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Information Society Technologies

**D.2.4.2: Showcase 2 (Final): "Multimodal Interface Safe  
Presentation of Valuable Objects"**

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<b>PP</b>	Restricted to other programme participants (including the Commission Services)	
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<b>CO</b>	Confidential, only for members of the consortium (including the Commission Services)	

## **EPOCH Showcase 2.4.2: MULTIMODAL INTERFACE FOR SAFE PRESENTATION OF VALUABLE OBJECTS Virtual Reconstruction of the Monks of Ename**

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### **1 Introduction**

EPOCH showcase 2.4.2 will present a reconstruction of the abbey of Ename and its inhabitants in historical times from around 1050 A.D. in a 3D scenario. The aim of the scenario is to present the "kromstaf" (an abbots crosier) as it was used in historical times. The scenario shows the monks and the abbot walking in the "ambulatory" of the abbey, entering the church and performing a religious ceremony.

VRLab's tasks are:

1. **Design** of the virtual monks and the abbot who were populating the abbey around 1050 A.D. based on historical descriptions of their clothes, shoes, hairstyles, etc.
2. **Animation** of these virtual monks inside the virtual abbey (reconstructed by *Ename Center*). Animations will be mainly of walking with the following constraints: specific walking path range, varying speed, ensuring a diversity of walking personifications, avoiding collisions with the environment and between the virtual humans.
3. **Rendering** of the whole scene into a video sequence which will be used in the final multimodal interface to present the "kromstaf".

We create a prototype of the scenario using our platform for real-time virtual reality simulations involving virtual humans [Ponder03]. After setting-up scenario and interactive fine-tuning of the parameters using our real-time application, a high-quality final video will be rendered off-line using 3D modelling tool such as 3ds max [Max04] or Maya [Maya04]. Compared to the traditional approaches, our animation pipeline provides a quick and efficient way to control a large amount of virtual humans following a complex scenario.

## 2 Design of virtual humans

### 2.1 Modeling and texture mapping

We created 3D models of virtual monks based on historical descriptions of clothes, shoes, hairstyles, and so on. Virtual abbot and monks were created using 3ds max modelling tool [Max04].



**Figure 1:** 3D model of the abbot.



**Figure 2:** 3D model of the monk.

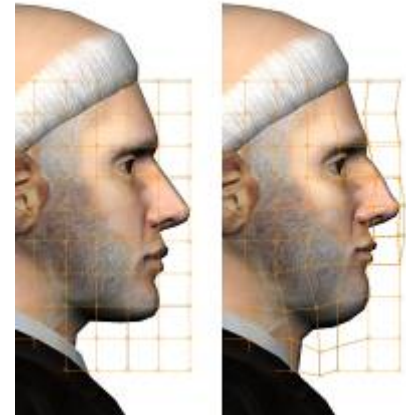
## 2.2 *Multiplying monks*

After designing a single “template” monk, we created eleven other monks by varying textures which are

applied on the same mesh and by modifying mesh with Free Form Deformations (FFD) to create unique appearances for all individuals.



**Figure 3:** *Different head models of monks.*



**Figure 4:** *Applying free-form-deformation to monk's head mesh.*

## 2.3 *Design of body deformations*

Meshes of virtual bodies of the abbot and the monks are animated by skeletal animation, where the surface of the body is calculated according to movements of

the underlying skeleton. Every vertex of the mesh has defined weighted binding to the bones of the skeleton. Body deformations are defined with Bones Pro plugin for 3DS max [BP3].



**Figure 5:** *body deformations for the abbot.*

The animation of clothes is performed in the same way as animation of the rest of the body; therefore clothes are not deformed in a realistic way (i.e. there is no physically-based dynamic cloth simulation).

Nevertheless, a careful set-up of deformation parameters can lead to relatively good visual results while radically decreasing simulation costs compared to full dynamic simulation.



**Figure 6:** *Virtual clothes deformed by skeletal animation.*



**Figure 7:** *A group of virtual monks.*

### 3 Animation pipeline

Classical animation of walking crowds is very tedious and time consuming because of numerous constraints that the animator has to take into account. Besides a basic task of animating cyclic displacement motion, the animator has to deal with walking personifications, upper body gestures, changes of speed, path variations, collision avoidance, and so on.

Our system ensures a realistic simulation of walking people without having to set animation for each individual virtual human. Our procedural walk engine [Boulic04] can automatically perform several tasks such as assignment of different gait styles, generation

of walking path inside a specific range while being able to vary walking speed and respect collision avoidance between the virtual humans. The animator does not have to manage manually all animation details leading to significant time savings.

#### 3.1 Gait styles

Setting different gait styles for walking virtual humans can greatly enhance their believability. Compared to traditional approaches, our gait style parameterization provides an efficient way to generate walking animations of biped characters of any size and proportions.





**Figure 8:** *Walking animation.*

We created a gait editor application where the animator can interactively design different styles of walking used as in input for our procedural walk engine. Editor allows to create easily, in real-time, a large variety of walking styles by scaling and offsetting the three body-centric translations and the 12 angles defining the generic posture (left and right sides can be characterized independently).



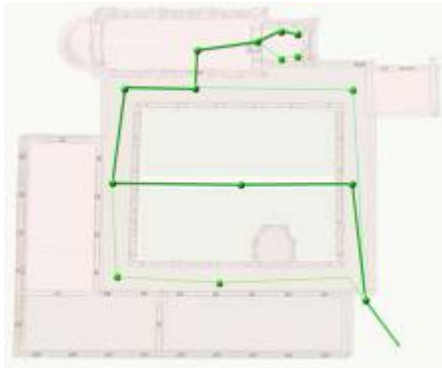
**Figure 9:** *Gait editor interface.*

### 3.2 Walking sequences generation

In order to generate believable walking sequences for a large number of virtual humans we will use our real-time crowd engine [Ulicny02]. The scenario is scripted in Python [Python04] and allows rendering of the whole scene in real-time: the system takes care of the path following, walking speed and style for all virtual monks while automatically adapting the

walking motion to their body size and avoiding collisions between them.

The animator does not need to animate each monk individually, or to care about collisions or other time-consuming details. The animator simply sets up way points of the desired paths and assigns groups of virtual characters to follow these paths.



**Figure 10:** Path set by positioning of way points (green spheres).

Instead of spending a lot of time in micromanaging animation, the animator concentrates on fine-tuning important global parameters such as definition of the various paths followed by the virtual monks inside the ambulatory, setting of the gait styles (either

specify it for each virtual monk, or in a random way), speed variations (min/max range), or mixing walking with extra keyframes (for example upper body "praying" posture).



**Figure 11:** Real-time simulation of the monks following their path (green spheres) in the ambulatory.

### 3.3 Generating animation file

Random parameters generate a large variety of different simulations for the same scene and the animator only needs to choose the most accurate simulation, according to the general believability of the group behavior.

The system will provide real-time capture of the whole simulation, which will save the various movements performed by each virtual monk into separate files. This saved simulation can then be used for real-time interactive simulations, as well as for rendering the scene into a high-quality production movie.

## 4 Integration and rendering

When each animated sequence for each monk is saved, the animator will import them in 3DS max (or Maya), merge them with the virtual environment (in this case, the ambulatory and church designed by *EnameCenter*) and set up all the necessary parameters for final high-quality rendering (materials, lighting, cameras, etc.).

## 5 Conclusion

The traditional approach to group animation is a long and tedious process where designers need to animate each virtual human individually, control manually collisions between virtual humans, take care of a large amount of small details. Change of one parameter will usually result in a need to re-do a major part of the animation, thus discouraging from creatively exploring different possibilities.

Our animation pipeline provides a quick and efficient way to control a large amount of virtual humans following a complex scenario, without having to animate each virtual human separately. The animator only needs to take care of global behavioral parameters, instead of focusing on tiny details for each individual animation. Thus our pipeline gives the designer more freedom in handling large and complex animated scenes, where the believability depends more on the global behaviors than on individual animations.

The final simulation can be used for different purposes including real-time interactive simulation, real-time augmented reality, or a production quality rendering for movies.

## 6 References

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## EPOCH Showcase 2.4.2: MULTIMODAL INTERFACE FOR SAFE PRESENTATION OF VALUABLE OBJECTS

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### Abstract

This showcase creates a presentation methodology that offers a viable alternative to displaying valuable historical artefacts, while providing an innovative way to tell the story of the object.

It demonstrates a simple solution for a tactile interface that is easy to integrate in a museum setting and can be used by individuals or guided groups alike. The system is robust and simple to use, both for the public and the museum staff.

A replicated historical object interfaces with its virtual 3 dimensional representation on a computer screen; the shape and details are felt on the replica. Touching buttons on the replica bring up information in a multi media application about the significant features of the artefact.

**Categories and Subject Descriptors:** *Archaeology, 3D modeling, Replica's, Interfaces, Multimedia.*

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### 1. Introduction

Many historical artefacts have an exceptional value due to their uniqueness, craftsmanship, precious materials, historical significance or a combination of several of these factors.



Safely and effectively exhibiting such objects has always been a challenge: the museum wants to make the object as visible and accessible as

possible to a broad audience, but must also restrict its access due to security reasons and the object's fragility.

Moreover, many exhibited artefacts contain a wealth of information – of symbolic or historical significance – which is not always apparent to the eye and difficult to explain.

Considering the costs involved in transporting, displaying, safeguarding and conserving, the number of people who can view the object and amount of information conveyed, the return is quite low.

Through the use of digital technology, the potential audience can be enlarged and the range of information linked to the object greatly expanded.

The goal of this showcase is to create a presentation methodology that provides a viable alternative to displaying valuable original objects, while offering nearly unrestricted – virtual – access to a general audience and a compelling and innovative way to tell the story of the object.

## 2. The existing techniques

Most Virtual Reality applications in medicine, engineering or robotics, use either joysticks, force feedback devices or haptic gloves to interface with a VR object and provide information about the shape, surface or hardness.

Unfortunately, these techniques are not very well suited to the Cultural Heritage environment. They are not sustainable from a practical and financial point of view, require expensive and complicated equipment, are high maintenance and have high computational requirements for real time calculation.

In this showcase, we are looking for a simple solution for a tactile interface that is easy to integrate in a museum setting and can be used by individuals or guided groups alike. It is robust and simple to use, both for the public and the museum staff. The replicated model interfaces with a virtual 3 dimensional model on a computer screen, the shape and details are felt on the replica.

There are many ways to interface with a virtual object.

### Mouse

A PC mouse is the most common interface. It has 2 degrees of freedom in one plane, i.e. X and Y.

These coordinates can be translated into rotational axes, to spin an object around its 3 axes, or move it when pushing a button.



### 3D Mouse



A 3D Mouse such as 'Wanda' is a navigation device with a joystick and 3 programmable buttons. They can be used to manipulate 3D objects in a virtual environment

With an embedded 6 DOF sensor, it can be used in free space, unlike a typical mouse or joystick.

6 Degrees Of Freedom means 3 rotational axes + up/down, left/right and forward/back

### Joysticks

A joystick, such as this 'CyberStick', is a base-free, Virtual Reality 3 DOF device that works with the tilting motion of the hand in mid-air.



**Haptic or data gloves** are gloves equipped with sensors that sense the movements of the hand and interface those with a computer.

They sometimes feature small vibrotactile stimulators on each finger and the palm of the hand.



The array of stimulators can generate simple sensations such as pulses or sustained vibration, or can be used to produce complex tactile

feedback.

**Force feedback gloves** are lightweight, force-reflecting exoskeletons that fit over data gloves and add resistive force feedback to each finger.

With the force feedback system, users are able to explore the physical properties of the computer-generated 3D object they manipulate and literally "feel" the object.

They also allow the operator to control a remotely-located robotic "hand".

The grasp forces are exerted via tendons that are routed to the fingertips via the exoskeleton. They can be programmed to prevent the user's fingers from penetrating or crushing a virtual object.



### Mechanical Tracking Devices

These measure position and orientation by using a direct mechanical connection between a reference point and the target. Typically, a light-weight arm connects to a control box, and encoders placed at the joints of the arm measure the change in position and orientation with respect to the reference point.



### Optical tracking devices

or wands come in all shapes and variations. Most incorporate on-off buttons to control variables in a simulation or in the display of data.



Their design and manner of response are tailored to the application. For example, biologists sometimes use wands like scalpels to slice tissue samples from virtual

brains.

The device is equipped with retro reflective markers, which are recognized by tracking cameras. The data from these cameras is then processed, the result being the coordinates of the markers, and hence the position of the body carrying the markers. Most wands operate with six degrees of freedom.

### Spaceballs

A spaceball is a 6 DOF motion controller that can zoom, pan and rotate models. It feels very much like holding the model in your hand.



The controller has sensors built in that feel the movement and the amount of pressure applied

controls the speed.

Our interface can best be compared to a 'spaceball' or a base less joystick

### 3. Techniques that were used for this showcase

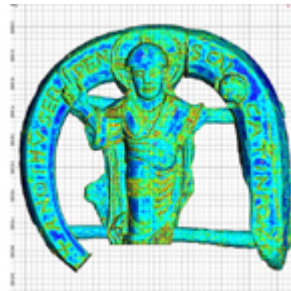
The showcase is based on the replica of a rare carved ivory top of an abbot's crook from the end of the 11<sup>th</sup> century, which is displayed in the museum of Ename. This serves as a physical interface between the user and a virtual object in a multimedia presentation.

A number of technologies were used to build it.

- A. laser scan of historic artefact
- B. replica
- C. electronics
- D. user interface

#### A. Laser scan

To replicate the artefact, a digital model the original was first needed. This was obtained by laser scanning.

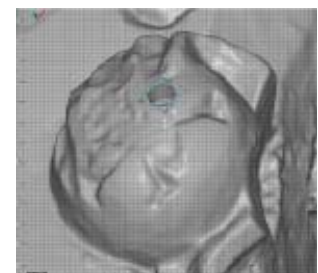


3 Dimensional laser scanning or digitizing is a technology that captures the digital shape of a physical object. It is a contactless method – compared to measuring

techniques with probes. It is extremely accurate, with a point spacing of 0.2mm, and of course non destructive!

The data output of a 3D scan can be points, polygons or polylines.

In our case, we used the exported STL (stereolithography) geometry.



## B. Replica

To build the replica, we used a rapid prototyping technique called Fused Deposition Modelling, or FDM. The FDM process constructs three-dimensional objects directly from the scanned 3D data.



The process starts with importing a scan file of the model into pre-processing software. The model is mathematically sliced into horizontal layers varying from 0.13 to 0.35 mm thickness. The system operates in X, Y and Z axes, extruding a molten thermoplastic modelling material one layer at a time.

The result of the solidified material laminating to the preceding layer is a plastic 3D model.

For our replica, we used ABS plastic. The model is almost as strong as an injection moulded part.

We built the model as 2 hollow shells with a thickness of 3 mm, so it would be easy to mount the electronic components inside. We then glued the two shells together.



## C. Electronics

### 1. Orientation sensor

In order to be able to rotate the virtual model that is visualized on a computer screen in exact coordination with the physical replica held by the user, we integrated an orientation sensor into the replica.



We used a 3 degrees of freedom, or 3DOF, sourceless tracking device.

This motion sensor provides a full 360° range. Since no cameras are used to determine its position, there are no line-of-sight restrictions.

3 DOF gives 3 rotation axes, i.e. angular coordinates. These are translated into X,Y and Z components to interface with our application.

In this case, 3 degrees of freedom were enough, as we were not interested in the relative position of the object in space.

The device connects to a Windows PC via the USB port.

Windows control and connectivity software provides sensor configuration, network interface and joystick emulation.

Motion prediction, adjustable rotational sensitivity and control of output data filtering allow fine tuning for our specific application.



## 2. Interface

Switches are mounted into the replica behind features that have an important meaning. When pushed, they trigger the multimedia application that allows the user to explore the object.

We used simple mechanical I/O switches. They are the most robust and cheapest solution.

The I/O signal then has to be converted into something usable for our PC application.

We do this through a simple digital I/O microcontroller. This small printboard has a USB interface and all the necessary software.



## D. User Interface



The platform on which we run our presentation is called ARCO. It is a system that provides a one-stop-solution for museums to create, manage and present both content and context for virtual exhibitions.

ARCO has been developed by the ARCO consortium, see their web site [www.arco-web.org](http://www.arco-web.org).

The University of Sussex, ARCO project coordinator, has used the ARCO system to build the showcase presentation – basically a virtual museum – and interfaced the abbot's crook multimodal interface to this virtual museum.

## 4. Applications

The applications for this showcase are limitless.

The interfacing technique can be used for any object that is neither too small nor too large.

The only requirement is that it can be scanned, meaning it will at one time have to be physically manipulated.

An alternative could be to build up a 3D model with modelling software, using photographs as a reference, but the model will then not be very accurate.

The application is also not limited to 3D objects: photos and paintings could be used as well.

## 5. Future developments

This showcase is the first step in developing a multimodal interface.

For the future development, we have a couple of options:

We can either stick to the idea of having a very realistic model, made from a 3D scan.

We should then perfect the electronic components and mainly try to reduce their size. We will also research alternatives for the mechanical switches. Although it was not a major concern for this showcase, they are rather large (approximately 14 mm deep), and might thus not fit into smaller replicas. Capacitive switches could be a good solution. Those switches have, besides their size (they consist of no more than a couple of layers of thin foil) the possible advantage to be totally invisible, glued inside the replica.

Another option would be to have a more generic model, say a very simplified representation of the artefact, and then use for instance haptic gloves to add the detail. The model could then be used for different objects - albeit similar in size and shape - which would save money and resources.

One major advantage to not needing an exact 3D computer model of the artefact is that the models would then not have to be scanned, and thus not handled. The VR model could be made using image based rendering techniques, where 3D models are built up from 2D photographs.

A third option is to use image recognition hardware and software to capture the position of the object and of the finger pointing at a detail needing explanations. This would totally do away with any electronic components inside the replica, opening whole new ways to replicate an object and removing the size restrictions.



# MULTIMODAL INTERFACE FOR SAFE PRESENTATION OF VALUABLE OBJECTS

## Exhibited Artifacts: Access and Information

Many objects of art have an exceptional value, due to their uniqueness, exceptional craftsmanship, precious materials, historical significance — or, usually, a combination of several of these factors.

Safely and effectively exhibiting such objects is always a challenge. On one hand, the museum wants to make the object as visible and accessible as possible to the public, while on the other, its access must necessarily also be restricted due to security factors and the object's fragility.

In addition, specially exhibited objects contain a wealth of information such as symbolic or historical significance, which is not always apparent to the eye. Considering the costs that are involved in transporting, displaying, safeguarding and maintaining the object, and the finite number of visitors who will view it on display, the number of people and amount of information conveyed about the object is quite small. The potential audience is much wider and the range of information that is linked to the object can be greatly expanded through the use of digital technology.

The goal of this showcase is to create a presentation methodology that provides a viable alternative to displaying valuable original objects, yet provides a way of offering nearly unrestricted "virtual" access and provides a compelling and innovative way to tell the story of the object for a general audience.



*The interactive replica*

**Exploration through Touch** The showcase is based upon a replica of the object which serves as the interface to explore the object. Through the use of an orientation sensor integrated in the replica, the object can be visualised on a computer screen in precise coordination with the angle it is held or rotated by the visitor/user. In this way, the user feels the shape and details of the object and sees the virtual representation of the object in the screen, behaving exactly the same way as the replica. By adding touch sensors to the surface of the replica in significant areas of interest, the user can explore the meaning of the object. Touching a selected feature on the surface of the replica brings up a story on the screen that explains some facet of the meaning and history of the object. For example, if the object bears an inscription, the user can learn what it means, and what message lies behind it, by simply touching the text. This tactile interface allows visitors to experience and explore the object in an exciting and innovative way — that would certainly not be possible with the original artifact.

This methodology is suitable for single visitors or families, but also for guided groups, as the visualisation of the object does not require any special equipment or glasses. As duplication of the object is easy and inexpensive, copies of the virtual object can be shown at multiple locations in one exhibition or at multiple exhibitions at the same time.



*The real ivory artifact*





The virtual model

**T**echnical Specifications The application is based upon the ARCO software of the University of Sussex, and a concept developed by the Ename Center. The replica is made through stereo lithography of a 3D model of the object, obtained by laser scanning. EPFL and the Ename Center create the 3D stories with virtual reconstructions of the Ename abbey and its inhabitants. The visualisation of the object is done through the most recent 3D flat screen visualisation techniques.

**P**artners This showcase uses a rare carved ivory head for an abbot's ceremonial staff from the end of the eleventh or beginning of the twelfth century, displayed in the Provincial Archaeological Museum in Ename, Belgium, and is being realised by:

- ▶ The Ename Center for Public Archaeology and Heritage Presentation, Belgium
- ▶ EPFL (Polytechnical University of Lausanne), Virtual Reality Lab, Switzerland
- ▶ University of Sussex, UK



#### Interested?

Are you interested in this showcase? Do you think that this approach can help you in creating effective Cultural Heritage presentation projects or can be integrated in new research projects? Please contact Heidi Tency ([heidi.tency@enamecenter.org](mailto:heidi.tency@enamecenter.org)) of the Ename Center at +32 55 232445.

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[www.epoch-net.org](http://www.epoch-net.org)

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