# OPTICAL MEASURE RECOGNITION IN COMMON MUSIC NOTATION

**Gabriel Vigliensoni**
gabriel@music.mcgill.ca

**Gregory Burlet**
gregory.burlet@mail.mcgill.ca

**Ichiro Fujinaga**
ich@music.mcgill.ca

## Abstract

We present an optical measure recognition algorithm capable of recognizing the physical location of barlines in a wide range of scores of common Western music notation (CWMN), deriving the bounding boxes for the measures, and storing these elements in a symbolic music file format (MEI).

When testing the performance of the algorithm on a ground-truth dataset of 100 images of music scores with manually annotated measures, our algorithm obtained an *f*-score of 91 percent with the optimal set of parameters.

## Measure recognition algorithm

### Approach

Our technique for locating the bounding boxes of measures within a music score relies on applying several image processing functions to the key stages of a decomposed OMR situation: image preprocessing and normalization, staffline identification and removal, musical object location, and musical reasoning.

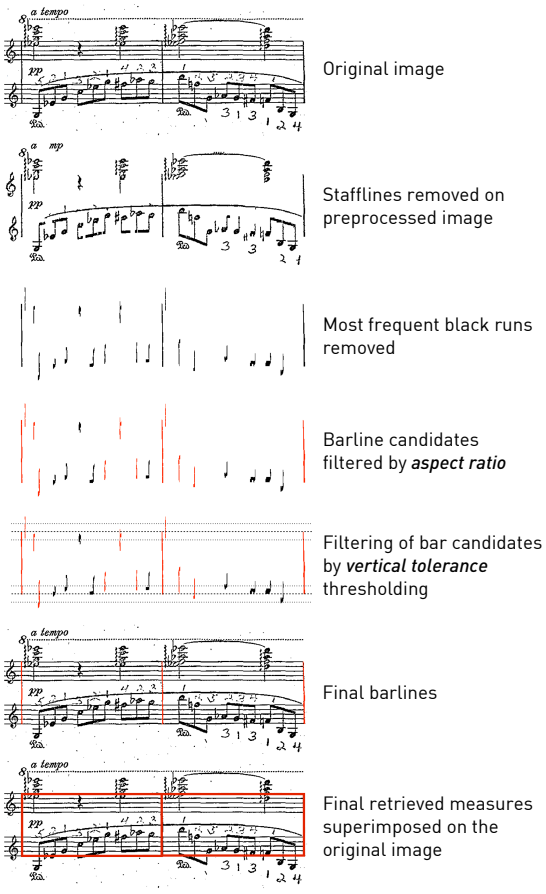



Figure 1. Process of extracting barline candidates.

### Implementation and critical parameters

Our implementation uses *Gamera* as the software framework to perform all pre-processing and filtering in the images, the *MusicStaves* Gamera toolkit to detect and remove staff lines, and MEI as the output symbolic file format. Barline candidates are discarded according to two parameters:

- ***Aspect ratio***: relation between the width and the height of a glyph
- ***Vertical tolerance***: allowed upper bound of the ratio between the height of a bar candidate and the system height where it belongs

### Staff-group hint

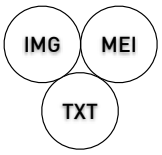
As we want to properly encode the output of our measure recognition algorithm into a symbolic music file, our approach requires prerequisite information supplied by humans, that encodes the structure of the staves on the music score being processed. We called this information the *staff-group hint*.

## Algorithm evaluation

### Ground-truth dataset

As there are no OMR datasets with annotated measure bounding boxes we created our own to evaluate the performance of our system. It consists of:

- 100 pages of common Western music notation randomly extracted from the International Music Score Library Project (IMSLP).
- MEI files with the absolute position of each measure occurring in the entire dataset, annotated by two musically-trained students with a custom-made application.
- TXT files with the staff-group hint for each image .




### Metrics and evaluation

The performance of our optical measure recognition algorithm was evaluated by computing precision, recall, and *f*-score statistics for the automatically recognized measures on each page of music in the ground-truth dataset.

Since we are not only concerned with the number of retrieved measures but also their size and physical position on the page, a measure is considered correctly recognized if its bounding box coordinates are within a quarter of an inch of its corresponding bounding box in the ground-truth measure annotations (measurements in inches are converted to pixels using the *pixels per inch* parameter from the metadata of each image in the dataset).

### Parameter tuning

Experiments were conducted to investigate the impact of different values of the *aspect ratio* and the *vertical tolerance* parameters. We iterated over a set of 100 combinations of these parameters.

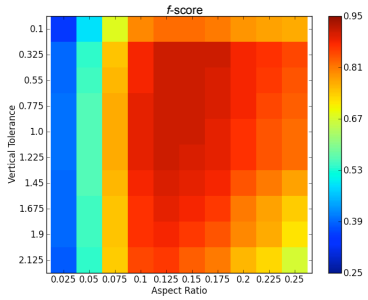



Figure 2. *f*-score results of the optical measure recognition algorithm. The x-axis displays different values of the *aspect ratio threshold* parameter. The y-axis displays different values of the *vertical tolerance threshold* parameter.

### Results

- *Aspect ratio* parameter highly influences the performance of the algorithm
- *Vertical tolerance* parameter does not have a strong impact, especially in the optimal value of the *aspect ratio*.
- With the best settings for the two parameters, our implementation yielded an average of *f*-score of 0.91 for the entire dataset.

### Acknowledgements

The authors would like to thank our great development team for their hard work: Nick Esterer, Wei Gao, and Xia Song. Special thanks also to Alastair Porter for his invaluable insights at the beginning of the project, and Andrew Hankinson for his thorough proofreading.

CIRMMT Centre for Interdisciplinary Research in Music Media and Technology · McGill · DDMAL DISTRIBUTED DIGITAL MUSIC ARCHIVES & LIBRARIES LAB · Social Sciences and Humanities Research Council of Canada · Conseil de recherches en sciences humaines du Canada · Canada