POPULARIZATION OF PHOTOGRAMMETRY

Prof. Dr O. Kölbl

Swiss Federal Institute of Technology, Lausanne - Switzerland
ISPRS Commission II

SUMMARY

The automation of photogrammetric measurements will considerably facilitate data acquisition by photogrammetric means. The incorporation of photogrammetric raster images in GIS workstations will allow the different users to refer easily to primary data. The topographic services could considerably facilitate these applications by supplying photographs of appropriate form, including information on the orientation elements derived from GPS. The automation of the height measurements and of the aerotriangulation represents the main conditions for this development.

KEY WORDS

Digital photogrammetry, GIS, Raster data.

1. INTRODUCTION

Plans and maps are an absolute necessity for all planning activities. However, the elaboration of these documents requires considerable efforts; furthermore, a map is largely schematized and shows only a selection of terrain objects. Although aerial photographs have numerous advantages compared to line maps, they are rarely included in planning processes and are too often considered as a mere tool for data acquisition only. Even town-and-country planners rarely refer to them.

These reserves about aerial photographs might be due to the limitations applied to their use for a long time. The Secret Services, in particular, have applied severe restrictions concerning their circulation,as they were convinced that these photographs showed too many details which might also be used for spying purposes. Another reason might be the rather complex use of aerial photographs. However, a real revolution is becoming apparent in this field and everything indicates that the integration of aerial photographs into geographic information systems, as well as the automation of height measurements, will lead to a considerable simplification of the restitution process. The latter will then become very similar to image processing, already largely used even on personal computers.

In order to sketch the future of photogrammetry, the paper will first focus on a technical review of the state-of-the-art. The presentation will start with the rather classical aspects, followed by the digital image processing of aerial photographs, in particular the automation of the measuring process. These considerations will lead to the conception of a restitution system composed of several components. Finally, different applications of photogrammetry and perspectives for the manufacturing industry will be presented.

2. OVERVIEW OF PHOTOGRAMMETRIC WORKING METHODS

Photogrammetric working methods have undergone decisive changes during the last years. The classical plotting methods on analogical plotters have been replaced by analytical procedures and already partly by purely digital procedures. This development is still in full evolution, particularly the automation of image processing and the handling of data in appropriate database management systems. The connection of a stereoplotter to an information system requires a high standard of communication between the different components.

2.1 Photogrammetric plotting in connection with an information system

Today, for handling and editing of large data sets, geographic information systems are usually used. As the photogrammetric plotting rapidly produces a great flow of data, it is logical to link the photogrammetric plotter directly to an information system. This connection also allows a direct reference to already existing data during the measuring process, which is of special importance when taking into consideration a hierarchy of precision for the different topographic features. For example, it would be especially useful to already take account of the legal boundaries when plotting the soil cover. On the other hand, the computer greatly facilitates data acquisition, and is of great help in data representation. This concerns for example the control of the rectangularity of buildings or the snapping of lines. Information systems of the second generation also enable definition of surfaces and thus the obtention of a proper topologic structure.

However, all these operations require considerable processing power and a continuous comparison of the collected data with the aerial photographs. This comparison can be carried out very efficiently by image injection : the information system generates a map on a monitor, which is then injected into the optical path of the plotting instrument. It is however preferable to realize this image injection in stereo and to superpose the properly adapted map on each photograph.

In recent years, industry has developed analytical plotters linked to information systems and including stereo image injection systems. Among them, the System 9-AP by Prime Wild GIS (cf. fig. 1), Leica's DSR 15 with connection to Infocam and Mapit, or instruments like Phocus from Zeiss. Currently, the remaining problems mainly lie in the efficiency of the processor power, as the operator's efficiency is too often slowed down by the time of reply of the information system.

2.2 Automation of the photogrammetric plotting

The automation of height measurement on the basis of aerial photographs currently presents the most important step towards a completely automated photogrammetric plotting. This problem has given rise to numerous research projects and various solutions have been suggested. A very promising method has been developed at the Laboratory of Photogrammetry of the EPF-Lausanne, in close collaboration with Leica (cf. [1]). This procedure is based on 'Multi-Templet-Matching', a calculation procedure developed on the basis of dynamic programming. This procedure determines the parallaxes for corresponding image sections, which are subsequently introduced into an adjustment procedure to model the terrain with the help of finite elements (fig. 2). This computation is iterative, as the photographs are resampled according to the terrain approximation by finite elements. To reduce the computing time, a Transputer network is used for image processing.

In a second phase, the terrain obstacles are eliminated by filtering and the height data are finally injected into a stereoplotter for a final control. In this phase, possible measurement errors can be corrected. According to various tests, it is possible to process a model within 12 hours with a precision higher than 0.1‰ of the flying height, provided that the terrain cover lies below 30%.

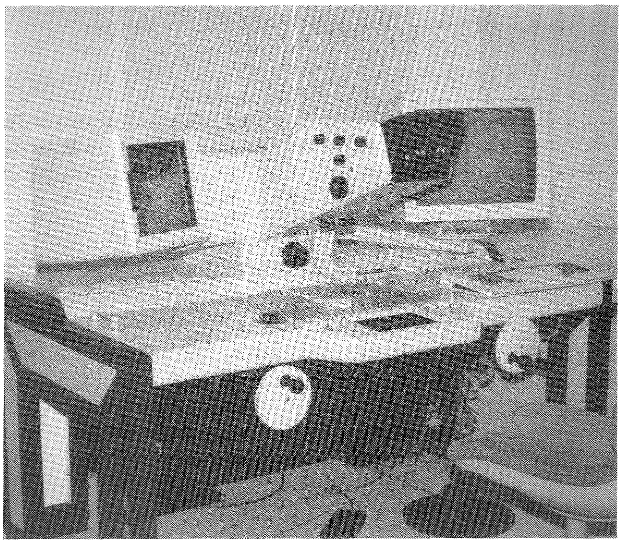

Fig. 1

Analytical plotter (System 9 AP) connected to a geographic information system including image injection in order to facilitate the dialogue between the photogrammetric plotter and the database management system.

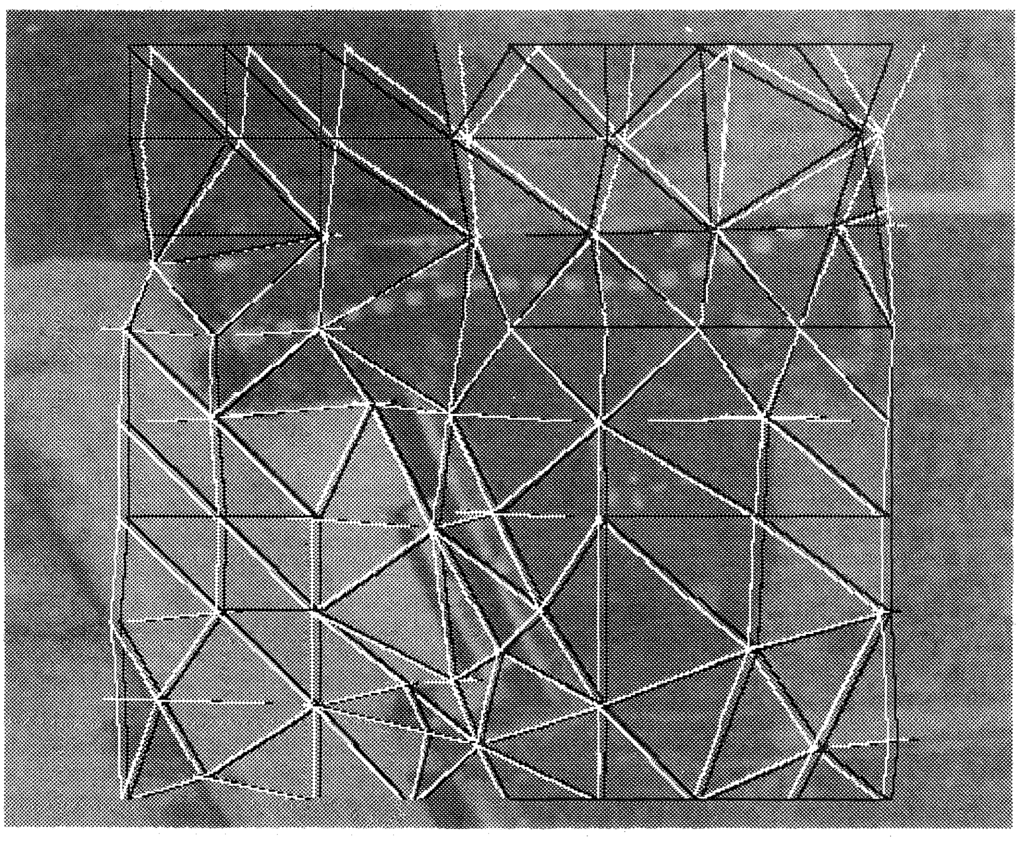

Fig. 2

Network of finite elements superposed on a section of aerial photograph as resulting from automatic correlation by Multi-Templet-Matching. The finite elements are used for the adjustment of the parallaxes determined from the individual templets. The white lines represent the parallaxes and the black ones the basic network of the finite elements. This approach also allows the detection of break-lines and the modelling of houses.

2.3 Components of a modern plotting system

These considerations lead to the conclusion that image processing will decisively influence the photogrammetric plotting process. But, as the analytical plotter did not simply take over all the functionality of the analogical plotter, but also led to computer-assisted mapping, it can also be expected that digital plotting should open completely new perspectives. Most probably, there will not be only one standard instrument, but rather various different components will emerge, which can be grouped together to make up a complete system.

The following components are likely to form such a plotting system (cf. also fig. 3) :

- **scanner** for the transformation of analogical images into digital images
- **image processor** for all time-consuming operations like the derivation of digital terrain models, the production of orthophotos, terrain visualization and automatic aerial triangulation
- **geographic information system**, able to incorporate raster data like aerial photographs (monoplotter)
- **analytical or digital stereoplotter** with image injection for the overall control of the results of automatic operations
- **raster plotter** for the production of pictorial documents and line maps
- **high-fidelity raster plotter** for the production of high-quality image products.

This list is certainly not exhaustive but shows that the stereoplotter will no longer play the key role as it has done so far. Various processes, like image correlation, will allow widespread automation of the production of cartographic documents. These operations will require high-performance processors and most probably parallel processors like the Transputer network developed at the Laboratory of Photogrammetry of the EPFL. Such parallel processors are also of value for other operations requiring great processing power, such as the management of a database for geographic information systems.

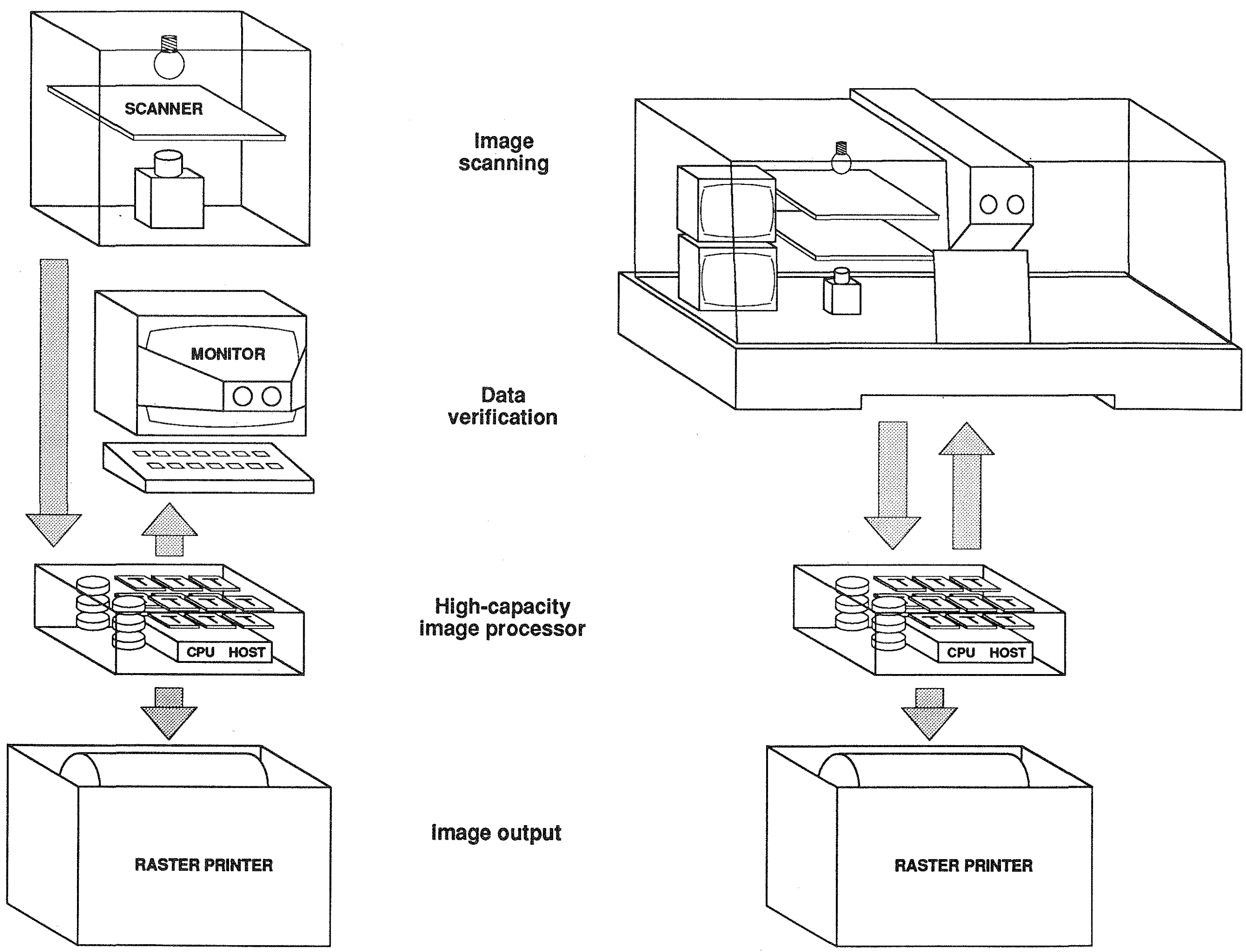

Fig. 3

Components of a photogrammetric image processing system using either a digital workstation (left) or an analytical plotter (right).

The most important result of this development will be that, in the near future, photogrammetric work will be realized on a simple interactive graphic working station. It will then be possible to display aerial photographs or orthophotos together with the vector data on a GIS station and so to transfer most of the plotting work onto a simple working station. Such a system will then be the standard system of a surveyor and will take its place in each office. It should also allow a much better circulation of photogrammetric working methods.

3. APPLICATIONS OF PHOTOGRAMMETRY

After these rather technical considerations, let us try to take up in more detail the application side. In this context, one should avoid restricting oneself to an evaluation of only the most efficient procedures, as account should also be taken of economic aspects. Consequently, we will first attempt to discuss the simplest procedures, like photo-interpretation or the reference to photographic enlargements, before studying the integration of these simple processes into more sophisticated procedures including computer technology.

3.1 Photo-interpretation

When observing an aerial photograph, preferably in color, one is immediately struck by the quantity of information that these documents contain (cf. fig. 4 and 5). One immediately distinguishes the vegetation, the communications network and the constructions. Aerial photographs represent a valuable tool for environmental studies, impact studies or various planning works. In the simplest case, photographic enlargement can be sufficient. Beside the enlargements, it can be extremely useful to observe the aerial photographs under a stereoscope in order to perceive the relief. Only stereo vision provides a real three-dimensional impression of the landscape and enables the height of objects to be incorporated into the evaluation. In Switzerland, photo-interpretation is mainly used for analysing the health of the vegetation cover, for soil cartography, for the establishment of a tree cadastre and other similar tasks.

3.2 Use of photographic enlargements

For a great number of planning projects for which photogrammetric plotting is used, it is possible, at least in a first phase, to base work on simple photographic enlargements of aerial photographs. As an example, we can mention the pilot study of a railway connection between the center of Lausanne and the University campus, which was achieved nearly exclusively with photographic enlargements (cf. fig. 6).

It is clear that simple photographs show considerable deformations compared to maps, especially in uneven terrain. These deformations are in general within a few percent and, for thematic mapping, the semantic information is very often much more important than the geometric information. The photos therefore offer the advantage of giving a multitude of information and of providing a very precise reproduction of the appearance of the area at the moment of the shot. On the other hand, projects presented on the basis of aerial photographs are generally much easier to understand and less abstract than line maps.

3.3 Integration of aerial photographs in a GIS

The great advantage inherent in the use of aerial photographs can be combined with the facilities of the work on a geographic information system. A basic requirement is of course that the geographic information system be able to combine raster images with vector data (fig. 7).

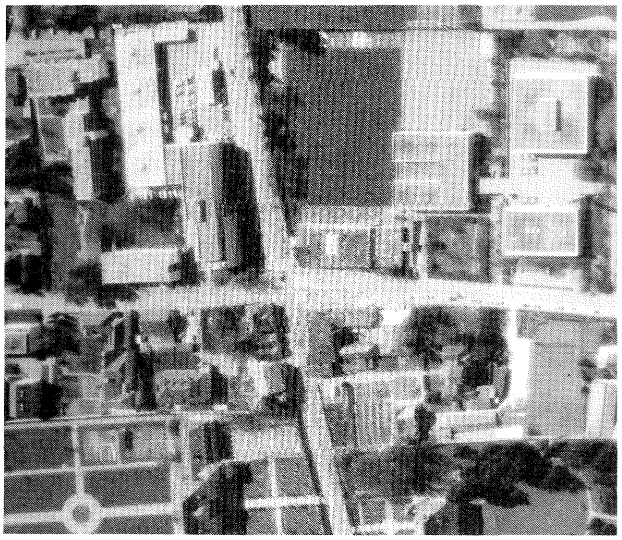

Fig. 4

Aerial photograph of a small town showing the quantity of details visible on such documents.

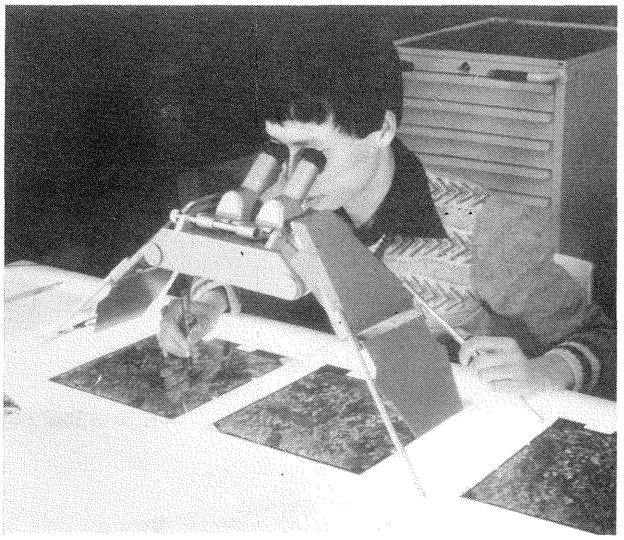

Fig. 5

Stereoscope, a standard instrument for photo-interpretation.

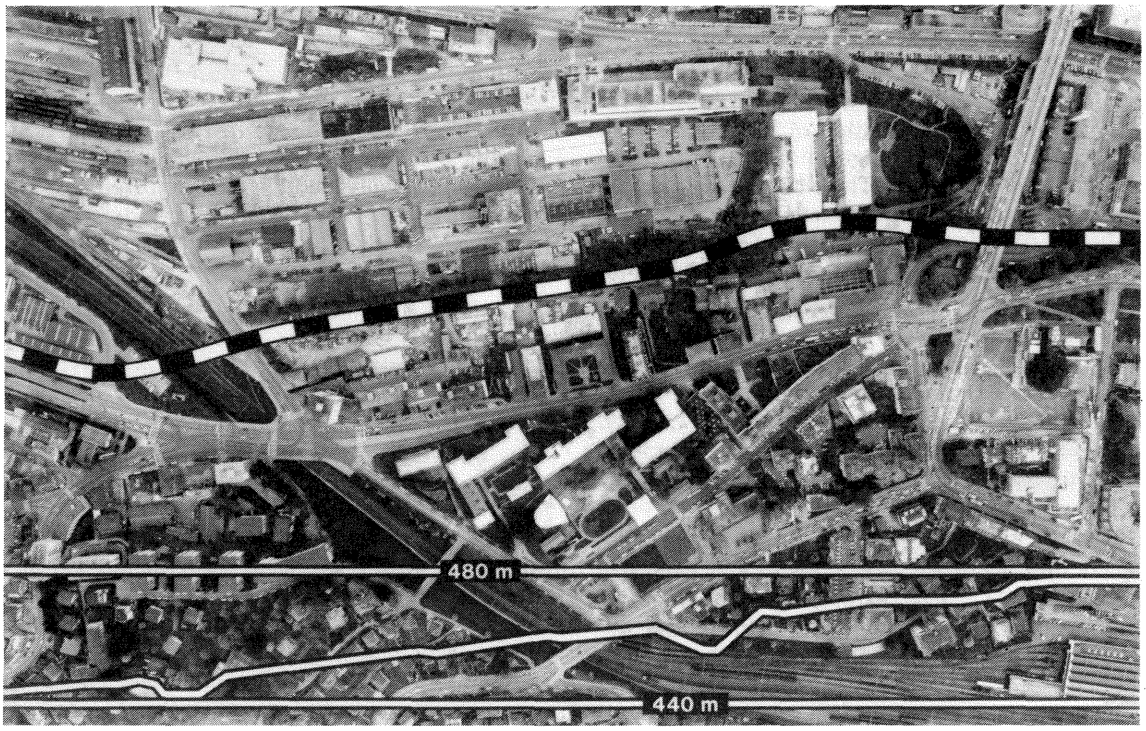

Fig. 6

Pilot study for a railway connection between Lausanne and one of its suburbs, executed with the help of enlargements of aerial photographs and very limited photogrammetric plotting. It is only along a very narrow corridor that profiles have been determined and that conflicting areas have been plotted.

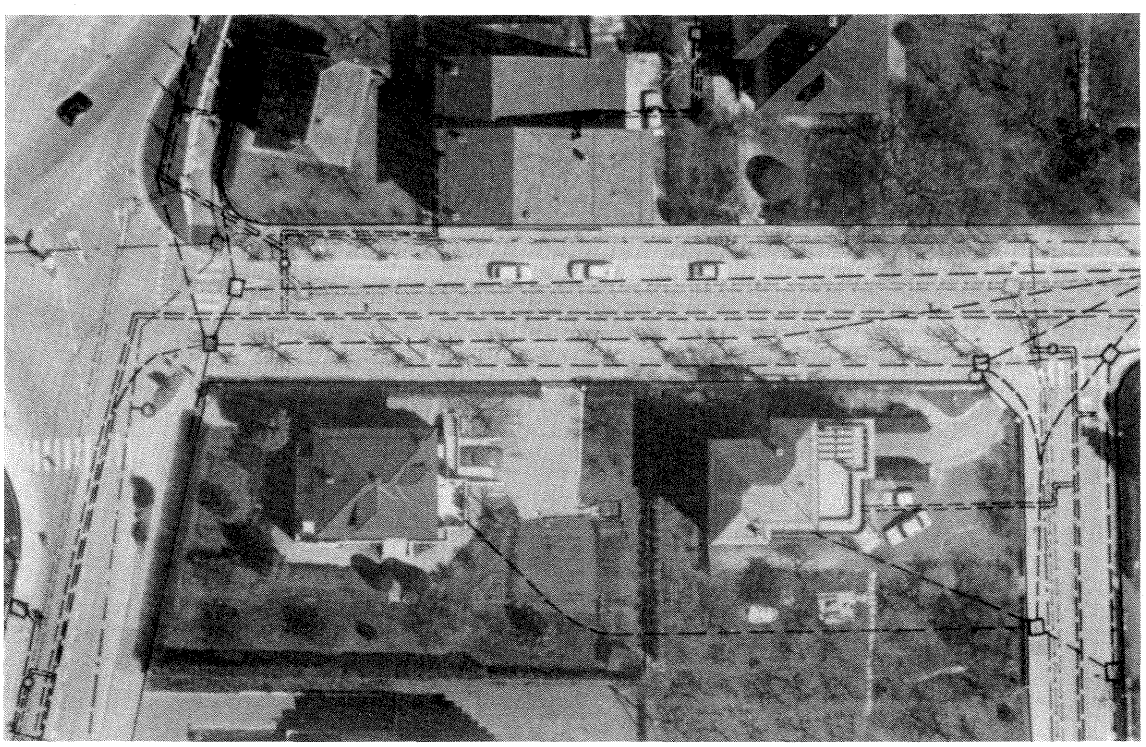

Fig. 7

Superposition of elements of a utility cadastre onto an aerial photograph, showing that the greatest part of a basic line map can be replaced by a photograph.

This combination of vector and raster data on a GIS will not only transfer the working load of photogrammetry to a GIS but will greatly enlarge the working possibilities thanks to the flexibility of image processing and the better presentation of the information. The possibility of digital image enhancement might play an important role here. The increase in contrast or the enhancement of selected details of photographic images should considerably facilitate the readability of such documents together with the vector information.

Another important point is the geometric flexibility. When working with a digital photograph, it is relatively easy to apply image transformations in order to reduce the effect of geometric deformations or even to apply differential rectifications on the basis of a digital terrain model. If deformations between the elements data and the photograph still remain, they should be mainly due to geometric errors in the vector data, which can be corrected on this basis (cf. fig. 8).

The combination of raster data with vector data also allows considerable simplification of the photogrammetric plotting. On a topographic map, one usually finds a considerable number of objects which have a mainly descriptive function, like vegetation limits, road limits, sidewalks or fences. These objects serve essentially for the visualization of the environment but are seldom included into the numerical analyses, such as for the optimization of a road construction. In replacing these elements by the photographic image, one can considerably reduce the requirements in detail plotting.

3.4 Terrain visualization

Another important aspect for planning is the possibility of visualization of the landscape including the planned object. Until now, this problem had to be solved by cartographic means. However, this requires a very good imagination and great experience with maps. This might explain why architects frequently work with sketches or photomontages in order to facilitate the general public's understanding of their projects. Computers, with the possibility of generating synthetic views, are now ideal means for visualization. This field is however in a process of great development and many of the aspects mentioned have already been realized; nevertheless, these applications are rather tedious and not always very easy to manage.

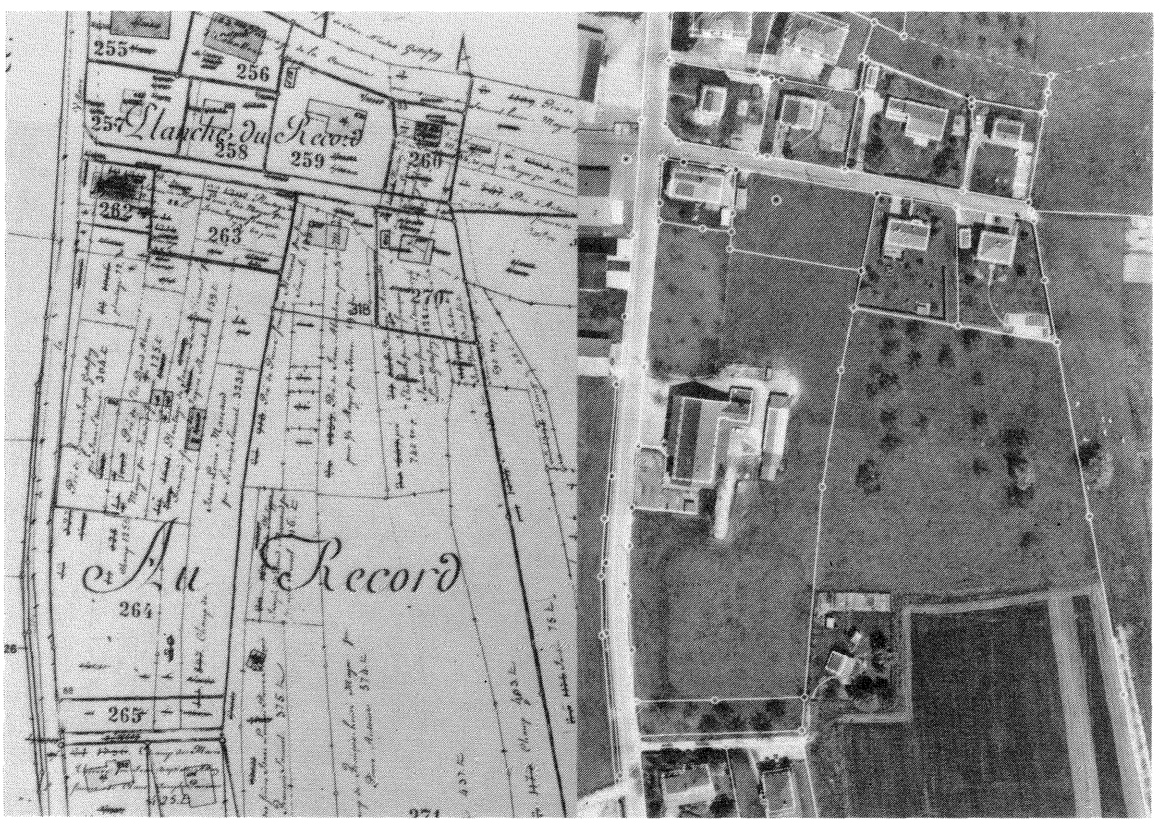

Fig. 8

Comparison between a cadastral map and an aerial photograph on which the property boundaries have been plotted. This superposition allows the detection of displacements between the cadastral state and the reality and can be used for geometric corrections (map reproduced by courtesy of the *Direction cantonale du cadastre de Lausanne*).

4. INDUSTRIAL DEVELOPMENT AND CONCLUSION

One can easily figure out that the GIS systems will play a key role in the future, not only for photogrammetric tasks but also for surveying in general and all kinds of planning activities. Photogrammetric means or even theodolites will be considered as peripheral systems interactively linked to the information system. However, the realization of such information systems calls for considerable effort. One gets the impression that the geographic information systems currently used still leave too many requirements unsatisfied, although they are in constant development, and rather large software groups are involved in this development. However, future development in this field may no longer be dominated by the classical photogrammetric and surveying firms. Not so many years ago, only a few factories specialized in optics and precision mechanics controlled the market in that field. They had also been able to build up a very efficient service organization which ensured the instrument maintenance and assisted in the technical transfer of know-how. Today, however, the requirements typically concern the field of computer sciences and technical progress depends on the progress in electronic components. Consequently, it is difficult to foresee who in the future will be the market leader in this field.

REFERENCE

[1] O. Kölbl, L. Cogan, U. Bach, D. Gasior, K. de Laporte :

'Multi-Templet-Matching für die automatisierte Bildauswertung'

Geo-Informations-Systeme n° 1 /1992, pp. 2-11.