LifePlus. Innovative revival of life in ancient frescos-paintings and creation of immersive narrative spaces, featuring real scenes with behaviored virtual fauna and flora.

1. What was the specific scientific/artistic/commercial goal for the project development?

- **Problem to be solved**

  Since antiquity, images were used as records of both events-lifestyles, as well as decorations. The possibility of reviving them will add a new dimension in understanding our past. However, the recreation of historic environments for serious study, education and entertainment is not new[1] although the methods for achieving the objectives have evolved considerably over time. Before the days of widespread books and printing, story tellers would conjure up visions of events and places, providing their listeners with an impression of realities (often augmented realities) elsewhere in time and space. Theatre, fine art and cinema have added to the richness of the explicit visual experience available to the viewer. They have made the interpretations of history more accessible to the general public, but at the same time narrowing the individual's scope for personalised, interactive experience and visualisation of the description of it.

  Therefore, for the application of technology to heritage to become a viable historical recreation tool, a combination of technological, economic and creative challenges must be overcome. Potentially a Virtual Reality-based heritage experience gives the visitor the opportunity to feel they are present at significant places and times in the past and use a variety of senses to experience what it would have felt like to be there. However, a review of the range of projects on the internet described as Virtual Heritage[2], shows numerous examples of virtual environments build as reconstructions of historic sites but sterile and devoid of population. Engaging characters that are needed in an interactive experience are now slowly coming into focus with recent EU funded IST projects (Charismatic[3]). The main reason for their slow adoption is due to a) the incapability of current VR rendering technology for realistic, entertaining, interactive and engaging synthetic characters and b) lack of interesting interaction paradigms for character-based installations. Historical frescos are a unique arrangement of "mise-en-scene" elements that enhance the user experience by creating a set of compelling narrative patterns, alas however in a static, two-dimensional way. The word "narrative" refers to a set of events happening during a certain period of time and providing aesthetic, dramaturgical and emotional elements, objects and attitudes[4]. Mixing such aesthetic ambiences with virtual augmentations and adding dramatic tension, can develop these narrative patterns into an exciting new edutainment medium.

  Therefore, LIFEPLUS proposes new development for the innovative revival of life in ancient frescos-paintings and creation of narrative spaces. The revival is based on real scenes captured on live video sequences augmented with real-time autonomous groups of 3D virtual fauna and flora. The metaphor, which will inspire the project approach, is

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[1] Computer Graphics and Archaeology: Realism and Symbiosis, David Arnold, Charismatic project, http://www.charismatic-project.com/

[2] Virtual Heritage Network, http://www.virtualheritage.net

[3] CHARISMATIC IST project, http://www.charismatic-project.com/

[4] Nandi A., Marichal X., "Transfiction", proceedings of Virtual Reality International Conference, Laval May 2000.

oriented to make the "*transportation in fictional and historical spaces*", as depicted by frescos-paintings, as realistic, immersive and interactive as possible. For that purpose, LIFEPLUS will aim to position itself between the extremes of real life and Virtual Reality, in the spectrum of "Mixed Reality"[5] and especially Augmented Reality (AR), in which views of the real world are combined in some proportion with specific graphic enhancements or augmentations. Apart for Virtual Heritage, LIFEPLUS aims to address the following emerging market needs:

- *Tourism and Education-Entertainment (Edutainment).*
  Novel operational paradigms (immersive AR virtual life) for edutainment experiences are preconditions for economic viability for all types of future Cultural and memory Institutions, Location-Based Entertainments and E-visitor Attractions.

- *On set visualization & Virtual Studio:*
  Film studios currently shoot films expecting to add in computer generated (CG) effects such as backgrounds, dinosaurs or CG characters later. Directors would benefit from the ability to see in real time or very soon afterwards an overlay of real and planned CG elements to decide whether the composition is acceptable. Broadcasters are also currently seeking to expand the use of virtual life in live broadcasts (e.g. Ananova[6]).

The project is defining new models-tools and affordable solutions for 3D virtual life simulations in AR environments with emphasis on two real-time commercialised end-products:

a) a mobile AR on-site guide based on immersive wearable computing
b) a middleware architecture of self-contained SDKs and APIs.

Innovative research will extend the state of the art of technologies developed in IST and other research projects for:

a) Real-time camera tracking in unknown environments (ENREVI project)
b) Immersive on-site guides based on mobile-AR units (ARCHEOGUIDE, ARVIKA)
c) Introduction of virtual humans in mixed reality environments (STAR) and synthesize a new real-time framework that will allow virtual fauna and flora to enhance real environments in AR for, a new breed of innovative edutainment experiences.

- **Quantified specific objectives**

The goal of LIFEPLUS is to push the limits of current Augmented Reality (AR) technologies, exploring the processes of narrative design of fictional spaces (e.g. frescos-paintings) where users can experience a high degree of realistic interactive immersion. Based on a captured/real-time video of a real scene, the project is oriented in enhancing these scenes by allowing the possibility to render realistic 3D simulations of virtual flora and fauna (humans, animals and plants) in real-time. According to its key mobile AR technology, visitors are provided with a see-through Head-Mounted-Display (HMD), earphone and mobile computing equipment. A tracking system determines their location within the site and audio-visual information is presented to them in context with their exploration, superimposed on their current view of the site. LIFEPLUS will extend that system and provide key new technologies to render lively, real-time animations and simulations of ancient virtual life (3D human groups, animals and plants). In greater detail LIFEPLUS quantified specific objectives are:

- *Real-time "realistic" virtual life*
  With the advent of virtual human actors such as the ones in the recent CG movie "Final Fantasy: The Spirits Within", the race for heightened reality is prominent and such impressive results highlighted the fact. Even in the area of real-time 3D CG the pursuing for hyperrealism

[5] Milgram P., et al. "Augmented Reality: a class of displays on the reality-virtuality continuum", SPIE Volume 2351: Telemanipulator and Telepresence Technologies, 1994.
[6] ANANOVA, http://www.ananova.com

is driven by hardware and algorithmic research, development as well as the viewers expectations set by the film industry. Thus the expert research partners, ***EPFL - Swiss Federal Institute of Technology*** and ***MIRALab – University of Geneva,*** and industrial leader, ***Bionatics S.A***., will upgrade their existing break-through technology to real time realistic mode. That involves

a) Hair simulation
b) Cloth animation
c) Skin rendering and interactive programmable shading
d) Plant simulation
e) Artificial life methods for behavioural animation of virtual characters
f) Multi-resolution scalable graphics for dynamic Levels Of Detail
g) Realistic facial emotion expression.

- *Automatic Real-time Camera Tracking*
  In order to mix 3D computer graphics (CG) with footage of the real world, the CG camera needs to be matched to the actual camera that took the footage. This process ensures that the computer graphics elements match the perspective and movement of the real objects in the real camera shot. Camera tracking, as this technique is called, has been so far performed off-line and mostly involves manual editing work. Fundamental research will extend the state of the art for camera tracking in unknown environments in real-time, for an interactive, immersive compelling historical recreation. The approach will extend the only available in the market automated offline AR camera tracking software, which is provided by the industrial leader, ***VMSL Ltd***. Research pioneers, ***IGD Fraunhofer Institute for Computer Graphics*** and ***FORTH (Foundation for Research and Technology - Hellas)***, will add further new developments in this complex topic.

- *Design of successful character based installations*
  In order for the overall installation to be successful, it must let people read the intentionality of the characters. Active research will provide new variety of ways to conceive such installations based on the latest research from Blumberg et al[7] and carried out by the industrial expert, ***noDna A.G.***. A clear challenge at present is that there is no established paradigm for what an AR immersive virtual heritage experience involving groups of virtual life simulation should look like. This impacts not only on the quality of the experience but also on the technological implementation and on commercial issues such as visitor throughput. New synergies between various disciplines (performing arts, AR technologies, marketing strategies) need to conceptualise characters in a way so that creators can generate AR installations that enable participants to read the desires, beliefs and actions of the virtual characters.

- *Expressive autonomous cinematography for interactive Virtual Environments*
  Dynamic cinematography and interactive lighting design assist in crossing the boundary between computers and people and conveying the characters emotions to participants.

- *Middleware architectural interoperable components according to ISTAG[8] and not a monolithic 'black-box solution'*
  Thus, the LIFEPLUS industrial partners will be able to carry out both individual and collective middleware component commercialisation. Furthermore, other research projects and market customers will be able to integrate the middleware components easily and affordable in their applications. Relations and possible synergy with other projects (STAR, ARVIKA, ARCHEOGUIDE) will be further explored. The main focus will be on the basic LIFEPLUS middleware platform that will be based particularly in three projects: VR-Platform from STAR and AR-Mobile Unit from ARVIKA- ARCHEOGUIDE.

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[7] Blumberg, Tomlinson, Downie, "Multiple Conceptions of Character-Based Interactive Installations", proceedings of Computer Graphics International conference, Hong Kong July 2001.

[8] Recommendations of the IST Advisory Group for Workprogramme 2001 and beyond "implementing the vision", http://www.cordis.lu/ist/istag

- *New AR product markets*
  To open a wide range of applications where Virtual humans, animals and plants will be merged into a real-time in a real scene, such as a) new breed of highly valued edutainment experiences and presentation methods for the education/entertainment and tourism industry b) pre-visualisation of special effects/ human animation in the movie industry c) many more practical and high potential applications foreseeable in fields such as maintenance, medical visualisation, guidance and information, e-learning, virtual prototyping etc.

- *Analysis of existing and future standards*
  These involve from Web3D (VRML), H-ANIM, X3D and MPEG to mobile telecommunication standards in order to specify the format to generate, store, retrieve and transmit the LIFEPLUS virtual life scenes. As far as it concerns the H-Anim (Humanoid Animation) Specification, this will be considered as a template to be adopted for Virtual Flora and Virtual Animal specification of articulated skeletons for their later simulation (animation-deformation)

2. What is the innovative aspect of the project or your particular research interest?

- **Innovation**
  "Within the EU, addressing the issues posed by the preservation, re-use and access to our intellectual capital will form the cornerstone of future economic growth and development. Access to these assets is essential for the education and improved quality of life of its citizens"[9]. **LIFEPLUS proposes an innovative 3D reconstruction of ancient frescos-paintings through the real-time revival of their fauna and flora, featuring groups of virtual animated characters with artificial life dramaturgical behaviours, in an immersive AR environment.** By its very nature, LIFEPLUS is a highly interdisciplinary project involving computer vision, computer graphics, user interfaces, human factors, wearable computing, mobile computing, computer networks, distributed computing, information access and information visualization. Although initially targeted at Cultural Heritage Centres, the paradigm is by no means limited to such subjects, but encompasses all types of future Location-Based Entertainments, E-visitor Attractions as well as on-set visualisations for the TV/movie industry.

- **Fundamental Research in Augmented Reality**

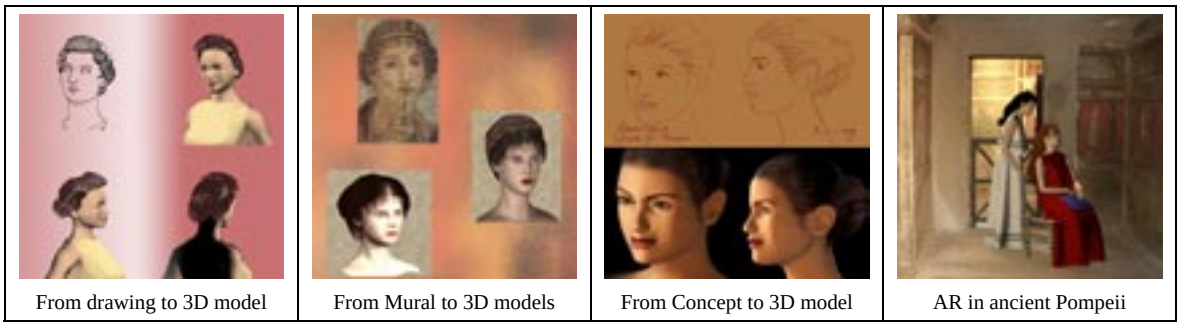
  - *Automatic real-time camera tracking in unknown environments*
    One of the biggest challenges in the Area of Augmented Reality that LIFEPLUS addresses is the real-time registration issue. To create a sufficient illusion of the CG augmentation, it is necessary to properly align real and virtual objects with respect to each other; otherwise the illusion that the two coexist is compromised. Therefore in order to mix 3D computer graphics (CG) with footage of the real world, the CG camera needs to be matched to the actual camera that took the footage (camera tracking or match moving). There are two significant technologies in current usage, which provide insight into the future challenges for camera tracking. The first technology is match moving in postproduction special effects for the movie industry. The second significant technology is real time camera tracking for the virtual studio. Up until 2001 most matchmoving was done by a manual process, in which the user chooses points and tracks them through the sequence. This has been a laborious and unpredictable process that requires skilled attention. In April 2001 ***VMSL Ltd*** released a product that can matchmove shots completely automatically. However, neither

[9] Ross, S. 1997. 'Consensus, communication, and collaboration: fostering multidisciplinary cooperation in electronic records', in INSAR (Supplement II), Proceedings of the DLM-Forum on electronic records, page 336.

existing system provides a solution to real time camera tracking in an unconstrained environment. ***VMSL Ltd*** together with ***IGD Fraunhofer Institute for Computer Graphics*** and ***FORTH*** (Foundation for Research and Technology - Hellas) propose to develop a camera tracker suitable for usage in unconstrained environments. Two solutions will be developed, broadly similar in concept. Both build on ***VMSL Ltd'***s current technology, with development needed to address the issue of real-time computation. ***VMSL Ltd'***s current technology relies on extracting features from a general scene, tracking these features through the image sequence and recovering the scene structure and camera position, orientation and internal parameters using structure from motion algorithms. In the first solution the through the lens data will be used to extract this data. The second solution will instead use auxiliary camera(s) pointing in different directions. For example in an outdoor scene these camera would point downwards at the ground, indoors they could point at the ceiling. Finally the information from through the lens and auxiliary cameras can be combined for the most reliable solution.

- **Fundamental Research in Virtual Fauna and Flora Simulation**

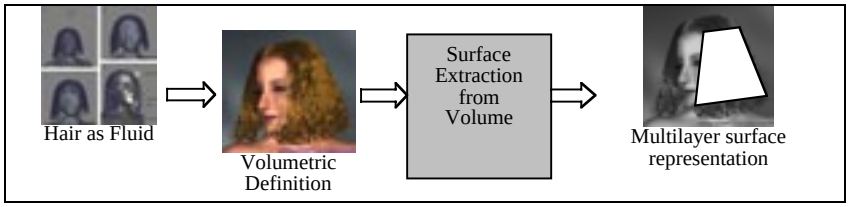
  ❖ *Real-time Hair Simulation*



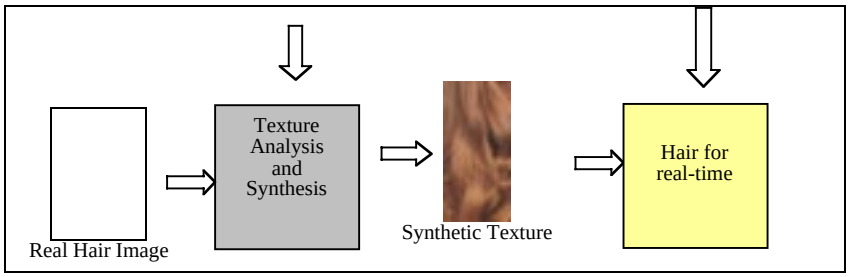
From drawing to 3D model | From Mural to 3D models | From Concept to 3D model | AR in ancient Pompeii

Making ancient hair styles

Beautiful "dynamic" "hairstyles" is one of the oldest human passions. Not surprisingly, recently even the Virtual Humans are involved in this art form[10]. In computer graphics, there has been significant work done in modelling of the class of the fuzzy objects, such as grass, fur and particle systems. However, believable hair for computer graphics in all its complexity and variety is far from reality. So far, ***MIRALab – University of Geneva*** concentrated on animating hair for high-end computer graphics with emphasis on the realism, with considerably large computing power and time. However, the techniques developed so far have potential in animating hair for real-time which will be major focus for the proposed project. Hair modelled as streamlines is essentially a volumetric model. The fluid flow being volumetric, followed by the volumetric perturbations such as noise and turbulence, provides a very efficient way of representing hair volume. However, we need to investigate new methodologies to convert the resultant volumetric definition to a surface definition, which is more suitable for real-time rendering.



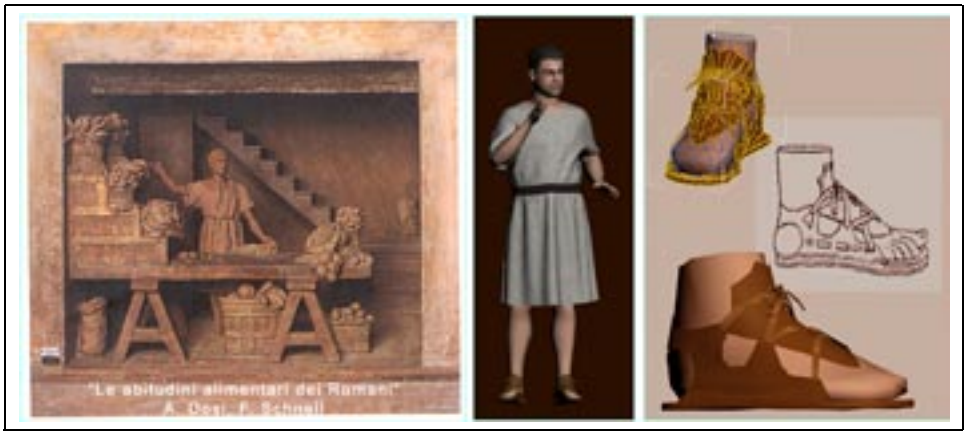
[10] Drascic D., Lilgram P., "Perceptual Issues in Augmented Reality", SPIE Volume 2653: Stereoscopic Displays and Virtual Reality Systems III, 1996.



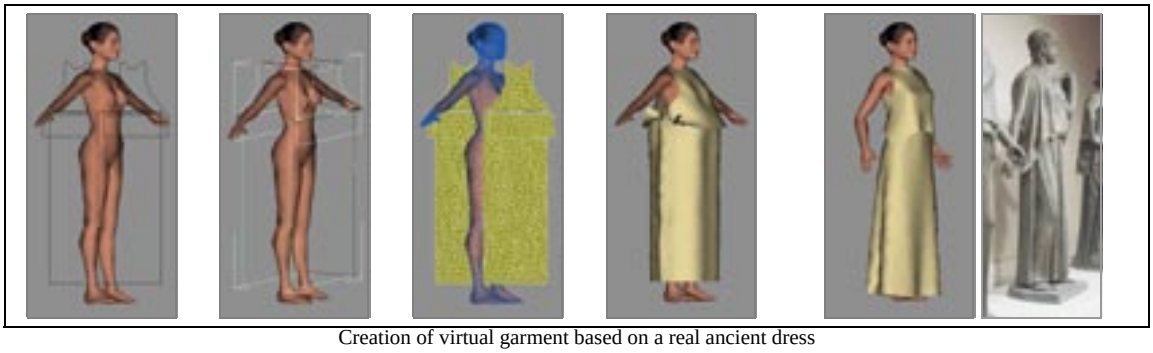
Converting volume of hair to a surface representation

- *Real-time Cloth simulation*

Cloth is one class of flexible objects that has received considerable attention in the computer graphics community. The appearance of clothing worn by modelled humans is of particular interest in animation. There is still a gap between the time consuming techniques that bring simulation accuracy and duplication of actual fabric mechanical parameters, and the efficient techniques that are able to manage complex animated garments with simplified mechanical models.


Virtual Garment based on real ancient dress

In order to define realistic cloth simulation systems that are able to simulate complex garments realistically while keeping a reasonable computation time, a deeper study of the cloth model and the identification of its movement behaviour at different level are necessary. This study should not intend to integrate yet more precisely the parameters measured for given fabric materials, but rather focus on the real-time constraints for the simulation and the visual cloth motion features to which the observer is sensitive. LIFEPLUS will implement a new real-time cloth simulation model that avoids heavy calculation of collision detection and particle system intelligently.


Creation of virtual garment based on a real ancient dress

- *Realistic Skin rendering and interactive shaders*

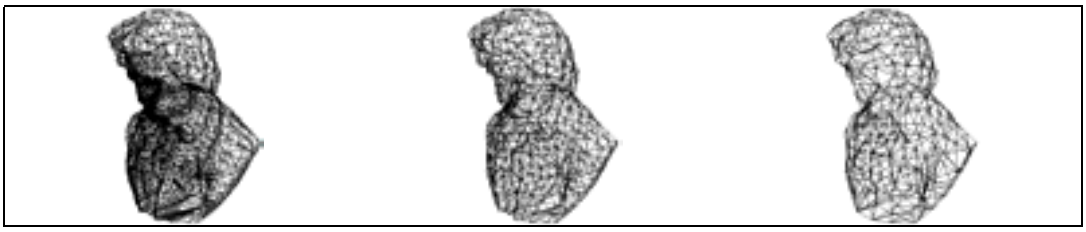
In order to make the characters skin look as real as possible, LIFEPLUS proposes a method that would render quickly and adapt easily to various lighting conditions. Per-Pixel lighting offers graphics applications the ability to provide extremely realistic lighting with a minimal of processing, bandwidth, and memory overhead. Thus Per-pixel lighting will be incorporated

for real-time realistic skin rendering as it offers the benefits of tessellating large polygons into several pixel-sized polygons without the performance impact of actually doing so (it recalculates all or part of the lighting equation on a per-pixel basis using texture elements, thus allowing dynamic lighting on a per-pixel basis). Programmable shading (the means for specifying the realistic appearance of synthetic objects) is topic in which LIFEPLUS is aiming to innovate by applying its principles in real-time virtual characters in AR environments. The new methodology will compile a shader (special purpose program that describes light source position, colour, rejection properties etc.) into multiple passes through graphics hardware.

- *Artificial life methods for behavioural animation of virtual characters*

LIFEPLUS simulations will consist of groups of autonomous virtual human agents existing in dynamic virtual 3D environment. Virtual humans will have some natural needs like hunger, tiredness, etc. which will guide selection of their behaviours. In order to behave in believable way these agents will also have to act in accordance with their surrounding environment, be able to react to its changes, to the other agents and also to the actions of real humans interacting with the virtual world. ***EPFL - Swiss Federal Institute of Technology*** aim is to develop behaviour model that is simple enough to allow for real-time execution of group of agents, yet still sufficiently complex to provide interesting behaviours. ***EPFL - Swiss Federal Institute of Technology*** intends to extend the concepts they have developed for multi-agent simulations to encompass more autonomy at the level of individuals. The major focus is to enhance the current multi-agent model with artificial life concepts, which will allow the virtual humans to live and work autonomously in the AR environment.

- *Multi-resolution scalable graphics*



Multi-resolution meshes of 3D polygonal mesh

Another LIFEPLUS innovation is to find out an approach that can generate multi-resolution representation that requires less production time, without any popping effect in animation, and suitable for deformable objects. An automatic method that can produce multi-resolution model with smooth transition between levels is required. It should also be able to adapt to any environment and give a reasonable result. We call this the scalable 3D graphics technique[11]. Hoppe[12] presented a good solution to rigid object called progressive meshes. It automatically generates smooth levels of detail for objects without increasing a lot of storage. However, the approach fails to deal with deformable objects, such as the skeletal characters. In LIFEPLUS, an approach that can only perform offline simplification to rigid object is not applicable and an innovative approach for real-time is required.

- *Real-time Plant simulation*

Virtual Plant Simulations

[11] Peercy, Mark S., Marc Olano, John Airey, and P. Jeffery Ungar, "Interactive Multi-Pass Programmable Shading", Proceedings of SIGGRAPH, 2000 (New Orleans, Louisiana, July 23-28, 2000).

[12] Carl S. Marshall, Stephen Junkins, Michael Rosenzweig and Jason Weber, Digimation Real-Time 3D Libraries with Intel Scalable 3D Graphics, Presentation for Game Developers Conference 2000.

Populating 3D real-time visual simulations with virtual plants has its own requirements with a particular emphasis on very low number of polygons, optimised texture sizes but realism of the plants. Dynamic billboarding and static cross planes are two techniques that the industrial leader in the field, ***Bionatics S.A.***, will develop further to meet the many constraints between an elevated refresh rate and the need for more realistic virtual landscapes. ***Bionatics S.A.*** will also investigate several other techniques such as:

- Slicing technique that "slices" a 3D polygonal representation according to privileged directions. Several slices are superposed in the real-time viewer in order to render the depth illusion of the 3D forms of the plant.
- Volumetric textures that reproduce the view angle dependency using bi-directional reflection distribution functions combined with bi-directional textures applied to volumetric texture pattern.
- Hybrid techniques that combine 2D and 3D representations. These techniques are satisfying the trade-off between performances, realism and animation capabilities.

Bionatics S.A. will also be developing solutions for representing groups of plants (bushes, forests etc.). For more than one single plant in real-time, the trade-off is clearly system-processor load vs. realism and ambiance.

❖ *Design of successful virtual character based installations*

Under the leadership of the industrial expert ***noDna A.G.***, LIFEPLUS partners will implement new ways of approaching the design of successful character-based interactive installations-paradigms, where participants can read the intentionality of these interactive characters. The focus is on the six perspectives from which intentional characters can be viewed, as described by Blumberg et al[13]:

1) as interactors on a variety of time scales,
2) as reciprocal interactors with each other,
3) as entities exhibiting a dynamic expressive range,
4) as a combination of allusions to existing media,
5) as creatures with life cycles,
6) as a collection of well-balanced components.

❖ *New interfaces for the "Nintendo & Playstation generation"*

The young generation is used to interacting with highly visual and interactive systems such as the computer games they grew up with. In accordance with the ISTAG[14] KET9: Multi-modal and adaptive interfaces, LIFEPLUS aims to provide new edutainment paradigms for accessing information in real environments (e.g. Heritage on site though the mobile AR guide involving historical virtual life simulations). Therefore LIFEPLUS aims to improve information appliances and information services through the integration and use of multiple modalities, including mixed realities. The innovative 3D reconstruction of ancient frescos through the real-time revival of their fauna and flora together with the Mobile AR on-site guide with Video See Through HMD will offer new forms of content, new ways of learning, new business models, new opportunities and new markets.

netzspannung.org was provided with the information above by MIRALab. However large parts have been published before: George Papagiannakis, Michael Ponder, Tom Molet, Sumedha Kshirsagar, Frederic Cordier, Nadia Magnenat-Thalmann, Daniel Thalmann: LIFEPLUS: Revival of life in ancient Pompeii. Virtual Systems and Multimedia, SMM2002-invited paper, October 2002 http://www.miralab.unige.ch/papers/128.pdf

[13] Blumberg, Tomlinson, Downie, "Multiple Conceptions of Character-Based Interactive Installations", proceedings of Computer Graphics International conference, Hong Kong July 2001.

[14] Recommendations of the IST Advisory Group for Workprogramme 2001 and beyond "implementing the vision", http://www.cordis.lu/ist/istag