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Multimodal travel companion enabled by Artificial Intelligence

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Abstract

The rail and urban transport industries are currently facing several challenges. Passengers demand a higher quality of the service while more attention is being paid to cost efficiency and subsidies allocation. Public Transport (PT) systems are increasingly equipped with automated data collection systems that can be instrumental in addressing these challenges. Data enables planners to investigate and quantify the costs of service deficiencies and the potential benefits of alternative solutions. At the same time, data allows for real time analysis and interaction with the passenger to improve her travel experience. In line with the EC rail transport strategy (Multi-Annual Action Plan-MAAP), My-TRAC project, co-funded by Shift2Rail JU, is devoted to do research and develop user centric services that will enhance passenger multimodal door-to-door experience. This will be done with the real time analysis of massive datasets that will provide recommendations through the My-TRAC Mobile App and accompany the user along her journey. On the other hand, Transport Operators will obtain feedback from the behavior of the users, being able to use anonymized statistics to understand the behavior of the passengers. My-TRAC will obtain higher confidence and adhesion contributing to multimodal transport services improvement and monitoring.

Keywords:

Travel Companion, Artificial Intelligence, Shift2Rail

Introduction

Passenger transport has increased significantly in the last decades and mobility needs of citizens are rapidly changing. The current transport system situation is worrying in terms of economic and environmental sustainability and has triggered a global awareness and willingness to undertake a holistic change, which is visible in the EU mobility strategy. In the 2011 Transport White paper, the European Commission (EC) stated its objective to drastically reducing world greenhouse gas emissions by 80-95% below 1990 levels by 2050 in order to mitigate climate change.

The rail and public transport industry are currently facing several challenges. Passengers demand a higher quality of the service and while more attention is being paid to cost efficiency and subsidies allocation. Public Transport (PT) systems are increasingly equipped with automated data collection systems that can be instrumental in addressing these challenges. For instance, the design and refinement of cost-effective measures can be supported by measuring, computing and projecting the expected impacts on costs and passengers. Data sources such as Automatic Vehicle Location (AVL), smart card data, floating device data (FDD) and GSM data may support PT design and decision making, in addition to efficient and high quality operations. Data can be used to gain a better understanding of passenger needs and behaviour, system performance and real-time conditions. Moreover, data enables planners to investigate and quantify the costs of service deficiencies and the potential benefits of alternative solutions, In line with the EC rail transport strategy (Multi-Annual Action Plan-MAAP), My-TRAC project co-funded by Shift2Rail JU, is devoted to research and develop user centric services that will enhance passenger multimodal door-to-door experience, resulting in a greater confidence and adhesion to rail transport services from citizens. Furthermore, My-TRAC will contribute to multimodal transport services improvement and improve adaptation to users' needs through the provided data, statistics and trends from the passengers' experiences while using the proposed platform.

Objectives

The main goal of My-TRAC is to develop a novel transport services platform for rail and urban public transport sector, designed for public and private transport users and operators in order to provide an improved passenger experience by developing and applying advanced behavioural and transport analytics and Artificial Intelligence algorithms to meaningful data gathered from diverse public transport and Open Data sources. My-TRAC will create a smartphone application that will connect information from various sources: (i) Public Transport (PT) operators for schedules and actual information (i.e., delays, disruptions), (ii) MaaS providers (i.e. car-sharing, bike-sharing, taxi services), (iii) Datasets related to the service and trip (i.e., parking availability, crowd density at stations, security) and relate this information with users' preferences and state-of-mind. Preferences affect strategic choices (when organizing a trip, e.g., Value-of-Time, owning a car) while state-of-mind of a traveller and actual level of service of PT affect dynamic choices (choices during a trip or immediately before, e.g., nervous about missing an appointment). The My-TRAC project will determine ways to measure both preferences and state-of-mind while the My-TRAC application will utilize this information to personalize information that the user receives from the application, further enhancing PT user satisfaction and quality of service. My-TRAC application will provide seamless transport services integrating established applications, such as operators' trip planning apps and providing an added value by applying efficient algorithms for behavioural analytics and connecting to other MaaS applications and related datasets.

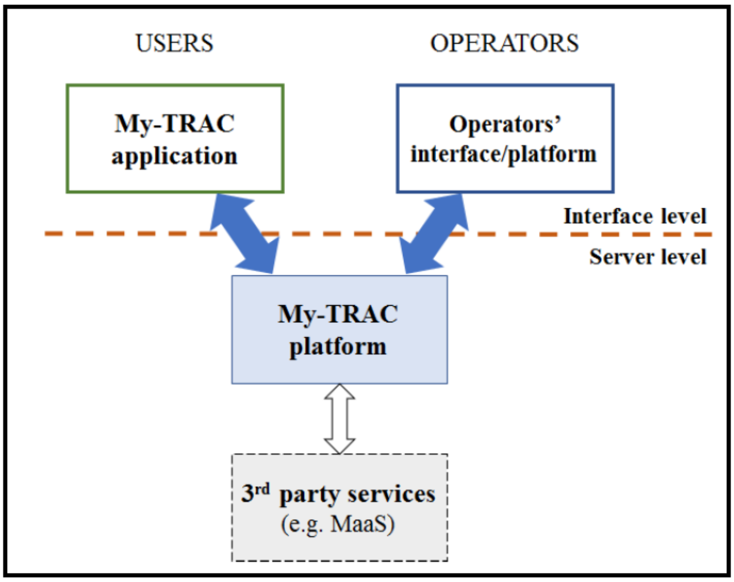

Figure 1 – My-TRAC platform

Thus, **My-TRAC clearly extends existing companion concepts through the introduction of human-like behaviour (Artificial Intelligence).** To that extent, the application is a real 'companion' that will take the strain of organising travel under all circumstances, thus improving a traveller's travel comfort and ease of travel. The My-TRAC application will create efficient data sharing methods among various applications which will be achieved by efficient app-user management (PT users, 3rd party apps for MaaS, operator apps). The My-TRAC application will provide interfaces for both users and operators, the former will receive improved trip planning information customized to their needs and state-of-mind, and the latter will benefit from receiving access to anonymized and aggregated behavioural data to be used in real-time and strategic planning activities.

Pilots

The application will be deployed and tested in pilots in which study groups will contain users and operators. The pilots are expected to be validated the usability of various aspects of the application (information received, efficiency of state-of-mind and preferences determination). Operators' groups will determine usability of behavioural data received from the application for dynamic and strategic planning and operations. Pilots will be used to test the My-TRAC application in a realistic environment. Two target-groups are distinguished for the pilots: Public Transport (PT) users and operators. In addition, PT users will be divided into control and study groups. During the pilots, the application will be distributed to a selected group of individuals in each pilot location: the Netherlands, Greece, Portugal and Spain. The pilots are run in cooperation with local transport operators: Nederlandse Spoorwegen in Netherlands, ATTIKO Metro in Greece, FGC in Spain and Fertagus in Portugal.

Concept

The My-TRAC project is expected to move beyond the state of the art and advance science and technology in the three main research pillars that constitute the project: PT user modelling, data analytics, user communication (Human Machine Interface). Furthermore, the project is divided into three phases. First, research on the topics of the main research pillars, second, creation of the IoT application and implementation of models and algorithms created in phase one and finally, execution of pilots. The third phase will create a feedback loop with phase 1; results and conclusions from the pilots will be used to improve the models and algorithms of phase 1 while improvements will be inserted to the application during project execution. The following Figure shows a schematic representation of the main project components and the high-level project flow described above.

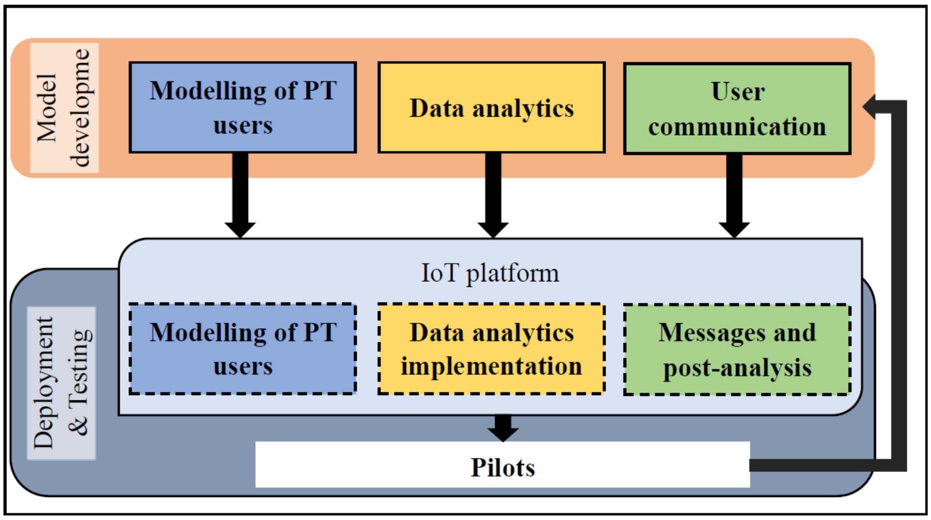

Figure 2 – My-TRAC components

The pillar of PT user modelling will provide scientific breakthroughs beyond the project scope. It is heavily involved with behavioural analytics and in a combination with the second pillar of data analytics, it will provide an exhaustive representation of the user traits that affect decision processes while diving deep into predictive analytics. This information will not only assist dynamic planning operations (i.e., when the user is moving), but also strategic planning operations that are performed by the operator. Furthermore, the project will examine trip sequences performed by multiple modes of transportation, including sharing schemes and automated vehicles concept. The analysis will also give significant recommendations to operators and policy makers concerning modern capabilities of multimodal concepts such as Mobility-as-a-Service. Finally, bilateral means of data exchange between operators and users will be examined for purposes of improving predictive capabilities of the created models that move beyond data visualization which is the commercial norm (for example, see traffic information of Google maps).

Artificial Intelligence enabled Travel Companion

My-TRAC is looking into expanding our understanding of decision making of travellers. Why people choose a certain mode of transportation over another, e.g. a car over a train, or a bus over a bicycle? How do they experience a trip, what makes them happy, or what drives their behaviour? Personal AI assistants, while still limited in capabilities, already proved to be valuable and useful for routine people's decision making. However, traditionally used decision making factors, such as the time of the trip, the cost, the number of transfers and others that are usually used by personal assistants (such as Google Maps Directions), are inadequate in many cases, since they fail to incorporate factors such as perception of a trip's comfort, perception of reliability (perceived chance to complete a trip as planned) or safety (e.g. avoiding large crowds), the state of mind of a traveller (e.g. a person late for an important meeting vs. a person travelling for leisure on a weekend), the purpose of the trip and familiarity of a user with potential options. Failure to include these considerations into personal assistants often results in recommendations that are (rationally or irrationally) suboptimal or those that are not followed by people. My-TRAC is looking into ways to quantify and incorporate all these factors into user choice modelling and intent recognition of a recommender system of its personal assistant and into ways to affect the rationality of users' choices by providing them extra information and reducing uncertainty where necessary. As mentioned, the recommender system of the My-TRAC application is expected to operate similarly to a human companion, which includes the following:

1. Learning about a user, their personal profile, entitlements and preferences.
2. Requesting additional information only when it is absolutely necessary, not being "in the way" of a person who knows what they are doing, but being able to provide an unrequested recommendation when there is a high chance that the user is doing a suboptimal action due to lack of knowledge or other factors.
3. Being "an oracle", i.e. receiving enough information to generate a comprehensive overview of the current transport situation and being able to predict how the situation will unfold.

In order to achieve its goals, the My-TRAC project employs several artificial intelligence techniques and collects data from as many sources as possible. The optimal travelling solution for the same origin/destination/timespan will nevertheless be different, depending on a user's situation and access to options (availability of a car or a bicycle, public transport discount card, etc.) and on their soft preferences and state of mind (purpose of the trip, being in a hurry, preference for comfort, safety, etc.). The personalized recommendation algorithm needs to take these factors into account. In Figure 3 you can see the schematic My-TRAC's approach to the personalised recommendation system. Collaborative filtering approaches (Goldberg et al. 1992), such as those used in Netflix or Amazon (Linden et al. 2003) are commonly used for providing well-matching personalized recommendations.

Collaborative filtering can be best described as an algorithm that finds users who have a similar profile and exhibit a similar behaviour to the current user, and by looking at other behaviour patterns of those users, find and suggest routes that best correspond to these behaviour patterns.

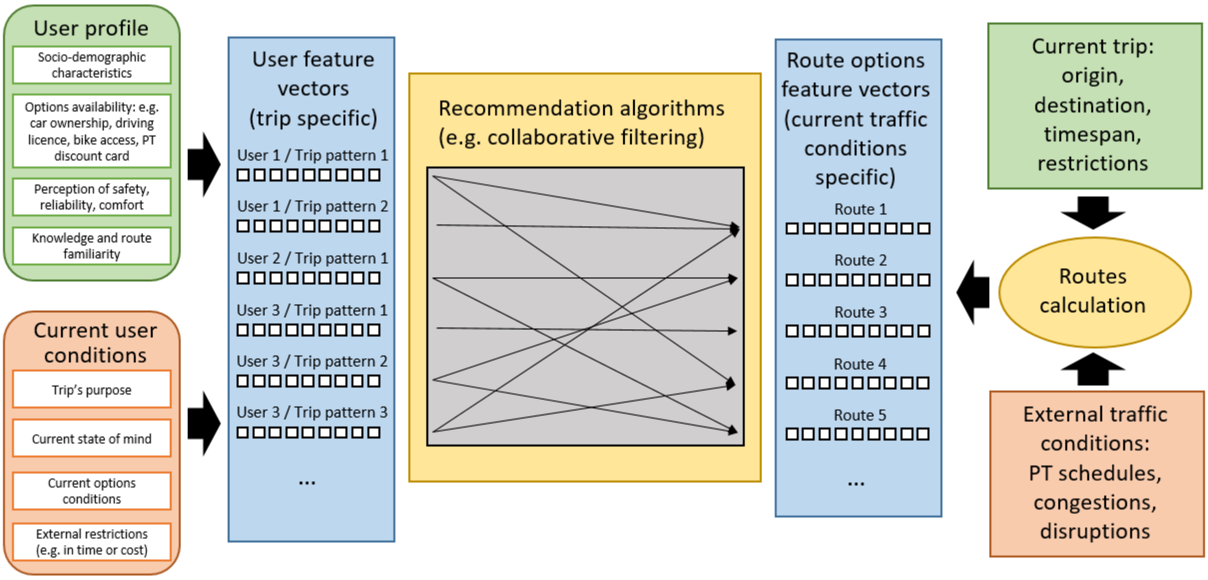

Figure - Personalised travelling recommendation systems needs to combine static information about the users, with their current state of being, and analyse current traffic conditions to propose the best-matching route.

However, in their basic form these algorithms assume persistence of features that describe users and items (routes, in our case), whereas in the transportation scenario we must deal with unique user situations and route circumstances every time (changing origin-destination pair, trip purpose, user's state of mind, external traffic conditions, etc.) Therefore, in order to take advantage of collaborative filtering, we need to transform each unique situation into a pair of pattern feature vectors, one to describe a pattern of a current user's situation, and the other one to describe a pattern of currently available routes and traffic conditions. The similarity search among users can then be done not only on their static parameters (e.g. socio-demographic situation), but also on their current unique conditions. In the same vein, the similarity between routes will take into account current traffic conditions, e.g. two different routes can be treated as partially similar in cases of heavy congestion. That can be explained by a simple example: users, that normally exhibit very different travelling behaviour, based on their comfort, safety and character profiles, can nevertheless exhibit a very similar approach to solving the transportation problem in case of an unplanned severe disruption with limited time available to reach the required destination (time becomes of issue, therefore cost and convenience are almost removed from consideration).

Basic collaborative filtering recommendation algorithm suffers from a "cold start" problem: a preferences of a new user in a system are yet unclear, therefore recommendations cannot be personalized. In order to avoid the "cold start", the My-TRAC combines user profiling with personalization. Profiling of travellers is a popular way to achieve market segmentation. For example, (van Hagen, 2009) presents six common psychological profiles of train passengers: the explorer, the individualist, the functional planner, the certainty seeker, the socializer, the convenience seeker. (Rudloff & Leodolter, 2017) propose to use a small set of initial questions for quick dynamic profiling travellers. My-TRAC follows a similar approach. At the initial setup of the application a small number of questions (4-5) should be asked in order to have an estimation of a user's profile. However, My-TRAC is also looking to complement it by analysing social information available from social networks, if a user allows access to these networks, e.g. by analysing the sentiment of their recent posts.

Travel behaviour analysis

Decision making when planning daily travel and while travelling, namely Travel Behaviour, is a complicated process which has been a field of research over the past decades. Researchers aim to disentangle this complicated process by identifying the factors that influence travellers' decisions and choices. Travellers may engage a variety of alternatives when planning to travel. Therefore, travellers, prior to and during their trip, makes various choices for deciding mode, route and time of departure. These choices depend on factors that are predetermined (e.g., car ownership, location of work) and on emotional factors (e.g., anxiety, perception of crowdedness). According to the literature, travellers evaluate the various alternatives based on their utility function, which describes the importance of each factor to the decision-making process.

In this research, we move one step forward by assuming that affective factors are also included in the process of decision making. More specifically, we consider that not only objective attributes of the trip, but also traveller's feelings and perceptions are being evaluated when trip alternatives are being compared. All affective factors are analysed under the broader concept of Travel Happiness, which is considered to be the happiness which every person experiences while travelling. Although the link between happiness and behaviour has not yet been well studied in the transportation field, some studies have shown that travel choices are more likely to be motivated by the goal of enhancing happiness rather by the traditionally studied concept of reducing travel cost. Travel Happiness, for the study, is defined as a part of the overall happiness that someone experiences and that is related with the stimuli the traveller engages when travelling.

In order to improve traveller's experience through the entire duration of a trip, My-TRAC will develop a transversal user centric platform, which will provide a passenger Travel Companion smartphone application coupled with a web-based interface for rail operators. The smartphone application will provide improved recommendations to travellers by understanding their perception on the different stimuli they receive while travelling based on a machine learning process. The interface will provide operators with real-time and strategic information on travel happiness and other data (e.g., flows, density, and interests) that will assist in improving the quality of transport services offered to and perceived by travellers. The achievement of the above-mentioned goals requires the understanding of travel behaviour, the exhaustive investigation of factors involved in the decision-making process of travellers and the identification of different mobility profiles.

Scope of the survey

The survey is aimed at identifying the factors that affect the mobility choices related to the mode of transport, the time of departure and the route followed. Moreover, data collected from the survey will be used to identify different mobility profiles of travellers by combining both mobility patterns/choices and socio-demographic characteristics. Finally, results will provide a preliminary assessment of different services, namely travel modes and provide an overview of the transportation system. The aim of the survey is to lay the foundations on which the planning and operation of the travel companion will be based. More specifically, the survey aims to collect the baseline data for generating the models of destination, mode, time-of-departure and route choice as well as the travel happiness model. The main aim of the survey is to ensure the quality of the data gathered and, by extension, its results. To this end, some goals have been set regarding the sample characteristics and more specifically concerning sample distribution between different travel modes and different ages. Since, the travel companion will provide information to both private vehicle and public transport users, half of the sample must be frequent users of private vehicles (car, motorcycle, bicycle) and the rest, public transport users (metro, bus, train, tram). Concerning age distribution, most likely users of smartphone applications with <54 years of age consist the majority of the sample (75%), but also a satisfactory sample of older adults (>55 years old) will be collected, which will account for 25% of the sample.

The survey will be implemented in Greece, The Netherlands and Spain with the goal to obtain 700 answered questionnaires from each country and 100 traces of user's position.

Methodological approach

The questionnaire designed for the purpose of this research consists of 4 parts and 27 questions. The first part of the questionnaire includes 12 questions and aims to identify different mobility profiles. Respondents are asked to provide information concerning their usual trip, namely trip purpose, mode of transport, number of transfers, travel costs etc. Moreover, in this part of the questionnaire we ask the respondents to report their level of happiness during their usual trip, their level of tolerance with respect to changes on network and service's conditions and their perception on the occurrence of any unexpected event. The second part of the questionnaire consists of 3 subparts and aims to reveal the factors that affect users' choices concerning mode, route and time of departure. Respondents are asked to assess the importance of each factor in the decision-making process, based on a 5-point Likert scale where 1 stands for "Not Important" and 5 stands for "Extremely Important". Furthermore, in the third part of the questionnaire respondents are asked to assess the travel mode that they use the most. More specifically, a list of services' attributes (Flexibility, Reliability, Availability, Safety, Security, Accessibility, Comfort) was given is given to the respondents and they are asked to assess each factor in a 5-point Likert scale from 1 = low to 5 = high. Finally, the last part of the questionnaire includes 7 questions regarding socio-demographic characteristics (gender, age, occupation, income, household size, home location and number of available vehicles) of the respondents as well as 4 questions concerning their attitude towards social media.

Execution of Questionnaire Survey

The questionnaires are completed via personal interviews conducted on the street, as well as via online means. In order to facilitate the process for both the onsite and the online survey, we used the Google Forms platform to create the questionnaire. The field survey as well as the online survey have a total duration of 6 weeks, starting from January 8th. On site survey is conducted in parking areas, metro/train stations with connection to other modes (bus, tram, etc.) and in activity/leisure centres. The geographic dispersion aims to include frequent users of each travel mode, as well as achieving sample characteristics goals.

Collection of Travel Traces

In order to further understand travel behaviour, travel traces are collected during the survey. More specifically, by the end of the questionnaire, respondents are asked to share traces from a typical week, as recorded in Google Timeline. The aim of collecting respondents' traces is to combine travellers' profiles emerging from the questionnaire survey with the actual everyday trips of the travellers. Traces will assist in analysing the interests of specific users and destination choice.

Conclusions

My-TRAC is looking into the decision making process of travelers, why people choose a certain mode of transportation over another, e.g. a car over a train, or a bus over a bicycle. Artificial Intelligence is applied to develop a personal assistants that look into ways to quantify and incorporate all the identified factors into user choice modelling and intent recognition of a recommender system of its personal assistant and into ways to affect the rationality of users' choices by providing them extra information and reducing uncertainty where necessary. To support the development of an AI enabled travel companion, the project has developed a survey aiming at identifying the factors that affect the mobility choices related to the mode of transport, the time of departure and the route followed. The final results of the survey will be available in summer 2018.

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