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.

What follows from our solution:
- meta-message: (even basic) mathematical morphology rocks,
- eventually...

for a human, music is harder to read without staff :P

Consider the rank filter:

\[

\kappa^\lambda_B(X) = \{ x \in E \mid \sum_{b \in X} 1_{x+b \in X} \geq \lambda \} \quad \text{with} \quad \lambda \in [1, |E|]

\]

1. extract chunks of staff lines;
\[

\varphi_1 = \kappa^\lambda_{B_1}(X) \cap \kappa^\lambda_{B_2}(E-X)
\]
with \( B_1 = \infty \) and \( B_2 = 2 \)

2. regularize their shapes;
\[

\varphi_2 = \kappa^\lambda_{B_2}
\]
with \( B = \infty \)

3. extend the chunks horizontally;
\[

\varphi_3 = \frac{1}{X,Y} \lim_{\delta \to \infty} \delta(X,Y)
\]
where: \( \delta(X,Y) = \delta_B(X) \cap Y \) and \( \delta^{-1}(X,Y) = \delta_B(\delta(X,Y)) \cap Y \),
with \( B = \infty \)

4. correct some defects;
\[

\varphi_4 = \text{id}
\]

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

\varphi_5 = \text{a non-morphological selection}
\]

6. reconstruct an image without staff lines.
\[

\varphi_6 = \frac{1}{I} \text{ if } (\varphi_4 \circ \varphi_5)(p) = \text{true} \quad \text{otherwise}
\]

with \( B = 1 \) and with \( R = 0 \)

Reproducible Research
(Evangelization from the Church of Mathematical Morphology)

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

Results and Comparison

<table>
<thead>
<tr>
<th>method</th>
<th>( H_1 )</th>
<th>( H_2 )</th>
<th>( M_1 )</th>
<th>( M_2 )</th>
<th>( L_1 )</th>
<th>( L_2 )</th>
<th>\text{mean}</th>
</tr>
</thead>
<tbody>
<tr>
<td>LRDE</td>
<td>0.96</td>
<td>0.97</td>
<td>0.97</td>
<td>0.97</td>
<td>0.97</td>
<td>0.97</td>
<td>0.97</td>
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<tr>
<td>NUASi-lin</td>
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<td>0.94</td>
<td>0.95</td>
<td>0.95</td>
<td>0.95</td>
<td>0.95</td>
<td>0.94</td>
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<tr>
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<td>0.93</td>
<td>0.93</td>
<td>0.93</td>
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<tr>
<td>Baseline</td>
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<td>0.89</td>
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<tr>
<td>INESC</td>
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<td>0.86</td>
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<td>TAU</td>
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<td>0.82</td>
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<td>0.84</td>
<td>0.83</td>
<td>0.86</td>
<td>0.82</td>
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<tr>
<td>NUS</td>
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<td>0.69</td>
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<td>0.70</td>
<td>0.67</td>
</tr>
<tr>
<td>LRDE-gray</td>
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<td>0.88</td>
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<tr>
<td>INESC-gray</td>
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<td>0.37</td>
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</tr>
</tbody>
</table>

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


