PROCEEDINGS OF THE 2nd WORKSHOP ON POSITIONING, NAVIGATION AND COMMUNICATION (WPNC'05)
& 1st ULTRA-WIDEBAND EXPERT TALK (UET'05)

Context based Navigation by a Dynamic Tour Guide

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Abstract - Tourists, even with a map, are often lost in a foreign city. To make sure not to lose their ways but to see the most important sights, many tourists take part in guided tours. But as these tours don't take place whenever they want, their sightseeing activities are pretty limited. What they really need is a personal guide that takes them wherever they want, provides context based information and brings them back in time. This is the main objective of the Dynamic Tour Guide (DTG). The DTG is a mobile agent enabling a personalized spontaneous guided tour. It selects attractions, provides navigational guidance by collaborating with standard navigation software and offers information based on the personal and local context, e.g. on the direction the tourist is approaching an attraction.

1 Introduction

Navigation systems in cars are standard equipment today. Routes are planned from one location to another, giving directives for the shortest way. But walking tourists still have the problem to find their ways in foreign cities. The first difference is that pedestrians are much more flexible than cars. They can walk against one way streets, change directions or cross streets. Hence the route calculation has to be different. Another difference is the technical infrastructure. Tourists need to have a GPS receiver to determine their position. Mobile devices like PDA's or MDA's can be upgraded with such a receiver. In connection with a navigation programme like Navigon (Navigon, 2004), which runs on a mobile device and is able to compute routes for pedestrians, this offers the possibility for a Dynamic Tour Guide. The first challenge is to compute an optimal tour given the personal and local context. During the execution of the tour the challenge is to communicate with standard navigation software which will guide the tourist to the next Tour Building Block (TBB) and to provide location-based information as soon as the tourist reaches it. Beside that, the DTG constantly supervises the progress of the tour and reacts on the tourist's behaviour (loss of way etc.) by adapting the tour.
The first section will examine related work. The architecture of the DTG will be covered in the second section, while the third one describes the realisation of the DTG with main focus on the interaction with a common navigation package available for Pocket PC's. A conclusion shall summarize the most important perceptions and point out possibilities for future developments.

2 Related work

Tour Guides have always been an important research topic. The following projects summarize the current state of the art:

- The Crumpet project (Schmidt-Belz, 2003b; Crumpet, 2004) enables a mobile agent to find certain sights, to present them on a map and to calculate a route to a selected one.
- The software developed by eNarro (Enarro, 2004) provides predetermined tours presenting the most important sights in many big cities all over the world. The tourist needs a PDA with a special player loaded with the content for the particular tour. She/he also has to have navigation software which

will lead her/him to the different places. The attractions are then presented using audiovisual information.

- In connection with the AgentCities (AgentCities, 2004) framework the "Fujitsu Laboratories of America" (Fujitsu, 2004) have developed an event organizer. Based on an ontology, it selects a restaurant according to the guest's preferences and makes a reservation when planning an evening. This is a step towards context-awareness, because the search for a restaurant is dynamic due to the user's preferences.

In contrast to existing tour guides the DTG computes an individual tour in real-time by considering available context information like personal interests and location based services. The DTG is directed towards pedestrians and thus needs according navigation software. In order to build the DTG the following challenges have to be addressed:

- Integration of and interaction with standard navigation software on mobile devices
- Acquisition of the interests of a tourist in a mobile context to seed the profile
- Ranking of TBBs by semantic matching
- Computation of a tour in less than 5 seconds
- Context aware interpretation of the environment
- Tour tracking and adaptation

3 Architecture

Expectedly most people will own a mobile device in the next couple of years, cities will be covered with WLAN access points and DGPS via the mobile internet will provide localization with a precision approaching 1 m (EGNOS/SISNeT, 2005; DGPS, 2005). These are the preconditions to broad adoption of a Dynamic Tour Guide - a software agent accessible through a mobile device. It consists of the following components:

- TBB: Tour Building Blocks = each attraction like a sight or a restaurant as a possible components of the tour. The TBB's are semantically modelled by a content provider using an AuthoringTool. This model contains general information like the address, and special content like interest coverage, picture-, audio- and video files. Each TBB will have its own WebService (WS) to provide these data. A service provider like a restaurant will wrap the local restaurant management system by a WS to grant public access to a transactional interface to e.g. reserve a table. The WSs of the TBBs are registered at a UDDI registry.
- DTG server: The DTG server is executing a semantic match algorithm to rank the sights for a specific tourist. A computationally more demanding task is the computation of a tour as a sequence of TBBs, reachable in the available amount of time (ten Hagen, 2004).

Based on the given architecture the following features are enabled:

- Localisation: The mobile device is aware of its current position, either in a city via e.g. the Global Positioning System (GPS-WAAS) or inside buildings like museums via WLAN, Infrared grids or RFIDs.
- Service discovery: After arrival at a destination the DTG agent will determine the next DTG server in a UDDI registry. Based on the personal interest profile and the time period set by the tourist (personal context), the DTG will discover the sights and services at this destination (local context), interrogate the corresponding web services to update the current information and then compute potential tours. The Tour Building Blocks (TBB) are offering a web service (WS) to provide current information.
- Navigation: After the tourist has selected and optionally modified a tour, the local navigation software will visualize the tour on a map and guide the tourist via audio information. In the background the DTG will consistently track the execution of the ongoing tour in order to request current contextual information from the TBB servers in real-time and display them on the mobile devices when the tourists approach a certain TBB. Any deviations like changing

walking speeds or additional breaks require a recalculation of the tour to make sure that the tourist arrives at the desired endpoint in time.

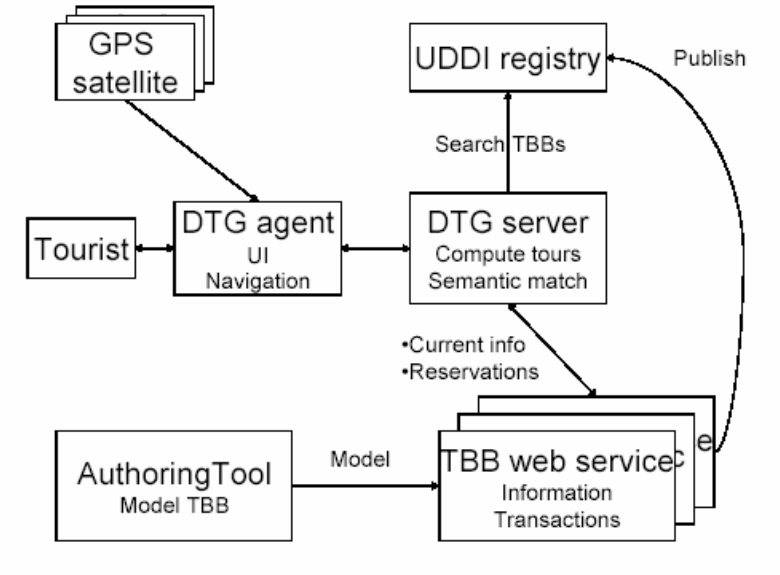

Fig. 1 System architecture

4 Context driven Navigation

Fig. 2 displays the complex functionalities of the DTG: the context driven tour adaptation, information provision and navigation by interacting with a standard navigator.

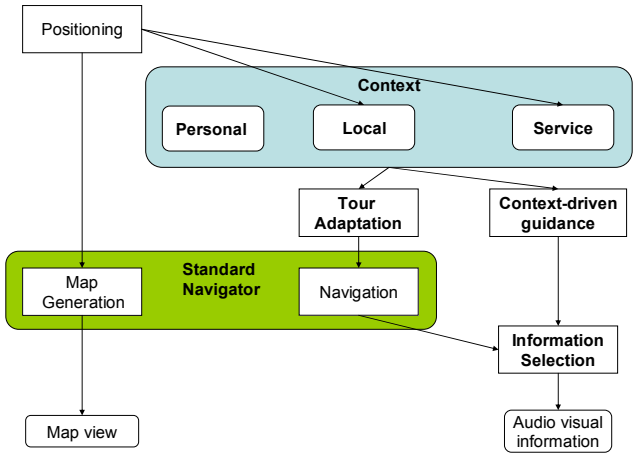

Fig. 2 Context driven tour execution and information provision

4.1 Context

Context spans the situational information. Any feature characterizing an entity and its environment determines its context. This context can be divided into different areas:

1. Personal context: The personal context includes ones personal information. It is defined by static elements like name or interests and dynamic elements like walking speed and current position
2. Local context: The local context consists of ones environmental information. These are for instance street and number of the actual position or the weather.

3. Service context: The services context describes the available services. Static elements are historic information about a sight, whereas a current exhibition or availability of a table in a restaurant is dynamic.

A context aware system is able to adapt its functionality because of filtered out contextual information (Korkea-aho, 2000). This is called ambient intelligence; the personal context is mapped with the services context and the local one. The DTG does so, using the following information to create a tour according to the actual context:

- Personal interests to rate (and select) the available sights
- The available time to limit the tour duration
- Opening hours of e.g. museums or restaurants to ensure availability
- The current position to determine nearby sights

Then it can plan an optimal, user specific tour.

Additionally, it will consistently supervise the ongoing tour and react on any deviations like changing walking speeds or additional breaks by recalculating the tour to make sure that the tourist arrives at the desired endpoint in time. Hence it has to react on changes concerning the context by constantly observing:

- The walking speed and tour duration to notice time problems
- The position to realize a tourist's approach to a sight or to get aware of distractions
- The walking direction to be able to call the tourist's attention to visible sights and start giving suitable information

4.2 Standard navigator

The DTG employs a standard navigator package installed on a mobile device to perform the task of navigating from one sight to another. This navigator is a separate program using geographical data to compute routes between TBBs, to display them on a map and to provide walking instructions. The navigator gives these instructions via audio to avoid the user holding the PDA in field of view all the time.

One of the main targets of the DTG is to ensure that the tourist gets back at the time that he has established at the beginning. Therefore the continuation of the tour has to be observed constantly. The initial tour for example is calculated for a walking speed of 5 km/h. If the tourist walks slower through the streets, the tour has to be adapted by removing some TBB's from the tour. Another important issue is detraction by a sight the tourist discovers along the way. In this case the standard navigator permanently tries to bring the tourist back onto the regular route. The DTG will instead use its knowledge about the context of the current position to recognize that the tourist is interested in this new sight, interrupt the audio instructions of the navigator and add the sight to the tour as a TBB. Essentially the DTG is taking the movements of the tourist as an implicit decision to modify the tour. The rest of the tour will be rearranged because the tourist hasn't the time to attend all other planned TBB's.

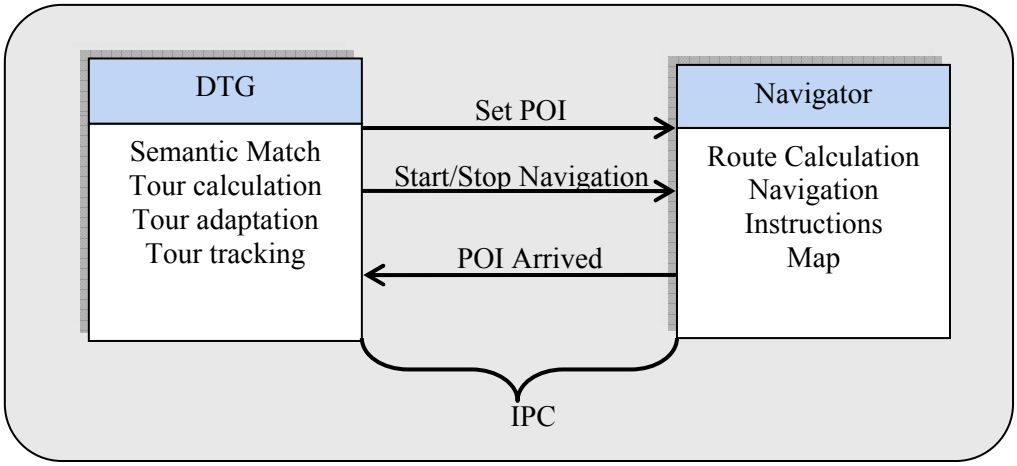

Fig. 3 Interaction between DTG and Navigator

4.3 Context interpretation

The DTG has to be aware of the tourist's position to detect the arrival at the next TBB. Therefore the local context of a TBB is modelled by storing all necessary data in an XML file. This also includes a separation of the area around the TBB into virtual geometric forms. As circles cause overlaps the most suitable ones are rectangles. Furthermore rectangles can be evaluated computationally efficient. Shown in Figure 2 is a TBB located at a certain street separated into necessary rectangles:

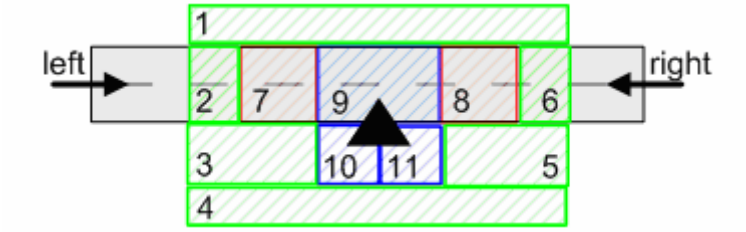

Fig. 4 TBB model

For every rectangle the upper left and the lower right coordinates are known. The coordinates of the tourist's current position are determined by a GPS receiver. To decide if the tourist is situated in one of the rectangles the following simple condition needs to be evaluated:

$$P^{up\_left}(x,y) \le P^{tourist}(x,y) \le P^{low\_right}(x,y)$$

When the tourist enters a certain rectangle, the following events are triggered:

Rectangles		Action
Actual	Last	
7	2	Alert about the forthcoming TBB, e.g. "On your **right** you see …."
8	6	Alert about the forthcoming TBB, e.g. "On your **left** you see …."
7	9	Alert about the departure from the current TBB + navigation to the next
8	9	Alert about the departure from the current TBB + navigation to the next
9	-	Information about the **front side** of the TBB
10,11	-	Information about the **back side** of the TBB
2	7	Navigation towards the next TBB
6	8	Navigation towards the next TBB
2,6	-	Navigation towards the current TBB
1,3,4,5	-	Alert of potential deviation and navigation back to the TBB or the route

Tab. 1 Actions when entering or leaving a TBB

The navigation software installed on the mobile device is performing the task of leading the tourist straight to the desired TBB. In the background the DTG prepares the arrival by downloading any available information that will be presented to the tourist then. Actually a pre-loader will be called at regular intervals, e.g. 5 minutes, to download all contextual information for the area the tourist can reach within a certain amount of time, like the next 10 minutes. As a side effect this forward looking caching makes the DTG more robust in situation with spotty mobile coverage.
Furthermore the DTG permanently checks the position of the tourist to detect the intrusion into a rectangle. The required information derived from his personal context is his current position and his moving direction, which can be determined from her/his recent walking path. Assumed the tourist is approaching the sight coming from the left side.

1. He first enters rectangle 2. As she/he hasn't been in nr 1, 3, 4 or 7 before, nothing happens, except that it is registered.
2. The tourist enters rectangle 7. This is the position the sight can be seen from. The DTG interrupts the navigator and continues the guidance. As the tourist comes from nr 2, he is alerted that she/he will soon be able to see the TBB on her/his right side.
3. The tourist enters rectangle 9. The DTG starts giving information about the front of the sight like its architecture style, history and so on by playing an audio file.
4. As long as moving around the TBB inside rectangles 9-11, the DTG keeps on presenting information occasionally changing the audio file to provide information about the backside of the TBB.
5. When the tourist departs from the sight and enters rectangle 4, maybe to take a photo. The DTG now stops giving information but alerts the tourist that he is leaving the right path and is recommended to go back.
6. Once the tourist leaves entering rectangle 8. As he has been in nr 9 before, the DTG just stops giving information and restarts the standard navigator do guide the tourist to the next station of the tour. In the background it prepares the next stop by downloading the necessary files for providing information at the following TBB or any other TBB in the immediate vicinity.

The method of context-driven interpretation described above is satisfactory for a small building like a tower or a house. But for larger attractions like a castle, a park or a big church, this scenario has to be extended by additional user guidance within the TBB itself. Having arrived, for instance at a big church, the tourist might stand in front of it quite helplessly, not knowing where to go and where any information is presented. The tour inside the whole tour might start at the front door of the church, showing e.g. a picture of its digital reconstruction on the screen of the mobile device. The screen will further present a map showing the single stations around the church with different information sources

as sketched in Fig. 5. The audio hints are using cross references, e.g. "Please enter the church to receive information about the organ." Inside the church, the tourist might hear an mp3-file of a concert. When moving out again the tourist is informed that he will receive historical information about the tower at the backside. With audible instructions supported by arrows on the screen the tourist is guided to the next station, as depicted in Fig. 5. This ensures that the tourist doesn't miss any important information about a TBB. These navigation instructions at a TBB's place, which might only be a small area, aren't generated by the navigator but are given by the DTG itself. They are static for each tourist, use environmental descriptions like "Move around the right corner straight towards the stairs." and depend on the actual position and the positions the tourist has already been at before.

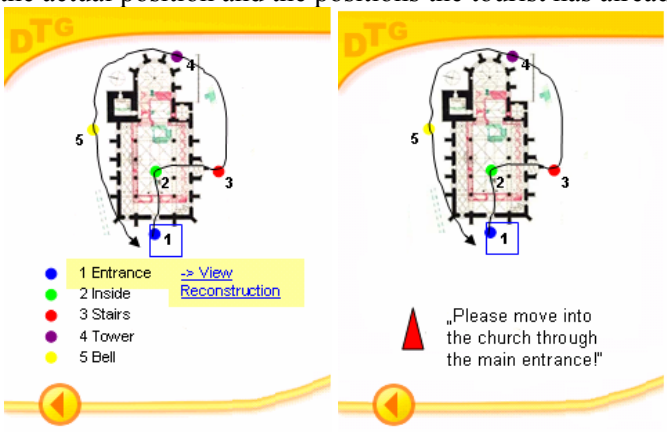

Fig. 5 User guidance at a TBB

5 Conclusion

The DTG uses context-aware navigation to guide and care actively for a tourist in a foreign city. Because of the communication between the DTG and the navigator over IPC it is possible to react on contextual changes and to present the information about a sight at the right time and in the right form. This avoids irritations with information about a sight which isn't visible yet. The DTG also interrupts the navigator directing the tourist if he obviously leaves the predetermined tour. After a recalculation the DTG starts the navigator with a new target. The DTG is always in control of the tour and makes it a comfortable guide for any tourist. In some sense the DTG makes intelligent use of contextual information to ensure that ubiquitous ambient intelligence doesn't turn into a permanent cacophony.

6 Acknowledgements

This project is part of VESUV (http://www.vesuv-projekt.de) in cooperation with Siemens AG, Microsoft's European Innovation Center (EMIC) and Fraunhofer Institute IGD. VESUV is supported by the Federal Ministry for Economics and Labour (BMWA).

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