THE TETHERLESS TOURIST:
AMBIENT INTELLIGENCE IN TRAVEL & TOURISM

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Mobile services find in travel and tourism a challenging arena for application exploitation, which can greatly benefit from the convergent impact of a number of enabling technologies referred to as ambient intelligence. Fulfilling the specific needs of tourists, travelers, and citizens on the move calls for appropriate paradigms to be implemented in key functions like user interfaces, display systems, interaction with information-rich contents, and information retrieval. This article briefly addresses the state-of-the-art and emerging technology environment and introduces appropriate user profiles, representative of various operational situations. As a result, a comprehensive vision of mobile services in travel and tourism is offered, with particular reference to cultural tourism.

Introduction

Travelers and tourists, or visitors, are categories that, for different—and sometimes concurrent—reasons, leave their habitual residence and move abroad. Once they have reached their destination, they tend to perceive the surroundings as something uncomfortable and sometimes hostile, at least psychologically. The travelers, consequently, feel displaced and, thus, extraneous to the environment.

This sentiment is a consequence of a lack of familiarity reflecting the impossibility of the visitor getting fully immersed in the new environment and completely enjoying it by associating appropriate information to the surroundings, as only a native could. The visitor is, then, psychologically encouraged, almost forced, to gravitate around the better known places, which in fact tend to become tourist dense. Therefore, she/he misses the chance of moving without constraints in the environment and ultimately is prevented from intimately enjoying it. In this sense the visitor is “tethered,” as her/his range of action is limited.

To overcome this limitation has been, over the centuries, a practical need and a cultural demand.
The concept of travel book or journal was developed as a means to help the visitor and to disseminate experiences and knowledge. Guidebooks developed in the second half of the 20th century evolved and eventually became the basic support for group tourism. They were initially intended for aiding cultural visitors while providing pictorial and textual information, sometimes of appreciable artistic value, and were subsequently extended to other fields, including gourmet, winery, and shopping.

Still, with guidebook and electronic aids available today, the tourist is tethered, owing to an inherent lack of interactivity with the environment. Technology can help to remove the tether by reestablishing the continuity of information with the environment, so that the traveler is replaced in a familiar context, by means of appropriate paradigms and metaphors.

Information and communication technology (ICT) is having a large impact on new services for travel, tourism, and leisure. Internet services are already available from a number of different organizations, allowing planning/reserving the trip, booking hotels, and renting cars via the Web. Online travel agencies are currently offering mobile services based either on cellular phone or personal digital assistants (PDAs). Synchronizing the PDA with a computer allows downloading information, making flight status, timetables, and other useful records of the reservations previously made, available in electronic format. The advent of wireless PDA (wPDA) will add real-time access/updating of information, making it possible to attain fully paperless and online operations. This travel information will be integrated with services like geographic map uploading, weather forecasts, around-the-clock updated Web cams, and more. This is leading to a shortening of the value chain, to a redefinition of the role of traditional travel agents, and to the introduction of new business models (Hemsley, 1999). It also represents an ideal market for e-commerce as intangible goods are involved, thus avoiding goods dispatching.

In the IV and V Framework Programmes, the European Commission put a great effort into promoting pioneering projects aimed at introducing new personal services and business models, specifically in the area of cultural tourism. A particular mention should be made here of the GUIDE and TOSCA projects, which will be described in detail below.

The aim in those projects was not only to experiment with new technical solutions, but, even more important, to define a “gentle” (or “calm” according to Mark Weiser) technological approach, capable of enriching the visitor’s experience, while preserving respect for the cultural values. An invasive or arrogant technological impact, in fact, would result in a possible rejection by the users or, even worse, in encouraging behaviors and habits that are exactly the opposite that tourism—intended as exchange and integration of different cultures—aims at achieving. The next step calls for offering fixed and mobile services related to situational issues in, and taking full advantage of, emerging technologies of ambient intelligence (Manes, 2001a).

 Ambient intelligence is currently being studied and developed for in-home applications. First prototypes of ambient intelligence for home systems have been developed, but the realization of true ambient intelligence calls for much additional research of multidisciplinary teams consisting of technologists, designers, and human behavior scientists, notably by groups such as that lead by Emile Aarts at Philips Media Lab (Aarts, 2000). The travel and tourism environment is very specific and requires ad hoc approaches and solutions. The ambience is often noisy and unknown, mobile services are predominant, real-time and user profile-tailored services are needed, and hand-free operation is required. Consequently, issues like user interface, navigation/localization, and intelligent software agents assume even greater relevance than in other ambient intelligence applications. Enabling technologies span from personal devices and human–machine interfaces to visual displays and connectivity; technology trend is briefly described in the following.

- **Personal devices.** Wearable computing is the natural evolution of the currently available PDAs. Since the introduction of the wearable headset by Ivan E. Sutherland in the 1960s, wearable computers have been in active development, aiming at downsizing the components for creating an unobtrusive, ergonomically workable tool. A wearable computer is made of a wearable platform operating with personal wireless local area networks, including unobtrusive input devices, a host of other context sensing and communication tools, and a visual
display unit, like the heads-up display (Campbell, Muller, & Randell, 1999). A smart badge is also included, for exact localization and identification. Wearability not only refers to size, but is a more extensive concept emphasizing the capability to be worn, much as eyeglasses or clothing are worn, and interact with the user based on the context of the situation. The wearable computer can act as an intelligent assistant, whether it is through an intelligent agent, augmented reality, or intellectual collectives; this allows the user to fully attend to the task at hand, while in the midst of other activities. The output device is a head-up display, competing for attention with the user’s surroundings. Context-sensitive agents are given, offering hints and reminders but never growing into a controlling influence. Context-driven systems are also needed, where tasks are initiated by the state of the user’s environment.

- **Human–machine interface.** Today available interfaces are basically explicit; they require a great number of different actions to state a complex entry, resulting in conflicts being established with other user’s activities in a given context. Evolution is toward implicit and context-aware HMI paradigms, appropriate to the specific user requirements, with user inputs gathered through sensing and modeling the person’s environment, so that user needs can be understood and even anticipated. Sensing requires physical/biological sensors; modeling task, user, and environment requires not only constant sensing contact with the user, but also contact via more traditional user interface paradigms. An example is represented by the Affective Wearable Computing (AWC) (Picard, Vyzas, & Healey, 2001), able to automatically respond to user preferences through physiological signals.

- **Visual display.** Evolution is represented by micro-optical displays or, in a longer term, by visual retinal displays (VRDs) (Chinthammit, 2001), capable of directly projecting the image on the retinal and allowing for hand-free operation and, even more important, ideally suited for augmented reality operation. Using the VRD technology it is possible to build a high-resolution, wide field-of-view personal display device that is lightweight and will operate in a high-brightness environment. VRD provides a focus-free image by displaying the image through the eye’s nodal point. Future goals are miniaturization in order to achieve a low-cost, wearable, and low-power device and combination with a pupil tracker system to adjust the laser beam to the pupil’s movements.

- **Connectivity.** The evolution is toward an online world where personal computer, servers, smart devices, and Internet-based services do collaborate seamlessly. By taking advantage of wireless communications, this would result in easy accessibility to documents regardless of the specific support (portable PC, PDA, mobile phone) at hand. Requirements to be fulfilled are interoperable applications, middleware capable of providing multidevice data consistency (even when disconnected), on-reconnection actions to update multidevice document versions, and ubiquitous access in the same file format. These requirements can be met only if other key issues such as privacy, security, connectivity, and authentication are dealt with properly. A first step in this direction is Microsoft .NET My Services (also known as HailStorm, see for reference: http://www.microsoft.com/net/), a platform for creating user-oriented Internet applications. .NET My Services represents a private and protected “digital safe” where users can deposit the data that can be accessed over the Internet and possibly share part of them with colleagues and friends.

Convergence in the above technologies will enable extensive exploitation of ambient intelligence in travel and tourism. Extensive and effective use of the concept of mobile augmented reality (MAR) will be possible, in particular. MAR assists the user by providing location-based and location-aware information (Feiner, MacIntyre, Höllerer, & Webster, 1997; Höllerer, Feiner, & Pavlik, 1999) as specifically required in travel and tourism services. Ante litteram examples of the potential applications of MAR to cultural tourism guidance using to-date available technologies are given by the low-end and high-end prototypes developed in the TOSCA project (Hemsley & Manes, 1999), to be described in detail below.
Ambient Intelligence in Travel and Tourism

Having briefly reviewed the technology trends in the key enabling technology, the impact of ambient intelligence on travel and tourism information services will be now discussed. Addressing this issue, it turns out that the inherent multiplicity of tourists’ needs and behaviors prevents the possibility of grouping all of them in one single category. Travelers, in fact, exhibit different user profiles depending on specific situations; they have different tasks at hand which may—or may not—coexist at the same time or in the same situation (e.g., business or leisure). Consequently, they exhibit different kinds of needs. To better fulfill user needs in different operational conditions, it is convenient to categorize different user profiles somewhat homogeneously in terms of technological approach and requirements. For this purpose, we classify three different user profiles related to three corresponding situational conditions.

- **On the move**: This profile takes into account information needed in real time, specifically provided to the user with reference to the trip, sometimes “on demand,” but most often determined by the changing context (e.g., delays versus scheduled, available transport, hotel confirmation, messages).

- **On the net**: This profile is basically related to remote and mobile access to the net by a traveler, allowing for cooperative i-work, m-learning, and m-web browsing, and requiring, in general, a complex interaction with multimedia information-rich contents through the user interface.

- **On the tour**: This is mainly intended for leisure and cultural visits. Specific requirements are navigation and guidance access to information based on human perceptual similarity, on location, and on item-related proactive interface and retrieval engines.

Scenarios for potential ambient intelligence application are given in the following, according to the three user profiles described. Particular emphasis is given to applications in cultural tourism, reporting the results of extensive experimentation in the previously referenced TOSCA project.

**On the Move Profile**

*On the move* concerns situations where information is needed in real time and specifically provided to the user, sometimes “on demand,” but most often determined by the changing context. A possible application scenario for this user profile is represented by a business traveler. When landing in an airport (Fig. 1) and entering the aerostation (step 1), she/he is first identified and localized using a smart badge; local information, available services, weather conditions, and other useful information are downloaded by the user’s computer via the airport LAN.

The user position is continuously tracked by smart badge and Mobile Location Services. The software agents (step 2) plan for ground transportation, confirm hotel reservation, send a message home, confirm the scheduled meetings for the day, or update the schedule according to the transport availability, traffic, and user’s profile. Guidance to the taxi stop (step 3) is performed via a Mobile Augmented Reality System (MARS) acting as a geographical information system and providing guidance in forms of icons superimposed to the real vision via VDR. Arriving at the hotel (step 4), the user is again identified; a number of operations automatically take place, like up-loading the room electronic key, registration, and accounting, setting up wireless communication, and establishing the room environment according to the user’s profile. Mobile services can be directly activated on the basis of previously defined user inputs (the agenda of the day), accounting for her/his profile and for local conditions and constrains, while minimizing or totally missing intentional human–machine interactions. This is an example of a proactive, context-aware wearable system based on technologies that, if not available “off the shelf,” are currently under development and possibly available in the predictable future.

**On the Net Profile**

*On the net* concerns mobile access to the net by a traveler, in a context of complex interaction with multimedia information-rich contents. Specific requirements are mobile and ubiquitous access, integration of mobile and native devices, natural interaction with information-rich sources, and highly interactive information/presentation capabilities. The first two requirements are related to connectivity and
communication platform issues and have been previously addressed; the last two are related to HMI issues and will be considered in detail, as they are of great importance in this context. A typical reference situation is represented by various net-related activities of potential interest to the traveler, like mobile Web browsing, i-meeting, m-learning, and cooperative i-work, all of them related to network access. Available HMIs and input devices represent the major sources of trouble as they are inadequate to support highly interactive access to information-rich sources. In today’s computers and PDAs, for instance, Web browsing occurs through a serial process where information is available in sequentially displayed windows, grouped in a tree-like structure (Najjar, 2001). The user explores the available information by moving backward and forward along the tree according to certain association criteria. Information appears as a flatland of data, according to Virilio (1999), where the user may experience waste of time, trouble in finding the object, frustration, dissatisfaction, and, ultimately, information anxiety. All that results in the concrete possibility of loosing orientation, particularly in a mobile environment. Input device limitations are a second source of trouble when interacting with information-rich sources. Interaction with information is mostly performed in today’s PDAs using surrogate-mouse devices like touch-screen. The combination of a touch-screen and window-structured browser is a typical example of the conceptual attitude to adapt human behavior to machine-limited resources and capabilities. It appears as the best possible trade-off with today’s available technology, but has the drawback of limiting the extensive (and desirable) use of human perceptual capabilities, which are only marginally involved in the process. Overcoming these limitations calls for creating a virtual reality (VR) environment where human and machine cooperatively interact, so that human perceptual capabilities can be widely involved. This is mandatory when interaction takes place with content-rich information and, particularly, in mobile applications. A radical revisitation of HMI’s characteristics is needed to innovatively redefine two key features in the human–machine interaction process, namely browsing mechanization and highly interactive information presentation. This results in a new approach to Web browsing: cooperative browsing. Cooperative browsing is based on the capability of people’s strength at
locating and orienting in a 3D spatial layout and represents the natural and most desirable way for interacting with content-rich information. Cooperative browsing requires the implementation of new immersive interfaces (e.g., hand-gesture mapped in a virtual space), replacing the limited mouse-like 2D touch-screen. An example of this kind of device is given by the programmable glove developed at Essential Reality (see for reference: http://www.essentialreality.com/) or, with a different and more challenging approach, by GloveGRASP (see for reference http://www.genreality.com). Alternatively, hand-gesture tracking based on a video camera system could be considered. A metaphor is implemented for linking the movement of the user’s physical hand to the affected movement of the virtual hand in the virtual environment. Accordingly, a 3D VR shared or cooperative space is established where the human naturally interacts with content mapped into the graphical world, via hand-gesture mapping or tracking. A schematic representation of this process is given in Figure 2. The metaphoric representation allows the user to perform even complex operations using everyday life gestures and tools. Accessing a file, for instance, can be implemented by opening a (metaphorically real) file in an archive, extracting a document, and pressing a (virtual) button for printing it.

The described cooperative browsing requires information to be displayed in a highly interactive and immersive presentation capable of appropriately integrating a variety of textual and visual information. An example is given by Flavia Sparacino’s work, at MIT Media Lab. Sparacino developed a metaphor for 3D Web browsing, City of News (Sparacino, et al., 1997). City of News is an example of a metaphoric representation of the Web where the user, following a link, creates new city elements that are added according to an algorithm that simulates artificial growth and evolution. To follow a link becomes equivalent to a pursuit of a possibility, which determines, in turn, a change in the environment. The advantage of such a representation is that human perceptual capabilities get more extensively involved, and the process of exploration takes advantage of the human capability of orientation and spatial association. 3D representation of the information, along with immersive interfaces like those previously described, represents a new paradigm for ambient intelligence in mobile applications.

**On the Tour Profile**

On the tour is related to leisure and cultural visits. The technologies and HMI paradigms previously described could find wide application in this area, in an even more critical environment, as cultural tourism represents a challenging, scalable laboratory for ambient intelligence and a primary tourist activity in Europe, where more than 600 million people yearly visit historical towns.

Guidance and on-demand cultural information retrieval are key requirements in this profile. Guidance requires localization and navigation capabilities well beyond those required by the on the move profile. Guidance in highly dense historical towns prevents using maps and GPS-based direction indicators, which may be ineffective or inadequate. On-demand cultural information retrieval requires a cooperative association process to be established, where the user locates himself in the environment, identifies the item of interest (e.g., a picture), and eventually associates the item to the appropriate content. The modern guidebook represents the elementary mechanization of this process, where the content is stored in a textual format. Audio guides were the first attempt at replacing, or even complementing, the guidebook with a digital electronic assistant. The cooperative association process is performed through a keyboard and with the aid of reference sign and text labels spread across the space; this approach, sometimes annoying to the user, re-
quires a ground infrastructure to be established and prevents accessing of details and remotely located items.

A pioneer EU project in the IV Framework, GUIDE (Gallery Universal Information Dissemination and Editing) Esprit project No. 23300, introduced a significant innovation represented by the “touch and play” audio guide, based on an original idea by the late Prof. David Clark, WP Leader in the GUIDE Project. The cooperative association process was implemented, at that very early technology stage, by means of photographic panels located in the environment (museum or historical site). The audio guide, basically a digital player, featured an active sensing element acting in conjunction with r.f. tags integrated in the panel. The implementation of the GUIDE system (Manes, 1998) is depicted in Figure 3.

The user, when attracted by a specific item (in this case a picture on the wall), identifies the corresponding picture on the panel; active retrieval of the appropriate audio content is then easily performed when the user approaches the sensing element to the corresponding tag. Different from traditional audio guides, the user can easily link to remotely located and far objects, while keeping free to be immersed in the cultural context (Fig. 3) without being annoyed by tedious keyboard operations (Hemsley & Manes, 1999).

GUIDE was tested in a large-scale EUROGUIDE trial in Firenze at Palazzo Vecchio and Museo Stibbert, in Perugia Centre Town, in Edinburgh at the National Museum of Scotland, and Wörlitz at the Kulturstiftung Dessau-Wörlitz Museum (Geschke & Manes, 1999). The GUIDE system, like guidebooks and traditional audio guides, is capable of providing information to the visitor, once the visitors is in the museum or historical site, but is unable to provide guidance for reaching the museum or the historical site.

The capability of supplying information as well guidance was demonstrated for the first time by a second EU project, TOSCA (Tourist Orientation and Support in Cultural Assisted tours) Esprit Project No. 26800. The system, originally conceived as a custom-designed hand-held computer, was replaced by a standard palmtop. The information consists of a sequence of pictures representing the subsequent steps of the tour with the appropriate audio content. The visit begins, for instance, at the hotel exit. The TOSCA guide (Fig. 4), once initialized, presents an image of the surroundings with reference for the next step in the form of a red square indicating the exact position to be reached (upper left). The procedure is serially repeated, thus resulting in a cooperative navigation system, which takes full advantage of the human perceptual capability of self-localizing and recognizing the sites. This approach is much more effective for providing guidance in dense environments than the more traditional based on GPS and maps. Once in a site of cultural interest (upper right), the user receives the appropriate information and might decide to visit a church (in this ex-

Figure 3. The Guide Project trial in Palazzo Vecchio, Firenze.
ample). Indoors, as outdoors, the system can provide guidance (bottom left) as well as on-demand cultural information (bottom right). The TOSCA system was tested in three different trial sites, Florence, the archaeological site of Dion, and Edinburgh. A number of early TOSCA prototypes are still available to visitors in the S. Maria Novella Area in Firenze (Manes & Verdon, 2000). A limitation of this approach is that the user has no degree of freedom in visiting the sites, as the information is available in a serial and predetermined way. The user is then forced to follow a predetermined program resulting in a synchronous operation mode.

Significant developments for evolving TOSCA to an asynchronous operation mode were developed, within the TOSCA project, by the Group at Universidad Politecnica de Madrid, leaded by L. Salgado. Salgado (2001) introduced new navigation concepts based on VR reconstruction, which represent an example of mobile augmented reality, that is, the superposition of a virtual (or metaphoric representation of) reality to the environment, for the purpose of guidance and information retrieval.

Application of the TOSCA concept to the new generation of cellular phones with Multimedia Messages Service (MMS) capability is immediate. In this case, all the content is stored in a remote server and supplied to the user on demand by a Wireless Internet Service Provider (WISP). Combination of images, in the form of MMS, and audio content, in the form of traditional phone calls, can provide both guidance and narrative information to the visitor (Manes, 1999).

Other examples of new concepts for providing both guidance and information retrieval are described by Sparacino (2002) and Manes (2001b). Sparacino, in particular, in her recent paper on “Wearable Museum,” shows integration of various technologies, like wearable, augmented reality, micro display, and infrared TAGs, capable of supplying the visitor with audiovisual story, but exhibiting the inherent limitation of requiring an on-field infrastructure to be set up.
Starting with the pioneering activity made in the above-mentioned and other EU projects, the impact of ambient intelligence and the convergence of key technologies can lead to large-scale exploitation of mobile services for travel and tourism. The next step is toward a fully asynchronous operation mode, where the user can freely interact with the environment, accessing on demand to the requested information on the basis of her/his momentary interest, which cannot be established a priori. This requires evolving from the operative association process previously discussed, to an information retrieval process based on some attributes related to the context and/or to the user. We classify three different information retrieval mechanisms corresponding to three different attributes, namely location, content, and gesture tracking.

**Location-Based Retrieval.** This requires a precise localization system and can be only effective in open sites largely benefiting from the integration of LMS and MAR technologies.

**Content-Based Retrieval.** This performs as a proactive user interface. The user, when in front of an item of interest, can obtain the required information through an identification process where the content is first acquired by the photo camera integrated in the currently available cellular phones also featuring MMS capability. The data are then routed, along with rough localization obtained via LMS, to a remote database where the retrieval mechanism takes place. Eventually, the retrieved content is transmitted back to the user. Content-based information retrieval is, in principle, not dissimilar to what was performed in TOSCA, with the difference being that, in TOSCA, all the graphic content had to be uploaded in the PDA and retrieval was cooperatively performed by the user.

**Gesture Tracking-Based Retrieval.** This is based on the concept of smart room. This is a method of tracking 3D position, posture, and the shapes of human hands from multiple viewpoint images (Wren, Azarbayejani, Darrell, & Pentland, 1997). The smart room can provide a new interactive vision-based setting that would allow the users to connect to their interfaces (or virtual/collaborative environments) in a more natural fashion, based on hand gesture. It eliminates the need for invasive sensors and the annoying umbilicus of wires that come with them. Applications of smart room to cultural visits are immediate, as a direct link is established via gesture tracking between the item of interest (e.g., a picture in a gallery) and the associated content (description of the item). A simple video camera system, embedded in the environment, can fulfill the job. Examples of application of this idea in a museum have already been described by Prof. Del Bimbo’s group in Florence (Baggiani, Colombo, & Del Bimbo, 2001).

**Conclusions**

This article addressed the potential impact of ambient intelligence technologies on travel and tourism information services. Ambient intelligence evolutionary paradigms useful for service exploitation have been discussed with reference to three different user profiles representing the user’s inherent situational complexity, resulting in a multiplicity of behaviors and needs. This classification helps at defining appropriate paradigms and at drawing a technology roadmap for ambient intelligence in travel and tourism, allowing for critical enabling technologies to be easily identified.

The area of cultural tourism has been specifically addressed. Key requirements in the related user profile are guidance and on-demand information retrieval. Results from pioneer EU projects have been discussed, showing the capability of providing both these requirements using the next generation of cellular phones and PDAs. Evolution toward asynchronous operation mode also has been discussed with reference to various information retrieval mechanisms.

The exploitation of ambient intelligence in travel and tourism, at rapid convergence of technologies, will be stimulated by other emerging applications, like m-learning, i-work, and electronically enabled leisure (e²-leisure). Cultural tourism is a potential “killer” application with a large and qualified market target, in a European leadership context.

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