

Spatiotemporal Thematic Maps for Sustainable Development of Heritage Site Tourism

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Abstract. UNESCO world heritage sites' list is getting longer and longer. Many sites among them have attracted countless tourists each year. However, the lack of efficient systematic surveillance and monitoring methods let the evitable and inevitable impacts of tourism development happen unperceived. Our research focuses on an e-tourism system with heritage sites monitoring to explore the possibilities for a long-lasting sustainable development and conservation of World Heritage Sites. On the basis of the status quo and trends of information systems for cultural e-tourism, we have implemented a community hosting service and proposed a generic theme model to compare spatiotemporal thematic maps to support heritage preservation work for sustainable development of tourism. A case study and prototyping are done on the UNESCO World Heritage Site Bamiyan Valley in Afghanistan. The concepts and solutions are the result of an interdisciplinary cooperation with architects for monuments preservation and cartographers.

Keywords. geographic information system, spatiotemporal database, heritage management, sustainable development, tourism.

1 Introduction

As of late 2005 the list of UNESCO world heritage sites has expanded from the first 12 in 1978 to 812 sites worldwide and is growing continually. A great number of sites among them attract countless tourists each year. The Internet has influenced the tourism greatly as well. The Internet networks communities of different culture and different location and makes the world much smaller. The Internet is changing our ways of preparing, performing, and documenting journeys. In 2003 30% of the U.S. adult population used the Internet to search information about travel destinations and 2/3 of

them, 42 million Americans, booked travel via the Internet (Werthner and Ricci 2004). E-tourism systems are not only a business opportunity in the information society on the sunny side of the digital division, they promote tourism boom in developed countries and at the same time it is especially applicable in developing countries to mediate travel information¹. However, in many cases the lack of efficient systematic surveillance and monitoring methods let the evitable and inevitable impacts of tourism happen unperceived. Many countries and regions have developed GIS and web technology based heritage information systems in order to comply with the guidelines to enhance public awareness on heritage issues. But most of them focus on presenting spatial information and making sites more known without promoting preservation goals, which might lead to further pressure on these sites.

Such a hard task can not be achieved within one discipline. Our research focuses on a heritage sites monitoring approach that brings together the views of cartographers, architects from the field of heritage preservation and regional and city planners in order to explore the possibilities for long-lasting sustainable development and conservation of World Heritage Sites. Each feature or attribute associated with a heritage site is stored for further analysis and the composition of a thematic map. Beyond spatial map themes, we survey possibilities to involve temporal themes to record preservation status and the events taking place on site along the time axis. Either architectural plans with preservation survey locations and information about the fieldwork or tour path information presented on a map at a large scale can be combined with temporal themes to present cultural styles and historical information of a site. On the basis of the status quo and trends of the development of information systems for heritage management, this paper proposes and compares various spatial, temporal as well as spatiotemporal thematic maps to support heritage preservation work and to promote tourism development in a sustainable way.

We aim at a community hosted heritage monitoring system that raises travellers' preservation awareness of heritage sites and supports their travel organization with modern information technologies on a global scale. This system can be used not only to mediate travel destinations' cultural and social information anytime anywhere but also to inspect the impact of tourism at a cultural heritage site. Moreover, travellers are connected among themselves via a community platform. In addition, some research work has been done in a community information system for cultural heritage management in Afghanistan (Klamma et al. 2005), which aims at documentation and preservation of afghan monuments and sites in a community. A case study and prototyping are done based on information and experiences for the UNESCO World Heritage Site Bamiyan Valley in Afghanistan. That distributed heterogeneous information is managed for map themes in GIS applications with spatiotemporal database technologies. Metadata are employed to enhance the interoperability and portability of spatiotemporal information. The concepts and solutions are the result of an interdisciplinary cooperation with architects for monuments preservation and cartographers.

The rest of this paper is organized as follows. Chapter 2 analyses the current e-tourism systems and the travellers' requirements of community information systems for heritage sites tourism. A community hosting service, a generic map themes model

¹ The E-tourism Initiative: http://www.unctadxi.org/templates/Startpage____1195.aspx.

and the prototype are introduced in Chapter 3. Chapter 4 gives a short conclusion and outlook of the future work.

2 Related work

Referred to cultural heritage sites, common information system technologies have been applied in cultural tourism for years and are still growing, namely e-tourism systems. The most existing e-tourism systems focus on the e-commerce realm. A requirements guideline for e-commerce in tourism is defined by WTO business council (2001). However, e-tourism should not be merely an e-commerce division or only aim at tour sales. In order to consider many other factors of tourism such as being in accordance to cultural heritage preservation and connecting user communities together, a web-based community information system for cultural site monitoring could be an appropriate approach to the development of heritage-friendly e-tourism systems.

2.1 Views from communities

One of the goals of the community information systems is to bring together communities from different research areas. Three user communities are involved: architects, cartographers and computer scientists. The challenges architects or monuments conservators encounter are data modelling, identifier, and naming problems. Thus, some standards especially of cultural heritage sites will be taken into account.

Cartographers focus on visualization of geospatial information. Geographic information systems are the platform to allow the user to analyse and explore data. Maps play an important role in Geographic Information Systems because they are a direct or indirect interface to the GISs, a sort of graphical user interface with a geospatial dimension (Kraak 2003).

Computer scientists try to use modern information and communication technologies to fulfil the functionalities within the community. Database and multimedia technologies are the key issues to realize the system.

2.2 Classification of e-tourism systems

Generally speaking, the most common e-tourism systems are versatile and can be observed with a division of several groups.

The first group is *e-tourism information providers* that focus on tourism information mediation such as official websites of local governments which can also be seen as city websites. An analysis of around 55 city websites worldwide shows that multi-lingual support, multimedia information and interactive maps are respectively 37%, 57% and 45% in average (Zhou & DeSantis 2005), which gives an overview of the current status of city websites collected by Yahoo. In addition, a great number of articles about travel's destinations are accessible in digital newspapers and maga-

zines. Internet users publish their own travel diaries with various online platforms like BBS, blogs and wikis, through which travellers can share travel experiences among themselves. With the development of web 2.0 and social software, some web sites are going to support traveller in three phases: pre-travel, mid-travel and post-travel. Activities of user communities are involved, such as to upload travel photos and to edit destinations information collaboratively. Some web sites like WorldBy.com² and world66.com³ are making destination guide with resources from user communities. World66.com provides travellers possibilities to find travel information, take it with and update it when return.

The second group is *information systems* with support of database technologies such as homepages of traditional travel agencies, and travel portals that integrate online information provided by different travel agencies. Users can book travels, plane tickets and hotels via those systems.

The third group is *geographic information systems (GIS)* with digital maps. Hardware devices such as GPS devices play an important role in these systems. GIS support spatial search and route planning for travellers. Besides some eminent online route planners and navigation systems, many advanced information technologies like agent and knowledge management technologies can be applied to arrange an optimised travel routing plan (Chiu et al. 2005, Niknafs et al. 2003, and Maruyama et al. 2004). Mobile devices are also greatly involved in this area (Krösche et al. 2004 and Schmidt-Belz et al. 2003).

The last group in our classification is the *virtual tour systems* with 3D technologies (Nielsen 2004). Google has launched the software Google Earth that delivers a 3D digital model of the entire earth. Through the “3D” model a virtual tour can be performed. So do Google Moon and Google Mars. NASA has deployed World Wind that visualizes not only the earth but also the moon as well.

Some improvement suggestions of the aforementioned e-tourism applications are concluded as follows:

- Lack of surveillances of the condition of cultural heritage: the problems on the sites often arise, as the tourist number increases. Impacts such as commercial promotion cause environmental problems.
- Inflexible search functions: the trend shows nowadays more and more travel portals collect information from separate travel agencies and present it to travellers in an integrated manner. However, spatial search functions are not integrated except some standalone route planner programs.
- Heterogeneous information sources: information sources for tourism are still distributed widely and heterogeneously. Tourism information about the destination is provided, however, inadequate for travel preparations. Travellers have to collect information from a lot of media ranging from books to the Internet. Even information from one web site is often unstructured. Standards are not widely used.

² <http://www.worldby.com/>

³ <http://www.world66.com/>

Summarily, most existing e-tourism systems just replace the role of traditional travel agencies to display digital travel catalogues and book tickets. Information system technologies provide potential solutions to inflexible search functions, scarce cultural information, and heterogeneity within a community. Recently some new forms of e-tourism systems for special user communities attract people's attentions. Jacucci and Salovaara (2005) have developed a system to support spectators to share multimedia in large-scale events like open-air concerts and sport events. Cultural tourism, sport tourism, and history tourism etc. are all served for special user communities. In addition, more and more mobile technologies based systems have been used to collect more local site information (Tummala & Jones 2005), as well as to assist the cultural heritage conservation e.g. in Italy (Maurino & Modafferi 2003).

3 Conceptual approach and prototyping

A community information system for heritage sites tourism can be realized through modern information technologies such as community hosting services, multimedia database systems, and spatial database and location based services (LBS). Besides a wide range of search functionalities including text mining, multimedia search, spatial search monitoring system based on search functions, thematic maps are an important approach to monitoring heritage sites to support sustainable development of tourism.

3.1 Concepts

The key concepts are to apply a community hosting service with GIS focusing on thematic maps to provide users an open, reliable, scalable and portable community information system for sustainable-developing tourism. In computer science, on the one hand, Openness assures the further system development in a sustainable way. On the other hand, it means the interoperability of system or system components to exchange data with other components or systems, or to perform in multiple environments ranging from workstations to cell phones. A reliable system aims at reliable system quality and information quality as well. The information should be neutral without any malicious manipulations. A scalable system is a system that does not show negative effects, when its size or complexity grows greater. So scalability guarantees that the system can be used by many user communities as well as by a single user. The portable criteria require the system to be able to run on different devices from PC to cell phones. The three main technologies are expected to have a major impact as follows.

Community hosting services

A derived concept is community of practice (CoP) that has been widely used as a fundamental for information systems.

Communities of practice are groups of people who share a concern or a passion for something they do and who interact regularly to learn how to do it better (Wenger 1998).

We have developed a novel community hosting service ATLAS (cf. figure 1). The Architecture for Transcription, Localization, and Addressing Systems (ATLAS) is derived from the idea of transcriptivity as a design principle for computer science (Jarke & Klamma 2005, Jäger 2002). The community development process is based on the idea of combining usability and sociability (Preece 2000) by constantly assessing and supporting community needs.

ATLAS aims at hosting and providing services to community information systems, so that tourism community building tasks are simplified. A wide range of interdisciplinary traveller communities can be hosted and involved into heritage sites monitoring.

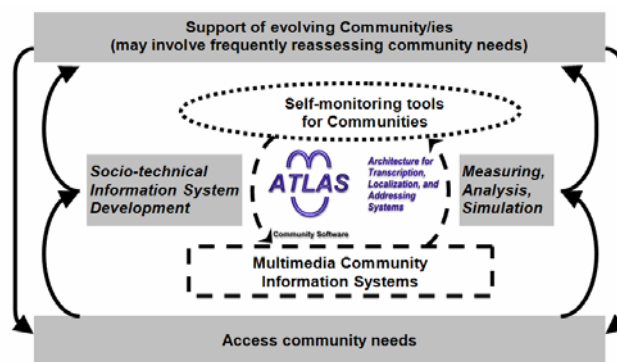


Fig. 1. Self-reflexive Information System Architecture ATLAS

On the database/repository level we use and develop further scalable state-of-the-art database technologies for the management of mass data and metadata for community systems. On the middleware level we realise scalable community hosting services like single-login, variable and fine-granular access control, mobility support, multimedia management, multimedia annotation, interoperable search and retrieval, matching, data/text/media mining etc.

Thematic maps approach

Map themes, especially the temporal themes are the key points to realize the heritage site monitoring. When the travellers can get an overview of the site information to different time point and periods, the conservation awareness can be accordingly raised to a higher level.

Much research has used thematic maps for sustainable development of tourism (Hama et al. 2005, Bahaire & Elliott-White 1999). However, the temporal issue is often missing. We propose 5 principles to choose map themes in order to promote tourism together with heritage sites conservation (cf. Figure 2). The selection of themes should be community oriented, should have an interdisciplinary view, should be based on multimedia, and follows spatial as well as temporal context. In addition, the themes have to be personal or community experience based and to be of narrative. Themes that meet the requirements can be applied to realize the heritage sites monitoring while developing tourism in a sustainable way.

Data and system interoperability

Interoperability can be enhanced by OGC specifications which are worldwide acknowledged GIS standards (Reed 2005). Furthermore the standards for multimedia and heritage sites are main aspects to support the GIS standards. Multimedia metadata standards enhance search and retrieval of multimedia data. The eminent multimedia metadata standards include MPEG-7 (Kosch 2003) and MPEG-21 (Bormans & Hill 2002) etc. In addition, many organisations for cultural information have specified metadata standards to describe cultural objects such as historic buildings, archaeological sites and museum objects appropriately, e.g. CIDOC⁴ and MIDAS (FISH 2003).

With a crosswalk among the standards, the condition, description and other characteristics of heritage sites can be easily converted to another metadata standard, which enables the sites monitoring on a common ground.

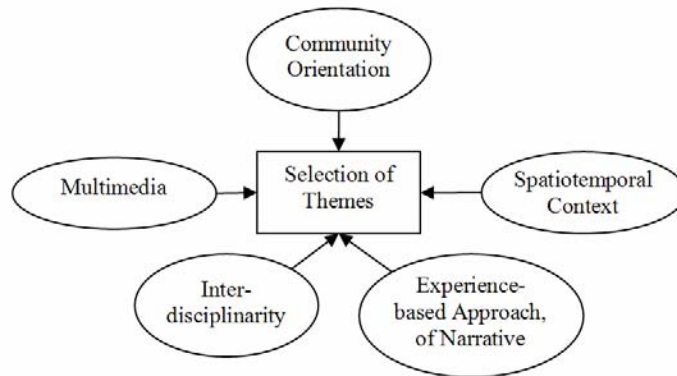


Fig. 2. Principles for Selection of Themes (Adapted from Hama et al. 2005)

With these technologies e-tourism community information systems for heritage sites monitoring can fulfil following major tasks:

Usually, history or culture awareness is prone to be neglected. In fact, travel has become a concept more than spatial movements on the earth. A travel in time is getting more and more interesting. Via such an e-tourism system, a travel site can be visualized in different time periods with timely cultural and historical information. With different temporal map themes travellers can be aware of the development of the site along the time axis. The heritage conservation awareness can be invoked.

In the systems arbitrary travel information can be well managed. Tourism information can be published in a global scale via the Internet. And the interoperability among distributed heterogeneous information resources can be enhanced for information integration with multimedia and database technologies. Moreover, travel experience information can be maintained and organized.

Diverse user communities ranging from travellers to monuments conservators are about to be networked via community information systems with the community hosting service, aiming at information and experiences sharing.

⁴ The CIDOC Conceptual Reference Model (CRM) homepage: <http://cidoc.ics.forth.gr/>

Location awareness can be granted to travellers by means of modern GIS technologies like GPS and Location Based Service (LBS) together with mobile technologies. Cultural information can be delivered to users on sites in real time.

3.2 Prototyping

We are still in the design phase of the system. We employ ACIS to prove our concepts. The main part of the user interfaces is depicted in Figure 3. Before tourists start a cultural tour in the World Heritage Site Bamiyan Valley in the central Afghanistan, they can use the interface on the top right to get maps with query results that are displayed in the maps as well as in a table with text and multimedia information. Thus, travellers can get cultural, spatial, and multimedia information of a visiting site and carry out various spatial queries like getting the nearest neighbourhoods, within a definite distance etc.

The monitoring functionality can be realized by building diverse map themes. Map themes in community information systems for e-tourism with heritage site monitoring can be grouped to different categories of the entities in the data model. For example, there are themes of sites of diverse spatial search and sites of periods, if temporal information is available. Through representing these themes in maps, travellers are aware of the evolvement of a site in different ages. Monuments conservators are aware of the impact raised by tourism development and so on.

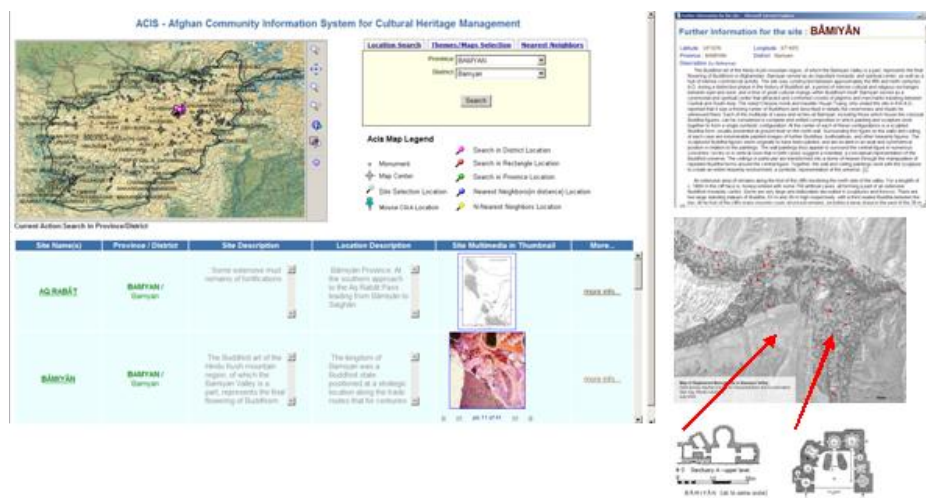


Fig. 3. left: the main user interface with boundary comparison; top right: site information window; bottom right: map of Bamiyan valley with location marks of the 26 monuments (site plans can be included and linked if available).

In addition, some temporal comparison can be done among boundaries, multimedia files, and social aspects. Different themes can be presented to the users, when they query the information. For example, in the main user interface two country bounda-

ries are displayed, as the users check the related themes. Those two country boundaries come from Afghanistan Information Management Service⁵ and from Perry-Castaneda Library Map Collection of the University of Texas at Austin⁶ as of 2003. The examples of themes concerned with the aforementioned principles are listed in Table 1.

In Bamiyan, 26 monuments and sites are surveyed by researchers at the Department of Urban History of RWTH Aachen University in the summer of 2005. Compared to the information extracted from some written documents, information about those sites is updated. The new survey comprises information (Name of surveyor, Date) and further:

- Basic Information: Village/settlement, House no., Coordinates, House name, Function, Inhabited/Abandoned, Type, Access, Owner
- Characteristics of Site: Description, Description of context, Component/Material (Wall, Surfaces int./ext., Roof, Doors/Windows, Decoration), Condition
- History: Original function, Date of construction, Transformations, Anecdotal accounts, Published accounts, Previous surveys
- Relevance: historical, urban, architectural, technical
- Photo Documentation: Film, Photo no., sketch and photo position plan (Date, Surveyor, Settlement/village, Monument, and Film No.)

All of the 26 monuments are located on the map of Bamiyan at a large scale. When the related site plans are available, they can be linked to the Bamiyan Valley map. The fieldwork can be regarded as personal experience and can be rendered as a map theme with a narration.

Table 1. Map themes select by the principles

Principles	Map themes	Map themes with temporal info
Spatial	-Sites of administrative divisions -Sites within neighbourhoods etc.	-A site in different periods -Sites of the same periods etc.
Multimedia	-Media collections -Media of a certain type etc.	-Characteristics of a site in the history -Media of a site in different periods etc.
Experience	-Fieldworks -Tour routes -Personal collections etc.	-Fieldworks along the timeline -Travels etc.
Community	-The distribution of fieldworkers -The distribution of communities etc.	-Community calendar with location info -Travellers statistics etc.

4 Conclusion and future work

Although many information systems have been designed and implemented for e-tourism, cultural heritage sites often encounter risks that arise with tourism develop-

⁵ <http://www.aims.org.af/>

⁶ <http://www.lib.utexas.edu/maps/>

ment. We have proposed to build up a community information system for e-tourism with heritage monitoring. The goal is to support long-lasting sustainable development of the cultural tourism.

Our current work is still at the beginning stage. It is mainly based on the community information system for heritage site monitoring with focuses on community building and thematic approaches. The system requirements in the context of e-tourism have been surveyed. Idea of community hosting service, thematic maps and interoperability are key concepts to realise a community information system which provides travellers cultural multimedia information of a heritage site at a different point of time. A prototype is implemented to present several themes of the World Cultural Heritage Bamiyan Valley.

Besides the system development, the digital content plays an important role. A lot of work needs to be done to collect abundant digital resources and to migrate distributed resources into the new systems.

Thus, the research in this field is full of challenges. The outcomes would give a good example for the application of community concepts, multimedia metadata technologies and GIS in community information systems for e-tourism with sites monitoring. On a global scale these systems need to be compatible to international standards. While there are many standards applicable from the aforementioned areas like multimedia, GIS, and cultural heritage, the interoperability of these standards in scaling e-tourism systems or the development of open, international standards for e-tourism are open issues. Seamless integration between cultural heritage community systems, e-tourism systems and personal or community webs will be a major research challenge for many years.

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