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RASTER SCANNING OF BATHYMETRIC PLOTTING SHEETS

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ABSTRACT

Raster scanning of the Service hydrographique et océanographique de la Marine (SHOM)'s bathymetric plotting sheets provides neural networks [2] with an excellent opportunity to confirm their strong capability compared with traditional computer methods in recognizing hand-written characters. This article describes the various stages necessary and comments on the first results obtained with recently acquired software referred to as RETINE.

I. THE NEED

Since its creation, and before the emergence of computer science, the Service hydrographique et océanographique de la Marine française (SHOM) accumulated thousands of analogue bathymetric plotting sheets, for the coasts of France, each containing several thousand soundings. The increasing needs of navigators for digital geographic data led to the setting up of a Geographic Information System (GIS) and the constitution of a Bathymetric Data Base that SHOM hopes to enrich with the results of automated digitization of these plotting sheets. The GIS should make it possible to create reliable and elaborate cartographic products; it is therefore essential to have available full and detailed data from the original hydrographic surveys.

II. THE PROBLEM

As a first step, it is envisaged that the bathymetric plotting sheets of the coasts of metropolitan France, drawn up since 1970, will be processed. There exist about two thousand of these on the continental shelf. Each one carries an average of ten thousand soundings inserted by hand or by machine (Fig. 1).

One person can digitize on a digitizing table up to two thousand soundings per day. It is a long and tedious task which, despite the careful attention of the operator, remains open to errors which must be detected and corrected. The final checking takes a hydrographic survey petty officer an average of two and a half days, which brings the total time to seven and a half days for a complete digitizing of one bathymetric plotting sheet. Under the established routine, three persons can digitize and check three plotting sheets per week. The digitizing of the hydrographic fund with which SHOM is concerned would require 25 years' work from such a team. The necessity of being able to use an automated tool became very quickly obvious. Such a tool must use character-recognizing techniques that are efficient and reliable. It is, for example, out of the question that it should make more mistakes than a human operator.

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[2] Simulating behaviour of human being.

III. THE SOLUTION

A. *RETINE software*

The RETINE software, developed and marketed by the firm METALOG, has been developed in Objective C, an object-oriented language, in the NextStep [3] environment. It works on a high-powered PC 486. The heart of the software includes a multi-layer neural network, elements of which must be initialised during a short learning period [1 ... 17]. A very ergonomic interface simplifies in the extreme the operations necessary for automatic recognition of soundings on bathymetric plotting sheets.

B. *Scanning of the analogue plotting sheet*

The original bathymetric plotting sheet is digitized on a SIEMENS CTX 330 S scanner with a resolution of 50 mm, i.e. 500 dpi (dots per inch). Analysing'is done in black and white.

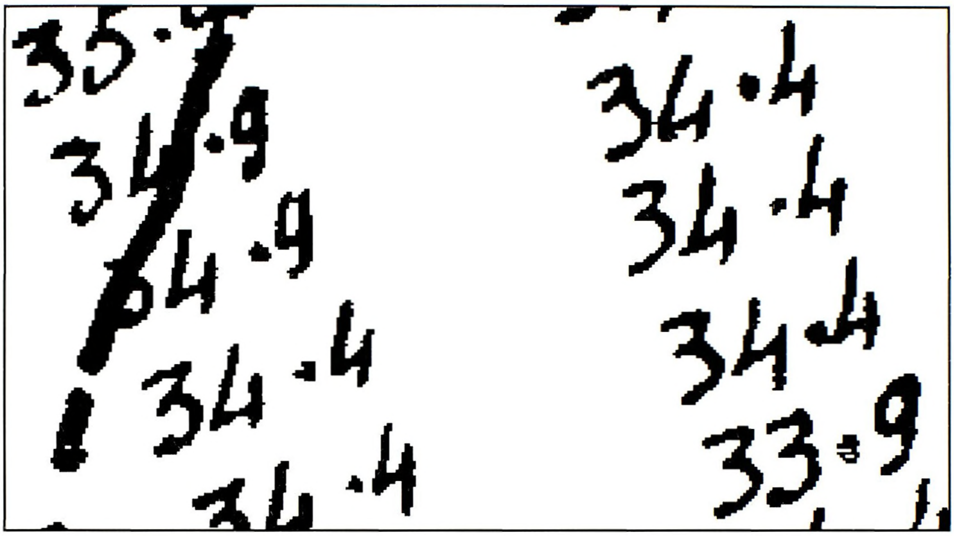

FIG. 1. — Partial view of a bathymetric plotting sheet after scanning.

C. *Extraction of outlines*

During an early stage, RETINE automatically extracts the outlines of a digitized image which carries about three hundred million pixels. This operation lasts for about an hour (Fig. 2 and 3). The image is not processed as a single block, since that would require too great a capacity in the active memory. In fact, RETINE proceeds, before analysing, by dividing the image into areas of 800 by 400 pixels.

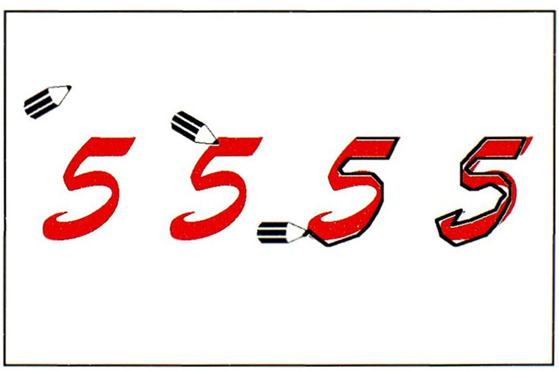

FIG. 2. — Method of extraction of outlines: detection of a gradient in colour, followed by outlining with octo-related Freeman vectors and preservation of the line.

[3] Proprietary name of a software.

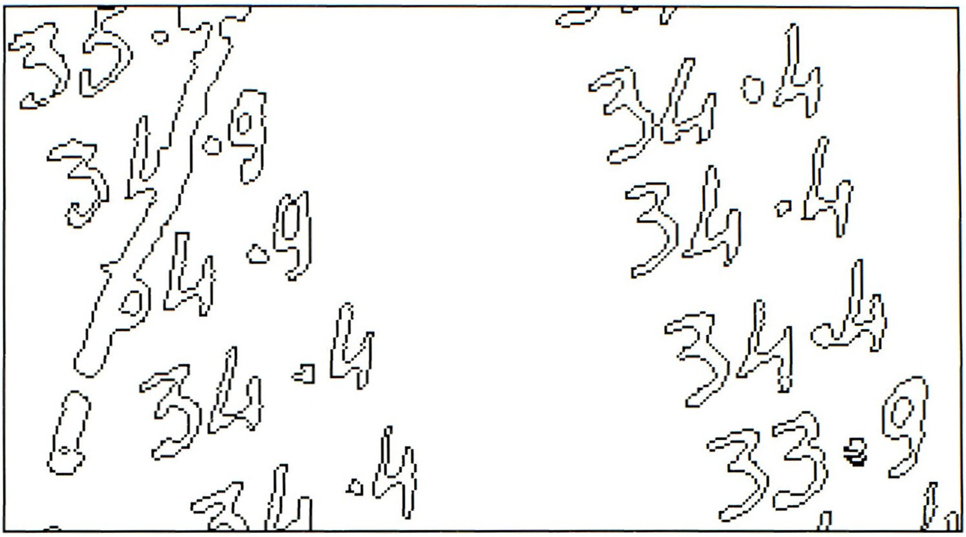

FIG. 3. — Appearance of the Figure 1 plotting sheet after extraction of outlines.

D. Initiation of neural network

An operator then proceeds to initiate the neural network. This initiation must make it possible to calculate the parameters of the network. In order to do this, he draws on the screen the outline of a figure and links it with one of the ten classes possible (Fig. 4 and 5). He renews this operation about ten times for each class. When the types of writing vary greatly from one plotting sheet to the next, it is necessary to repeat the initiation stage.

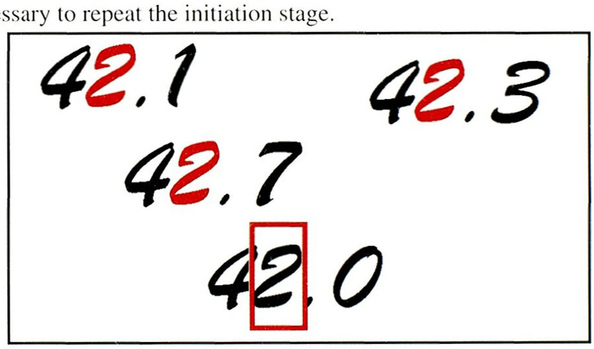

FIG. 4. — Interface for learning of figures : the outlines which it is wished to link with the current class are indicated (2).

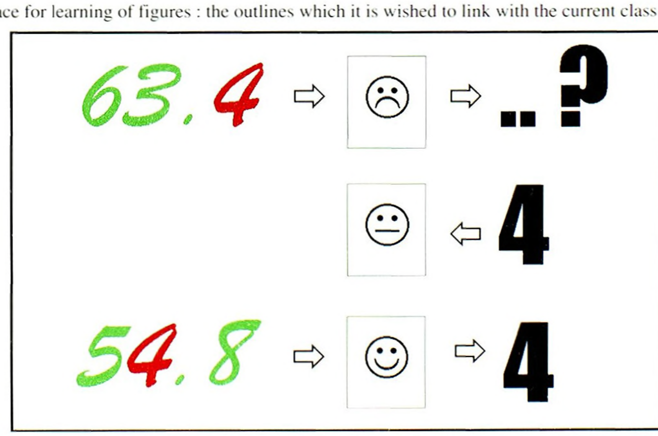

FIG. 5. — The different stages of the initiation period:
Several similar outlines are present for entry into the network
The output required is indicated to the network
The process is repeated as often as necessary until the network makes no more mistakes.

Classification conventionally uses Fourier's descriptors [18]:
- about ten coefficients suffice to represent a given outline,
- there is no variance in homothety and in translation,
- a filtering of the high frequencies together with a weighting of coefficients enables an excellent immunity to noise to be obtained.

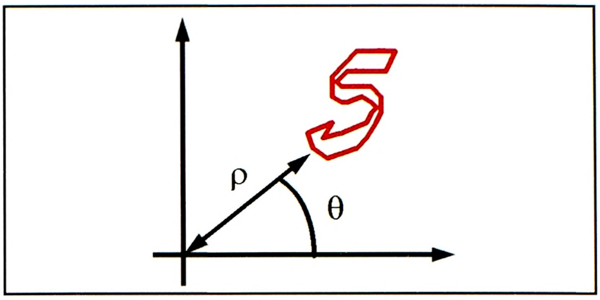

FIG. 6. — Fourier's descriptor corresponds to polar representation (ρ,θ) of a point in the outline (in red)

This method has some shortcomings when, for example, outlines that are usually closed open accidentally. To overcome this type of problem, it is necessary to link several representation groups with one class, which would be translated in the intermediate space of Fourier by hosts of possible vectors (Fig.7 and 8). It is also possible to multiply the approaches by using a bitmap representation of the shapes to be recognized.

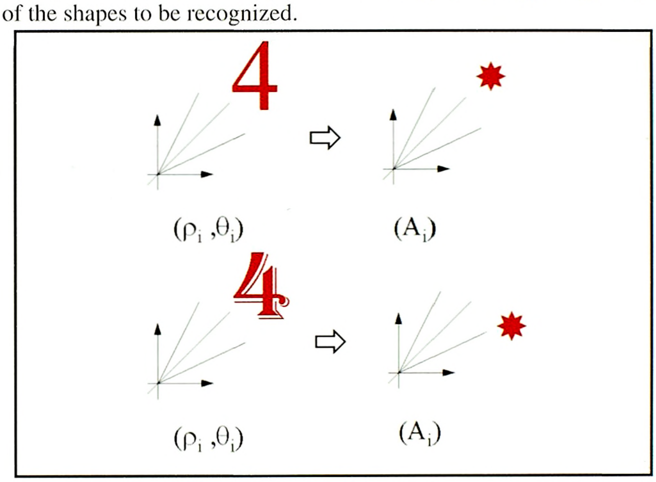

FIG. 7 — Spatial representation of representation groups:
Fourier's N descriptors of the figure are sought and the corresponding vector in a space of dimension N is drawn, the process is repeated on other similar figures and a host of very closely grouped points is obtained.

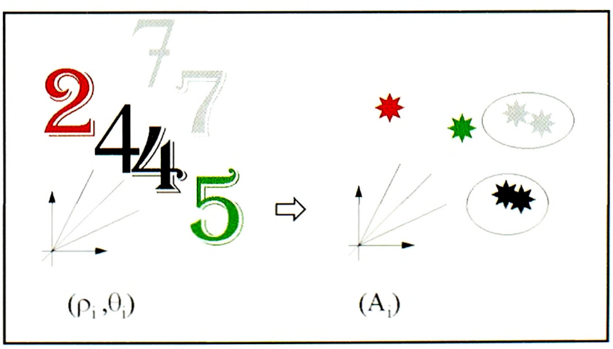

FIG. 8 — Spatial representation of representation groups:
at the end of the initiation period, the neural network knows the distribution of each of the Fourier space hosts.

Finally, one must also specify to the software the way in which the recognized figures will be ultimately reassembled to form bathymetric soundings. The preceding initiation is therefore completed by indicating in the picture the possible sounding structures.

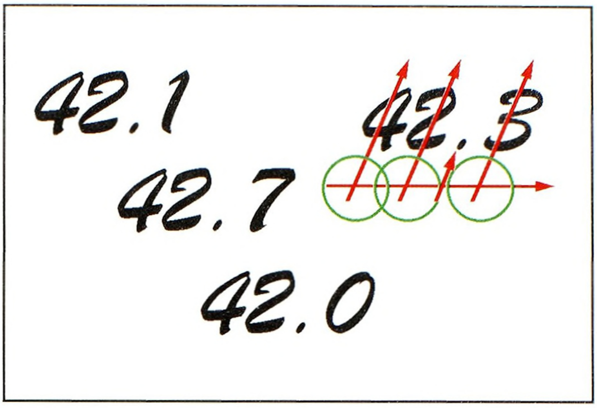

FIG. 9. — Learning of possible sounding structures: arrangement and orientation of figures, tolerances in spacing, ...

Tolerances as regards the encumberment and the orientation of the writing of sounding figures are automatically linked with the structures to be recognized. In dense areas, where the written figures are very similar, the software can thus eliminate poor figure associations and generate good hypotheses.

It is also possible to specify the extreme depths between which the soundings fluctuate and, when the plotting sheet lends itself to the operation, to indicate a certain orientation for the written figures that is common to all the soundings. That enables the software to interpret without ambiguity traditional symmetries in writing (e.g.: 68 and 89).

E. Automated recognition

After extraction of the outlines and initiation, automated recognition is effected on a portion of the image, to test the quality of the network, then on the whole plate. The operation then requires eight hours of calculation : there are, successively, recognition of the figures, of the points which locate the soundings, and assembling of the figures to form soundings.

IV. RESULTS

On bathymetric plotting sheets of the continental shelf, of varying difficulty and carrying about 8000 3-figure soundings, the following results are obtained, on average:

Structures	Structures detected	Structures not detected
8 000	78,1 %	21,9 %
Figures	Figures detected and recognized	Figures detected and not recognized
24 000	95,7 %	4,3 %
Soundings	**Soundings recognized**	Soundings not recognized
8 000	**68,4 %**	31,6 %

Note: A recognized sounding is a sounding whose structure has been detected and all of the figures of which have been recognized.

One hour suffices for the operator to enter the figures for which the tool failed. Indeed, those figures that are difficult to recognize have been memorized during the automated processing before being submitted successively to the operator who does not even have to indicate them on the screen. But it takes one or two days for an operator to correct the wrong soundings and to add the missing soundings on the complete image : the result of the automated recognition is superimposed on the original image. The outlines not linked to a sounding structure appear in a different colour from the outlines identified as belonging to soundings (Fig. 10).

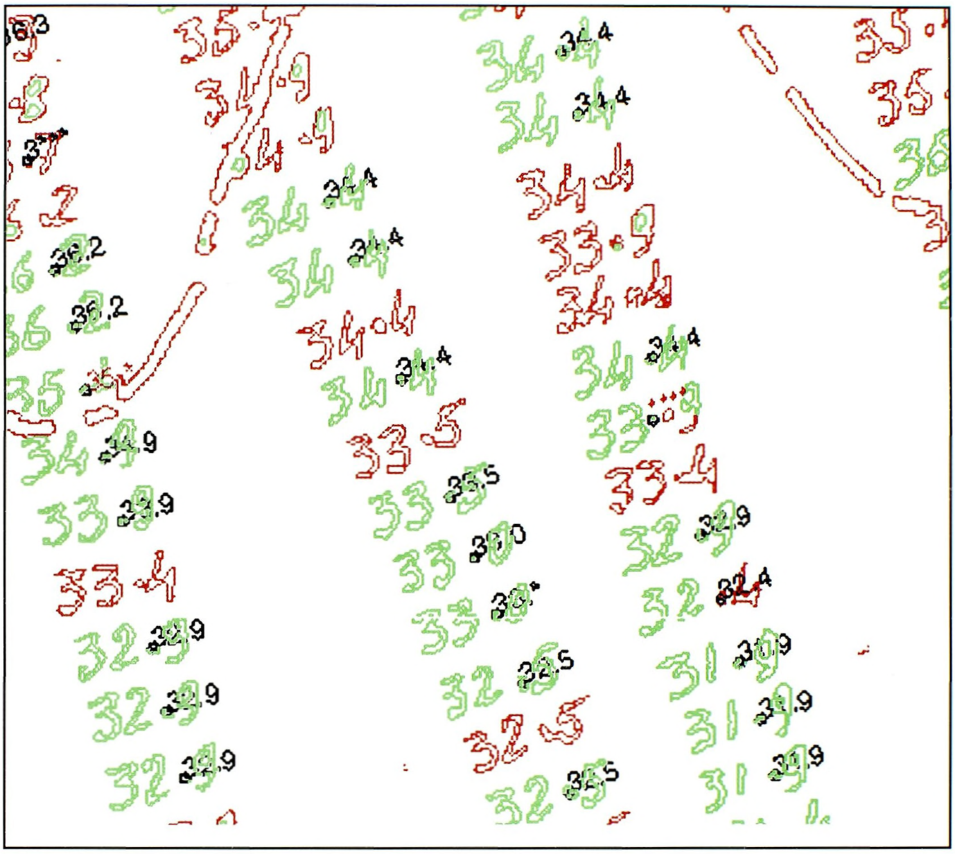

FIG. 10. — Interface of manual correction

The analysis of the results of the automated recognition makes it possible to distinguish three types of error (Fig. 11 to 13):

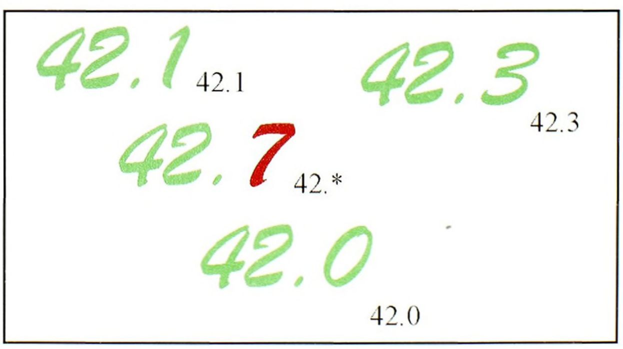

FIG. 11. — The tool has recognized a sounding structure but has failed on one (or more) of the figures making up this sounding (4.3% of cases).

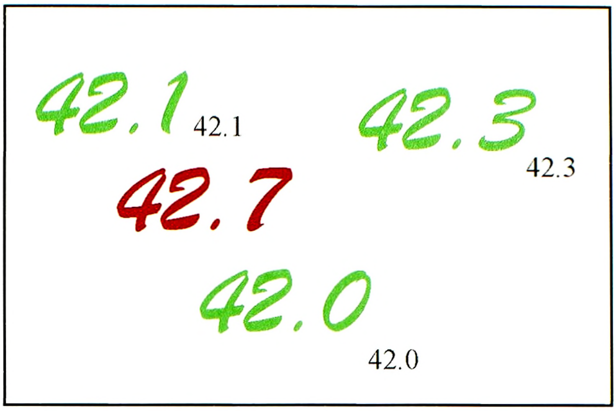

FIG. 12. — The tool has not recognized the structure of a sounding and it must be entered completely (21.9% of cases).

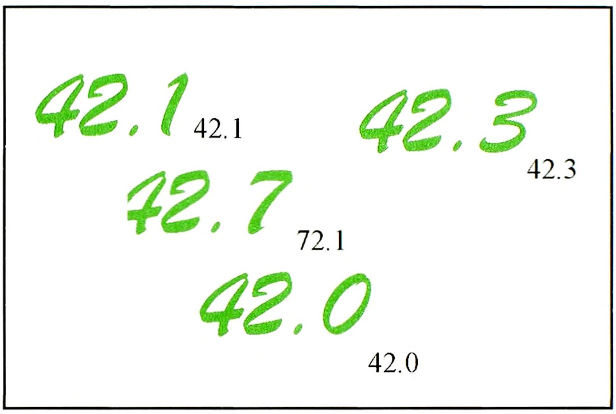

FIG. 13. — The tool has committed an error which must be detected and corrected (fewer than 1% of cases).

The soundings are next written in a file in a format which enables control drawings to be made, digital terrain models to be constituted, and final verifications to be carried out (Fig. 14).

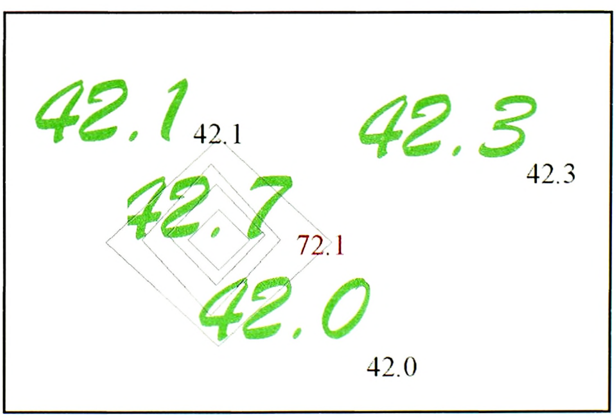

FIG. 14. — Drawing of depth curves and colouring of figures : aberrant figures become very obvious.

Seeking a result without error requires another day or two of verifying by a hydrographic survey petty officer. While some errors are easily detectable when they concern hundreds of metres, the same does not apply for errors concerning only metres.

V. CONCLUSIONS

With the currently available tools, under established routines and carrying out digitizing and checking operations in parallel, it is possible for a data capture operator and a hydrographic survey petty officer to process two to five bathymetric plotting sheets per week and to digitize SHOM's hydrographic plotting sheets, on average, three times as quickly as before.

The final checking stage is still very long and deserves special attention. It may be compressed and checking tools better adapted than those currently in use should enable precious time to be saved.

In addition, many objects cause interference with the writing of soundings and still hinder automated recognition : depth curves, grid, graduations, various symbols ... It is not ruled out that new techniques for recognizing characters might one day solve these last problems and reduce the still laborious stage of hand correction.

Finally, the search for residual errors might not always be so systematic. It is, in fact, perhaps judicious to distinguish several levels of quality of digitizing which satisfy needs as widely varying as those of navigation and those of oceanography.

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