A MORPHOLOGICAL METHOD FOR MUSIC SCORE STAFF REMOVAL

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At a Glance

Problem statement:

- staff removal = not a straightforward task...
- ...specially with ancient and degraded handwritten music scores.

Why it is interesting:

- staff removal = a key to improve the recognition of music symbols

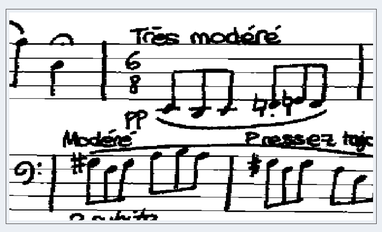
What our solution achieves:

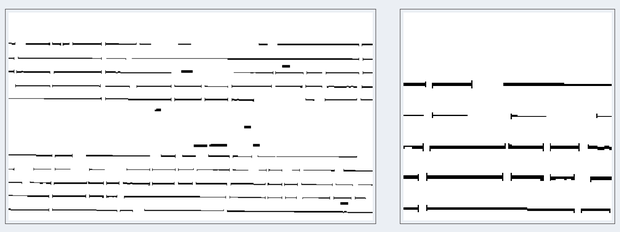
- a simple and fast solution,
- winning method of the staff removal competition at ICDAR 2013. \o/

What follows from our solution:

- meta-message:
  (even basic) mathematical morphology rocks,
- eventually...
  for a human, music is harder to read without staff :P

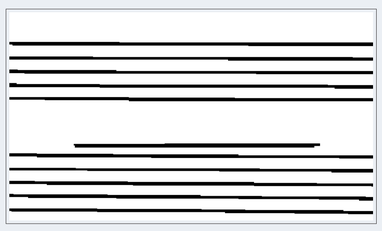
Processing Chain = Very Basic Mathematical Morphology Operators

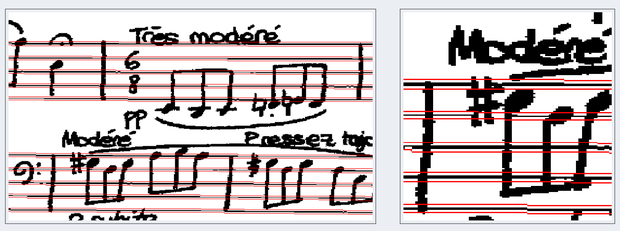

Input image I.

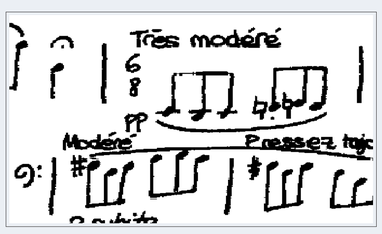

Step 1: permissive hit-or-miss.


Step 2: horizontal median filter.


Step 3: horizontal reconstruction.


Step 4: about nothing.


Step 5: line selection (contour superimposed).


Step 6: local vertical median filter.


Ground truth.

Consider the rank filter:

$$\kappa_B^\lambda(X) = \{ x \in E \mid \textstyle\sum_{b \in B} 1_{x-b \in X} \geq \lambda \} \quad \text{with} \quad \lambda \in [\![1, |B|]\!]$$

1. extract chunks of staff lines;

   $\varphi_1 = \kappa_{B_1}^{\alpha|B_1|}(X) \cap \kappa_{B_2}^{\beta|B_2|}(E \setminus X)$

   with B_1 = and B_2 =

2. regularize their shapes;

   $\varphi_2 = \kappa_B^{|B|/2}$ with B =

3. extend the chunks horizontally;

   $\varphi_3 = \mathcal{R}_Y^\delta(X) = \lim_{n \to \infty} \delta^n(X, Y)$

   where: $\delta^1(X,Y) = \delta_B(X) \cap Y$ and $\delta^{n+1}(X,Y) = \delta_B(\delta^n(X,Y)) \cap Y$,

   with B =

4. correct some defects;

   $\varphi_4 \approx \mathrm{id}$

5. select staff lines, i.e., get rid of tie lines;

   φ_5 = a non-morphological selection

6. reconstruct an image without staff lines.

   $$\forall\, p,\ \varphi_6(p) = \begin{cases} \kappa_B^{|B|/2}(I)(p) & \text{if } (\delta_R \circ \varphi_5)(p) = \text{true} \\ I(p) & \text{otherwise} \end{cases}$$

   with B =  and with R =

Reproducible Research (Evangelization from the Church of Mathematical Morphology)

CVC-MUSCIMA database of score images	→	http://www.cvc.uab.es/cvcmuscima
our C++ image processing library "Milena"	→	http://olena.lrde.epita.fr
full source code of our method	→	http://publis.lrde.epita.fr/geraud.14.icip
online demo	→	http://olena.lrde.epita.fr/demos/staff_removal.php

→

Results and Comparison

method	H_1	H_2	M_1	M_2	L_1	L_2	*mean*
LRDE	**0.96**	**0.97**	**0.97**	**0.97**	**0.97**	**0.98**	**0.97**
NUASi-lin	0.92	0.94	0.93	0.95	0.93	0.95	*0.94*
NUASi-skel	0.92	0.93	0.92	0.93	0.93	0.93	*0.93*
Baseline	0.91	0.89	0.91	0.89	0.91	0.89	*0.90*
INESC	0.91	0.85	0.92	0.86	0.92	0.86	*0.89*
TAU	0.78	0.82	0.81	0.84	0.83	0.86	*0.82*
NUS	0.65	0.69	0.65	0.69	0.66	0.70	*0.67*
LRDE-gray	0.72	0.72	0.80	0.80	0.88	0.87	*0.80*
INESC-gray	0.39	0.36	0.39	0.36	0.39	0.37	*0.38*

F-measure of the results w.r.t. to different methods (raws) and degradations (columns). H / M / L are respectively high / medium / low noise addition, and the subscript denotes one of the two different kinds of mesh-based distortions; our results are emphasized in bold faces.

Selected Bibliography

[1] A. Fornés, A. Dutta, A. Gordo, and J. Lladós, "CVC-MUSCIMA: a ground truth of handwritten music score images for writer identification and staff removal," *International Journal on Document Analysis and Recognition*, vol. 15, no. 3, pp. 243–251, 2012.

[2] V.C Kieu, Alicia Fornés, Muriel Visani, Nicholas Journet, and Anjan Dutta, "The ICDAR/GREC 2013 music scores competition on staff removal," in *Proceedings of the IAPR International Workshop on Graphics RECognition (GREC)*, Bethlehem, PA, USA, 2013.

[3] M. Visani, V.C Kieu, A. Fornés, and N. Journet, "The ICDAR 2013 music scores competition: Staff removal," in *Proceedings of the International Conference on Document Analysis and Recognition (ICDAR)*, Washington, DC, USA, 2013, pp. 1407–1411.

[4] G. Lazzara, R. Levillain, T. Géraud, *et al.* "The Scribo module of the Olena platform: A free software framework for document image analysis," in *Proc. of the International Conference on Document Analysis and Recognition (ICDAR)*, Beijing, China, 2011, pp. 252–258.

[5] R. Levillain, T. Géraud, and L. Najman, "Why and how to design a generic and efficient image processing framework: The case of the Milena library," in *Proceedings of the IEEE International Conference on Image Processing (ICIP)*, 2010, pp. 1941–1944.