STEREOSPACE: AN IDEA FOR PHOTOGRAMMETRIC DATA COLLECTION

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ABSTRACT

StereoSpace is software for continuous stereoscopic exploration of stereopairs blocks. It exceeds the limit of conventional photogrammetric workstations allowing performing data collection using different stereopairs at the same time. StereoSpace permits to cross the boundary between two near models without any time stop.
It is based on a new product concept; we can call StereoPhotoMap, where all preliminary photogrammetric steps as inner, relative and absolute orientation have been already carried out in advance. It is designed to perform a simple consultation of a high structured data collection based on a hierarchical tree without any limit of complexity.
The system is fully integrated with Digital Photogrammetric Workstation StereoView, which gives all tools needed to make the whole preparation work. It allows even inexpert users to collect data from a stereopairs mosaic with the advantage of an immediate combining of geometric and thematic feature. The main features of the system are: continuous 3D navigation, photogrammetric measure in each point of the model, multiple stereo windows simultaneously opened. StereoSpace works in a standard PC.

INTRODUCTION

In last few years it has been carried out a strong research work between Dipartimento di Georisorse e del Territorio of Politecnico di Torino and MENCI SOFTWARE with the NIKON INSTRUMENTS commercial partnership.
The goal has been the definition of a new cartographic instrument and concept called StereoPhotoMap (SPM) and its informatics solution called 3Dnavigator, commercialised as STEREOSPACE.

1 StereoPhotoMap

The software is founded in the SPM concept. The name already explains the main idea:
Stereo because uses 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 stereo model, well known at plotter cartographer.
Through the drawing the model looses the feature of *real* becoming *representation*. The subjective interpretation, even if fixed by standard criteria, takes the place of the measurable reality present in stereo model.
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, such as for example 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.

1.1.Peculiarity of StereoPhotoMap

SPM runs out of the limit posed by the stereopairs.
If the stereoscopic image is subordinate at the stereopairs use, it s also true that the model s tridimensional exploration stimulates the interest to extend the navigation to close models. The observer is rapt in the stereoscopic navigation and passes through the space without notice the photograms limit line, because the exploration movement is fluid and easy.
During the stereoscopic exploration, or measurements or entities tracing or any other function allowed, the photograms selection and loading are automatic at all.
So we can consider the stereo photogrammetric block as a unique continuous stereo model.

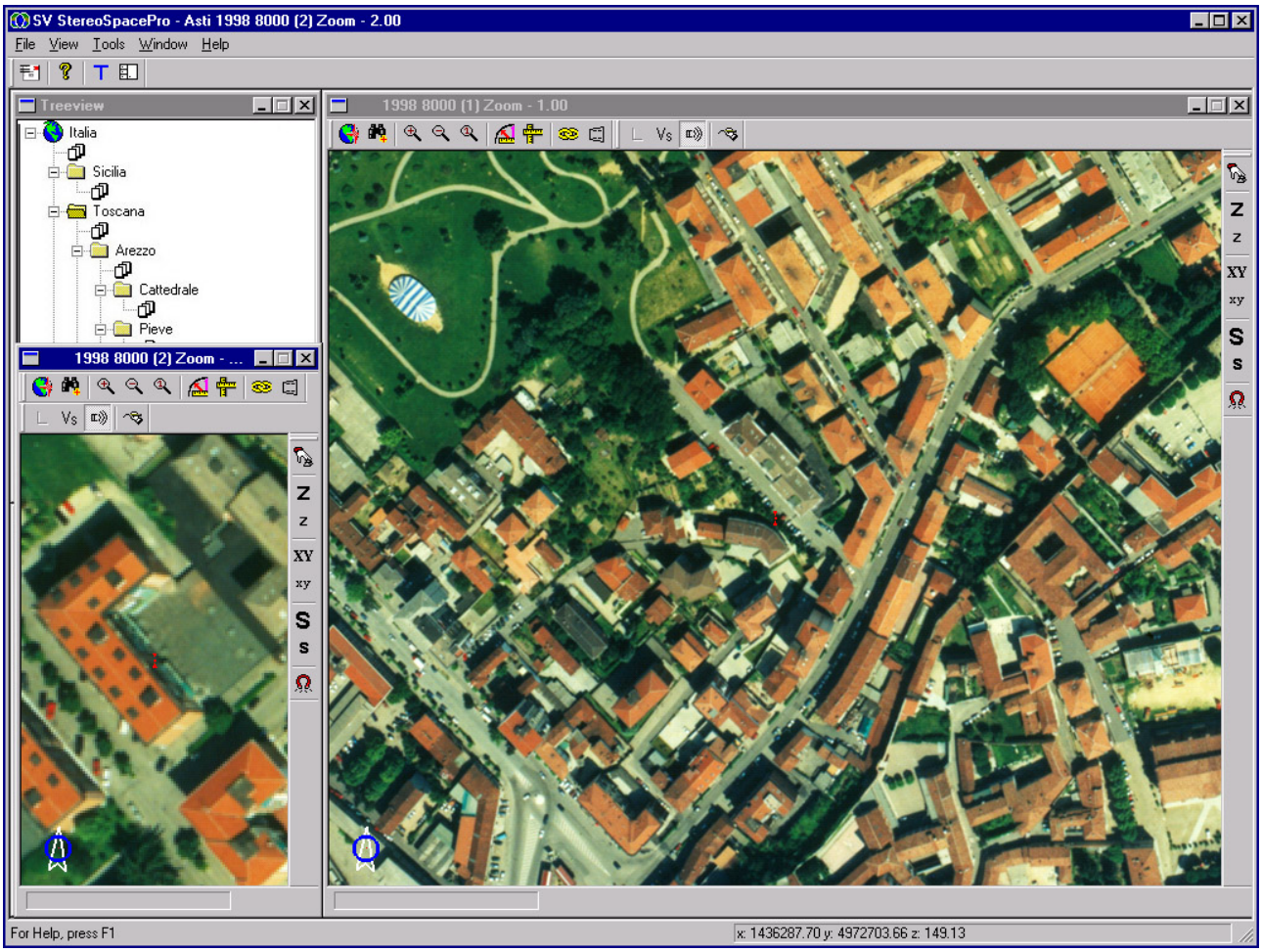
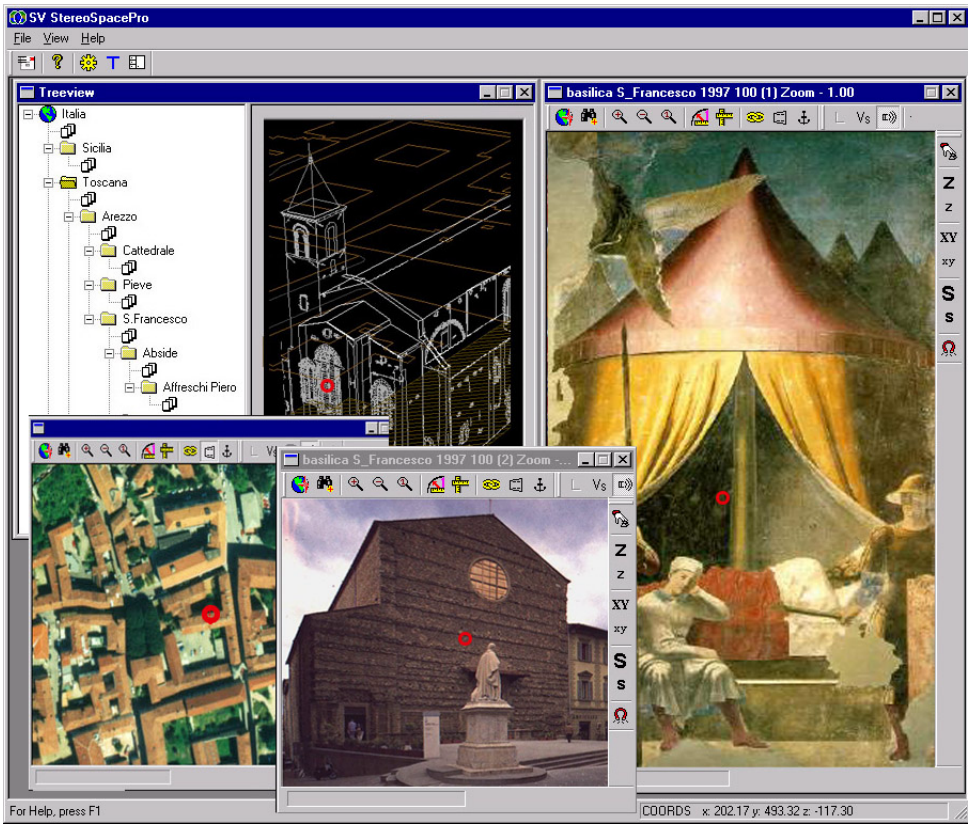


Figure 1

Another SPM s peculiarity is the possibility to be metrically consulted and so taking 3D metric informations like positions, distances, areas and so on.
What described theoretically has its realisation in the 3D navigation software STEREOSPACE (SS). It is developed for aerial and close range photogrammetry applications. This software collects the ideas contents in the SPM concept or digital continuous model and it organises models in an easy and efficient interface on PC.
SS peculiarities are:

- Quickness of loading and visualisation of high-resolution images
- Multidocument management able to visualise in stereoscopy more models contemporaneously
- Integrability with Windows
- Tree View Data Management
- Stereoscopic models dynamic navigation
- 3D Measurement
- Automatic stereopairs selection and loading
- Contemporary stereoscopic comparison between more models
- Drawing window
- Automatic elevation positioning
- Dynamic link through stereo models
- Epipolar resampling on the fly
- Floating/locked images vision technology
- Automatic continuous scrolling of stereo models



The picture beside shows the main SS window. On the left there is the overview composed by tree view structure and monoscopic graphic overview.
On it is visible the mark indicating the position of the current active point.
The same point can be individuated in each stereoscopic window. One is an aerial view of Arezzo town, one is a close range stereopair of S.Francesco church and finally the last is a detail of Piero della Francesca frescoes inside that church.

Figure 2

2 Data structure

STEREOSPACE software realises mainly a ***server-client*** *system.*
Server: All the data mentioned before, located on a removable support (CDROM o DVD), on a computer working in a local or remote site (Internet, Intranet or others). These data collection consist in images, orientation files, overview map (raster and/or vector together) and file describing the links between elements in the final structure. Oriented models can be simply collected from any operator even not expert, using specific tools (SV Master) available in StereoView Suite; can be simply recovered also orientations previously realized with any other software.
In general case of a new workflow may be highly productive to use all the tools available in StereoView Suite like scanner calibration, inner orientation, aerial triangulation, stereo plotting, automatic DEM generation and orthophoto production. Each one of these contributes in its specific functions to realize the whole stereoscopic database.
Client: The StereoSpace user that can access data even in local that in remote way.
The client is the STEREOSPACE station with an easy stereoscopic visualisation system that allows everybody to be able to use it. In fact it s not requested a particular preparation for the system s use.

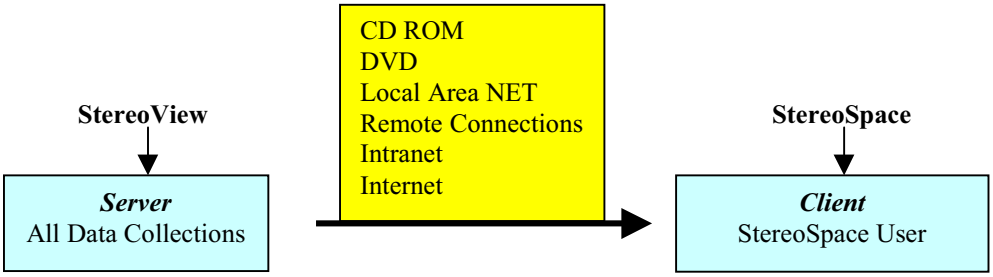


Figure 3

2.1.Photograms digitalisation and orientation

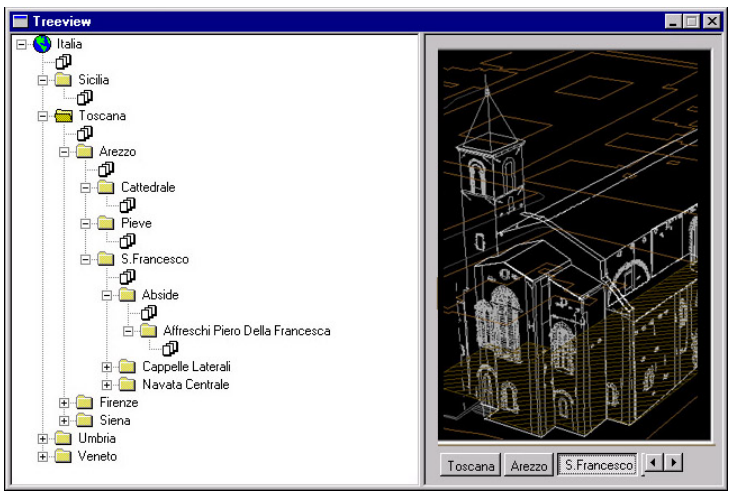
This phase needs to be done with special care because on this depends even the model s stereoscopic visual quality and its metric precision.
It s a good rule to use a photogrammetric scanner otherwise a geometric distortion correction is needed (SV Scan).
The acquisition s resolution depends on the final data use: documentary, thematic, archivist or other. There is no theoretical limit of using images with a resolution between 600 and 4000 dpi. Images are archived in raster cryptographic format or in TIFF/JPEG standard.
Each photogram contributes singularly to SPM data collection. In fact StereoSpace chooses automatically which image must be selected to optimise the stereoscopic visualization according to the point visited during navigation. It means that we can import single images from any other source available. We only need the continuity of the model that depends on accuracy of orientation.
We suggest using aerial triangulation, particularly with bundle block adjustment.

3 Models management

StereoSpace uses a tree view structure to manage all the blocks inserted. There is no theoretical limit at block insertion number.
Each block became a logic unit with same peculiarities, called sub-project (SP), that can be exported or imported from/to other SPM without any modification.
SP main parameters are:

- SP name
- A reference map raster or vector (overview)
- An array of oriented image classes
- A bounding box of navigable zone
- A class of parameters describing the co-ordinates transformation between the SP and its parent (three points in 3D or a rot translation matrix or a point and three angles)
- Other sub-project
- Date and scale definition
- Automatic link to other blocks
- Starting point of navigation

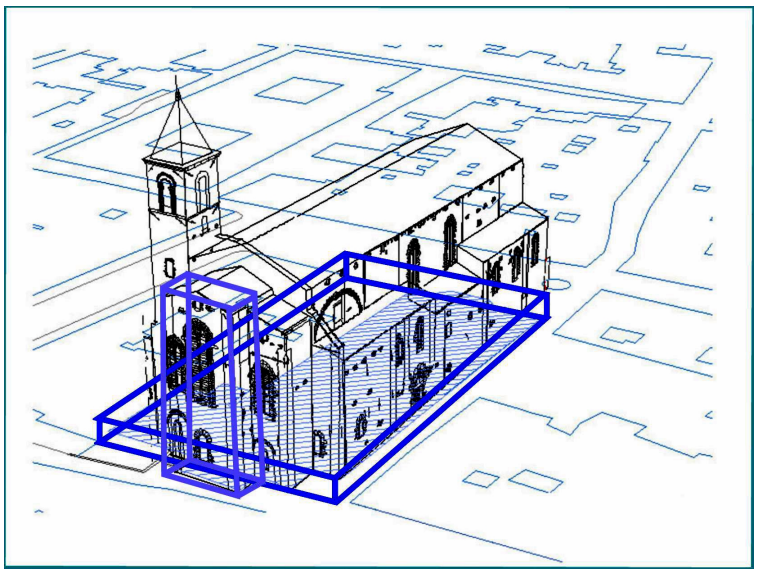
Hereditary characters aren t inside the unity but it depends from its position in the structure. So each sub-project or SP group can be integrated in other SPM. SPM is indeed a SPs open set where their number can assume any value starting from one. A single SP can be considered as an atom of SPM, that is the elementary element of each project.



For example if we consider Arezzo as a SP of Tuscany and Tuscany a SP of Italy each other Italian region can be inserted into that SPM. In Arezzo there are some other SP, for example the most important churches of the town. S.Francesco is one of these. If this basilica is divided in some architectonical parts we can select, for example, the apse and, over it, the frescoes of Piero della Francesca.
Each SP is represented in the tree-view of StereoSpace as a folder containing its data files and, at the same time, other SPs. This representation isn t only schematic because the folder really exists: all data needed for stereoscopic navigation inside the block are fully contained in it.

Figure 4

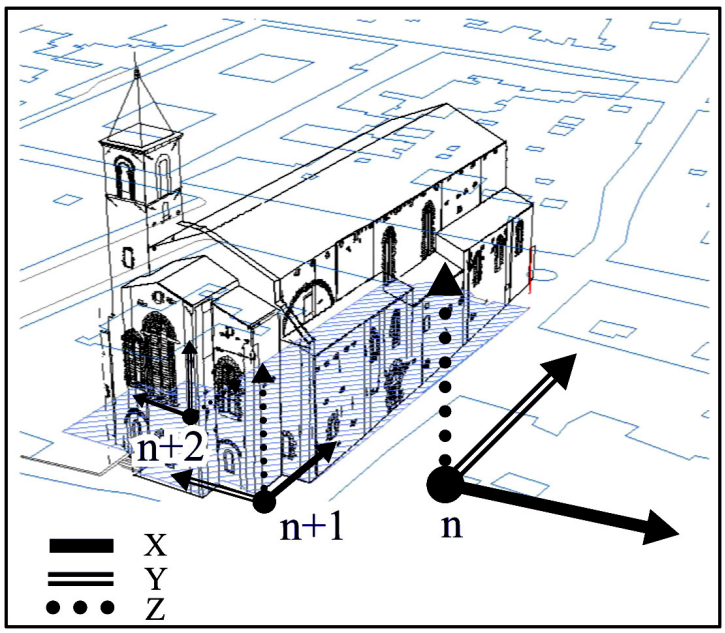
In the overview frame is possible to select the overview level that can differ from stereoscopic frames opened at the moment. Navigating inside SPM we can observe a cursor moving in the overview respecting the correct position in its co-ordinates system. This may happen because the software combines each element of SP chain local co-ordinates system. The overview is split in two parts: one is the tree view, which represents schematically SP chain, the other is the graphic window where is possible to select the map of each SP that is hierarchically parent of the current SP.



From the current SP, and its overview, we can also be informed of which other SP have a stereoscopic navigable volume in the overview area of the current stereo-frame. As we can see in figure 5 there are represented two different bounding-box in relation to each SP insisting in that area. A direct selection of a specific bounding-box let us navigate to that stereo model. The bounding-box number is equal to SP items.
There are three main methods to access in stereo models:
1) Directly from tree view.
2) Selecting correspondent bounding-box.
3) Following logical links previously defined that can be independent from topographical position.

Figure 5

For example it is possible to link the basilica of S.Francesco in Arezzo and other place where are some frescoes of the same type and make a stereo model comparison between the two SP. Exactly the same can be repeated for aerial cartography.
Moving the single folder throughout other SPM we have only to adjust the coordinate reference. In fact each SP is metrically linked with its parent and only with it, so that all children folder are automatically tied in the cinematic chain of the project.



The simple relationship between level n and level n+1 is:

$$X_{n+1} = X_n R_{11} + Y_n R_{12} + Z_n R_{13} + X^0 n$$
$$Y_{n+1} = Y_n R_{21} + Y_n R_{22} + Z_n R_{23} + Y^0 n \qquad [1]$$
$$Z_{n+1} = Z_n R_{31} + Y_n R_{32} + Z_n R_{33} + Z^0 n$$

Where R_{ij} represent the generic element of rotation matrix and X^0, Y^0, Z^0, define the origin of co-ordinates system n+1 with reference to co-ordinates system n.

Figure 6

4 Hardware system

Both mentioned systems either StereoView either StereoSpace are designed for standard PC.
The base hardware has the standard characteristic of a Pentium II with 128 o 256 Mbytes RAM with a *stereo-ready* graphic board. The stereoscopic visualisation occurs with the use of LCD glasses (active) or with a polarising screen and passive glasses.

5 Application s fields

Numerous are the application s fields in which the SPM is a valid help for the comprehension and the documentation of the objects in exam. The fact that the photographic operation and the topographic survey represent just a small part of the total cost of the survey production, suggest the SPM s use in all the situation in which it s necessary to document in the present time the subject. Taking the photograms and orienting them it s enough to create a database able to document the subject at that time, without doing any other elaboration. The SPM in fact is a map in fieri always ready to give the 3D informations requested by the observer.
Moreover the chronological evolution, SS 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:

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

CONCLUSIONS

The SPM and its informatics correspondent SS 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 tridimensional 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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