ON THE MANAGEMENT AND INTEGRATION OF PHOTOGRAMMETRIC DATA AND METADATA IN CLOSE-RANGE APPLICATIONS

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ABSTRACT

The growing use of photogrammetry in close-range applications (e.g. architecture, archaeology, urban conservation) and the increasing availability of digital imagery and systems make it more and more necessary to set-up appropriate databases to maintain the complex whole of information, data and metadata, coming from photogrammetric surveys and processes.
The efficacy of such a database in an organisation could be increased by integration with Digital Photogrammetric Systems and furthermore by the development of interfaces with Geographical Information Systems, providing the user with tools for spatial queries on metadata.
The paper deals with this question starting with general considerations and the presentation of an actual project currently being developed.

1. INTRODUCTION

In the last few years we have witnessed the diffusion of photogrammetry in an ever broadening application field. Alongside the traditional cartographic applications some very interesting experiences have taken place in close-range applications, in particular in the areas of cultural heritage, industry and in various scientific applications (medicine, etc.).
This process was certainly favoured by the growing use of digital data and processing techniques, mainly due to its characteristics of flexibility, low cost and the fact that they are easily integrated.
This phenomenon must be put into the context of certain points:
- advantages of digital imagery and digital products, also in terms of integration in well established processes of documentation and surveying;
- availability of new instruments to perform the photogrammetric process in a digital environment with the use of off-the-shelf hardware;
- automation of complex procedures (orientations, DEM generation, rectification,...);
- access to photogrammetric tools no longer limited to specialists: there is increasing use on the part of the GIS (Geographical Information System) community;
- the possibility of a direct interface between photogrammetric products and existing information systems (e.g. Architectural Information Systems or Land Information Systems).

In the face of the ever widening diffusion of photogrammetry on the part of new users, also non-specialist, we have not always witnessed an adequate capability to manage photogrammetric data in terms of its totality and all its potential, when the new digital systems allow photogrammetric data to be processed in a completely new way.

The problem is particularly noticeable in the area of cultural heritage: numerous bodies, both public and private, make systematic and sporadic photogrammetric and topographic surveys with the aim of documenting, safeguarding and restoring artistic and architectural heritage. However, in many cases the risk of not organising and efficiently managing the immense wealth of acquired information is run. Therefore it is possible that an enormous quantity of data is collected - one only needs to consider images - without the whole body of information, without which this data is unusable for metric purposes, being sufficiently well. In other words, all the metadata (data about data) which describe, not only the content of the images but also its characteristics that allow photogrammetric processing, are not correctly managed.
This almost certainly prevents the possibility of the data being used in the future or by others, for example with the aim of monitoring over time. It increases the possibility of the incorrect use of the data itself. It prevents the wealth of knowledge offered by photogrammetry from being fully exploited by other consultation and survey approaches carried out on the same objects.
Taking these considerations as a starting point, in terms of this project, photogrammetric data is concentrated on as a form of information; particular emphasis will be given to digital data without however entering the field of digital processing possibilities. After a brief analysis of the digital images' characteristics, the conceptual outline and logic of a database for managing the relevant data and photogrammetric metadata is described; even if this approach can in the main be shared with other applications, the project was born as a result of the activity in the cultural heritage sector.
In the last paragraph the possibility of integrating the database with GIS and DPW (Digital Photogrammetric Workstations) type programs is discussed.

2. CHARACTERISTICS OF DIGITAL IMAGERY

There are certain important characteristics that make digital data particularly interesting from a photogrammetric point of view:
- integrity and storage of the images is guaranteed over time;
- image contents are not subjective;
- easy and rapid data transfer and duplication
- the possibility of performing image transformations with image processing procedures, available also in desktop packages;
- data access by Internet or Intranet;
- the possibility of using shared image databases.

The aims of this paper do not include a discussion of these aspects, but a brief examination of some of the trends taking place in terms of data typologies will follow, in particular concerning physical image formats and characteristics.

As far as the physical format of data is concerned, there are many solutions available today which are unfortunately not always sufficiently standardised. Certain raster formats are in general use, often developed from application environments linked to publishing. Amongst the most widely diffused of these are TIFF (Tagged Image File Format), BMP (Microsoft Windows Bitmap), GIF (Graphics Interchange Format), TGA (Targa). A promising open industry standard, with some interesting characteristics such as multiple independent resolutions, flexible compression and color management options, is FlashPix, developed jointly by Kodak, HP, Live Picture and Microsoft.

An interesting solution, often adopted for close-range photogrammetric applications, is the Kodak Photo CD (Hanke, 1994; Thomas et al., 1995), which constitutes a multi-resolution product for the scanning of traditional small and medium format films (main characteristics of the two existing Photo CD versions are shown in Table I).

type	resolution	size (pixels)	compression	RGB file size
Base/16 (Master/Pro)	low (thumbnail)	128x192	no	72 Kb
Base/4 (Master/Pro)	low	256x384	no	300 Kb
Base (Master/Pro)	medium (TV)	512x768	no	1.1 Mb
4 Base (Master/Pro)	high (HDTV)	1024x1536	yes	4.5 Mb
16 Base (Master/Pro)	full	2048x3072	yes	18 Mb
64 Base (Pro)	professional	4096x6144	yes	76 Mb

Table I – Main characteristics of Master Photo CD, in which the image pacs consist of 5 resolutions, and Pro Photo CD that is applied for medium format and provides also a 6th resolution, the 64 Base. Note also that the dynamic range of the Pro scanner is larger than that of the Master Photo CD scanner, which allows better results from over-saturated images.

Other formats specifically concern geographical type images or those which can in any case be used for metric purposes. In this case they must also confront the problems of image georeferencing and geocoding, essential for the use of raster imagery in GIS applications (Bitelli, 1997b). To this end, various proprietary type solutions are available on the market, whilst there are fewer in the public domain: amongst these GeoTIFF (Ruth and Ritter, 1995), an extension of the TIFF standard that is now supported in the main systems on the market, should be noted.

Many formats provide the possibility for the data to be compressed in order to reduce its volume and hence the problems of storage. Compression techniques can be divided into logic type and physical type methods (Bashkaran and Konstantinides, 1995): an example of the first type is the use of colour maps or look-up tables whereas the methods used in the physical type can be divided into Model-Based (such as the use of fractals) and Waveform-Based. The latter, for their part, include lossy methods (e.g. by using DCT, Wavelet or Fourier) and lossless (with statistical procedures such as the Huffman code or with universal approaches like Run-Length coding or Lempel Ziv). One of the most widely adopted solutions for photographic images is the JPEG standard, a lossy method that uses DCT technique; its performance in photogrammetric applications were investigated by several authors giving different results in terms of image compression ratios, from 1:3 to 1:10, in order to maintain an acceptable geometric degradation of the images (Kern and Carswell, 1994; Lammi and Sarjakoski, 1995).

Certainly the problem of managing a large image archive is one of the main obstacles to the diffusion of digital techniques in photogrammetry: however developments in technology allow high capacity, durable, low cost storage devices to be used (for instance optical storage systems like CdRom, WORM, MO, DVD), and new promising developments that could push this problem into the background can be foreseen (Nebiker, 1997) .

3. DATA AND METADATA MANAGEMENT

It has already been said that the question of having appropriate storage devices could find ever more efficient solutions for the major part of users of photogrammetry and for the area of image processing in general. Therefore the main problem will not be that of having sufficient space for storing the imagery, but that of having a system capable of supporting the user in accessing and correctly using these data. To this end it is essential that an exhaustive apparatus for describing the data, or "metadata", is adopted. There are certain standards of metadata already in existence or that are being developed that are specifically designed to deal with geographical information (the European CEN/TC 287, the FGDC - Content Standards for Digital Geospatial Metadata in U.S.A. , the international ISO TC/211). These allow, with different approaches, also for a description of raster datasets.

According to (Nebiker, 1997) the basic categories of spatial metadata can be structured into certain main topics:
· Identification Information
· Data quality Information
· Spatial Data Representation Information
· Spatial Reference Information
· Entity and Attribute Information
· Distribution Information.

As can be seen from a detailed examination of the points listed above, this information is mainly suited to describe datasets related to territory, but it needs to be modified for datasets acquired in close-range applications.

In the development of the present project it was felt necessary to pay some attention to the necessity of conserving, together

with the original imagery and its descriptive data, a strictly photogrammetric set of information, useful in supporting the various phases of survey, orientation and restitution typical of a photogrammetric process.
The aim of this is to satisfy an increasingly important necessity emerging in the area of cultural heritage, where above all there exists frequently the need to maintain centralised archive storage of the relevant metadata derived from different surveys carried out by different agencies at different times. Furthermore, well organised photogrammetric records, without even the need for restitution, represent a valuable asset for the future:
· in planning and achieving a partial or integral restoration in the event of an object being damaged
· in detecting change
· in detailed studies.
This necessity was also recently underlined in the CIPA Intern. Symposium, held in Gothenburg, Sweden in 1997. Amongst the conclusions reached by the Symposium are the following; "There is a need to manage the recorded information. The development of Monument Information Systems (MIS) becomes vital", "There is a clear need for using technologically advanced tools, which offer wider flexibility and reduced cost". Another interesting trend in terms of this, is the use of results acquired by non-photogrammetric users surveying architectural and archaeological objects for non-professional purposes. Recent experiences have shown that also non-specialised users with non-metric cameras, following appropriate principles like CIPA 3 x 3 rules (Waldhausl and Ogleby, 1994), can in many cases provide acceptable results.

With reference to some recent projects, and following some previous experiences that took place in an archaeological context (Bitelli et al., 1997a), the necessity for developing a system, easy to use but complete in its content and potential, in order to manage the data and metadata coming from close-range photogrammetric surveys, emerged.
The proposed solution is that of a Relational Data Base Management System (RDBMS) for managing the metadata and a file based system for the original images.
The project, still under development, began with an analysis of the requisites, conducted by indicating certain needs that the system must be capable of meeting. For example it must provide answers to the following type of questions:
· Are some images available for this building? Where are they stored and in which format? Retrieve the contents of the related calibration certificates.
· Extract from the database the data needed to perform the internal and external orientations of the images acquired during a specific photogrammetric survey, and create from them the files for orientation and restitution by a specific digital photogrammetric package.
· What is the derivation of a final, graphical or numerical, product?
In the development of the logical design a compromise was made between the need for storing the overall information and the envisaged practical use of the system.

Some main entities were identified:
· project
· photogrammetric survey, a campaign carried out in the framework of a project
· data acquisition set, related to a homogeneous set of pictures acquired during a specific survey
· topographical control survey for the establishment of GCP's
· camera data
· lens data
· camera/lens calibration certificate
· reseau certificate
· orientation-restitution, in the form of main metadata about the results of such procedures
· original images, maintained separately in large volume storage systems or in different physical places, but, when possible, available as thumbnails for preview purposes
· derived images and different final products.
Starting with this phase, the physical design was made up of the drafting of the tables and the relationships between them; a set of attributes was defined for each table, each one being characterised by its own domain and with specific validation conditions.
The prototype is made using Microsoft Access on Microsoft Windows 95 operating system.
Figures 1, 2 and 3 show simple screen shots from this prototype. The first refers to the data related to a survey, the second to an homogeneous set of images and the third to the reseau of a semi-metric camera.

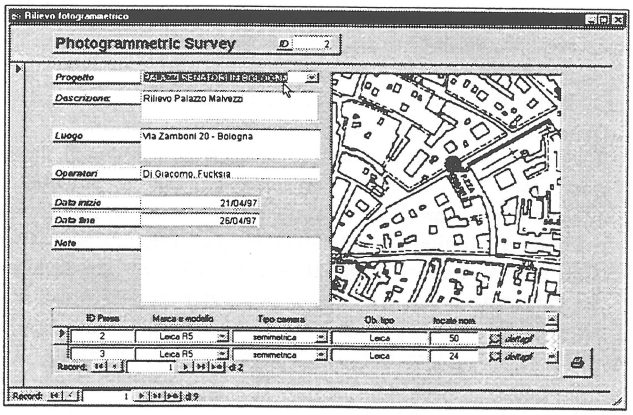

Figure 1 – Screen shot for a photogrammetric survey, in which different sets of pictures can be acquired.

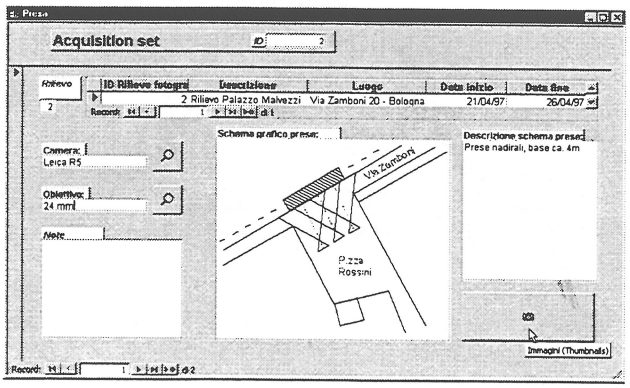

Figure 2 – The data related to a set of pictures acquired during a session of a photogrammetric survey.

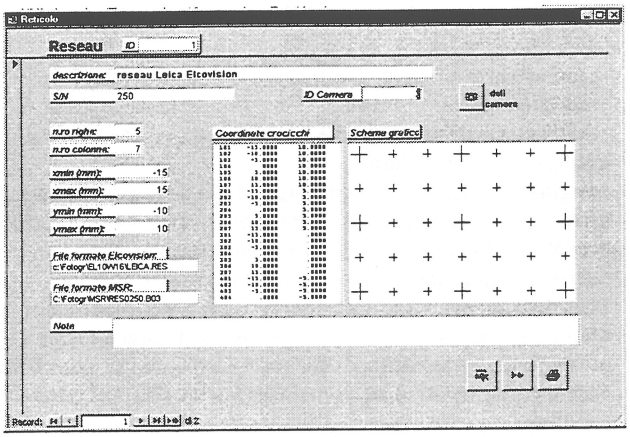

Figure 3 – Screen shot for data related to a reseau certificate.

4. TOWARDS AN INTEGRATED MANAGEMENT SYSTEM

The photogrammetric database briefly presented is intended to be the first element in a system that integrates, by means of appropriate procedures and interfaces, the potential and functionality of three main subsystems:

· the photogrammetric database;
· a digital photogrammetric workstation (DPW);
· a geographical information system (GIS).

The figure 4 shows the outline of such an integrated system where each element is self-sufficient but can be powered by information or procedures supplied by other elements; for example, the digital photogrammetric package, on the basis of some already known essential data supplied by the database, can constitute a sort of three-dimensional mouse available to the GIS, to which it can supply fundamental data such as orthophotos. In turn the GIS can be used for querying, with spatial type primitives and on the geographical basis, the contents of the database.

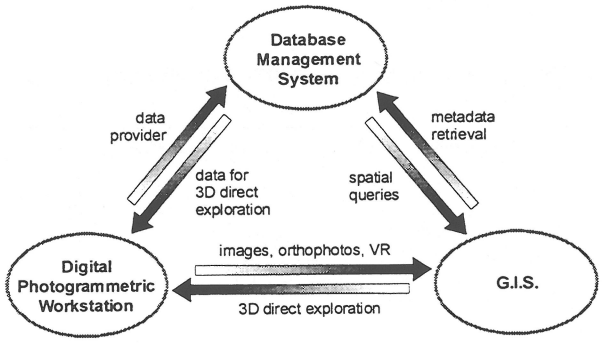

Figure 4 – Schema for integration of photogrammetric RDBMS, DPW and GIS.

The system must be open and customisable in order to support different products and platforms.
Achieving this definitely ambitious and not easy to implement aim could provide a very useful solution for a large number of situations. It can be achieved with the technical tools available today, even on a PC platform.

5. CONCLUSIONS

A database system, currently under development, for managing data derived from photogrammetric surveys, and with particular relevance to the field of close-range applications, has been presented. Its most suitable applications include archaeology, architecture, engineering and industry. Such a system might find its most complete application when interfaced with GIS type products and Digital Photogrammetric Workstations. This would provide interesting prospects for integration between study methods that are diverse in nature and aims.

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