

Teaching Computer Aided Documentation to Conservation Specialists

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Abstract

The Istituto Centrale per il Restauro (ICR) is one of two Italian governmental institutions, offering the degree of 'restauratore' (restorer or conservation specialist). Starting next year, the ICR will institute new teaching programs, in which Digital Documentation (in terms of methodology, principles and disciplines) will be part of the already existing 'drawing techniques' program course. In D.D., our interest area will be CAD techniques applied in documentation for conservation.

Since 1992, the ICR has activated a project, aimed at simplifying the use of CAD tools in mural painting documentation. And, this year, three of the ten final theses were carried out, using D.D. techniques: for drawing, drafting, and data entry, as well as for the planning of relationship between various types of data.

One of the objectives of those theses was to demonstrate how necessary it is, for every conservation specialist, to record in a permanent format, all data resulting from different conservation actions.

The condition survey reports, developed by the three theses, investigated the state of conservation, techniques of execution, and history of previous restoration actions of various ancient Roman mural paintings, which are part of three archaeological monuments:

- Auditorium di Mecenate (Attura, Zelli)
- Casa di Livia al Palatino (Cici, de Riso Paparo)
- Tempio Rettangolare al Foro Boario (Billi)

The paintings were visually inspected, and their conditions were recorded graphically in the field, on laptop computers, equipped with AutoCAD programs, customised for each different painting.

The survey was designed to use both analogic images, done with the assistance of the ICR Documentation Group, and vectorialized files, obtained by automatic procedures. Since the manual recording stage was skipped, the three examples were a useful test of both efficacy and quality for on-site digital condition reports.

While initially based on NorMaL protocols (ICR and CNR conservation standards), their various symbols were customised, following suggestions obtained from previous ICR, ICCROM, and Getty Conservation Institute experiences, which were all developed by Buzzanca.

Menu customisation made it possible to operate the software with a very short training period: all complex command sequences were performed automatically by previously generated macro strings.

The documentation structure include a standard way of naming files. A clear and understandable procedure for naming files was, indeed, critical, to allow sharing of information and communication protocols. For the same reason, the way in which the data was organised was also critical.

Since all three theses used the same standard, they constituted a useful test in that regard, and have also proved that laptop computers are a powerful tool for conservation specialists in the field: they are easy to operate, and their low cost makes them available to a great number of professionals.

Moreover, the whole process was carried out using a small amount of technology. A more powerful computer was used, only for data storage, back-up, and the printing of drawings.

Our experience shows that menu customisation and macro generation are an effective way of minimising the need for learning complex programs, such as AutoCAD, and that they are also useful in reducing errors in data entry. As a matter of fact, accuracy and efficiency have been greatly improved. We present each set of documentation, with an emphasis on a particular aspect of the documentation process.

Introduction

While the technological landscape is quickly upgrading, and costs are declining precipitously, the use of CAD techniques, in the field of conservation, has increased during recent years, and may well be, in a short time, the standard technique for producing condition reports.

Production without shared rules. To make information exchange possible, we need a well founded standard, and a clear understanding of the rules and conventions used in the recording of documentation.

In this paper¹, we intend to analyse how powerful CAD techniques are in conservation, and to describe a field documentation technique, and the development, using common software, of a useful information instrument, for the recording of data on thematic maps.

Since 1992, the Istituto Centrale per il Restauro² (ICR) has been running a project, aimed at simplifying the use of Computer Aided Design (CAD) tools, in mural painting documentation. The software structure was tested by ICR's student conservators, in some educational work-sites, over the last two years³.

¹ All the theoretical part (except of digital photographic methods) are based on BUZZANCA, G., 1997, *Documentazione grafica ai fini di restauro. Sistema informativo di cantiere per la raccolta di dati storico-conservativi*, Relation about the Visiting Scholar period in Documentation Program-Getty Conservation Institute, Los Angeles-Roma, manuscript

² The is one of two italian governmental institutions offering a degree of restauratore (restorer or conservation specialist).

³ For the customisation tools the software structure developed by Buzzanca was tested by ICR's student conservators in Santa Cecilia in Trastevere Educational Work-Site (Conservation Specialist F.Capanna and A.Guglielmi and Director D.Radeglia; base map M. Gorini e M. Sangiorgio; photographic documentation A. Rubino; CAD customisation G. Buzzanca) on summer 1996 and summer 1997. The S.Cecilia documentation structure was developed by F.Capanna starting with the DOC.NORMAL/G/DM 1/94 (M.Gorini, M.Paris, L.Rissotto). Based on Santa Cecilia's experience was produced by Buzzanca and Capanna a booklet "Manuale sulla personalizzazione di AutoCAD" (Instructions on the customised AutoCAD menu) for educational use that is the only text to have under complete review the ICR's "Local Information System".

Other tests was carried out, as a part of a global documentation digitalization program, in ICR's San Clemente Education Worksite (Conservator Specialists C.D'Angelo e C.Mora and Director F.Sacco). Using this software other complete works carried out in the last years were: Santa Maria Maggiore in Rome Condition Report (M. Orru', C.Ranzi); State of Conservation and Technical Execution Documentation in Giotto's Frescoes in Cappella degli Scrovegni, Padua (M.Orru', C.Ranzi, E.Giorgi); Angor Wat and Preah Ko Condition Report (S.Warrack and Cologne University). Anagni Cripta Frescoes' Condition Report (Conservation Specialist F.Capanna and student conservators). The last one in the list was the first one (1992), in a prehistorical development, seed of all those.

The principal goal was to reach a situation, in which the conservator (or the draughtsman) could digitally report, in a definitive way and directly on site, all the data related to mapping techniques, distinct for each category and class, which characterise the graphic documentation of a conservation operation. Obviously, the recording, in a permanent format, of all written and visual information accumulated during the examination, and treatment of cultural property, must be the goal of each conservation specialist.

This should be accomplished without altering in a drastic way the intrinsic complexity of the software used, while avoiding any prior, hyper-specialist, technical preparation.

In the last year, three of the ten final theses⁴ were carried out using D.D. techniques: for drawing, drafting, and data entry, as well as for the planning of the relationship, between various types of data.

The condition survey reports, developed in these three theses, investigated the state of conservation, techniques of execution, and history of previous restoration operations of various ancient Roman mural paintings which are part of three archaeological monuments:

- Auditorium di Mecenate (AM);
- Casa di Livia al Palatino (CV);
- Tempio Rettangolare al Foro Boario (TR).

The mural paintings were visually inspected, and their condition was recorded graphically on computers, equipped with AutoCAD programs, customised for each different mural.

The survey was designed to use both analogic images⁵ and vectorialized files, obtained by automatic procedures.

While initially based on the NorMaL⁶ protocols, their various symbols were customised, following suggestions obtained from previous experiences.

Menu customisation made it possible to operate the software with a very short training period: all complex command sequences were performed automatically, by previously generated macro strings.

⁴ A thesis was yet done using this software in 1995. See ORRÙ, M., 1995 Il manufatto di interesse culturale nella sua realtà materica. Proposte di analisi delle informazioni relative alle indagini conoscitive, thesis, Roma: ICR

⁵ With the assistance of ICR Documentation Group

⁶ ICR and CNR conservation standard

The documentation structure included a standard way of naming files. A clear and understandable procedure for naming files was, indeed critical, to allow the sharing of information and communication protocols. For the same reason, the way in which the data was organised was also critical.

Since all three theses used the same standard, they constituted a useful test in that regard, and have also proved that laptop computers are a powerful tool for conservation specialists in the field. They are easy to operate, and their low cost makes them available to a great number of professionals.

We present each set of documentation, with emphasis on a particular aspect of the documentation process, especially on digital photographic documentation, and its conversion to a vector format.

But mainly, we are looking for clarity in the process and the problems, where technology is simply a medium of the theoretical approach.

With regard to problems, we must solve all of the problems linked to the digital acquisition of the graphic base, to the planning of the form of the documentation, to the standardisation of the topology of the hatch patterns, and to the customisation of CAD software.⁷

Standard

In contrast to the layout and symbols of paper drawings, which in most countries are more or less standardised, the techniques for managing digital CAD data are not yet improved.

The necessity to manage and transfer information⁸ in digital format, between participants in a project, has become of vital importance, and requires a clear and understandable documentation structure. Problems are often encountered, due to inconsistent information compilation.

A prerequisite for efficient data transfer and sharing, is that all the information in models must be structured and partitioned in standardised ways.

Our activities involve, not so much the building of an all-new software, as the checking of who, what, when, where, why, and how. We can find a lot of market-oriented standards. According to our specific documentation necessities, the technical drawing standard is "de facto", AutoCAD.

Of all the AutoCAD features, perhaps the most significant is the possibility to structure the data in an unlimited number of layers. Layering⁹ is a widely used method for structuring data

⁷ See: BUZZANCA, G., 1997, *Computer Aided Documentation. Documentation for Conservation Condition Survey. Thematic maps for condition reports*, Los Angeles-Roma, GCI, manuscript; and BUZZANCA, G. 1995, *Documentazione Grafica ai fini del restauro. Sistema informatico per la raccolta di dati storico conservativi*, Relazione Tecnica, Roma: ICR-ICCROM

⁸ BJORK, B.C., LOWNERTZ, K. & KIVINIEMI, A. 1996. "ISO 13567- The proposed International Standard for Structuring layers in computer aided buildings design", in TURK, Z. 1996 *Construction on the Information Highway. CIB Proceedings Publication 198*. Electronic proceedings available on <http://www.fagg.uni.lj.si/bled96>.

⁹ Many layering hypothesis were proposed by documentation experts. The better hard worker is the american architect Eiteljorg. You can read a lot of his document. Read, for example, those that follow:

ETTELJORG, H. 1995, *CSA layer naming convention*, Available from <http://csaws.brynmawr.edu/web1/newslet.html>

in CAD-models. A layer may be described as a characteristic or attribute of any CAD geometrical entity.

In layering systems, each primary drawing in a CAD-file may be assigned to a layer, according to a pre-defined nomenclature¹⁰. In this way, layers should be designed to separate data types.

The organisation of the standard is based on the fundamental principle of a clear and logical separation of information. In addition, layer management plays an important role, for every CAD user, in minimising and simplifying commands.

In other words, the use of CAD layers allows drawings to be organised and manipulated. This may be very important to improve organisation in graphic data management.

Therefore, if we standardise and enforce a *hierarchical file and layer naming system*, documents will be improved and their quality enhanced.

During the last few years, national standardisation organisations, professional associations, user groups for particular CAD-systems, individual companies, etc., have issued numerous standards and guidelines for the naming and structuring of layers in building design. In the field of conservation, a standard does not yet exist..

But the experiences, explained here, provide a clear and understandable naming technique, which permits quick and automatic access to individual layers, without having to remember individual names¹¹.

The layer structure must permit the sharing of information between disciplines. If this sharing is accomplished properly, no repetition of data should occur.

In addition, we want to underline the importance¹² of colours in data organisation. Using different colours in a layer, it is possible to implement the information quality, thus obtaining very powerful tools to manage specific data.

Models for documentation

The graphic documentation is made up of two different models¹³ (kinds of representation), which are combined

___1993, "Layer Names Again", *CSA Newsletter*, v. V, n° 4

___1991A, "Layer Names for Excavations", *CSA Newsletter*, v. IV, n° 1

___1991B, "Layer Naming Convention", *CSA Newsletter*, v. III, n° 4

___1990, "Layering Standards - Some Changes", *CSA Newsletter*, v. III, n° 3.

___1989, "Preliminary proposal for Archaeological Layering Convention", *CSA Newsletter*, v. II, n° 3

___1988, "Layer Naming Conventions Important in CAD", *CSA Newsletter*, v. I, n° 1

¹⁰ In layering systems each drawing primitive in a CAD-file is assigned to a defined layer and the user can then interactively decide the layers to show on the screen or to plot.

¹¹ To accomplish this, each letter (or group of letters) in the layer name designates its information according to its position as well as the letter itself; an X in the first position it's different meaning from an X in the second position.

¹² It's the first time that we accept a colour based documentation. The Nor.Ma.L standard prescribes only B/W documentation, but, obviously, it's a out-of-date standard, unaware of the technical and methodological developments.

¹³ A documentation logical definition it's published in SACCO, F.1993, "Il problema della documentazione grafica dei restauri", 25-34, *Materiali e Strutture*, III, 1. An other point of view looking for a digital transation and verification of the Sacco'explications it's contained in BUZZANCA, G. & GIORGI, E. 1995. "Documentazione grafica assistita da elaboratori. Note operative", 119-138, *Archeologia e Calcolatori*, 6; (unfortunately both are in italian language and without illustrations).

together. The first one concerns the object, as such, and the second one concerns the historical and conservational information, selected and grouped by category.

The informative model is realised by means of graphic symbols (patterns, symbols, letters), superimposed on the first model.

The object model can be both a photo and a drawing. ICR's experiences are, to date, only accomplished with drawings¹⁴.

The ICR uses photographs to outline the iconographic representation and to obtain the "object, as such". However, there are different methods by which this data may be acquired.

In manual conservation condition reporting, the usual procedure is to have a synthetic drawing, as a base, to record "thematic maps". Making the synthetic drawing, it is important that the object maintain the correct relationship between the iconographic characteristics and its topographical location.

Symbols and patterns, pertaining to the object's historical-conservative condition report, are the graphic extension of a list of terms, structured according to the categories system.

The experiences described here are a numerical translation of the logical structure outlined above. We use a complex relationship between the models, and a defined documentation structure.

Object's model

An aspect of fundamental importance, for every type of digital documentation, is the acquisition of the data, in a computer-compatible format, where the acquired co-ordinates will have sufficient accuracy, in relation to the aims of documentation. These co-ordinates must be codified, structured, and labelled with descriptive codes or appropriate attributes.

In recent years, the method used for converting information to a CAD-recognisable, digital format has been the point of departure of all vectorial, computer-aided documentation.

The problem of the integration of vectorial and raster data has usually been seen as research for the best solution for the vectorialization of raster data. In recent years, the functions of the conversion of data from raster to vectorial format, has been modified to visualise, to edit, and to use the two types of data at the same time.

The latest developments are geared towards user-friendly interfaces, that enable the customer to make data accessible without format limits.

The customer must be able to use the full elaboration potentialities contained in the two types of data.

To obtain this, we have to:

1. improve a simultaneous visualizing procedure, as well as a customised user interface that renders the integration more user-friendly;
2. homogenise the structure of the archives;

3. make the management and retrieving of the associated descriptive data possible;
4. make the vector/data translation easier and more useful.

Essentially there are three ways, in which the data can be acquired in digital format:

1. with digital instruments, that record the co-ordinates of the single points;
2. with digital instruments, that acquire entire areas in digital format;
3. by means of digitalisation methods, where the data contained in already existing designs can be converted, manually or automatically.

The first two systems make reference to surveying activities, that must be carried out in the field, in the restoration worksite. The last activity can take place inside the laboratory, because it is based on the elaboration of existing documentation. The physical place, where documentation activity is principally carried out, is the restoration worksite.

Digital Data acquisition and editing for Object' Model

Photographic documentation

The innovation introduced by digital photography is that it allows real-time control of the results of every photographic session, which is a matter of utmost importance in photographic documentation.

We experimented with digital photography for the first time, while restoring the Roman mural paintings, in the Auditorium di Mecenate and in the Casa di Livia al Palatino, both located in Rome. On these occasions, we pre-arranged the graphic backgrounds and thematic tables in the field, thus avoiding the waste of time, between the various phases of the process.

A computer can only manipulate numbers, and our need to translate every image into numbers came as a consequence of this fact. The process could be separated into two aspects: spatial dimension and chromatic quantity. The first aspect consisted in dividing the image into a given number of rectangles of the same size (pixels), in which the ratio between width and height was always equal to one. The number of pixels determined the image size. The size and quality of the image were proportional to the amount of information, needed to define it. This mean that more definition equaled more space, occupied by the image in the computer's hard disk, but mean also, that small details could be made clearly visible.

The chromatic quantity, on the other hand, was the set of numbers, that had to be assigned to every pixel, in order to define average colour. It was a quantity, defined by the intensity of electromagnetic radiation, related to the visible spectrum's frequency.

How to render the *right* colour was not a simple matter: the perception of colours is still an unsolved problem. We were able to create a vast range of colours, by mixing the so-called *primary colours*, which, in the case of cathode tubes and laptop computer screens are red, green and blue (RGB), while those used in printing are cyan, magenta and yellow (CMY). We called 'Bit' the scale of intensity of each primary colour. The gap between its minimum and maximum value

¹⁴ ICR's digital documentative worksites for recording of historical and conservative information were carried out, up to today, using the Buzzanca's menu customisation on release 12 and 13 of AutoCAD (Educational version).

was divided into a given number of levels, and the greater their number, the greater the accuracy of the colour's definition.

The digital back Dicomed Field Pro (DDC 7520, 2GB), together with a CCD (Charge Coupled Device)¹⁵, in tri-linear scanning, allowed the complete scanning of an image. Its tri-linear matrixes were formed by three files of ccd elements, covered by three RGB filters. A motor, turning a worm screw, moved the matrix, line by line, over the image's surface.

The camera, during the process, had to be firmly fixed in place, to avoid distortions in the final image. The shootings were made using a Sinar E 10X12 optic bank camera. The mobile body of the optic bank camera was mounted over a monoslide which held two adjustable supports: the front support holds the lens plaque, and the back support held the frosted, focusing glass.

The scanner chassis was mounted on the latter, and could run freely on the slide and be blocked at any required position. The bellows, whose function was to create a light-proof space between lens and focal plane, connected the two supports. Its expandability determined the camera's limits, in terms of the minimum and maximum focusing length of the lens¹⁶.

The back support, the one which held the frosted glass, allowed the chassis to be inserted, both in vertical and horizontal positions¹⁷.

During the CL shootings, we used a wide angle lens, with a field angle of 90°, because we were not able to put the camera at a convenient distance from the paintings. We traced an alignment, perpendicular to the walls, and the twelve shooting positions were made perpendicular to it.

We overlapped them about 10% of their total surface,¹⁸ and used a mobile scaffolding to move the camera between the various positions;¹⁹ and the digital back was instructed by a laptop Apple Power Macintosh 117 MHz, 64 Mb RAM, and active matrix screen.²⁰

The first step was image framing. The second step was light source calibration²¹, in reference to light temperature: to do this, a Kodak, neutral grey cardboard was placed near the subject, and *light calibration*, a feature which operates on the colour levels, was then activated from the computer's menu.

The *preview* feature allowed calculation of the exposure parameters (shutter speed and diaphragm aperture), in respect to the subject's dimensions, the required resolution, and the area to be scanned.²² While operating the *Take Picture* program, the digital back cannot suffer any vibration. Marks²³ must also be applied on the image for purposes of identification, perspective transformation, and overlay calibration.

The use of a *normal lens*²⁴ in the Auditorium di Mecenate allowed us to reproduce the white veils, overlaid on the paintings. The images, which were named according to the various shooting sessions, were imported into Photoshop, for subsequent manipulations, and finally renamed in BMP.²⁵

Graphic documentation

To obtain a metric and iconographic drawing of a mural painting from a series of photographs, is a simple and economical matter. The point is that every photograph (since perspective distortion is unavoidable, even if it has been taken from a position parallel to the subject), is valuable only in terms of description.

Using ArchLine©²⁶ we were able to rectify the photograph's distortions, by means of its transformation into a vectorial file which, in turn, became an architectural and iconographic, full-scale drawing.

The initial photograph was downloaded on the program's interface, which permitted us to perform all the desired procedures operating the mouse (or the trackpad).

Perspective calibration determined the dimensional correspondence between a flat surface portrayed in a photograph, and the Cartesian axes of the workplan of the software.

It functioned by straightening out, on the workplan, the marks previously selected on the photograph, and subsequently bringing it to full-scale dimension. The software required at least four marks, which, for best results, had to be placed as near as possible to the image's corners.

Starting from a bitmap image, the 'overlay' feature created a file with the .ovl extension.

An overlay file is an auxiliary file, which contains the information regarding the way in which the original image is interpreted, with particular emphasis on the correspondence between pixels and units of measure (millimetres). It must be named exactly the same as the original bitmap file.

²¹ We used a constant light source: four tungsten 800W lamps at 3200°K colour temperature. These lamps generate excessive heat, though, which affects sensor's efficiency and results in a lack of blue radiations. Furthermore, this can be dangerous in terms of the micro-climatic conditions of the murals

²² Since the CCD matrix is smaller than the film, the scanned area is 90% of the total.

²³ They are required for the tune-up of the 'overlay' extension of ArchLine.

²⁴ By 'normal', we define a lens whose focal length is equal to the diagonal of the film or the back.

²⁵ The Dicomed digital back saves only TIFF files

²⁶ The software was tested during the development of the thesis.

¹⁵ CCD sensors register the light's total intensity, but they are more sensible to the spectrum's red end than to the blue one. As a matter of fact, they react intensely also to the infrared wave length. Red, green and blue filters subdivide the light in the RGB channels used to save the image as a digital file. An infrared filter covers all the CCD's area to avoid excessive red values.

¹⁶ The focusing length is the distance between the nodal plane of a lens aimed at infinity and the focusing plan.

¹⁷ One of the sides of the frosted glass is a Fresnel lens which assures the same amount of light on the whole image area. Its surface is constituted of a series of small concentric rings and, directing the light toward the photographer's eye, acts as an objective's lens.

¹⁸ In order to have more conjunction points, useful for the graphic restitution of the paintings.

¹⁹ The performance of a wide-angle lens is strictly related to how a change in the distance affects the image's perspective. Tri-dimensional subjects can be distorted towards the image's outer edges because the rays of light which do not coincide with the optical axis hit the film with an oblique angle, and not with a right angle. This phenomenon does not occur if the subject is a flat surface and is parallel to the camera, which must be placed in front of its center and perpendicular to the ground: in this case the rays of light reflected by the subject will be coincident with the optical axis of the lens.

²⁰ The set was conceived to be used in a photographic studio, controlled by a table computer. We experimented it in the field with a laptop Macintosh for the first time in these occasions.

Since ArchLine© offers a wide range of drawing tools, these can be selected to obtain the best possible reproduction of a given subject.

Once the overlay file was erased, the drawing could be further modified, using the 'multitrans' feature: it allowed the moving, rotation, enlargement, and reduction of the image.

Historical and conservational information

The conservation worksite is characterised by the direct acquisition of data for analytical and/or documentary purposes. It would be better to report information about the materials, structure, past history, current condition, and environment of the cultural property through digital instruments.

Computer instrumentation must be conceived in terms of small stations, with user friendly interfaces, that can be used by the documentation technician with minimal training. In worksite activities, unconditioned technical operativity²⁷ is fundamental. Therefore, the choice of the various places, in which computer instrumentation is scientifically applied, have particular value.

Empirically, we can distinguish two systems:

- the field as an *open system*. In the worksite, it is possible to take advantage of enormous computer potentialities, in order to store and to manage, in a simple way, a great amount of data;. Activities are focused on the recording phase.
- the laboratory as a *closed system*. This is a case, with closed or governed system, where new interpretative models can be experimented with and new diagnostic techniques tested. This is the place for theoretical experimentation.

So, to be able to increase the amount of collected data and the quality of the scientific control, in the evaluation of data, we decided to try direct digital recording on site.

This was a way of implementing immediate and interactive information verification, and of producing a *reading system*, able to orientate and co-ordinate other modalities of survey through *thematic maps*. The drawings were a *natural frame* for collecting the various constructive, historical and conservational data.

This technique is of vital importance in the organisation and manageability of work. The customer can decide, according to the degree of interactivity required, which layer to activate, in order to record, to visualise, or to plot the information.

The experiences

The study of wall paintings, which is the subject of this thesis, has been set up both from a technical point of view, as well as from an understanding of the causes, that have determined the present state of preservation.

Graphic documentation has provided the fundamental framework for this study, and has permitted the recording of technical, conservational data in special thematic tables. These graphic tables were divided into the following

categories: Techniques of Execution, State of Preservation and Previous Interventions, and had a specific aim: to provide a complete picture, that could be immediately understood and interpreted, from all the information available, from the study of the paintings.

The development of graphic documentation required various phases, different for each of the wall paintings, and for which, computerised documentation could always be used.

The choice of surfaces to be documented was governed by empirical motives:

- legibility of the surfaces and the iconography;
- possibility of close and direct observation;
- presence of significant problems, relative to the state of preservation (traces of products used in previous restorations, chromatic alterations, saline efflorescence, and so on).

For the development of the object model (graphic background), various procedures were used:

TR	Drawing made with a scanned wire	Thematic mapping on site
AM	Graphic background carried out directly by computer	Thematic mapping on site Thematic mapping in studio
CL	Graphic background carried out directly by computer	Thematic mapping on site

The poor state of preservation of the wall painting in the TR determined the choice of a graphic foundation, that was developed from photographs, taken in 1925 (when the paintings were still fully legible).

Development of the graphic base proceeded in the following phases:

- photographic images were transferred manually onto transparencies;
- each transparency (relative to single figurative compositions) was converted to a common scale (1:10);
- the graphic foundations of each wall were subsequently examined in detail, on site, so as to confirm the accuracy of the manually recorded information.

The next phases were then done, using the computer. The hand drawn graphic background was first scanned with a large format scanner, and then vectorised automatically, using special software.

For AM and CL, it was necessary to carry out a photographic campaign, in order to be able to begin graphic documentation.

In order to do this (we were, in this case, working on a 2D object), it was essential that the shots be taken in such a way as to be exactly perpendicular to the ground and parallel to the surface of the wall painting.

²⁷ You can see, here, the paper BISHOP, M.H. et alii "Digital Recording of the Condition of America Tropical, a Mural by D.A.Siqueiros" concerning a raster/vector documentation example.

Due to the large dimensions of CL, it was necessary to divide the surface of the wall painting into zones, which were photographed individually, and then recomposed as a single image photo mosaic.

This photographic image was used as the graphic background, over which the drawing would be made.

The drawing was traced by mouse using the usual graphic conventions, in terms of the typology and position of the various elements²⁸.

By using a rich set of line types, which were selected in relation to the scale of the particular feature being documented, it was possible to guarantee a high level of accuracy and graphic quality.

Small adjustments were made in CAD, in order to correct the orientation of the files.

Various digital maps²⁹, concerning techniques of execution, state of preservation and previous interventions were carried out³⁰, using AutoCAD software, in which the menu file was specially modified.

AutoCAD offered the possibility to organise information in a succession of layers, that permitted the operator to subdivide recorded data into single thematic tables (each represented on a single layer), which referred, in homogeneous groups, to specific keywords on the menu. The latter represented the Categories (techniques of execution, state of preservation, previous interventions, diagnosis, etc.).

Vectorial graphic background was a separate layer, and the individual layer, on which the data was recorded could be superimposed over it.

The organisation of files, that contain graphic information, (like the thematic mapping files), was controlled by a special file naming system³¹.

Using the special menus, it was possible to turn on, or off, any of the layers, independently.

The methodology of data acquisition was different for each of the sites.

By using a portable computer, on-site, it was possible to transcribe the data directly into the computer, while observing the wall painting, and thus eliminated one of the steps, necessary in manual operation, which is usually carried out in two phases; first on site, and then in the studio.

²⁸ For instance, the line has been designed with three different depths: 0.5 mm for the brush over which pictures have been placed; 0.3 mm. For the picture contour, and 0.2 mm. For internal decoration

²⁹ All five curators have had developed some experience at two didactic workshops at S. Cecilia (1996-1997) and S. Clemente (1997).

³⁰ For the graphic documentation, 3 portable computers and a desktop have been used. These are the main features: Portable Pentium 133 Mhz, 16 Mb Ram, 2 Mb video RAM, 2Gb HDisk; Portable PENTIUM 120 Mhz, 16 Mb RAM, 1 Mb video RAM, 800 Mb HDisk

Portable 486 DX2, 66 Mhz, 24 Mb RAM, 1 Mb video RAM, 800 Mb di HDisk 486 DX4, 100 Mhz, 16 Mb RAM, 1 Mb video RAM, 500 Mb HDisk;

³¹ Each image data base was composed of a file identifiable by a single code, for instance: CLATPS where the first two letters were a label for domus Casa di Livia (CL), the second was an identification of the context (atrio=AT), the third identified the walls over the images were found (parete sinistra=PS -left wall-)

In the case of CL, a portable computer was used on site, with a sort of documentation team, in which one operator closely observed the surface of the wall painting, while the other was positioned in front of the computer monitor. The presence of the operator, in close proximity to the wall painting, was useful, since it allowed rapid survey and accurate verification of damage to the fresco, and thus, facilitate recording of data.

Moreover, in the case of three dimensional surfaces, it was not always possible to have a scaffolding, that permit full observation of the various types of damage and alteration, by a single operator; therefore, this division of roles seemed opportune in this case.

It was not always possible to have a portable computer on site. In contrast to the undoubted, numerous advantages of the portable computer, it should be noted that in some cases unfavourable environmental conditions can make the use of a portable problematical (uneven working surfaces, use of the track-ball, limited battery life). The use of paper can be more versatile, in these cases, even though there is sometimes a loss of precision, which means that there must be a series of controlled print-outs, to check the levels of accuracy.

In the case of AM, two computers were used, one portable and one desktop, and the collection of data was carried out autonomously. The portable computer enabled the data to be directly transferred in front of the wall painting, while the use of the desktop required, at least in the survey and codification phase, one more step. All the thematic maps were carried out by hand, on site, on a print-out of the graphic background, which was subsequently transferred into the computer³².

Through the use of a physical and logical structure, which is carefully standardised³³, data, which is separately gathered, can be coherently unified into a single file, and, therefore, into a single graphic image.

In order to compile the various tables, it is necessary to carry out the following operations;

- select the category in the menu bar (techniques of execution, state of preservation, previous interventions, diagnosis, etc.);
- select the layer, onto which the data will be recorded (i.e. paint layer);
- outline the area into which the data will be inserted (using a closed polyline);
- select the hatch pattern, that will be inserted into the outlined area;
- select the closed polyline, and apply the hatch pattern.

³² Looking the final prints at the end of the work, it has been observed sometimes that the understandability of signs which compose the image base were undistinguishable with thematic mappings. It has been necessary a reconstruction of the best hatch pattern possible to the used grids, in order to warrant a good understandability of all images in a final presentation at 1:10 scale. Colour using satisfy completely the need of distinguishing the signs related to the graphic base from the constituents of the thematic mapping.

³³ Each curator has introduced some variations which have been incorporated in the final main reconstruction, following the same rules.

In conclusion, the critical analysis of these three separate examples, allows us to appreciate the advantages, that digital documentation offers, with respect to usual, manual documentation.

These advantages can be summarized as follows:

- rapid, punctual, and correct execution in documentation phases;
- immediate visualisation of sets of information;
- the possibility for interactive analysis of information, through the superimposition and confrontation of mapped areas;
- rapid updating, following standard procedures;
- drastic reduction in costs of documentation;
- easy exchange of information, according to pre-defined formats;
- representation of information, detached from the possibly subjective point of view of the operator.

Conclusions

The general objectives of this search have been:

- to develop computer science instruments and their applications;
- to study structures of the data,
- to study hierarchy and relationships between the various information models;
- to study physics and digital communication standards.

The substantial hypothesis is the necessity, above all, in documentation activities, for the construction of shared models, that can respect and integrate the purposes, structures, processes, and people of various professions, to construct a SIMPLIFIED INTERFACE LOCAL INFORMATION SYSTEM (SILIS).

This should not be so much a container, but a network for communication and data exchange between users of the same information system, and where the geometrically determined representation of the object, obtained using CAD software, must be the hinge element of the system.

To develop digital data management systems, that are interactive, low cost, and manageable from the computer, means the promotion of a dimension of scientific decentralisation, in which the component interacts, through a variety of powerful systems of connections. This can be defined as PLANNED ANSWER SYSTEM SOFTWARE. (PASS)

Anyway, processes were carried out using a small amount of technology. Information recorded on site was transferred to a more powerful computer only for storage, for back-up, and finally for printing of the drawing.

Tests showed that menu customisation and macro generation are an effective way, to reduce the need for fully learning,

complex programs. They also proved that it is method, that reduces errors in data entry, by obtaining a greater degree of accuracy and efficiency, available to a larger number of users, both because it's user-friendly and low-cost accessible.

Economy, simplicity, and absolute clearness for the customer, must be essential characteristics of the system.

The management of documentation presents the problems of conservation modality, data transfer from and to other systems, and detailed structural understanding of documentation.

There is no reliable criterion, for estimating the qualities of computerised graphic (or non-graphic) documentation. The only criterion would seem to be, in public and private offices, the thoroughness (and correctness, according to national or regional standards) of the paper print-out. But, to reduce the content of digital information to print quality is, clearly, nonsense.

The development proposed in this search, is to integrate various documentation formats to their graphic base. We can define this as a *reading system*, capable of orientating and co-ordinating other methods of survey where the restorer must know the typology and means of information to be supplied (Input) or retrieved (Output) from the computer.

We want to restore conservators to the heart of the organisation of the conservation project. We want to implement a standard documentation structure that allows the restorer to restore, the conservator to conserve, and the documentation expert to record.

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