Understanding and influencing spatio-temporal visitor movement in national parks based on static and dynamic sensor data

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Within large urban agglomerations national parks play an important role in the daily life of the citizens: apart from influencing the local climate they are major areas for recreation. National park operators strive to balance the needs of individual visitors with the needs of wildlife and plants and find a way to motivate people to respect restricted areas. A current project in Vienna aims at influencing the movement patterns of visitors by offering user centered information that takes into account the spatiotemporal behavior of the other visitors and the national parks infrastructure information. The spatiotemporal behavior is collected via a variety of sensors including GPS enabled PDAs, which also function as guiding devices.

1. Management of National parks: balancing recreation vs. protection needs

Within large urban agglomerations parks play an important role in the daily life of the citizens: apart from influencing the local climate they are major areas for recreation.
There are a quite a large number of cities where national parks or biosphere parks are part of a city or close to its borders, e.g. Vienna, Austria, Sydney Australia or the 2014 Olympic host city Sochi, Russia. The wider Viennese urban area has about 2.5 million inhabitants and two national parks in the vicinity. Sydney has about 4.1 million inhabitants, who can reach more than five national parks for a day trip. The Sochi National park is located in the mountains that surround a city of 390.000 inhabitants. In conjunction with the upcoming Olympic Games and the impact of the expected increase in tourism it is currently discussed how the national park can be protected.

One of the major questions the national parks face is: how to protect the nature, while at the same time offering access for as many people as possible?
For the operators of national parks it is of utmost importance to balance the needs of individual visitors with the needs of wildlife and plants and find a way to motivate people to respect restricted areas. Therefore national parks and their visitors need information about each other in order to offer, plan and enjoy visits, while at the same time protecting the nature.

Based on these needs a research project in Vienna currently examines the movement patterns of national park visitors with a variety of sensors and methods. The idea behind the project is to get an overall picture of the visitor movement (based on historic and real time data), associate the movement data with infrastructure information of the park has (e.g. sensible spots, spots to see special flowers and plants, etc) and influence visitor movement with regard to nature protection issues. To influence the visitors they will receive two different sets of information when entering the park: either a more general information on where to go and what to visit – based on historic data – or real time information tailored to their interest via a GPS enabled PDA. The ultimate goal is to significantly influence the distribution of visitors within the national park, thus distributing the stress for the nature more evenly, while at the same time protecting special areas.

2. Collecting, predicting and influencing spatio-temporal movement

Three different research institutes cooperate with two national parks to make sure that the developed technology fits the user needs of the park operators and the park visitors alike. The research teams focus on the further development of a GPS/GALILEO based mobile guide, useful visualisation methods, the development of a robust pedestrian analysis and prediction model and a concept for sustainable recreation planning, while two National Parks do not only offer different test sites, but also bring their expert view on typical visitors requests, as well as national park operator requirements specification for the analysis and prediction tool to the project.

In order to gain knowledge over the spatial and temporal distribution of national park visitors and their individual behaviour observations are made by the use of surveys, travel reports and pervasive sensors such as light barriers, video systems, pressure, heat or infrared sensors that are installed at specific points along the route network. However these methods gain only low resolution and low entropy information about a persons` spatio-temporal behaviour.

The only way to collect the individual movements in a sufficient quality is by the use of GPS enabled devices. First attempts to use GPS as monitoring technology for park visitors for spatiotemporal analysis and modelling showed the possible high practical impact for park management. [1] [2]

Therefore the national park visitors are equipped with a GPS receiver and the GPS tracks are collected on a central server for further analysis. In order to convince national park visitors to use such a GPS device we follow a two tier strategy: on the one hand an easy to use GPS enabled mobile guide is developed,

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[1] Arrowsmith, C. and Chhetri, P., 2003, Port Campbell National Park: Patterns of Use A report for the development of visitor typology as input to a generic model of visitor movements and patterns of use. Department of Geospatial Science, RMIT University, Melbourne, Victoria

[2] Morris, S., Gimblett, R., and Barnard,K., 2005, Probabilistic Travel Modeling using GPS Data. International Congress on Simulation and Modeling, Melbourne, Australia, Dec 2005.

which offers location and time based information to the visitors while at the same time tracking their routes. (see Fig. 1) On the other hand visitors act as mobile "measurement units" through the usage of the mobile guide and provide GPS position data with high resolution. This tracking information is anonymously transferred to the analysis and prediction tool, which delivers easy to use information for the national park management about the spatiotemporal visitor behaviour on an aggregated manner (e.g. preferred routes, travel length, duration, stops, etc.). (see Fig. 2)

At the same time the prediction tool feeds back information to the visitor and offers routes according to the visitor's preferences, e.g. sending her to an area less crowded, which still offers the spots (flowers, animals) he wants to see most. Moreover the visitor can assess his own collected information via an online diary that shows his route and spatial information along this route together with pictures or audio files he has collected during his visit.

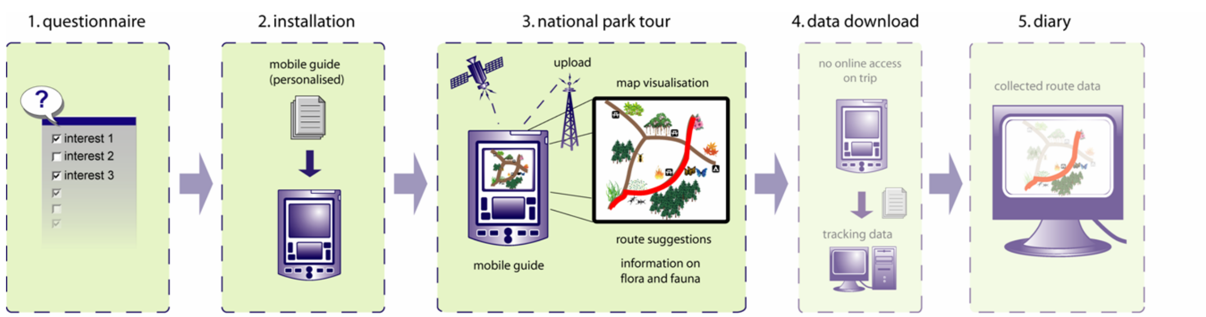

Fig. 1. Benefit for the visitor by using the GPS enabled guide.

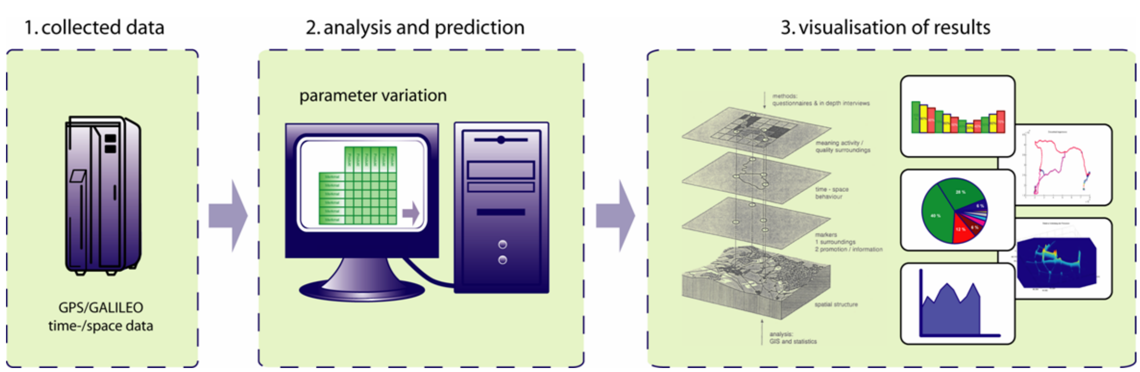

Fig. 2. Benefit for the national park operators based on the collected GPS data

2.1. Data collection, analysis and visualisation

As it cannot be assumed that all visitors will use a mobile guide, additional people counting techniques at entrances and fixed locations complement the satellite based measurements. To analyse the GPS data it is pre processed with outlier detection and map matching methods. Afterwards several analysis algorithms are applied to discover the required information such as preferred routes, travel length and duration, stops and duration and visitor frequencies at certain route segments. Different information is combined to understand the spatiotemporal behaviour of the visitors: e.g. by comparing the stop analyses results with the geo referenced places of interest the popularity of certain areas in the park is measured and by analysing the adjoining route segment the popularity of specific tours can be derived. The information is fed into a spatiotemporal analysis tool that enables the park management to examine the acceptance rate of thematic routes and places of interest and revise the routing strategy if necessary. The national park operators can make spatial and temporal restrictions and will get the spatial visitor distribution in the centre map containing the path network showing the visitor frequencies of the individual path segments and at the entrances. Also the frequencies at places of interest and analysed stopping areas can be displayed. So it is possible to determine popular places and the attractiveness of them over time and with regard to the current visitor groups. Typical analyses are trip length and duration, stop duration, speed distribution and number of visited places.

2.2. Movement prediction, information feedback and validation

The GPS position and counting data sets are combined with the actual meteorological data (actually the even more complex parameter of the "felt temperature" is included into the model) and provide the basis for prediction models, where future visitor counts and routes are estimated. On the basis of large long term data sets a reliable prediction tool will deliver planning information to the park management taking into account actual weather conditions and seasonal dependencies. The model is currently developed and will be implemented until autumn 2008.

The models will be used by the national park management to create new routes and offer real time information and dynamic route changes to visitors who rent a GPS enabled PDA.

3. Conclusion

The general idea behind the described project was to turn the data that is collected via sensor network into valuable information that can be used to influence people's behaviour. A crucial point was to find a method to motivate people to share their movement patterns with the national park management and understand how they will benefit from the information that is fed back to them. This has worked surprisingly well: 245 people used the GPS enabled PDAs during a test time of two days – even though no real time information about the park could be provided.

The first part of the project has focused on evaluating and implementing data acquisition methods and developing analysis algorithms. Currently the prediction model is improved, benefiting from the constant stream of counting data. However more and constant GPS data is needed to evaluate the prediction accuracy of the model. In the second test phase the individual spatio-temporal motion behavior will be closely monitored in order to analyse the willingness of the visitors to follow the suggested routes.

4. Motivation for Participation in the Workshop

While more sensors deliver an abundance of data about the environment which can be used for a multitude of different control and guiding measures it is not clear yet how to balance the needs of the individual with the needs of a community or a society.
The typical problem in transport lies in car navigation where it has to be decided whether to integrate all possible streets into the maps or whether to keep some of them hidden in order to protect residential areas from through traffic or to make sure emergency services find less frequented routes.

In the described project in Vienna the aim is to give national park operators the possibility to get insight into their visitor's spatio-temporal motion behavior with the ultimate aim to influence their route choice. At the same time visitors make their personal data (GPS tracks, interest profile) available to the national park operators because they benefit from individual route information tailored to their interest profile. At the same time the users do know that in order to protect the nature they will not be guided to completely off – beaten tracks. It is part of the project to analyse the willingness of the visitors to balance their individual benefit against the benefit of the society.

This aspect of balancing needs and information and the willingness to alter behavior I would like to discuss in a workshop that aims at employing pervasive computing to protect the urban atmosphere.

5. Biography

Katja Schechtner is the head of Human Centered Mobility Technologies at arsenal research. Her team focuses on capturing, analyzing and simulating human mobility behavior. She has studied architecture and urban planning at the Technical University of Vienna, Austria (2001) and Columbia University, NYC, USA. She also holds an MSc in economics and communication from the DUK, Austria (2004). Currently she is finishing her PhD in Urban Planning at the TU Vienna, Austria and the ETH Zürich, Switzerland with her thesis about "Ambient Urban Intelligence". She has worked as an urban planner in The Netherlands, Ireland and as a senior consultant in urban planning and transport telematics in Japan.