VIRTUAL CAMPFIRE - CULTURAL HERITAGE MANAGEMENT AND PRESENTATION ON MOBILE DEVICES BASED ON INTEROPERABLE CROSS PLATFORM MPEG-7 MULTIMEDIA WEB SERVICES

R. Klamma[a]*, G. Toubekis[b], Y. Cao[a], D. Renzel[a], M. Jarke[a], M. Jansen[b]

[a]RWTH Aachen University, Information Systems & Database Technology, Ahornstr. 55, 52056 Aachen, Germany
(klamma, cao, renzel, jarke)@dbis.rwth-aachen.de
[b]RWTH Aachen University, Aachen Center for Documentation and Conservation, Templergraben 49, 52056 Aachen, Germany
(toubekis, jansen)@sbg.arch.rwth-aachen.de

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ABSTRACT:

Smart devices, application mobility, portability, service reliability and data interoperability raise much attention of the international cultural heritage community recently. Web 2.0 and social software turn users into prosumers which results in a great amount of multimedia content and metadata for the community on the one hand. On the other hand, it asks for new concepts to develop better mobile applications for cultural heritage data management. We designed and realized a cross media and cross community framework called *Virtual Campfire* within the German excellence research cluster *UMIC (Ultra High Speed Mobile Information and Communication)*. It consists of a set of services providing diverse mobile communities MPEG-7 based multimedia content processing services to use heterogeneous data sources. The services include real-time multimedia creation and processing, collaborative semantic enrichment of multimedia content and collaborative storytelling on different mobile devices. Based on such a service oriented architecture Virtual Campfire enables the flexible realization of community information systems with diverse and complex multimedia content such as videos, images and 3D data. The Virtual Campfire prototype realized on the iPhone and Nokia smart phones is able to support documentation activities on-site in cultural heritage fieldwork.

1 MOBILE WEB 2.0 IN CULTURAL HERITAGE MANAGEMENT

Technological development in recent years is increasingly driven by issues of ubiquity and interoperability of network technologies, applications, services and devices. Meanwhile, social software turns users into *prosumers* (i.e. consumers and producers in parallel) anywhere at any time. Due to the Web 2.0 and social software a vast amount of multimedia content is generated. In order to manage these abundant amounts of content it is unevitable to make use of efficient retrieval techniques based on semantic metadata. For (meta)data management in cultural heritage documentation there exists an observable gap between domain specific metadata standards for cultural heritage with limited relation to multimedia description or processing standards such as CIDOC CRM (ISO, 2006) etc. and emerging multimedia description standards such as TV Anytime (EBU, 2009) and MPEG-7 (ISO, 2004) which are not bound to specific application domains. Former attempts (Hunter, 2000, Hunter, 2001, Hunter, 2002, Doerr et al., 2003) to close this gap have been biased by socio-technical issues in research and development processes for information systems in cultural heritage management and by the speed of technical innovations, which lead to the Web 2.0 and ubiquitous computing. Both technical trends are merging into the new mobile Web 2.0. Especially fieldwork in the domain of archeology and cultural heritage preservation has become a major application area for the incorporation of mobile devices in documentation tasks.

The growing gap between technical and domain-specific semantic metadata was not only observed in cultural heritage management, but also in other domains (Gladney, 2007, Zhao and Yang, 2005). One path to follow is to create multimedia semantics by gradually enriching technical multimedia metadata with general as well as domain-specific context information. Thereby, context information in multimedia has not only incorporate the widely known spatiotemporal context information in form of GPS coordinates and time/date information but also technical information on devices and software used as well as social context information, e.g. about the creator, his professional status and his professional networks. Here, a second viewpoint comes into play.

Nowadays it is mission-critical not only to communicate within a professional community of a certain expert level but also with non-experts. Communication is necessary to raise awareness for cultural heritage management tasks and to incorporate the media production of non-experts into the multimedia discourses of a professional community.

Based on this socio-technical approach on mobile Web 2.0 in cultural heritage management the following research questions arise. How can we facilitate a complex professional collaboration with the help of mobile technology and multimedia in semi-public discourses about cultural heritage management? How can we bring together domain experts and non-experts in a community of practice (Wenger et al., 2002) with different requirements concerning security, multimedia processing and domain knowledge?

Based on the experiences drawn from intercultural and intergenerational learning explored in the *Bamiyan Valley Development* case study in section 2 we present in this paper the comprehensive Virtual Campfire scenario of complex collaboration in a mobile Web 2.0 setting in section 3. Details on the web-based and service oriented technical infrastructure are revealed in Section 4. In section 5 we discuss our experiences with the approach so far and evaluate the opportunities and challenges. We conclude and give an outlook to further work in the last section.

2 THE BAMIYAN VALLEY DEVELOPMENT COMMUNITY CASE

Before we propose our scenario of applying mobile multimedia services and technologies within cultural heritage communities, we observe individual and collaborative knowledge work in communities of practice on the Bamiyan Development Community, which we have hosted since 2005. Operating a community portal is an effective way for long-term digital information preservation, while community activities can monitor and guarantee secure accessibility of digital cultural heritage (Gladney, 2007).

The common interest of the Bamiyan Development Community is the preservation and development of the Bamiyan Valley in the Islamic Republic of Afghanistan. The valley is located in the heart of the Hindu Kush Mountains and is perhaps best known for the tragic demolition of the two Giant Buddha statues by Taliban extremists in March 2001. The Bamiyan Valley with its archaeological remains has been listed among UNESCO's World Heritage Sites since 2003. Its long term preservation can have a major impact on sustainable tourism and economic development for the entire region. But the destruction of the country's cultural heritage by the Taliban went much further. The destroyed Buddha statues are only the tip of the iceberg. More than 20 years of military conflicts in Afghanistan caused the destruction of national science structures and historic archives. By moving large parts of the paper based archives and cultural collections out of the country, scientists and professionals fleeing from the war scattered expertise and knowledge all over the world. The generation of scientists and professionals trained and working before the war is now reaching retirement age.

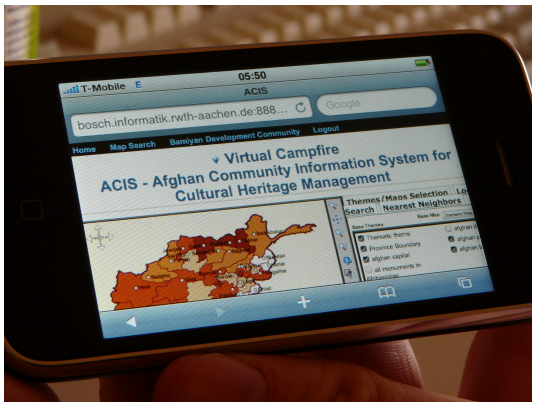

Figure 1: ACIS in the Bamiyan Development Community Portal

Since almost no preservation work was possible for about three decades in Afghanistan during the periods of conflicts, the problems to manage today are manifold. Currently, many Afghan scientists and professionals trained in other countries return to their homeland in order to help rebuild academic structures and management infrastructure in the cultural heritage sector. While the elder scientists and professionals have personal knowledge about the condition and precise location of sites and monuments from before the war, young scientists and professionals use modern information technology and new scientific methods to augment their knowledge.

In order to bring both generations together, they need a channel to communicate and cooperate. We have created a community portal at *http://www.bamiyan-development.org* in order to initiate the international and intergenerational cooperation in this matter. The spatiotemporal multimedia database *ACIS (Afghan Community Information System)* for cultural heritage management is fully integrated into the portal (cf. Figure 1). ACIS has initially been designed as host for data of the national inventory on sites and monuments of Afghanistan (Klamma et al., 2005). With the integration into the community portal collaborative production and dissemination of various types of media (photos, videos, drawings) can be realized with the help of the ACIS community members. Individual community members have contributed trailer videos to support the community idea and attract further interest of the public. Interviews with heritage experts on the preservation of Bamiyan are shared via the portal.

An example may illustrate the professional work in the community. Various researchers, engineers and other professionals record the condition of the niches of the destroyed Buddha figures in the Bamiyan valley during a campaign. The applied measurement technologies cover high-end 3D laser scanning and stereometry as well as common devices such as GPS enabled camera systems. All material including digital images with additional stored GPS coordinates can be requested by a mobile multimedia database on a laptop of a researcher.

The international community can retrieve and access materials with the help of the community information system presented later. Members can collaboratively tag and even reuse media in other documents by using recombination or embedding techniques. However, media are only released to the public after a careful approval by community experts. After successful approval, they are ready for being shared with the public using tools such as flickr or YouTube in order to raise interest for the restoration work in the Bamiyan valley.

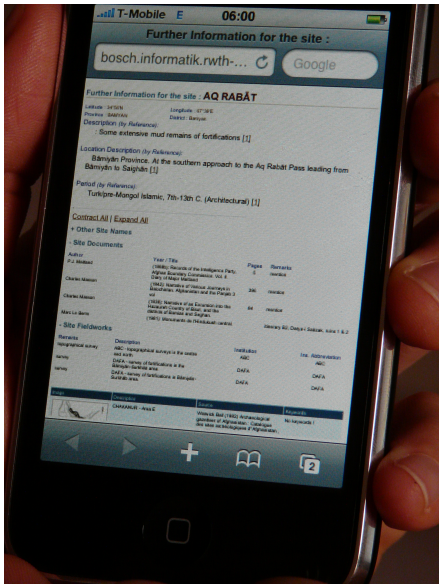

Figure 2: Detailed ACIS view on a cultural heritage site

We can draw the following conclusions from operating the community portal. Non-experts are interested, but need a clear agenda for participation (draw also on experiences from Wikipedia). Experts are concerned about quality and accuracy of the collected material to be made available following the rules of a distinguished security. Media are only retrieved and presented to users with sufficient access rights. Lessons learned are listed in Figure 3 in form of a SWOT analysis.

3 VIRTUAL CAMPFIRE

The Virtual Campfire scenario has been established in the German excellence cluster UMIC (Ultra High Speed Mobile Information

Strengths	Weakness
• built-in multi language functionality and assistive technologies • personal user and forum areas • multimedia enabled • user identity and security rights management • ACIS database and external free multimedia resources(youTube, flickr) integration	• content production mainly in English • thematic focus is very narrow • dependency on community facilitator • unstable socio-political environment affects active user participation • inter-generational learning does not take place in the Portal itself but on the ground locally in Afghanistan
Opportunities	**Threats**
• sharing of practise experience • sense of belonging • access to specialized knowledge in the expert forum • synergy through integration of ministries, aid agencies, policy makers and local organisation websites	• low participation by experts • low participation by non-experts • lack of funding and institutional support • lack of up-to-date content • lack of relevance (focus on Bamiyan too narrow)

Figure 3: SWOT Analysis of Bamiyan Community Portal

and Communication) to demonstrate future mobile social software applications with real-time multimedia processing and semantic enrichment of multimedia materials by complex collaboration of user communities (Cao et al., 2009, Cao et al., 2008b). Virtual Campfire intends to provide cross media and cross community support for the management of multimedia contents. It serves as a framework for various services enabling communities to share knowledge about multimedia contents. The idea is to facilitate inter-generational knowledge exchange by means of a virtual gathering for a certain event or a topic, e.g. a heritage conservation campaign, using storytelling methods to communicate memory based episodic knowledge and experience (Tulving, 1972) via enrichment of document based semantic knowledge. Narration and storytelling using multimedia is one of the main means to create, share and re-contextualize knowledge. Within UMIC this scenario has been extended to work on different mobile devices.

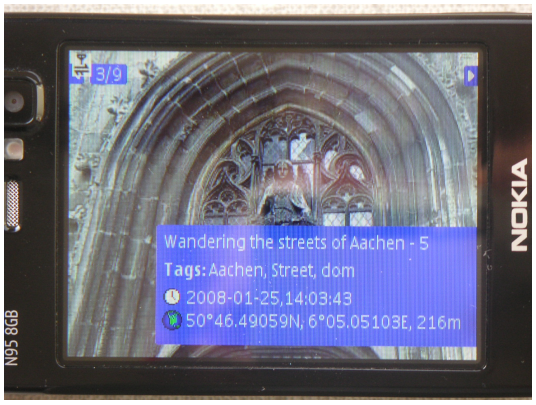

Figure 4: The mobile media viewer (Nokia N95 version)

3.1 Multimedia Creation & Sharing

In the Virtual Campfire scenario we provide tools to create and enrich arbitrary multimedia material with respective metadata on various mobile communication devices such as the Nokia N95 (Fig. 4) or the Apple iPhone (Fig. 5). Technical and contextual semantic metadata provided by the mobile device (device type, media file size, video codec, GPS based spatiotemporal information, etc.) are automatically merged with manual annotations by the user such as freetext descriptions, keyword tags and additional semantic basetype information on persons, depicted items or places and associated ideas (agent/object/place/concept in MPEG-7 terminology) occurring in the media. Special attention has to be paid to the management of access rights to multimedia content in order to guarantee data security. For every service usage involving

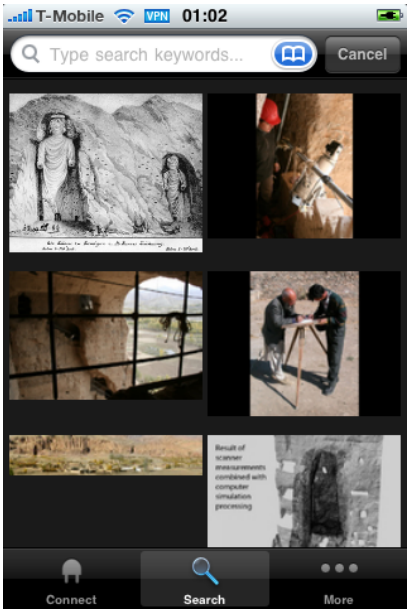

Figure 5: The mobile media viewer (iPhone version)

access to individual media our system allows the definition and enforcement of fine-grained access rights for users, groups or whole group hierarchies. If desired, service usage can be monitored and traced by communities and its users.

3.2 Multimedia Search & Retrieval

In our scenario we offer different multimedia search and retrieval methods. The first method is based on plain keyword tags nowadays used in most Web 2.0 applications. Users can explore the tag space with the help of a graph-based visualization of the tag co-occurrence network. Thereby, tags are visualized as nodes. If two tags were assigned to the same medium, their nodes are connected by an edge. Lately, we have implemented semantic context-aware queries based on SPARQL (Cao et al., 2008b, Cao et al., 2009). Multimedia search results are presented as a thumbnail gallery, where users can either refine their search or retrieve selected media and metadata.

3.3 Re-contextualization in Complex Collaboration

In Virtual Campfire we offer a number of services for the re-contextualization of media. The first service is a combined spatiotemporal multimedia database application we have explore further in our Bamiyan Valley case study in Section 2. The second service is a mobile media viewer. The third one is a collaborative storytelling service, a web application combining a classic multimedia production environment for non-linear stories with typical Web 2.0 features for user generated content. Users can collaboratively author non-linear multimedia stories following the MOD paradigm (Sharda, 2005), thereby remixing various multimedia elements. The service was combined with a game engine to create training sessions for local professionals in Bamiyan (Spaniol et al., 2008).

4 MPEG-7 ENABLED WEB SERVICES

The Multimedia Content Description Interface (MPEG-7) (Manjunath et al., 2002, ISO, 2004) defined by the Motion Pictures Expert Group (MPEG) aims at providing a rich set of metadata descriptions for complex multimedia knowledge management in order to

enhance search and retrieval of media content. MPEG-7 defines a multimedia library of methods and tools in a flexible and extensible framework to describe multimedia content. Among them, the MPEG-7 Multimedia Description Schemes (MDS) (ISO, 2003), in particular visual and audio description schemes are interesting for cultural heritage management. In addition, the MDS provides a standardized set of descriptors for multimedia semantics. Interoperability and information exchange between MPEG-7 and other standards can be achieved easily. A mapping between MPEG-7 and Dublin Core has been proposed in (Hunter, 2000) and realized in (Spaniol and Klamma, 2005).

We use a combination of multimedia content and semantic descriptions to store specific information for cultural heritage management following the MPEG-7 standard. MPEG-7 semantic descriptions are specified as semantic networks consisting of seven base types of *semantic tags*(*Agent*, *Object*, *Place*, *Time*, *Event*, *Concept* and *State*) as well as relationships between them (e.g. *timeOf*, *locationOf*, *agentOf*, *depictedBy*, *etc.*). Current tagging systems allow users to assign tags to media without reflecting any community membership thus creating flat folksonomies (Delicio.us, 2009, flickr, 2009, Last.fm, 2009) in the Web 2.0 terminology. Every user has access to all tags assigned by all users, possibly within the contexts of different communities. However it is not possible to specify in which community context a tag has been assigned. This extended notion implies that tag accessibility has to be controlled by the system. We call such a community-aware semantically enriched collection a *commsonomy* (Klamma et al., 2007).

A user should only be able to access a tag if he is member of the community in whose context the tag has been assigned. Community aware semantic enrichment is now realized by controlling tag visibility. Whenever a community member intends to tag a multimedia content item an MPEG-7 semantic description service is used to check, if the set of semantic tags he wants to assign exists already in the system. In case not he can use the semantic service to create the missing semantic basetype descriptions. In the next step the respective semantic basetype references are assigned to the multimedia content description in a given community context.

All of the above mentioned services were designed and realized based on our *Lightweight Application Server (LAS)* (Spaniol et al., 2006) (Figure 6) providing mobile communities a set of core and multimedia content processing services to connect to heterogeneous data sources. The Java-based LAS API based can be used to extend the server functionality by adding three basic element types: *LAS Connectors* realize client-server communication using a particular protocol. Connectors for HTTP, SOAP and lately XMPP have been realized. *LAS Components* are internal elements encapsulating functionality for common tasks such as database access to be shared among services. *LAS Services* define the actual functionality offered to clients including the possibility to create service mash-ups. A service defines a set of methods remotely invokable via one of the connectors. LAS provides a set of built-in core services for the management of sessions, users, hierarchically organized groups, roles and fine-grained access rights to arbitrary security objects.

All interaction between the server and the clients can be monitored using MobSOS (Renzel et al., 2008), a community-oriented traceability tool for web service invocation. The base requirements for MPEG-7 based multimedia services on the LAS server are as follows. There should not be one monolithic MPEG-7 service but a set of services each of them offering functionality for a given part of the MPEG-7 standard (e.g. multimedia content, semantics, collections, classification schemes, etc.). Since MPEG-7 is

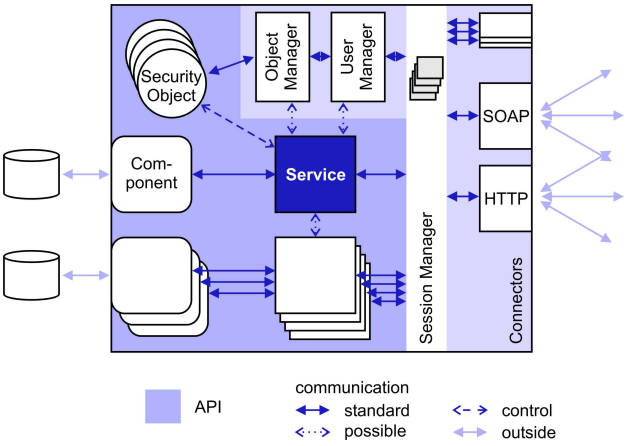

Figure 6: Lightweight Application Server - LAS

XML-based, the basic functionality of an MPEG-7 service is the creation, retrieval, update and deletion of persistent XML documents guaranteeing validity against the MPEG-7 XML Schema at all times. Documents are stored in native XML databases supporting common XML retrieval and manipulation operations (Berglund et al., 2007, Boag et al., 2007). These MPEG-7 based multimedia services are the foundation for the implementation of mobile applications as described in section 3 including multimedia up/download, annotation, tagging and non-linear digital storytelling.

5 EXPERIENCES, OPPORTUNITIES, AND CHALLENGES

Virtual Campfire offers an open architecture designed to flexibly create information systems in versatile application domains. It combines advanced multimedia standards and database technologies that support the creation of mobile information systems on different devices. Its applicability in various scenarios has been tested, e.g. in ACIS and iNMV. By using these services and components via standard communication protocols, a large variety of (mobile) interfaces as well as rapid design and prototyping of multimedia based mobile software can be facilitated. In general, development for mobile devices is a rather complex endeavor for the following reasons.

First, the number of different browser versions on mobile devices is a magnitude of order higher than on desktop computers with varying implemented functionalities. Developers have to concentrate on a handful of browsers which may be not that widely distributed. Second, development kits for mobile devices require a different development spirit. Given the mobile device hardware restrictions they exhibit limitations e.g. in terms of memory usage, power consumption or display size in comparison to desktop developer kits. On the other hand they offer lots of new opportunities regarding the mobility factor and the support for a wide variety of mobile sensors such as GPS receivers, cameras, microphones or even RFID tag/reader combinations. Third, testing under realistic conditions is a costly and time consuming undertaking.

Innovation in mobile technologies is thus not only an enabler but also a threat to software development teams with limited resources. Ultimately, we have to seek constantly for new resources and cooperation opportunities to stand the speed of new mobile products pushed into the market. Middleware, like the one developed with our MPEG-7 cross-platform services turned out to be very helpful and productivity was increased by several factors. The separation

of concerns helps developers to focus on different tasks. Service developers concentrate on the development and orchestration of services within the middleware while application developers and interface designers concentrate on look & feel of specific devices and interfacing the services in a user oriented way. In workshops both developers grouped to exchange experiences and ideas. Developers are supported also by hardware and system specialists with distinguished knowledge about servers, databases and load balancing.

The MPEG group has recognized lately the importance of middleware for the propagation of their content-related standards ranging from MPEG-4 to MPEG-21. The new middleware initiative of the group the *MPEG eXtensible Middleware Vision (MXM)* (ISO, 2008) is the first attempt to create middleware services with a similar focus like ours. Most helpful was the introduction of the Virtual Campfire scenario. While the LAS environment was developed in a couple of R&D projects in advance, the scenario was the answer to an everlasting question, how to give a non-technical context to developers and professionals using the services. The storytelling approach was an innovative and differentiating approach to service-oriented development and to mobile service consumption. The metaphor of a Virtual Campfire incorporated best our idea about collaboration, knowledge sharing and inter-generational learning. The usage of services and content production is constantly monitored and subject for other ongoing research projects. One example shows the innovation in aspects of knowledge management in our approach. In the evaluation of the storytelling approach we have considered the expert value of a community. Figure 7 is showing the distribution of expert knowledge according to the used tags of the experts using our self-developed expert finding algorithm (Cao et al., 2008a).

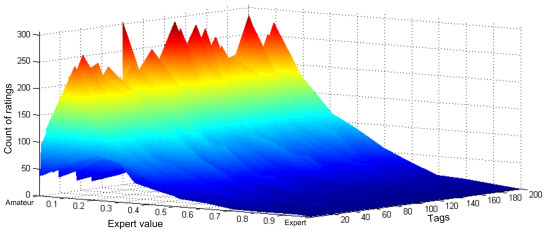

Figure 7: Distribution of expert knowledge according to keywords

We have used randomly generated data sets (normal distribution). The expected value for the keywords is around 0.3, i.e. the knowledge of normal members about a topic is relatively low compared to the knowledge of the best expert. Observing such values over time will indicate how storytelling can change the common knowledge level in a storytelling community for good or for bad.

To strengthen our competences and to promote the idea we created an international workshop series called *Storytelling and Educational Gaming (STEG)*. One of the first outcomes is a joint project between the *Harokopio University* in Athens/Greece and us in the IKYDA program. The project is dedicated to non-linear storytelling in museum padagogy for the former battleship *G. Averoff* now transformed to a naval museum. Two further interdisciplinary cultural heritage management scenarios will be presented as future work in the upcoming section.

6 CONCLUSIONS AND FUTURE WORK

Coming from a socio-technical information systems development perspective we asked two questions in this paper. First we asked how to incorporate mobile technologies in a Web 2.0 manner in cultural heritage management activities. Second we asked how to integrate also non-experts to professional discourses about multimedia in cultural heritage management. For both questions, we presented the Virtual Campfire scenario s a possible first answer.

This scenario works with mobile technologies for an ongoing semantic enrichment of multimedia materials in professional discourses by: a) multimedia annotation and sharing; b) semantically enriched search and retrieval; and c) re-contextualization of multimedia artefacts in knowledge intensive collaboration processes like storytelling.

We have demonstrated how to integrate such a scenario in a concrete community like we did with the Bamiyan Valley Development community. This international group feels responsible for the sustainable development of the Bamiyan Valley in Afghanistan. Among other tools, the community makes use of a community portal where we integrated the various service based tools. We gave some details about the technical realization of the scenario using an MPEG-7 cross-platform multimedia middleware. More important, we discussed our experiences in developing services for mobile devices using the middleware and show the current limitations and our actions to overcome them.

For future interdisciplinary collaborative research and development work in the field of cultural heritage management within UMIC we have developed two new scenarios. The first scenario will explore the usage of semantically enriched videos in heritage documentation and the second is about incorporating cultural heritage preservation in results derived from remote sensing data for planning purposes in urban or regional development. Both scenarios are described very shortly in the following.

The video 3D scenario: Limited available ressources for documentation activities at cultural heritage sites require quicker, easier and cheaper aquisition and processing methods. Further integration of device functionalities (GPS, digital documentation) is underway and automatization of documentation processes such as automated extraction of measurement data and 3D information can be realized already using cost efficient standard video documentation hardware or even advanced mobile phone cameras. Thus computational efforts can be focussed to create meaningful semantically enriched information from extracted 3D information and incorporated into new 3D environment for storytelling or game-like 3D worlds such as Second Life.

The remote sensing scenario: Remote sensing data from high-resolution satellites supported by airborne drones used to identify cultural site information in remote areas becomes increasingly important in urban and regional planning processes. We plan to use the survey results from large heritage areas aquired by programmable un-manned helicopters equipped with video camera systems (so-called tiny helicopter cameras) and GPS receivers. This data collected on-site can also be combined with satellite data from other sources such as web based services. And this data can be incorporated into complex and collaborative planning processes for urban or regional planners, e.g. in cultural site management.

Both scenarios demonstrate the opportunities for fruitful cooperation between cultural heritage professionals, engineers and computer scientists in a highly interdisciplinary field. Currently, one of the most critical bottlenecks is the lack of high skilled human resources for the ever growing need of high quality digital documentation. It is indispensable to consider new educational programs in the future leading to an independent engineering degree in digital documentation for heritage preservation.

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