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Ambient Intelligence on Personal Mobility Assistants for Sustainable Travel Choices

Daniele Magliocchetti[a*], Martin Gielow[b], Federico Devigili[a], Giuseppe Conti[a], Raffaele De Amicis[a]

[a]*Fondazione Graphitech, Trento, Italy, 38123*
[b]*Faculty of Computer Science and Electrical Engineering , Rostock, Germany, 18059*

Abstract

An increasing amount of attention is being paid by local public administrations, national and federal governments as well as by international institutions, such as the European Commission, to improve personal mobility within urban environments through the use of public transports. Improving mobility through increased use of public transportation is strategic to reduce energy consumption, to lower emissions and pollution levels, to improve public safety and to dramatically reduce congestions and road traffic. Reducing private transportation clearly brings significant benefits not only to citizens' quality of life and public health but it also results in a more efficient urban system as a whole, with consequent substantial economic benefits at the wider societal level. At the same time, it is difficult to change human habits and people using public transports should have an efficient and user friendly way to access the best travel options suitable for their needs. Based on this assumption, this paper presents a prototype for an ambient intelligent urban personal mobility assistant, i.e. a software for smartphones and tablets which promotes use of public transport by helping user to identify the best travel option across a multi-modal transport network, through a user-friendly interface that intelligently adjusts to user preferences, and behavior.

Keywords: *Personal Mobility Assistant, Intelligent Transportation System, Mobile Computing, User-Friendly mobile HCI, Pattern Recognition, Android OS*

1. Introduction

Personal transportation worldwide has a tremendous impact in both economic and environmental terms. As noted by Rodrigue et al. [4], transportation has direct impact on climate change and biodiversity, noise, air, water and soil quality as well as indirect consequences on policy making. In Europe alone transportation is accountable, according to the European Environment Agency (EEA), of nearly one third of all the energy consumption and of more than one fifth of all greenhouse gas emissions of EEA countries. According to Eurostat - Statistical Office of the European Communities, in nine out of 32 EEA member states more than 85% of passengers travel demand is based on private car transportation. The resulting number of vehicles is extremely high due to low average occupancy rate which was, in 2007, on average, 1.8 passengers in Eastern European countries and 1.54 in Western Countries.
The issue is bound to worsen since, according to IEA/SMP (International Energy Agency / Sustainable Mobility Project) model projections until 2050, passenger demand in terms of total passenger-km travelled, will constantly grow. In fact more than half of EEA countries have witnessed an increase in use of car-based passenger transport, coupled by an increase in terms of car ownership of nearly 2% per year, which has brought to an average of 42% of EU citizens being owner of a car in 2009. In general terms, not only within Europe, the rate at which car-based passenger transport increases varies according to economic levels of various countries. In countries such as Germany, France, Italy, the UK and Spain there has been a reduction in the last years, while in other emerging economies, such as Lithuania, use of car has grown by 200% in the last decade.
Unfortunately the overall increase in land passenger transport demand corresponds to a reduction of rail and bus travels, with car-based travels increasing at higher rate. In fact, as noted by the EEA, "the 20% growth in demand between 1995 and 2008 makes it increasingly challenging to stabilize or reduce the environmental impacts of transport" [1]. The impact of road transport has serious consequences in terms of pollution with cities such as London, Paris and Rome having the highest emission levels in the EU. According to the EEA, car

* Daniele Magliocchetti. Tel.: +390461283397
Fax: +390461283398; E-mail:
daniele.magliocchetti@graphitech.it
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transportation is by far the most polluting travel means in terms of emission per passenger-km, outpacing other transport modes, depending on the emission parameter, by more than one order of magnitude. In fact road transport is the main responsible for NOx emissions, the second main responsible for PM2.5 and other gases such as CO, the third contributor to PM10. Furthermore the improvement in terms of emissions, achieved by development of greener engines and fuels mostly used on public transport vehicles and partially on private cars, is partiallyoffset by the increasing number of vehicles and although there is a mobility growth among the citizens, there is little motivation to improve the infrastructure quality.

Car transport is also a major killer. It is estimated that road accident caused in 2004 1.2 million fatalities worldwide with the highest percentages (90%) occurring in low-income countries, where in-car safety system are less diffuse and where the city infrastructures cannot withstand the traffic growth. Motor vehicle collisions rank as the sixth cause of death in the USA and are accountable for 48% of severe injuries in Canada, according to Canadian Institute for Health Information. Similar figures are reported on the other side of the Atlantic, as according to Eurostat, in EEA-32 the annual number of fatalities caused by road transport was close to 42,000 on 2007 compared to less than 90 fatalities per year accounted by the sum of rail water and air transport.

A study dating 2004 by the EEA [3] shows that, although environmental awareness on implications and effects of transport among the population in Europe is significant, the actual behaviour of those who claim to be more environmentally-aware is often not sustainable. Often the crucial factor to deploy environmentally sustainable travel behaviours is to help people overcome the increased inconvenience caused by the use of public transport (i.e. roadblocks, diversions, accidents, etc.), have a way to motivate people on using public transportation by making them aware of their contribute to the environment and also something that is amusing and flexible to user needs.

This evidence is at the heart of the problem which has been tackled by the EU-funded i-Tour project of which this paper illustrates the software client. The project i-Tour -"intelligent Transport system for Optimised Urban trips" is developing an intelligent infrastructure to support personal routing over a multimodal transport network in urban and sub-urban contexts.

The client has been specifically designed to stimulate use of public transport in place of using private cars, deploying a number of user-friendly techniques to minimize the inconvenience typical of travelling by public transport. To do so it facilitates access to contextualized travel information by borrowing methodologies typical of ambient intelligence to deliver a smarter interaction dialogue with the central system, adapting to user travel styles by changing the routing results and the interface with the final user. Furthermore the client promotes and encourages use of public transportation through a number of incentives based on serious gaming strategies, awarding those users who opt for sustainable travel choices (e.g. those providing most significant CO2 or PM savings) in place of travelling by car. The client is specifically developed for smartphones and tablets. The widespread success of these portable IT devices is significant as highlighted by a study dating 2010 edited by The Pew Center [6] as well as in [7] where the amount of smartphone sales in 2011 will exceed the number of personal computers. The study, which involved more than 2.500 adult users in the US, shows that there is a substantial share of mobile phone users using their device for other activities rather than phoning. This is true across several age groups with peaks of 90% of those users aged 18¬29, down to 82% of users aged 50-64.

The remainder of the article is organized as follows: section 2 provides details about the current research status, section 3 describes the personal mobility assistant and its user-friendly solutions to help taking sustainable travel choice while section 4 provides details about the contextual awareness of the system and examples of its adaptation to the environment and finally, section 5 provides conclusions and possible future extensions of the system.

2. State of the art

Routing systems have essentially been developed for car navigation with few adaptations (for instance to cater for cyclists) to deal with an extended road network database which includes bike lanes and paths suitable for riding. Little attention has been paid to providing different types of routing, for instance based on landmarks met along the street or supporting integration within several transportation network services (i.e. alerts) and even less attention has been devoted to take in account alternative way of travel based for example on car sharing or certified hitchhiking.

Web-based systems such as Google Transit are an extension of a standard web-based routing system. CityAdvisor (http://www.cityadvisor.net/) is an application for Windows Mobile 6.0 powered phones that provides routing over public transport network based on indications and symbols of different network lines. The indications provided are essentially the ordered list of unimodal journey that the user has to take to reach destination, without providing any navigation neither on how to reach them nor on how to transit among different journey segments. Furthermore no advanced recommendation is available based on specific user preferences neither a mechanism based on updates is set in place.

Several studies have tried to create mobile applications trying to incentivize use of sustainable travel choices. A study carried on in the US [8] has shown that "if obstacles to not driving could be overcome, motivations other than eco-friendliness could be used to motivate green travel". The study highlighted that while only a minority (19%) of the people interviewed considered eco-friendly travel as one of their priorities, the vast majority (72%) declared that they would be willing to set goals for them to travel in a more sustainable way. The study also showed that the users were willing to interact with abstract iconic representation, with regards to visual feedback, rather than numeric representation. The authors highlight the importance of adopting iconic representation bringing advantages such as evocativeness or aesthetics.

When referring to scientific literature dealing with contextual awareness, ambient intelligence and multimodal interaction, research has focused on developing techniques capable to identify as much contextual information as possible. Relevant works include the Context Managing Framework, developed by Korpipää et al. [9] which employs a context manager, a set of resource and context recognition servers which eventually act as an interface with the final application. Other middleware include SOCAM (Service-Oriented Context-Aware Middleware) [9] to create context aware services for mobile applications. CASS (Context-Awareness Sub-Structure) [11] is a similar middleware capable to retrieve information from different distributed sensors, collect them and interpret them. Another system specializing in context awareness for mobile devices is Hydrogen [12] which distinguishes between local and remote context, the former being the awareness available from the mobile device, the latter being the awareness available from other devices. A further framework is CORTEX system based on Sentient Object Model

[13] specifically designed to cater for mobile scenario requirements.

A very large corpus of research paper is available on the field of so called ambient intelligence, where behaviour of users have been monitored in closed, very controlled "smart" environment. Increasing attention is being paid to monitoring movement behaviours of users, mainly for health monitoring and/or improving reasons. Examples include the work of Consolvo et al. [14] which make use of mobile phones connected to portable fitness sensing units connected to mobile phones via Bluetooth. Information on movements is used by the mobile phone to create forms of incentive to promote physical activities and healthier lifestyles. Other similar applications make use of external sensing units [15]. Several research works make use of information coming from sensors fitted on mobile phones as in the case of WISDM (Wireless Sensor Data Mining) project [16] where Android phones are used to detect activities such as walking, jogging, ascending or descending stairs or stationary state (e.g. sitting or standing). Information was sampled at a frequency of 20 Hz. To perform classification, recordings were divided into 10s long reading which were used to extract six key feature readings, namely average acceleration for each axis, standard deviation for each axis, average absolute difference, average resultant acceleration, time between peaks (the time between sinusoidal patterns peaks associated with activities for each axis) and binned distribution.

Typically the parameters relative to each context state are defined in a standard attribute-value tuples. Each sensing unit generates tuples (or corresponding objects when developed in more recent object-oriented frameworks) with information on each measurement. Several components act as unimodal sensing devices and then transfer this information to a further high-level component which aggregates the information from low-level sensing devices and infers the final state regarding a given context. Techniques have also been developed to extract information from historical data accessing information from a database which operates as context memory.

Similar approaches have been developed by the scientific community dealing with multimodal interactions. In this context with the term "multimodal" we refer to the possibility of interacting with a computer interface through multiple interaction modalities (e.g. voice, gestures, gaze etc.), as opposed to "multimodal" transports which refer to trips based on different types of transportation means (bus, train etc.). Several research works have explored how to "fuse" information coming from single unimodal recognizers, into a more articulated multimodal action. The problem indeed is similar to those tackled by research in the domain of contextual awareness and aims at interpreting the combination of commands according to the user's context. A number of "fusion engines" have been developed as can be read in surveys such as in [17]. In fact among the most famous to assess the best merging of information coming from the different recognizer we find semantic fusion [18] [19], the MTC (Members-Teams-Committee) method [20] as well as other relevant statistical techniques. The adoption of Multimodal Interface in the mobile devices brings improved ergonomics through adoption of more natural interactions and it allows greater naturalness in the way the user interface the machine through the adoption of human communication patterns [21].

3. The Personal Mobility Assistant

It is important to underline that the very nature of i-Tour, which in fact is a personal multi-modal travel assistant, requires complying with a number of additional requirements usually not handled by standard navigation systems, the majority of which is essentially designed for vehicle-based navigation. In fact, although i-Tour supports standard routing, for those segments of the journey where the user will have to drive, the focus of the routing algorithm (and therefore of the system in general and its interface more specifically) is on public transportation as well as walking or cycling, in order to promote the most sustainable travel patterns.

For this reason it was required a specific interface that could allow easy identification of the most convenient travel solution among several possible options within a complex multi-modal transport network. In fact when travelling across a very complex transport network (e.g. in London, Paris) the same destination can be reached through a number of different combinations. This becomes particularly critical when dealing with an infrastructure capable to manage real-time information including location of vehicles and loading state.

The route selection process relies on an interaction paradigm based on a graph-like structure. The graph has been developed to provide the user with an essential set of information required for the user to appreciate the best travel options as well as the state of the current trip. The graph, as visible in Fig. 1, has a circular topology and it is dynamically adjusted as soon as updates are received from the server routing component. The graph is meant as user-centric representation, in that the centre of the graph represents the current position of the user. Each branch is divided in sub-branches according to the number of different connections available at a certain location during the trip (i.e. bus stop, train stop, etc.) required to reach the destination. Names of connecting stations are also shown. An icon informs the user of the various travelling pattern planned within each travel solution. There are various visualization modes that can be selected to identify the best route, specifically:

- Time to reach the final destination.
- Distance to reach the final destination.
- Emission (In terms of CO_2 or PM) generated to reach the final destination.
- Cost to destination.

The distance from the centre of the graph can represent either the time required to get to the destination, or the distance, or the emission. When the user switches between the different views the graph adjusts automatically to account for the new configuration. Regardless of the visualization mode, the graph always shows the various alternatives available to reach the same destination. In other words all the leaf nodes (the terminating nodes) of the graph all represent the same destination. The various branches represent instead the different routes available to reach the final destination.

Depending on the selected visualization modes, the various nodes are placed, following a radial approach, at a distance which is function of the time, distance, emission, cost required to reach a given place. This way it becomes very easy for the user to identify the best option according to its preferences. For instance, when in time mode, the user can immediately identify the best solution (i.e. that bringing the user to destination in the shortest possible time) as the solution identified by the shortest path. Similarly, when in emission mode, the user can identify the most sustainable option, by selecting the shortest route, i.e. with the lowest emission in terms of CO_2 or PM. As soon as the user selects a segment this is highlighted and when the user

Fig 1: Images taken from the travel mobility assistant: at the centre, the graph travel solution interface with details about each possible user choice; from left to right:, the augmented reality view with position of bus stop, the home screen menu with alerts, travel data and weather conditions; the park disk interface with information about the travel expected timings; the three dimensional view showing a route; All the views provide an example of the route visualisation system.

selects the segment additional information on that part of the travel is shown (e.g. bus number, expected delay etc.). Each node of the graph reports the name of the corresponding station. The various graphical features of the graph are used to inform the user about relevant information on each travel option. The recommended travel option, i.e. the option providing fastest, most sustainable, shortest or cheapest solution (depending on the visualization mode), is highlighted by the corresponding branch of the graph being rendered with a thicker line. The recommended option is also highlighted with high contrast, while less favourable options are rendered with lower contrast. Circles in the background highlight the top three options, providing the means to appreciate immediately the most interesting travel options for the users. An icon next to the three different routes clearly identifies the first three best choices. It should be noted that to improve readability the graph is not linear. Each segment of each branch, which represents an independent unimodal journey, additionally is associated to an icon that shows the corresponding transport mode (e.g. train, bus etc.). Additionally colouring is consistently employed to inform the user about quality of service. In particular the colour of the arc informs the user whether the very journey leg will or will not be comfortable - for instance due to the amount of passengers on-board that very vehicle or due to other factors that may influence the judgment of the user.

This information in fact summarizes the overall concept of quality of service resulting both from the information gathered by the system (e.g. information coming from sensors on-board a bus informing of the amount of passengers on a given vehicle), as well as information coming from the community of users through the recommender system (e.g. a bus may be badly rated because unclean). Similar colour code is used to inform the user on quality of service at exchange stations (e.g. platform packed with people).

The user can prune away undesired travelling options, by clicking on a red (delete) button next to each leaf node. The graph then automatically readjusts to maximize the readability. Since clicking on a relatively small icon on a small screen (as in the case of Smartphone) is not user friendly, especially when in a mobile context (e.g. while walking), the user can remove undelivered option by simply placing a finger onto the corresponding icon and by shaking the mobile device. Since this information is based on measurements provided by the sensors fitted on-board the mobile device, we have introduced a safeguard to avoid accidental deletion of travel options based for instance of sudden accelerations detected by the accelerometers, e.g. detected when the user is walking downstairs holding the device in their hands. The deletion process, when performed through a movement of the device, is to be confirmed through a finger gesture by dragging it downwards, as if nodding, or on sideward, to cancel the operation.

Although information updates are received on a regular basis from the network, the user can force a complete recalculation of the available travel option by drawing a circle gesture over the screen (as refresh). To avoid accident triggering of commands, the user has to confirm this option with a gesture of the finger. Whenever the system receives new information on the current trip (either through forced or automatic update) the graph automatically adjusts to account for new arrival or departure time and the graph center is updated reflecting the actual user position. If a delay is expected, with regard to the initial information, this is highlighted by the system. The circle corresponding to the travel option becomes either red (in case of delay) or green (if arrival is expected ahead of schedule), while the position of each node of the graph is adjusted accordingly (if delay is expected the position will be moved away when set to the visualization of time of arrival).

The graph can also be used to show additional information wherever available. For instance information on weather conditions can be shown next to each travel leg when this requires walking or cycling. Information related to social networks and users communities can be also provided next to the graph, for instance to inform a user that other members of their social network are travelling along the same travel leg at the very same time.

This kind of interface, due to its simplicity, is flexible enough to be used among all the main components of the personal assistant, with the selected trip rendered with different scalings as a straight colored polyline with several icons on top of that, (see Fig. 1b, d, and e). This line, visualised not only on the home view but also on the 3d map, shows the starting point and the current user position, any possible stop-over or transfer as well as the final destination while an icon next to each travel segment shows the transportation means relative to the given segment. For each of the icons or travel segments the colour refers to the “quality of service” as already illustrated when

detailing the graph. This may be the load level of a transportation means (e.g. the ratio between number of persons within a train and maximum capacity), when referring to journey legs, or information on the quality of service at the station, for instance the crowding level as detected at the various platform.
Further information on expected duration of each trip segment and expected transfer times (e.g. to catch a connecting train) can be accessed through a specific interface, resembling a parking disk, which can be used to switch between segments of the journey, by rotating the dial at the top of the screen. For each of them the interface shows connections and expected arrival time, waiting time to the connection and overall time to destination.

4. Multilevel Contextual Awareness

To enhance the personal assistance experience, the i-Tour interface is based on an underlining contextual awareness system to adapt its views to user's habits and behaviour. It features adaptation to different activities (if walking, cycling, driving etc.) by inferring information about the user's and the environmental context. The inference results are based on data retrieved from sensors fitted within the smartphone. The term sensors is meant in a wider sense here and it includes explicit built-in devices:

- Accelerometer
- Gyroscope
- Compass
- GPS
- Microphone
- Light
- Wi-fi, Bluetooth, GSM/Cell network

as well as implicit information retrieved from web services data, in order to obtain additional information (e.g. weather forecasts).
A flexible mechanism to use information from a variable number of sensors, depending on the device used and the capability to provide data (e.g. GPS may not get a fix inside a building), was developed. The mechanism had to be able to retrieve the data from the sensors, process this independently and then infer information based on the combined data of all sensors. This information can be divided into two main categories:

- Movement: standing still, walking, running, stairs up, stairs down, cycling, riding a car/use of public transport;
- Ambient conditions: Indoor / outdoor, brightness, noise, weather;

Figure 2 shows the design of the multi-level approach taken in i-Tour to achieve an accurate recognition of the user's context. On the lowest level, sensor data is recorded from the Recording Module. Particular attention has been devoted to the flexibility of the architecture that can easily be extended with new sensors with the adoption of the visitor design pattern, separating the algorithm from the sensor data objects exposed by the Android API. Once a new sensor becomes widely available on smartphones, a developer will be able to easily define a new sensor objects that will be inspected from the multimodal engine like all the other sensors.
Based on the sensor data and previously recorded training data, the Recognition Module calculates probabilities for the user's context, separately for each sensor.
Finally, these probabilities are passed on to the Fusion Module, which combines the per sensor results.

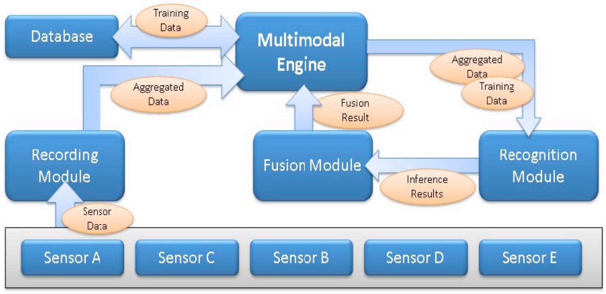

Fig 2: Design of the Multimodal Engine

The Multimodal Engine is the orchestration component and is in charge of communication between the models, stores the inference results for further use in the application and connects to the user interface (see fig. 3).
In order to enable appropriate detection of the user's context, it is necessary to compare the sensor readings with existing training data. Each entry of the training data contains a specific feature vector of sensor recordings of a time interval of a set duration and the user's context that was specified for it. Default training data is provided with the application but adapting to the physiology of the user as well as possible variations in sensor readings across different manufacturers can be difficult and for this reason they are unobtrusively given the option to confirm or to correct inference results that will be used to improve and gradually replace default training data, as shown in figure 3, where the recognized status is provided on the top left corner and an options menu is always available by selecting the icon to correct inaccurate predictions.
The Recording Module automatically calculates values for a given set of features for intervals of sensor data (adjustable, between 1 and 10 seconds). The resulting feature vector, along with the raw sensor data, is then passed to the Multimodal Engine for further analysis.
The Multimodal Engine now hands the aggregated data to the Recognition Module, together with the previously mentioned training data, retrieved from an attached database. There the data is processed, by calculating probabilities for the user's context, separately for each sensor.
To do so, a pattern recognition algorithm is employed based on an adaptation of the k-nearest neighbour algorithm (KNN). Specifically, the feature vector to be analysed, after being normalised with cached sensor mean and standard deviation is compared to the normalised feature vectors from the training data for the corresponding sensor. In order to determine the similarity between two feature vectors, the Euclidean distance is used as a distance metric. The lower the distance between two vectors, the more similar they are. Once the distance to each interval of the training data has been determined, the average distance to each user context is calculated.
Finally a probability function is applied on the results in order to obtain the probabilities for each possible user context.
With the probabilities calculated per sensor, the information is now forwarded to the Fusion Module. This module merges the probabilities of each separate sensor to obtain a final inference result. The Fusion Module also creates a weight map, by assigning a weight to each probability retrieved from the Recognition Module, based on the sensor that was used and the user context recognized (e.g. GPS may be given a high weight for determining movement at high speeds, like in motorized vehicles, but a lower weight for running and cycling). Additionally, the Fusion Module tries to use, wherever possible, the history of recorded intervals, to infer further

information. This could be the case when interruptions in the GPS signal or sudden changes of brightness occur, which may indicate the user has entered a building or tunnel. Further examples include a fast movement after standing near a bus stop for a while, which may indicate the user has entered a bus or a sensible change in the amount of light when it is still daytime, which may indicate the user has entered a building. In this case we can even detect if the device is not inside a pocket if there is a proximity sensor available and if it does not detect anything or if outside is a sunny day.

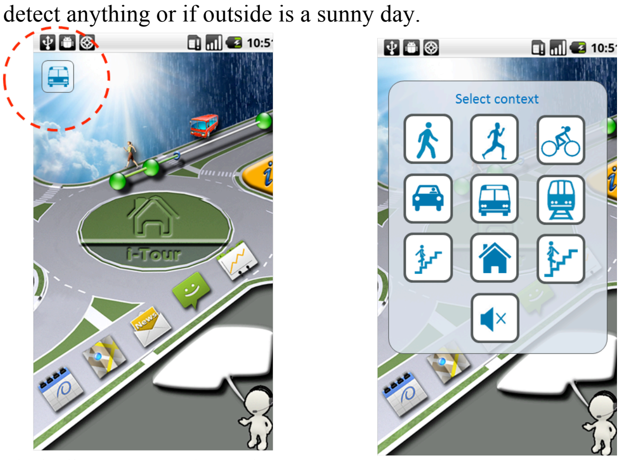

Fig 3: Context detection (left) and context selection (right)

Once all the options have been considered and adjustments to the resulting probabilities have been made, the final result is forwarded again to the Multimodal Engine for further use of the inference results.
According to the detected state the interface provides adaptation to adjust for the contextual conditions thus improving the final user experience with the personal mobility assistant by providing the user only the most relevant features for each particular condition.
When walking or jogging the system improves dimensions of icons and other interface parts of relevance to improve readability, like the park disk interface (fig. 1d) or a magnified version of the graph (fig. 1e) giving less relevance to other unnecessary components like the travel statistics or the detailed calendar view replaced by simple intuitive icon notifications provided to the user only when there is an incoming event or a particular travel status has been reached. If headsets are used, the interface should complement messages with sound or voice feedback, else, if headsets are not in use, or the user is walking or running, clear instructions should be provided through easy recognizable sharp sounds informing the users of the availability of a feedback. The interaction with these messages should be achieved with fast interaction paradigms such as gestures or vocal commands. For example while walking or running an incoming suggestion provided by the system as a big popup on the screen with acoustic sound, like the request to re-compute a route after an accident, can be agreed or disagreed by simply dragging the finger over the screen top-down or from left to right or the refresh of a current view can be invoked by drawing a circle on the screen (see fig. 4). At the same time, other means of interaction are disabled like the switch between information panels by bending the device, since it can open undesired functionalities when enabled on the move. When cycling all visual feedback should be minimised (if detected in the pocket) and complemented with voice/sound commands (if headset is available). If the headset is not used feedback should be provided through precise sound (beeps or other easy to recognise sound feedback) associated to actions played at high volume. Use of vibrotactile feedback should be

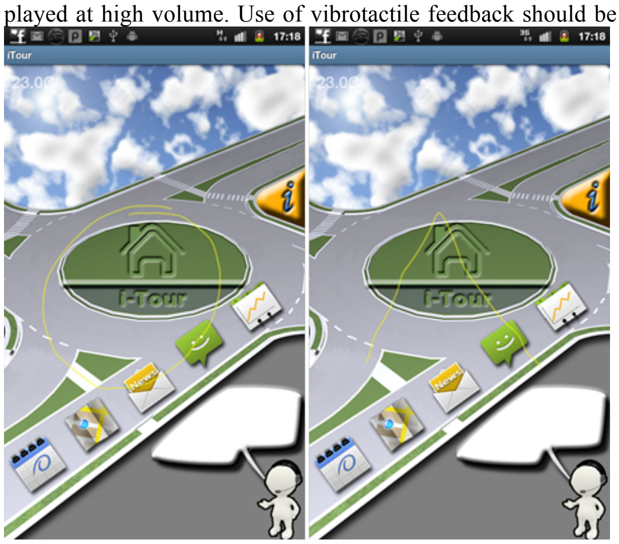

Fig 3: Example of recognized gesures (refresh view and go back)

reduced as this may not be detected by the user. It should be noted that whenever one of the strategies listed above is adopted, the system should provide some means to get to the original (un-adapted) stage in a very simple manner. This is obviously required both to compensate for possible mistakes by the system to recognize the actual contextual information and to let user interact with a function regardless of context adaptation.

5. Conclusions and Future Works

The combination of an effective interface on a mobile device to assist urban citizens in their everyday life together with a multimodal engine able to identify different traveling statuses represents an innovative approach to personal travel assistance that goes beyond the simple satellite navigation since it creates a two way relationship between the user and the urban environment. The approach proposed can be easily extended to improve intelligence provided by sensor with other contextualized information gathered through the network. For instance information on current weather conditions, gathered from web-services, can be used to adjust the interface when in outdoor environments. When low temperatures are reported while outdoor, the interface could adapt to cater for possible use of gloves.
Further planned improvements include increasing the accuracy of the recognizer and test it on a wider set of individuals especially taking into account large urban context, with several means of transport and an heterogeneous set of environments. In particular, we plan to inspect the contextual awareness on subways exploiting the capability of smartphones built-in microphone to recognize metro sound patterns.
Other extensions of current functionalities includes developing gaming interfaces to incentivize use of public transportation. The challenge for the gaming interface of i-Tour is therefore to create games that leverage requirements from the real world and turn them into a playful experience rather than trying to adapt gaming strategies to travel conditions. Most interestingly the interaction shall have to account for the constrains, typical of most public travel condition, of a linear trip, where the user moves from A to B along a given route. A number of strategies are being identified to deliver engaging and motivating types of games, to increase both competition among various travellers and collaboration among peers to help travellers develop

specific awareness on sustainability issues and promote sustainable and healthier travel habits. Last but not least further extensions may include gathering of contextual information to detect accidents and trigger automatic alerts. In fact information from accelerometers could be used to detect sharp acceleration characterizing fall or impacts, which could be indicators of accidents (for instance while cycling or running/walking). This information could be particularly useful, for instance for elderly people, to help the users set an emergency call (e.g. through voice command). Full automatic emergency call mechanisms should be avoided or subject to a number of control steps (e.g. only failing to get response after a number of requests from the system) to reduce the chance of false calls e.g. generated when dropping the mobile device on a table when arriving at home.

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