Renzo Carlucci *,

"*The Iconometric Model*"

* Università degli studi dell'Aquila, Italy

Aprile 1991

Abstract

The project shown in these pages realizes a new system for metric documentation and catalogation of cultural estate.

At present we know that photogrammetric methods are too expensive and onerous. For instance only in Italy the immovable patrimony to be catalogued is in the order of hundreds of thousands of units.

The proposed method is aimed to techniques and instruments for a simplification and standardization of some operations made by surveyors; its principal characteristic, beside functionality and precision, are quickness and saving.

The iconometric model has been applied in the Erocare project "RE.FRAN" and will be realized by the holding LEICA in conjunction with ITALCAD.

Its hearth is a semimetric kind of photo camera which is provided with a built-in system for distance measurement. Furthermore a tools for drawing vectors on raster helps to calculate distance, areas or to get thematic maps directly from photo - image.

A specific software for digitized images management is employed in order to get scaling and rectification of the photograph.

Introduction.

The need to realize such a project rises originally in the field of knowledge, classification and arrangement in catalogues of the Italian cultural estate, which is under the Direction of the Ministry for the Cultural and Environmental Assets. This does not prevent the proposed realization from finding a large application also in other fields.

As for what concerns the above stated main purpose, it is well known that one of the emerging fundamental imperatives for the preservation and restoration of the huge Italian artistic-cultural patrimony consists in its knowledge through a systematic work of documentation and classification.

The State Organizations which are in charge of this within the Ministry for the Cultural and Environmental Assets are: the Istituto Centrale per il Catalogo e la Documentazione (I.C.C.D.) as for what concerns reconnaissance of the historical and artistic aspects of the cultural estate, and the Istituto Centrale del Restauro (I.C.R.) for what concerns the ascertaining of their state of preservation.

The catalographic activity of both Institutes shows itself in the drawing up of suitable cards allowing the survey and the computerized data recording of the relevant graphic and alphanumeric data. One of the main difficulties which may arise during the graphic data survey consists, in most cases, in the lack of availability of existing and reliable surveys and graphic representations. This fact forces to execute the surveys according to each case with a remarkable waste of time and a high increase of the catalographic costs.

Besides, the photogrammetric equipment, too, is expensive and can't be proposed for an extensive application if one just thinks that only the historical-artistic real estate to be card-inde-

xed can be estimated in the order of magnitude of hundred of thousands of units.

Hence, the need to project and execute procedures and instruments to put at the cataloguers disposal in order to simplify and standardize some surveying operations having the necessary requirements of cheapness and low operating costs as well as of ease of handling and of high capacity and operating speed.

The herewith proposed "iconometric model" has been thought to satisfy such requirements.

It will consist in a semi-metric photographic camera, i.e. equipped with marks inside the camera body which detect a cartesian coordinate system. After being inserted, they allow to print an image which can be reconstructed geometrically and dimensionally. The camera will also have an EDM (Electronic Distance Measurement) which, by means of a simple software, detects the graphic scale of the obtained image. It will then be able to treat this image, inserted by a scanner in the screen, in order to obtain a scale drawing by means of a CAD system.

On the drawing it will be possible to realize any type of different graphic themes in order to point out the degree of deterioration of the materials and components of the building.

Such a system may be useful to survey the fronts of the historical buildings and of the decorative details, sculptural groups, moving artistic objects allowing to carry out these operations with a remarkable speed and an acceptable degree of accuracy.

The accuracy degree and the image resolution capacity have been studied in order to be used in the future cartographic campaigns envisaged by the law 19.01.90 no 84 which finances with 130 Milliards of Lit. in the next years program of interventions for the classification and the drawing up of an inventory of the cultural and environmental assets as well as of a cognitive up-to-datable map of the risk situation of the cultural estate.

Particularly, as for what concerns the risk map of the Italian cultural estate, the illustrated system corresponds to what requested by the technical specifics enclosed to the instruction for the card-indexing of the deterioration of the architectural estate, which were proposed by the Istituto Centrale del Restauro.

In conclusion, the "Iconometric Model" represents an efficient and technologically advanced answer to the need of a graphic documentation which can't be satisfied by the traditional manual surveying systems.

Project description and organisation

The realization of the project is divided in 3 sectors:

- **Iconometric camera realization.**
  Made by Leica Heerbrugg AG Special Product Division (Swiss) and Leica Wetzlar (Germany).
- **Software development.**
  Made by Italcad Tecnologie & Sistemi (Italy).
- **Field testing.**
  Research and experimentation developed in the Università dell'Aquila (Italy), Istituto Centrale del Restauro (Italy) and branch office in Rome of Leica Italia S.p.a.

Sector A. The iconometric camera

A.1. The iconometric model

In the process of catalogue of cultural estate the archive of photographic images has a particular importance to allow later further analysis even if the object is destroyed.

It is evident the necessity that the above mentioned photographs are to be achieved by those who, experts in photographic documentation of cultural estate, are able to signify the possibility offered by the means.

But if we add to such ability some metrical informations, the process of catalogue becomes more complete, moreover giving to future users a mean for analysis on artistic objects surely reliable, from the quantitative point of view.

The here proposed *iconometry* is based on the geometric relationships between the real object and the corresponding positions on the photo image.

With such a method is possible to carry out a plan of quick catalogation by the input of an "*iconometric model*" in workstation image treatment aimed to the acquisition of metrical and thematic data on architectonic degraded surfaces.

The different possibilities offered by photogrammetrical methods may today be distinguished, with relation to the resulting image, in:

- photographic
- only graphic
- numerical graphic

The first, by ortophotogrammetry or optical rectification, produces enough definite metrical documents.

The others, just or numeric graphic, offer for a resulting product some sketched out drawings following the principal lines of the object. Realized by mono- or stereoscopic photogrammetric methods, such drawings loose the strength of the photo image, acquiring in precision and accuracy.

Furthermore the result is submitted to the operator's interpretation.

The *iconometric model* belongs to the first above mentioned techniques. His intent is to acquire a document that is at the same time expressively clear (the photo image) and metrically distinct (the geometric relationship), without lack of precision.

A.2 - The geometric relationship.

Assuming the hypothesis to minimize the work for photo documentation and related topographic operations, accepting besides the natural consequence of loosing high precisions, is possible to proceed to a brief survey of objects assimilated to planes (with only two principal dimensions because the third is negligible), like paintings, wall of buildings, etc., by rectification of a photo image.

The possibilities of extrapolating measures from this photo rectified image, are surely suitable for the aim of quick catalogation and documentation of cultural estate, where usually high precision and its related costs are not justified.

The high precision resulting from stereo-photogrammetric methods is not always required from the historians of arts, architects, or specialists working in the field. In that case a general dimensioning of the image may come from the knowing of the external orienting parameters of the camera and the distance from the object.

This may be realized in all cases when the object is assimilated to a two-dimensional plane rectifying the image if the film plane and the object are not coplanar.

Obviously if we want to measure in the third dimension (depth) we are forced to use only the usual stereoscopic photogrammetry, with the consequent increase of work in the taking phase, in the topographic phase and in the plotting phase.

The parameters needed for the projective transformation in a single photo image are:

- the distance from the object;
- the vertical angle between the film and the object plane;
- the horizontal angle between the film and the object plane.

In the case of a double model from 60% overlap, many more parameters are needed in order to proceed to a stereo plotting:

- the distance of the two takings and their relative position;
- the vertical angle for both photographs;
- the horizontal angle between the film plates and the line trough the two taking points;
- the rotation angle around the taking axes for both photographs.

To obtain a "iconometric" photograph containing in itself the data for its identification and for the metric aim, it is necessary to print directly on the film this data:

- 1) Object code, at least 10 digits
- 2) Data, 6 digits, with automatic set.
- 3) Scale, or distance, 4 digits, automatic measurement from the film plane to the object point on the target of view-finder also marked on the reference-plate.

Such minimal configuration, defined **SOLUTION 1**, is an economical way to get an iconometric archive of cultural estate.

Adding two more elements:

- 4) Vertical direction of taking axes, 7 digits 3 decimals,
- 5) Horizontal direction of taking axes, 7 digits 3 decimals,

it is possible to get more simplification in the rectification phase and moreover a little increase of accuracy.

The above mentioned directions might be determined with at least two methods:

The first is measuring distances also in two corners of the photograph so that the relative position of film plate and the object surface are known.

A second way is direct measurement of the two directions by theodolite or a compass electronically connected to the camera.

This last possibility is said **SOLUTION 2**.

A.3. - Technical specification for the camera.

The technical specifications for the iconometric camera are:

- Automatic distance measurement from the principal point of the lens to target on the object. Projection and recording on the film of such distance or the derived scale by the focal length.

- Superimposition on the film of a reference reticle similar to that of semi-metric cameras.

- Superimposition on the film of numeric or alphanumeric code.

- Possibility to use the same body camera with normal, metric or iconometric lens.

- And only for SOLUTION 2, superimposition on the photograph of data about vertical direction and horizontal direction to a target point or to the North (azimuth).

Required accuracy in distance measurement: 1/1000 of the distance from the object (better if possible 1/5000) (I.e.: for 50 m of distance, accuracy = 5 cm or in the second case = 1 cm).

Then in the photograph we'll have in superimposition:

1. OBJECT CODE
2. DATE
3. SCALE(DISTANCE)

moreover for SOLUTION 2:
4. ZH DIRECTION
5. HO DIRECTION

The use of iconometric photographs are to be foreseen in:

1. Quick automatic plotting (image rectification by acquisition during the scanning process of a.m. data about distance and angles)

2. Stereoscopic plotting by classic methods but with automatic raster acquisition of orientation parameters.

Sector B. Software development.

The use of "iconometric" photograph may be only that to archive the images in order to get a metric images card-index or that of a qualitative and quantitative immediate data acquisition. In such a case is previewed the acquisition on a video computer of the scanned image for a further treatment.

For this purpose a computerized system for images management and projective rectification will be assembled with the possibility to output an hardcopy of the treated image.

The hardware and software specifications have to satisfy the following list:

- Raster acquisition of photograph by scanner
- Raster acquisition of orientation parameters printed in superimposition on the film.
- Determination of the parameters for the projective transformation.
- Raster transformation by metrically relating pixel to the real position and subsequent stretching.
- Vector on raster annotation by mouse or tablet to draw line or polylines. Simply metrical determination like areas or distance to be put in the data base management system.
- Hardcopy black and white (shade of grays) or colour.
- Data archiving.

B.1. Software Architecture

The application software is made by a set of different modules integrated in a single user interface environment. The software modules needed to implement the information system are the following ones.

1. Scanner driver
This software module, usually a standard module supplied by the peripheral vendor that needs some integration work, is responsible of the control of the scanning device.

2. Raster editor
The purpose of this module is to enhance the scanned image and suit that one to exigency of a accurate damage documenting. Functions performed by this module among the others are: edge enhancement, edge softening, cutting of subimages, scaling.

3. Metrical raster
This module allows projective transformations in a automatic way, or by dialogue with the user and imposition of simply geometrical relations; for example parallelism conditions and orthogonality.

4. Raster annotation
This module allows the use to "annotate" the picture, drawing polylines and filled polygons on the raster image; the coordinate system in which this object are drawn is the one defined by the module previously described, so it is possible to measure the length or the area of the annotation and this measure is congruent with the effective measure of the architectural object.

5. Hardcopy unit driver
The function of this software module, usually a standard one supplied by the peripheral vendor, is the control of the hardcopy device.

6. Data archiving
This module is made by a set of custom made procedures built on top of commercial relational data base management system (RDBMS) conforming the SQL standard. The purpose of this module is to store and to retrieve in a "user friendly" manner all the data (text, images, annotation, etc.)

7. Integration and user interface
This is the module that integrates and controls all the other modules. It is made by a graphical user interface (G.U.I.), built

with the standard tools found in the X Window environment, and a set of interfaces between the different modules.

B.2 Hardware Configuration

In this section we describe the hardware requirements of the information system, taking in particular evidence the standards the system itself relies on.

Workstations

The software is based on what is now a de facto standard in the graphical workstation market, the Unix operating system coupled with the X Window graphical environment; this allows us to be independent from any particular hardware vendor, since all major computers makers are compatible with these standards. The computers used in this project has some particular needs, imposed by the graphical and interactive nature of the application: it is mandatory to have an high resolution visualization system (at least 1024 x 768 pixels, with a depth of 8 bit that allows the display of 256 colours from a palette of 16777216; (colour means shade of grays too); furthermore the workstation, to achieve acceptable response times, has to be generously configured in terms of RAM (Random Access Memory); we think that it must be equipped with no less than 12 Mb of RAM. The need to interconnect different workstation leads to the adoption of a network standard; we chose Ethernet with TCP/IP protocol and NFS, one of most used combination today.

Peripherals

Since we operate with continuous tone image, we need some particular device to bring those images in computer readable form and to output the modified images in "Human readable form.

Scanner

A digital scanner is a device that reads an image producing a digital equivalent on which computers operate. The price range of these devices is very Wide, depending on spatial resolution, input format and colour possibility, so we plan to support three configurations. The entry level solution is an A4 size gray shades scanner with a resolution of 300 dpi; the medium priced solution is an A3 colour scanner capable of 400 dpi; the top level solution is a 35 mm film colour scanner with a resolution of 4000 dpi.

With this last device is possible to skip the photographic printing phase. Assumes great importance in this contest the future possibility to get images on magnetic form directly from Kodak laboratories.

Hardcopy unit.

The purpose of this device is to generate an hardcopy of an image; we plan to support two different solution. The entry level solution is an A4 size black and white laser print (Postscript compatible) with a resolution of 300 dpi; the more priced solution is an A4 or A3 colour thermal transfer hardcopy unit, with a resolution of 300 dpi.

Sector C. Field testing

The realized prototypes will be subject to a field testing by the researchers of Università dell'Aquila, by the technicians of Istituto Centrale del Restauro in Rome and in Laboratories of branch office in Rome of Leica Italia S.p.a.

The program foresees:

1. Field survey and data acquisition aimed to relevant objects in historical centres under the co-ordination of the Dipartimento del Architettura e Urbanistica dell'Università dell'Aquila.

2. Singling out of samples and standards for the draft of a file-card aimed at quick catalogation directly related to iconometric images, by technicians of The Istituto Centrale del Restauro.

3. The improvement over relation between the iconometric camera and the management software executed by samplings and tests in the laboratories of branch office in Rome of Leica Italia.

Actual production phases.

The Special Product Division of Leica Heerbrugg actually make the camera. The work in progress phases are:

Step 1. Assemblage of the first functional model with this characteristics (see pict. 1):

A) An optical measurement system (ODIN) based on the optical-rangefinder principle. Measurement are made at constant time interval (every 0.15 s) in about 0.05 s. The treatment by least-square error method give the resulted distance with a precision now reached of 0.10 m in a range from 10 to 70 m.

B) A particular Databack permits to project and record on the film the measured distance (or the scale on the target in the object of survey) with the informations required like Data, Code Number, etc...

Step 2. AMO System. The Functional model above mentioned is projected only in order to study and develop a second model AMO System that will have better characteristic in functionality and suitability.

The need of compactness in this camera is aimed to satisfy quick work in catalogation. High technologic integration of electronic components such as not to compromise the possibility to take snapshots.

The high cost of the reduction of electronic pieces dimensions is now a limit that will bring to a second model not yet fully compact.

This will be realized as follows (see pict. 2):

A) A range-finder (AMO) positioned near the lens in a more reduced dimension compared to the functional model.

B) A Databack R specially modified to accept more data then the standard one.

C) An electronic device in a pocket container which is able to calculate distance and scale referring to the focal length.

Step 3. Final Iconometric Camera. The integration between the system for distance measurement and the lens is the goal to be reached in short time. Moreover the direct connection of the measured data to the Databack through the body of the camera will bring to a real compact iconometric camera.

In that way will be realized a camera similar to a standard one and the final philosophy should be to have one only body with more optional components.

Conclusions.

The integrated system is studied for the research in the Cultural Assets, but may be useful in other scientific fields or professional use.

Its originality consists of versatility in surveying large scale campaigns, keeping the level of accuracy near values higher than the allowed maximal standard error.

Index.

RE.FRAN - EUREKA\Eurocare Project: EU598.	LEICA	Author: Carlucci	Date: April 1991
OBJECT: Iconometric Camera specifications aimed to pre-classification of Historical-Artistic assets.			

SOLUTION 1.

Recorded data :

1 - OBJECT CODE : 10 digits

Manual input in the Data-Back

2 - DATE : 6 digits

Automatic input

3 - SCALE (DISTANCE): 4 digits

Automatic measurement of distance from point of view to the center of photograph and evaluation of scale referred to principal distance of lens.

Recording form :

Directly on the film in alphanumerical and if possible in code bar form (this eventuality is to be studied in function of the automatic scanner acquisition by Italcad).

Distance Measurement :

By EDM integrated into standard lens ELMARIT-R 1:2.8/35 mm.
Range from 1.5 to 100 m, precision required 0.10 m.

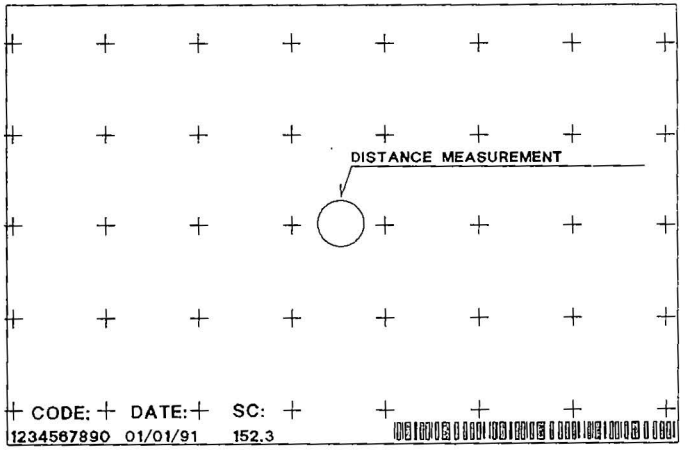
Data input :

By Data-Back. Allowed input of

OBJECT CODE (every photograph used)
DATE set. (rarely used)
LENS princ. dist. " "

Possibility to switch from SCALE mode to DISTANCE mode.

SAMPLE OF PHOTOGRAPH



RE.FRAN Iconometric model - EUREKA\Eurocare project no: EU598 - C - NPC - Area: ENV			LEICA. Sector 1: Iconometric Camera
Date : April 1991	Author: Carlucci	Working Group: LEICA Heerbrugg AG - Special Product Division	Ref.:

SOLUTION 2.

Recorded data :

1 - OBJECT CODE : 10 alphanumeric digits

Manual input in the Data-Back

2 - DATE : 6 digits

Automatic input

3 - SCALE (DISTANCE) : 4 digits, 1 decimal digit

Atomatic measurement of distance from point of view to the center of photograph and evaluation of scale referred to principal distance of lens.

4 - HORIZONTAL DIRECTION : 7 digits, 3 decimal digits

Interface to Compass or theodolite

5 - VERTICAL DIRECTION : 7 digits, 3 decimal digits

Interface to compass or theodolite

Recording form :

Directly on the film in alphanumerical and if possible in code bar form(this eventuality is to be studied in function of the automatic scanner acquisition by Italcad).

Distance Measurement :

By EDM integrated into standard lens ELMARIT-R 1:2.8/35 mm. Range from 1.5 to 100 m, precision required 0.02m.

Manual input of data:

By Data-Back. Allowed input of

OBJECT CODE (every photograph used)

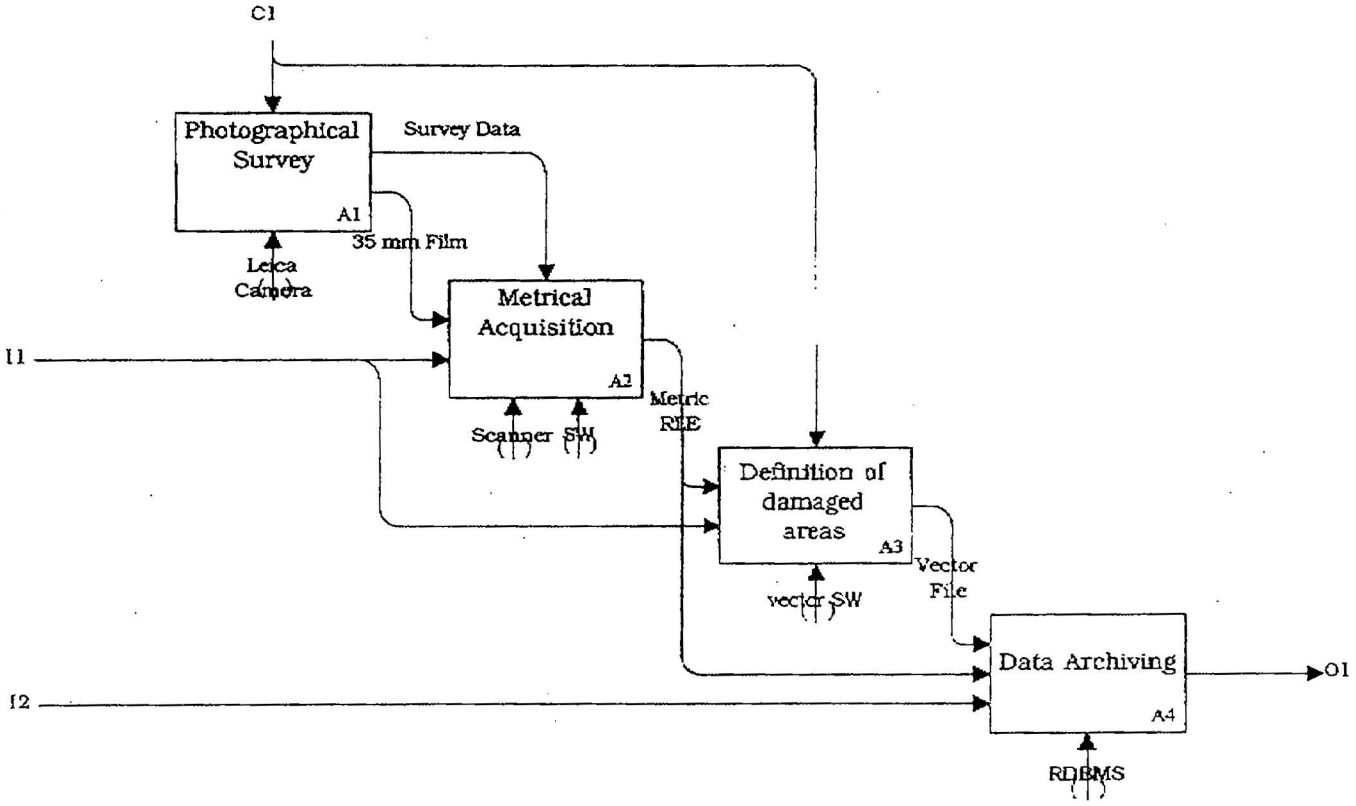
DATE set. (rarely used)

LENS princ. dist. " "

Possibility to switch from SCALE mode to DISTANCE mode.

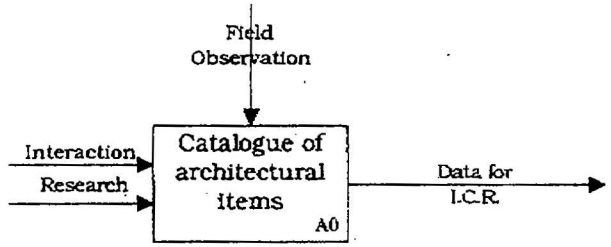
	PROGETTO: ReFran AUTORE: E. Reggiani NOTE: 1 2 3 4 5 6 7 8 9 10	DATA: REV:		ELABORAZIONE	DATA
				PRELIMINARE	
				APPROVAZIONE	
			X	PUBBLICAZIONE	

CONTESTO:



NODO:	TITOLO:	NUMERO:

	PROGETTO: Re.Fran AUTORE: E. Reggiani NOTE: 1 2 3 4 5 6 7 8 9 10	DATA: REV:		ELABORAZIONE	DATA	CONTESTO:
				PRELIMINARE		
				APPROVAZIONE		
			X	PUBBLICAZIONE		

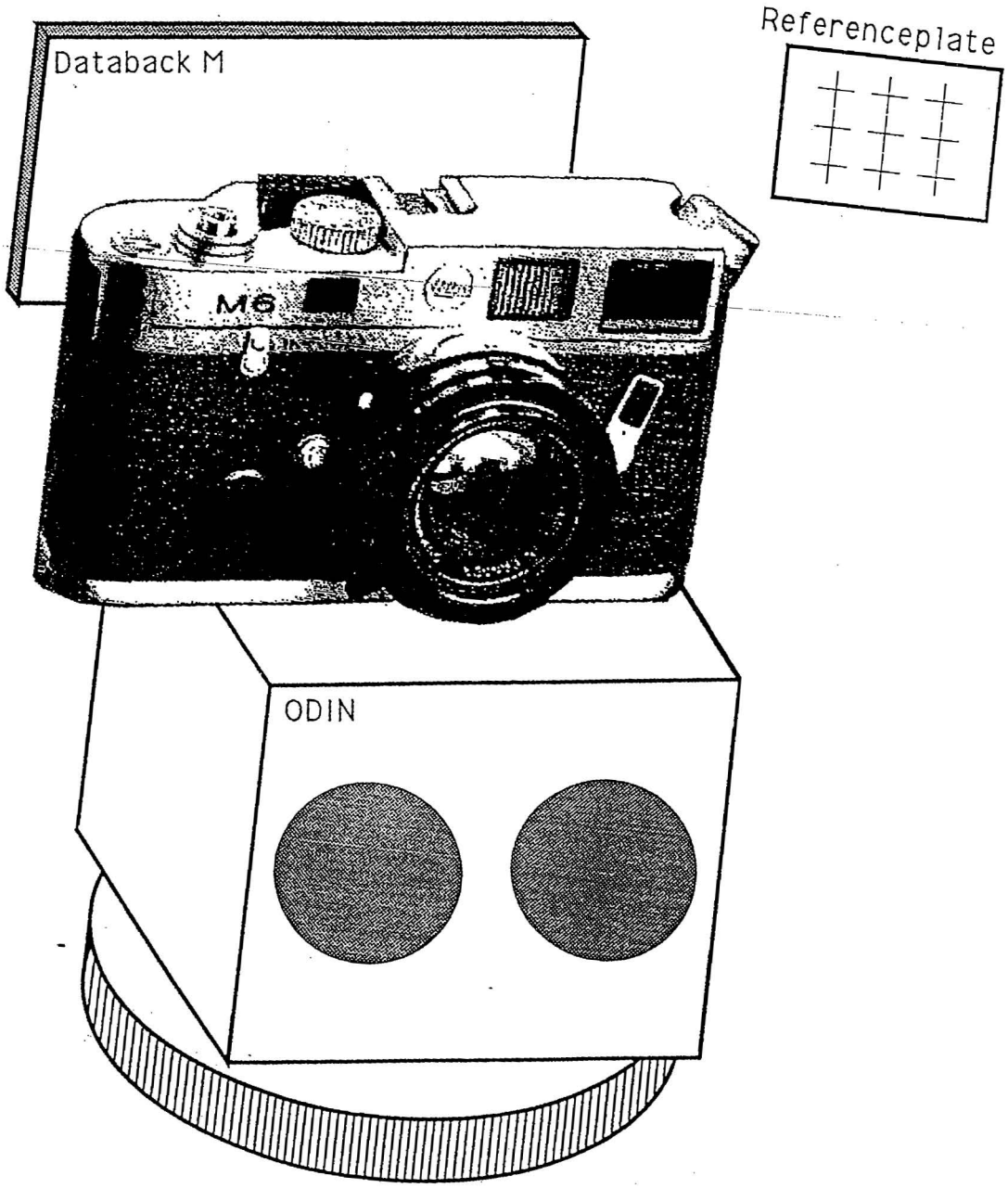


NODO:	TITOLO:	NUMERO:

Leica
Heerbrugg AG

Tij 3465
22. Juli 1991

AMO
Functional Model



Leica
Heerbrugg AG

AMO System