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New Trends in Virtual Reality Visualization of 3D Scenarios

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<http://dx.doi.org/10.5772/46407>

1. Introduction

Virtual Reality (VR) is successfully employed for a real huge variety of applications because it can furnish major improvement and can be really effective in fields such as engineering, medicine, design, architecture and construction, education and training, arts, entertainment, business, communication, marketing, military, exploration, and so on. Therefore great efforts have been paid over time to the development of more and more realistic and sophisticated VR scenarios and representations.

Since VR is basically a three-dimensional representation of a not real environment, mainly due to computer-generated simulation, Computation and Visualization are the key technologies to pay attention to. But while the Computational Technology experienced an exponential growth during the last decades (the number of transistors on an integrated circuit doubles approximately every 18 months according to the Moore's law), the Technology devoted to Visualization did not catch up with its counterpart till now. This can represent a limit or, even, a problem, due to the fact that human beings largely rely on Visualization, and the human reactions can be more appropriate in front of spatial, three-dimensional images, rather than to the current mainly adopted two-dimensional Visualization of scenarios, text and sketches. The current adoption of flat panel monitors which represent only the "illusion" of the depth, does not completely satisfy the requirement of an "immersive" experience.

In VR, a Visualization in three dimensions becomes more and more mandatory, since it allows more easily the humans to see patterns, relationships, trends, .. otherwise difficult to gather.

This chapter describes the actual requirements for 3D Visualization in VR, the current state and the near future of the new trends. The final goal is to furnish to the reader a complete

panorama of the state of the art and of the realizations under development in the research laboratories for the future possibilities.

To this aim we report the most significant commercial products and the most relevant improvements obtained with research prototypes for 3D Visualization in VR. In addition an interesting patented technology is described for which the screen is not made by a solid material as it usually occurs, so that the viewer can even *walk-through* the visualized scenario.

2. Requirements

The requirement for 3D Visualization in VR seems that can be now partially or, in some way, completely satisfied thanks to new possibilities offered by the latest technologies. We are not thinking to the “standard” 3D representation furnished by flat monitors, but real new 3D Visualization which can occur in a three-dimensional room environment, furnished by dedicated equipment, which allows to visualize any scenario from any perspective.

That’s the way to realize the longed “real” immersive experience, even going beyond mere images visualized on a screen, toward ones that we can interact with and *walk-through* or *navigate-through* (the so called *Princess Leia effect* from the *Star Wars* movie) because no solid support for projection is necessary.

Today, the term VR is also used for applications that are not properly “immersive”, since the boundaries of VR definition are within a certain blur degree. So, VR is named also for variations which include mouse-controlled navigation “through” a graphics monitor, maybe with a stereo viewing via active glasses. Apple’s QuickTime VR, for example, uses photographs for the modelling of three-dimensional worlds and provides pseudo look-around and walk-through capabilities on a graphic monitor. But this cannot be considered as a real VR experience.

So here we present and discuss new technologies and new trends in Virtual Reality Visualization of 3D Scenarios, also reporting our personal research and applications, especially devoted to new holographic systems of projection.

This chapter covers the aspects related to the Visualization tools for VR, talking of their requirements, history, evolution, and latest developments. In particular an novel authors’ patented technology is presented.

We can expect from the future weaker and weaker boundaries between Real Environment (RE) and Virtual Environment (VE). Currently RE and VE are recognized to be the extremes of a continuum line where Augmented Reality (AR) and Augmented Virtuality (AV) lie too, according to the proposition of Milgram & Kishino (1994, see Figure 1). But we believe, in a near future, this line will become a circle, with the two extremes to be overlapped in a single point.

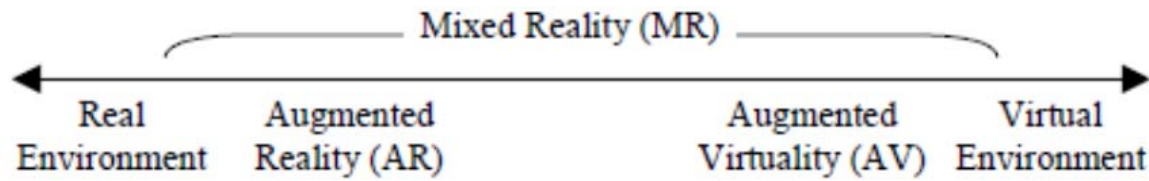


Figure 1. Virtuality-Reality Continuum

It means it will occur a difficulty or, even, impossibility for human senses to distinguish between Reality and Virtuality, and that's the real challenging goal. But, to this aim, the Visualization Technology needs to realize a burst of speed.

In the following we'll treat the new technology regarding Immersive Video, Nomatic Video, Head Mounted Displays, 3D AutoStereoscopy, Transparent Displays and HoloMachines. We will focus our attention in particular on 3D AutoStereoscopy and HoloMachines, since we have been spending efforts and gained experiences on these two technologies during latest years.

3. Actual state of new trends

Among all the commonly adopted methods to visualize a virtual or real scenario, there are some technologies worth to be mentioned as the more interesting ones, representing the actual state of new trends. So, in the following the Immersive Video, the Nomadic Video and the Head Mounted Displays are reported.

3.1. Immersive video

Immersive Video (IV) technology stands for 360° video applications, such as the Full-Views Full-Circle 360° camera. IV can be projected as multiple images on scalable large screens, such as an immersive dome, and can be streamed so that viewers can look around as if they were at a real scenario.

Different IV technologies have been developed. Their common denominator consists in the possibility to "navigate" within a video, exploring the scenario in all directions while the video is running. The scenario is generally available for a 360° view, but it is visible in a reduced portion at time, changeable according to the user's preference. Currently a few Company are devoted to IV technology, but their number is expected to growth exponentially. Let's consider here the major examples.

A first example comes from the Immersive Media® Company (www.immersivemedia.com) which is a provider of 360° spherical full motion interactive videos. The Company developed the Telemmersion® system, which is an integrated platform for capturing, storing, editing, managing spherical 3D or interactive video. A complete process of developing and building "spherical cameras", through the manipulation and storage of data to create the interactive imagery, to the delivery of the imagery and creating the immersive experience on a user's computer. Video shootings are realized by means of a spherical

device in which different cameras are embedded in a way that images can be captured all around, with the only exception of the real base of the device. A limit comes from the not so performing Shockwave video format, but a “migration” to the Flash format can allow a partial improving of the performance.

The Global Vision Communication (www.globalvision.ch) furnishes technology regarding Immersive Video Pictures and Tours. In particular, their 360° interactive virtual tours can be easily integrated on existing website, or be a website themselves. Each individual panorama in a virtual tour is 360° HD-quality, clickable and draggable, linked to the others through hotspots for navigation and displayed on a customized map, featuring a directional radar. The virtual tour can be enhanced with sounds, pictures, texts, and hotpots.

The VirtualVisit Company (www.virtualvisit.tv) offers services related to 360° imagery too. Their services range from creation of 360° photography of facilities and programming high quality flash-, java- and iPhone/iPad compliant virtual visits.

The YellowBird® Company provides another example of end-to-end 360° video solutions (www.yellowbirdsdonthavewingsbuttheyflytomakeyouexperiencea3dreality.com). They shoot, edit, develop and distribute interactive 360° concepts with some of the most progressive agencies, broadcasters and brands around the world.

Another example we can mention is the Panoscope 360° (www.panoscope360.com), which consists of a single channel immersive display composed of a large inverted dome, a hemispheric lens and projector, a computer and a surround sound system. From within, visitors can navigate in real-time in a virtual 3D world using a handheld 3-axis pointer/selector. The Panoscope 360° is the basis of the Panoscope LAN consisting of networked immersive displays where visitors can play with each other in a shared environment. Catch&Run, the featured program, recreates a children's game where the fox can eat the chicken, the chicken can beat the snake and the snake can kill the fox. The terrain, an array of vertically moving rooftops, can be altered in real time, at random, or by a waiting audience trying to “help” players inside.

In the IV frame is concerned the European FP7 research project “3DPresence” (www.3dpresence.eu), which aims the realization of effective communication and collaboration with geographically dispersed co-workers, partners, and customers, who requires a natural, comfortable, and easy-to-use experience that utilizes the full bandwidth of non-verbal communication. The project intends to go beyond the current state of the art by emphasizing the transmission, efficient coding and accurate representation of physical presence cues such as multiple user (auto)stereopsis, multi-party eye contact and multi-party gesture-based interaction. With this goal in mind, the 3DPresence project intends to implement a multi-party, high-end 3D videoconferencing concept that will tackle the problem of transmitting the feeling of physical presence in real-time to multiple remote locations in a transparent and natural way.

Interesting immersive VR solutions come from CLARTE (www.clarte.asso.fr), which is a research centre located in Laval, France. In November 2010, CLARTE introduced the new

SAS 3+, a new Barco I-Space immersive virtual reality cube for its research projects. The I-Space is a multi-walled stereoscopic environment (made of three screens, each of 3x4 meters) that surrounds the user completely with virtual imagery. The SAS 3+ installation at CLARTE is powered with eight Barco Galaxy NW-12 full HD projectors and designed with three giant 4 by 3 meter glass screens.

The UC San Diego division of the California Institute for Telecommunications and Information Technology (Calit2, www.calit2.net), developed the StarCAVE system. It is a five-sided VR room where scientific models and animations are projected in stereo on 360-degree screens surrounding the viewer, and onto the floor as well. The room operates at a combined resolution of over 68 million pixels - 34 million per eye - distributed over 15 rear-projected walls and two floor screens. Each side of the pentagon-shaped room has three stacked screens, with the bottom and top screens tilted inward by 15 degrees to increase the feeling of immersion. At less than \$1 million, the StarCAVE immersive environment cost approximately the same as earlier VR systems, while offering higher resolution and contrast.

The IV technology is still quite “immature” and expensive but, despite all, it appears to be really promising, thus we can image the future with the current quality problems outmoded, and it will be possible to “navigate into” a movie in real effective ways, looking at the scene from a whatever point of view, even without pay attention to the leading actor but to a secondary scenario.

The IV technology experienced an improvement in performances thanks to new software plug-ins, the most interesting ones coming from Adobe and Apple.

In particular, the Flash® Immersive Video format, developed by Adobe, is especially adopted as a web solution to “navigate” in a street view, and keeping the mouse’s cursor in the direction towards it is intended to go, the scene will change accordingly (see www.mykugi.com as an example).

Also Apple Inc. is interested in the IV technology, and developed the QuickTime Virtual Reality (QuickTime VR or QTVR) as a type of image file format. QTVR can be adopted for the creation and viewing of photographically-captured panoramas and the exploration of objects through images taken at multiple viewing angles. It functions as a plugin for the standalone QuickTime Player, as well as working as a plugin for the QuickTime Web browser plugin.

3.2. Nomadic video

A different way of visualization comes from the Nomadic Video (NV) approach realized by researchers of the Technische Universität Darmstadt (Huber et al., 2011). The display surface is not required to be dedicated and/or static, and the video content can change upon the surrounding context decided by the user. Everyday objects sojourning in a beam are turned into dedicated projection surfaces and tangible interaction devices. The approach is based

on a pico-projector and on a Kinect sensor (by Microsoft Corporation). Pico-projectors and Kinect capabilities (motion tracking and depth sensing), might be able to turn any old surface into an interactive display (with varying results of course). Everyday objects, of the real scene surrounding the user, become a sort of “remote control”, in a sense that the pico-projector plays different scenes according to their arrangement in the space. Makeshift display surfaces - a piece of paper or a book, for example - can be manipulated within a limited 3D space and the projected image will reorient itself, even rotating when the paper is rotated. The level of detail displayed by the projector can also be altered dynamically, with respect to the amount of display surface available. The NV system also allows everyday objects to function as a remote control since, for instance, a presentation can be controlled by manipulating an object within the camera’s field of vision.

Another example of NV comes from the “R-Screen” 3D viewer, that was premiered at the Laval Virtual Exhibition, which is a VR 3-D devices and interactive technology conference that took place in Laval, France, on April 2009. The device is the result of collaboration between Renault’s Information Technology Department and Clarté, the Laval Center for Virtual Reality Studies – which designed and built it. The 3D viewer enables users to walk around a virtual vehicle, as they would with a real vehicle. The “R-Screen” is a motorized screen pivoting 360° and measuring 2.50 m wide and 1.80 m high. It follows the movements of the user in such a way as to always be directly in front of the user. The system adopts several 3DVIA Virtools modules, including their VR pack. The concept was developed by Clarté and patented by Renault. A virtual, scale-one 3D image is displayed on screen. A computer updates the image according to the movements of R-Screen, enabling users to view the virtual vehicle from all angles.

3.3. Head Mounted Displays

The Head Mounted Display (HMD), also known as Helmet Mounted Display, is a visor that can be worn on the user’s head, provided with one or two optical displays in correspondence of one or two eyes. The possibility to adopt one display for one eye, allows different images for the left and right eyes, so to obtain the perception of depth.

The HMD is considered to be the centerpiece for early visions of VR. In fact, the first VR system also highlighted the first HMD.

In 1968, computer science visionary Ivan Sutherland developed a HMD system that immersed the user in a virtual computer graphics world. The system was incredibly forward-thinking and involved binocular rendering, head-tracking (the scene being rendered was driven by changes in the users head position) and a vector rendering system. The entire system was so cumbersome that the HMD was mounted directly to the ceiling and hung over the user in a somewhat intimidating manner.

One of the first commercial HMD can be considered the Nintendo's Virtual Boy, a 3-D wearable gaming machine that went on sale in the 1990s, but bombed, partly because of the bulky headgear required as well as the image being all red.

A recent product was developed by technology giant Sony, that has unveiled a HMD named Personal 3D Viewer HMZ-T1, that takes the wearer into a 3D cinema of videos, music and games. The Sony's personal 3D viewer is being targeted at people who prefer solitary entertainment rather than sitting in front of a television with family or friends. Resembling a futuristic visor, the \$800 device is worn like a pair of chunky goggles and earphones in one. It is equipped with two 0.7 inch high definition organic light emitting diode (OLED) panels and 5.1 channel dynamic audio headphone. The gadget enables the wearer to experience cinema-like viewing, equivalent to watching a 750 inch screen from 20 metres away.

But probably the more interesting HMD was developed by Sensics Inc. (www.sensics.com) with the SmartGoggles™ technology, based on which was realized the "Natalia", a highly-immersive 3D SmartGoggle available as a development platform to content and device partners, with the expectation that it will be available to consumers later in 2012. Natalia has got on-board: 1.2 GHz dual-core processor with graphics and 3D co-processor running Android 4.0; true 3D display 360 degree use; embedded head tracker for head angular position and linear acceleration; dual SXGA (1280×1024) OLED displays, supporting 720p, 64 degree field of view for excellent immersion; embedded stereo audio and microphone; WiFi and Bluetooth services.

Generally speaking, the HMDs have the advantages to be lightweight, compact, easy to program, 360° tracking, generally cheap (even if, for some particular cases, the cost can be as high as 40,000\$), and let's experience a cinema-like viewing.

But, important drawbacks are a low resolution (the effective pixel size for the user can be quite large), low field of vision (Arthur, 2000), aliasing problems can become apparent, the high latency between the time a user repositions his/her head and the time it takes to render an update to the scene (Mine, 1993), effect of level-of-detail degradation in the periphery (Watson et al., 1997), the fact that the HMDs must be donned and adjusted, and that they are not recommended for people 15 years old and younger because some experts believe overly stimulating imagery is not good for teenagers whose brains are still developing.

Actually we can affirm that the HMDs did not take-off till now. In fact, outside of niche military training applications and some limited exposure in entertainment, the HMDs are very rarely seen. This is despite interesting commercial development from some very important players like Sony who developed the LCD-based Glasstron in 1997, and the HMZ-T1 during the current year.

4. Near future of new trends

4.1. AutoStereoscopy

Latest trend in visualization aims to furnish the "illusion of depth" in an image by presenting two offset images separately to the left and right eye of the viewer. The brain is then able to combine these two-dimensional images and a resulting perception of 3-D depth is realized. This technique is known as Stereoscopy or 3D imaging.

Three are the main techniques developed to present two offset images one for eye: the user wear eyeglasses to combine the two separate images from two offset sources; the user wear eyeglasses to filter for each eye the two offset images from a single source; the user's eyes receive a directionally splitted image from the same source. The latter technique is known as AutoStereoscopy (AS) and does not require any eyeglasses.

An improvement of the AS refers of AutoMultiscopic (AM) displays which can provide more than just two views of the same image. So, the AS realized by AM displays is undoubtedly one of the really new frontier that must be consider for the near future to realize the "illusion of depth", since leaves aside the uncomfortable eyeglasses and realizes a multi-point view of the same image. In such a way the user has not only the "illusion of depth" but the "illusion to turn around" the visualized object just moving his/her head position with respect to the source.

4.2. Alioscopy

The "feeling as sensation of present" in a VR scene is a fundamental requirement, and the AM displays go in that direction. So, we want here to present the "Alioscopy" display that is one realization of such technology, with which our research group is involved in.

The movements, the virtual interaction with the represented environment and the use of some interfaces are possible only if the user "feels the space" and understands where all the virtual objects are located. But the level of immersion in the AR highly depends on the display devices used. Strictly regarding the criteria of the representation, a correct approach for the visualization of a scenario helps to understand the dynamic behaviour of a system better as well as faster. But an interesting boost in the representation comes, in the latest years, from a 3D approach which offers help in communication and discussion of decisions with non-experts too. The creation of a 3D visual information or the representation of a "illusion" of depth in a real or virtual image is generally referred as Stereoscopy. A strategy to obtain this is through eyeglasses, worn by the viewer, utilized to combine separate images from two offset sources or to filter offset images from a single source separated to each eye. But the eyeglass based systems can suffer from uncomfortable eyewear, control wires, cross-talk levels up to 10% (Bos, 1993), image flickering and reduction in brightness. On the other end, AutoStereoscopy (AS) is the technique to display stereoscopic images without the use of special headgear or glasses on the part of the viewer. Viewing freedom can be enhanced: presenting a large number of views so that, as the observer moves, a different pair of the views is seen for each new position; tracking the position of the observer and update the display optics so that the observer is maintained in the AutoStereoscopic condition (Woodgate et al., 1998). Since AutoStereoscopic displays require no viewing aids seem to be a more natural long-term route to 3D display products, even if can present loss of image (typically caused by inadequate display bandwidth) and cross-talk between image channels (due to scattering and aberrations of the optical system). In any case we want here to focus on the AS for realizing what we believe to be, at the moment, one of the more interesting 3D representations for VR.

Current AutoStereoscopic systems are based on different technologies which include lenticular lens (array of magnifying lenses), parallax barrier (alternating points of view), volumetric (via the emission, scattering, or relaying of illumination from well-defined regions in space), electro-holographic (a holographic optical images are projected for the two eyes and reflected by a convex mirror on a screen), and light field displays (consisting of two layered parallax barriers). Figure 2 schematizes current AutoStereoscopic Techniques. See Pastoor and Wöpping (1997), Börner (1999) and Okoshi (1976) for more detailed descriptions.

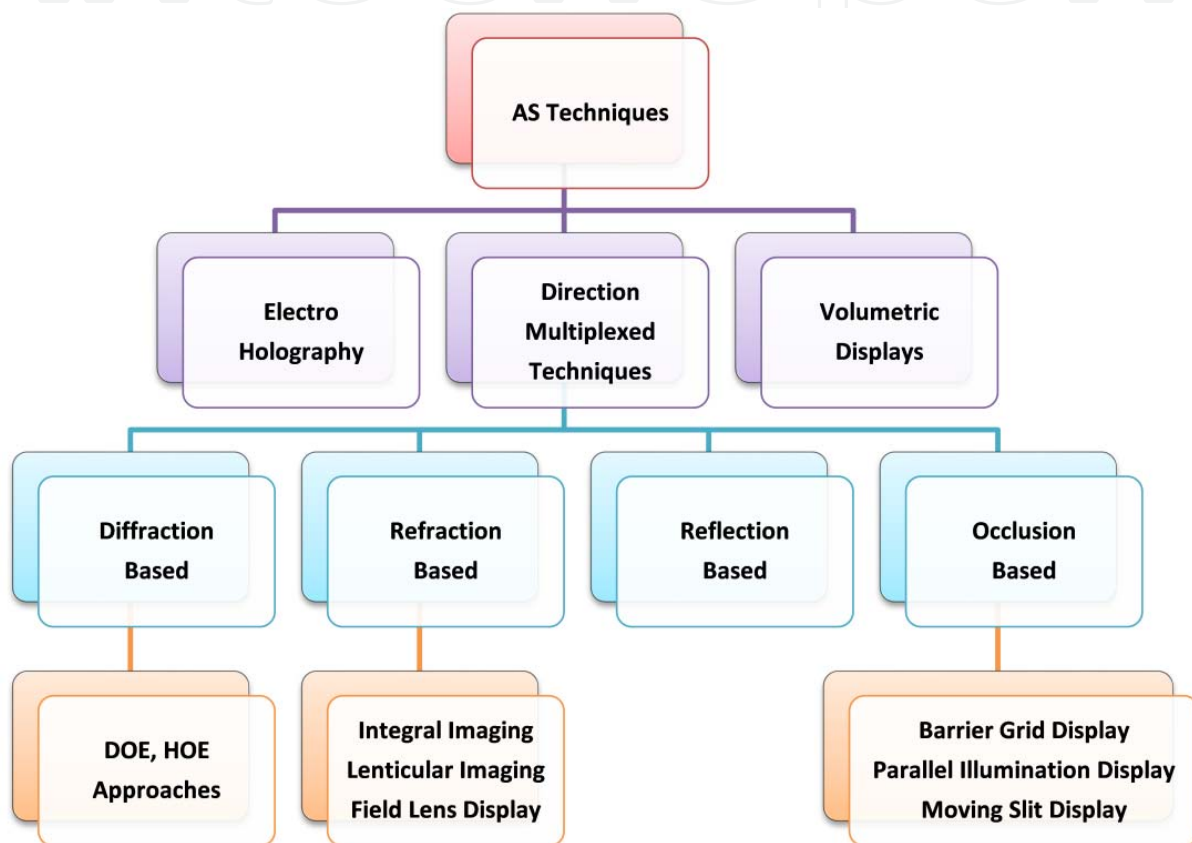


Figure 2. Schematization of current AutoStereoscopic techniques

Our efforts are currently devoted respect to four main aspects:

- user comfort,
- amount of data to process,
- image realism,
- deal with real objects as well with as graphical models.

In such a view, our collaboration involves the Alioscopy company (www.alioscopy.com) regarding a patented 3D AS visualization system which, even if does not completely satisfy all the requirements of a “full immersive” VR, remains one of the most affordable system, in terms of cost and quality results.

The 3D monitor, offered by the Company, is based on the standard Full HD LCD and its feature back 8 points of view is called *MultiScope*. Each pixel of the LCD panel combines the three fundamental sub-pixel colour (red, green and blue) and the arrays of lenticular lenses (then Lenticular Imaging, see the schematization of Figure 2) cast different images onto each eye, since magnify different point of view for each eye viewed from slightly different angles (see Figure 3).

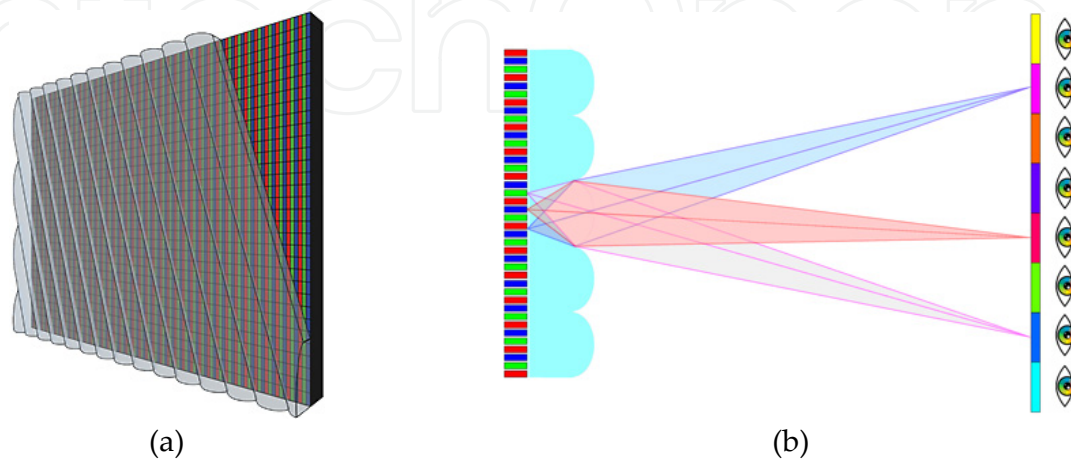


Figure 3. (a) LCD panel with lenticular lenses, (b) Eight points of view of the same scene from eight cameras.

This results in a state of the art visual stereo effect, rendered with typical 3D software such as 3D Studio Max (www.autodesk.it/3dsmax), Maya (www.autodesk.com/maya), Lightwave (www.newtek.com/lightwave.html), and XSI (www.softimage.com). The display uses 8 interleaved images to produce the AutoStereoscopic 3D effect with multiple viewpoints.

We realized 3D images and videos, adopting two different approaches for graphical and real model. The graphical model is easily managed thanks to the 3D Studio Max Alioscopy plug-in, which is not usable for real images, and for which it is necessary a set of multi-cameras to recover 8 view-points (see Figure 4).

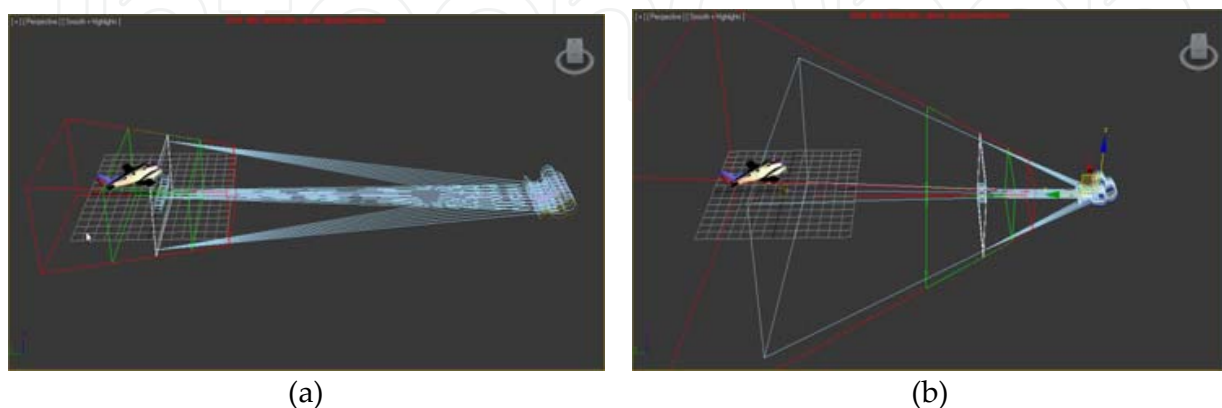


Figure 4. The eight cameras with (a) more or (b) less spacing between them, focusing the object at different distances

The virtual images or real captured ones are then mixed, by means of OpenGL tools, in groups of eight to realize AutoStereoscopic 3D scenes. Particular attention must be paid in positioning the cameras to obtain a correct motion capture of a model or a real image, in particular the cameras must have the same distance apart (6.5 cm is the optimal distance) and each camera must “see” the same scene but from a different angle (see Figure 5).

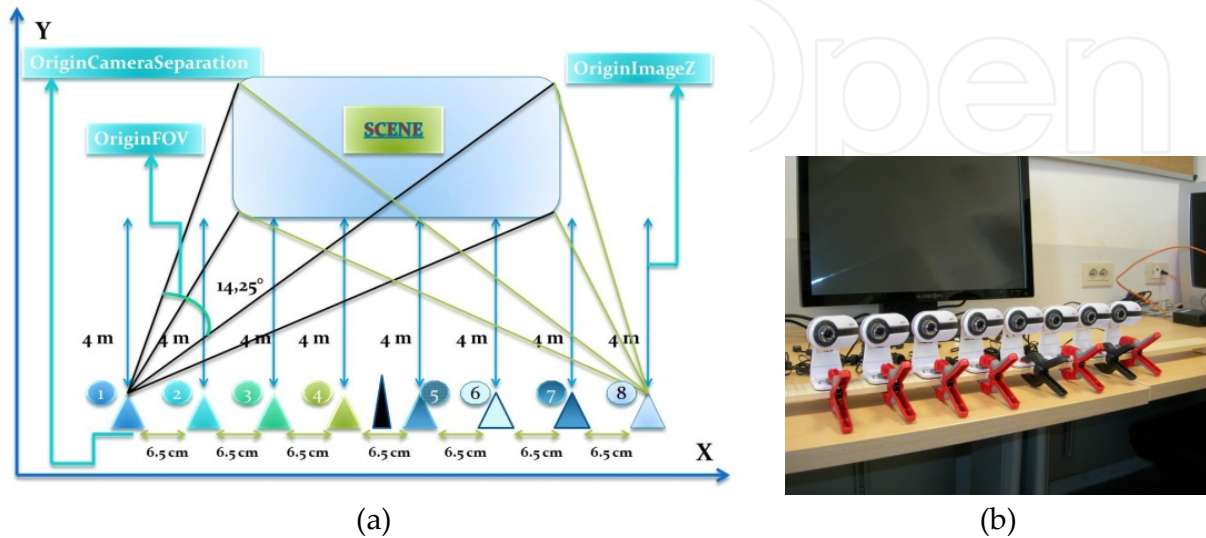


Figure 5. (a) Schematization of the positions of the cameras among them and from the scene, (b) the layout we adopted for them

Figure 6 reports screen captures of three realized videos. The images show blur effects when reproduced in a non AutoStereoscopic way (as it happens in the Figure). In particular, the image in Figure 6c reproduces eight numbers (from 1 to 8), and the user see, on the AS monitor, just one number at time depending on his/her angular position with respect the monitor itself.

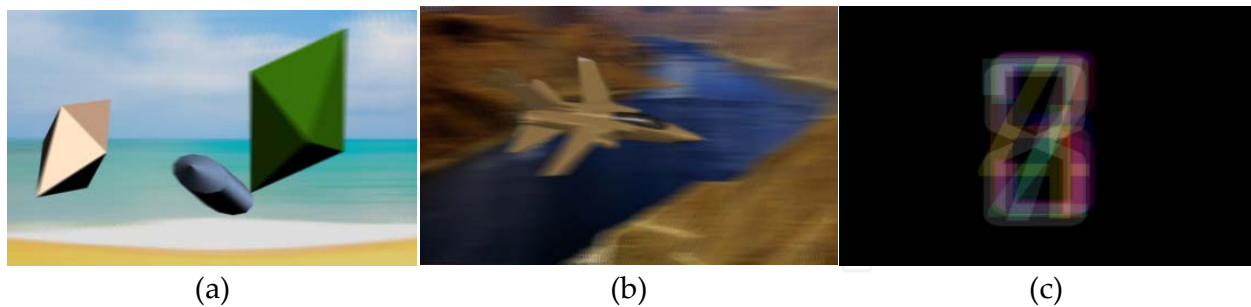


Figure 6. Some of realized images for 3D full HD LCD monitors based on lenticular lenses. Representation of (a) virtual and (b) real object, while the (c) image represents 8 numbers seeing one at time by the user depending from his/her angle of view.

The great advantage of the AS systems consists of an “immersive” experience of the user, with unmatched 3D pop-out and depth effects on video screens, and this is obtained without the uncomfortable eyewear of any kind of glasses. On the other end, an important amount of data must be processed for every frame since it is formed by eight images at the

same time. Current personal computers are, in any case, capable to deal with these amount of data since the powerful graphic cards available today.

4.3. Transparent displays

Cutting-edge display technologies have brought us many new devices including thin and high-quality TVs, touchscreen phones and sleek tablet PCs. Now the latest innovation from the field is set to the *transparent technology*, which produces displays with a high transparency rate and without a full-size backlight unit. The panel therefore works as a device's screen and a see-through glass at the same time.

The transparent displays (TDs) have a wide range of use in all industry areas as an efficient tool for delivering information and communication. These panels can be applied to show windows, outdoor billboards, and in showcase events. Corporations and schools can also adopt the panel as an interactive communication device, which enables information to be displayed more effectively.

From research groups of Microsoft Applied Science and MIT Media Lab has been developed a unique sensor OLED (Organic Light Emitting Diode) transparent technology. It is the base of a "see-through screen".



Figure 7. A Kinect-driven prototype desktop environment by the Microsoft Applied Sciences Group allows users to manipulate 3D objects by hand behind a transparent OLED display (www.microsoft.com/appliedsciences)

Again from Microsoft Research comes the so called "HoloDesk", for direct 3D interactions with a Situated See-Through Display. It is basically an interactive system which combines an optical see-through display and a Kinect camera to create the illusion for the user to interact with virtual objects (Figure 7). The see-through display consists of a half silvered mirror on top of which a 3D scene is rendered and spatially aligned with the real-world for the user who, literally, gets his/her hands into the virtual display.

A TD is furnished by Kent Optronics Inc. (www.kentoptronics.com). The display contains a thin layer of bi-stable PSCT liquid crystal material sandwiched between either plastic or glass substrates. Made into a large size of meters square, the display exhibits three inter-switchable optical states of (a) uniform transparent as a conventional glass window, (b) uniform frosted for privacy protection, and (c) information display.

A transparent LCD Panel comes also from Samsung Electronics Co. Ltd (www.samsung.com) with the world's first mass produced transparent display product, designed to be used as a PC monitor or a TV. This panel boasts a high transmittance rate (over 20% for the black-and-white type and over 15% for the colour type), which enables a person to look right through the panel like glass. The panel utilizes ambient light such as sunlight, which consequently reduces the power required since there is no backlight, and it consumes 90% less electricity compared with a conventional LCD panel using back light unit.

The TDs are not so far-away to be used in every-day life.

Samsung announced to start mass production during the current year of a 46-inch transparent LCD panel, that features a contrast ratio of 4,500:1 with HD (1,366x768) resolution and 70% colour gamut. The company has been producing smaller 22-inch transparent screens since March 2011, but the recently-developed 46-inch model has much greater potential and wider usage.

LG Company (www.lg.com) is involved in the TD technology too. A 47 inch Transparent LCD display with multi-touch functionality has been realized with a full HD 1920×1080 pixel resolution. The Panel is an IPS technology with 10.000 K colour temperature. LG developed also a WVGA Active Transparent Bistable LCD which could be for future Head-up display (HUD).

4.4. HoloMachine

All the previously reported display systems are based on a solid support, generally a monitor or a projection surface. But a great improvement comes if the reproduction of a scene is realized with a *non-solid* support.

The holographic technique satisfies in principle this requirement. With the term of "holography" is generally referred the technique by which it is recorded the light scattered from an object and later reconstructed by a beam which restores the high-grade volumetric image of that object (see Figure 8). The result is that the image appears three-dimensional and changes as the position and orientation of the viewer changes in exactly the same way as if the object were really present. Unfortunately, the holography claims a technology that is still too complex and too expensive to find common applications in everyday life, so new possibilities are currently under investigation.



Figure 8. An example of hologram

A first new type of approach comes from the public lightshow displays, in which a beam of laser light is shone through a diffuse cloud of fog, but the results are not as good as a the reconstruction of a real scenario pretends, and the technique is limited to realize just written words or poor drawings.

The real new possibility is due to a new machine which realizes a screen made out of nothing but micro-particles of water. The HoloMachine (see Figure 9), that's the name of the innovation, is a patented technology (patent no. PCT/IB2011/000645), deposited by the authors of this paper, consisting of a holographic projection system which does not utilize solid screen but an air laminar flow, aerial, inconsistent, somewhat everybody can go through. The machine “creates” the illusion that the images are floating in mid-air.



Figure 9. The compact hardware of the HoloMachine. The woman indicates the slots from which the micro-particles of water are ejected. Courtesy of PFM Multimedia (Milan, Italy)

The heart of the system is an ultrasonic generator of “atomized” water, so that tiny droplets (few microns in diameter) are convoyed, sandwiched and mixed in a laminar airflow that works as a screen on which you can project (through a dedicated commercially available video-projector) images realized with a 3D-technology, Chroma-Key based. The subsequent holographic images you can obtain on this air laminar flow result suggestively aerial, floating in the air, naturally going-through by any spectator, disappearing and reappearing after have been passed through.



Figure 10. (a) An image appears to be “suspended” in air and (b) a viewer can “pass through” the image with the hand Courtesy of PFM Multimedia (Milan, Italy)

This type of projection is very advantageous because it allows images to be reproduced where otherwise it would be very difficult to arrange a solid projection support due to space or light constraints or difficulties in installing conventional screens. Another advantage is because of absolutely absence of invasiveness with respect to the environment wherein the images are intended to be projected. Because of this, two of these machines have been adopted in the archaeological site of Pompeii, in Italy, one representing Giulio Polibio “talking” to the visitors and the second representing his pregnant wife swinging on a rocking chair and caressing her baby (see Figure 11).

Stands its characteristic, the HoloMachine can find application in museums, in science centres, in lecture theatres, in showrooms, in conference centres, in theme parks, in discotheques, in shopping malls, in fashion shows, etc., and for product launches, special event, entertainment purposes, advertising matters, multiplayer games, educational purposes, .. and in general for VR applications, or even Augmented Reality applications, for which “immersive” feeling for the user makes the difference.

From a mere technological point of view, this holographic projection technology takes advantage of the optical properties of water, indices of reflection and refraction, for generating a circumscribed volume of an nebulized air-water mixture, dry to the touch, that will behave like a screen adapted for image projection. This screen can be defined as “virtual” as it is only made of an nebulized air-water mixture, a turbulence-free “slice” of air-water a few millimetres thick, and once it is “on”, it is possible to reproduce moving images on it, thereon using the more or less traditional methods such as the video projection, laser projection, live shot projection with video-projector, etc. (see Figure 12).

Since the light coming from the video-projector is reflected/transmitted with angles which depend on the position of the illuminated point of the air-water “slice” (the inner/outer point of the slice, the narrower/wider the reflection/transmission angle), the viewer experiences a sort of “holographic” view, since he/she has the illusion of the depth, having two offset images from the same source but separated to each eye.

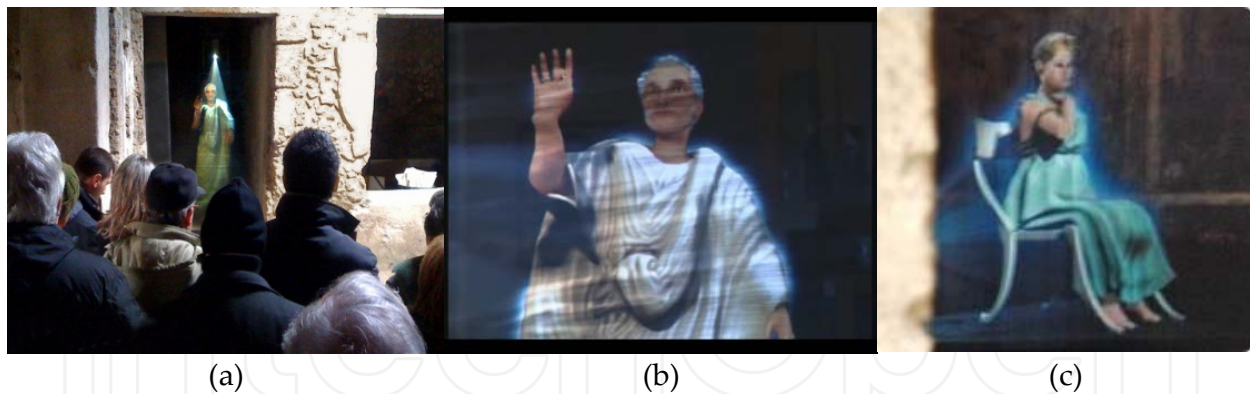


Figure 11. 3D holographic scenes of Giulio Polibio and his wife in their domus at the archeological site of Pompeii in Italy (Courtesy by PFM Multimedia Company)

In principle this machine can generate images of any size. The limit is due to the technology adopted to eject the air-water mixture for which it depends the distance the air-water mixture keeps its consistency, before spreading all around. But, according to fluid-mechanic principles, a mixture of air-water which is denser than the surrounding air, could help to stabilize the system. Of course, if the machine is utilized in open space, the air-water mixture might be ruffled by a blast of wind but, when it occurs, the “slice” itself would refill with air-water and the images are reformed really very quickly, as well as it happens if a person goes *through* the screen.

The machine project design was conceived in a way that people would not get wet when *passing through* the “screen” and that the machine could operate within a broad range of environmental conditions, particularly thinking about the surrounding light conditions. The best viewing results are of course obtained in dark environments, but even under the direct rays of the sun, the images can still remain appreciably visible, the limit being due only to the light output capabilities of the projector (recommended 4500 ANSI lumen or higher), which can be any commercially available one.

In any case, the resulting definition and colour saturation of the projected images are not perfect (see Figure 11) and can still be improved, but this does represent a surmountable problem. It is mainly related to some parameters such as the type of fans that pump away from the machine the air-water mixture, the velocity the mixture reaches, the temperature, the real dimensions of the tiny droplets, their electrostatic charge, the Reynolds Number of the mixture flowing. So, a better image definition can be obtained with a better control of these parameters.

Also interactivity can be implemented, realizing an “immersive” touch screen, so expanding the application possibilities. The shown images can change, react or interact with the user as he/she changes the laminar air flow with his/her body (or even a simple blow!), also depending on the point/area where the laminar flow is deformed. Poke a finger at the screen, and the nebulized air-water mixture is interrupted, allowing the system to detect where you have “clicked”.

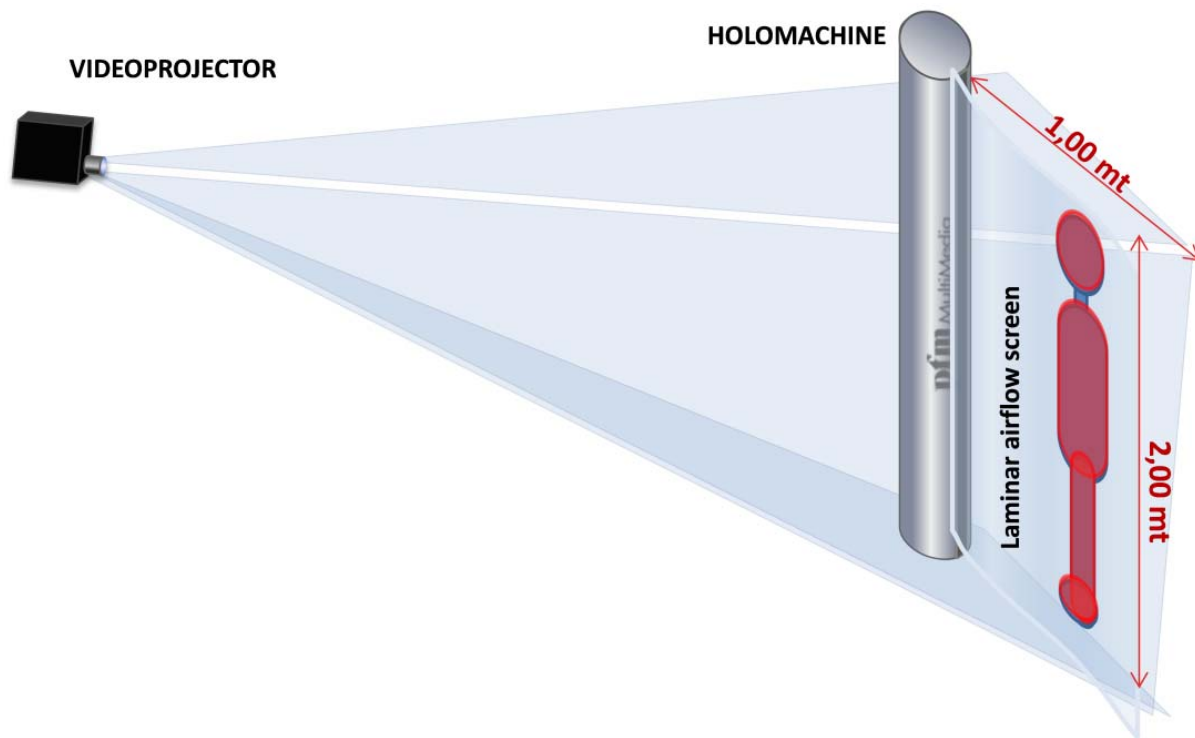


Figure 12. A scheme representing the HoloMachine. A Video Projector illuminates a screen made out of nothing but micro-particles of water

5. Conclusions

The final goal of VR is to deceive the five human senses in a way that the user can believe to live in a real environment. This means that the Real Environment and the Virtual Environment can be “confused” and the line of Figure 1 can become a circle so that the two extremes can result in only one point.

To this aim we have to develop systems to artificially create/recreate smells, flavours, tactile sensations, sounds and visions perceived to be physically real. After all, the Immersive VR can be thought as the science and technology required for a user to feel present, via perceptive, cognitive, functional and, even, psychological immersion and interaction, in a computer-generated environment. So, these systems have to be supported by commensurate computational efforts to realize computer-created scene, real-time rendered, and current computer machines can be considered reasonably adequate (also because they can work in cluster configuration with a high degree of parallelism). So, the main energies must be devoted to the development of new sensors, capable to better “measures” of the reality and, over all, new transducers, capable to convert an electrical signal into somewhat detectable by human senses in a way to be confused as “real”, so that the user forgets that his/her perception is mediated by technology.

This chapter describes the new possibilities offered by the recent technology to obtain a virtual “vision” that has to be as “real” as possible. In such a view, panoramic 3D vision must be preferred and the better if the images can be “realized in air”, i.e. without the adoption of a solid screen, as well as it happens in reality. So, details were furnished of the AutoMultiScopic

for 3D Vision, in particular with the description of the Alioscopy screen, and details of the Holo-Vision for screen-less Vision, in particular with the description of the HoloMachine.

But an immersive system must be completed with the possibility of interaction for the user with the environment. So gestural controls, motion tracking, and computer vision must respond to the user's postures, actions and movements, and a feedback must be furnished, with active or passive haptic (Insko, 2001) resources. For this reason, the HoloMachine can be provided with sensors capable to reveal where and how its laminar flow is interrupted so that the scene can change accordingly.

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