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EPOCH

Excellence in Processing Open Cultural Heritage

Network of Excellence

Information Society Technologies

D3.5: Progress and plans for Common Infrastructure (including NEWTONs)

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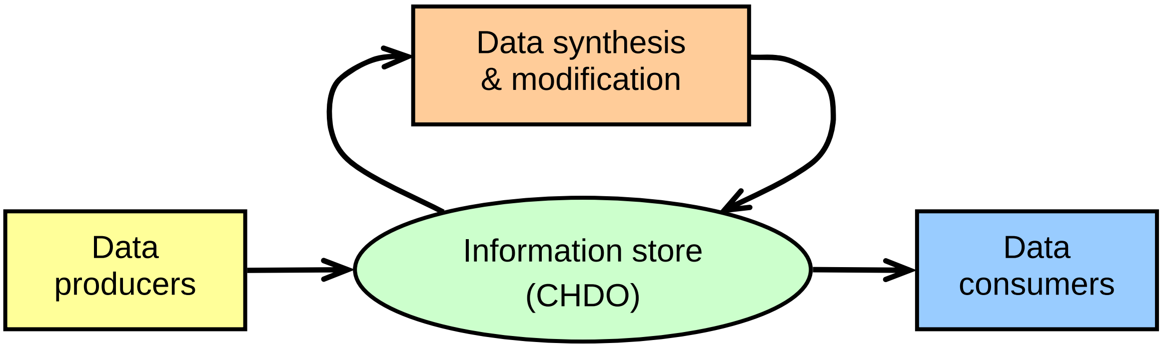
1 Common Infrastructure – an introduction

Deliverable D.3.3.2 explained why we switched from a monolithical pipeline view of cultural heritage processing to an information processing view for the Common Infrastructure Activity. This information processing is illustrated in the figure below: all the data is available in the information store and tools are generating/manipulating this data. In this view, a cultural heritage application is a set of tools, which are linked together by exchanging information.



In order to implement the cultural heritage applications, we first of all need a set of tools. Epoch tools are developed as part of Activity 3.2 as well as in Activity 3.3. An overview of these activities is given in respectively section 4 and section 3 of this deliverable.

The information store is the central element in the information processing view. Although it can be mapped to any real information storage, the information store does not actually define an implementation, but only a way to exchange data between tools. Probably a better name for it is a "*Cultural Heritage Data Object*" (CHDO). It is an agreed-upon way to keep all related cultural heritage data together for storage/exchange. Section 2 describes the requirements for such an object, as well as an implementation proposal which is still under discussion among the Epoch partners.

But before we can start defining the CHDO, the different ways to exchange data between tools must be explored. We use tool chains not only to test the interoperability of tools, but they also provide the basis for the definition (and the validation) of the data exchange requirements of the CHDO. Since most NEWTONs (Activity 3.2) target some cultural heritage application, they already constitute a first set of tool chains. Section 5 describes additional, even more ambitious tool chains, which combine NEWTONs with other tools from Activity 3.3. So, although interoperability issues are already to be confronted within individual NEWTONs, these additional planned tool chains are explicitly intended to transcend the boundaries between individual Technical Areas of the Common Infrastructure or individual NEWTONs.

The structure of this report is as follows. Section 2 elaborates the concept of the CHDO further, and describes measures to arrive at its detailed definition. Section 3 gives an overview of the past Common Infrastructure activities, with an emphasis on the additions generated during year 2. Section 4 does the same for the NEWTONs. Section 5 describes the tool chains.

2 Cultural Heritage Data Object

A "*Cultural Heritage Data Object*" (CHDO) is a data item, which keeps all related cultural heritage data together. An example of such a CHDO is a 3D model of an object. The CHDO stores not only the 3D model itself, but also the way to obtain it (original scan data, information about processing steps and their parameters). Furthermore other annotations (e.g. in CIDOC-CRM format), other metadata (e.g. intellectual property rights) and links to other objects and descriptions can be provided.

Of course, a CHDO can not hold all the cultural heritage data of one application. For instance, all information on an archaeological site, ranging from 3D models to annotations and para-data, is too extensive to store in one object. For practical reasons CHDOs must have a finer granularity. As long as proper linking tools are provided, this is not a real limitation.

Starting from an overview of the diversity of cultural heritage data in section 2.1, a proposal for a CHDO is given in section 2.2. Finally section 2.3 describes the Epoch activities to support the definition and standardization of such a CHDO.

2.1 The diversity of cultural heritage data

In the different cultural heritage applications one finds quite a diversity of data characteristics. This is illustrated by the following three aspects: classes of typical usage, types of data, and the required accuracy. The CHDO should be able to accommodate all these different aspects.

Typical usage

The table at the next page summarizes the different requirements for the three different classes of usage:

1) preservation,
2) exchange, and
3) presentation of the data.

An important aspect of cultural heritage data is its sustainability, but this is only important for preservation data, i.e., data which should be preserved for at least some decades. The life span of exchange data is much smaller and its format is more determined by the properties of the tools which are exchanging data. On the other hand, the life span of display or presentation data solely depends on the presentation application. Its storage format must be optimally tuned to the (speed) requirements of the application. Typical presentation standards, such as SMIL, are not very suited for preservation purposes.

	Preservation	*Exchange*	*Presentation*
Sustainability	important	less relevant	irrelevant
Standards used	few non-proprietary	few	application driven
Standard extensions	avoid	allow	allow
Compactness	desirable	desirable	irrelevant
Fast running	irrelevant	less relevant	important
Fast development	irrelevant	less relevant	important
Wide use	irrelevant	desirable	desirable

The preservation format is usually considered to be the master format. This means that converters must be available to transform the preservation format into the exchange and the presentation format. Therefore, reusing the preservation format as exchange and/or presentation format reduces the conversion effort. Furthermore, one has to be aware of the fact that every conversion may lose information and/or accuracy. This is one of the reasons to avoid in-place processing of the preserved data.

Data types

Cultural heritage data usually has a heterogeneous nature. The tools work on different types of recorded data (images, 3D models, GIS information, text notes …) as well as on different types of semantic data (meta-data and para-data, such as provenance, interpretation and other knowledge). For a peer review of the interpretation it is necessary to store all the information on the data processing steps, including programs and scripts used together with their parameters. Additionally, presentation applications often require user interaction, so they need to store animation and event processing.

A very important aspect of all these cultural heritage data is their relations, including the hierarchical aspects. Therefore the linking facilities must be rich enough to support all kinds of links, including links to a part of an object (e.g., the head of a 3D model of a statue).

Required accuracy

From the accuracy point of view, two different classes of data can be distinguished:

- *Recorded data* is recorded or generated data, which might be used later for analysis and interpretation. This data must be preserved with a maximal accuracy, i.e., the accuracy of the recording equipment.
- *Illustrations* (e.g. textures, movies, and sound) are only meant to look or feel or sound good. The accuracy is less important here as long as the perceptual quality is appropriate. This data can be preserved with a minimal accuracy corresponding to the required perceptual quality.

These classes have quite different requirements on the formats, e.g., on the allowed compression. Since recorded data must be kept at maximum resolution, compression of recorded data must be lossless. On the other hand, only the perceptual property of illustrations must be maintained so they can undergo a lossy compression.

2.2 Proposal for a CHDO format

Requirements for a CHDO

The CHDO is the basic unit for storing cultural heritage data. It should at least be defined for preservation purposes, although it can be useful for exchange of data also. It contains multiple types of data, ranging from recorded data to semantic information. It can be linked to other information (including other CHDOs and parts thereof) to form another CHDO at a higher hierarchical level.

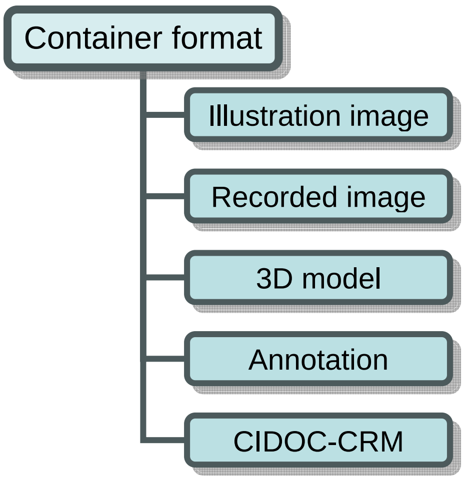
If it is used for data preservation, the CHDO should be write-once. This means one can add information and links to it, but never change or remove information. Modifying a preservation CHDO should not be done in-place; it must result in a new CHDO.

If it is used for data exchange, the CHDO must accommodate multiple standards or exchange formats. If tools support a common exchange format, it is very inefficient to convert it to another intermediate format just for the sake of having only one exchange standard. Of course, we have to make guidelines to reduce the number of exchange formats to a strict minimum. As the former president of IBM once said: “I love standards; there are so many to choose from”.

Structure of the CHDO

There are three ways to implement a CHDO:

- One can select one data type as the primary type, select a standard for it and extend the standard to accommodate other types of information. Let’s call this the “*primary type implementation*”. An example would be to choose 3D as the main data type, select X3D as the corresponding standard and extend X3D with additional fields to store other data, such as CIDOC-CRM data.
- One can choose an appropriate standard for each type of data and provide linking information between the elements. A CHDO element is a part of the CHDO data, which has a certain data type. The CHDO becomes a collection of loosely coupled information and the CHDO coherence is solely defined by the linking information, distributed over the elements. Let’s call this the “*juxtaposition implementation*”.
- One can choose an appropriate standard for each type of data and provide a tight coupling between the elements by using a container format. The CHDO is the container together with its elements. The container format contains all top level CHDO information as well as intra-CHDO linking information. Let’s call this the “*container implementation*”. The figure on the right illustrates the concept: each subtype has its own format and elements use the standard designed for them; the container holds the relations and all data not specific to one element. Note that this is only an illustration of the concept: not all types are present and elements may be used more than once (e.g., more than one 3D model).



After an internal discussion via mailing lists and at WP3 management meetings, we have come to the conclusion that the container implementation seems the most promising candidate for a CHDO implementation.

The main disadvantage of the primary type implementation is that it abuses the primary type standard (X3D in the example above). It relies on the fact that this standard allows standard extensions (which is the case for X3D). The problem with extensions is that they are not part of the standard, which makes them unusable for preserving information. One could get round this problem by providing all the necessary tools to handle the extensions (e.g. an Epoch specific viewer) oneself, but this is very costly and very hard to sustain in the long run. A better solution is to have your extensions incorporated into the official standards by having them accepted by the international standard committees. Not only is this a very time consuming effort but it will only work if cultural heritage is a substantial part of the target group of the standard: it may work for CIDOC-CRM but not for X3D. So the primary type implementation can not be used as a preservation format.

The juxtaposition implementation solves this problem by using a specific standard for each type of data. However it still provides no solution for the relations between CHDO elements. Since these links are completely external to the CHDO, we not only need a fixed standardized linking procedure but each CHDO element must also have a registered identifier in order to guarantee sustainable links. Therefore the juxtaposition implementation is less suited as a preservation format.

Almost all of these problems are solved by using a container implementation: only extra-CHDO links have to be taken care of. But the container implementation has an important additional advantage: it decouples the standardization aspects of all the different data types. With a container implementation we are not looking for a big global Common Infrastructure, but we divide it into elements, each with its own optimized implementation, and we look for a way to combine it into one CHDO ("divide et impera" as the Romans told us). This not only makes the problem manageable but it allows us to switch a standard implementation for one type without impact on the rest of the CHDO. This flexibility is certainly an advantage for exchange formats: we can replace JPEG by JPEG2000 without redefining the CHDO if all tools support it.

Which container format to use?

Several standards can be used to provide the container format. This ranges from quite simple and general standards, such as RDF, to more general standards, such as METS or MPEG-21. The advantage of the more complex ones is that they already have provisions for all kind of extra features, such as IPR-management, item adaptation and scripting. Since all of these standards are very general, we certainly need application specific profiles for cultural heritage applications.

The discussion on the preferred standard for the container format has just started. A Task Force has been set up in order to discuss the container related issues (cf. section 2.3). Final conclusions have not been reached yet, but a report containing an initial overview of candidates is under construction.

2.3 Activities towards a CHDO standard

After discussing the general concepts of a CHDO, we decided at the March 2006 management meeting to elaborate the container implementation. Because of the fruitful discussions on the 3D mailing list, we decided to extend this way of working to the other CHDO issues. Four discussion forums have been started:

- *3D standard* (moderator: Sven Havemann)
  One of the important cultural heritage data types is the 3D model. The complexity of 3D information and the lack of an outstanding candidate for a single standard warrant a separate discussion forum for this topic.
- *Non-3D multimedia standards* (moderator: Bert DeKnuydt)
  For other multimedia data, prominent standards are available, so discussions on these standards can be grouped in one forum. This forum will also cover all kinds of multi-dimensional data, such as GIS information and CAD-like data.
- *Semantic information and metadata* (suggested moderator: Tyler Bell)
  This forum covers all kinds of annotation formats, meta- and para-data. This also includes ontology standards such as CIDOC-CRM.
- *Container standards* (provisional moderator: Luc Van Eycken)
  This forum covers only the general issues of the CHDO. This includes the choice of a container standard as well as standards for linking information.

For each forum a moderator has been appointed to guarantee that the discussion stays focused to the forum topic. If the moderator notices that too differing topics are discussed in one forum, this forum will be split. Moderators are also responsible for detecting issues better to be handled by another Task Force, or where decisions by the own Task Force have an impact on the issues discussed by other Task Forces, so that they are informed or are put into the loop before final decisions can be taken.

Each of these forums will not only discuss the issues related to that topic, they will also make guidelines for selecting standards and eventually (if really needed) proposals for standard extensions. They will also define application specific profiles for cultural heritage applications, certainly at the container level but probably also at the type level.

At the EVA2006 General Assembly, all Epoch partners were invited to join the discussion forums. All partners will also receive an email invitation to join the discussions. This way we can obtain standard guidelines which are supported by the entire Epoch community.

3 Common Infrastructure Activities

Activities for the Common Infrastructure are organized according to 7 Technical Subareas, each with their own subarea leader. For ease of reference, we first list these subareas, and add their coordinators:

1) Multi-lingual and semantic data processing – *David Arnold*, Un. Brighton
2) Databases and knowledge management – *Achille Felicetti*, PIN Firenze
3) Mobile-wearable-ambient systems – *Nick Ryan*, Un. Kent
4) Recording and data representation aspects – *Paolo Cignoni*, CNR-Pisa
5) Visualisation and rendering – *Sven Haveman*, Un. Graz
6) Multi-modal interfaces – *Halina Gottlieb*, TII Stockholm
7) Virtual humans and other avatar technologies – *John Glauert* , Un. East Anglia

3.1 Multi-lingual and semantic data processing

Current status and Progress

In multilinguality we are complementing a partly home-made open domain multilingual lexicon by thesauri for Cultural Heritage (CH), as well as building a multilingual parser. Generation issues are being considered. In Semantic Data Processing (SDP), we are documenting the data used in a previous EPOCH showcase into CIDOC-CRM. A basic interface for Question and Answering is developed under the JENA framework and RDQL (RDF Data Query Language). Natural Language Processing (NLP) techniques have been applied and developed for integration into the general framework for assembly and presentation. This has meant the development of a multilingual NL front-end and speech generation. In SDP, last year was dedicated mainly to using tools, such as PROTÉGÉ, to manipulate and get familiar with CIDOC-CRM, for which we have selected a simple transport format (Resource Description Framework).

Interactions

There is a close interaction with two Newtons. With *CHARACTERISE* because we provide the NL interaction and experiment with interfacing issues with another 3D system. With *AMA* because of the automated tool developed for mapping CH data into CIDOC-CRM. In particular, discussions with regards to mappings other than from museum collections (e.g. cities and excavations) are currently taking place.

Highlights

On top of the core EPOCH conference VAST, we have attended to the 2nd European Workshop on the Integration of Knowledge, Semantics and Digital Media Technology (EWIMT 2005, 30 Nov – 1st Dec, London, UK) and presented our work at a Special Interest Group Workshop in Nürnberg, GER (14-15 Nov.).

3.2 Databases and knowledge management

Archaeological documentation management system

The system for archaeological documentation management based on eXist developed in year 1 has been fully implemented, with the goal of developing a product usable by heritage professionals with little technical skills in substitution of commercial products, fully XML-native and supporting Xquery. Features added in year 2 were aimed at facilitating such use and are the following:

- The system can accept a generic DTD/Schema and generate the database accordingly. Page layouts for standard data models are being created.
- The system implements a visual interface to build queries, aimed at non-technical users, based on any combination of conditions on "fields", i.e. XML elements.
- Fast search tool available.
- Data collections may be distributed. The locations of relevant collections (URI) are listed in a configuration file. (This feature is experimental.)
- Complete management/editing of documents (input, change, etc.) incorporated in the system (previously documents had to be edited using an XML editor and then uploaded in the database).
- Optional output of results as PDF documents.

Draft documentation of the system is also available. The creation of the tool is part of the strategy fostering mapping of archaeological documentation to CIDOC-CRM (cf. the AMA Newton), enabling migration if desired and providing tools for the management of the documentation after the conversion to the standard.

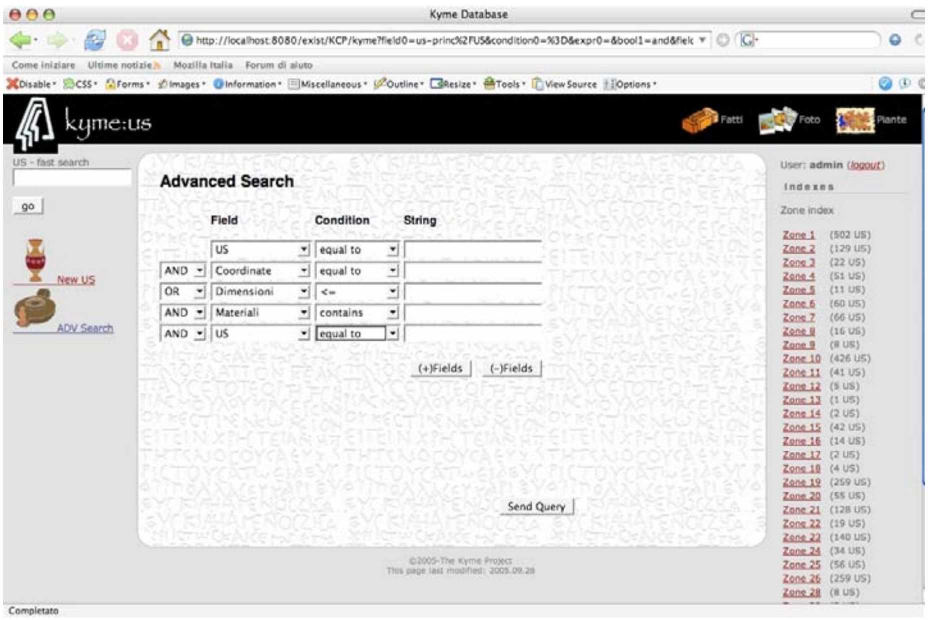


Figure 1: The search window: search fields may be added to the query using the buttons

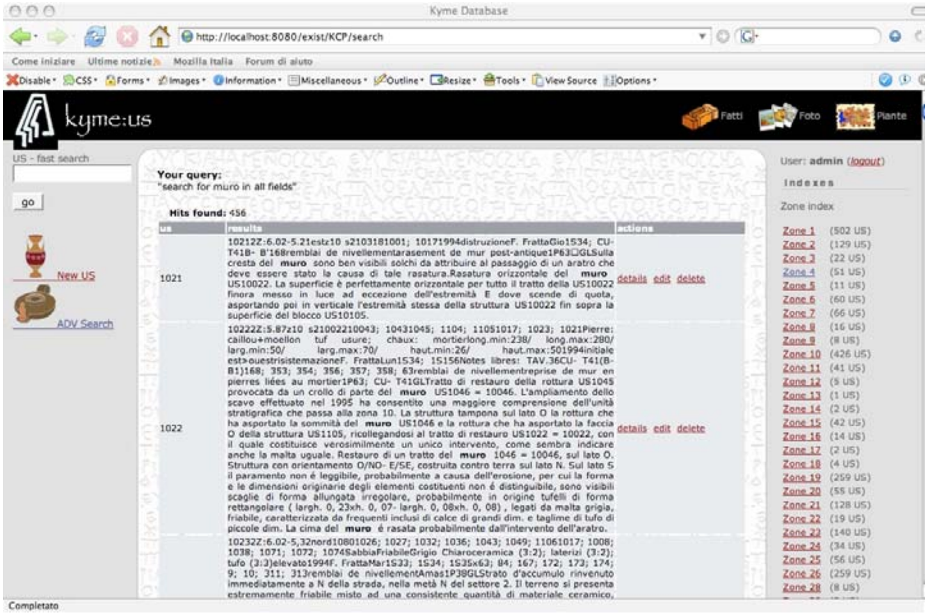


Figure 2: Query results (partial view)

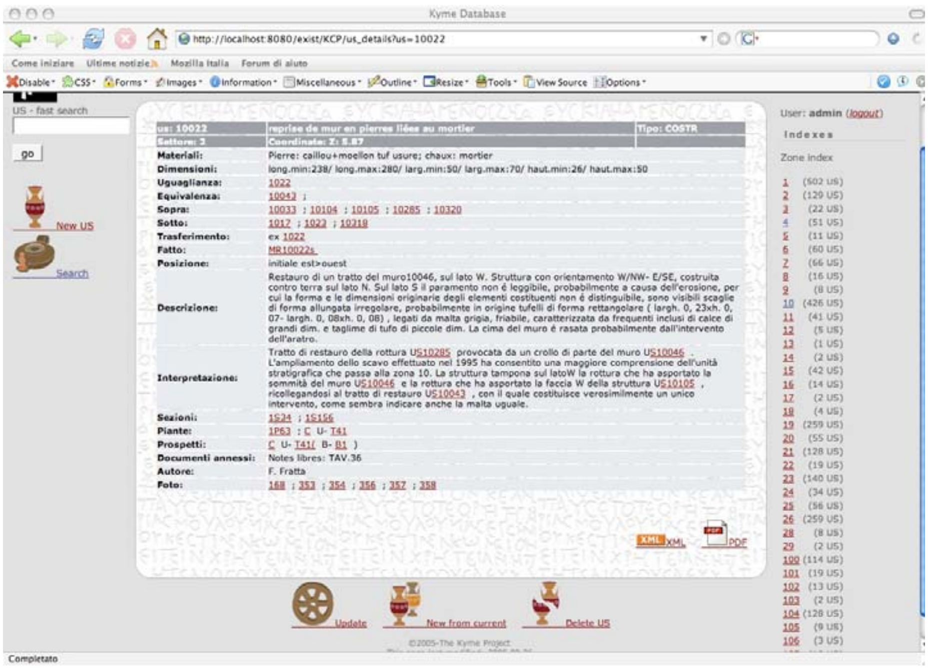


Figure 3: Visualizing a document

Ontologies for cultural heritage (activity linked with WP4.2 standards)

A seminar was organized in Florence with the collaboration of the Faculty of Architecture, University of Florence on "*Ontologies in Humanities: Archaeology, Architecture and Cultural Heritage*". The seminar took place in Florence on 27 January 2006 with some 30 participants. A team from the CNR Laboratory for Applied Ontology (Nicola Guarino, Aldo Gangemi and Stefano Borgo) were invited speakers, together with Andrea D'Andrea (PIN) lecturing on *Ontologies for Cultural Heritage* and Chiara Cirinnà (Faculty of Architecture, University of Florence) lecturing on case studies in Architectural studies. Some 10 contributions were collected in response to a call for papers, concerning diverse fields of applications. Papers will be published in a proceedings volume.

At the seminar "Ontology Based Modelling in the Humanities" organized by the University of Hamburg (http://www.c-phil.uni-hamburg.de/view/Main/OntologyWorkshop) on 7-9 April 2006, a paper on *A preliminary Ontology-based model applied to the descriptive / interpretative of archaeological excavation* was presented by A. D'Andrea.

3.3 Mobile-wearable-ambient systems

Current status

The core technical partners in this area are UNIKENT and ARCES, with further input from POLIMI, DS, ETH and others.

Prior to the start of EPOCH, UNIKENT had developed *MobiComp*, a prototype support infrastructure for smart environments and context-aware applications. As part of the evaluation of this infrastructure, an initial version of the *FieldMap* data collection tool was developed. FieldMap enables archaeologists and other field scientists to carry spatial data into the field using a handheld device, to collect new data, and to access remote, web-based resources whilst in the field.

Within EPOCH, UNIKENT activity in this area concentrated initially on developing a public release of an improved version of FieldMap, building on established and continuing collaboration with RUG. RUG has provided two or more opportunities per year to perform extensive field trials at their survey sites in Italy, and have adopted FieldMap as their main data collection technology. In addition, they have specified and collaborated in the design and evaluation of several modules to support specific field survey methodologies. This collaboration continues and will form part of the evaluation of the Newton project CIMAD.

ARCES activity during year 1 and year 2 has concentrated on background research, prototype design and implementation of components to support visitor guides through multimedia mobile devices. In particular:

- MobiComp Tracker, Aggregator, and Listener components for experimental sensors and location solution currently used at ARCES
- Prototype middleware for sensor integration at system level
- Prototype middleware for integration of 3rd party sensors within MobiComp
- Remote wireless (Zigbee, Bluetooth) sensors for improved user activity recognition and wearability
- Example calibration and integration procedures for sensors in mobile devices
- HCI components for on-site tours:
  - Vocal interface component based on VoiceXML standard
  - Sensor-driven Panoramas for virtual-to-physical mapping
  - Prototype of sensor-driven 3D engine
  - Prototype of panorama player for Windows Mobile platforms
  - GPS localization components (Sirf and NMEA standards)
  - Mixed mode localization with on-board sensors and stereo cameras (co-funded by University of Bologna, in cooperation with AlmaVision SpA)
  - Prototype algorithms for guided tours

Progress

During year 2 of EPOCH, FieldMap development concentrated on ensuring import/export compatibility with several widely-used GIS systems and, in parallel with similar work on MobiComp, migration of the code base from the outdated Personal Java (jdk 1.1.8) specification to the more recent J2SE and J2ME specifications. The system now runs on desktop and laptop machines, as well as a range of handheld devices under the J2ME Personal Profile. An experimental implementation is under way to enable a reduced version of FieldMap to run on Java-enabled mobile phones.

Additional technical work has been done by ARCES on:

- Improved HCI components (Panorama viewer, vocal interfaces, 3D engine)
- Porting of localization software to Windows Mobile OS.
- Demonstration of prototype remote wireless sensors
- Tracking algorithms based on remote wireless sensors
- Mixed mode (GPS/WiFi) localization techniques for indoor/outdoor environments
- Exploratory analysis of power consumption in mobile devices and context-based power management solutions

ARCES and UNIKENT have begun a close cooperation on establishing an updated version of MobiComp as a key component of the CI support for mobile, wearable and ambient systems. Work on providing a more formal basis for MobiComp has begun, with UNIKENT working towards new J2SE and J2ME implementations to be known as MobiComp2 and scheduled for completion early in year 3. The main thrust of the joint effort is in specifying an extensible XML Schema and OWL ontology for the language used in communicating and storing contextual information. Existing components developed at ARCES and UNIKENT will be adapted to this new model.

Interactions

MobiComp v2 will provide a key basis for the development of the Newton project CIMAD. This project aims to demonstrate the rapid development of context-aware applications and smart environments using an Application Builder tool to assemble MobiComp components. Existing and new MobiComp components will be developed at ARCES and UNIKENT and made available to the Application Builder. CIMAD will demonstrate the applicability of MWA tools throughout a Cultural Heritage workflow, but concentrating on data collection and public presentation. The data collection component will build on UNIKENT experience with FieldMap and involves interaction with partners in the *Databases and Technology Management*, *Recording and Data Representation* technology areas. The public presentation component will build on ARCES, DS and POLIMI experience with WHYRE, in consultation with partners in the *Visualization and Rendering* and *Multi-modal Interfaces* technology areas. Close collaboration with partners working in the WP4.2 *Standards* area and the AMA Newton is well established and will underpin both our CI and Newton work.

Highlights

Partners UNIKENT and ARCES organized a very successful workshop entitled *Smart Environments and their Applications to Cultural Heritage* at the UbiComp'05 conference held in Tokyo, Japan, in September 2005. UbiComp is the main international conference in the area of ubiquitous and pervasive computing. Contributions to the workshop came from other partners ETH and POLIMI, and researchers from Australia, Japan, South Korea, Taiwan and USA. The proceedings of the workshop have been published as an EPOCH publication.

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3.4 Recording and data representation aspects

Current status

The main objective of this subarea of WP 3.3 was to provide a set of tools and practices that make possible a uniform shareable data management through the pipeline of processing of recorded/modeled 3D data.

While issues on rendering and storage of 3D data, like for example the choice of a common exchange format, are strictly related with this area, they are the main subject of subarea 5. In this subarea the main focus is on the creation, modeling and processing aspects of the 3D data representations.

3D WebService

University of Leuven’s tool that allows uploading images, and getting sent back automatically generated 3D models, directly from the images, had already been demonstrated during the first review. This service is now on-line for free, non-commercial use by registered users in the area of Cultural Heritage.

MeshLab

Focusing on the 3D datasets that come from scanners or image-based techniques such as the 3D Webservice, tools are needed that process their large unstructured meshes. These tools should act as *glue* for interchanging the data, and mostly for adapting them towards the requirements of different applications. Indeed, in most cases it is not simply a matter of format conversion but 3D data has to be processed. For example the output of a 3D acquisition device is just a set of different tessellated meshes that represent 3D objects as viewed from one direction each. These meshes usually need to be merged together in a single well shaped mesh and the desired accuracy and complexity depends mostly on the target usage of this mesh. Interactive mobile applications can e.g. not make use of the full precision obtained by 3D scanning technologies and simplified representations have to be created. Similarly some cleaning operations (removal of unimportant parts, noise) often have to be performed on the meshes. At the start of Epoch, no such free tools were available. This has been remedied by making CNR-Pisa’s MeshLab tools available.

Procedural modeling

In this subarea we also investigate the interactive design of 3D models. The efficient creation of such models is a crucial task in cultural heritage since lots of artefacts or environments are completely destroyed and cannot be reconstructed by scanning. Thus the models have to be created from scratch in a CAD-like environment i.e. based on plans, paintings, rules etc. However, modeling is a very expensive process and requires computer graphics expert knowledge – which is not affordable for archaeologists. Therefore, several partners are developing tools for procedural content creation: (1) GML is a low-level language to capture the description of procedural shapes. It is freely available and currently browser plug-ins and a scene-graph integration are developed. (2) The CityEngine is a tool for the procedural modeling of architecture. A novel shape grammar has been introduced and the software-development is in its final stage. A library of detailed and/or large-scale models is online and available to the different partners for performance and integration testing. Collaboration between both tools is planned for the next year.

An important aspect of this subarea is the management of 3D data that do not come directly from automatic acquisition techniques (a.k.a. 3D scanning). This work included establishing the correct exchange format and/or using a common scene graph rendering framework for the various applications, as discussed under subarea 5.

Progress

3D WebService

The main progress made since the launch of the 3D WebService has been the inclusion of more powerful wide-baseline matching techniques on the server side. This is a crucial part of the overall 3D WebService, which allows the system to start from images that are taken farther apart. Experience gathered from the initial users of the system has made clear that they tend to take images from viewpoints that are quite different. Wide baseline matching then still allows the software to find matches, and to bootstrap itself from there. Hence, several image sets that could not be handled with the initial version of the software, can now be dealt with successfully.

On the client side, the GUI has been improved. Export capabilities to several formats including X3D and Collada have been added. The Webservice website has been refurbished and a more comprehensive user manual has been written.

MeshLab

The MeshLab system, developed by CNR-Pisa, will act as *glue* among the various applications in the epoch network as described in the above section. The first version of this tool is also available to the community, since January 2006. Regularly updated and improved, it is already able to perform most of the features for which it was designed. The current version (0.7) is able to:

- manage large set of unstructured 3d data (meshes of 10M of triangles can be loaded and processed)
- perform almost automatic cleaning operations over large unstructured meshes
- import, convert, simplify and export meshes in a variety of formats.

In the next months the following features should be added to the system:

- robust support of Collada data format, that also require reading/preserving/writing XML annotations;
- high quality simplification algorithms for adapting the complexity of 3D data to different needs of the network partners;
- robust integration of multiple range maps in a single mesh;
- Automatic storage and documentation of the processing done over a mesh for archival and repeatability purposes.

CityEngine

The CityEngine system, developed by ETH Zürich, provides architectural modeling tools. This system has not only been developed further during year 2 of the project, but has also been evaluated through two collaboration projects with archaeologists: the reconstruction of Pompeii (cf. Figure 6) and – still ongoing – the reconstruction of Xkipche, an ancient Mayan city (cf. Figure 7). Version 3 of this tool will be available to the community in the summer of 2006. The current version (2.9) is able to:

1) evaluate and interpret all kinds of architectural rules (a library with a rule set for classical architecture, which is relevant to cultural heritage, is already available and can serve as an implementation example);
2) create unique large-scale city models as well as very detailed building models;
3) perform rule-based distribution of (urban) vegetation;
4) interactively explore and modify based on a sophisticated user-interface;
5) import and export of GIS data and meshes in a variety of formats.

In the next months version 3 will be finished/stable (mainly UI improvements have to be implemented yet) and manuals will be written.

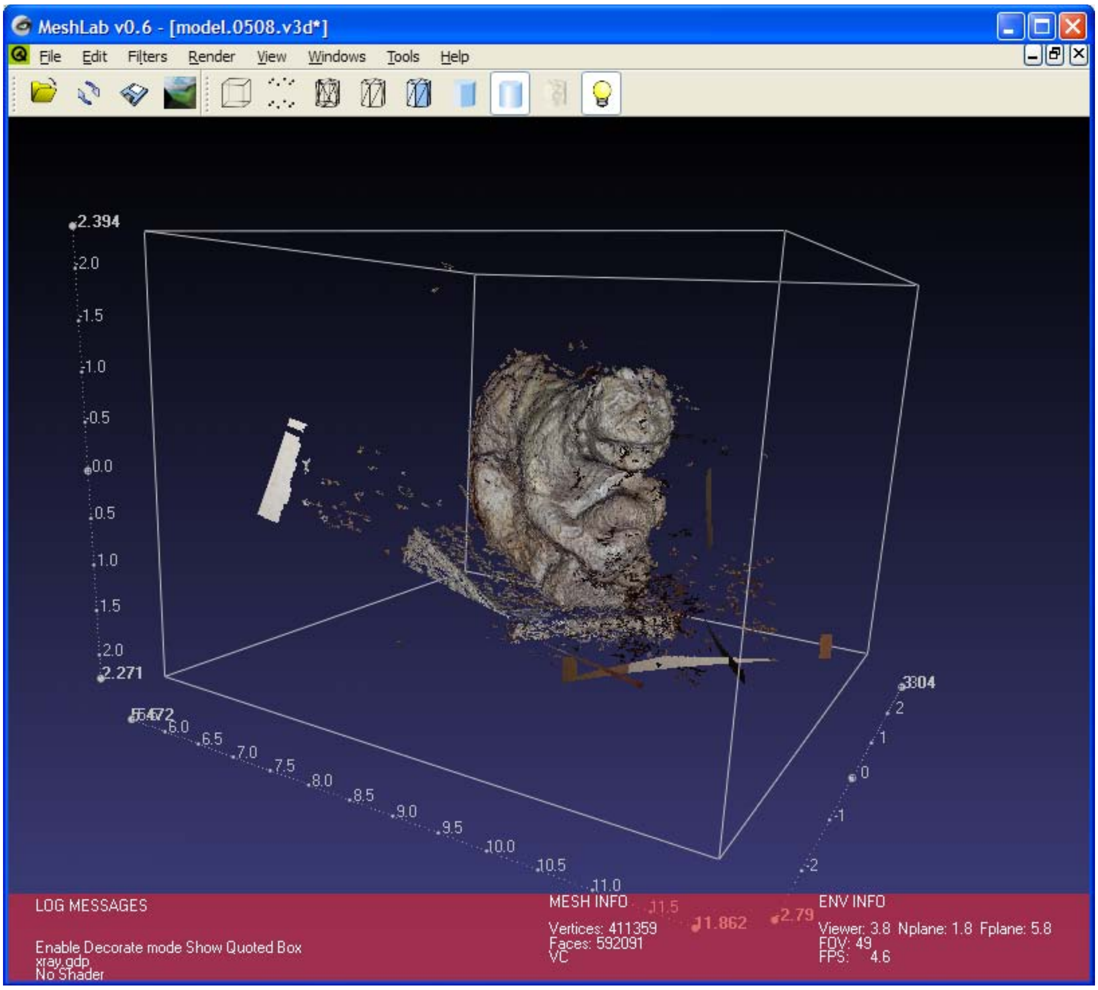

Figure 4: A snapshot of the current release of the MeshLab tool. The object shown is a half a million triangle mesh obtained in MeshLab by integrating and filtering five range maps generated by the 3D WebService.

Figure 5: An example of the automatic filtering operation performed by the MeshLab tool. Small floating triangles caused by acquisition noise are automatically removed.

Figure 6: The ancient city of Pompeii was reconstructed using procedural methods provided by the CityEngine tool.

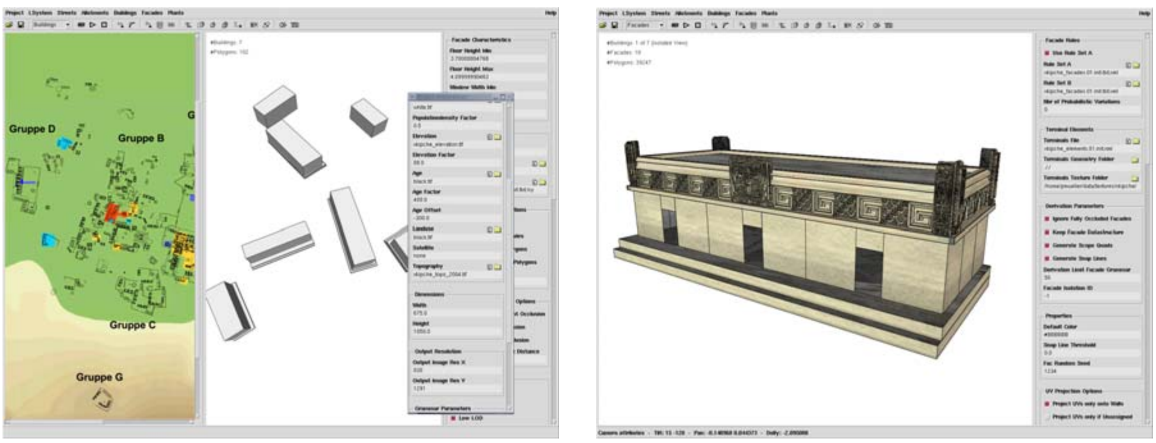

Figure 7: Screenshots of the CityEngine. Another example application is the rule-based reconstruction of a Mayan site.

Interactions

As mentioned before the areas 4, “data representation” and 5, “visualization” share many common issues. The most important decision that affects both of the areas is the choice of Collada as an XML-based 3D storage data format. The correct support of this data format, that also requires robustly reading/preserving/writing XML annotations, is under development for MeshLab and the CityEngine. Collada is already supported by the 3D WebService.

The possibility of interchanging and adapting 3D objects is of a fundamental importance in the contest of the various Newtons. We see for example that given some adaptation of the meshes to the different needs of the applications there can be fruitful exchanges of results among the following Newton projects: 3DKIOSK IMODELASER CHARACTERISE, and

probably CIMAD**.**

Highlights

The 3D WebService has been used successfully by several Cultural Heritage professionals already. It has been demonstrated at a Unesco workshop in Mexico, which has been supported by Epoch, and met with great interest there. Recently, people from the Louvre joined our community of users.

CNR-Pisa has developed and released the first versions of the MeshLab processing tool aimed to fill the gaps in the mesh processing discussed in the above sections. The system is under GPL open source license and is publicly available free of charge. The last two versions of the MeshLab system have been already downloaded approximately 700 times (April 06) and its web site (MeshLab.sourceforge.net) got more than 7000 page views in first quarter 2006.

The development of the CityEngine has led to a publication from ETH Zürich at SIGGRAPH 2006. This conference has a particularly high visibility, and will also be complemented with a course at SIGGRAPH. Furthermore, a high-profile report was published in ‘Digital Production’, the leading German-speaking magazine for digital content creation (with a print run of 16000 copies and aimed at professional users rather than scientists).

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3.5 Visualization and rendering

Current status

The main strategic topics of work in the last year were (i) to establish OpenSG as a common rendering platform, and (ii) to agree on a common 3D file format. The work in area 5, "visualization & rendering", was therefore executed in close collaboration with area 4, "Recording & data representation". Also through the starting Newtons it became clear that an urgent and pressing matter is now the fast availability of a common 3D infrastructure. More precisely, "3D engineering guidelines" were needed for Epoch, and were also partly provided, for:

- **Storage** (*long-time archival*)
  Solution: Collada or X3D
  Status: Fundamental issues resolved, first implementations underway
- **Rendering** (*3D application framework*)
  Solution: OpenSG
  Status: resolved, solution is promoted within the consortium
- **Processing** (*documented process chain*)
  Solution: Shape processing tools
  Status: Tools available for shapes represented as meshes (Pisa MeshLab)
  Pending issue: Standard way of process documentation

Without a common base the inter-operability of the software modules from different partners (and different Newtons, in the long run) can not be assured, which would be a critical situation. In order to avoid this and to resolve issues rapidly, a 3D-taskforce was established. It takes the form of a mailing list, the issues discussed (and resolved) on which are furthermore documented in a moderated wiki.

Progress

Adoption of OpenSG as common Epoch rendering platform

This ongoing task has gained great momentum during the last year. Several partners have ported their visualization software to OpenSG, others have started to do so. Most notable examples:

- Massive multi-resolution meshes from Pisa
- BTF-rendered models from Bonn
- Subdivision surfaces from Braunschweig
- GML models from Graz
- 3D Web service viewer from Leuven
- Animated avatars from Norwich
- Procedurally generated urban environments from Zürich

First integration experiments are very promising; several visualization modules from different partners could be combined in a common 3D application. UEA expressed reservations about the current usability of OpenSG for deformable objects, which were reported to the OpenSG community.

The CityEngine Viewer, developed by ETH Zürich, will provide real-time rendering of procedurally generated environments (generated with the CityEngine - see section 3.4). The viewer is based on the OpenSG 3D engine and will investigate new approaches for architectural level of detail handling. Especially for cultural heritage (i.e. classical architecture with very detailed and richly decorated models), high-performance level of detail techniques are crucial for a convincing real-time visualization. In the viewer, several contributions of other partners will be integrated, e.g. (1) the OpenSG integration of GML provided by Brighton, (2) GML-based level of detail provided by Graz, and (3) massive mesh rendering methods provided by Pisa. Development started in February 2006 and in its current state, OpenSG evaluation has been finished and basic model import procedures have been implemented. Furthermore, for a HMD visualization, a Vicon tracker interface has been integrated into OpenSG.

For the further promotion of the common interactive rendering platform it was decided to create two sets of tutorials:

- *Extending OpenSG*: Many partners are developing “custom shape representations”, i.e., special algorithms and data structures for digital historic 3D objects. In order to facilitate their integration into the Epoch visualization software, tutorials were created demonstrating the exemplary integration of a few representative custom shape representations.
- *Using OpenSG*: The next step will be to set up tutorials that demonstrate the rapid development of complete 3D applications. This will clearly document the benefit of using Epoch technology for, e.g., creating next-generation location-based CH experiences, as well as for any sort of visualization of CH datasets.

The 3D file format issue

The file format issue is inseparable from the visualization; in fact it is a prerequisite: The visualization needs to import the data to visualize from some sort of file. Technically the most challenging issue was to identify a common 3D file format that suits all needs of Epoch. This is far from trivial because of

- the very diverse requirements, from sustainability (long-time archival, cf. the preservation formats in Section 2.1) over numerical robustness, wide spread use, space efficiency, and a possible storage of 3D objects in a database, to the compatibility to CH standards (e.g., CIDOC/CRM), and
- the fact that every 3D tool in the Epoch Common Infrastructure must support it, which is a serious challenge from the software engineering point of view.

It was finally decided to use an XML based file format, i.e., either Collada or X3D. In principle XML provides a standardized way to attach arbitrary *annotations* to 3D objects, i.e., further auxiliary data such as metadata or database IDs referring to externally stored semantic information. In practice, though, the greatest problem is to make sure that these annotations are faithfully maintained also when a shape is processed (edited). This is delicate especially when annotations refer to only a part of a shape (“hand of a statue”).

A Collada importer/exporter for OpenSG, which is also capable of robustly reading/writing XML annotations, is currently being developed as an important part of the Epoch visualization infrastructure.

Interactions

As mentioned before the areas 5, “visualization” and 4, “data representation” have collaborated closely in the reported period to provide an important part of the Epoch CI. Consultations joining areas 5, “visualization” and 1, “semantic data processing”, have lead to using Collada as an XML-based 3D data format.

The Newton 3DKIOSK now provides the 3D Webservice. Several partners have acquired an account and regularly upload image sequences. The client-side GUI of the 3D web service uses OpenSG and supports Collada and X3D. 3DKIOSK also provides the mesh processing suite MeshLab from Pisa as Open Source, hosted on sourceforge. Furthermore, 3DKIOSK has provided some of the OpenSG extension examples used for the tutorials.

The Newton CHARACTERISE has extreme real-time demands since a close-up of a moving avatar on a tiled display requires thousands of vertices to move synchronously. This issue has been identified and is being worked on.

3.6 Multi-modal interfaces

Current status

The Interactive Institute has investigated into current museum applications of interface technologies. In order to reduce the cost, the study has been limited to the Nordic countries. An overview has been generated of the kinds of interfacing technologies that have been used or experimented with, and the conclusions about their actual usability will be collected. Interesting cases have been identified, for use in art galleries, historical museums, and heritage sites.

Progress

Mapping of the applications in the Nordic countries.

One of TII's activities during this period has been collecting and evaluating Nordic projects regarding multimodal interfaces in CH. We have included science centers, research institutes, heritage sites and nature, art and culture museums. In Sweden we included eleven projects connected to museums and heritage sites and from R&D institutes we have included eleven projects. We included five projects related to museums in Finland and four projects related to R&D institutes. In Norway, Denmark and Iceland we included two projects each connected to museums. There are three institutes in Norway, five in Denmark and in Iceland we have no results in our search of R&D institutes working with multimodal interfaces. The institutes in Sweden, Finland and Denmark appeared more evolved compared to Norway and Iceland where they are still in an early phase of R&D regarding multimodal interfaces for cultural heritage.

At the moment we are working towards fulfilling the following project goals:

- Putting together inventories of available/existing technologies (with a special focus on multi-modal interfaces) as well as identifying relevant formats and standards. The results of this evaluation are to be complemented and integrated with the WP3.3 matrix. The result will include Europe with emphasis on the Nordic countries.
- Test usability and effectiveness of tools and environments for CH applications (We have had the possibility of doing studies of usability regarding several projects)

Development of interactive applications.

The Interactive Institute has a profile that aims to develop as low-cost and efficient solutions as possible for CH, since the resources often are limited.

A touch of Kandinsky is an installation in the form of an interactive carpet, aiming to increase the understanding of contemporary art. The carpet is designed with different figures each sensitive for pressure. This is possible due to built-in sensors placed directly under the carpet, developed by The Interactive Institute. The sensors consist of two layers of aluminium-foiled paper with perforated plastic foam in between. When pressure added the foiled surfaces gets connected and with that working as a switch. The sensors are connected to the MIDI sampler transforming it to MIDI-data, sending the sounds to the speakers.

The Meta.L.Hyttan. By re-animating the steel industry hall using site-specific interactive media the historic blast furnaces in Avesta are being transformed into an interactive environment for visitors to learn and experience history, science and art. The primary tool used by the visitor to interact with the environment is a special flashlight available in an educational and a poetic version. The space is equipped with special hotspots that pick up a coded and invisible beam from the flashlights. This technique is the same as in a remote control, it sends a coded signal with infrared light, the hotspot picks it up and automatically triggers the local media event associated to the zone and the flashlight. The underlying system uses standard network technology, running the same protocols that operate on office networks and the global Internet. Together with an adaptable software platform, developed by the Interactive Institute, this system becomes easily scalable and cost efficient.

China before China. This permanent exhibition at the Museum of Far Eastern Antiquities (Östasiatiska museet) tells the story about the conditions in China before it was China. The installation is a computer controlled interaction and media system consisting of 22 sensors; three touch screens, eleven magnetic reeds and eight motion detectors of the same kind used for burglary alarms. The system (except the video-wall) is running on a single computer with software (developed by the Interactive Institute) based on the MIEL interaction language. The computer get all information from the 22 sensors, based on this information it creates a reaction. All audio comes from a computer-based audio-player, developed by The Interactive Institute. It handles 32 loudspeakers in the installation, each loudspeaker can be controlled separate and any audio clip can be played on any loudspeaker. This is a very cheap and yet reliable method for distributing sound in installations. The video-wall is based on the commercials system Watchout by Dataton, running on 9 computers and 8 video projectors.

Access in Mind is an audiovisual installation for the art galleries helping visitors to respond to works of contemporary art and aims to stimulate and encourage young people to explore contemporary art using a multimodal approach – light/dramatized audio. The design consists of a “ball-chair” equipped with speakers and 3D sound. The sound system also produces vibrations in the chair through a basic unit in the seat. Light is projected through a number of Plexiglas plates combined with diodes that randomly project different colors. The chair is covered with foamed polythene plastic, and is placed on a wooden podium, which hides the computer and rest of the technology.

Interaction & collaboration with Senheiser - Development of guides for Universeum.

The audio guides present four different animals: wolf, beaver, adder and salmon – animals that follow *The Water's Way* through Sweden and which all have increasingly smaller habitats because of influences of mankind. In the audio guides, the child listens to one of the animals narrate about conditions governing its life in the Swedish landscape. Every audio guide consists of a headset and a bracelet decorated so as to associate to one of the animals.

The four audio guides have separate scripts read out by different actors and they stop at different stations in *The Water's Way* area. The wolf's audio guide is the longest in time and the most multimodal of the four and stops at most stations. It encourages the child to actively interact with the exhibit's environment and has environmental sounds, sound effects and dramatized music. The beaver's audio guide has no interaction but has environmental sounds that enhance the feeling of being out in nature. The salmon and adder are both without interaction and sound effects – they consist only of an actor's storytelling voice. These disparities allowed us to study how increased levels of interaction and auditory dramatization affect children's experience of the environment and stories of the animals.

The chosen technical solution is called *Guideport* and has been developed by *Sennheiser.* The headband of each animal contained a receiver and a set of headphones. 11 small identifiers located throughout the venue at *The Water's Way*, triggered the receivers to play the appropriate files when the child wearing the receiver entered a certain predefined area. The next audio track came on as soon as the child leaved the area and entered a different zone. This meant that the child could do things in her own pace.

Interactions

Possible projects and participating partners for the Interactive Salon:

- *The EPOCH 3D Multimedia Kiosk (3DKIOSK)*
  Partner and Contact: Paolo Cignoni from ISTI; Institute of Information Science and Technologies of the National Research Council in Pisa, Italy.
- *On Site Reconstruction Experience*
  The institutions collaborating on the realization of the showcase "On Site Reconstruction Experience" are: ETH Zürich, Computer Vision Laboratory, Switzerland, Fraunhofer Institut, Darmstadt, Germany.
  Contact: Prof. Luc Van Gool of ETH Zürich or Dr. Didier Stricker of Fraunhofer IGD Darmstadt).
- *Multimodal Interface For Safe Presentation of Valuable Objects*
  Participants; The Ename Center for Public Archaeology and Heritage Presentation, Belgium, EPFL (Polytechnical University of Lausanne), Virtual Reality Lab, Switzerland, and University of Sussex, UK
  Contact; Heidi Tency, Ename Center, Belgium.

- *Multilingual Avatars*

  This showcase was realized by the following EPOCH partners: University of East Anglia, UK, Technical University of Braunschweig, Germany and University of Brighton, UK

  Contact: Dr. Andy Day of University of East Anglia.
- *Archaeological Documentation for the Semantic Web*

  The system is being developed by several partners at different locations to test it under as many diverse conditions as possible. Other contributors are in the meanwhile proposing additional case studies. The core partners are; PIN, Italy, University of Oslo, Museum Project, Norway, University of Kent, UK, Paveprime, and University of Naples “L'Orientale” - CISA, Italy.

  Contact; Prof. Franco Niccolucci, PIN.
- *Image-Based Modeling*

  This showcase was developed by the following EPOCH partners: ETH Zürich, Switzerland, and KU Leuven, Belgium

  Contact Prof. Luc Van Gool of KU Leuven.

Highlights

Planning of Interactive Salon in Autumn 2006 – showroom for EPOCH’s applications to museum staff, students in CH, and meeting forum for CH content providers, SMEs and users.

Furthermore, several publications have appeared.

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3.7 Virtual human and other avatar technologies

Current status

Year1: ARP (Avatar Research Platform) technology was added to OpenSG for the Multilingual Avatar Showcase demonstrated at Vast2004 by UEA. New node types created for OpenSG to facilitate the animation and rendering of multi-lingual virtual humans in a city scene. The virtual 'guide' has lip synchronization for natural communication of information to the user touring the city. UNIGE has actively participated in Showcase Integration 6, for the 3D simulation of the daily life inside the Abbey during the 12th century.

Year2: ARP toolkit rewritten for future proofing (.NET) by UEA. The toolkit was originally written in the now outdated Borland C++ environment. It has been ported to .NET C# in order to continue development. The toolkit has had a lot of development in terms of import and export capabilities, allowing models, skeletons and motion data to flow to and from most mainstream modeling applications (incl. Maya, 3DSMax, MotionBuilder, SoftImage). EPFL and UNIGE have been actively working towards releasing the basic components of their VHD++ platform as open source, for the EPOCH community. In particular, EPFL is handling the migrating of code sections of the VHD++ platform ensuring that no legal issues prevent the use of the VHD++ platform by the EPOCH community. When completed, the migration of the source code will permit the deployment of the VHD++ platform under the LGPL license for a wider distribution between the EPOCH community. In addition, EPFL and UNIGE are preparing additional materials such as documentation and tutorials to improve the adoption and learning curve with the system.

Progress

Automatic techniques for crowd placement and navigation in city scenes have been developed and presented at Vast 2005. These are based on processing the 3D scene into 2D maps to indicate areas of the scene that can be immediately accessed or navigated toward.

After a period of investigation, we have proposed that the COLLADA (COLLAborative Design Activity, see Figure 8) standard be used as the 'native' format for both virtual humans and scenes. COLLADA has native support for virtual human data structures and can also be extended to facilitate the interchange of other data required in our virtual worlds such as terrain height maps, occluder shadows, metadata, etc. In effect, the recent development of the COLLADA standard gives and great support from major Digital Content Creation tools companies offer great opportunity to reduce the development of customized and simulation specific exporter. In key aspect of relying on COLLADA for CHARACTERISE is that the format guarantees to encode the exact information. However, as the format is continuously improved, the effort will be dedicated on the latest stable iteration of the standard (currently 1.4).

OpenSG has been revisited following the showcase demonstrated at Vast 2004, but issues still remain with the dynamic nature of virtual humans (memory overheads, rendering speeds, synchronization of audio and visual components important for speech, and the updating of the positions of dynamic objects causing the humans to disappear or appear incorrectly). Finding solutions or alternatives is an ongoing investigation.

The use of the graphics card processor for deforming the virtual human mesh structures has been investigated with promising performance improvements (on supported hardware). In

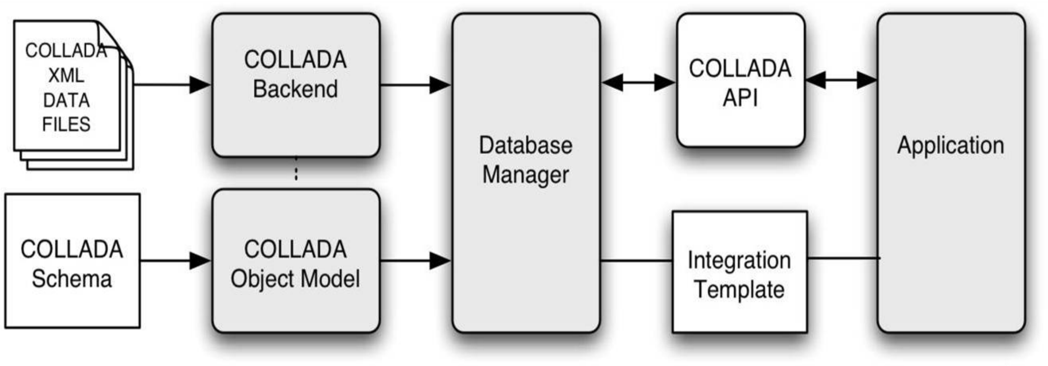

Figure 8: Collada integration pipeline.

addition, the elaboration of particular vertex and pixel shaders for increasing the variety in the virtual characters is continuously progressing as presented at VSMM 2005.

To remove another manual process in the display of virtual humans, an automatic method of creating billboard/impostor images and simplified human meshes has been developed.

To control the behaviors of virtual humans, a data-driven method for generating basic virtual humans emotions with added variety in animation has been developed.

Interactions

There has been an early distribution of VHD++ from EPFL and UNIGE which is being evaluated at UEA. This should mean that we can make good progress when the full VHD++ release is provided. It is too early to tell how the combination of VHD++ and OpenSG will work as a number of outstanding issues remain with OpenSG. These have been communicated to the OpenSG developers, users, and project partners and we await progress.

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[1] A Framework for Real-Time Virtual Crowds in Cultural Heritage Environments. G.Ryder, P.Flack and A.M.Day, in Short & Project Papers Proceedings, Vast 2005, pages 108-113.

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4 Newton Activities

Six Newton projects were accepted for funding:

1) 3DKIOSK: 3D processing, from capturing to visualization
2) AMA: Open Source tool for mapping datasets to CIDOC-CRM form
3) CIMAD: Configurable framework for smart CH environments
4) IMODELASER: Integration of laser scanners and imaging devices for 3D modeling
5) UPGRADE: Integration and fusion of acoustical, optical and platform navigation data for underwater archaeology
6) CHARACTERISE (formally called VIRTUMAN): Creation of a Scene Population Toolkit

This section describes the activities for these Newton projects. The only exception is the UPGRADE Newton, which hasn't started yet.

4.1 3DKIOSK

Current Status

The goal of this project is to make the integrated use of acquisition and showcasing 3D technologies an easy to adopt obligatory standard for museums. The project is structured in two components: acquisition and showcasing.

For the acquisition part the Epoch 3D Webservice, which allows selected users to upload image sequences and reconstruct 3D range maps, has been active and several Epoch partners have acquired an account and regularly upload image sequences. Similarly the MeshLab tool has been downloaded and used by various partners.

For the showcasing part most of the work has been done in creating the common software framework for all the partners of the project.

Progress

On the side of the web server for automatic reconstruction several wide-baseline matching techniques have been implemented. This makes the Webservice much more stable as it can now handle images that are recorded further apart. On the client side, the GUI has been improved. Export capabilities to several formats including X3D and Collada have been added. The Webservice website has been refurbished and a more comprehensive user manual has been written.

On the server a new database has been constructed, targeted towards integration with the CNR-tools. Recordings can now be structured in scenes. Every scene can hold several sequences. A common SVN server has been set up for code interchange between CNR and KUL. A first version of the CNR integration tool has been installed at KUL and integrated with the distributed processing network, also used for the 3D reconstruction service.

The first versions of the MeshLab processing tool have been developed and released. The system is under GPL open source license and is publicly available free of charge. The last two version of the MeshLab system have already been downloaded approximately 700 times (April 2006) and its web site (MeshLab.sourceforge.net) got more than 7000 page views in the first quarter of 2006. The system is able to load directly the raw output of the Epoch reconstruction web service and prepare it for further alignment and merging.

The showcasing part has started to build a common software framework for the different rendering techniques. The OpenSG scene graph has been chosen as a common framework and the various partners are integrating their technologies under a specialized node of this architecture. ISTI-CNR has provided state-of-the-art technologies for the interactive visualization of massive triangulated models using out of core multiresolution structures. TU-Graz, has integrated the scripting/modeling language, the Generative Modeling Language (GML), into OpenSG.

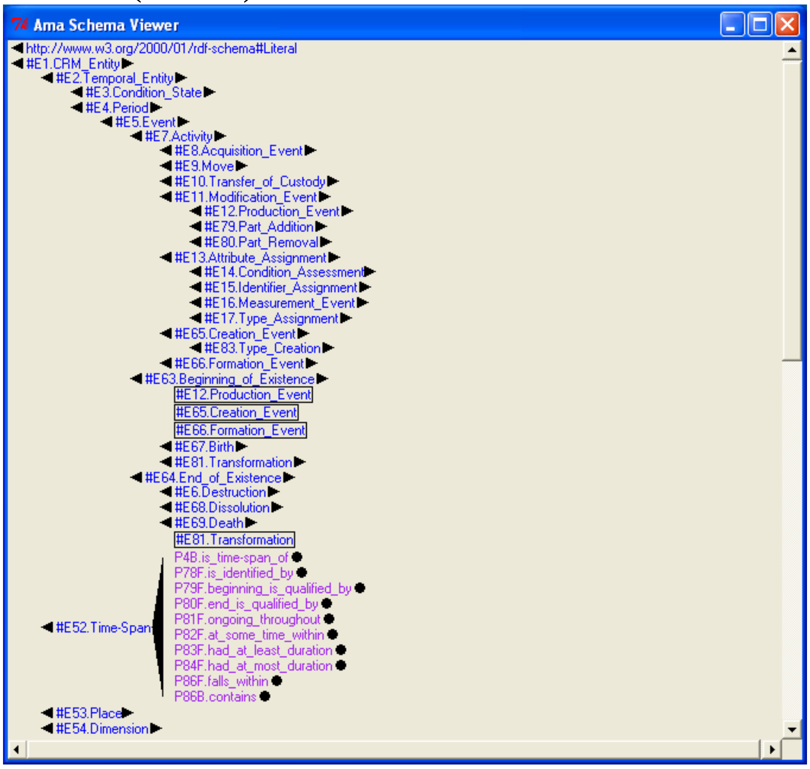
Interactions

The possibility of interchanging and adapting 3D objects is of fundamental importance for the interaction of the various Newtons. We see for example that given some adaptation of the meshes to the different needs of the applications, there can be fruitful exchanges of results among the Newton projects IMODELASER, CHARACTERISE, and probably CIMAD.

4.2 AMA

Progress

- 2-3 February 2006. Kick-off meeting in Prato.
  Participants: F. Niccolucci, A. Felicetti, F. Iacotucci, G. Marchese (PIN), C. Perlingieri (CISA), C-E. Ore (U. Oslo), S. Saccenti, M. Crescioli (UNIREL), M. Vandamme (VARTEC), G. Lange (ROB), IrinaTarnoveanu (CIMEC), Lyat Ayzencot (IAA), T. Bell (Oxford Digital).
  Results: Summary of the project goals. Presentation of archives to be mapped to CIDOC-CRM as test cases (PIN, CIMEC, ROB, IAA). Evaluation of tools proposed for documenting the data models. Discussion of work done on Italian archives. Preliminary design of the survey on documentation standards in museums and sites. Preliminary design of the mapping tools. Future work planning.
- February and March: Circulation of available material; compilation of a form on test archives; design of the survey. design of the mapping tools.
- 3 April 2006. Meeting at EVA. Participants: F. Niccolucci, A. Felicetti, G. Marchese (PIN), C. Perlingieri (CISA), J. Stabell (U. Oslo), S. Saccenti, M. Crescioli (UNIREL), M. Vandamme (VARTEC), IrinaTarnoveanu (CIMEC).
  Results: Evaluation of work done; presentation of the design of the text mapping tool based on IKEM (VARTEC) and of the mapping tool (UNIREL), with preliminary screenshots of prototypes (still with limited functionalities); such screen-shots have been presented to discuss the interface, which has been accepted by the team.



Plans for further work

- Completion of the survey by end May.
- First working version of the prototypes of the mapping tools by mid June.
- Another meeting planned for mid July to evaluate the functionality of the tools on test archives and the results of the survey.
- Presentation of early results planned for VAST2006.

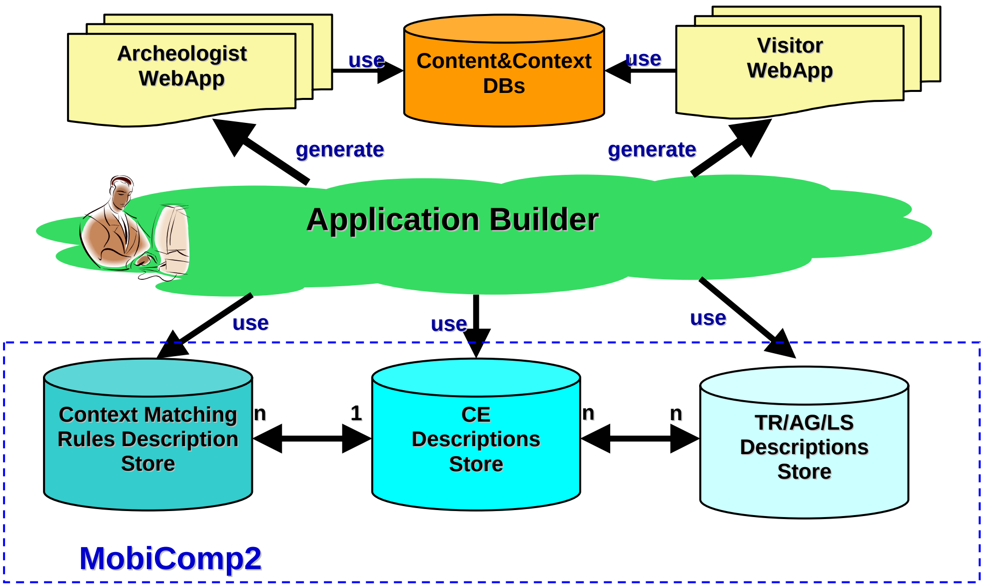
4.3 CIMAD

Current status

CIMAD stands for *{Common Infrastructure, Context Influenced} Mobile Acquisition and Delivery of CH Data*. The CIMAD target is the conception and development of a demonstration framework for building and running mobile CH applications in smart environments at any stage of the EPOCH "pipeline". Example applications will be generated at the data capture end (field survey and excavations) and at the dissemination end (covering two profiles: visiting students and specialists). The framework is intended to become a component of the Common Infrastructure, and relies on the results of activities carried out in WP 3.3.

Progress

As expected, Activity A1 (Specs and planning) is under way, and in the first month of activity a general CIMAD architecture has been defined (figure below) and some relevant decisions were made.



The mobile applications will be Context Aware Web Applications created with the support of the Application Builder. The Context Management Infrastructure is provided by MobiComp2, currently under development as a contribution to the Common Infrastructure.

Trackers, Aggregators and the Listeners (TR/AG/LS in figure) are the main client side MobiComp components and are selected by the application builder to suit the application requirements. They enable the mobile clients to create and retrieve context elements (CE) stored in the Context Store. The context-aware behavior of the expected applications is enabled by "Context Matching Rules" to be specified for each application using the Application Builder.

Specified EPOCH Standards will be adopted where appropriate (data, metadata, transport and communication). With reference to the above figure, the following EPOCH Standards to be applied to CIMAD modules and communications have been selected:

- XML and HTTP for communication between components
- XML-based languages for data querying and retrieval
- XML and XSL for data presentation
- CRM-CIDOC mapping of import/export data for interchange with other EPOCH components
- GML (Geographic Markup Language) for all spatial data representation

Work underway within Activity 1:

- Specification of the Application Builder.
  Definition of the following interfaces and mappings between this NEWTON and the tools produced by other NEWTONs or already specified in the CI:
  - Interface to MobiComp2
  - XML-Schema Interface definition of CIMAD datasets for XML databases cooperation
  - CRM mapping of XML Schema elements (in cooperation with AMA Newton)
  - GML mapping of spatial elements
- Selection of suitable mobile platform architectures.
  At the moment, the following clients are considered:
  - Java 2 MicroEdition Personal Profile
  - .Net 2.0 Compact Framework

  A clear interface to sensor subsystem will be specified in order to support third party sensors.

Interactions

Interaction with other NEWTONs and with the CI is a requirement of the above mentioned activity. Such interaction shall be agreed with the WP3 Leader.

4.4 IMODELASER

Progress

For the image-based modeling of the church of Agios Nikolaos (Crete), a set of approximately 45 images has been used. After the image acquisition and the surveying of the object by means of a total station, the images were oriented to recover the camera poses and 3D object coordinates of some homologous points. Afterwards, other points as well as edges are identified in the images to completely reconstruct a virtual 3D model of the church. Due to the complexity of the object and the absence of well defined corners and edges, all the measurements are performed manually.

In the Figure 9 two screenshots representing the recovered camera positions as well as a first raw model of the church are reported.

The next steps will be the generation of surfaces starting from the extracted edges and points and the texture mapping of the generated 3D model for photo-realistic visualization.

Moreover, different experiments will be performed to test our automated surface measurement algorithms.

Surface reconstruction had to be done to generate a piecewise linear approximation of the object surface from the point cloud (sampled points from the real object surface). Since the geometry is complex, the 2.5D triangulation of the point cloud (the projection of the point cloud into a plane or sphere, performing Delaunay triangulation and lifting back the model into 3D space) generates a topologically incorrect surface model. Thus, a 3D triangulation (Tetrahedralization) followed by surface extraction from the volumetric convex hull is required.

3D surface reconstruction from the 3D convex hull is an open problem even in computational geometry communities. Here, we have employed the most advanced approaches and we've contributed to the improvement of the approach using a neighborhood graph. The approach is

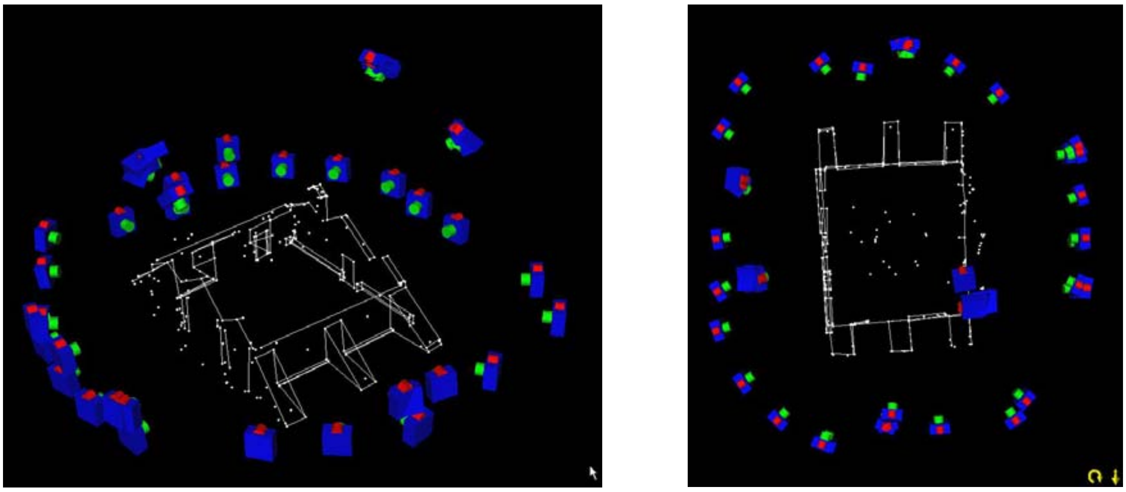


Figure 9: Two views of the recovered camera poses and a wire frame model of the church. Approximately 45 images are employed for the modeling of the heritage object.

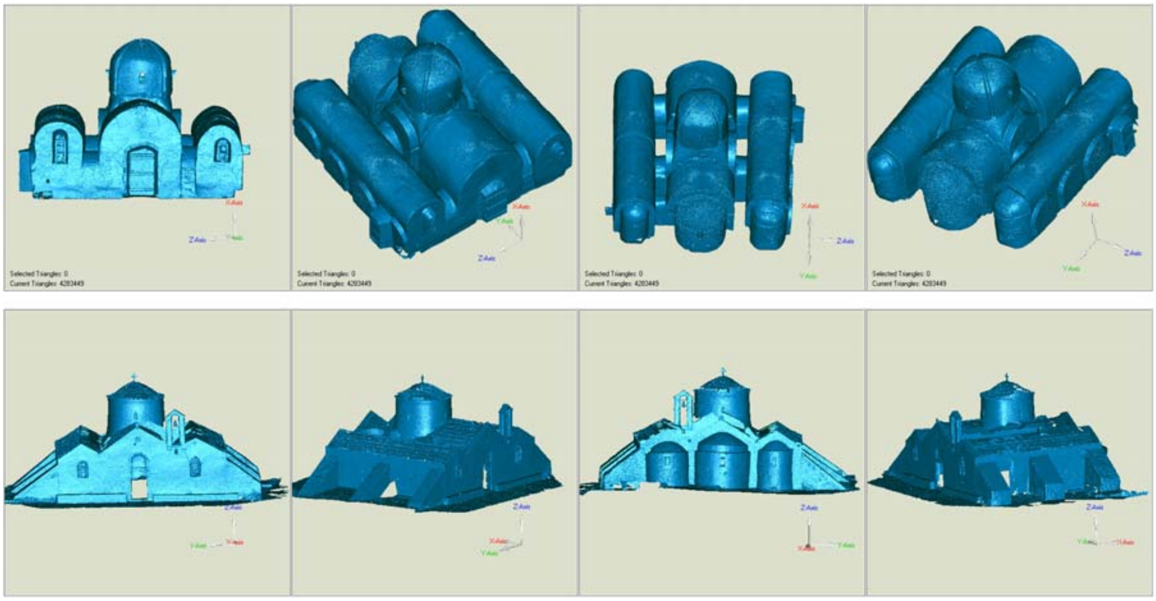


Figure 10: The 3D surface model of the interior (1st row) and the exterior (2nd row) of the Crete church.

based on the pruning of the initial surface model obtained by the extraction of the Gabriel graph from the 3D volumetric convex hull. The pruning is done in several steps based on topological relations, 2D manifold properties, a proximity graph, EMST (Euclidian Minimum Spanning Tree) and a neighborhood graph, KNN (K-Nearest neighborhood), followed by a hole filling process.

Although the implemented approach is not a complete solution of the problem, it shows interesting results. One should notice that most of the process is done automatic and with the minimum user interaction. In addition no threshold or predefined value is required. Figure 10 the result of the algorithm on the point cloud of the church.

In future work, the combination of edges measured from the oriented images, and point cloud data from laser scanning will be integrated in order to benefit from the advantages of both sensor systems.

Interactions

We proposed the following possible interactions, especially with other NEWTONs:

1) *3DKIOSK***:** 3D data acquired and processed in the frame of IMODELASER can be made available for further processing in the pipeline defined by the 3DKIOSK partners. Although editing, registration, decimation and meshing of the 3D data is also performed during processing in IMODELASER, our data may serve as well for the application of these steps by the 3DKIOSK partners, which would allow us to compare and evaluate various approaches for the 3D data processing workflow. Furthermore, the results from IMODELASER, 3D models as well as algorithms, should be disseminated to users via web as planned in 3DKIOSK.
2) *CIMAD***:** 3D models resulting from IMODELASER could be used as additional data which may be associated to contextual data acquired using mobile devices and later be integrated to information systems in museums or for tourism purposes. The proposed

multi-sensor data capturing and the tools and algorithms which are to be developed could be used to acquire and process 3D data in the frame of CIMAD applications.

3) *CHARACTERISE***:** As photorealistically textured 3D models stand at the end of the processing pipeline in IMODELASER, they are well suited to be used as reality-based virtual environments for avatars. Furthermore, the knowledge we have acquired during IMODELASER and previous projects conducted in our group, could be provided for 3D data acquisition tasks in CHARACTERISE.

Highlights:

IMODELASER will contribute to a higher degree of both, accuracy and automation, in the process of 3D data acquisition and modeling. Wide automation is a prerequisite in order to increase the acceptance of modern 3D data acquisition techniques in the cultural heritage community, as it will enable also non-experts to apply 3D scanning and image-based methods for cultural heritage documentation and recording.

4.5 CHARACTERISE

Progress

UNIGE has established an itemized workplan for the Newton CHARACTERISE project. This workplan involved the open-source release of several key software libraries for the VHD++ VR/AR Real-Time Character Simulation framework. A subset of these to be released libraries is scheduled for early pre-release, so that UEA can already design their modules in interoperable and compatible to the VHD++ framework manner.

EPFL is preparing the deployment of the VHD++ kernel by setting up repository of both source code and documentation as well as preparing tutorials helping UEA and other partners to develop their own components within the VHD++ platform. EPFL is now investigating the best opportunities to deploy and provide tools (forum, mantis website …) for the providing active support.

Figure 11: Virtual Humans (UEA)

Figure 12: Hellenistic actors (UNIGE)

Figure 13: Monks (VRLab)

Interactions

UEA will be investigating and integrating where possible UEA virtual human technology with that of EPFL and UNIGE. UNIGE has contributed in the following tasks: a) Unified framework for 3D applications, b) avatar standards for cultural heritage by active participation in the discussions with the other partners and demonstrations of the VHD++ framework and principles during the Brighton EPOCH meeting. UNIGE has also performed a number of compatibility experiments and proposed the adoption on the OpenGL ES Collada format as a 3D data interchange format among EPOCH partners and especially for virtual characters. These compatibility experiments involved testing both COLLADA Discreet 3DSMax and Alias Maya exporters for supporting a number of features for virtual character support, such as linear blend skinning, biped joint animation, multi-texturing, vertex coloring etc. EPFL has contributed in the following tasks: a) Component-Based framework for 3D real-time applications which take advantages of single-post multi-processors architectures such as modern PCs b) XML-base syntax use to configure virtual environments independently from the code base. c) EPFL has performed a number of experiments to choose the most appropriate toolkits for designing GUIS interacting with the VHD++ framework.

5 Testing interoperability using tool chains

From the technical point of view, a tool chain is a cooperating chain of tools. Its purpose is to test the “common” in the Common Infrastructure, i.e., to test and evaluate the interaction of tools. From the marketing point of view, a tool chain is a mini-application, so it could be used to demonstrate the application to potential users in order to show off the possibilities of Epoch tools. But these “showcase like” scenarios are not the primary goal of this research.

As reported in previous deliverables, some Epoch partners are already testing tool chains on their own. At VAST2005 we decided to define a couple of extra tool chains, starting from the accepted NEWTON projects. Since most NEWTON projects specify some interaction between tools, tool chains can be defined with a minimal effort by combining NEWTON projects and/or extending them with a few extra tools.

At the NEWTON kick-off meeting (Leuven, December 2005), the proposals for tool chains were discussed. More tool chains were discussed, but these two were selected to start with:

- Virtual visitor centre for a Cultural Heritage site
  It is built around the NEWTONS CHARACTERISE and 3DKIOSK, possibly with extra input from IMODELASER and UPGRADE.
- Archaeological field survey
  It is built around the NEWTONS CIMAD and AMA, possibly with extra input from 3DKIOSK.

Later on a third one was added:

- Scholarly use of Epoch tools
  It is built around the NEWTON AMA, with input from 3DKIOSK and possibly from CHARACTERISE.

Should tool chains be real applications?

When the first two tool chains were defined, we looked for real environments to test these tool chains. The suggested ones were the museum in Tongeren (Belgium) for the first tool chain and the sanctuary of Timpone della Motta (Italy) for the second one.

However, implementing a real application has several drawbacks. First of all, this application does not fit into the participating NEWTONS as such because (at least some of) the NEWTON projects were not written with this specific application in mind. So some NEWTONS must be redefined to fit in the tool chain (e.g. use Tongeren instead of Norwich within the CHARACTERISE NEWTON). But another major drawback of real applications is that they require a lot of extra work, time and cost. A stand-alone application requires a specific and consistent user interface, which takes a lot of extra work to develop. Furthermore objects have to be moved around (e.g. objects of Tongeren must be scanned with non-movable equipment from Bonn), which takes a lot of time and is very costly.

Therefore, to investigate whether all implementation issues have indeed been successfully addressed, we have allowed the tool chains to be "inconsistent". To ensure our integration works, tool chains should thus be regarded as proof-of-concept implementations, rather than turn-key solutions. It means that a tool chain must show how tools are integrated into an application but the application which is implemented by Epoch does not necessarily have to be historically and/or geographically correct. For instance, we can combine the town of Norwich with objects from Bonn and Italy, all from different centuries. This way we can prove the feasibility of the tool chain with a minimal extra cost.

5.1 Virtual visitor centre for a Cultural Heritage site

The purpose of this tool chain is to allow people to virtually visit sites which are normally closed to the public or which no longer exist. The visitor is guided through the virtual site by an avatar. At predefined places the visitor can examine some objects (e.g. buildings or excavated objects) using a separate 3D-viewer. The visitor can also ask questions about the objects, preferably in his natural language.

Tools from NEWTONS

The whole of the CHARACTERISE NEWTON fits into this tool chain and from the 3DKIOSK NEWTON, the second part about the interactive 3D-Kiosk and the image based rendering is a natural part of this tool chain. Eventually 3D-models from the IMODELASER and UPGRADE NEWTONS could be integrated into the tool chain.

Tools from Common Infrastructure

- Multilingual query-answering for CIDOC-CRM collections (Brighton)
- Image & 3D databases (PIN)
- 3D data editing suite (CNR)
- New house representation and city modeling (Graz)
- Grammar based framework for generating buildings (ETH)
- Visualization of huge data sets (CNR)
- Framework for 3D applications (Brighton)
- Avatars: collision avoidance, XML-based scripting language, and better integration of speech (East Anglia/EPFL/Geneva)

Integration aspects

Tools as well as their interaction are further being specified, certainly non-intra-NEWTON interactions. Some examples are town navigation & avatar steering, and the selection of multimedia formats. (A separate working group is currently looking into the 3D related standards, including X3D and Collada.)

The user interface will be kept very simple. The CHARACTERISE application will be the main program which can be interrupted by user input. So the integration program waits for user input, interprets it and calls the appropriate subtask. The subtasks can be developed independently.

The integration puts it all together, so it is the responsibility of all participants. Additionally a tool chain leader is appointed to follow up the time schedule. For this tool chain, John Glauert accepted this extra task.

5.2 Archaeological field survey

The purpose of this tool chain is to handle all aspects of the acquisition and storage of archaeological data, obtained from a field survey. This includes the mobile acquisition of traditional field survey data as well as landscape data (e.g. its 3D shape) and annotations. All these data and their relationship will be stored into a CIDOC-CRM compliant database, together with existing historical data from other projects.

Tools from NEWTONS

The central NEWTON of this tool chain is CIMAD, more specifically its field survey part. The mapping of existing data to CIDOC-CRM is handled by the AMA NEWTON. For the acquisition of landscape data, the 3D acquisition part of the 3DKIOSK NEWTON seems very suited.

Tools from Common Infrastructure

- Context aware infrastructure MobiComp (Kent/Bologna)
- 3D data editing suite (CNR)
- 3D web tool (KUL)
- Image & 3D databases (PIN)

Integration aspects

The same questions as in the previous tool chain about multimedia and non-multimedia data arise here. But since the applications differ, answers can be expected to be different too. Furthermore, creating multi-modal data by linking all kind of sources together is a very important new aspect here.

The CIMAD framework is the central component in this tool chain. The other tools of this tool chain should be added to it or rather integrated into it. Therefore the tool chain leader comes from this NEWTON, namely Nick Ryan.

5.3 Scholarly use of Epoch tools

The purpose of this tool chain is to demonstrate how tools developed in EPOCH may be used by heritage scholars, such as archaeologists and historians (in various domains: history; art; architecture; science; technology; and so on), in their scientific activity. The matrix below shows a preliminary list of areas in which there is a substantial potential for a scholarly use of EPOCH tools.

Application Type	Data Collection/ Sources	Data Analysis/ Organization/ Management	Data Processing	Geometric & Image-based Reconstruction	Dynamics and integration	Communication
Tool	Tools for data capture	DBMS Ontologies KM tools	Image processing & 3D modeling	3D tools	VR & related tools (avatars, VW)	e-publishing, collaborative tools
Define research questions		X				
Gather information and resources	X	X				
Form hypothesis			X	X	X	
Perform experiment and collect results		X	X	X	X	
Analyze results		X		X	X	
Interpret data and draw conclusions		X		X	X	
Publish results				X	X	X
Formulate & discuss new hypotheses					X	X
Start a new investigation	X					

Tools from NEWTONS

The central NEWTON of this tool chain is AMA. As illustrated in the table above, tools from 3DKIOSK and CHARACTERISE fit in.

Tools from Common Infrastructure

Most Common Infrastructure tools can be integrated, but initially the following aspects will be investigated:

- Image & 3D databases (PIN)
- 3D data editing suite (CNR)
- 3D web tool (KUL)
- House/city modeling (Graz/ETH)

Integration aspects

Since databases are the central component in this tool chain, Franco Niccolucci is the tool chain leader here.