EXPLORING 3D-MODELS IN A STEREOSCOPIC WAY: A TOOL FOR KNOWLEDGE, DOCUMENTATION AND MEASUREMENT OF CULTURAL HERITAGE

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ABSTRACT

The paper presents some applications realised with the digital stereoscopic navigation system on two architectural subjects and particularly on documentary photograms of mural paintings. The system StereoSpace is a three-dimensional stereoscopic navigator, specifically thought to be used in digital photogrammetry.

Keywords: stereo-space navigator, 3D models, vector/raster, computer graphics.

1. INTRODUCTION

The system StereoSpace is a three-dimensional stereoscopic navigator thought specifically to be used in digital photogrammetry, deriving from an intense developing activity carried out by the menci software with Politecnico di Torino - Dipartimento di Georisorse del Territorio in the context of a convention with *Nikon Instruments s.p.a.*. It is a digital stereoscopic navigator for documentation, three-dimensional representation and measure of cultural and artistic heritage. It's based on the capacity of manage continuously more than one photogrammetric model, previously oriented. In synthesis, it is a 3D metric photograph, which reproduce the whole object observed, or, in other words, a three-dimensional photographic model that can be measured and on which it's possible to draw in the space.

2. THE STEREOPHOTOMAP

On the grounds of the software implementation there is the StereoPhotoMap's idea.

The name already explains the main concept:

Stereo because makes use of the stereoscopic visualisation, *Photo* because founded on photograms, *Map* for the metric properties that it contains.

We can consider the traditional descriptive cartographic representation as a simplification of the informative contents present in the stereomodel, well known at the plotter cartographer. In fact, at the moment he marks the entity following the stereoscopic image's tridimensional outlines that he observes in his instruments, he makes an inevitable interpretation operation.

Through the drawing, the model looses the feature of "real" to become a representation. The subjective interpretation, even if fixed by standard criteria, takes the place of the *measurable reality* that the stereoplotter presents at the operator's eyes.

The main idea consists in translating the stereomodel utility from the instrument to the final users, avoiding the passage through the drawing representation. The main job of the mapmaker will be to describe the typological aspect rather than the morphological one, realising the correct database for a good menage through a territorial or architectonic informative system.

Traditional representations extremely complex and expensive, for example such as the contour lines, loose in this context their descriptive sense, and it takes advantages of the possibility to enrich the map of the typological contents.

3. STEREOPHOTOMAP-STEREOSPACE

What described theoretically has its realisation in the 3D navigation software StereoSpace, specifically produced by menci software and distributed all around the word by Nikon Instruments. It is developed for Cultural Heritage applications and it has specific functions of visualisation and interpretation exactly of close range photogrammetry. This software collects the ideas contents in the StereoPhotoMap concept or Digital Continuous Model and it organises all in an easy and efficient interface on Windows NT.

To realise this product, we count on:

a. Quickness of loading and visualisation of high-resolution images.
b. Multidocument management able to visualise in stereoscopy more than one model contemporaneously.
c. Integrability with Windows NT.

4. STEREOSPACE MAIN FEATURE

Taking into account the digital technology progress in comparison to traditional methods we summarise the main point:

- Stereoscopic models' dynamic navigation
- Lot of Stereoscopic models' contemporary vision
- 3D Measurement
- Possibility of having the full "real" model
- Point's co-ordinates always visible
- Diagnostic evaluation and metric information not simply available with the same precision and quickness
- Data Permanency (not support decay)
- Measures boxes exportable in Excel
- Parallel comparison between different zone, different decay situation
- Comparison of the same model in different chronology
- Parallel comparison of different model
- Stereoscopic visualisation comfortable and relaxed
- More than one user can consult the same model contemporaneously (with special glasses)
- Check on Pc's monitor rather than "in situ"
- Approach to the stereo model with zoom
- Drawing window
- Thematic map and elementary entities exportable
- Degrades map draw on the stereo model
- Easy system and friendly interface
- Costs reasonable to everybody

5. SPECIFIC APPLICATIONS

The examples we show are applications realised with the digital stereoscopic navigation system on two architectural subjects and particularly on documentary photograms of mural paintings.

The first case, well known to everybody is the stereo model of the vaulted roof of the main nave of the inferior Basilica of *San Francesco in Assisi*. The stereophotogrammetric survey has been made by the FO.A.R.T. Company of Parma for the Ministero per i Beni e le Attività Culturali - Soprintendenza per i Beni AA.SS dell'Umbria. Photograms has been taken after the calamitous event of the earthquake happened in September 1997. In fact are well visible the damaged zones. The instrument allows to analyse directly "in live" every single model's detail. The stereoscopic navigation in fact allows to reach every zone of interest and to make measurements and tracings moreover diagnostic analysis and evaluation on the state of conservation. The possibility of loading different details, and visualise them contemporaneously, offers a great help in the study and comparative analysis of the structure and of the decay, see Fig.1.

The second case consists on the stereo model of the *cupola of the church del Purgatorio a Terracina (Latina)*. The survey has been realised by the arch. Paolo Salonia of CNR, ITABC-Montelibretti (Roma).

6. THE *CUPOLA OF THE CHIESA DEL PURGATORIO*: 3D GEOMETRIC MODEL AND STEREOSCOPIC INTEGRATION VECTOR/RASTER

The principal concept on which is based the example we present is the statement that technologies and methodologies born to solve questions in territorial scale are valid tools for a documentary approach, scientifically rigorous, even in the buildings scale of cultural heritage. This process is based, in a first phase, on survey operations to check the metric contest, the different descriptive typology (history, materials, decay's nature) and the creation of the base on which realise next analysis and thematic maps. The second phase should have a visualisation and data managing system in which we can make a reality reconstruction in a flexible way, useful to the different users' typology.

Usually the procedure consists on the graphic restitution of the images' contents, through a digital stereo plotting with control points topographically known in their co-ordinates (x, y, z).

The photograph has a complete informative content totally corresponding to the reality either in the quantitative- dimensional aspect (geometrical) or in the qualitative- phenomenological (descriptive).

The target reached became the creation of a system where the final user has a unique photographic image geometrically controlled. On it he can operate the different analysis function, interpretation and project, avoiding the graphic passage.

6.1. Test on specific application case

It has been done an experiment on the vault of the Chiesa del Purgatorio in Terracina. It's a building on the upper part of the town, on the site of an ancient originally nucleus of XIII century. Great

rearrangements in XVIII century transform the church inside and outside, as we can see nowadays.

The main monument's feature is represented by the cupola-cap built on concentric corbels and it poses on the drum that is the same cylindrical shape of the church's interior which is inscribed in a quadrangular shape.

The cupola's internal part is tempera painted in the period style. It represents subjects, which return to the church's name attribution. The mural paintings don't present particular interest even artistically or for the constructive technique or for the state of conservation. Trough the survey operations we took data for the cupola's geometrical three-dimensional model and for the stereoscopic photographic model of the painted surface.

The aim has been to realise a vector-raster integration between the 3D model, see Fig.2, and the stereoscopic photographic model in 3D navigation software that allows at the different users' typology an analysis and interpretation trough the complete stereo model's usability.

6.3. Initial acquisition phase

The cupola has a circumference 's diameter of 13 meter and the height related to the base level is around 7 meter.

Work phases:

- Data acquisition for the 3D geometric model:

  Positioning the topographic instrument -Laica DISTO LASER, related to a total station Pentax- in the middle of the church (instrumental height m. 1.483, distance from the central cupola's intrados m. 15.938), has been taken totally 874 points (x y z) on 16 vault's vertical sections (16 half-circumference);

  Then it has been taken 1211 points (x y z) on 16 vault's horizontal sections (16 circumference).

- Data acquisition for the stereoscopic photographic model

  Positioning the camera (ROLLEI 6006, 6x6 semi metric, objective 80 mm., Kodak Professional film 120 ASA) in a zenith orientation to the vault, it has been realised 5 photographic strips of the same vaults, from one to the opposite side of the church (totally 27 photograms which cover all the surface with an 80% overlap).

  Posing the topographic instrument -Laica DISTO LASER, related to a total station Pentax- in the middle of the church has been taken totally 45 control points (x y z) distributed on the mural painting.

7. SYSTEM STRUCTURE

StereoSpace software realise a ***server-client system***.

The server is founded by all the data that can be located on a removable support (CDROM o DVD), on a computer working in a local net or with simplified models on remote sense (Internet or other). This data collection is simply stereoscopic model correctly archived. Usually it's a product of photogrammetric operators who know exactly the stereopairs orientation technique even in independent models or in aero-triangulation methods.

The client is the StereoSpace station with an easy stereoscopic visualisation system that allows everybody to be able to use it. In fact, the use of the system doesn't require particular preparation.

7.1 Data Production.

Usually the data producer is a company specialised in cartography data production that use a client station for the check of the server's data. After having taken the photograms and the topographical survey, the work phase specific for StereoSpace are described above.

7.2 Photograms digitalisation.

This phase needs to be done with special care because on this depends even the model's visual quality and its metric precision. It's a good rule the use of a photogrammetric scanner; when it is impossible it's indispensable to do the geometric distortion correction (for example with SV Scan).

The acquisition's resolution depends on the use of the data: documentary aim, thematic, archivistic or metric. It depends also on the dimension of images. There is no limit of using big images. Frequently it works with a resolution between 600 and 4000 dpi. Images are archived in raster cryptographic format or in TIFF standard.

7.3 Models' orientation

We work with the proper orientation software (SV Triangulation-StereoView Suite-menci software). The block orientation warrants the model continuity trough the photograms, avoiding the danger of interruptions that can compromise the good stereogram's utilisation and the measurement's precision. It's possible to use lots of oriented stereopairs. The single photograms orientation has been coded and manages in a database, which contents all the necessary parameter to describe the external orientation, see Fig.3.

What we describe is what we can consider a photogrammetric block and so it's clear that the process that bring to its creation is the standard productive process of a photogrammetric map related to the main phase of topography, photograms capture and orientation.

We underline the possibility of reuse all the data of a work done in traditional photogrammetric way, if well archived, even if it will be better a productive process developed entirely with digital technique.

8. APPLICATION FIELDS

Numerous are the application's fields in which the StereoPhotoMap is a valid help for the comprehension and the documentation of the objects in examination. The photographic operation and the topographic survey represent just a small part of the total cost of the survey production: it suggests the StereoPhotoMap's use in all the situation in which it's necessary to evaluate in real time the state of conservation. Taking the photograms and orienting them it's enough to create a database able to document the subject's condition, without doing any other elaboration. StereoSpace, trough the contemporaneous consultation of lots of stereoscopic models, will allow the three-dimensional comparison between two situations.

The *StereoPhotoMap in fact is a stereo plotting "in fieri", always ready to give the 3D information requested by the observer.*

Moreover the chronological evolution, StereoSpace allows comparison between models realised with different photographic techniques (visible, IR, UV) or between models in different scale. The main application's fields are here summarised:

- Cultural Property Conservation
- Architecture
- Archaeology
- Cartography
- Geology
- Town-planning
- Agronomy
- Forest Science

9. CONCLUSION

The StereoPhotoMap and its informatics' correspondent StereoSpace represent respectively an idea and an advanced technology in the numeric cartography production and managing. The main goal we reach is the simplicity and the immediacy of its consultation.

With this instrument we want to propose nothing more that a "three-dimensional mouse" to navigate, measure and document the space that surround us.

The integration of this easy instrument with sophisticate territorial or architectural informative system represents a very efficient binomial between data production and data consultation destined to a customer's units even more big.

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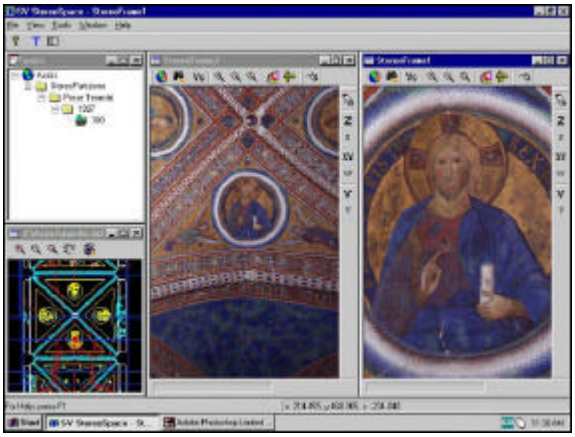
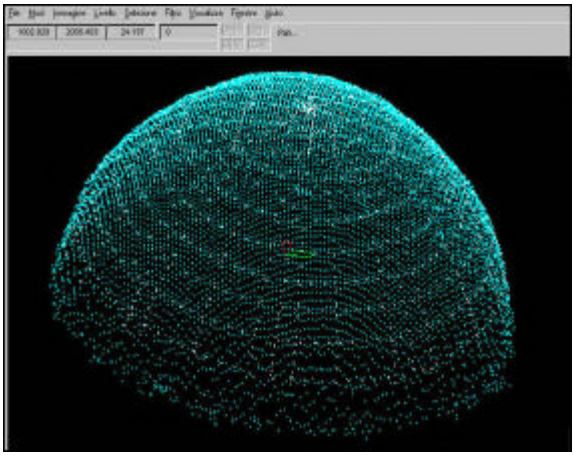


StereoSpace: two stereo frames contemporaneously opened
Figure 1



StereoView: DEM on vault of chiesa del Purgatorio
Figure 2

SV Triangulation: point collimation phase
Figure 3