# NEW VR SYSTEM FOR NAVIGATION AND DOCUMENTATION OF CULTURAL HERITAGE

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***Abstract:***

*The key idea of this work is an innovative VR system for the navigation of archeological sites. Being very flexible, comfortable and easy to improve it results a going-on and very useful tool for Cultural Heritage documentation and tourism promotion.*
*Strong point of the proposed VR solution is its VVVV visual programming interface that is a powerful application for real time video synthesis, characterized by physical interfaces that facilitate the handling of large media environment and allow to interact in real time with motion graphics, audio and video.*
*Experimental results show how the proposed VR solution is able to handle high resolution imagery giving always good performance in terms of static and motion quality. Moreover it allows a powerful customization in terms of input and output devices, widening in this way its application field (tourism on Cultural heritage sites, museums, high resolution architectural analysis and spherical panorama photogrammetry).*
*In particular in this work different pointing peripheral devices have been set: mouse, graphic table, joystick, touchscreen and video/laser tracking systems. In the same way different multi-visualization systems have been tested by means of monitors and beams projectors.*
*Moreover ad hoc user interfaces have been designed to improve different functionalities such as museum navigation (tourism guide to drive the user trough different optional starting exploration points) and pointing device for plotting (spherical coordinate acquisition tool for photogrammetric survey).*

**Keyword: Virtual Reality, cultural heritage, museum navigation, photogrammetric tool**

## Introduction:

Virtual interactive navigation, better called dynamic perspective interactive navigation, is a digital representation tool with high performance in terms of reliability, user participation and extensive photographic documentation.
VR (Virtual Reality) means a large set of computer-simulated experiences allowing participants in virtual or augmented environments to gain accurate spatial knowledge. These virtual environments usually result from simple or complex computer models enabling user interaction by means of computer devices: pointing (mouse, etc.) and visualization devices (screen, etc.).
According to virtual navigation, first, a distinction must be made between 3D environments (usually virtual reconstructions) and photographic representations of really existing scenes.
This second chance of virtual navigation was first proposed by Apple Inc. in 1985 (QTVR technology) and nowadays developed by different programming languages (Flash, Java and other proprietary software). In this way it becomes strongly accessible and well-suited to be displayed

with different operation system and browsers. On the other hand it still has its drawbacks: device management, navigation mode and interface set up are not fully configurable by the user.
Different parameters can be taken into account to judge these kind of VR elaborations: image quality, movement fluidity, software accessibility, chance of easy implementation and GUI customization etc.
According to this grading system the innovative VR navigation solution proposed in this work results to be high-quality although working with high resolution panoramic scenes. Fig.1 shows how it is possible to take advantage of a flowing navigation to appreciate frescos in Villa Pojana and pay attention to their details.
Strong point of the proposed VR solution is also the chance to be open for contributions and augmented by the possibility to set different hardware configurations.
In particular in this work different user interactions have been tested, setting different pointing peripheral devices and complex multi-visualization systems.
An experimental result is fixed in Fig.2 where the developed VR application allows the user to play with an holographic touch screen device as unique navigation tool .
Moreover according to latest developments in spherical photogrammetry the proposed VR solution can be developed and turned to be a useful tool for pointing and spherical coordinate acquisition. As shown in Fig.3 a GUI is designed to easily get homologous points and store their spherical coordinates (J,f) .

**Fig.1 - Virtual navigation of frescos in Villa Pojana (Andrea Palladio, Vicenza)**

**Fig. 2 - Holographic touch screen device (Libyan museum, Tripoli, Libyan Arab Jamahiriya)**

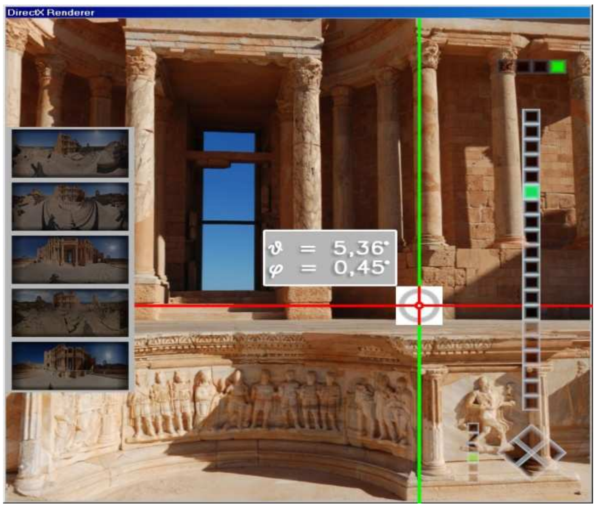


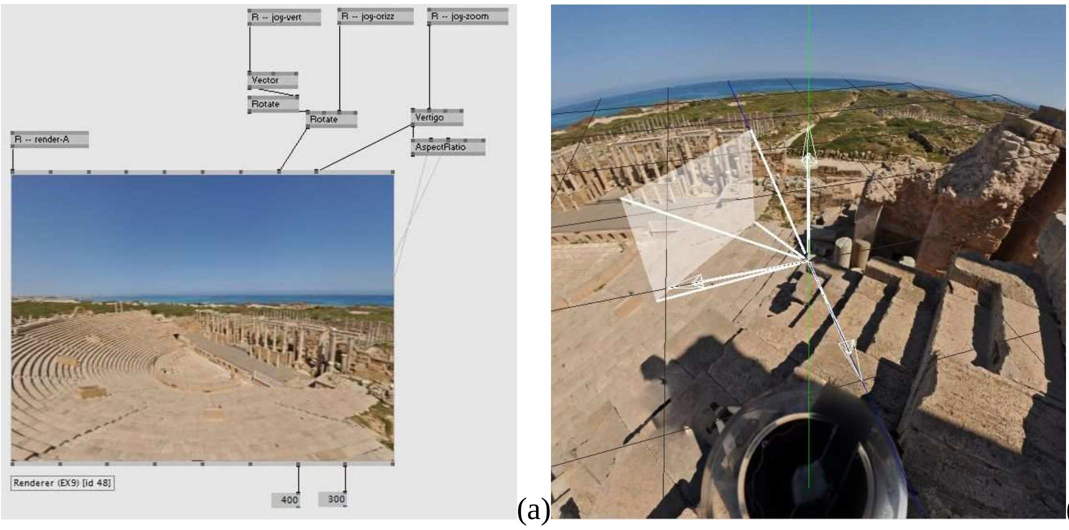

**Fig. 3 – GUI for coordinate acquisition**

**The graphical programming authoring environment:**

The programming language used in this work is vvvv that is free for non-commercial use and available through its website.

vvvv uses a data flow approach and a visual programming interface for rapid prototyping and developing.

vvvv is written in Borland Delphi. Plugins can be developed in the .NET Framework in C#. Applications written in vvvv are commonly called patches, consisting of a network of nodes. Patches can be created, edited and tested while they are running and are stored on the disk in standard XML format. In Fig. 4 is shown an example of patch with its input and output nodes: the patch allows to set the direction and the render field of view (Fig.4a) and to orient the camera in the virtual scene (Fig. 4b)




(a) (b)

**Fig.4 – *vvvv* patch(a) and the relative simulation of the camera in the virtual scene(b)**

The base platform is Windows operating systems, restricting in this way its field of use. Also limitative  is the impossibility to run the real-time navigation on web browsers.
This kind of programming language allowed to create a VR solution running on standard commercial PCs, maintaining nevertheless a high quality of navigation.

**Perspective principle and experimental results**
The visualization of the virtual scene is implemented in a real time 3d environment.
The navigation system controls a virtual camera inside a spherical geometry (Fig.5). The camera is positioned with the nodal point (the position where the photographs were taken) on the origin of the axes.
A spherical mapping is used with an equirectangular projection as texture (Fig.6). This kind of projection allows to better exploit the image and avoid resolution problems on the rendered surface. Such kind of problems are frequents when different projection types are used, as the cubic or cylindrical one.
The resulting image is error-free, especially in the zenith and the nadir positions that are always critical.

**Fig.5 - Rendered geometry with UV spherical mapping coordinates**

**Fig.6 - Panoramic image in equirectangular projection**

One innovative feature of the proposed software is the possibility to navigate the whole panorama image or its single portions only giving their  positions inside the equirectangular projection.
User interaction is implemented through the control on the direction of the point of view and on the focal length. Furthermore it is possible to insert secondary parameters of control like the

velocity-response of user inputs and the sensitivity, in relation to the focal length: sensitivity is decreased for longer focals.
In automatic way, the image resolution is used to set the focal value in order to preserve the image effective pixels and avoid in this way loss in image quality.
To widen the range of use and the typology of installation, numerous input devices were used, to show the remarkable flexibility of the tool.
Besides the mouse are used both common input devices like PS2 Joypad and MIDI controllers, and more complex pointing systems such us touch-screens or multiple touch-screens.
Moreover, integrating and modifying web-available libraries, a low-cost video tracking system is created, using simple webcams.
To demonstrate the adaptability of the system to multiple input devices, a system of laser tracking is used for the individuation of the position of the user inside a room.
In particular the optical axis $R_x$, $R_z$ rotation and FOV, necessary to set the direction and the render field of view, are expressed in terms of local coordinates and acquired in this research with the aid of multiple input devices:

- Mouse/joypad and its absolute coordinate acquisition on the rendered window (Fig.7),
- touch-screen and hand-movements defining range and velocity parameters,
- video-tracking and tracking tool position acquisition (Fig.8),
- laser-tracking system and user position acquisition (Fig.9).


**Fig.7 - Joypad pointer and monitor visualization devices.**

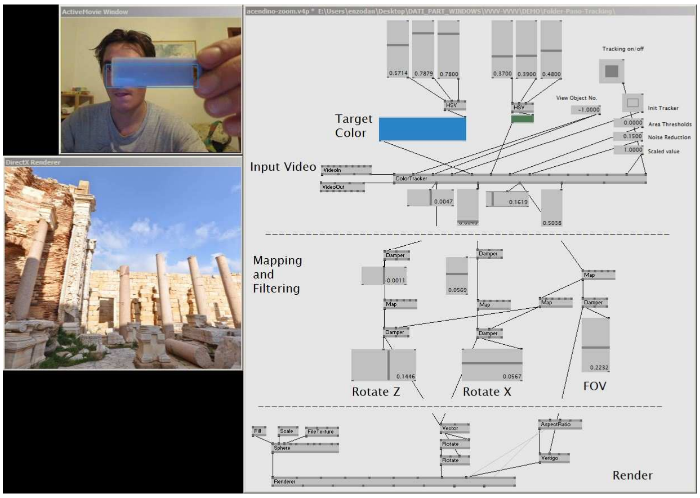


Fig.8 - Video tracking for Rx, Rz and FOV acquisition and relative vvv patch

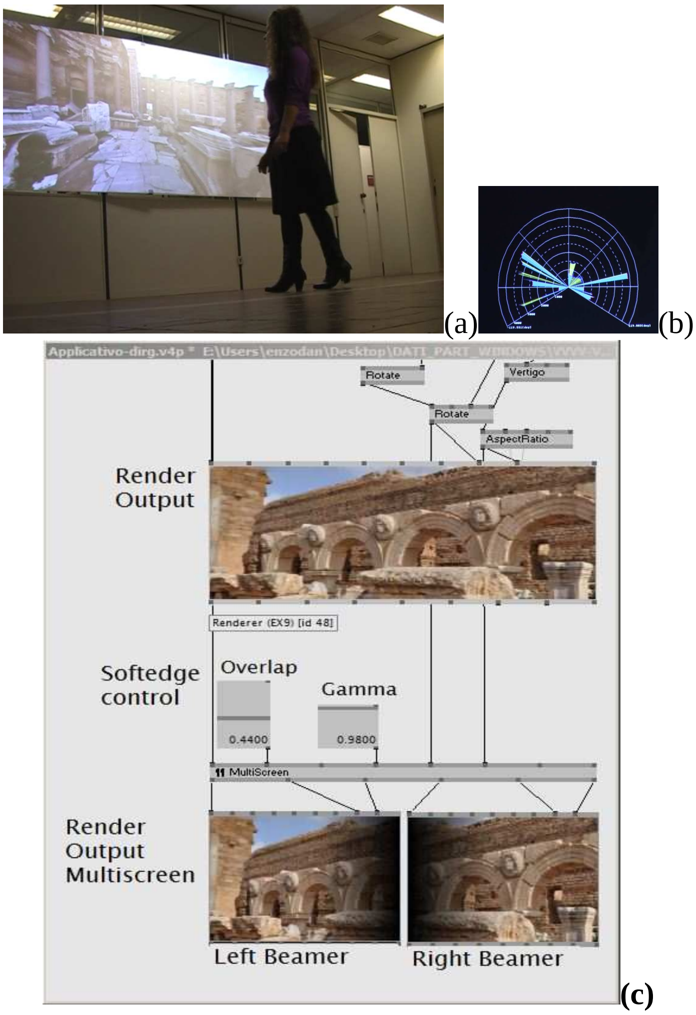


Fig 9 – Laser tracking with multi projection system (a,b) and relative vvvv patch (c)

One of the greatest limits of other available softwares is the impossibility to modify their graphical interfaces: this limit is overcame by designing a custom interface to drive the user in its virtual tour. Fig. 10 shows the designed Virtual tour GUI that allows the user to choose the starting points for its virtual navigation of Leptis Magna archeological site,


**Fig.10 - Virtual tour GUI, Leptis Magna archeological site, Libia.**

## Conclusion

The experimental results underline the performance of the VR developed application in terms of flexibility (different input/output device settings), navigation quality and reliability.
Moreover being comfortable and easy to improve and customize it results a going-on and very user-friendly tool for Cultural Heritage documentation and tourism promotion.