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EPOCH

Excellence in Processing Open Cultural Heritage

Network of Excellence

Information Society Technologies

D3.3.2: 2nd 6-monthly EPOCH Pipeline Description

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University of Leuven

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Dissemination Level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

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Work package 3, activity 3.3: Common infrastructure

Objectives

The second deliverable of WP3.3 in the first year is the architectural design for the underpinning infrastructure, which identifies the required components and the interactions required between them. These interactions will then be compared with candidates for standardised interfaces, to allow development of plug-in components to the common infrastructure.

This gives rise to the following detailed JPA18 objectives for WP3:

1. To define the overall architecture and constituent components of the common infrastructure.
2. To evaluate existing tools as potential constituent components.
3. To identify (with Activity 4.2) the standards to which the common infrastructure should conform and in particular required data types, formats and interfaces to existing systems to which the components should interface.

Description of work

- gathering of the different component working groups to discuss approaches to the development of the Common Infrastructure
    1. multi-lingual and semantic data processing: partners 1 and 71,
    2. databases and technology management: partners 2 and 3,
    3. mobile-wearable-ambient systems: partners 30 and 52,
    4. recording and data representation aspects: partners 4 and 48,
    5. visualisation and rendering: partners 1, 19, and 56, and
    6. multi-modal interfaces: partners 20 and 46
    7. virtual human and other avatar technologies: partners 1, 49, 50, 56

- putting together inventories of available / existing technologies according to the above categories
- identify relevant formats and standards for these categories (consulting with Activity 4.2 as appropriate), and analyse them from a CH point of view

- technical benchmarking of those technologies compatible with CH needs
- these activities are centrally coordinated
- the work is coordinated with that of the Stakeholder Needs team (WP2.1) and Research Agenda team (WP2.5)
- results / conclusions from the showcases produced in year 1 are integrated
- results / conclusions from the Horizontal and Vertical Technology Watches are integrated

Input from other EPOCH teams

Input from the Stakeholder Needs team

The important general considerations from deliverable D2.1.1 for the definition of a common infrastructure are:

- need for a framework to guarantee interoperability among existing systems and facilitate data reuse
- need for sustainability in regard to the accelerating progress of technology
- need to maintain international standards
- need to encourage an open source approach
- attention to safeguarding scientific accuracy during data collection and processing by making a clear distinction between fact and hypothesis

Good interpretation of cultural heritage also means that a wide range of sources (oral, written, research, traditions ...) is used to create the interpretation and presentation, as the result of a multidisciplinary study. Therefore, we need a framework for exploiting all available information sources. In technical terms, this means that its data structures allow information from multiple domains. Today, databases in cultural heritage cover in many cases one single discipline and are not suited to *contain multiple domain information*, created by a *multitude of researchers*, physically *present at different locations*.

To ensure proper involvement of all parties concerned, interpretation technology needs to be anchored within the stakeholders and involved communities, and not be the monopoly of high tech companies. In technical terms, we need an affordable and easy *content management system* as the kernel of interpretation systems, which must be designed to be *adaptable* and *open*.

Input from the Standards team

In the report on standards (deliverable D4.2.1) an extensive survey is made of standards currently used in cultural heritage, not only for museum collections but also for monuments and archaeology. The emphasis is put on standards for documentation and description, not on standards for storage, e.g., of 3D-data.

For archaeology, there is no international standard, but a plethora of national standards. The proposed solution is to check the compliancy of the different standards with CIDOC-CRM and provide mappings between them.

The suggestion is also made that standards should be used which guarantee that no double data acquisition is ever required to produce valuable cultural communication. This implies that we keep all data available for future use. Furthermore, not only the raw data has to be stored, but also metadata and interpretations, including their interrelation.

From the Pipeline to a Common Infrastructure

The other dimensions of the Pipeline

As explained in D3.3.1, there are several orthogonal ways to describe cultural heritage applications. A first dimension consists of the seven *functional technology areas* as described in the application for the network. These areas correspond to the blue numbered boxes in Figure 1. This classifies cultural heritage activities from a computer science point of view.

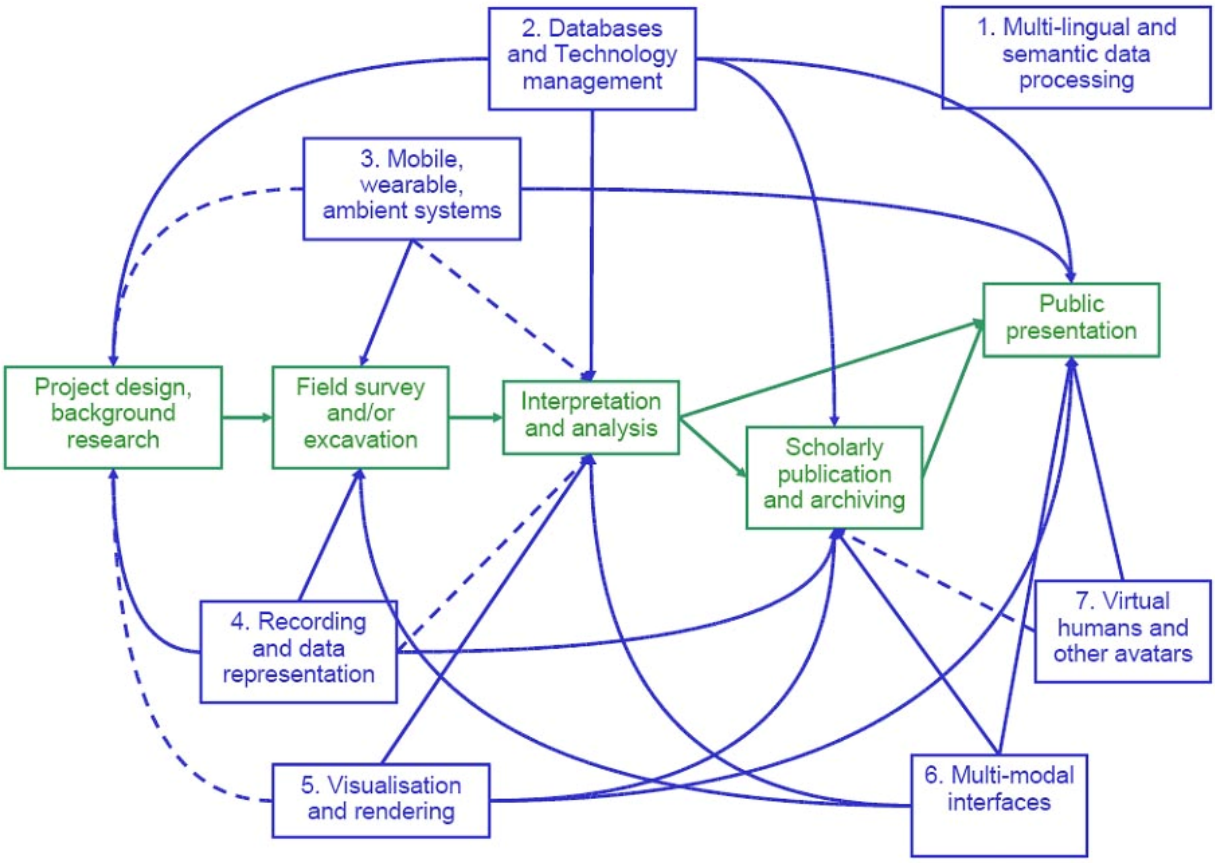


Figure 1: Relation between the typical CH pipeline (the green chain of boxes) and the functional areas (the blue numbered boxes).

A second dimension describes the chain of practice in archaeology and museums. This *cultural heritage pipeline* corresponds to the green unnumbered boxes in Figure 1. This figure also visualizes which technology area impinges upon which part of the archaeological or cultural heritage process, but without the feedback loops and iterations. It is important to note that due to the loops and iterations the process is not a real pipeline where information enters on one side and propagates through transformations towards the end of the pipeline.

A third dimension enumerates the *different tools for the different application domains*. The domains correspond to (subsets of) the different stakeholder communities as described by the Stakeholder Needs team (Heritage Policy, Local Authorities, Cultural Heritage Sites, Museums and other Cultural Heritage Organisations, Associated Communities, Tourism, Education, and Technology). Tools may be specific for a domain or may be shared. For instance, avatars can be used in many applications but Harris matrix tools are very specific to excavations.

This classification is a good way to categorize tools, but it is less useful for defining a common infrastructure for cultural heritage applications. Such an application can be represented by a cloud of points, which cover only a part of this 3D-space. Even for applications with similar goals, their point clouds can be very dissimilar. On the one hand, this 3D-space is too extensive to derive a common infrastructure from it. On the other hand, each dimension in itself is not enough to describe all applications so it cannot be the sole basis of a common infrastructure. Therefore, we need another approach to tackle the problem.

The information processing view

Another way to look at the cultural heritage processing is to follow the information through the application. A first conclusion is that very few applications cover all aspects of data processing in a domain. Most applications deal with only one aspect or at most a few. A consequence of this fact is that applications are not self-contained: they use data from or produce data for other applications, so we need intermediate storage. This is certainly needed if loops and iterations are present, not inside but between applications. Furthermore, data is often re-used by different applications. A final conclusion is that many applications may take their inputs from multiple other applications.

For this kind of processing, the information flow can be depicted as given in Figure 2. All the data is stored in the information store. This data can not only be used to generate output, but it can also be modified or synthesized into new data.

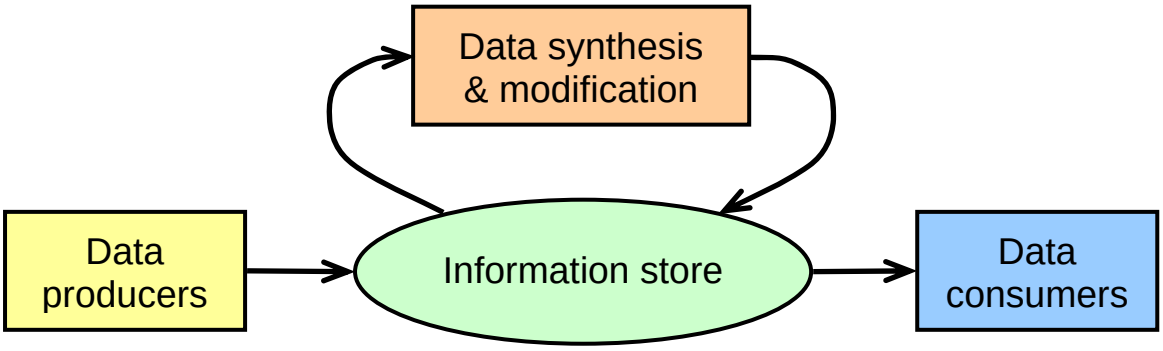


Figure 2: Information flow

The central element is the *information store*. In theory, it stores all cultural heritage data, which was ever produced or which will ever be used by cultural heritage applications. In order to avoid mixing up measured data and interpretation, this store should hold the raw data (the original "mother data" as well as the transformed data) with the accompanying metadata, which describes all extra information and transformations applied to it.

Data is input in the data store in two ways. First of all, *data producers* generate data for it. Examples of such producers are tools to measure/scan objects and field data, or tools to add comments.

Another way to generate data is to *modify or synthesize existing data*. The data synthesis implies that multiple sources are used to generate new data. Examples of these transformations are generation of virtual objects and worlds, annotations, and the interpretation of data.

Finally, the data from the information store can be output to users by *data consumers*. Usually they also use multiple inputs. Examples of data output are not only all kinds of display, with or without user interaction, but also the outcome of queries for information from the data store.

Of course, a real application cannot hold all cultural heritage data and all tools for working on it. In practice we only need a subset of the information store as well as of the tools, just enough to get the job done. If needed for other applications, we can merge it with other information stores. This is not a problem as long as all information stores are based on the same foundation and *data synchronizing tools* are available.

The common aspects of cultural heritage infrastructures

Starting from the information processing view, a few aspects can be found which are common to most cultural heritage infrastructures, namely about the storage and exchange of data. In the next section, these common aspects will be translated into the concepts behind the EPOCH Common Infrastructure.

Essential to a sustainable data exchange is the use of standards. Standards should not only cover the storage/exchange of raw data, but also of metadata, including intellectual property rights and its creation and processing history. It is the responsibility of the tools to keep them up-to-date.

If applications and tools are given, the main problem is their interoperability. When the information flows as depicted in Figure 2, all exchange of data happens in the information store. Of course, one can only devise an appropriate way to store data if one knows how the data was produced and how it will be used. Therefore, applications and tools must be studied to extract what kind of input/output data is used. Not the actual format of the data is important, but its characteristics. From this information a (sub)set of formats, which covers most of the types of data, should be promoted for new tools and applications. If needed, conversion programs can be written for old tools.

The EPOCH Common Infrastructure

The main goal of the EPOCH Common Infrastructure is to enhance the exchange and query of data and interoperability of tools. It should not be seen as a turnkey system from which one can build complete solutions. Starting from requirements and boundary conditions, it should provide guidelines for the information store and the tools to work on it.

Although the word 'pipeline' is often used to describe the Common Infrastructure in the original Technical Annex (JPA1), it is more useful to think of a network of tools that can be linked into multiple pipelines, and where the tools perform transitions between specific data types.

Requirements

To guarantee interoperability, the framework must define rules to extract data from and store data into the general cultural heritage information store.

The framework must be as implementation technology independent as possible, since we want to prevent it from becoming outdated too quickly. This also implies that the framework cannot be restricted to the currently available tools and applications only. It should be able to embrace new emerging technologies.

The framework should not be tied to just one cultural heritage domain. Its concepts should be applicable in most of these domains.

To guarantee sustainability, the framework should be based on international standards as much as possible. The open source approach is also encouraged, but not enforced. Users should be able to use commercial tools and businesses should be able to develop based on the Common Infrastructure.

The information store

The EPOCH information store does not define an implementation, but only a way to exchange data. Real existing database implementations should fit in this concept without too much problems, whatever way they use to actually store the data.

Starting from the evaluation of tool combinations and in cooperation with work package 4, standards are being selected for application domains. Special attention will be paid to the use of a common ontology in order to avoid semantic problems. Another issue of importance will be to ensure that metadata can be systematically moved along with the other data it is related to.

The tools

Existing tools are explored and categorised according to the matrix classification described in D3.3.1. This inventory serves two purposes:

1. It provides a comprehensive overview for new and experienced users.
2. It helps to detect the needs for data exchange protocols.

EPOCH activities towards a Common Infrastructure

Recommendations for standards

The use of standards is an essential part of our concept. For some types of information, the choice of a standard is pretty straightforward. All multimedia based data, including the IPR aspects, is sufficiently covered by the widespread MPEG standards.

For the ontology of the information store, the CIDOC-CRM standard is preferred, as suggested by the Standards team. Because of the existence of established national standards, mappings between those standards and CIDOC-CRM will be provided, for instance by Newton actions.

For other areas, the choice of a standard is far from clear because of its varied applications. E.g., for the representation of 3D-data three classes of applications can be defined: unstructured (at acquisition time), structured (scene-graph based), and geographical. These are described in appendix A.

Finally, as experience with tools grows, application specific parameter settings can be suggested, such as specific XML schemas. This requires a continuing effort to translate this knowledge into guidance on the practical use of standards.

Inventory of Cultural Heritage tools & benchmarking

In the appendix B an updated list of tools is given. The subarea coordinators have been asked to coordinate one (or more) of the functional areas. This will include keeping the list of relevant, existing tools up-to-date for that area with the help of the other partners, monitoring the relevant standards for that area in coordination with the standardisation team, detecting gaps within that cluster of functionalities, etc.

To avoid a proliferation of tools, which only differ in implementation environment, it was decided to promote some environments. A first example here is the adoption of the OpenSG framework for 3D rendering by the Network. Its great advantage is that 3D approaches and techniques developed from different partners can be combined within one and the same application. An example would be a special geometry node from group A, a crowd simulation from group B, and a scanned dataset from group C. Integration with the VHD++ framework will be explored for the area of avatars.

Although benchmarking tools was one of our goals, it proved to be impractical for the current set of tools. Benchmarking is only possible between two or more programs with the same functionality. But most of the programs have a (at least slightly) different audience and/or scope, so it's not fair to compare them. For specific tools, such as 3D scanning, benchmarking is possible but these benchmarks are already available on the web or otherwise (e.g., Spar Point's SparView reports). More information is available in deliverable D3.1.1. Furthermore, some Newton actions will concentrate on these aspects.

It was considered to change the benchmarking into providing an Epoch quality label, which is possible even if no competitors are present. However, this idea was abandoned because of legal difficulties (liability issues in case of criticisms about commercial tools, for instance).

Testing and/or development of tool chains

Tools must be combined to test their interoperability. These tests provide the basis for the definition of the data exchange requirements and they provide their validation.

Such planned interoperability tests based on the combined use of tools include, but are not limited to:

- excavation recording tools and documentation collection
- wearable aspects, from acquisition to presentation
- 3D acquisition – 3D data editing – OpenSG based rendering
- procedural 3D modelling of large environments – 3D data editing and decimation – fast rendering

To properly conduct tests, one needs a repository of data. So one of the goals is to provide such a repository or to provide access to existing ones. For instance, repositories for 3D information and avatars are needed. Instead of a physical repository, a link repository might be more appropriate. In this context, the Network will investigate the need for Digital Object Identifiers (DOI).

Appendix A:
Standards format and procedures for CH 3D scanning

3D scanning technologies have evolved considerably over the last years. Yet, these developments involved mainly non CH areas: reverse engineering and entertainment. In these two areas 3D scanning technologies were able to solve a set of well-defined issues and to do so in an economically advantageous way. For example 3D scanning technologies are often used in the process of building digital models of hand made prototypes.

One of the reasons why this has happened is because the specifications involved were clear directly from the beginning. For example, when turning a real hand made wooden prototype into a digital 3D CAD model, the final required precision and the format of the final data depend on the manufacturing work flow. In other words, in most industrial fields 3D scanning has covered a well-defined niche in an established workflow where formats, procedures, expectations, and precision are pre-defined.

On the other hand, in the CH world the requirements and even the final objectives of 3D scanning are not well defined. In spite of many successful scanning campaigns in which famous artefacts and sites were digitally acquired, the actual advantages that they brought are not always clear, especially not from the point of view of CH scholars. The most evident result often was the acquisition itself and the production of a nice multimedia event aimed at the public or to the press. Without a recognised need of employing the 3D data in an established pipeline the necessity of adhering to existing standards and formats never emerged, and, consequently, the data of many scanning campaign lie somewhere unused and often coded in some proprietary, closed format.

For the same reason the tools that are used to process and prepare data collected during 3D scanning campaigns are often those used in industry and architecture, and which are geared towards different objectives. For instance, for the editing of 3D scanned data of medium scale objects (like statues or detailed artefacts) the tools more commonly used are Rapidform (Inus Technologies), Polyworks, and Geomagic. All show high performance in the field of reverse engineering (for example they include tools for helping building a parametric or NURBS based representation) but have evident limitations or even fail when processing very large data quantities as needed to recover all the details of a complex statue. In the industrial world this kind of problem does not occur because usually the object can be decomposed into smaller pieces (according to the manufacturing process).

Similarly, in the architectural field time-of-flight scans can be considered as extensions of the classical point-point theodolite based measuring tools. This kind of considerations has driven the design of the software tools coming with the Leica/Cyrax class of scanners, one of the market leaders in the range of the time-of-flight scanners. These tools are able to manage all the acquired data mainly as point clouds instead of triangulated surfaces.

In conclusion, the current status exhibits the following negative aspects that could/should be (at least in part) answered by the actions taken by the EPOCH network.

1. In CH related fields there often only is a superficial knowledge of the real potential of 3D data for CH (beyond the pretty pictures)
2. There is no single, established standard format (i.e. there are many different standard formats for 3D data, but often people do not use them). Collected data risk to be dispersed/underused/lost.
3. There are no standard acquisition procedures, so the process of acquisition itself is not recorded and the quality of the final data is often unknown.

Point 2 and 3 could be remedied by specific actions. Regarding point 2 at least two observations have to be made, which are discussed next.

Existing formats

Nowadays there exist many different 3D data formats. Most of them are tied to some application/environment (3ds/obj) and no single format can be used for all possible purposes. This issue can be solved by defining at least three classes of 3D data and choosing for each one a preferred format.

1. *Raw:* Simple unstructured raw 3D data, mainly as a collection of triangles or points, eventually with attributes on the single primitives (like color, texture); they are able to manage very large datasets. *Examples: ply, stl*
2. *Structured:* scene graph representation. Very versatile, able to structure data according to the semantics of the model. Well suited to represent modelled environments or collections of scanned objects that are included in reconstructed environments. *Examples: wrl 3ds, obj, and many many others.*
3. *Geo-referenced/topographic scale:* large dataset, of architectural entities usually obtained with time-of-flight technologies (like an archaeological site, or a monumental facade); this data could/should typically be integrated with GIS databases.

Other classes of formats could be described like for example those based on generative languages.

Encouraging format adoption

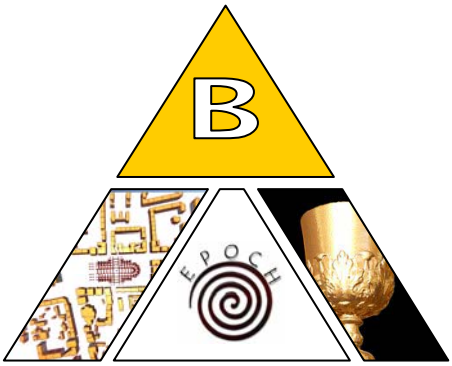
It should be noted that in general the adoption of a given format is something that is is quite difficult to obtain in practice. Probably one of the best approach is to provide some added value to the users by means of open tools that follow the above formats. This could be the case of some of the newton projects submitted. If the tools are sufficiently attracting it should make that the chosen formats gain visibility and could help them to become diffusely adopted.

Standardizing Acquisition Procedures

As to item 3 of the first list, the documentary value of a scanning campaign is also strongly related to how the scanning was performed. 3D scanning, especially in the CH arena, is not a *black box* standardized tools. There are many variables that can affect precision, confidence, repeatability, and completeness. For this reason it is important that other information should be collected during a scanning campaign. A short and possibly incomplete list of valuable data to be collected and distributed together with the final data includes:

1. *Hardware specifications:* brand, type and technical characteristic, nominal precision, etc.
2. *Precision:* what was the final estimated precision that could be assumed at the end of the scanning action (due to the many different kinds of overlapping errors that are involved), possibly considering uncertainty and sampling density issues.
3. *Completeness*: How complete was the scanning campaign. What percentage of the surface has been covered and acquired, how and when missing parts were reconstructed,
4. *Postprocessing:* detailed info on the postprocessing tools used during the generation of the final model, starting from the raw samples; what aligning algorithms or software package were used. How range maps were integrated. Subsampling and decimation issues should also be clearly reported.

Nowadays this information is not simply and directly available for many completed and publicized scanning projects; when available often the above data are scattered over many different (and sometimes labile/unstable) sources like papers, web sites, manuals of discontinued software tools. And this makes it quite difficult to effectively compare and review scanning actions. One of the consequences is that CH institutions may find it difficult to evaluate if a commissioned scanning campaign has been performed as it should have been.



Appendix B: Updated list of tools

The tools are described using the same matrix structure as used in the previous report. This matrix structure is an alternative view of Figure 1.

	1 Multi-lingual and semantic data processing	2 Databases and knowledge manage-ment	3 Mobile wearable ambient systems	4 Recording and data represen-tation	5 Visuali-sation and rendering	6 Multi-modal interfaces	7 Virtual humans and other avatars
A Project design, background research	1A	2A	3A	4A	5A	6A	7A
B Data acquisition	1B	2B	3B	4B	5B	6B	7B
C Interpretation and analysis	1C	2C	3C	4C	5C	6C	7C
D Scholarly publication and archiving	1D	2D	3D	4D	5D	6D	7D
E Public presentation	1E	2E	3E	4E	5E	6E	7E

1A
Project design, background research
Multi-lingual and semantic data processing

Key words: multi-modal retrieval

In this area several promising projects exist. Some of the more interesting are:
- CIMWOS: Archiving and retrieval of words and images
- DRUID III: Multimedia indexing and retrieval on the basis of Image Processing and Language and Speech Technology
- Mumis: Multimedia Indexing and Searching Environment

1B
Data acquisition
Multi-lingual and semantic data processing

Key words: knowledge extraction

Clarity (Cross Language Information Retrieval and Organisation of Text and Audio Documents) was an IST-project. A demo is available.

Texts in classical Greek, early modern Latin and old Norse are digitalized by the Cultural Heritage Language Technologies project, In this project also tools and resources are developed and/or adapted to enable for example multilingual information retrieval in these languages.

1C
Interpretation and analysis
Multi-lingual and semantic data processing

Archaeology - spell checker is a custom spell checking list for archaeology - in a number of word processor formats. It can be downloaded here as a zipped file or a self-extracting file.

The Penguin is a computer application for grammar and spell checking that makes use of the whole of World Wide Web as its database. Because it draws on the Web, rather than a static, local dictionary stored on your computer, it works with every language, it continually expands as the Web grows, and is hence updated every second.

1D
Scholarly publication and archiving
Multi-lingual and semantic data processing

Key words: machine translation

Comprendium Online Translator is a free machine translation tool offering informative translations of either web pages or texts up to 1000 characters for quite a number of languages pairs (languages currently involved: Catalan, Spanish, French, English, Italian, German, and Russian). It deals with general vocabulary, common social vocabulary and common technical vocabulary.

BabelFish Translation also offers free translations for texts up to 150 characters, or web pages. It gives informative translations, and among the languages for which translations can be provided are Chinese, Japanese, English, German, French, Dutch, Italian, Spanish, Portuguese and (modern) Greek.

Systran offers free MT translation (languages involved are a.o. English, French, German, Spanish, Dutch, Portuguese, Swedish, Russian and Arabic) of small texts (up to 150 words) or web pages (informative quality). It also offers professional translations.

1E
Public presentation
Multi-lingual and semantic data processing

Key words: machine translation, speech recognition, text2speech

The IRST Al Fresco system is a museum guide that sits on a hand-held device. It takes visitors round an Italian museum, and is multilingual, but with no VR. “ALFRESCO is a prototype with the purpose to exploit the potentiality of integrating natural language with other communicative modalities”, so it is multimodal. “The approach relies on the technological possibility of moving in a rich information space with rapid interleaving of different information and different media, and on the high-level integration into a coherent information seeking dialogue”.

The ILEX system system generates dynamic labels for visitors to a Scottish museum. It is a web based system, is not multilingual and does not involve any VR. The focus of the project is automatic text generation, in order to “produce descriptive, explanatory, or argumentative texts to accomplish various different communicative tasks”. The very dynamic nature of the labels “has a number of advantages, such as taking into account the visitor's level of expertise about the objects, as well as the discourse history —the objects which the visitor has already seen— so that information the visitor has already assimilated can be taken into account description of the object currently being viewed can make use of comparisons and contrasts to

previously-viewed objects, while omitting any background information that the visitor has already been told".

M-PIRO is an extension of the ILEX project. While "ILEX served up personalized information objects", M-PIRO main advance is that "it develops an authoring tool (developed at NCSR "Demokritos") to help museum creators create and edit the domain-specific knowledge base and linguistic resources". It is multilingual, uses a museum guide, but no VR, although one partner ("Foundation of Hellenic World") "have been working on a new M-PIRO prototype that will embed the project's technology in their immersive VR system".

The NICE project has just completed and a working system can be used by visitors in the Hans Christian Museum in Odense Denmark. "NICE aims to demonstrate universal natural interactive access, in particular for children and adolescents, by developing natural, fun and experientially rich communication between humans and embodied historical and literary characters. The communication consists of domain-oriented spoken conversation combined with 2D input gesture into a 3D dynamic graphics virtual world inhabited by the fairy-tale author Hans Christian Andersen and animated characters from his fairy-tale universe. For the first time, professional computer games technologies are joined with advanced spoken interaction, and speech recognition technology is specially developed for recognising the speech and spoken linguistic behaviour of children and adolescents".

NECA promotes the concept of multi-modal communication with animated synthetic personalities. A particular focus in the project lies on communication between animated characters that exhibit credible personality traits and affective behaviour. The key challenge of the project is the fruitful combination of different research strands including situation-based generation of natural language and speech, semiotics of non-verbal expression in situated social communication, and the modelling of emotions and personality." The i-Guide showcase was heavily based on the NECA architecture.

MBROLA is a free Phoneme-to-Speech system which includes many voices, among them English, French and German, for which a free Text-to-Phoneme is also available.

FreeTTS is a speech synthesis system written entirely in the JavaTM programming language. It is based upon Flite: a small run-time speech synthesis engine developed at Carnegie Mellon University. Flite is derived from the Festival Speech Synthesis System from the University of Edinburgh and the FestVox project from Carnegie Mellon University. Free.

Festival offers a general framework for building speech synthesis systems as well as including examples of various modules. As a whole it offers full text to speech through a number APIs: from shell level, though a Scheme command interpreter, as a C++ library, from Java, and an Emacs interface. Festival is multi-lingual (currently English (British and American), and Spanish) though English is the most advanced. Free.

Flite is a small, fast run-time synthesis engine developed at CMU and primarily designed for small embedded machines and/or large servers. Flite is designed as an alternative synthesis engine to Festival for voices built using the FestVox suite of voice building tools. Free.

ViaVoice is a multilingual commercial TTS.

Nuance is a multilingual commercial TTS.

WaveSurfer is an Open Source tool for sound visualization and manipulation. It can be used as a stand-alone tool for a wide range of tasks in speech research and education. Typical applications are speech/sound analysis and sound annotation/transcription. WaveSurfer can also serve as a platform for more advanced/specialized applications. This is accomplished either through extending the WaveSurfer application with new custom plug-ins or by embedding WaveSurfer visualization components in other applications.

SVOX Mobile is the industry's first concatenative text-to-speech for mobile operation systems, such as the Symbian OS, Windows CE and others. Commercial software.

ScanSoft RealSpeack SOLO is a Text-To-Speech (TTS) solution, optimized to enhance embedded conversational applications. Commercial software.

ScanSoft VoCon-3200: he ASR Embedded Development System is a complete rapid programming and scalable deployment solution for adding speech recognition to embedded applications. Commercial software.

Sphinx: The packages that the CMU Sphinx Group is releasing are a set of reasonably mature, world-class speech components that provide a basic level of technology to anyone interested in creating speech-using applications without the once-prohibitive initial investment cost in research and development; the same components are open to peer review by all researchers in the field, and are used for linguistic research as well. Open source.

Sayz Me is a very simple text to speech reader. Copy text from web pages, emails or documents and this free utility will read the words out aloud to you. Sayz Me uses the Microsoft speech engine and synthetic voices. Listen to text and give your eyes a rest. Great accessibility software as you can adjust the font size and color to assist reading. Very simple and easy to use. Best of all its free. Open source.

2A
Project design, background research
Databases and knowledge management

Key words: multi-modal retrieval (by expert)

The Oxford ArchDigital custom designs server- and client-based solutions that integrate databases, multimedia, and geographic information. Their solutions are built around a series of modules that function independently, or combined to form an extremely powerful Content Management System. Oxford ArchDigital builds for applications for all platforms (particularly Windows, Linux, and Unix) and wherever possible uses open source solutions including PHP, MySQL, and Apache.

ForeSight DXM (Data eXchange Manager) gives you better ways to view, manage and analyze your survey data. You can easily transfer data from Survey ProTM to your laptop or PC so you can use it to see your survey graphically. ForeSight DXM helps you manage project files, check data for accuracy and completeness, make simple edits and prepare data for your field survey or CAD development. Commercial software.

Photonet is a graphically-orientated automated cataloguing system for collections of aerial photographs. It was created in response to the needs of the Royal Commission on the Historic Monuments of England, the custodians of the National Library of Aerial Photography. The initial target machine was a Digital MicroVAX.

2B
Data acquisition
Databases and knowledge management

Key words: (distributed) databases

IDEA - Integrated Database for Excavation Analysis models the structure of archaeological data recording, rather than a specific data recording method, and then provides the user with a view of their data which corresponds with their method of data recording. IDEA is a relational DBMS written in Microsoft Access and provides a flexible, user-customisable framework for recording data from archaeological excavations. IDEA does all the hard work of establishing a 'clean' relational structure with around 80 tables, but it is in no way prescriptive about what is to be recorded or how it is to be recorded. IDEA accommodates archaeological concepts such as stratigraphic relationships, artefact 'lots', refitting sequences, reconstruction from fragments, hierarchical classifications, grouping of deposits into features, phasing etc., as well as many-to-many links such as those between artefacts, deposits, features and the drawings and photographs on which they appear. These are data structures which are often too complex to be incorporated directly into the structure of project-specific systems. IDEA handles all these structures without programming - relationships and classificatory schemes are built through menus and data entry forms.

Integrated Archaeological Database System, IADB's concept was formulated over five years ago. The project was initiated by Stephen Stead and has been developed by Michael Rains with archaeological support from Peter Clark and Richard Sermon. The IADB is built around the SUAT site recording system which itself has undergone development and refinement over time. The overall structure is essentially hierarchical and consists of five levels: Finds, Contexts, Sets, Groups, and Phases. The first two levels, Finds and Contexts, are formed by the Level II site records.

Minark DBMS is a DOS-based flat file DBMS with many features targetted at archaeological and other types of data characterised by coded data, repeating fields, missing data & free-format text. Minark will run in a DOS window under Windows. Minark was developed by Ian Johnson between 1981 and 1988 (Version 4.12) with further development in 1989-91 leading to Version 5.

Plot is a Windows based GIS for working with artifact data. It allows the user to map any group of squares or levels, to color code the map by artifact type or level, and to link the artifacts on this map to their respective records in associated tables. This program was written to deal with total station and analysis data from the Paleolithic sites of Fontéchevade and Pech de l'Azé IV. Others have adapted it to their own sites. The install includes two data sets (Microsoft Access format). One is an empty database with minimal database structure. The other is a sample from one unit at Combe-Capelle Bas.

DSpace is a digital repository designed to capture, store, index, preserve, and redistribute the intellectual output of a university's research faculty in digital formats. DSpace manages and distributes digital items, made up of digital files (or bitstreams) and allows for the creation, indexing, and searching of associated metadata to locate and retrieve the items. It is designed to support the long-term preservation of the digital material stored in the repository. DSpace is also designed to make submission easy: DSpace Communities (such as university departments, labs, and research centers) can adapt the system to meet their individual needs and manage the submission process themselves. Open source.

Intrasis (Intra-site Information System) is an archaeological information system for recording and managing field data. The system is based on GIS technology.Intrasis can be modified to suit many different kinds of excavations. There are basic functions built into the system to store and process data information. Several functions and extensions make Intrasis an powerful support for archaeologists.

Oracle DBMS: Commercial DBMS, suited for multimedia, spatial, textual and further data types. Requires database knowledge on the user side. Free license for development available on the internet.

MySQL: Free object-relational DBMS software, providing among other things a spatial data format.

2C
Interpretation and analysis
Databases and knowledge management

Key words: data mining

ArchaeoPackPro! is a software package that unifies all the elements of computer usage during archeological campaigns and provide an interactive research tool for data analyses after campaign ends. It uses a unique graphics user interface in 3D environment, allowing simultaneous and interactive work with the 3D terrain model, Databases, Statistical and mathematical analysis, 3D models of archaeological finds, etc. It will open a new chapter in archaeological documentation and interactive fieldwork, offering an ultimate context preservation tool for versatile field documentation, its safekeeping, flexible presentation and publication possibilities for a new age archaeology.

Re:discovery's Archaeology Module provides a complete record-keeping and interpretive research database for artifacts and their original context (site, major site features, excavated opening, and level). The archaeological records are integrated with the objects database to manage cross-mended objects and a study collection. As with all Re:discovery modules, the screen format is flexible to best reflect the nature of the artifacts and the kind of information being tracked. Commercial software.

ArchaeoData is an excavation database on Microsoft Access, developed since 1998 by ArcTron GmbH. This incorporates project management and finds processing, a scientifically defined finds book, and image processing, including the systematic recording of archaeological data. This database processes a wide ranging level of reports, as well as handling plans and profile sections. The description formulas are developed around various archaeological criteria, such as pedology. The database can search and print out detailed archive material quickly via different adjustable data sourcing. Commercial software.

Cart@net, developed by Planetek Italia, is the solution for the management and consultation of large raster datasets, ideal to distribute on-line catalogs of cartographic data. Cart@net allows to visualize and interrogate a cartographic vector database by Internet, effecting researches based on graphic and alphanumeric standards, and to visualize the raster cartography related to the area of interest. In fact the whole raster database is accessible, without solution of continuity, together with the window of the vector data. The system, developed to integrate with vector servers, results perfectly integrated with both Autodesk Map Guides, server for the distribution of vector cartography, that allows to create, publish and distribute extremely detailed vector maps on Intranet and Internet, and Image Web Server, for the distribution of raster data.

DILAS (Digital Landscape Server) is designed for the efficient generation, management and visualisation of large 3D city models. With DILAS it is now possible to establish and maintain high-resolution regional to national 3D landscape models within an integrated database environment. DILAS is a modular extension of GRIDS, GEONOVA's well-established high-performance imagery and height data management solution.

2D
Scholarly publication and archiving
Databases and knowledge management

Key words: multi-modal retrieval

M3 - minisis management for museums is one of the worlds top cultural assets management applications. This tailored application for Museum Management created via the SMA (Standard MINISIS Application) enables members of the art, museum, archaeology and natural science communities to manage their mission critical tasks. At the same time, given the SMA toolkit, clients are permitted further customization to meet the changing demands of this ever-evolving industry.

Museolog is a software system, developed by EUROCLID within UNESCO HeritageNet project, and localised by NGO Open Systems where initial functions of input and editing of museum catalogues are provided by a modern intuitive graphical interface using forms and menu.

Elettra is a Media Asset Management platform designed for the preservation and exploitation of huge media archives. Elettra was born in the context of the Radio RAI Audioteca project, which ruled the moving from analogue to digital of more than 300.000 broadcasting hours.Elettra supports the processes of digitisation, storing, organising, searching and retrieving of specific content from source media or digital archives. Commercial software.

ADLiB Museum is an integrated Collections Management Application designed to support Spectrum procedures. The system is configurable to meet the requirements of individual Museums. ADLIB Museum includes integrated imaging and comprehensive terminology control facilities. Public access searching is available, with optional access through XML and ASP based web interface. Commercial software.

Museum-Online is an Austrian company providing services to museums. These services include a system for archiving museum objects in a database and the development of the museum's website.

Image management software: a selection of commercially available systems can be found at http://www.tasi.ac.uk/advice/delivering/pdf/ims-software.pdf.

3B
Data acquisition
Mobile wearable ambient systems

Key words: portable logging tools, AR overlays

Fundacion Atapuerca: IBM BIS developed a console application allowing direct access from the server – or a network-connected computer – to the database for checking all the information which researchers entered from the field. The IBM Wireless e-business solution also includes a number of functions so the system can record previous data, requiring researchers to write a minimum amount, and an information-checking system which detects possible data errors.

FieldMap is a context-aware data collection and information access tool for use in field sciences.

The RAMSES project aims at the deployment of a system, allowing the archaeologists to communicate in real time not only with text, but also with drawings, to other field hosts and to the rest of the scientific community, using the fixed host as a gateway to Internet. The software counterpart of this project consists on two subsystems:

1. ARCHEO is a graphical software for archaeological excavations developed for Microsoft Windows 3.x (or higher) and presently installed on mobile, pen-based system. Archeo allows, through a user friendly graphical interface, the introduction of data in form of drawings or text (or both); its particular design is intended for the use on pen-based computers, where the mouse and the keyboard are not available and the user is forced to insert data by hand.
2. A.D.E. - Archaeological Data Environment is the receiver/container application installed on fixed hosts present at base camp. All of the portable computers present in the field can connect to A.D.E. to send or receive information. A.D.E. purposes are the following:
   - Provide physical storage for portable computer's data
   - Management of radio network
   - Connecting the base camp to remote host with WAN
   - Gateway to Internet

3D
Scholarly publication and archiving
Mobile wearable ambient systems

Key words: smart tags

The Matrix Public Network is a little system of distributed publishing where everyone is a potential publisher and everyone is a potential subscriber. As a node on the network, you can subscribe to any of the other nodes and the little audio messages the node sends out to the network go to that node's subscribers.

3E
Public presentation
Mobile wearable ambient systems

Key words: VR/AR technology, portable museum guides, smart tags & positioning technology

The PAST project has designed and developed an advanced ICT infrastructure (the PAST system) which exploits a number of key technologies, among which, in particular: handheld PCs, wireless networks, dynamic user profiling techniques, dynamic scheduling and planning techniques, XML technologies. In the new PAST scenario a person entering an archaeological site receives a Handheld PC (connected via wireless network a PAST Server at the site headquarter). The tourist will use the Palmtop all the visit long. He will register himself in to the system providing few personal information about himself, his interests, the time available for the visit, etc. The PAST system, based upon such few data, is able to profile the visitor and to organise a personalised plan for the visit. PAST is able to guide him across the site, pointing him out specific items (e.g., a building, a ruin, etc.) and delivering via the handheld

PC context-specific, relevant information (such as photographs, drawings, movies, text, etc. from an XML native database). Besides the amount of information, the level of details and the way of presenting them is not fixed, but rather different for different visitors, based upon system knowledge of the visitor's profile.

The augurscope is a portable mixed reality interface for outdoors use. The augurscope consists of a tripod-mounted display that can be wheeled to different locations and then rotated and tilted to view a virtual environment that is aligned with the physical background. Video from an onboard camera is embedded into this virtual environment. The augurscope utilises a GPS receiver, electronic compass, accelerometer and rotary encoder to acheive global position tracking at the same time as smooth local interaction. In August 2001 we tested an initial application in which the public explored Nottingham's medieval castle from the site of its modern replacement. Analysis of use revealed issues with lighting, movement and relating virtual and physical viewpoints, and showed how environmental factors and physical form affected interaction.

Ekahau Positioning Engine (EPE) software enables location tracking in any standard Wi-Fi network (802.11 a/b/g). Unlike competing technologies, that require expensive special infrastructure on site, EPE is a pure software-only solution that works with any off-the-shelf Wi-Fi access point.

WHYRE is a wearable, hands-free, sensory augmented, context-aware MultiMediaGuide, designed to turn museums and archaeological sites into communicating machines. With WHYRE a visitor can access simultaneously the exhibits and the related multimedia contents through a minimal context-dependent interface. WHYRE was developed within MUSE, a research project conducted by Ducati Sistemi S.p.A., in co-operation with the University of Bologna, the Politecnico di Milano, and other partners. WHYRE is based on an IA32 mobile platform and its operating system is Windows XP Embedded. A sensor module includes a GPS receiver, a compass, two accelerometers and a gyroscope. The sensors provide position, azimuth, as well as roll and pitch information. The platform is controlled by the application "MuseXPRunner", consisting of an execution engine coupled to an XML interaction definition file. The XML file specifies the policies while the engine implements the capabilities. Prototype of a commercial product.

A key element of EQUIP is its shared data service, which combines ideas from tuplespaces, general event systems and collaborative virtual enviroments. EQUIP has been used in several projects within the EQUATOR Interdisciplinary Research Collaboration (IRC) in the UK. One of these projects is augurscope (cfr. supra).

The Mariposa nomadic system offers the public interactive, targeted multimedia contents next to the works of art that are displayed in the museum. These appliances follows visitors as they are wandering around the rooms and give oral and visual comments according to where they are located in the museum.

4B
Data acquisition
Recording and data presentation

Key words: portable logging tools, geophysical methods, 3D acquisition On-site feedback

ShapeWare (Eyetronics) is a 3D scanning solution that captures objects, faces and bodies in 3D. ShapeCam consists of a digital camera and a specially designed flash device mounted on a lightweight frame. It allows users to freely move around objects of almost any size, capturing 3D geometry and textures by simply taking pictures. Photos captured with the portable ShapeCam are processed and assembled in 3D within the ShapeSnatcher Suite software. The process produces fast and accurate 3D digital models. It creates the shape and colors of the original object, face or body in 3D. Commercial software.

ShapeCapture is a software package for accurate 3D measurement and modeling. Several commercial software packages are now available for modeling from images. However, most of these approaches do not demonstrate high geometric accuracy sufficient for applications other than visualization. ShapeCapture™ is a software tool that implements our approach to creating highly accurate 3D models from images. Areas of application where it is currently in use covers Aerospace, defense, industrial process, control and measurement, architecture, archaeology, 3d animation, forensics, support for laser scanning and 3d sonar support.

Archimedes3D is the architecture, measurement and documentation system for buildings. The key features are geodetic and photogrammetric programs that support local measurements and are used in the production of facade documentation. Discover Archimedes3D for itself and get a picture of the system.

The ModelMaker W is manufactured by 3D Scanners UK. The system consists of a scanning head mounted onto a Faro arm attached to a tripod.The scanning head is designed to be held in the hand and the path of the laser strip is controlled manually.

Proleg Stratigraf is the complete framework for field archaeologists that allows you to record, document, analyze and interpret archaeological sites. It integrates in a single place field registration data, photography, bibliography, artifacts inventory, the archaeological drawing and the Harris matrix, creating thus, a real Digital Model of the excavation. The model provides you with a vision of what the site is really like and therefore the ability to act and interpret based on totally reliable information. Various versions (LITE, PRO) provide progressively more powerful registry and interpretation tools. Commercial software.

TheoLt is a data capture application that can be used on site by non-surveyors, using data directly from the reflectorless EDM equipment, producing CAD data files on site in standard AutoCAD DWG format.

RiSCAN PRO is the companion software for the RIEGL's LMS-Z instrument series of 3D laser imaging scanner systems. RiSCAN PRO is project orientated, i.e., the entire data acquired during a measurement campaign are organized and stored in RiSCAN PRO's project structure. These data include the scan data itself, coordinates of control points and tie points,

and all transformation matrices necessary to transform the data of multiple scans into a common well-defined coordinate system. Furthermore, in case the scanner is equipped with an optional High-Resolution 'HR' digital camera, camera images are also managed by RiSCAN PRO.

DVP provides the user with a comprehensive photogrammetric package. DVP Complete W/S incorporates functions for the superimposition of vector data and the import of numerous image formats. It also includes DXF, DGN and ASCII translators, MicroStation and AutoCAD interfaces as well as visual project manager, namely the DVP Visual Model IndexTM. DVP Complete W/S also integrates functions that facilitate the automatic or manual reading of orientation data.

4C
Interpretation and analysis
Recording and data presentation

Key words: shape analysis

The Bonn Archaeological Software Package (BASP) is a non-profit software project for and by archaeologists which has been developed cooperatively since 1973. It now includes more than 70 functions for seriation, clustering, correspondance analysis, and mapping tools for archaeologists working with IBM compatible PC's under DOS and all versions of Windows. It also includes programs for three dimensional display of data, for finding rectangular structures in scanned excavation plans containing thousands of postholes, and for the rectification of extremely oblique aerial photographs and their superimposition on large-scale scanned maps under Windows NT/2000 and Windows 95/98/ME.

ArchEd is a tool for drawing Harris matrices which are used in archaeology. Beside its ability to edit such drawings it also contains an automatic drawing feature which redraws a given graph nicely. A similar program was developed at the Amt für Bodendenkmalpflege in Bonn in 1990. While this older program runs on DOS - systems and uses the keyboard as input device, ArchEd runs with Win2000, XP or WinNT and can also use a mouse as input device.

Proleg MatrixBuilder is a unique software for archaeologists that automatically generates a fully customizable and error-free Harris Matrix taking into account all context chronologies. It is a product ideally suited to those interested in adding an "off the shelf" matrix-drawing tool to their existing excavation recording system.

gnet - jnet is a graph browser/editor that can be used for visualising, analysing and exploring archaeological stratigraphy and other directed graph-based data. Gnet development ceased several years ago. More recently an entirely new project began to develop jnet a program with similar functionality, but capable of working on a wide range of devices from handhelds to servers and supporting collaborative graph manipulation.

STRAT has been designed for archaeological interpretation in 3D space. Strat has the capability of combining legacy stratigraphy data from notebooks with contemporary photogrammetric data.

ArcDig is a Windows program designed to present information about an archaeological site in a new way. ArcDig is a program that allows you to dig down through a site's layers, discover and examine finds, and go to web pages giving further information about them. Open source.

Phidias is a powerful digital photogrammetric system which is used for any kind of image measurement. PHIDIAS is integrated into MicroStation and well suited for 3-dimensional documentation of complex buildings and facilities.

SIDGEIPA is mainly dedicated to the management and retrieval of the archaeological information, including a number of useful functionalities in order to assist the archaeologists as well as the fieldwork researchers in the tasks of storing, processing and exploiting the obtained information related to excavations. The tool is even now in continuous evolution, being improved with new functionalities as they are suggested by users.

4E
Public presentation
Recording and data presentation

Key words: 3D acquisition, space representation, user profiling

The TimeMap project is researching methods for recording, indexing, analysing and delivering Humanities data with spatial and temporal components. We add value to historical and contemporary information by making it accessible on the web through indexed access to scattered resources, interactive maps, timelines and map animation.

5C
Interpretation and analysis
Visualisation and rendering

Key words: data visualisation techniques (cf. economic analysis), procedural methods

PhotoModeler software offers archaeologists and anthropologists a unique tool for conducting research and performing analysis in their work. (MS): "Photogrammetric software package suited mainly for close range photogrammetry. Image orientation and 3D data acquisition for small objects and architecture documentation and recording. Commercial software. very easy photogrammetric software for image triangulation, bundle adjustment and object reconstruction. Allow the definition of lines/edges which can be imported as constraints in the

bundle. Allow only manual measurements of the points. It's a black box providing few statisic info on the adjustment. VRML output of the reconstructed 3D model."

Australis 3D: Photogrammetric software package suited mainly for close range photogrammetry. Image orientation and 3D data acquisition for small objects and architecture documentation and recording. Provides also camera calibration and 3D transformation functions. Commercial software. (MS): "Good bundle for camera calibration and image orientation. Less function than Photomodeler, but more reliable. no VRML output. Allows automatic measurements in case of coded targets."

XLimage 2.0 allows all Internet/intranet/2,5G/3G users to view high resolution images quickly and interactively. It is therefore an ideal product for all providers of visually rich content. Commercial software.

ER Mapper is the solution to the demand for high-quality imagery. ER Mapper does it all for you: Orthorectification, mosaicing, color balancing and compression. The Orthorectification wizard quickly and accurately rectifies airphotos to the proper datum and projection. This wizard gives you step by step directions, which makes it so easy to use.

The free TNTlite products provide a complete and integrated system for GIS, image processing, desktop mapping and cartography, relational database, and other geospatial processes. A full featured image processing subsystem is provided. Satellite, aircraft, or on-site field photographs can be scanned, imported, georeferenced, warped, registered, overlaid from various dates, interpreted interactively on screen, combined with both mathematical and combinational logic, automatically interpreted, converted to polygons, and so on. This means that vertical or oblique images from the air, ground, or even from subsurface remotely sensed data can be corrected, enhanced, interpreted, and used as a basis for mapping. Historical photographs can be scanned, enhanced, and placed onto their proper position on modern landscapes. Site photographs taken with digital cameras can be imported, manipulated, and merged with other site data.

TruFlite: A 3D terrain visualisation package, capable of handling USGS, IDRISI, and ArcView files. A free version is available.

Geomedia: GIS software package for vector and raster data storage, analysis and visualisation. Commercial software.

ArcGIS: GIS software. Provides a wide range of data formats, analysis functions, customisation options, database access and so on. Commercial software.

GRASS GIS (Geographic Resources Analysis Support System) is an open source, Free Software Geographical Information System (GIS) with raster, topological vector, image processing, and graphics production functionality that operates on various platforms through a graphical user interface and shell in X-Window. It is released under GNU General Public License (GPL).

Matlab: development tool for mathematical purposes, program development. Commercial software.

ENVI is the ideal software for the visualization, analysis, and presentation of all types of digital imagery. ENVI's complete image-processing package includes advanced yet easy-to-use spectral tools, geometric correction, terrain analysis, radar analysis, raster and vector GIS capabilities, extensive support for images from a wide variety of sources, and much more.

MapInfo is a commonly used desktop GIS software package produced by the MapInfo Corporation.

Scandig3D is a tool for handling laser scanner data directly in AutoCAD. ScanDig3D uses 3D-Orthophotos, a new technology provided by Riegl Laser Measurement Systems. High resolution digital photos show more details, therefore they can be digitized more easily than conventional scanner datasets comprising just clouds of points. Furthermore, the digital photos can be used as textures for rendering purposes on digitized objects.

IDL is a software package for data analysis, visualization, and cross-platform application development. IDL combines tools for any type of project, from "quick-look," interactive analysis and display to large-scale commercial programming projects.

5E
Public presentation
Visualisation and rendering

Key words: virtual reconstructions, VR/AR

There is a limited number of mainstream modelling tools. To some extent, the market is dominated by the two high-end packages 3D Studio Max and Maya. Some of the other wider spread modelling tools are in the following list.

- Maya: 2099 Euro
- 3D Studio Max: 3500 Euro
- Houdini: 1300 USD
- Rhinoceros: 900 USD
- Cinema4D: 700 Euro
- Lightwave: 600 USD
- Caligari truespace: 600 USD
- SoftImage: XSI 450 Euro
- Sketchup: 475 USD

The high-end CAD market is firmly dominated by the 'major CAD companies'. They provide high-end functionality at a high-end price. But they usually have very good conditions for academic and educational institutions.

- AutoCAD
- Dassault Catia

- Pro/Engineer
- SolidWorks
- UGS SolidEdge

Two open source products are outstanding:

- OpenCascade
- Blender

Spatial's 3D software development technologies provide the foundation for the successful development of innovative, high-performance applications. By integrating Spatial's quality products, our partners can reduce development costs, optimize development resources, and improve time-to-market.

VCLab 3D Scanning Tools: Post-processing of 3D scanned data is still the bottleneck for a wider diffusion of this technology. VCLAb developed second generation tools for processing 3D scanned data. In particular, their tools support: range maps alignment, range maps merge (or fusion), mesh simplification and color attribute management. The software suite has been implemented by scratch and encompasses both up-to-date solutions and some original methods (merging, simplification, color management and, in part, alignment).

VrmlPad is a professional editor for VRML programming. Key time-saving features include powerful editorial abilities and visual support for the scene tree and resource operations. Commercial software.

Internet Space Builder (ISB) is a user-friendly authoring tool suitable for designers of all levels. With ISB, creating 3D models for the Web is now easier than ever before. Commercial software.

Quicktime VR is Apple's award-winning photorealistic cross-platform virtual reality technology that makes it possible to explore places as if you were really there. All major applications that play QuickTime movies can also play QuickTime VR movies. At the intersection of commercial photography and new media technology, QuickTime VR moves the photographic image from the flat, 2D world into a more immersive experience, complete with 3D imagery and interactive components. Interactive content design and immersive imaging allow the viewer to explore and examine detailed virtual worlds using a computer and mouse, not cumbersome goggles, headsets or gloves. Commercial software.

OpenWorlds Horizon Extensible Browsers is not one but a suite of Web 3D and multimedia browsers built using our OpenWorlds developer libraries. Horizon is a free, customizable, extensible version which supports industry standards including VRML and X3D as well as advanced extensions including real-time shadows, reflection mapping, true reflections (mirrors), NURBS, and many other features. Horizon permits you to make your own C++ built-in nodes to extend the basic capabilities through our Horizon SDK. This permits you to add non-standard features such as device support, real-time video textures, and networking capabilities thereby easily creating your own custom application which supports industry standards such as VRML and X3D, but provides additional capabilities beyond those specifications.

OpenGL is the foremost established environment for developing portable, interactive 2D and 3D graphics applications. Since its introduction in 1992, OpenGL has become the industry's most widely used and supported 2D and 3D graphics application programming interface (API), bringing thousands of applications to a wide variety of computer platforms. OpenGL incorporates a broad palette of rendering, texture mapping, special effects, and other powerful visualisation functions. Developers can make use of the impressive power of OpenGL across all popular desktop and workstation platforms.

3D Canvas is a real-time 3D modeling and animation tool that incorporates an intuitive drag-and-drop approach to 3D modeling. Complex models can be constructed from simple 3D primitives, or created using 3D Canvas' Object Building Tools. Modeling tools are provided to deform, sculpt, and paint 3D objects. Freeware.

Point Cloud is a reverse engineering software to process point clouds. Point Cloud can reconstruct a triangular mesh over a cloud of points or drape a surface over the points. A point cloud can be created by scanning the surface of an object (surface scan) or by scanning the entire solid (solid scan). Point Cloud understands this difference and processes points differently in each case. Commercial software.

DTMZ: software of chair of photogrammetry/ETH Zurich for terrain interpolation based on bilinear finite elements method. Restricted to ca. 200.000 points. Allows to create contour lines using different curve parameters for smoothing, generation of regular grids, 3D wireframe views and further interpolation functions. Accompanied by a lot of data conversion, editing and statistical processing tools.

Z/I Image Station: Digital Photogrammetric Software Package for aerial and satellite imagery. Supports automated aerotriangulation, DTM generation (manually and automatically), Orthophoto generation and 3D feature digitisation. Intergraph Geomedia and Bentley Microstation are required. Runs under WIN 2000. Commercial Software.

SCOP: terrain interpolation and visualisation by INPHO. Commercial software product suited for large datasets (up to 1 billion points) derived photogrammetrically or by airborne laser scanning.

Virtuozo: Digital Photogrammetric Software for aerial imagery. Allows Orthophoto generation, DTM generation, 3D feature digitisation. Commercial Software.

Arpenteur: digital photogrammetric software by ITU Strassbourg.

PolyWorks: 3D CAD software with a lot of editing functions, commercial product.

Deep Exploration: 3D CAD tool for editing and visualisation of 3D data. Supports a wide range of common data formats. (MS): "Deep Exploration has the strong point that it includes several popular formats to translate from/into. Also it uses the graphics card to perform visualisation of what the user is trying to translate, which makes it fast but limits at many cases the size of the data than can be loaded (examples- Everest and Bamiyan valey DTM). Though that the control that the user has over the way the data is translated into a different

format is very high and this is important. Problems have appeared when working with VRML models as it changes the reference system axes after export (switches the Y and Z axes). Also allows the generation of video/animation of 3D models."

Geomagic Studio: 3D tool for data editing, merging and co-registration of point clouds. Provides manifold functions, e.g. outlier detection, surface generation, visualisation etc. Geomagic Studio is basically a modeling software. (MS): "By default it suppose that its raw input data is dense and homogen point cloud. It can wrap surfaces or even volumes to the point clouds. But it has limited capabilities for editing task. In version 4.1. surface generating module does not offer any option to user. In addition it can not wrap good surface mesh to heterogen point clouds. It needs uniform point density. We did not test new version (v.6) for meshing purpose yet. But at least new version offers some options to user in the surface wraping module. It has a very advanced module for comparing the surface (tolerance)."

PCI Geomatica: Processing software for satellite imagery. Supports different sensors, ortho rectification, DEM generation etc.

Skyline Terra Explorer/Terra Builder: Landscape visualisation with focus on real time navigation and large datasets. Allows DTM, texture and vector data import and provides additional information inside the 3d model like labels, panoramic views, moving objects and basic measuring functionality.

Terrainview: Visualisation software which allows to navigate through landscapes, city models etc. in real time. High image quality. 3D models have to be built by the software distributor, commercial software.

Cosmo Player: free browser plugin for Internet Explorer and Netscape Communicator. Allows navigation through VRML models in real time, especially via Internet.

QSplat: (MS): "A software that was used for interactive visualisation of laser scanned data from statues of Michelangelo was presented in SIGGRAPH 2000 Conference. It was developed in the frame of the Digital Michelangelo project. It is called Q-Splat and it can be downloaded for free and with the source code (written in C) There are some limitations as far as input file format is concerned but they supply some basic converter (PLY format to QSPLAT). I have tested it under our Solaris - it works... Its not commercial. The goal of this software is to demonstrate the ability to load Levels of details from large size data and visualize them interactively even in low end computers. IT uses point based rendering and OpenGL. Very portable." Open Source.

The Panorama Factory from Smoky City Design is a panoramic stitching program. It can be used to create high-quality panoramas from a set of overlapping digital images. The Panorama Factory transforms (warps) the images so that they can be joined seamlessly into panoramas whose fields of view can range up to 360 degrees.

Tools for Agent-Based Modelling

G-Vista is a software component for realtime 3D terrain visualization.

MicroStation is Bentley's flagship product for the design, construction and operation of the world's infrastructure. MicroStation and ProjectWise, Bentley's server line for AEC collaboration, form a robust foundation for Bentley's comprehensive portfolio of software solutions.

3dMapper is a landscape visualization and three-dimensional mapping application developed by James Burt and A-Xing Zhu at the UW-Madison Department of Geography. It allows researchers to quickly overlay topography with GIS data layers and draw lines, polygons and point data at arbitrary locations in the 3-D view. The program was written as part of the SoLIM project, funded by the USDA Natural Resources Conservation Service.

With Exhibits3D any museum can be visited on line and can improve the visibility of its collections, promote all its exhibitions worldwide, and also plan events that would be impossible in the real world. Without any technical support, museum operators can use Exhibits3D to create spaces where to set expositions and can decide to change the exhibits whenever they want. This could be a good solution also to show works that are stocked for lack of space, for instance.

Cortona VRML Client is a fast and highly interactive Web3D viewer that is ideal for viewing 3D models on the Web. A set of optimized 3D renderers guaranties the best visual quality on both PCs with the latest video-cards and those with more basic video card capabilities. Cortona VRML Client works as a VRML plug-in for popular Internet browsers (Internet Explorer, Netscape Navigator, Mozilla, etc.) and office applications (Microsoft PowerPoint, Microsoft Word, etc).

OpenSG is a portable scenegraph system to create realtime graphics programs, e.g. for virtual reality applications. It is developed following Open Source (LGPL) principles and can be used freely. It runs on IRIX, Windows and Linux and is based on OpenGL.

ArCon is an application designed for architects and house builders (also self-builders) to assist in the visualisation of designs and production of drawings suitable for planning applications and building regulation approval. It features a 2D plan interface for the layout of each floor of the building; an extensive range of pre-built doors, windows and furniture to populate the building; a 3D viewer to see the final building; a Roof Editor including dormer windows; a comprehensive stairs editor and more. Able to import DXF plans, create AVI movies and photorealistic images. Commercial Software (£650).

MultiGen-Paradigm is an extensive suite of applications for the creation and rendering of large scale environments. All stages of creation are covered, from terrain and individual buildings to support for 3rd party modules. Includes:

- Creator "MultiGen Creator is the industry's leading software for creating highly optimized, high fidelity realtime 3D content for use in visual simulation, urban simulation and other applications. The integrated and extensible toolset puts more interactive realtime 3D modeling power in your hands than any other modeler."
- Creator Terrain Studio "CTS is a revolutionary approach to terrain generation from MultiGen-Paradigm. With in-depth experience and technology solutions for delivering terrain generation tools, MulitGen-Paradigm understands the challenges and

complexities of generating scalable terrain models for realtime 3D applications. CTS delivers tools that manage the process and workflow necessary to create superior synthetic environments."

- Vega "Vega is MultiGen-Paradigm's premier software environment for the creation and deployment of real-time visual and audio simulation, sensor, virtual reality, and general visualization applications. By combining advanced simulation functionality with easy-to-use tools, Vega provides the basis for the most productive process for building, editing, running and deploying sophisticated applications quickly and easily."
- SiteBuilder 3D "MultiGen-Paradigm's new breakthrough product, SiteBuilder 3D, allows you to quickly transform ArcView GIS 2D map data into a 3D visual - with just a few clicks of your mouse. Seeing your data in 3D provides greater insight --- and helps you better visualize spatial relationships for sound decision-making. SiteBuilder 3D is delivered as an extension for ArcView® GIS software, so you don't have to learn complex 3D modeling techniques to see your data in 3D. All 3D scene generation is done from inside ArcView GIS. If you're involved in a realtime 3D project involving ArcView GIS map data, you won't find a comparable high value -- and low-cost - solution for your 3D needs like SiteBuilder 3D."
- ModelBuilder 3D "ModelBuilder 3D is a companion product to SiteBuilder 3D from MultiGen-Paradigm, Inc. Users can quickly generate 3D models of real-world buildings, objects, and vegetation for incorporation into an interactive display of 3D GIS data generated in SiteBuilder 3D, an extension to ESRI's ArcView application. The objects created with ModelBuilder 3D are output natively to OpenFlight format, a de-facto standard for realtime 3D graphics and compatible with the SiteBuilder 3D Model Librarian for use as 3D symbols. ModelBuilder 3D is based on MultiGen Creator™ technology, field-proven for more than fifteen years in use in military and commercial training, visual simulation, and entertainment applications. The SiteBuilder 3D interactive 3D view of your GIS data can be greatly enhanced with realism and speed with models created and designed with the robust polygon editing and texturing tools available within ModelBuilder 3D."

Commercial, individual component prices vary.

MapCube is a visualisation application capable of creating 3D worlds from numerous data sources including aerial photographs, lidar height data and 2D ground-plan maps (including GIS). Listed examples: GIS 3D visualisation, Urban Planning, Disaster Simulation, Viewing Simulation (large urban environments), Navigation of a city (both pedestrian and vehicular), and Media Content Production e.g. visualisation of new site developments. Commercial, no demo, limited online information.

MetaVR: -WorldPerfect | Virtual Reality Scene Generator (VRSG)- Software for the creation of large scale virtual worlds. Allows for manipulation of existing terrain models to add higher resolution features; for example roads, airfields and rivers. With the VRSG product, real-time navigation is provided (bias appears to be toward aerial viewpoints), supporting multiple-channel display systems with 2D overlays (HUDs?), sounds, animations. Additional plugins are available for e.g. networked first-person navigation of environments (example given shows military personnel training). Commercial.

World Construction Set (WCS) is "the newest innovation in 3D landscape modeling, rendering and animation software". Full modelling functionality of all world components is provided; along with both real-time walkthroughs and high-quality rendering possible. Worlds are not restricted to one particular type, thus allowing for large sparse environments or small feature-packed urban settings. Facilities for importing and exporting, trees, sky, animated objects, roads, digital height map, buildings, satellite imagery and more. Commercial ($500).

World Builder Pro is a scene builder for creating and rendering 3D environments, with a strong bias toward outdoor scenes. Digital Element claim it "ships with more plants than any other terrain generation tool" and, it has extensive features for the modelling of plants. Imports and export to most standard 2d and 3d formats, along with a integrated elevation editing feature to edit the terrain. Commercial ($700). Compatible with 3DSMax, Maya, LightWave and SoftImage.

Vue d'Esprit is an application for generating scenery that can then be populated with objects imported from other modelling packages. Although it supports animation, it is more suited for offline scenes (not walkthroughs). Commercial ($200).

XFrog by Greenworks Organic Software comes as either a plugin for Cinema4D or Maya, or as a standalone program. It is primarily aimed at the modelling of trees and plants, although is also capable of creating other organic structures; "Trees, Flowers, Bushes, Organic Architecture and Abstract Organic Structures". Greenworks also provide solutions for reduction in the detail of the results, as needed when populating large scenes with many trees. Commercial. Xfrog plugin: $400. Xfrog standalone: $300-400.

Bryce 3D is "a fun, feature-packed 3D environmental modeling and animation package". Aimed more at the generation of static scenes rather than large realtime environments, with a very unique user interface, Bryces strengths lie in rapid initial creation with subsequent fine-tuning. This enables new users to see results quickly before becoming expert. Commercial ($80).

An extensive list of terrain software can be found at the Terrain Tools & Software website.

6E
Public presentation
Multi-modal interfaces

Key words: storytelling, AR presentations

The ARCHEOGUIDE system consists of a site information server and a set of mobile units that are carried by visitors. A wireless local network allows the mobile units to communicate with the site information server. In addition, the site will be furnished with the elements necessary for a tracking system to sense the position and orientation of users wearing the equipment. The site server maintains a database with all information pertaining to the site.

The contents can be accessed and downloaded to the mobiles over the wireless network. In addition, the site information server incorporates software that allows the creation of new content through the exploration of the 3D model of the site. The mobile units comprise a Head Mounted Display (HMD), a camera, microphone, earphone and a lightweight portable computer with a simple input device. The portable computer is equipped with devices allowing it to communicate with the site information server through a wireless data communication network and devices that sense the position and orientation of the user. The mobile units maintain a local database that stores a subset of the site information pertaining to a particular area of the site for a particular user and visit profile. As the user moves around in the site the mobile units communicate with the site information server to download information relevant to the new area of the site the user has entered.

The Timescope 1 system consists of a video camera, a computer system, two monitors, and a touch screen. A specially designed on-site kiosk houses the system and protects visitors from the elements. The video camera is directed toward a particular section of the archaeological remains (for instance the visible foundations of the Saint Salvator church) and it transmits real-time video images of those remains to the monitor screens in the kiosk.

The CAVE (Computer Automatic Virtual Environment) a type of semi-immersive or immersive VE display suitable for the culture environment. Developed by the University of Illinois in Chicago, the CAVE consists of up to six large display screens arranged in a cube. Stereo graphics are projected onto each screen, and multiple users can stand in the middle of the cube and engage with the VE. If additional head-tracking technology is provided for one of the users, the perspective will change in sympathy with the movement of his or her head.

The Museum Wearable is a real time storytelling device: it is a museum guide which in real time evaluates the visitor's preferences by observing his/her path and length of stops along the museum's exhibit space, and selects content from a large database of available movie clips, audio, and animations. The museum wearable targets individual visitors with special learning needs or curiosity, and offers a new type of entertaining and informative museum experience, more similar to immersive cinema than to the traditional museum experience. The museum wearable identifies three visitor types: busy, greedy, and selective, which have been selected as the essential museum visitor types from the museum literature. It uses a custom-made infrared location sensor to gather tracking information about the visitor's path in the museum's gallery and uses this information to introduce evidence in the dynamic bayesian network which interprets the sensor information and delivers content to the visitor. The network performs probabilistic reasoning under uncertainty in real time to identify the visitor's type. It then delivers an audiovisual narration to the visitor as a function of the estimated type, interactively in time and space.

The Storytent is a mixed reality interface to support interactive storytelling experiences for children. A projection screen is shaped to form an A-frame tent. Two projectors throw synchronised images of a virtual world (or other graphical content) onto the outside of the tent,supplemented by several loud speakers. Conceptually, the storytent is a form of traversable interface that allows participants to physically pass into and out of a virtual environment. It provides views of interaction to those who venture inside as well as to those who remain outside.

ICT: there is a system in development called “Integrating Architecture” that “will provide an integrated infrastructure for fundamental research in the disparate areas of artificial intelligence (AI), graphics, sound, animation, and immersive display technologies, such as FlatWorld (the Mixed Reality Simulation Space) and the Virtual Reality Theater”, which could be relevant for EPOCH.

7E
Public presentation
Virtual humans and other avatars

Key words: virtual narrators & presenters, populated virtual sites

WebTalkCube is a powerful software architecture that allows developers creating Virtual Reality Three-dimensional Cooperative worlds, in which people can meet, chat, and interact, access to bi-dimensional multimedia content by means of an Internet connection. In the three dimensional space, visitors can see themselves and the other participants to the cooperative experience as avatars. Avatars, and the 3D space, can be viewed from multiple perspectives, offering multiples views of the same space and giving participants the possibility of seeing at a glance how many people are in the same environment, and what they are doing. In the 3D space, visitors can examine and interact with virtual objects in the world (e.g., animating the virtual reconstruction of a Leonardo da Vinci’s machine at the Museum of Science and Technology in Milano), and share this experience with other visitors (who can see him or her, send comments etc.). Or visitors can access 2D multimedia content space (e.g., to look for in depth information) by selecting the “bridge” points in the 3D space. Finally, WebTalkCube supports the development of cultural games and their integration in the cooperative 3D environment.

Densely Populated Urban Environments: the aim of this project is to populate the 'dead' virtual cityscapes that are appearing in increasing numbers from labs and companies around the world. UCL has one such model, representing 160 square km of London. To populate it one needs to simulate thousands of virtual humans (avatars). Various issues regarding rendering and behaviour simulation for these urban environments, are addressed, such as for example, collision detection, rendering of the animated avatars, improved illumination and simulation of pedestrian movement.

Free WebFace toolkit software.

Artificial Life: stylised characters, specifically targetted at mobile phones

Avatar-Me creates an avatar using a booth for use in other applications. Visit their booth and have an avatar created of yourself, then visit the website to retrieve it. From their website they state that the avatar will be useable in many areas, although not all are currently doable: on-line computer games; creating home animations; making over your body, face and hair; trying on virtual clothes; using A-mail (Avatar e-mail); in 3D chat-rooms; in virtual conferences; for

identity applications; as your 24-hour virtual representative in Cyberspace; as part of your job-search resume; for on-line dating.

Di-O-Matic produces plugins for 3DSMax for assisting in the creation of avatar meshes and animations. Example: Morph-O-Matic, designed as a tool to assist animators in creating complex facial, hand, and other morph animation in a production environment. Morph-O-Matic allows users to control morph animations to a greater extent than what is possible with standard modifiers like morpher, linked xforms, or even bones systems.

Digimask

DigitalSpace

Commons Geo-metricks: Low polygon count avatars available for purchase.

Kiwilogic AG

LifeFX

MIT's Media Lab

Novomind

Oddcast: animated, talking, cartoon-style avatars for use in webpages. Several products, including: The VHost™ Studio is an easy-to-use authoring tool that allows users to create and embed customized animated characters within HTML pages, ad banners and Flash movies. Any non-technical user can easily create and update characters, backgrounds and audio messages effortlessly, without touching the underlying code. Basic HTML and JavaScript programmers can utilize the VHost™ Studio's APIs to create advanced interactions with users based on their rollovers, clicks, and browser cookies. The VHost™ Studio also allows operators to publish characters that read text to create dynamic speech.

Pulse

Safe Work (Human Modeling Technology)

Seestorm

Sensory Inc.'s Fluent Animated Speech technology brings animated 3D objects to life with speech synchronized to mouth dynamics, facial gestures, and emotional expressions. Animations move naturally as characters talk and understand. Emotions are enacted through an emotional mark-up language. Used with Sensory speech technologies and text to speech processing, Sensory's Fluent Animated Speech software can create life-like avatars for unprecendented realism.

TeleVirtual: Working in partnership with scan company, AvatarMe, a world record for human avatar production was established by Televirtual during Year 2000, when over 260,000

human avatars were produced in the Millenium Dome in London. The Avatars produced via full body scanning booths were then able to walk, run and display a variety of physical skills via imported motion capture data. From midpoint in year 2000, Televirtual added communications skills to the Avatars produce in this fashion, allowing them to talk and deliver emails. Televirtual operates a number of commercial and research based projects designed to further the use of avatars for personal communication, and in entertainment and leisure applications. Televirtual also conducts joint operations with another UK Avatar production company, DigiMask. DigiMask also uses photogrametry procedures to make Avatars, but concentrates on building high fidelity human heads in 3D. These may be imported into Televirtual's performance software, allowing them to feature in Television programmes and other advanced entertainment forms.

Vapour Technology have created software for taking Avatar-Me avatars and converting to other applications, including: Avanew – Avatar editing and animation tool (and from this program, avatars can be exported to Autocad .DXF, Alias .OBJ, VRML, Half-Life, Quake3). The Sims, Half-Life, Unreal Tournament.

VICOMTech is a research centre. A few projects of interest:

- Avatars - Conversational User Interfaces
- Advanced conversational user interfaces for human-machine interaction, based on the representation of an interlocutor with (multilingual) speech capabilities, at the voice level, and the corporal/facial animation.
- Human Computer Interaction (HCI): Study of the interaction techniques and its implications regarding the use of computer-based applications in the context of real access to the Information Society.
- Knowledge Agents: Software agents able to navigate autonomously through different information sources and Knowledge bases with the aim of fulfilling specific tasks determined by the user.

Virtual Clones specialise in creating all levels of avatar meshes, from lower resolution game characters to those suitable for movies. Virtual Clones body modelling technology allows surface properties and deformations to be captured as part of the full body scanning process.

Virtual Personalities, Inc. Uses Microsoft Agent characters, with ability to read from text, using natural language processing. BannerBot is a free animated talking character. Using the BannerBot™ creator, you can easily create a unique talking banner and place it on your website in minutes.

Conversive, Inc. produce web, email and telephony based natural language agents.