

DIGITAL ORTHOPHOTOGRAPH AT IGN - FRANCE

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Abstract

In 1984 a first test of digital orthophotograph was already presented by IGN-F during the Rio Congress. This test showed that a profitable production could be considered, providing to choose an adapted material and to develop a performing software.

IGN-F decided to use a Pictral system, built by Matra french company. This image processing system comprises an array processor allowing to accelerate repeating calculation. The software developed by IGN-F was operational since october 1987. It allows to do the following functions :

- correspondance between coordinates measured on the photographic film and those on the digitized one.
- rectification using the same deformation grid than a classical orthoprojector.
- automatic mosaïcking and contrast adjustments in relation with output scanners.

Some examples will be shown during the congress.

1) Introduction

IGN-F used since 1977 an analogical production line for orthophotograph, based on a WILD AVIOPLAN OR 1 orthoprojector. This process is now well known, for geometric quality as well as for image quality. But it remains dependent from some operations of photographic reproductions that imply losses in accuracy and resolution, in relation with the original negatives. In addition this method is badly adapted to mosaïcking operations : for instance it is difficult to match black and white adjacent sheets and even impossible in colour.

Due to these conditions it appeared interesting to create a full digital processing line, using image enhancement and mosaïcking techniques developed for spatial imagery processing (Landsat and Spot). A first test of feasibility in colour was done in 1984 on the Gevrey-Chambertin sheet, at a scale of 1/5 000, from an aerial survey at 1/20 000. This test allowed to define a methodology and to prepare the choice of the best materials. These systems were bought in 1986 and 1987 ; softwares were written by IGN engineers and the production line was operational since october 1987.

II) Principle of the digital line

1) General remarks

The aim of orthophotograph is to obtain a photograph superposable to the map, eliminating all deformations due to relief and aerial survey conditions. These corrections are done by elementary cells in order to be assimilable to bilinear transformations. In its principle the correction consists of going from an irregular grid in the original negative reference to a regular grid, in the orthophotograph projection ; the resultant image is generated according to this regular grid, on an image scanner.

The practical realization of such a correction was done until now by optical-mechanic devices : it is the case with WILD OR 1 orthoprojector. But in its principle the algorithm of geometric correction used in digital line is identical to the one of OR 1, using the same kind of modelling than classical orthophotograph.

2) Calculation process

The elementary cell of the regular grid to be obtained should be a square function of an entire multiple of pixels of final image (i e 4 X 4, 8 X 8, ... 64 X 64). Dimension of this cell is chosen, as for OR 1 slit in analogical line, in relation with relief characteristics of the ground.

a) Deformation model

As in classical process the first operation is calculation of deformation model, in negative coordinates, from elements of the perspective bundle and digital terrain model (DTM). This step implies determination of a correspondance law between terrain system (X, Y, Z) and coordinates of the negative to be corrected (x, y) defined by fiducial marks on aerial camera. This correspondance law is established from some points, known in both systems.

Z altitudes of regular grid nodes, already defined in X, Y are issued from DTM. As X, Y, Z of elementary cells are so known it is sufficient to apply them the previous correspondance law for obtaining negative coordinates.

b) Negative digitizing

This operation is done on a photogravure scanner, ie DIOS system (Digital Input Output System) which ensures digitizing, checking and digital data recording functions.

c) PICTRAL system processing

All the other geometric and radiometric processings are done on a PICTRAL image processing system built by MATRA french company. That includes the following phases :

- calculation of a linear model for transformation of negative coordinates in line-column coordinates of the image. This operation is done by marking on the display unit ground points known in negative coordinates.

- application of this transformation to the deformation grid nodes in order to obtain a grid in image coordinates.
- application of radiometric correction to the image for contrast enhancement, atmospheric haze reduction, aerial camera vignetting correction, etc.
- negative rectification.
- eventually, automatic mosaïcking from corrected images.

d) Negative rectification

This is the main phase of the digital line and the most expensive in time computer. Its objective consists of geometric and radiometric corrections of the original image in order to obtain the final orthophotograph.

Geometric interpolation determines for each pixel of the corrected image coordinates of its antecedent in the raw image. This operation uses the deformation model which provides image coordinates of the antecedent of regular grid on the output image.

Coordinates of a given pixel of the image are calculated by bilinear interpolation in relation with antecedents of cell angles of which it belongs. This process ensures image continuity at the boundaries between cells.

Radiometric interpolation allows to determine pixel values of the corrected image, from raw image pixel values. Two methods are employed :

- the first one, named nearest neighbourhood which consists of taking value of the nearest pixel from antecedent in raw image
- the second one, where pixel value is interpolated in relation with those of 16 neighbouring pixels by bicubic formula.

This last method needs longer calculation time but provides finest details discrimination particularly in heavy upgraded zones.

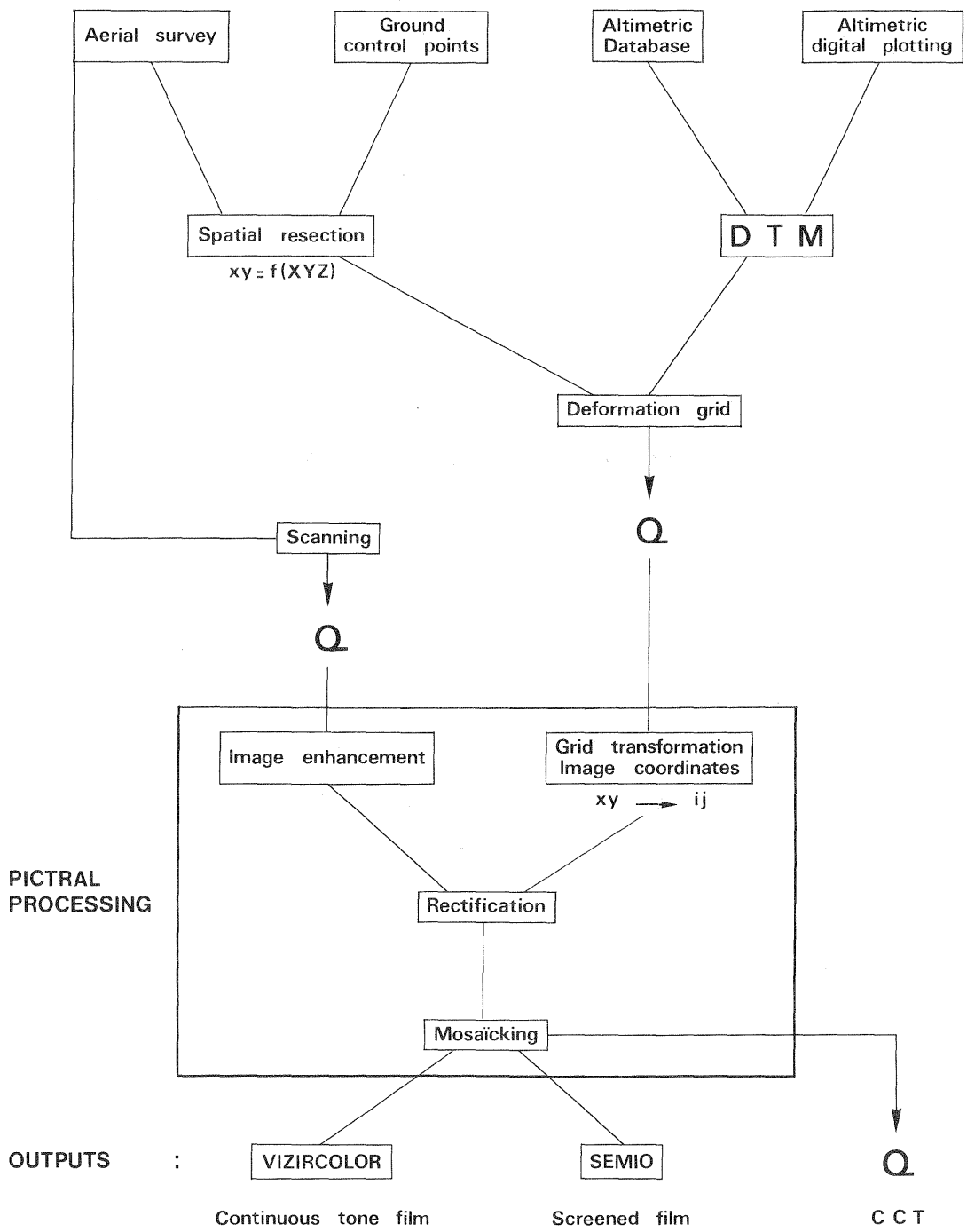
e) Corrected images mosaïcking

Digital line allows to do automatically several images mosaïcking by comparison of radiometric histograms in the common zone of images to be mosaïcked, and determination of a lowest radiometric difference line.

3) Corrected image outputs

According to the kind of document, final output image can be produced on different scanner systems :

- DIOS or VIZIRCOLOR for black and white continuous tone films
- VIZIRCOLOR for colour continuous tone films
- SEMIO for monochromatic or colour separated screend films, in order to realize four colour offset printing.



III) Materials of the digital line

1) DIOS system

This system comprises a digitizing and printing unit and a computer unit for checking, recording and exchanging data with other systems.

The digitizing unit is a HELL CHROMAGRAPH 299 scanner modified for exchange of data with the computer unit.

The computer unit comprises :

- a 80 286 microprocessor with a 512 kbytes memory,
- an image display unit, with a resolution of 512 X 512 pixels,
- a fixed disk of 500 M bytes,

and some other input output devices.

Some characteristics

- Maximum scanning size : 50 X 60 cm
- Maximum scanning speed : 900 lines per minute
- Minimum pixel size : 10 micrometers

Scanning is done from either black and white or colour documents ; in this case three successive passes are needed in order to obtain a selection in blue, green and red.

2) PICTRAL system

This system has the following elements :

- a Motorola 68010 mini computer with a 1 M byte memory
- a mass storage with two fixed disks of 160 M bytes and a removable disk unit of 300 M bytes
- an array processor designed for image processing, with a 2 M bytes memory
- a video unit with
 - . three memory planes
 - . a processing board with feed back, for radiometric processing
 - . a display unit of 1024 X 1024 pixels
 - . a graphic digitizing device
- an input output unit (i e a tape subsystem of 1600 or 6250 b/in)

3) VIZIRCOLOR system

It is a digital image plotter, which can work in black and white or in colour. It comprises a printing scanner, piloted by a micro

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computer which reads image values on a magnetic tape. The film is placed on a turning drum where are focused on a same point three beams of red, green and blue colours. These lasers print each pixel of the image.

Some characteristics

- Maximum size of the printed film : 48 X 75 cm,
- Minimum size of pixel : 25 micrometers,
- Optical density : adjustable from 0.3 to 2.8,
- Number of density levels : 256, for each primary colour.

4) SEMIO system

This system is used for outputs intended for offset printing. It comprises a panel of optical, photographic and computing tools which allow to produce computer assisted cartography. In the present case it is only used an image plotting unit, for screened film production from digital files. Printing is done by means of an argon laser camera, on black and white high definition film for each of the four components : yellow - magenta - cyan - black for four colour offset printing. Therefore it is necessary to determine, during the Pictal processing, the printing rates for each of the separated colours.

IV) Examples of realizations

Several works were realized by digital line, first in black and white, then in colour, in France and for foreign countries. For instance here are considered operations of Modane and Autun in France, the one of Boma in Zaïre.

The site of Modane, in Savoie needed realization of 12 orthophotographs, from an aerial survey at 1/30 000 digitized at a step of 40 micrometers. The final product consists of 5 sheets at a scale of 1/5000. Therefore each sheet implies an average of 4 matchings between corrected images, automatically produced on PICTRAL system. Rectification is done by the nearest neighbourhood method ; that needs about 20 minutes for each aerial photograph, i e 5000 X 5000 pixels at a step of 40 micrometers. Each matching needs about 30 minutes.

The site on Autun area, in Saône et Loire is partly produced by digital line, at a scale of 1/2000, from an aerial survey at 1/10 000 done with a very long focal length aerial camera (Zeiss RMK/60). Final product is a colour photographic print, realized from VIZIRCOLOR film. In addition four screened films were produced on one sheet, for a four colour offset printing .

The site of Boma, in Zaïre, is produced in black and white, at a scale of 1/10 000 from an aerial survey at 1/50 000 with a 88 mm focal length aerial camera. This survey was done during two periods in 1985, by different meteorological conditions. The presented sheet is at the junction between the two surveys ; all matchings are automatically realized.

V) Conclusions

Digital line provides important technical advantages. It allows a better image quality of the final document, particularly in colour. But above all it brings an effective solution to the problem of adjacent image matching, for geometry as well as for radiometry. Time of realization is appreciably lower than for classical line and some intermediary operations such retouching or photographic reproductions are eliminated.

From an economic point of view, the first sites show that costs are of the same order than for OR 1 line, in case of medium difficulty site. But digital line becomes profitable in case of difficult site with numerous adjacent image matchings, for instance Modane site. At IGN classical and digital methods should remain complementary and bring all flexibility in charge distribution, according to technical particularities of the works.