A VIRTUAL REALITY TOUR FOR ENVIROMENTAL STUDY

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ABSTRACT:

We present the survey of Guasco Hill in Ancona by means different surveying integrated methodologies like GPS and total station reflector less. A Digital Terrain Model, well integrated with existing structures, closed to the reality, has been build-up. The 3D model, characterized by high accuracy a spatial resolution, generated by applying computer graphics technologies, becomes an important document for the study of some landscape aspects for the environmental impact on the new town planning. The application of VR techniques integrates the visualization and animation of the three dimensional modelling to landscape analysis. The use of the VRML format produces the possibility to obtain some views of the 3D model and to explore it in real time. It is an important goal for the spatial information sciences.

1. SURVEY'S ORGANIZATION: APPLICATION OF INTEGRATED SURVEYING TECHNIQUES

The present work is the results of a survey project undertaken for the Public Administration of Ancona town, in view of a planning project regarding the top and west side of the Guasco Hill. This area is about 3 ha wide and mostly irregular, with slopes and vertical masonry, buildings (Figure. 1).
Because of the presence of thick vegetation and man made structures, integrated techniques have been used to obtain an optimal and complete survey.

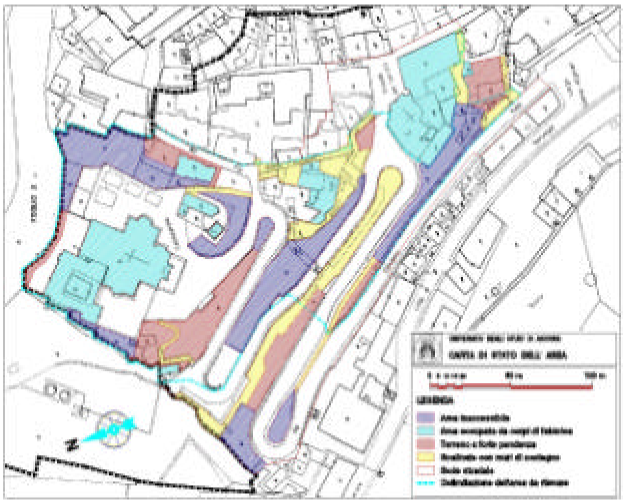

Figure 1. The surveyed area

Moreover, the stations' distribution and the detail points' density have been strongly affected by visibility conditions. We used different technologies: GPS for the primary network, and reflectorless tacheometry for the completion of the area: the 19 GPS stations have been linked each other with tacheometry traverses, generating 48 stations (Figure 2); for the details we observed an amount of about 7100 points (Figure 3).

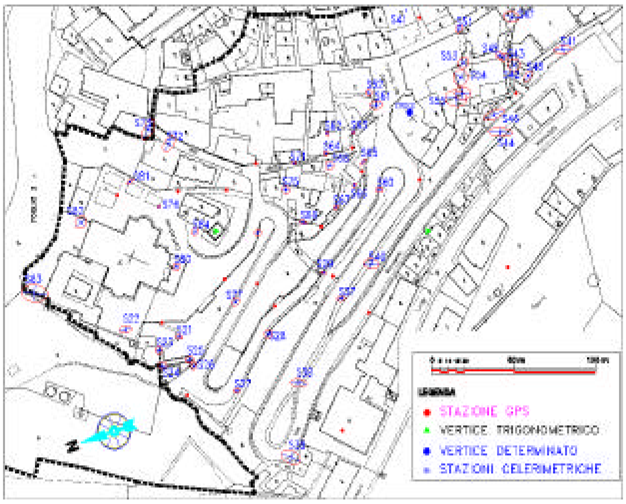

Figure 2. The network

Figure 3. The cloud of points for the detail

We then processed the database containing three types of observations. The estimated accuracy is ±0.10 m. For blunders detection we used in a very first stage SURFER software (Golden Software) (Figure 4).

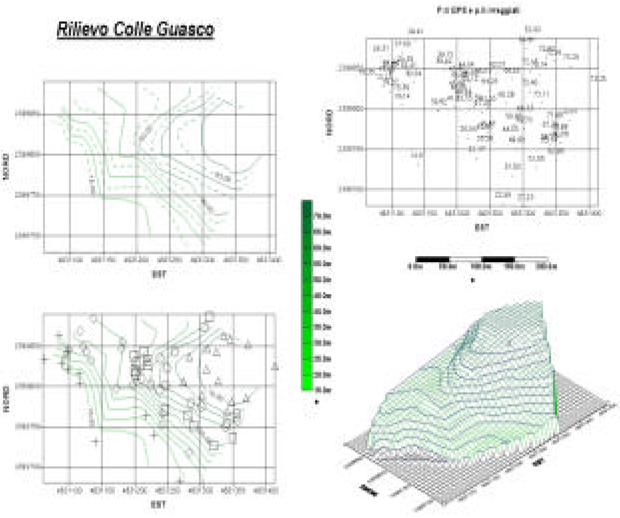

Figure 4. A preliminary 3D representation of Guasco Hill

2. VRML (VIRTUAL REALITY MODELLING LANGUAGE): A NEW REPRESENTATION TECHNIQUE

Virtual reality is the digital transposition of real scenes and objects using informatics' technologies; interaction between user and virtual reality is made possible by navigation systems, 3D vision instruments, manipulation objects tools and so on. To generate a realistic virtual representation much more than a simple 3D model is needed, which can be as easily interpreted as more realistic is rendered (Rheingold, 1993). VRML (Virtual Reality Modelling Language) is a language, specifically designed to describe 3D scenes, which has an increasingly number of users as it can be interpreted by a WEB browser. [1]

The main difference between VRML and other most popular 3D design and rendering tools is the non static conception of the language, which creates a 3D scene in the same moment when the observer navigates in it and interacts with it, without the need to change views and to regenerate each time all the objects while moving.

Traditional digital imagery is mainly focused on the quality of the resulting images, so that modelling software can easily take hours or days to process a single image or to generate, using more than one image, the amazing animations in movies or videogames. In virtual reality the images have not been previously processed, being produced in real time; to obtain a fluid movement it's then necessary to display at least 25 images per second, otherwise virtual movements can result inaccurate and not continuous – that is why visual quality of images, resulting from digital animation software, is far from the photographic one. Another difference is the level of interaction with the user; in traditional animations the user can decide which part of the images' sequence to visualize, he can move back or forward, choose the velocity; everything is previously programmed. In virtual reality the user can decide what to see, he can choose the most interesting point of view, even to position in any place in space; he can select an object, rotate and scale it, change its colours, and even interact with the surrounding environment.

On the other hand a disadvantage to be encountered, while browsing a virtual 3D scene with a common browser, is the intrinsic slowness of the net, which decreases even more due to the dimensions of the files which usually manage a virtual 3D world, composed by a lot of objects, polygons, textures, sounds and animations.

3. VISUALIZATION OF 3D OBJECTS ON GRAPHIC DISPLAY

Three-dimensional objects are displayed on video on a two-dimension surface by a virtual reality application. Such a representation can be obtained as perspective and or axonometric projection. A 3D view involves a projection as well as a view volume, which is a region in 3D space containing parts of the scene and of the objects not to be cut off in a three-dimensional representation. The specific projection and the view volume provide all the possible information needed to realize the *clipping*, the process that divides each element of the figure in visible and invisible parts, so to eliminate the last ones, as well as to realize the needed projection in the bi-dimensional plane. The projection plane (*view plane*), is defined by a point on plane (*View Reference Point,* VRP), the view point, and by a perpendicular to the plane itself (*Video Plane Normal*, VPN). A window to be defined in the viewplane will contain what is to be mapped in the *viewport*, (a rectangular region in the visualization dominion used to represent an image or a drawing), while what is projected on the *view plane* outside the window will not be represented. The view volume is a constraint for the section of the world to be clipped and projected onto the *view plane*; a *front clipping plane* and a *back clipping plane* parallel to the view plane cut again the view volume, so to obtain in the representation only the objects which are positioned between the two planes (Figure 5).

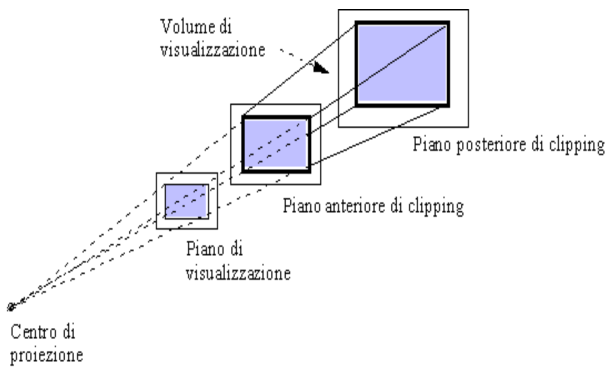

Figure 5. The view volume

The VRML coordinates' system defines the point where the user stands, the system is based on the typical mathematical representation of three-dimensional space, a clockwise system projecting X, Y, Z axes in the cartesian mode. The bi-dimensional projection is performed in the positive Z direction (Rogers et al., 1990). VRML units are arbitrary and not linked to any external measuring system; it is anyway desirable to use a measuring system connected to the real world, to verify the

[1] The acronym VRML has been created in 1994 by Mark Pesce and Tony Parisi. In 1995 the first version of the language enabled a static representation of the real world, while afterwards in the language the possibility to relate behaviours and objects was introduced; the current version VRML 97.

perspective projection which can easily be distorted else way. In a virtual 3D world it is important to understand how to move in space and to plan a route. Everything to be seen in a VRML world is an object built by the computer starting from the points' clouds used to create the scenes' objects' frames. Linking each other points belonging to the same scenery, the computer models objects inside a frame (*structure rendering*), which contributes to elevate objects' realism, even if they're still empty. Applying surfaces (objects themselves: polygons), to frames, the objects become solid; that is why entities are percept as groups of objects and not as points' clouds. Polygons are the basis of the created three-dimensional worlds, and they have to be regarded as infinitely flat surfaces; they can considerably vary in colour, brightness, reflective properties and so on.

A VRML file is an ASCII file (.WRL extension) containing all the information and commands needed to describe a virtual world (Tittel et al., 1997).The commands will describe shapes of single objects, textures, and obviously positions of the same objects in a 3D space, as well as the information on how to move in such a world (Figure 6).

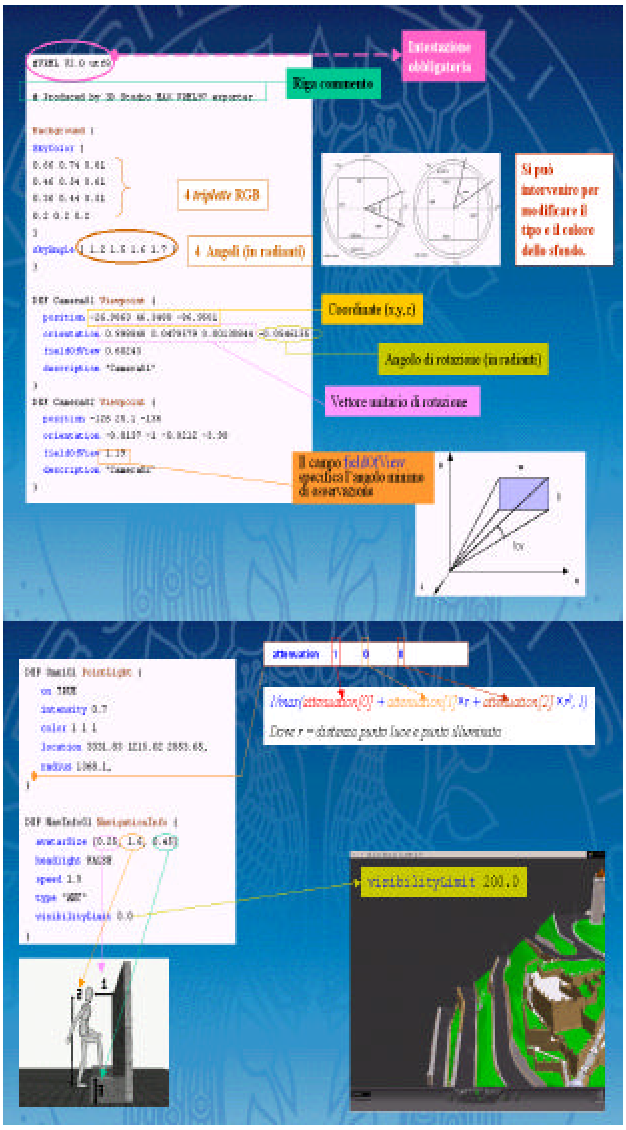

Figure 6. Some sections of VRML file containing all the information and commands needed to describe a virtual world

4. GENERATING A 3D MODEL IN VIRTUAL REALITY: THE GUASCO HILL

Many developing tools are provided to write a VRML file; usually a simple text editor is enough to describe a simple virtual world. In our case the three-dimensional representation of the Colle Guasco from the obtained data with the survey was not possible, consisting in describing an area about 3ha wide, full of ground elements, man made objects such as buildings, roads, retaining walls, stairways and so on with a remarkable level of detail. As for all object oriented programming languages (C++, Visual Basic, etc.), specific tools are provided for VRML too, so to simplify code writing even without an accurate knowledge of the language. VRML is an object oriented language, as it provides a series of objects (joints) used to perform multimedia actions, to build interactive worlds and to create three-dimensional graphics. Joints store data into fields and events; those elements describe shapes and their properties in the VRML world. A web browser reads a VRML file and follows the instructions (stored in joints) the create the desired VRML world. Fields define the kind of shapes to design, their position, colours, and all the information necessary to render the world. Events give joints the capability to evolve.

In this project the shape of the ground and roads has been processed and represented as contour lines, while splines define again solid objects (Figure 7).

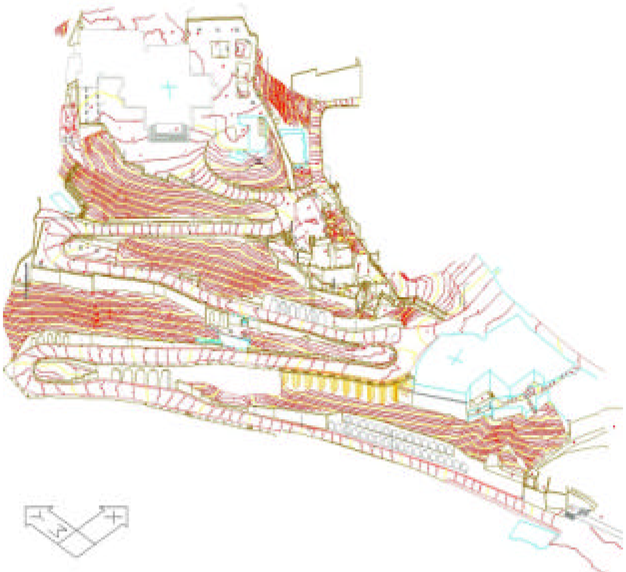

Figure 7. Contour lines representation

A complete wire frame has been obtained, showing a satisfactorily level of details (Figure 8). The obtained three-dimensional view is optimised for a better axonometric projection, hiding all the lines and objects not seen in it.

Once exported in the .WRL format, the wire frame model hasn't solid properties any more; only a few objects actually have proper surfaces. Even so, our model presents some positive sides:

- The passage to 3D virtual reality has been simplified by the previous creation of contour lines (splines) which have been substituted with surfaces to better represent both ground and carriageways;
- Some buildings have not been surveyed in details, but their representation is not a problem, as they can be visualized as volumes from their base polygons.

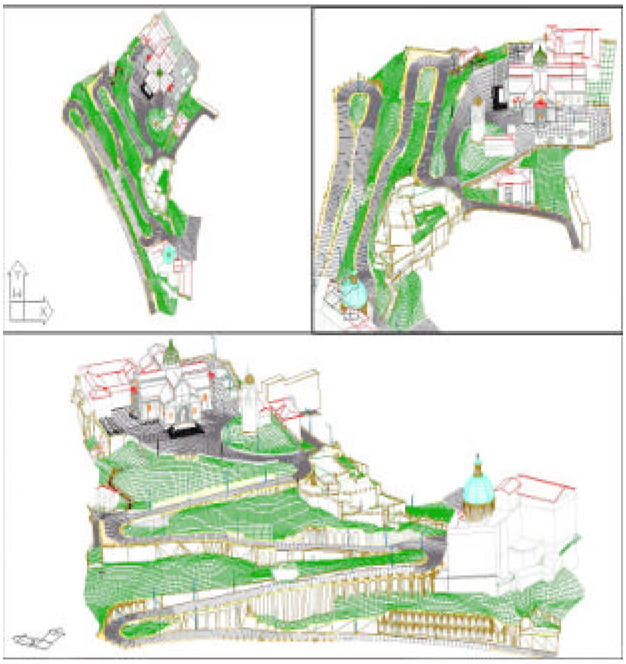

Figure 8. Wire frame representation

The whole model contains at this stage all the objects situated on the hill, such as walls, buildings, roads, ground, stairs and so on; different views can be produced with different lights, shades, colours rendering effects and rectified photographs (Figure 9).

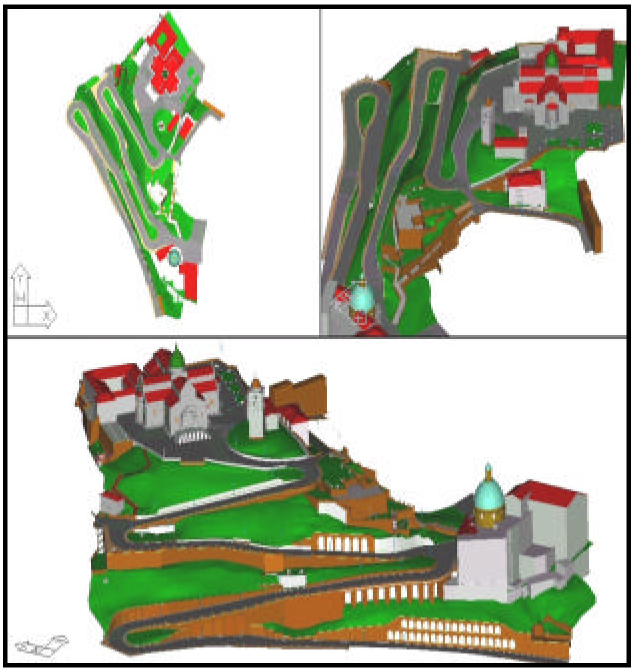

Figure 9. 3D model produced with different lights, shades, colours rendering effects

Properties can be modified directly changing the VRML code with a normal text editor, but obviously a graphical environment can simplify the job; the AutoCAD model has then been imported in 3D STUDIO MAX (the resolution has been set accordingly to the desired final quality). This last software includes powerful rendering engines, lots of graphic and three-dimensional animation tools, so to create and export objects and virtual worlds in VRML (Fangi G. et al., 1999). Creating a .WRL file with 3D STUDIO MAX increase productivity, enables to manage a huge data quantity, simplifies view points' insertion, lights and so on; the VRML file can be produced even without knowing the language. The VRML code written in this way is not yet optimised, and one of the problems is for example the values' repetition. TRAPEZIUM's software CHISEL can verify data and optimise files, erasing repeated or unused values, reducing dramatically the .WRL file's dimensions (in our example reduction has been about 65% of the original file). The file is so far ready to be imported by any VRML browser. It is still possible anyway to modify details such as colours, to insert predefined views, add and /or remove objects, light spots and so on.

Playing a video file, a user watches the virtual world from a predefined point of view chosen by who created the file; VRML provides tools both to create the three-dimensional environment and to examine it; any user is so free to decide what to do in the virtual world he's browsing. Three-dimensional management of this "panorama" in Internet can then be performed with software such as COSMO-PLAYER, a generic Internet Explorer plug-in, one of the most popular browser. Using a VRML browser it's possible to choose the scenery's orientation and the perspective visualization. Any browser provides many navigation options (Figure 10).

Results' quality is usually important in Computer Graphics, so it's obvious that in any comparison between a video or a static image produced with a graphic software or with a virtual reality browser, the graphic software would always be better. To balance quality and velocity is a fundamental step: there always have to be the chance to manage in real time movements, views, actions. In our example this balance is shifted towards a fair detail's level, compromising so a bit navigability: that is however a limit due to the hardware we had, not to the language.

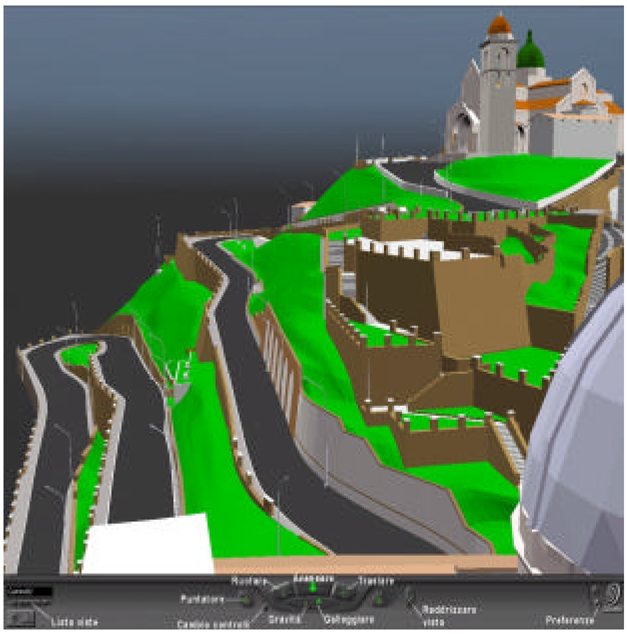

Figure 10. A VRML scenery: the perspective visualization obtained from many navigation options

In this case VRML can be viewed as a data container, the result of a survey to be managed three- dimensionally and graphically in a pc. Relatively to that topic we show some views of the Colle Guasco taken with a normal camera and from the VRML model (Figure 11).

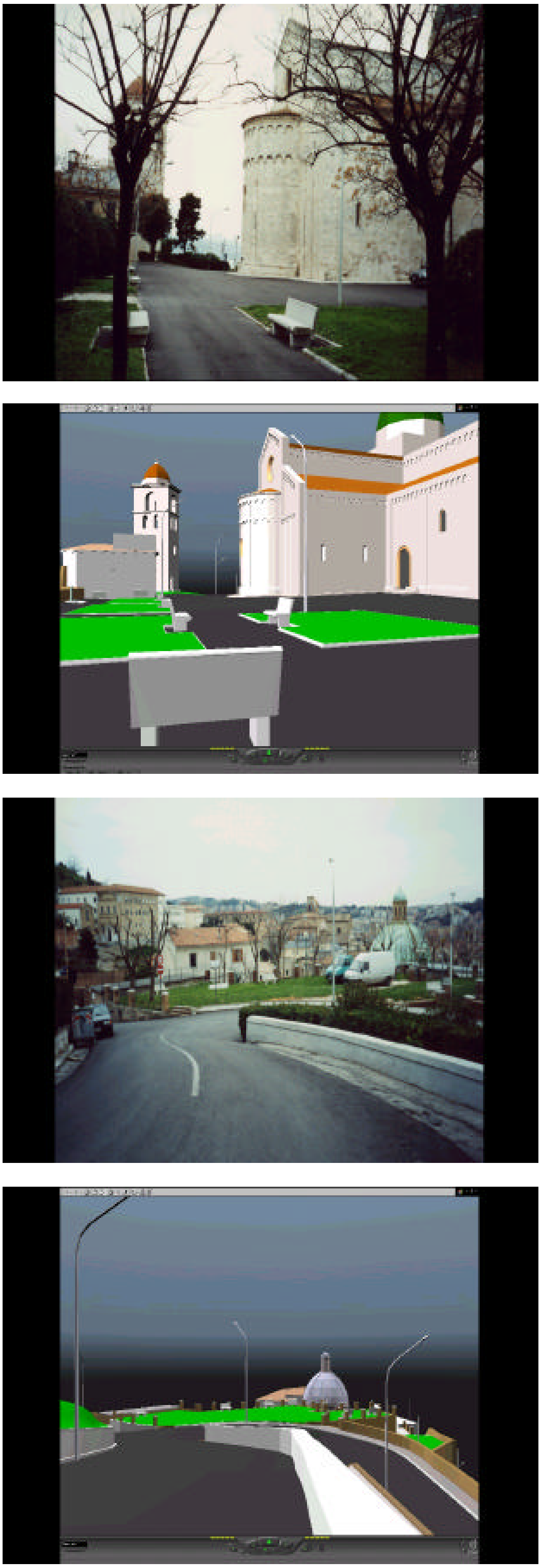

Figure 11. The real view vs. the virtual one

5. VIRTUAL REALITY: AN INNOVATIVE CHOICE SUPPORT TOOL

The procedure is time consuming and therefore expensive and critical to obtain a realistic surface texture with complex shapes. Some software tools exist, but they require a lot of human interaction. Nevertheless when there is a need to represent, in the most realistic manner, objects and the world where they are placed, it is more efficient than the classical representations, like plans, views, and sections, etc. This is better than using static images or drawings, as any user has more possibilities to read and interpret what is displayed. We have now a new instrument that can influence design techniques in many fields, such as engineering, architecture, city planning and environmental modelling. Also, time dimension has been introduced, to allow an interactive interchange between user and world, which gives a remarkable contribution to environmental impact studies relatively to realism, reliability, visibility, routes' usability.

In our example the preliminary rearrangement project of the Colle Guasco by Architect Umberto Riva has strong environmental impact: the top of the hill shall in fact be isolated with a high retaining wall, like an acropolis, tourist vehicular entrances will be closed, pedestrian routes realized with stairs or elevators. Citizens will then have the chance to taste the usability of that project before its execution. Designers as well as administrators will then have to take note of these new technologies which perform their power as decisions' support tools.

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