GPS-monitored itinerary tracking: Where have you been and how did you get there?

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Abstract

Within research to the objective of itineraries it is a requirement to acquire for a (large) group of respondents during a certain period for each conducted trip the location and time of depart and arrival, the route, travel mode, and also the activity purpose (i.e. travel to work, family visit, or just a walk for leisure). All trips must be reported and for each trip the requested data must be correct, complete and valid. In our research a GPS device is used to track and log the geometry and time for all trips during the research period, and a web map application is used by the respondents to specify the departure, the arrival location and the activity purpose of each trip. In that way we try to avoid errors, log gaps, and invalid entries, and we provide a mean to correct these once they are made. In conjunction existing geo-information is used to automatically interpret the traces and translate these into meaningful trips and activities.

1 Introduction

In order to support urban and transport planners, analyzing and modeling travel patterns have since long been an important area of transportation research. Analyzing and modeling their activity and travel patterns places heavy demands on data collection. Measuring the exact times and locations of journeys taken by individuals is therefore an essential element of travel behavior research.To provide detailed activity and travel data, the use of activity/travel diaries has become much more widespread since the nineties. This data collection method offers in principle the advantage that the complexity of activity patterns can be recorded with much more accuracy than when respondents are asked to reconstruct from memory their past travel behavior and activities. However, it suffers from some disadvantages including the burden on the respondent, the difficulty for respondents to write down exact descriptions of the locations, and inconsistencies between trips and activities.

One method for which there are great expectations in transport research is data acquisition through a Global Positioning System (GPS). This technology uses signals from satellites to determine someone's position within a range of no more than 10 meters. Through a GIS application the travel behavior of the respondent is reproduced on a map for visual validation by the respondent and for automatically classification and justification by GIS network algorithms.

Apart from its benefits, however, this state-of-the-art method has its difficulties as well, including problems with the use of the device, reception of the signal, handling of the data, etc. Worldwide experience with GPS devices for collection of travel data is poor, and mainly related to devices in cars.

The planned destination and goal of the itinerary can be answered before, during or afterwards the trip. In-car route navigation is an example of the first question, as the driver will have to announce the destination to the system. But the destination will only be definitive, when that place has been reached. An interactive system can request the user during the trip to state where he is heading. Again, this will only be true, as long as the destination had been reached. A survey afterwards is the best option, as the visualization of the GPS track (positions and time) is a way to remember it. In the research of Hovgesen (2005) this kind of 'passive GPS registration' is called to be 'a powerful tool for the survey of spatial behavior'. But, 'given the present state of GPS technology, the track points that can be attained from a persons movement over a longer time span is unlikely to be continuous'. So, in the user-interactivity phase, one has to validate the GPS track, or at least the actual depart and arrival locations have to be given, before one can link the destination and the way of transport to the corrected GPS track.

Following this introduction, section two gives an overview of data collection for travel behavior in general and related research with respect to the possibilities and disadvantages of GPS. Section three focuses at our approach of GPS monitored itinerary tracking, where after section four addresses the actual GPS track log processing to meaningful activities and trips. Section five gives some conclusions and recommendation.

2 Data collection for travel behavior research

As has already been indicated in the previous section, measuring the exact times, distances and locations of journeys taken by people is an essential element of research into travel behavior. Information about travel behavior has traditionally been collected from written questionnaires or telephone interviews about aspects of travel behavior. The information gathered includes details on the frequency of commuter travel, daily and occasional shopping trips, visits to public amenities, leisure activities, social calls, and so on. Traveling times and distances are also asked about, as is the means of transport. This approach entails a number of significant disadvantages, however. The range of travel patterns depends on the variation of destinations listed in the questionnaire: destinations that are not included do not appear in the overall pattern. Also, such surveys reflect only the perception of the respondents as regards timings. It has been shown that this is an area subject to systematic distortions: short journeys are often forgotten about, as are those that do not involve a route either starting or ending at home. Furthermore, the various methods of transport and other relevant details are not accurately remembered, with car users underestimating their traveling times and public transport users overestimating theirs (Ettema et al, 1996; Stopher, 1992).

2.1 Related research in itinerary tracking

To avoid these drawbacks, the use of activity and/or travel diaries has become much more widespread since the nineties (for example, see Stopher and Wilmot, 2000; Dijst, 1995; Snellen and Timmermans, 2001; Maat et al, 2004). Respondents use their travel diary for a few days to record departure and arrival times, travel movements, the destination being visited and/or activity being attended, the means of transport and any other information. Activity diaries offer in principle the advantage that the complexity of activity patterns can be recorded with much greater accuracy. However, there are disadvantages as well. First, the burden on the respondent is considerable, as the diary has to be (preferably) carried around on a daily basis, while detailed information about travel times, locations and activities has to be noted down for every movement. The result is that there is a strong possibility of non-response. Second, respondents will tend to postpone writing down their notes so that they ultimately put down inaccurate information about traveling times and locations, or indeed forget about entire journeys altogether. In an evaluation of different types of diary, Arentze et al (2001) reported a systematically more inaccurate and limited pattern of activity on the second day of diary entries. In order to reduce the burden, respondents are usually asked to keep the diary for only a few days (Schönfelder et al, 2002; Schlich and Axhausen, 2003). Third, it seems that giving an exact description of locations is not always easy for respondents: what is the exact location of the post office, the letterbox or the park that has been visited? Finally, paper surveys often contain many inconsistencies as a result of registration errors, such as activities that begin before the previous one has ended, journeys from locations, which were never arrived at in the first place, and unrealistic traveling times.

2.2 Possibilities of GPS in trip and activity recoding

One method for which there are great expectations in transport research is data acquisition through GPS. This technology uses signals from satellites to determine someone's position within a range of no more than 10 meters. Cars are these days more often than not equipped with a kind of route navigation system, i.e. a portable 'Tom Tom Go'. These systems are quite capable to direct the user to the destination by a combination of maps, pictograms, and voice. As 'a Tom Tom' uses a GPS receiver to determine the current position, it is thought that each general GPS device is a kind of route navigation system. It is not; basically a GPS receiver processes the code signals from the GPS satellites in 'line-of-sight' to a location determination in latitude, longitude and elevation according to the WGS-84 reference system. Only the combination of a GPS device, smart software, up-to-date digital maps and an intelligent user interface makes a route navigation system to what it is. To track where you have been seems however not that difficult, as you only have to store the successive GPS locations during the itinerary. By carrying a GPS receiver, the location of a respondent can be registered at any time. The places along the route taken by the respondent are linked to the times at which he was at these places and are stored in the receiver as coordinates. By entering the coordinates in a GIS application, the travel behavior of the respondent is reproduced on a map.

The method has a number of important advantages. Data acquisition via GPS should mean that the research would be one of the first travel behavior studies that do not suffer from the significant shortcomings of the diary method. First, there is much less of a burden on the respondent, so that not only the numbers of non-responses are greatly reduced, but also that information can be gained from a whole week, rather than just a few days. This is an important benefit because travel behavior patterns are becoming more and more varied in time and range, partly as a result of people working part-time or further from home.

Second, the degree of accuracy and completeness this method brings is way beyond anything that can be achieved through conventional paper surveys. Indeed, it is the case that not only the precise starting and finishing points of travel movements are recorded, including the exact times, but that the route itself can also be accurately traced. By linking the details registered in a GIS application to information on the spatial structure, it can be determined which travel mode was used (verify whether journeys were undertaken by road or rail) and which amenities were visited (Schönfelder et al, 2002). An important element in terms of accuracy is that inconsistencies are, to a large degree, avoided. A third advantage is that the data is immediately available in digital form, which eliminates the need for time-consuming and error-prone manual data input.

2.3 Disadvantages of GPS in trip and activity recording

However, there are also highlighted a number of disadvantages in the literature. Firstly, the cost of the equipment is still relatively high. In addition, the method has to be explained in more detail, which means the researcher has to actually deliver the GPS and provide instructions on its use, as well as collect it again at the end of the survey period. Secondly, although the GPS registers time and location, it does not record extra details, such as the reason for the journey. This kind of information will still have to be recorded by hand, be it on paper, on-line, or a combination of the two using a Personal Digital Assistant (PDA). This option simply makes the collection of the data more expensive and entails an even greater burden on the respondent. Thirdly, the presence of buildings in urban areas means that satellites are not always 'in view', leading to the possibility that the location of the respondent cannot always be determined.

2.4 Collaborative GPS tracking

Nowadays Web Map Services (WMS) and Web Feature Services (WFS) are a mean to disseminate geo-data to literally everyone connected by Internet based on the open standards of the Open Geospatial Consortium (OGC, 2000). The providers of these services, however, also decide which data is made available. As shown, GPS devices are a mean to store your own traces. The traces are, if combined with an activity as within the project described in this paper, of interest for other people. This demand is especially an issue when these data are not made available through the regular geo-data providers. Hikes, skate routes, mountain bike trails, holiday trips, or even the location of 'open' wireless local area network (WLAN) hotspots, all these data are likely to be used by a dedicated group of users, most often the ones who will provide their share of the data in the first place.
Some neat examples of these collaborative composed GPS track databases exist. The Geoskating project is among the finest, as it will show through a map interface where to skate, and how well the road is suitable for this kind of activity (Geoskating, URL). This example is however limited in functionality, as it is not possible to upload and download your own skate tracks. This possibility is given among other initiatives, by the GPStracks and MotionBased site (GPStracks, URL; MotionBased, URL). Both initiatives opts the possibility to map the routes by Google Earth. If you want to know which WLAN access points are freely available in your neighborhood the Wardrivemap will give you the answer by a database loaded by GPS enabled WLAN access point tracers (Wardrivemap, URL).
All these examples show the possibilities of collaborative GPS track websites. It is therefore a pity to see that none of these initiatives is yet using OGC compliant solutions for providing maps or data.

2.5 Person-based itinerary GPS tracking

Person-based itinerary GPS tracking systems are not comparable with in-car route navigation systems, although both use GPS to determine their actual position in real time. As most people do have good experiences with this kind of guiding tools, they expect the same characteristics of stand-alone, personal, GPS tracking devices. That is not the case, as in-car systems do have the characteristic to be part of the traffic. In contrast, person-based GPS tracking devices can be, literally, everywhere. In-car systems could work-around the fundamental issue of receiving enough GPS satellite signals – as in GPS hostile environments like tunnels and height rise buildings areas – by extra sensors like an odometer, an electronic compass and an inertial navigations system. Besides, the simple fact that cars drive at streets is used by all kinds of dead-reckoning algorithms to keep and forecast the calculated position at the up-to-date digital road network. Power supply is not an issue at all as it plugged to the battery of the car and the antenna is well positioned at the roof or at the front window. And as cars are normally at the same place as where the driver left it behind the start-up acquisition time of the GPS device is reasonable.
A person is not very well designed to use a GPS device. For the best operation the GPS device should be held in the hand, as this will allow the user to operate it. A position in front of the user is also appropriate to read the display and it provides direct access to the sky for a good satellite reception, but no one wants to hold the device for 24 hours for just to be tracked. Power drain is also an issue and the GPS device should operate without extra sensors, although the combination with an electronic compass is an option.

2.6 Related research in GPS monitored itinerary tracking

Several comparisons were made using a paper diary (see Lee-Gosselin, 2002). The use of GPS is not a new approach in person-based itinerary tracking. The last years several papers and reports on GPS enhanced household travel surveys have been published. These papers describe the possibilities on using GPS in this kind of surveys and the recording of the activity. A separate GPS for registering every journey was provided in only very few cases. (AVV, Draijer et al, 2000). A remarkable issue within the studies conducted outside Europe is the focus on the car as the only possible travel mode. This will reduce all kind of problems in power supply and GPS reception, i.e. in the study in Texas, USA (Forest, 2005) the power supply of a GeoStats GeoLogger is attached to the cigarette lighter socket in the vehicle and the antenna is mounted to the roof. Also in (Wolf, 2001) a study in Georgia, USA is described where the only travel mode under consideration is the personal vehicle. The study described in Sidney, Australia (Stopher, 2003) is again an in-vehicle travel-mode study with the GeoStats GeoLogger. This rugged device is quite heavy and bulky, mainly due to the battery pack to operate it over three days. For the study in London, UK (Steer, 2005) that characteristic was not a limitation to use it as a normal personal travel-tracking device. But the far better wearable Garmin Foretrex was used for the survey in Denmark (Hovgesen, 2005). Here in this European city the individuals carrying these kind of person-based GPS devices registered very accurately transportation on foot, bicycle or private motorcars. The use within public transportation, like busses and

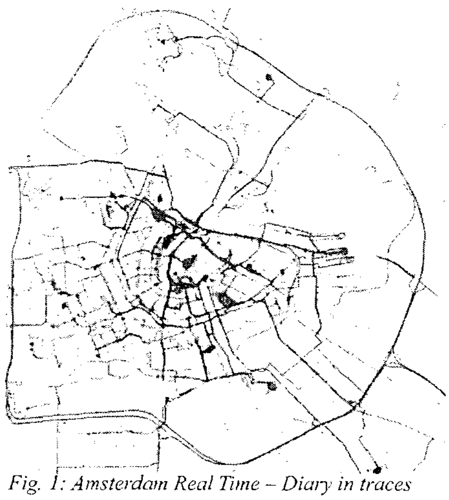
Fig. 1: Amsterdam Real Time – Diary in traces

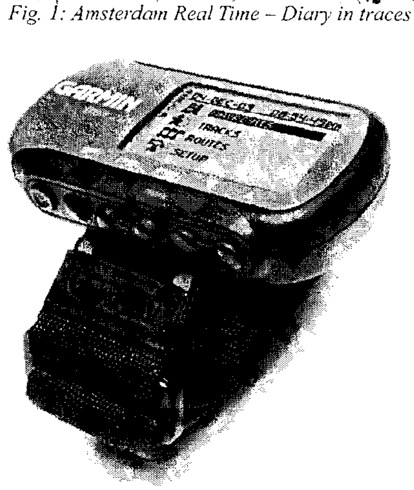
Fig. 2: Garmin Foretrex 201

trains, posed greater challenges to GPS as a survey tool as the signal reception by the GPS antenna is much more difficult to control.

3 GPS itinerary tracking

3.1 System requirements of person-based GPS itinerary tracking

To track someone by means of a GPS device during a longer period is a quite demanding task. First and for all, the device should acquire its location during the trip, or more specific: the trip track points should be logged. Several options are possible to perform that task.
One can use a GPS device equipped with internal memory to store thousands of track points at the device and download those after the survey by a serial or USB connection to a computer and upload the track logs to a central database. All commercial available 'outdoor' GPS devices, like the Garmin and Magallen products, offer this possibility. They differ with respect to the track log only by the available memory for storage; most models offer 10,000 points. Another problem is the use of a proprietary communication protocol, which demands special programs to download the data. Ones downloaded the user has to choose from a bunch of file formats; although the XML based GPX format is regarded as an industry standard (Topographix, URL). A last barrier is caused by the serial connection that is still used by even the latest models like the Garmin Forerunners. The .gpx file could now be uploaded to a server. It is possible to use these kind of .gpx files, but as GPX is XML based, a XSLT transformation can be applied to create the insert statements to store the track points in a geo-database like PostgreSQL/PostGIS (PostGIS, URL). Another option is to connect a basic GPS device by wire or wireless (Bluetooth) to store the track points directly at a separate logging device like a PDA, or through a mobile 'smart phone' that will send the tracks by GPRS or UMTS directly to a central database. Although these last options do have a lot of advantages, like real-time access to the trip-track data, and also the possibility to inquire the respondent about the trip activity right ahead, it doubles the risk on power drain. But there exist some neat examples of this kind of activity reporting, like the Amsterdam Real Time – Diary in traces project where the mobile behavior of users in the city is visualized, see Figure 1 (Waag, URL). Another example is given by the GeoSkating project that aims to automate the creation of interactive, multimedial skate maps (Geoskating, URL).
The last option works very well, but we have decided to use a 'stand-alone' GPS device for both acquiring the track points and store them. The main reason for that approach is to make the system robust by avoiding as much as possible power-drain and dependences on all kinds of wireless communication between devices. A second reason is the GPS device of choice itself. The Garmin Foretrex 201(see: Figure 2) is well designed light and very wearable at the wrist, it has a running time of more than 14 hours, and it has a track log capacity of 10,000 points which will be maintained in memory even as the battery is drown. The use of a rechargeable battery has, besides the environmental advantage, the benefit to be a kind of a reminder to download the track log right ahead when the device is plugged to the AC-adapter.

3.2 Determining itineraries from GPS track logs

An itinerary is a trip from a departure to a destination. The GPS devices, however, will only start to track and store the locations as soon as the receiver has a position-fix. It is to a certain extent possible that this start of a recording is not at the actual location of departure, but somewhere along the route, because it might take some time before the first position determination takes place. If the almanac data – the course orbital parameters for all satellites – is unknown by the receiver, this information is first to be received from one of the GPS satellites. Once known, the receiver knows where to expect a certain satellite at the given time. For exact positioning however the ephemeris data – the precise orbital and clock correction data – has to be received from the GPS satellites used. As this information is only broadcasted each 30 seconds this will delay the positioning. But it not as bad as it sounds, as long as the receiver is within a range of 300 kilometers from the last use, the almanac can be used. So the receiver knows where to expect the satellites. The ephemeris data is 'fresh' for a certain period, thus if the receiver is powered off for only a couple of hours, the receiver knows the position of the satellites and it will restart positioning with a so-called warm-start within a couple of seconds.

3.3 Validation and interpretation of GPS track logs

To be sure the receiver starts logging at the departure; it is a recommendation to the respondents to examine whether or not the GPS device is powered and positioned before moving. This departure location can be marked at the receiver explicitly by user-specified waypoints. But as this action will require an extra awareness and user interaction of the respondent of the itinerary survey, this option will not be regarded as an option in the test conducted. Besides, in most of the cases the respondent will depart from a location arrived at the previous trip, so this position could be derived from the history. Within the web-based itinerary survey afterwards the user has anyway the possibility to pin-point characteristic locations, like home, work, public transportation stops, etc., explicitly. This will open the possibility to 'link' the start and finish of a track log to these locations.
During the route itself the GPS will record positions only at discrete locations, i.e. at turns. This will reduce the total storage of the track log of an itinerary undertaken considerably. The receiver has also a so-called auto stop mode, where a certain track point is marked as 'start of this trip' when the receiver resumes moving from a location where it has been stayed for a specified time. This 'start of the trip' mark is thus also given at the actual start of an itinerary. The total track log of a day will thus be separated in logical parts by the GPS device itself.
It is predictable that each part of the track log is undertaken with a specific travel mode. As the speed of travel is to be determined from the track log data, it is possible to validate the user's input; it is quite unlikely to bike with a speed of 80 km/hour.
How well modern GPS receivers operate these days, there will be always gaps in the recoding; either by bad satellite reception, or by misuse of the GPS receiver by the respondent. As we are not interested in a complete coverage of the trip by GPS track points, but in the itinerary itself, this omission does not have to be a problem, as long as the main characteristics of the trip itself can be recovered. One possibility to determine the route of the trip is by a shortest path analysis based on an up-to-date road network. If all track points are to be reached in time order, this network analysis will result in the most predictable route on the network. This kind of validation works however only if the travel mode is known, and the network data (road, railroad) with relation to these models (car, train) is available.

4 GPS track log processing

4.1 Conceptual model

When people communicate or when systems have to be developed it is important that the involved parties do agree on the meaning of the used terms. That is, for a given term they associate similar concepts. This may sound trivial but in reality this is not the case, therefore attempts are made to formalize the meaning of concepts (and the associated terms). One approach is to describe the concepts in a graphical way and depict associations with others terms/concepts; such as specialization (refined more specific concept), aggregation (collection of other elements), etc. Within the Unified Modeling Language (UML) this is called a class diagram (Booch, Rumbaugh, and Jacobson, 1999). In addition to these associations also properties (attributes) belonging to the concepts may be specified (e.g. a person has a name and a day of birth). These properties further describe the concepts by listing the relevant attribute names and types (e.g. string and date in our example). It is also possible that certain types of operations (methods) do belong to a class (e.g. compute the age of a person).
So, when setting up an itinerary tracking system, researchers have to communicate with the persons who's itineraries are being investigated. They have to agree on the meaning of concepts such as Trip&Activity, KnowLocation, Trace, TracePoint, Person, GeoObject, etc. The UML class diagram is given in Figure 3.
In the UML class diagram the different symbols have a well-defined meaning: a concept or class is depicted by a box of three compartments: 1. class name (e.g. Person), 2. attributes (e.g. name: String) and 3. operators. A normal association between two classes is indicated by a solid line (without arrowhead); for example the association 'LivesAt' between the classes Person and KnowLocation. The multiplicity of the association is indicated at both sides: '*' at the side of Person meaning that at a given KnowLocation n Persons may live and '0..1' at the side of KnowLocation meaning that a given Person may live at 0 or 1 KnowLocations.
An important object in GPS monitoring of itineraries is the Trace, which belongs to exactly one Person; this multiplicity of the association is indicated with a '1', which is normally not depicted in a UML class diagram. Reversely a Person may have a Trace or not yet have a Trace (indicated with the '0..1' multiplicity). A Trace has attributes such as begin and end date. More important a Trace can be seen as an aggregate of TracePoints (indicated via the solid line with a black diamond at the side of the Trace). Again the multiplicities are indicated near the ends of the solid line depicting the aggregation. In this case it is stated that a TracePoint belongs to exactly one Trace ('1', not depicted) and that a Trace consists of one ore more TracePoints ('1..*'). The attributes of a trace point are the time and x, y and z coordinates of the location. Note that a TracePoint has also an association with itself: 'next', indicating the next TracePoint within a Trace. Operations available for the TracePoint are speed and acceleration, which can be computed based on the location and time stamps of successive TracePoints.
The collection of known geographic objects ('the map') is modeled with the class GeoObject, which has two specializations: GeoLocation and GeoInfra. A solid line indicates the fact that something is a specialization of another class with an open arrowhead in the direction of the more generic class. KnowLocations in our model (such as houses, shops, offices, etc.) are associated with exactly one 'map' GeoLocation object (the reverse is not true: there is not a KnowLocation of every GeoLocation). At a KnownLocation a certain type of activity can take place. The types of recognized activities are given in the enumeration type ActivityType and include: live (at home), work, recreate, shop,... (not indicated in the UML class diagram). The GeoLocation objects are point

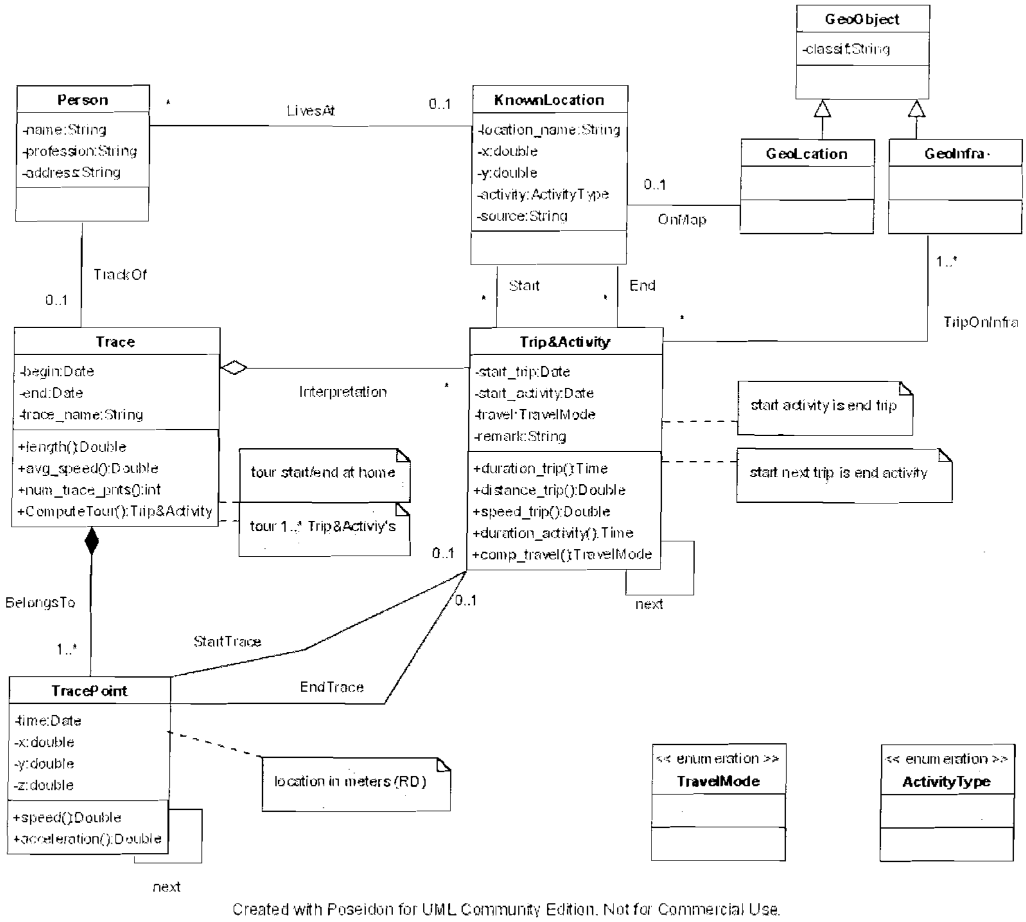

Fig. 3: UML class diagram depicting the relevant concepts in itinerary tracking

objects (again not indicated in the UML class diagram). The GeoInfra objects are line objects representing transportation infrastructure: roads, railways, waterways, bicycle paths, footpaths, etc.

The central concept in our model is Trip&Activity, which covers two aspects in one concept: first the trip (traveling, varying location) and second the activity (at a fixed KnowLocation). The Trip&Activity concept has a start_trip and a start_activity time (date). Actually the 'trip' part ends at the start_activity. The 'activity' part ends at the start of the subsequent trip (next Trip&Activity). The possible manners of traveling are given in the enumeration type TravelMode, which could contain values such as: car, train, boat, bike, etc. (not indicated in UML class diagram). In the GPS monitored itinerary tracking a Trip&Activity can be linked to one Trace (and reversely a Trace represents a number of Trip&Activity's). Again this is an aggregation, but in this case an open diamond is used in order to indicate that the elements could exist without the composite object. One last important concept is Tour; the smallest sequence of subsequent Trip&Activity with the characteristic that begin and end location are the same. However, this is not modeled as a class but as a method of Trace (as it can be computed and does not have to be stored explicitly).

This conceptual model does not only allow people to communicate in an unambiguous way, it is also the basis for system implementation. First of all, the model can be used to define the database schema or model, which is used to store the captured data. Further, the model may be used to build the user interface: input forms may be derived from the class (concept) definition; e.g. the form to define a new person. Also the output may be presented in a tabular form based on the class definition; e.g. the discovered Trip&Activity's (grouped per tour) table. The nice thing is that these can (for a large extend) be created automatically. This concept is known as the Model Driven Architecture (MDA). The implementation of (large parts) of the system is automatically derived from the (formal) model.

4.2 Web map client to determine reliable itineraries by user-responses

To assist the end-user with the processing of their daily activities, an interactive map with the GPS log combined with reference data will be displayed in the browser of the user. In order to create this combined map, the GPS data is first transmitted to the server, there it is processed and stored in a database. Once it is in the database, it is available for interactive display via a Web Map Server (WMS). Below the two separate processes: getting the GPS data to the database and getting a map back to the user are described.

In the first step of the process, the GPS data needs to be transferred from the GPS device of the respondent to the database server. The process takes place in a few steps:

- The respondent connects the GPS to the PC and uploads the GPS data to the computer and save the track data to a GPS file
- Via a web interface the GPX file is uploaded to the web server.
- In the web server the GPX file is converted to the database insert statements and sent to the database server.

Now, the data is in the database and is available for analyses, but it can also be displayed on the respondent's web interface as an image. For this MapServer is used. MapServer is an open source development environment for constructing spatially enabled Internet web applications (Mapserver, URL). In MapServer the GPS data of the respondent is combined with a background map and converted into an image (GIF, JPG) that can be displayed in the web browser of the respondent.
At the respondents' side, this map is very useful as a reference when the respondent is asked to completely describe their daily activities. The web map will be incorporated at the client side as a reference. It will contain four layers in total: (1) Background map; (2) KnownLocations; (3) Processed GPS points; (4) Non-processed GPS points.
Every time a respondent has entered an itinerary, it will be posted to the web server and at the same time a fresh version of the web map will be requested. All of the GPS points that fall within a time-period that has already been logged as an itinerary, will be placed in the layer named "processed GPS points" and will receive other color identifications to separate them from the "non-processed GPS points". Besides that, there will be some basic controls as zoom functionality, dragging and requesting point information (date, time).
Existing geo-information (map) and derived movement information (speed, acceleration) can be used to automatically interpret the traces and translate these into more meaningful trips and activities. One thing that only the user can enter is the remark associated with a Trip&Activity; e.g. indicating motivation or purpose. When filling in the logbook in case of less (or none) automatic interpretation of the traces, the user is asked to enter itineraries (their movements between locations where they show a certain main activity). To enter an itinerary, one needs to specify a point of departure and a point of arrival. The choice has been made that these must be KnownLocations to ensure that a user is spared the effort of entering the same location information several times. Since every person has repetitive behavior, the use of KnownLocations will save time and energy in the end. All in all, the user must be able to add KnownLocations through the map interface.
So all in all, the map and the web forms are strongly interconnected. When the form posts its data, the map adjusts its content in conjunction with the updated database. Next to that, the user is able to generate his or her personal KnownLocations to streamline their data processing.

5 Conclusions and recommendations

It is to be expected that GPS monitored itinerary tracking will replace the use of 'old-fashion' paper travel diaries in the near future. However, the gathering of a complete and correct database of the itineraries of a large group of respondents by equipping this group with GPS tracking devices is not an obvious task. The disruptions in the receiving of satellite signals have to decrease, and besides that limitation, only the recording of locations during the day gives not enough information to provide a detailed overview of trips and activities. Within this research project the feedback of the respondent to validate and correct the recordings is done by a well-designed, web-based, map-oriented trip and activities processing application. Intelligent data processing algorithms will support this process.
In the near future a kind of GPS logging is used by a large group of people to record a variety of activities. The processing, storage and dissemination of this special kind of spatio-temporal data will be supported by the development of collaborative GIS environments. For that reason the current available geo-portals have to be extended with functionality for standardized user input, processing and presentation of spatio-temporal data.

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