An Interactive Virtual Environment to communicate Vesuvius eruptions numerical simulations and Pompeii history

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Abstract

This paper describes a visual analysis and communication system that allows to interact with numerical simulations modeling complex natural phenomena, as volcanic eruptions, within their landscape environment. Moreover it describes how to effectively valorize the cultural context related to the territory using virtual archaeological reconstructions or historical sources whenever available having in mind educational and communication purposes.

The case study presented is related to the area of the volcano Vesuvius, close to Naples Italy, very well known for the eruption occurred in 79 a.D. The volcano is currently being monitored to face future eruption risks.

The framework presented not only allows to integrate the results of computing intensive simulations with geographic datasets for a fully interactive 3D high-resolution navigation around the volcano but also to performs an interactive virtual environment to access cultural heritage data.

The goal is to perform new kinds of interaction and create user-friendly interfaces to communicate and explain scientific phenomena as the impact of the eruption together with cultural data providing access to databases and meta-information that exist beyond the landscape itself as GIS data, historical sources and virtual archaeology reconstructions.

Moreover the framework that performs the interactive virtual environment is designed paying attention to multiplatform and multi channel portability. The interaction within the Vesuvius' landscape can be conceived not only for immersive graphics devices as Virtual Theaters but also for Virtual Sets for TV programs making contents fully available for educational purposes.

CR Categories: K.3.1 [Computer Uses in Education]; K.3.2 [Computer and Information Science Education]; J.1 [Administrative Data Processing]; J.5 [Arts and Humanities]

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1 Introduction

Scientific visualizations connected to VEs (Virtual Environments) reconstructions can broaden our perceptual faculties and allow the interaction between numerical models and empirical data.

Graphics applications came about to make it easier to understand complex numerical constructions via a synthesis through images, as they create original modes to surf the Net and to

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make inquiries in visible, invisible, hypothetical and imaginary worlds.

A Virtual Environment is therefore, per se, a complex system and for its realization it is in fact necessary

- to know how to build a virtual digital scenario;
- to obtain validation and certification for the related digital sources/information or simulations
- to design an interactive interface with "readers/viewers".

Products based on interactive Virtual Environments, therefore, not only do retain the information available to the scientific community,[14] but also store them more effectively and make them more user-friendly.

Thus VEs are an alternative to both the need to simplify most communications and to the passive stance imposed by most media[15].

The approach that can be suggested to surfers is the ancient myth of Ulysses, where journey and knowledge join together, a sort of space for "augmented knowledge" available to everyone and able to communicate complex multidisciplinary research results to a broader audience as in the case study of the Vesuvius' area.

2 From the scientific problem of explosive volcanic eruptions to the numerical simulation and its implementation

Explosive volcanic eruptions are among the most fascinating and hazardous phenomena in nature.

During these catastrophic events, a mixture of gas and pyroclasts (ash, pumices, lithics, and magma droplets) is ejected at high velocity, pressure, and temperature from the volcanic conduit, forming a supersonic turbulent jet. When the jet has exhausted its initial thrust, it can either rise by positive buoyancy or collapse under the effect of gravity, depending on its averaged density. In the first case, a "Plinian" column (after the name of Pliny the Younger, who first described the eruptive column of the 79 a.D. Vesuvius eruption) rises in the atmosphere and spreads like an umbrella at a typical height of some tens of Km. In the second case, a hot avalanche of gas and pyroclasts propagates at high velocity down the volcanic slopes (pyroclastic flows). Pyroclastic flows represent one of the greatest volcanic hazards for the populations around a volcano. A 3D numerical model for the simulation of volcanic columns and pyroclastic flows has been therefore developed in the framework of the European EXPLORIS project [16].

The multiphase flow model of Neri et al. (2003)[17] describes the transport equations of a multiphase mixture composed of a gas phase and several particulate phases representing the different pyroclasts classes. For each phase, the complete set of Navier-Stokes equations are expressed by substituting the density by its bulk density and by adding source terms for inter-phase momentum and energy exchange. The transport equations are discretized by adopting a Finite Volumes approach on a rectilinear, non-uniform 3D mesh, including an accurate description of the embedded volcano topography.

The system of the discretized equations are solved by a parallel SOR iteration method. The non-linear mass and momentum coupling in each cell is solved by a pressure-based predictor-corrector method: an iterative non-linear solver, suited for compressible multiphase flows.

2.1 Parallelization strategy

The parallelization of the numerical algorithm is based on the SPMD (Single Program Multiple Data) paradigm and it is implemented through the MPI interface. The 3D computational domain is decomposed into smaller sub-domains of nearly equal size, in order to balance the computational load, and each processor is charged of the solution of the model equations in one sub-domain. The mechanism of data storage and communications among the processors is based on the ghost-cell approach and holds for any number of processors.

The parallel code has been ported and tested on three different parallel systems in CINECA[18]: the IBM Power 4, the IBM Power 5 and the Intel Xeon cluster. Different tests have been performed with small grids (64^3 and 128^3 elements) and for a simulation time of 100 seconds, to better calibrate the model and assess the computational requirements of a large-scale simulation of an eruptive Vesuvius' scenario. The tests have shown that the speed-up curve tends to saturate with a small grid (64^3), when the number of processor increases over 32, in fact the communication becomes non-negligible with respect to the computation. With 128^3 elements the saturation becomes quite evident after 128 processors.

2.2 The results of the simulation

A numerical simulation of a Sub-Plinian eruption has been carried out to quantitatively assess the pyroclastic flow hazard at Vesuvius. The numerical simulation of the first 1500s of eruption, on a domain of $12\times12\times8$ Km^3 discretized into 180^3 cells, lasted about 48 hours on 440 processors of the IBM Power5 cluster.

The eruptive conditions were characterized by a mass eruption rate of 5×10^7 Kg/s, an exit velocity of 175 m/s and an initial vent diameter of 250m. Two particle classes of 30μm-2800 Kg/m^3 and 500μm-1000 Kg/m^3 in equal amount have been used. The initial density of the eruptive mixture was 6.3 Kg/m^3.

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[14] Shannon's theory on the sampling of information contents clarifies the importance of sampling frequency in order to keep the information content of a signal unchanged as it shifts from analogical to digital environments. The theorem was first applied in sampling the human voice (a mono-dimensional signal) and can be applied to n-dimensions: two dimensions for images, three to reconstruct spatial scenarios, four to follow phenomena that change in space and time.
A message seems to surface in Shannon's theorem: with more complex signals, greater attention must be paid to the dimension that changes in a more complex manner. This is necessary in order to be sure not to miss a possible information content, even though it does not necessarily coincide with the relevance of contents. The increase in dimensions is a typical feature in the mathematical description of complex problems and it is important to think about a tool that may show us how not to lose information as we move to multi-dimensional digital environments. An effective sampling of the phenomenon/event one wishes to communicate might be of help in obtaining patterns that will make it easier for the general public to interpret and analyze such events, and provide useful feedback to the author.

[15] This technological experience, together with our recent approach to issues concerning the world of communication, urges two considerations. The first recalls a statement by Kaplinski "…We live in a world that goes towards simplified modes for understanding ourselves and the world itself …" and the second concerns Sartori's fierce criticism that TV viewers are unable to develop abstracting thinking. SARTORI G. 1997, "Homo Videns". Laterza.

[16] Exploris project (Explosive Eruption Risk and Decision Support for EU Populations Threatened by Volcanoes) funded by the European Unions's research programme into the "Energy Environment and Sustainable Development" chapter (Proposal no. EVR1-2001-00047, Contract no. EVR1-CT-2002-40026).

[17] Neri, A., T.E. Ongaro, G. Macedonio, and D.Gidaspow, Multiparticle Simulation of Collapsing Volcanic Columns and Pyroclastic Flow. J. Geophys. Res. 108 (B4): 2202, 2003.

[18] CINECA Interuniversity Supercomputing Center, Italy www.cineca.it

The simulation results describe the formation of the volcanic column (Fig.5), its instability and the partial collapses. Pyroclastic flows form all around the crater and propagate along the volcanic slopes following the main topographic valleys, reaching the sea, about 7Km from the vent, at 1500s (Fig.6). The simulation highlights the effect of the Mt. Somma relief acting as a natural barrier for the invasion of pyroclastic flow along the Northern sector of the volcano and deviating the pyroclastic flows along its scarps.

3 From simulation in scientific visualization to knowledge visualization

Scientific visualization tools are mandatory for researchers involved in the numerical modelling in order to analyze the results of the simulation.

3.1 The approach to Scientific Visualization

At the beginning of the 90s the Scientific Visualization system adopted by the VisiT lab (Visual Information technology lab, CINECA) [19] was AVS[20].
The visualization techniques provided by AVS include color mapping, volume slicing, glyphs, isosurfaces, isovolumes, streamlines, surface and volume rendering.

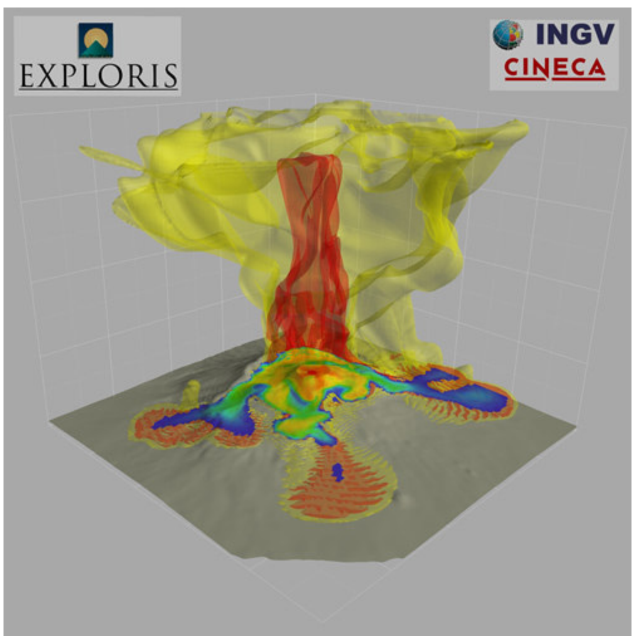

Figure 1: Eruption simulation visualization by AVS/Express.

These techniques are still the most currently used. What has changed is how visualization is designed.
In fact, in AVS each functionality is presented to the user as a building-block and a particular visualization is created by connecting these blocks in a visualization-network.
This approach was very powerful, but it turned out that non-trivial visualizations required a well trained user to be set-up.
Moving to VTK library [21] different benefits have been obtained:

- Flexibility: visualizations may be set-up by code. This approach in certain circumstances might be more efficient than using a network-editor-UI. However a Visual Editor is available [22].
- Since VTK is free, there are no limits in releasing /distributing the resulting visualizations
- The good VTK documentation is also to be mentioned together with the active VTK community.

More recently, on top of the Visualization Toolkit and ITK [23] our laboratory developed a framework called OpenMAF [24]. OpenMAF is a free and open source framework for the rapid development of applications in the field of scientific applications and it pushes the VTK visualization capabilities further in different directions. It increases the number of managed datasets, handles time varying datasets and presents new UI metaphors. Entities that can be added are: New type of DataSet, new Visualization-Pipelines, new Views and new Operations.

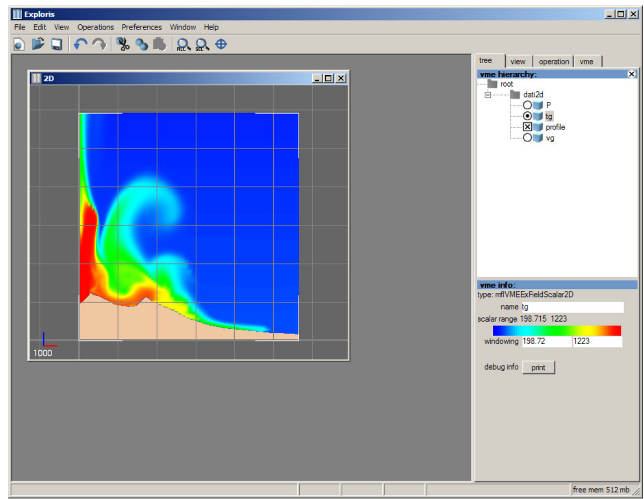

Figure 2: An example of an OpenMaf based application, a scalar visualization related to the eruption simulation, pressure values.

3.2 The Vesuvius' scenario visualisation and communication framework

The Interactive Virtual Environment conceived for the Vesuvius area is a scenario for the presentation of quantitative analysis of explosive eruption and the evaluation of the likely effectiveness of possible mitigation measures such as land-use planning, engineering interventions in buildings, emergency planning and community preparedness.
The specific aim of the visualization and communication project is to integrate the results of the eruption numerical simulations with geographic datasets for a fully interactive 3D high-resolution navigation around the volcano preserving a correct perception of the quality of the simulation.
The main graphics steps to achieve this task are the landscape reconstruction and the implementation of two visualization tools with different characteristics one for the analysis Exploris-A(nalyzer) and the other for the communication Exploris-V(iewer).

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[19] ViSIT lab http://www.cineca.it/sap/area/teatrovirtuale.htm
[20] AVS http://www.avs.com/
[21] VTK http://www.vtk.org/
[22] vtkGUI http://visit.cineca.it/vtkGUI/
[23] ITK http://www.itk.org/
[24] OpenMAF http://www.cineca.it/B3C/MAF

3.2.1 The landscape reconstruction and connection to GIS data

An added value to the scientific simulation of Vesuvius' eruption comes out by using and integrating geographical and historical data. The reconstructed terrain under the eruption concurs a better understanding of the future foreseen event.
Three types of GIS (Geographical Information System) data have been collected for the Vesuvius area : a DEM (Digital Elevation Model), orthophotos and Shape Files (ESRI file), with demographic information.
All these three types of files, according to the definition of GIS data, include the geographic position useful to overlap and handle together all the data. The original coordinate system was Gauss Boaga, a typical Italian geographic system, but it has been translated in the more common ED50 UTM zone 33[25].
The digital elevation model is organized in a matrix (1193 rows x 1157 cols) having a resolution of 20 m. The DEM is derived from a Triangulated Irregular Network (TIN) obtained interpolating spot heights and contour lines of 5m contour interval of a map at a nominal scale 1:5000[26]. The TIN approximates the surface of the considered area by a network of triangular plane facets and the algorithm used is a variation of Delaunay's method [27].
The orthophotos used for texturing and land use are 6 tiff images (RGB format) covering a large part of Vesuvius' area. They have a high spatial resolution (cell size of 1 m) allowing to identification of several detailed elements such as roofs, roads, sidewalks, trees etc. The images came from the IT2000 campaign[28].
The vectorial data are referred to Ercolano municipality, one of the 18 municipalities around Vesuvius, and include 3 main informative layers: buildings, viability and census data. In the project, the buildings are organized in 4 main typologies (residential, industrial, religious, social-administrative), the viability was described through 3 typologies (motorway, ordinary road and ordinary railway) and the census data are available for each residential building as derived from 1991 Istat Italian Census. These themes come from a detailed GIS realized for 7 circumvesuvian municipalities[29] mapped at the nominal scale 1:2000 for the highly urbanized areas (using a photogrammetric survey at scale 1:7000) and at the nominal scale 1:5000 for the rural areas (using a photogrammetric survey at scale 1:13,000). This GIS contains more than 400 natural and artificial thematic layers organized in 9 main categories (Orography, Idrography, Vegetation, Rail communications, Road communications, Buildings, Administrative boundaries, Points of certain determination and Toponomy) and many subcategories. Each one of these aspects is identified by a unique code and is linked to a relational database where a great number of information is stores for each single feature.
The first important step was to generate the 3D virtual terrain around Vesuvius' area. It has been created using a commercial software, Terravista (Terrex) that combines two sets of information, one on geometry and the other one on textures. The second step was the creation of special layers with the most important helpful information to understand better the entity and peculiarities of the simulated event. The choice of particular layers (buildings' disposition, population density and street networks) has been addressed to supply to Civil Protection Department a greater decisional support in case such an event the will take place. In fact this area turns out very highly populated and this emergency will involve all the European Community.
Moreover it is possible to add any layers that gives useful information. A lot of data are available about Pompeii.
Therefore all existing information can be integrated in the same framework as archaeological and historical, geological or environmental ones.

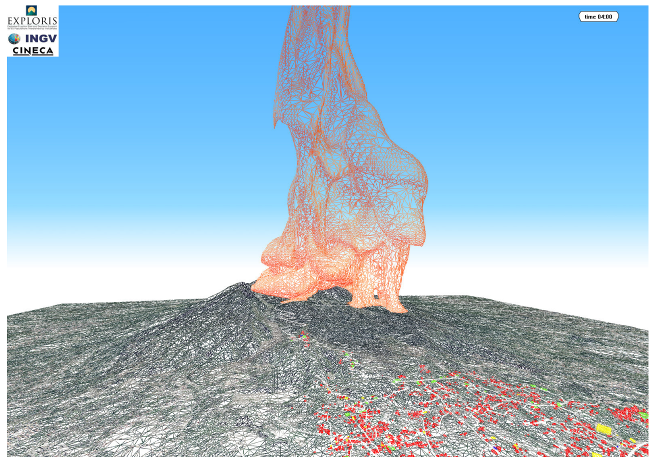

Figure 3: Wireframe representation of the DTM , the simulation and GIS data.

3.2.2 The Scientific Visualization tool

It is a tool specific for scientific purposes able to process big data sets (tens of scalar and vector data over grids up to 2003 elements.
It provides the following features:
• Terrain (digital elevation model) visualization;
• Time dependent scalar and vector fields visualization;
• Streamlines, isocontours, animations computing and visualization;
• Saving/export of new data, images, animations.
It is based on the MAF (Multimod Application Framework) technology of CINECA. The framework allows the development of multimodal visualization application where different views of the same data are synchronized and when the position of an object changes in one view it is updated in all the other views.

[25] European Datum 1950 (ED50), Universal Transverse Mercator (UTM) as projection, zone 33 is the related zone for the Vesuvius' area
[26] Pareschi M.T., L.Cavarra, M.Favalli, F.Giannini, 2000, GIS and Volcanic Risk management, Natural Hazard, 21, 361-379
[27] Favalli M. and Pareschi M.T., 2004. Digital elevation model construction from structured topographic data: the DEST algorithm. J.Geophys. Res., DOI: 10.1029/2004JF000150
[28] Compagnia Generale Riprese Aeree, 1998
[29] Pareschi M.T., Santacroce R., Favalli M., Giannini F., Bisson M., Meriggi A., Cavarra L. "Un Gis per il Vesuvio". Felici Artigrafiche Ed., maggio 2000, pp. 57.

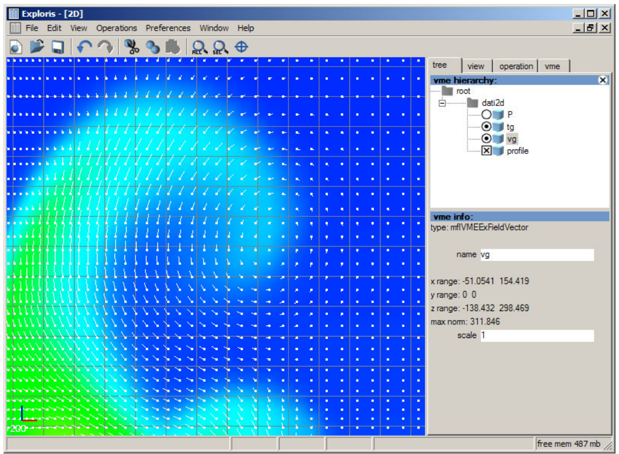

Figure 4: 3D data view, a vector field visualization.

3.2.3 The communication tool

It is specific for dissemination or demonstration and educational purposes in order to show the most interesting results in a more friendly way.

It provides the following features:

- Visualization of the terrain (digital elevation model) plus GIS information (buildings, topography,…);
- Visualization of large data sets original or coming from the Scientific Visualization tool Exploris-A;
- Interactive ("real time") navigation of large landscapes at high resolution;
- Virtual theater stereo rendering visualization;
- Virtual set porting.

It is based on VisMan (Virtual Scenarios Manager) a powerful programming interface by CINECA for creating real-time visual simulation and other performance-oriented 3D graphics applications.

VisMan simplifies development of applications used for visual simulation, manufacturing, simulation-based design, virtual reality, scientific visualization, interactive entertainment, architectural walk-through, and computer aided design.
It provides collision detection over the 3D world and connections between 3D objects and databases of multimedia objects (html documents, images, sounds, movies, …).

Visman is a software framework developed at the Visit laboratory inside Cineca, that is mainly dedicated to cultural heritage projects. It is written entirely in C++ and uses the wxWidgets and OpenGL Performer libraries; is available on Windows and on Linux systems (IA32 and IA64). So the software is scalable from a PC to an SGI Prism visual computer.
It has been used to develop advanced systems within virtual cultural environments.[30]
3D reconstructions are the starting point for the interaction with the virtual world: with the simple click of the mouse button, 3d objects can be connected to information coming from relational databases, multimedia files, GIS, and so on.
Each 3D linked object is highlighted by a hint that appears when the mouse cursor runs over the object. Also automatic 3D search is possible from the linked information, for example looking for a 3D object from the related database record.
The navigation is similar to "first person shooters" videogames with collision detections with the virtual world. Thanks to naming conventions, special nodes inside the scene graph are recognized and treated in particular way, and also some GUI is created to handle the behavior of those nodes; for example particular nodes are switches, links to database or multimedia files, evolution nodes, Image Based Render, scene switch nodes (model deepening), and some others.

Thanks to ExplorisA, the simulation, that has been saved in RAW format, has been processed in the VTK format.
Using ExplorisA we can export the quantities we find more interesting for evaluating the simulation, in the form we find more appropriate, so we chose the iso-surface because the conversion to Performer was easy and because the iso-surface is suitable to be transferred on top of the territory.
The quantities that have been mostly studied are mass concentration and the temperatures, because they have been considered more representative of the phenomenon.
ExplorisA exports the single frames of the simulation (1 frame every 2 seconds of simulation) in the VTK format.
The VTK files are then converted in the pfb format (native OpenGL Performer format) by a utility that uses the open-source library vtkActorToPF [31].
In this phase, also different materials are given to the iso-surfaces (for instance transparency and different colours for inner and outer surfaces) that would be more fitting for the related quantity (red-yellow for temperatures, and so on).
At the end of the process, for every frame of the simulation and for every iso-surface there will be one pfb Performer file.
Visman wasn't able to support 3D animations, so it has been modified and enhanced so that it would read a sequence of pfb files and would load them under a pfSequence node for animation.
The greatest problem at this point was the memory limit on Windows 32 bit platforms, since we had "only" 2 Gbytes of memory per process for applications; in fact we had loaded the full simulation on an SGI Prism machine, but mostly for portability we wanted the simulation to work in real-time on PCs as well. The solution was to have a dynamic loading of data, so that only a small number of frames would reside in memory (5-10 frames to use as a buffer), the rest is periodically loaded. From our tests, a good PC can load a new frame every 0.5 seconds or slightly more, so this is the limit for fluidity of the animation on PCs. The loading period is customisable anyway, for tailoring the system performance of the machine where the application is running; moreover, controls have been added to stop, resume and restart the animation.

[30] Guidazzoli et al., "Databases and virtual environments: a good match for communicating complex cultural sites. SIGGRAPH 2004

[31] http://brighton.ncsa.uiuc.edu/~prajlich/vtkActorToPF

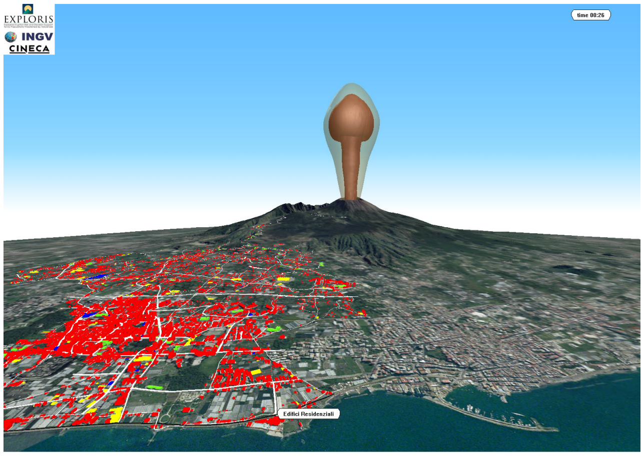

Figure 5: Formation of the volcanic jet at 25s.

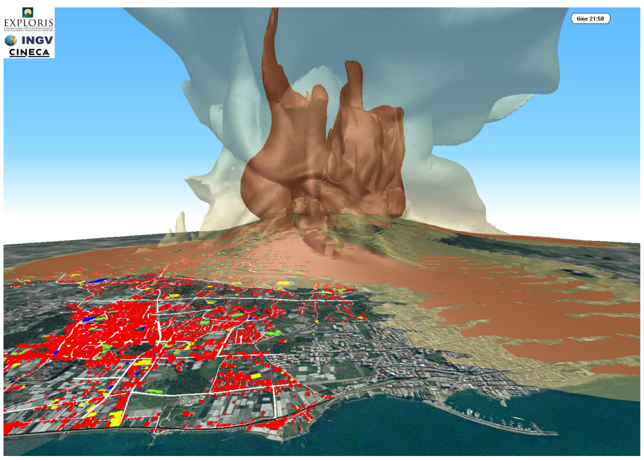

Figure 6: Toward the end of the simulation: 25 minutes after the beginning of the eruption. The isosurfaces correspond to total particle concentrations of 10^{-4}(inner) and 10^{-6} (outer).

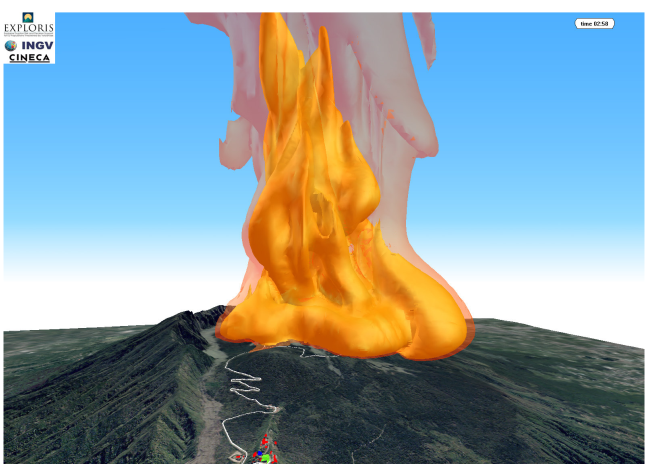

Figure 7: Temperature isosurfaces at 350 and 100 degrees Celsius.

4 Merging Vesuvius landscape scenario to virtual archaeology reconstructions and cultural information

The interaction with the Virtual Environment created for the simulation of Vesuvius' eruption allows users to be immersed in a sort of *hic et nunc* but, at the same time, it permits them to retrace and understand historical events which occurred in the same area at different periods as in the case of well known Pompeii history.
Our framework has been designed in order to provide a complete and contextual access to already existing local digital products related to the same geographical area.
This aspect enables a user to put into relation different historical events and topics, gathered under the same contextual "roof" that unifies even apparently disjointed cultural resources like Virtual Archaeological applications, developed at Bologna University, databases produced by Pompeii Superintendence or museums, archives and private research centres without any preclusion to other future realizations.
Combining these resources in a visual geographical portal not only unifies a set of applications, but also constitutes a more complex conceptual access, creating a new way to manage and use Virtual Cultural Heritage.
The geographical interface is the starting point for accessing all the different 3D reconstructions and data.

4.1 From research models to virtual scenographies

The aims of the "Pompei – Insula del Centenario IX 8" [32] project are the documentation, study and valorisation of the Insula IX of Pompeii, called "Insula del Centenario" from the large *domus*, excavated in 1879-1880, which occupies its main part.

Figure 8: Insula del Centenario, Pompeii.

[32] The "Pompei – Insula del Centenario IX 8" [32]Project was started in 1999, thanks to the efforts of Daniela Scagliarini Corlàita of the Department of Archaeology - Bologna University. It has been realized in the framework of the MUSE Project (funded by MURST within the National Research Program on Cultural Heritage Parnaso) conducted by Boconsult, a Ducati sistemi Division, in cooperation with Bologna University, CINECA and Sinet

The Virtual Insula del Centenario consists of two immersive virtual environments: as it is nowadays - in order to stimulate comparisons and to make possible the access in an area where tourists are not admitted, and as it was at the time of the eruption that, in 79 A.C., destroyed Pompeii - in order to visualize archaeological hypotheses and theories based on the study of ruins and findings. The project *"Casa del Centenario in Pompeii"* has reconstructed part of this Pompeian house starting from the present structures: frescos, taken away and stored in a museum, have been artificially put again in their original position; frescos left on the walls and damaged due to weather impact have been "replaced" with less spoiled versions worked out using photos taken in the Thirties; ruins have been integrated with reconstructed lacking sections (e.g. the higher part of walls, coverings, fixtures). This reconstruction has been used in several ways:

1 – with PDAs, for helping the context awareness on the archaeological site.

2 – with a desktop, for both navigating the model and accessing the Data Base.

3 – in the Virtual Theatre, as the one in CINECA, for experiencing a sense of physical immersion in the virtual environment.

4 – models have been used also during a conference that was broadcasted via streaming video and that it is still available on the Web[33] .

A further opportunity was located in the use of models for the realization of a TV documentary. Since the communication tool, described before, has been designed with a high degree of compatibility with the Virtual Set it took just a few days work for adapting the models and interactions to it.

Now, once that documentary has been shown on TV on the national channel, it has entered an archive created by RAI[34]: Mosaico, a TV mediateque for educational support. In a framework called Mosaico, people, teachers in particular, find a list of educational TV programs and can ask for their programmed broadcast on the RAI Educational satellite channel. People need just to be registered and then they will be notified about the date of transmission.

[33] http://www.cineca.it/convegni/ut_natura_ars/

[34] http://www.mosaico.rai.it/

Figure 9: Casa del Centenario, Pompeii archaelogical site.

Figure 10: A screen shot taken from the TV documentary.

Such applications should offer not only flexibility from the usability point of view, but also portability, hence enabling the application to run on many different visualization platforms available today.

In order to make such virtual environments more user-friendly, it is necessary to improve access to and understanding of contents by providing the general public with new paradigms for access and use.

Virtual Reality applications and interaction via palmtops will grant a better surfing experience inside the reconstructed environment. Different communication forms, such as the Internet, streaming videos, virtual worlds within Virtual Sets will most likely increasingly integrate. It is necessary to understand the specific features of each medium while

foreseeing possible synergies between such new communication modes within the specific framework of Virtual Environments.
The creation of virtual scenarios implies a new organization of work. For example, within the framework of Virtual Cultural Heritage, the creation of real-time applications based on 3D digital models develops within a multidisciplinary environment where computer experts, architects, archaeologists, historians, scriptwriters work to bring about Virtual Reality applications.
The development of a VR product relies on a working method that makes use of different professional skills and foresees constant feedbacks between technical, computer-oriented and liberal arts experts. Moreover the usage of a framework based on an open source software, can be considered an important added value for a real "open heritage".
The use of open source tools is changing the approach to Virtual Reality applications in the heritage sector, leading to the creation of personalized spatial tools useful to link/connect all the data acquired during survey campaigns; keep the same geographical projection used in GIS projects; maintain the same GIS data formats; generate quality paged and tiled terrains of the area from GIS data; maintain the same modeling formats of three-dimensional monuments and sites reconstructed with photo-modeling or scanner-laser techniques and processed with external software; create libraries of 3d models and vegetation typical of the area and of the period; connect directly inside the three-dimensional geographical space the models and the vectorial themes; work dynamically at the reconstruction of the visible archaeological landscape, testing hypothesis, using the same data even for complex VR applications, useful for example for museums with a story-telling approach; and finally publish the results of surveys over the Web, updating them at each new campaigns through web plug-in.
The ability to use open source technology allows the dissemination of content without additional cost and the customization of applications.
We are also working on the port of VisMan VE visualization component from Performer (proprietary) to OpenSceneGraph (open source) foundation library.
This porting activity will allow us to have a scalable presentation architecture, from high end VR installations to low end, plug in based web fruition.
Anyway, we believe that due to enhancement in both network bandwidth and spread of 3D client graphics performance, the ability to produce web-accessible content and application is a key issue in 3D content production pipeline.
Moreover the correct use of the product will then be guaranteed by communication experts who will coordinate all the project components. It is usually necessary to involve several institutions to bring together such well-structured teams, and this is exactly our experience in the Vesuvius' scenario reconstruction.

5 Concluding remarks: multi channel outputs and future research

Our experience somehow highlighted how the concept of *media morphosis* can also apply to a medium such as VR. The latter will necessarily involve more media and maybe it will force other media to change – the same happened when TV ushered in the transformation of the radio.
Today Virtual environments – just like early cinema – are new media that still goes through an "amazement effect" stage, but VR will soon need to devise its own language and its own specialized genres. VR curators must be able to interact with different disciplines and to exploit the potential of computer science in order to accompany users as they surf complex scenarios. The scientific results of the Exploris project have produced a new research project with archaeological purposes.
Starting from the reconstruction of the Roman time Vesuvius' topography based on geological data and historical sources, a new simulation of the past is going to be run.

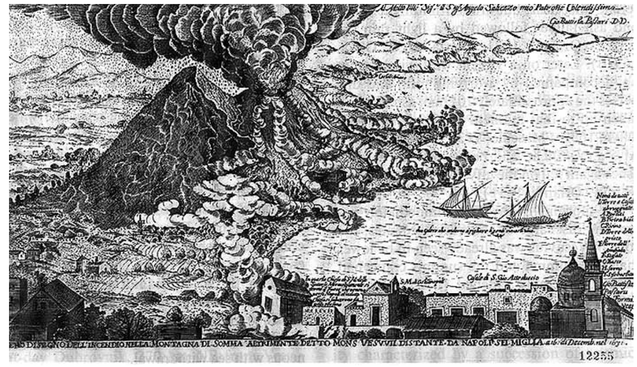

Figure 11: Giovan Battista Passaro's drawing (1631)

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