again dictated by the need to intercept young adults proficient in the use of smartphones. So, 28 individuals were recruited for a two-week survey from March to April 2016. The sample was composed of 70.4% males and 29.6% females and average age was around 25. Mode distribution for home-study trips was as follows: 39.3% private vehicle, 21.4% public transport and 39.3% slow mobility. 57.1% of the students lived out of town, the remaining 42.9% in town. Since the participants were students, most of their travel time was spent on home-university-home trips. The survey also included students who already travelled sustainably. This had a dual purpose: 1) to demonstrate to car-drivers that students with similar socio-economic characteristics managed to travel using sustainable means; 2) to obtain information on sustainable travel behavior, so as to design PTPs containing more convincing travel alternatives. During the first wave, 140 daily observations (5 days x 28 participants) were collected containing detailed information about each participant's in- and out-of-home activities and trips, Examination of the activity/travel patterns (Table 1), in relation to participation ("P"), duration and number of episodes per day (Epi/day), revealed that most of the day is spent at home (15h58'), on average 6h18' in out-of- home activities and 1h43' travelling. Regarding travel behavior by mode (Table 2), the private car is used at least once in 41% of the observations with average duration of 54 minutes a day. Trips by slow mode accounted for 86% of the observations, with an average daily duration of 61 minutes. Public transport, with a level of participation of 24.2%, is used for an average duration of 68 minutes a day.

Table 1. Daily activity time allocation

Activity	P [%]	Duration [h.min])	Epi/day
In-home	100	15.58	9.5
Out-of-home	95	6.18	5.1
Trips	95	1.43	8.6

Table 2. Daily travel behaviour by mode

Activity	P [%]	Duration [h.min])	Distance [km]
Private Transport	61.0	54	25.2
Public Transport	25.2	1.08	18.9
Slow mobility	86.3	1.01	3.6

Of the 11 students (39.3%) who travelled mainly by car 8 were selected for whom a feasible sustainable travel alternative could be suggested. Thus, they received a PTP containing a series of travel alternatives designed on the basis of their activity/travel patterns collected in the first wave and constructed using Google Maps API. Six of the eight students selected agreed to participate in the second monitoring phase that lasted 5 days. During the second wave two students changed their travel behavior, using the suggested alternative for the 5 days, 1 student tried the recommended alternative but did not continue to do so and 3 participants did not change their travel behavior at all. Comparison of the average weekly values for the first and second waves showed a reduction in the time spent travelling by car of 47.7% and a reduction of costs of 35.7%. As for CO_2 emissions, these decreased by 35.4%, while calories burned as a result of active trips increased by 202.4%. Figure 3 sums up the overall benefits after implementation of the second wave.

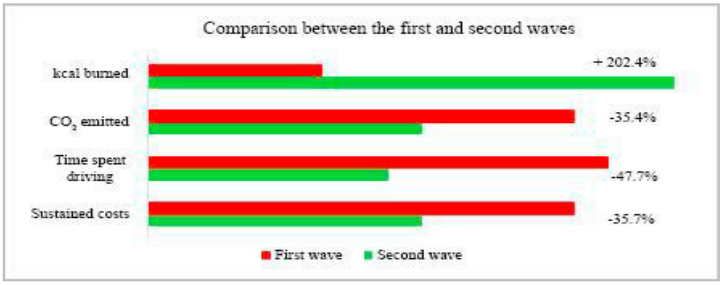

Figure 3. Comparison between the first and second waves of the second pilot test

As, unlike the first, the second pilot test was geared towards the process of behavior change, we introduced a point rating system, whereby the student with the most sustainable travel behavior was awarded a €15 gift card. Most of the students judged the idea of the classification and prize as a further stimulus for behavior change. In particular, as the students involved in the second wave knew each other, the possibility of winning a prize represented a real challenge among friends and a further incentive to change their travel behavior. This is confirmed by the fact that around half of the sample would have liked to have been notified not only when he/she, but also the others earned points. This feature is being incorporated into the improved version of the platform.

Another important feature is the use of persuasive messages. Whereas the first test focused on the design of these messages, one of the purposes of the second test was to analyze the efficacy of these messages in influencing decisions to travel. The majority of the participants judged the persuasive messages (Fig. 4) to be graphically pleasing and found that they succeeded in making them reflect on the consequences of their own travel behavior. When positive (approval), the messages conveyed the feeling of being able to improve the environment (100%), put them in a good mood and feeling better about themselves (66.6%). Negative messages (regret), on the other hand made them feel guilty (66.6%). The participants also thought the completion bar was a good idea though some would have preferred introducing intermediate objectives with a prize for achieving them.

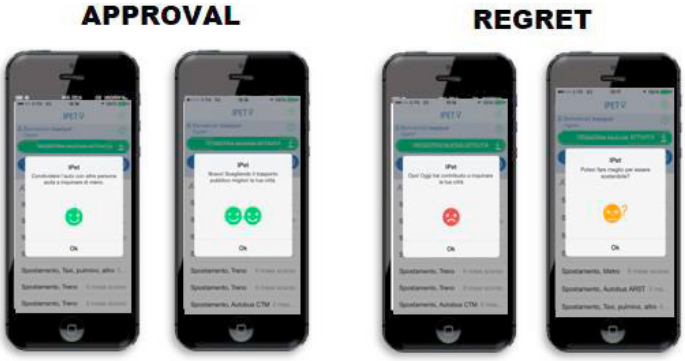

Figure 4. Persuasive message containing both text and cartoon

3. Conclusion and future research

The aim of this work was to test the usability and efficacy of a computer platform for collecting data on mobility and implementing a VTBC program. In spite of the small sample, several interesting aspects emerged. In the first place, considering the complexity in terms of resources, time and availability of people to participate in a VTBC program as described herein, it is important to establish criteria for participant recruitment. Suitable candidates need to be carefully chosen, intercepting individuals with a strong aptitude for modern technology such as smartphones. They also need to be motivated to participate and willing to consider a change in their travel behavior that is both feasible and beneficial. Motivation is fundamental to behavior change. In fact, the collection of mobile data with a passive application of this type requires a major commitment on the part of participants in the survey.

Unmotivated individuals are unlikely to provide accurate data or to understand their importance for recommending alternative travel options. Additionally, the literature has demonstrated that behavior change can only be evoked if the proposed alternative is advantageous and if the individual is actually willing to change. Thus, identifying the right target is important. For the above reasons only, a small sample was intercepted, nevertheless appropriate for achieving the objective of the pilot tests to assess and improve the platform's features. The participants' feedback demonstrated that despite demanding greater commitment than passive data acquisition, the platform proved acceptable, easy to use and non-invasive. The active participant-platform interaction is a fundamental feature as it allows individuals to continuously engage in the program, thereby enhancing their motivation, as well as the collection of more detailed and accurate data, making the information more authoritative. Another interesting aspect concerned behavior change itself. Half of the sample tested the suggested alternative while two thirds of these also changed their travel behavior definitively, choosing a sustainable alternative to the car. These results are comforting, though in terms of number, given the small sample size, the tests could not provide conclusive evidence. Projection of the results to the large scale (again intercepting the right target), suggests that a non-negligible number of individuals may be likely to change their travel behavior: future work will extend the study to include a larger sample in an endeavor to promote more sustainable means of transport alternative to car use. In this sense, we are working with the University of RomaTre to improve the study. In particular, this collaboration has increased the number of available data and made it possible to compare two vastly different urban realities, the cities of Cagliari and Rome.

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