11th Annual GEBCO
Bathymetric Science Day
Valparaiso, Chile
12 October 2016

ScanBathy : A new solution to digitize depth data from historic survey sheets

Ronan Créach[1], Sébastien Bosch[2], Laurent Boutry[2], Jonathan Genevier[1], Paul Claverie[2] and Alexandre Badez[2]

(1) SHOM, 13 rue du Chatellier, CS92803, 29228 Brest CEDEX 2, France
(2) Magellium SAS, 24 rue Hermès – BP 12113, 31521 Ramonville Saint Agne Cedex, France

Context

SHOM gathered over the past centuries more than **75,000 analogue field sheets**, some of the oldest dating from the **early 1800s**. Before the digital era, soundings were recorded as **hand-plotted numerals** on bathymetric sheets that were used to produce nautical charts.

Data recovery and rescue are crucial in most cases, for example in areas that were not mapped with modern technologies or to improve understanding of seabed changes in nearshore areas.

Technical environment

ScanBathy was developed by the French company Magellium, tailor-made for optimizing SHOM digitization of historical survey sheets and **replacing RETINE software** (Louvart, 1996).

The software is mainly built on GDAL, OpenCV, Deeplearning4J, Qt and Eclipse RCP libraries.

Functionalities

1- Project Initialization

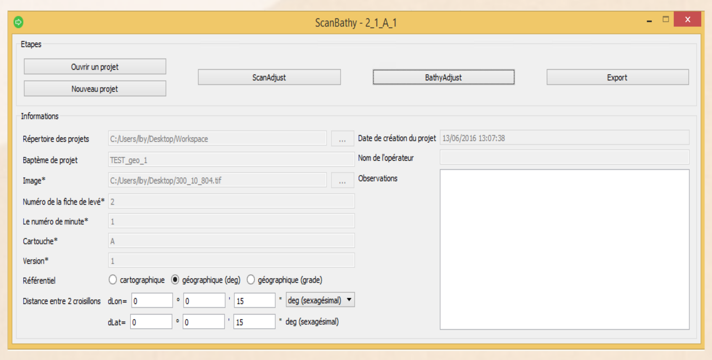

Fig 1. Launcher tool deals with project management/workflow and export tasks.

The main interface is used for:

- **project management** (create, modify, archive);
- **project workflow** (import, georeference, digitize and control);
- data **export**.

The field sheet is loaded from a file or a URL in **TIFF** or **JPEG2000** format at **300dpi or higher**.

Metadata associated with the digitization project are created through this interface.

Print and export functions are used to generate the digitizing outputs that will populate SHOM bathymetric database.

2-Georeferencing

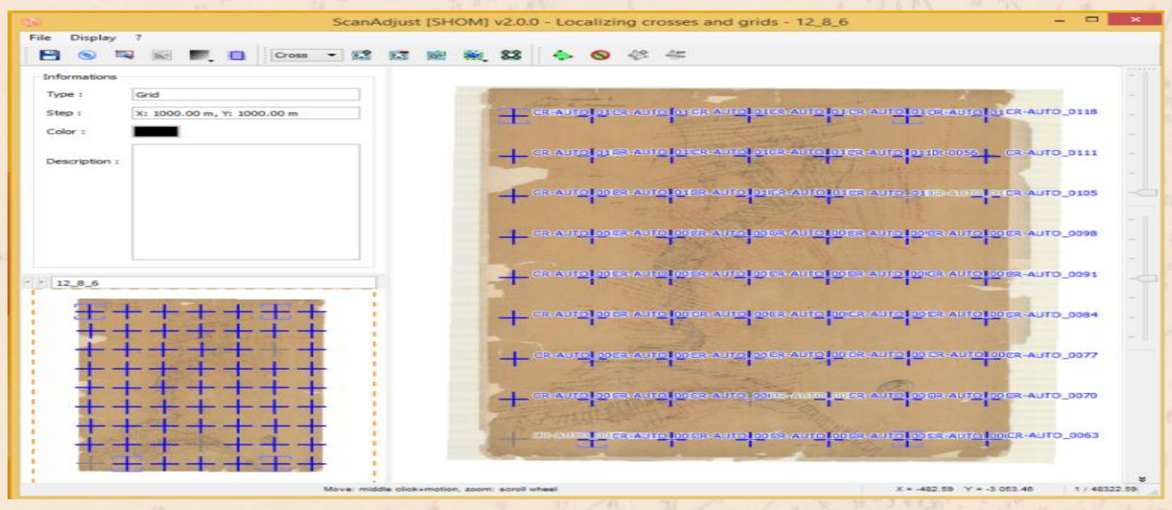

Fig 2. The ScanAdjust tool is dedicated to the georeferencing task.

ScanAdjust module is an efficient tool dedicated to georeferencing tasks. It is segmented so that only the **necessary functions are displayed at each step of the process**.

It uses **cartographic annotations**, like crosses or grids, to compute geometric models. The user either manually **picks up control points** on these marks or uses the **automatic crosses detection tool.** Moreover, special control points are used to compute local deformation models, which greatly **correct local deformations induced by the foldings** of the sheets.

As the geometric deformations are **viewed** on the fly on screen, the validation is done with great ease and accuracy.

3- Soundings Digitizing

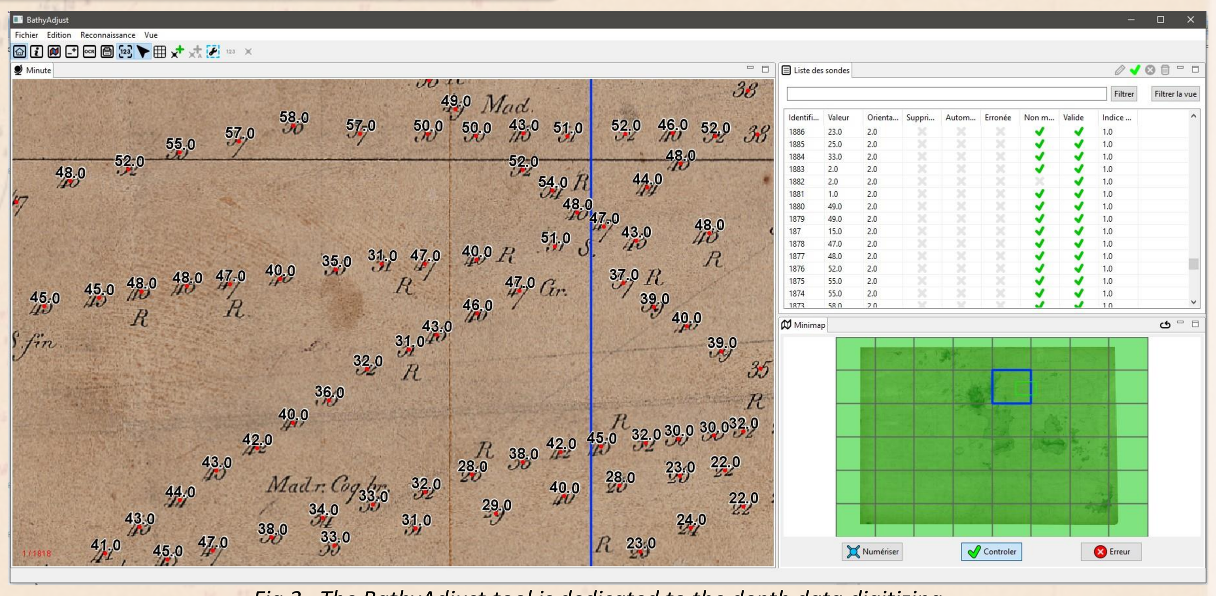

Fig 3. The BathyAdjust tool is dedicated to the depth data digitizing.

The digitizing tool has been iteratively developed with **feedback from digitizing operators** with focus on:

- comprehensive label styling settings for each digitizing mode;
- **customizable shortcuts** for every actions;
- **"click-saving" graphical user interface (GUI) choices.**

Three digitizing mode are available:

- In **manual mode,** soundings position and depth are entered by the operator.
- In **semi-automatic mode**, soundings depth is provided by OCR while the position is manually entered.
- In **full-automatic mode**, position and depth values are generated using OCR and geometrical settings, in an area given by the operator.

4- Optical character recognition (OCR) and machine learning

Specialized OCR techniques have been developed in order to cope with **handwritten soundings** detection. Some challenging digit recognition issues have been tackled such as **automatic orientation detection** and **digits clustering in dense soundings areas.**

Depending on the maps and training datasets, ScanBathy is able to switch between a **convolutional neural network** classification approach and a **Support Vector Machine** (SVM) one. Both methods offer significant results and improve substantially the soundings detection rate.

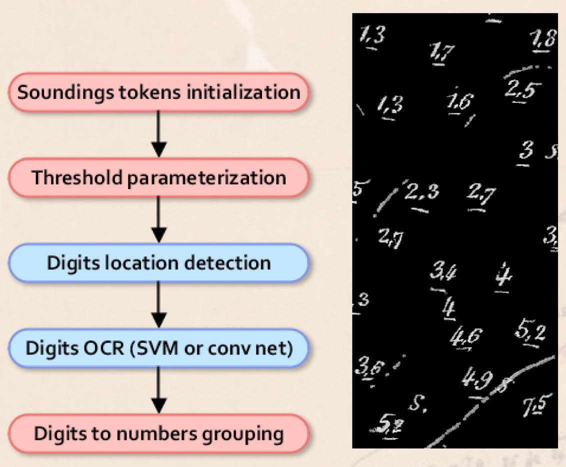

Fig 4. Left side: handwritten soundings recognition workflow. Right side: thresholded soundings examples. Digits are noised with contour lines.

Thresholding and preprocessing are of great importance to feed the classifier with clean and normalized inputs. A **bilateral filter** and **morphological operators** are combined while keeping **straightforward settings** for users. Digits preprocessing normalizes their dimensions, radiometry and orientation.

The software is provided with **ConvNet** classifier trained on the NIST special database 19 (SD19) (Cireşan et al., 2012) containing ~430,000 handwritten digits. Despite its amount of samples, SD19 is not fully representative of the studied data. Trainings with SD19 reach **99.4% of accuracy** but only 80% over bathymetric fieldsheets data. Further optimization of the Convolutional Neural Network implementation generated better detection score on the fieldsheets reaching **90% of accuracy**.

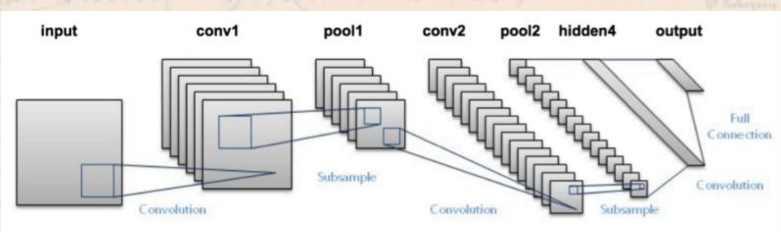

Fig 5. LeNet layers architecture. We use ReLU instead of pooling, a dynamic learning rate and dropout on the last layer

If there is not enough samples to train the ConvNet classifier, the software allows **to create a learning dataset from the soundings sheets**. Once the learning set is created, a **SVM classifier** may be trained (Arandjelovic and Zisserman, 2012). The learning is done from the projection of the pixel values in the **Histogram of Oriented Gradient** space.

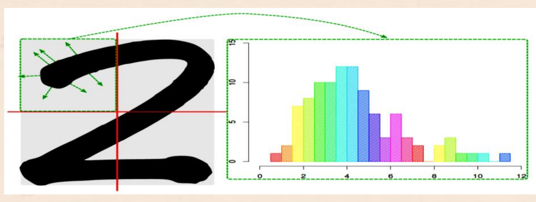

Fig 6. Histogram of Oriented Gradient

This method has two benefits:

- **Few samples** (20-30 by classes) are enough to reach good detection rate;
- While having poor results on another soundings sheets, it offers **95-98% accuracy on the trained sheet**.

The **ConvNet is a more universal** method **but in this context** (little truth data), the **SVM offers a better accuracy** at a low cost for the user. Once the digits have been well detected, a vast numbers of digits are correctly grouped to form the soundings values.

5- Production control

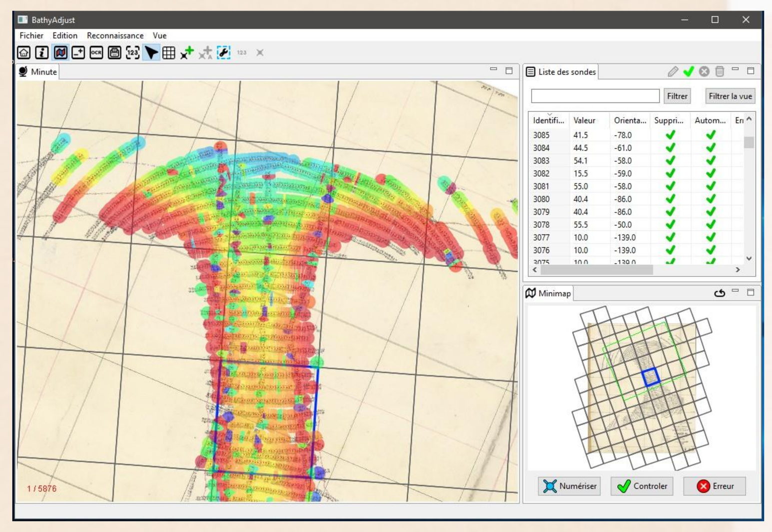

Fig 7. A close-up look at the hypsometric rendering used in the control mode.

A dedicated selection mode allows to **quickly check and potentially edit** the values of the soundings.

A **validation grid** allows to bound the inspected areas. A grid cell can be identified as checked only once the user has controlled every sounding inside. It facilitates an extensive validation without omission.

A layer map with a **hypsometric lookup table (LUT)** helps to visually identify erroneous values.

Conclusion

ScanBathy is a **new quality assessed** and **time-efficient** solution to tackle the massive job of **digitizing soundings from historic survey sheets.** It has been **tailor-made** for this specific task and benefits of **years of user experience from the SHOM operators.**
The **advanced OCR and machine learning techniques** implemented greatly **speed up the production with a gain up to 5x. The exhaustive settings** will allow to tune at no cost the digitizing interface **to deal with every kind of survey sheet.**

References

Arandjelovic R. and Zisserman A., 2012. **Three things everyone should know to improve object retrieval.** in proc. *IEEE Conference on Computer Vision and Pattern Recognition CVPR 2012*
Cireşan, D. C., Meier, U., and Schmidhuber, J., 2012. **Multi-column Deep Neural Networks for Image Classification.** in proc. *IEEE Conference on Computer Vision and Pattern Recognition CVPR 2012.*
Louvart, L. 1996. **Raster scanning of bathymetric plotting sheets.** *The International Hydrographic Review*, Monaco. Vol. LXXIII, No. 1, March