

The SIMSSA Project: Search as access to digital music libraries

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SIMSSA | Single Interface for Music Score Searching and Analysis

- SSHRC Partnership Grant (2014-2021)
- PI: Ichiro Fujinaga (McGill University)
- Partners include the British Library, Bodleian Libraries at Oxford, Bibliothèque Nationale de France, Bavarian State Library, New York Philharmonic Archives, Alexander Street Press, RILM, and RISM Switzerland among others

How it works:

1. Library digitizes scores
2. Optical Music Recognition
3. Symbolic Encoding with MEI
4. Search and Analysis

- How do we access the scores?
- How can we teach computers to read musical scores?
- How will music search and analysis work?

How do we access the scores?

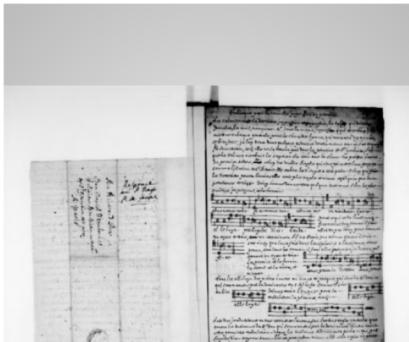
International Image Interoperability Framework



MusicLibs.net

 Search
Search 67323 documents from 12 sources. [>> Pitch Search \(Experimental\)](#)

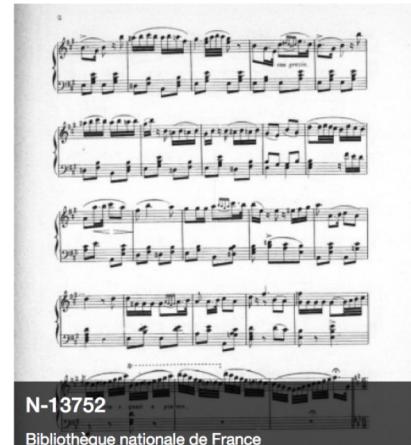
Selected items



Français 20000

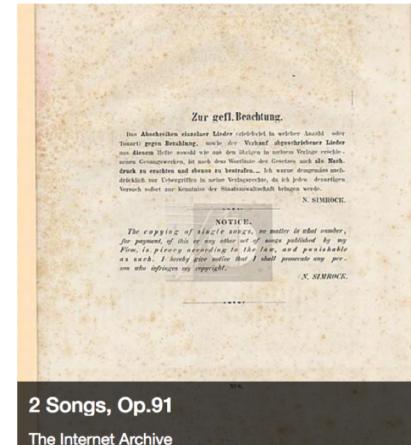
Bibliothèque nationale de France

<i>à venir</i>	Réunion de Musique de Génie de l'Opéra et les deux journées d'Exposition à Paris, Palais du Tribunal Galerie de l'Opéra, N° 8, clé de l'Opéra.
MÉTHODE	SOUTIENS
<i>Bérardin — Pichot, Dobrotvar — Rostal,</i>	<i>Soutiens contre-temps dans deux exercices</i>
	<i>Quatre exercices pour la main droite et quatre pour la main gauche</i>
	<i>Le doigté et le doigté de l'index</i>
	<i>Le doigté et le doigté de l'index</i>
	<i>Le doigté et le doigté de l'index</i>
GAMME	PONT-POURRIE
	<i>Deux exercices</i>
	<i>Dois — une heure</i>
	OUVRIERIES POUR PIANO
	<i>Deux exercices</i>



N-13752

Bibliothèque nationale de France



2 Songs, Op.9

The Internet Archive

How can we teach computers to read
musical scores?

Optical Character Recognition

- Makes images of text machine-readable
- XML

Optical Music Recognition

- Makes images of sheet music machine-readable
- MIDI, MusicXML, MEI

Music Encoding Initiative (MEI)

Singstimme.

Langsam.

V. 1. Du

V. 2. Wie

V. 3. So

V. 4. Wie

Pianoforte.

```
<music>
  <body>
    <mdiv>
      <score>
        <scoreDef meter.count="2" meter.unit="4" key.sig="3s">
          <staffGrp symbol="line">
            <staffDef n="1" label="Singstimme." lines="5" clef.shape="G"
              clef.line="2"/>
            <staffDef n="2" lines="5" clef.shape="G" clef.line="2"/>
            <staffDef n="3" lines="5" clef.shape="F" clef.line="4"/>
          </staffGrp>
        </scoreDef>
      </score>
    </mdiv>
  </body>
</music>
```

Example borrowed from the MEI tutorial at music-encoding.org; music is Robert Schumann's *Der Abendstern*.

Commercial OMR

2

S o n a t e

(in B dur)

für das Pianoforte componirt

von

Serie 10. N° 15.

Schubert's Werke.

FRANZ SCHUBERT.

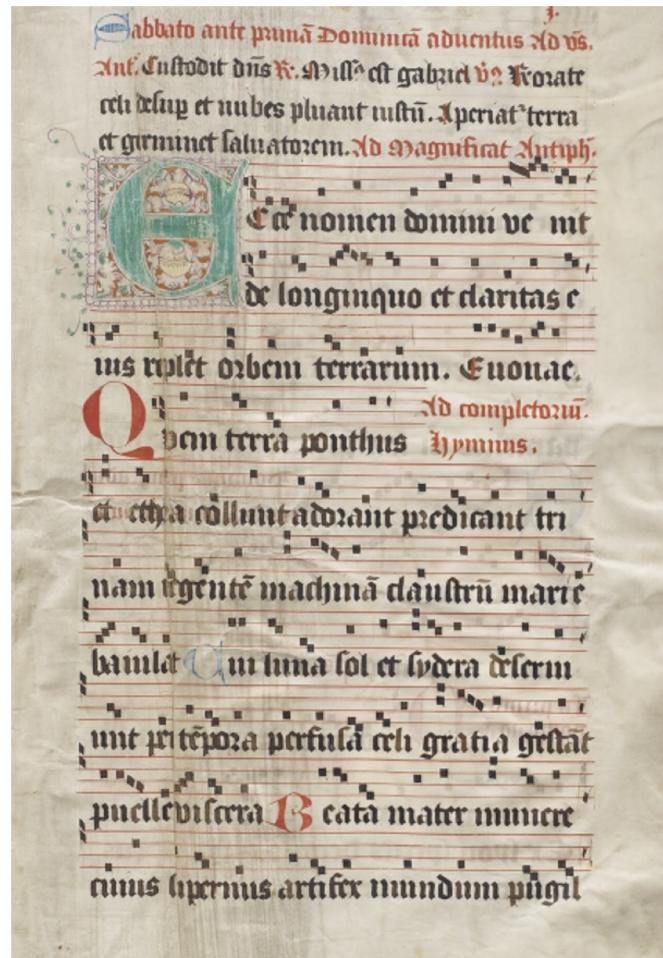
(Componirt im September 1828.)

Molto moderato.

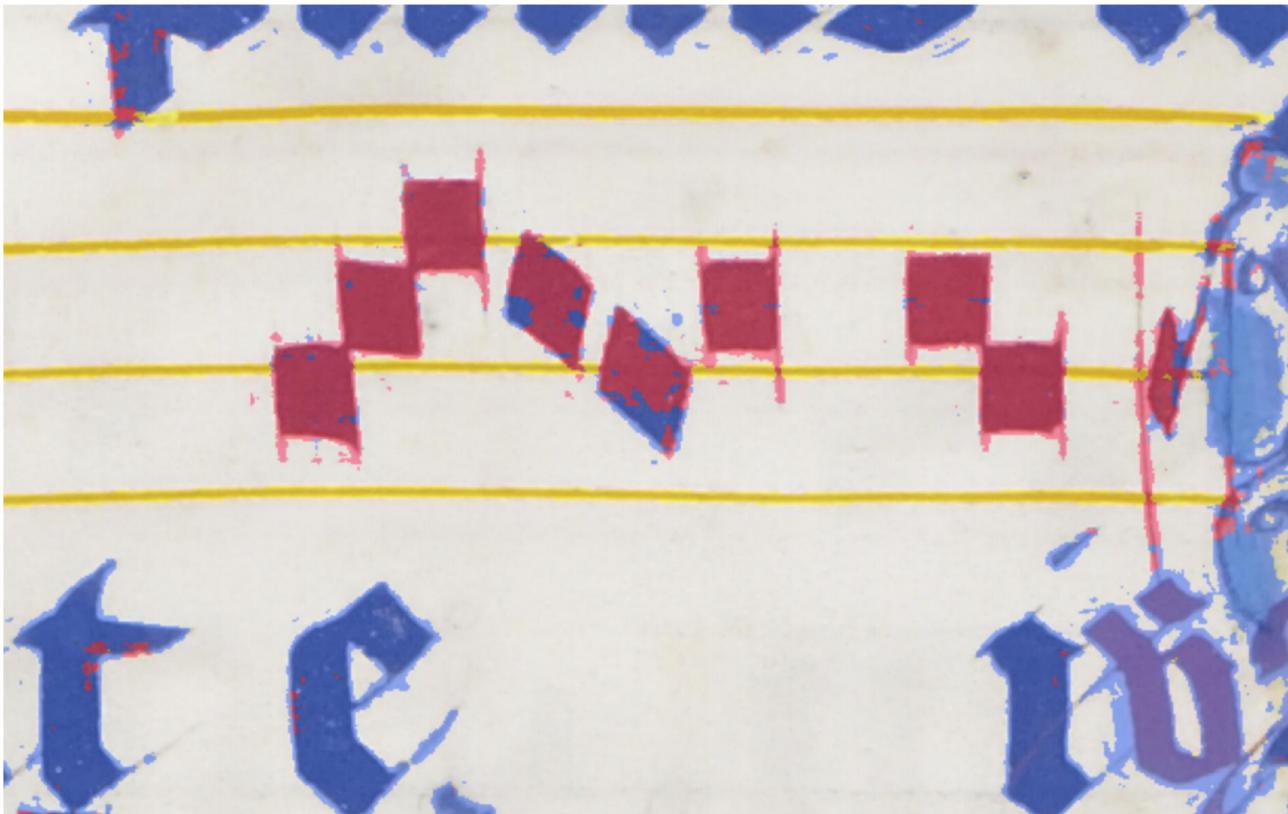
The musical score for Franz Schubert's Sonate in B major, Op. 15, No. 10, begins with a tempo marking of Molto moderato. The music is written for two staves of a piano. The top staff uses a treble clef and common time, featuring a series of chords with dynamic markings 'pp ligato' and 'tr'. The bottom staff uses a bass clef and common time, providing harmonic support. The score is in B-flat major.

Salzинnes Antiphonal CDN Hsmu M2149.L4

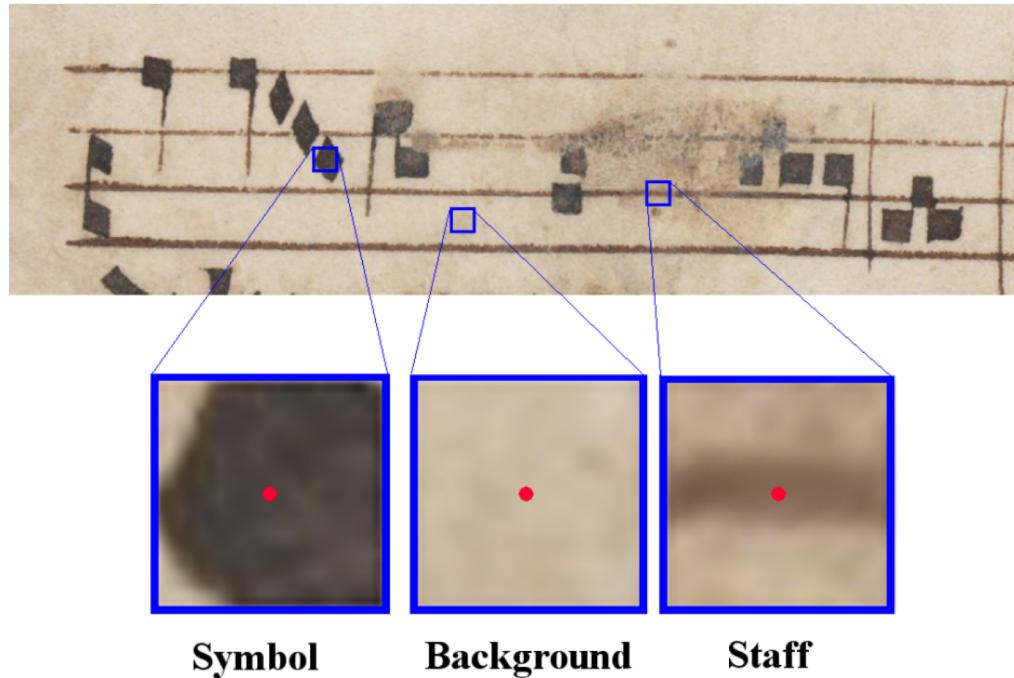
<http://cantus.simssa.ca>



Pixel.js: Making ground truth data



Pixelwise Classification



Interactive Classifier: Identifying glyphs & training our OMR

Interactive Classifier Submit Corrections and Re-Classify Finalize Classification and Save GameraXML Group Glyphs and Re-Classify

Classes

- clef
 - c
- neume
 - climacus
 - clivis
 - podatus
 - porrectus
 - punctum
 - torculus

neume.climacus

neume.clivis

Edit

Connected Components

Class **neume.climacus**

Splitting

Manual ID false

Confidence 0.8058486954409073

Position (1221, 1221)

Dimensions (55, 54)

16

Neon.js: Correcting OMR output

Neon.js File ▾ Hotkey Glossary | Help | Developers | DOMAPI

Editing CF-013

APPEARANCE

Image Opacity:

Glyph Opacity:

MODE

+ Insert Edit

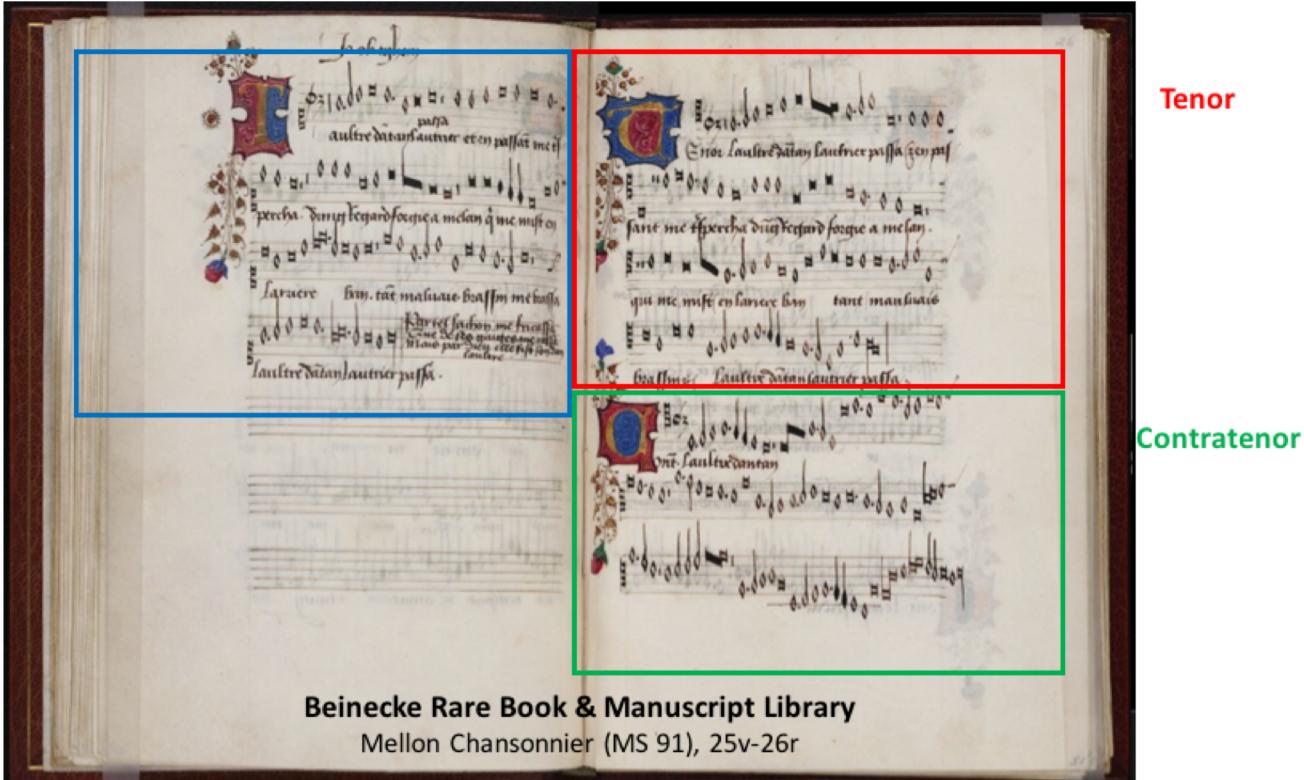
EDIT

Ungroup Merge Systems
 Delete Undo
 Refresh Select All
 Zoom Staff Lock

vñ.
genis domine. Misereberis syon. versus.
Q uia tempus misericordi eius quia
venit tempus Misereberis syon. Hymno.
Deus creator. vñ. Korate
celi desup. Ad magnificat. Ant. N e timcas
maria inuenisti gratiam apud domi
num ecce concipies et paries filium alle

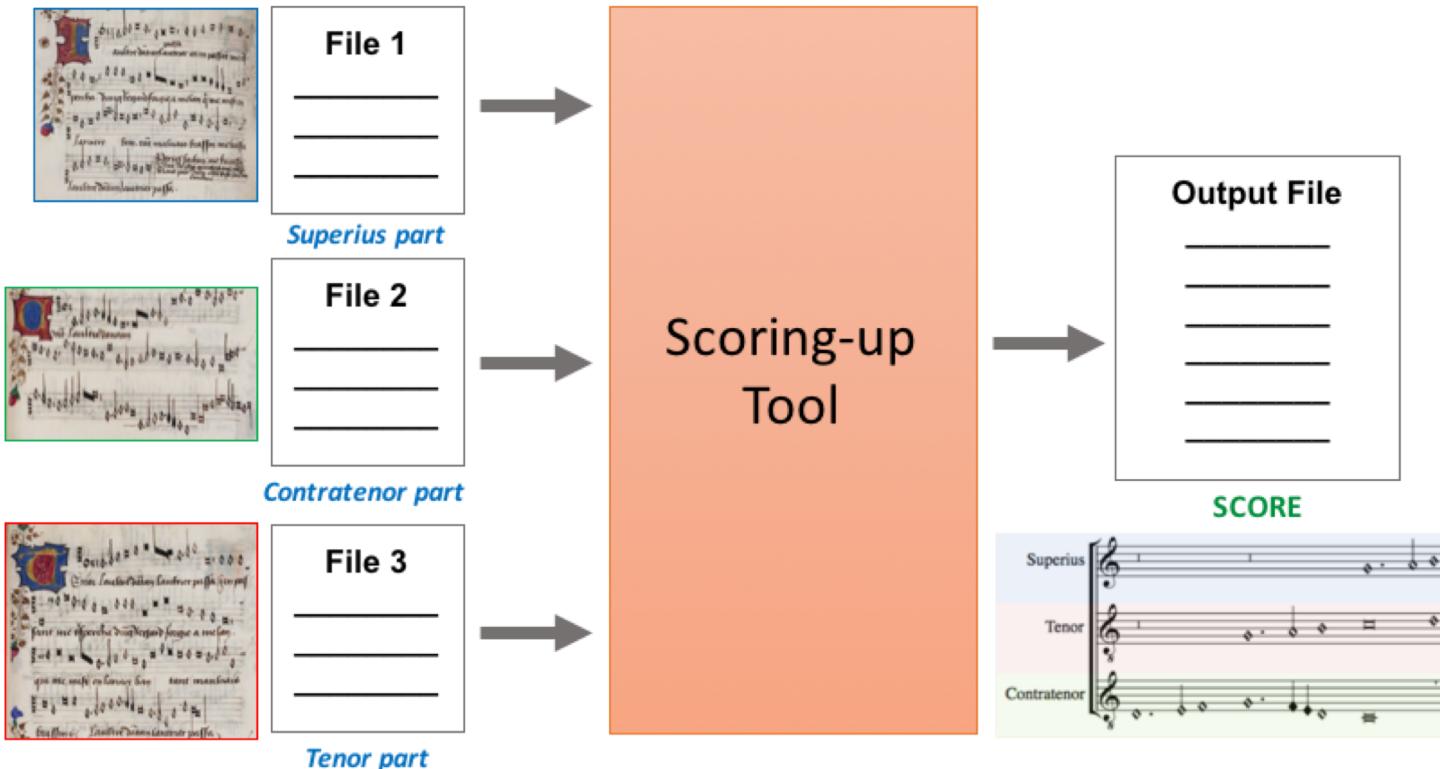
Scoring-up Tool

Superius



Slide courtesy of Thomae Elias, Martha Eladia, Julie Cumming, and Ichiro Fujinaga. "Automatic Scoring up of Music in Mensural Notation." Presented at the 46th Medieval and Renaissance Music Conference, Maynooth, Ireland, July 2018.

Scoring-up Tool



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Crowdsourced OMR Correction



- Making tools more user-friendly
- Collaboration with Partner organizations and user communities

How will music search and analysis work?

Melodic Search

Garfinkle, David & Peter Schubert. “Computer-Assisted Corpus Analysis Finds a Signature Progression in Willaert and Palestrina.” Presented at the 46th Medieval and Renaissance Music Conference, Maynooth, Ireland, July 2018.

1	**kern
2	*clefG2 → Clef
3	*k[] → Key Signature
4	*M4/4 → Time Signature
5	=-
6	4c e a cc
7	4B- f b- dd

The image shows a musical score fragment with a treble clef, a 4/4 time signature, and a key signature of one flat. A red arrow points up from the table to the treble clef, and another red arrow points down from the table to the key signature. A blue arrow points down from the table to the time signature.

<https://patternfinder.elvisproject.ca/>

PatternFinder About Github

```
1 *kern
2 *clefG2
3 *k[]
4 *M4/4
5 =
6 4c 4e 4a 4cc
7 4B- f b- dd
8
```

Search!

Powered by Verovio Humdrum Viewer and Ace text editor

#23 Occurrences

Tu es Petrus (1601) Credo à 6

140

Dies sanctificatus Credo à 4

151

David Garfinkle

Filter out inexact transpositions?

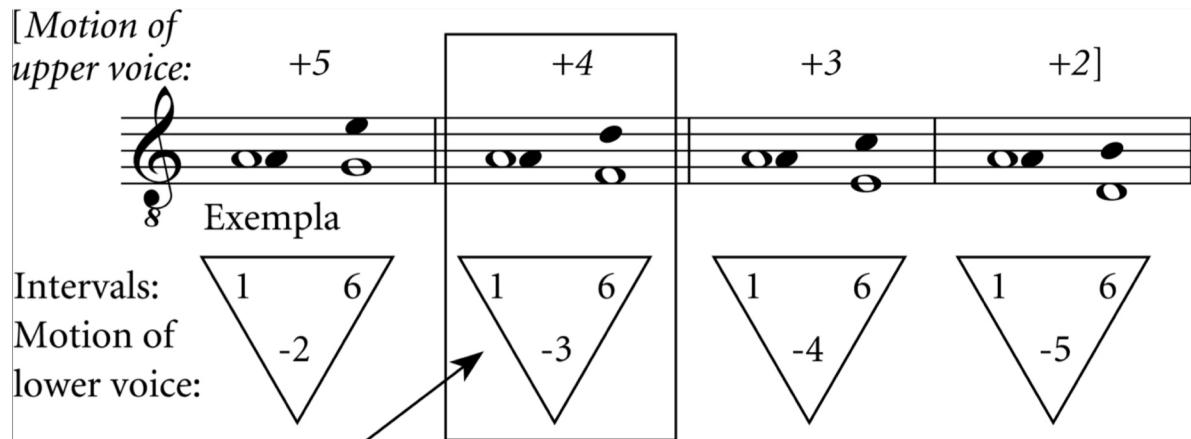
of intervening notes
0 0

Chromatic transpositions mod 12
-12 12

A red circle highlights the 'Filter out inexact transpositions?' checkbox and its associated settings.

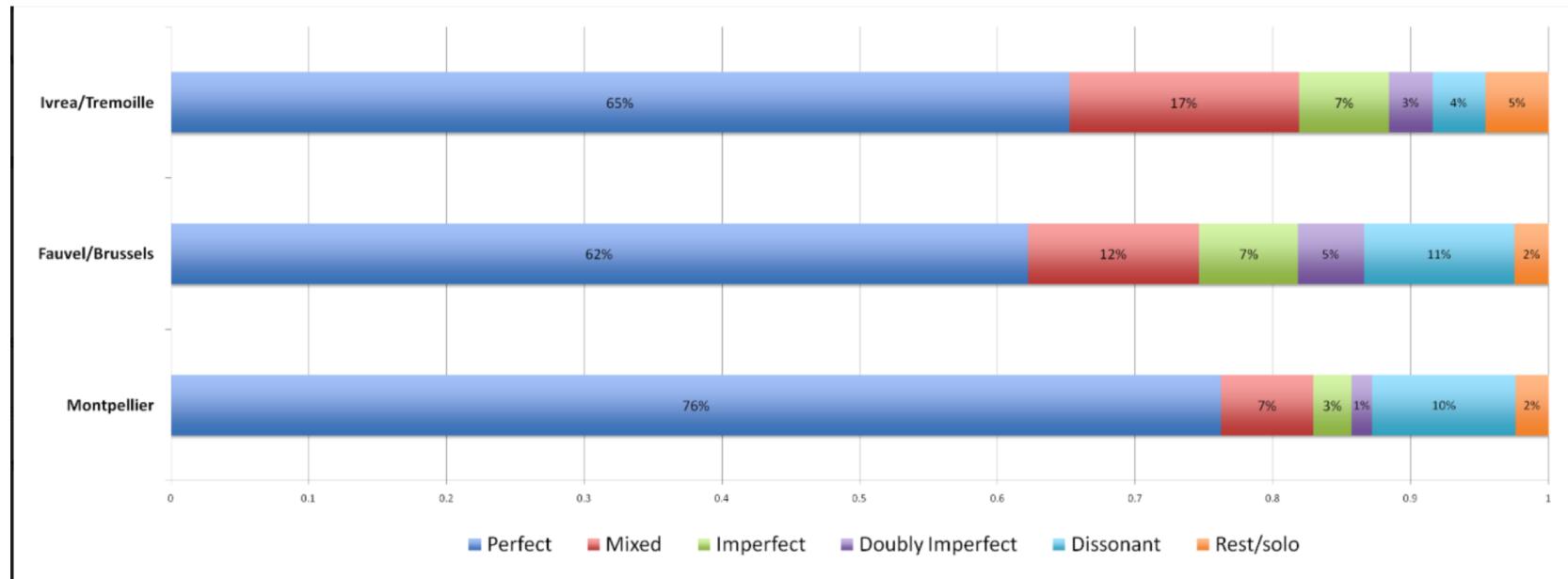
Corpus Studies

Schubert, Peter, and Julie Cumming. "Another Lesson from Lassus: Using Computers to Analyse Counterpoint." Early Music 43, no. 4 (November 2015): 577–86.

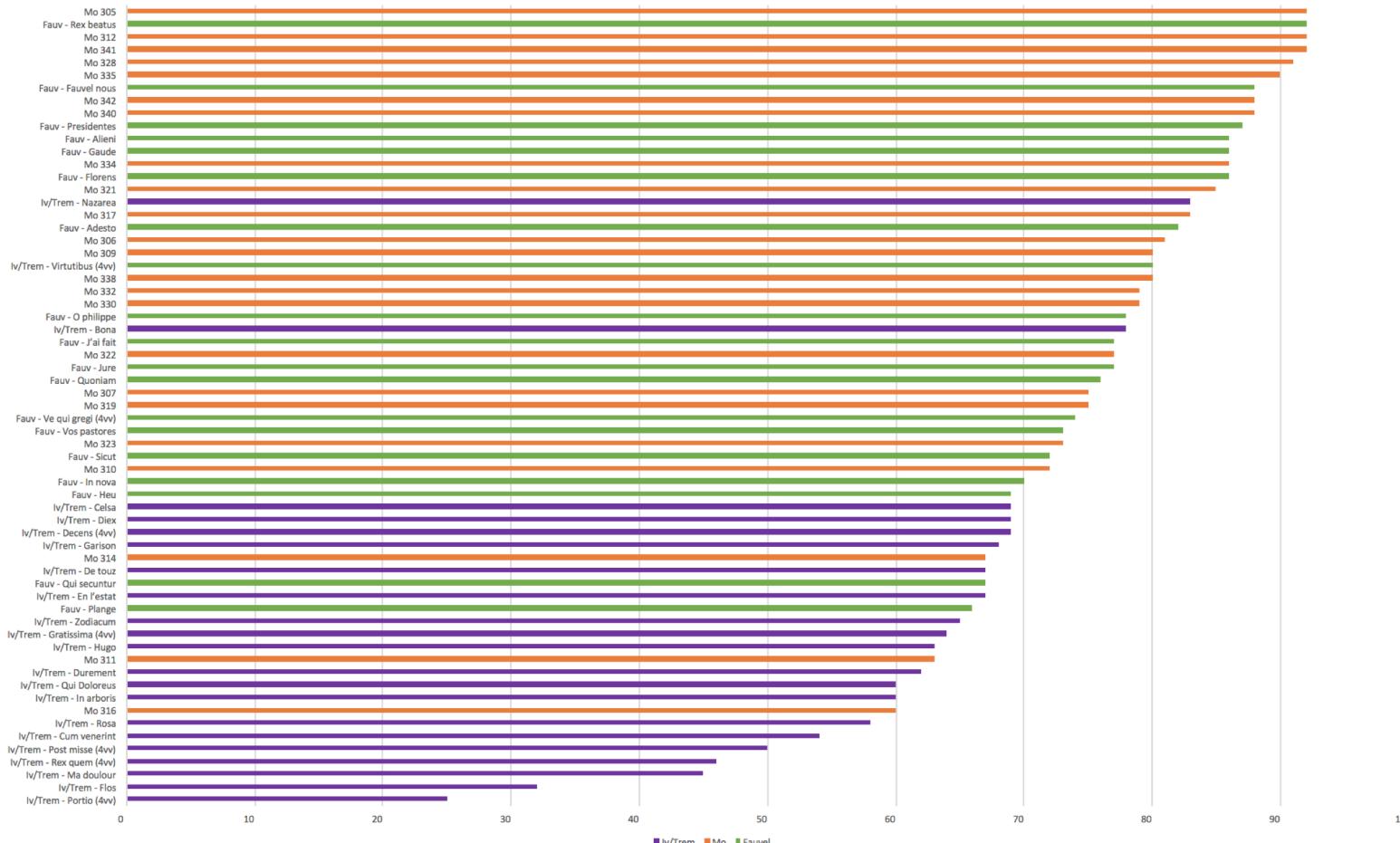


A musical 'word' or 2-gram: 2 vertical intervals linked by a melodic motion of the lower voice (upper voice implied).

Desmond, Karen, Emily Hopkins, and Sam Howes. “Measuring Polyphony: Analysing Stylistic Change in the French Motet Repertory, C1300-1350.” Presented at the Workshop on SIMSSA VIII, McGill University, Montreal, QC, May 21, 2016.



Percentage of perfect sonorities for all pieces



<http://measuringpolyphony.org/>

MEASURING POLYPHONY

DIGITAL ENCODINGS OF LATE MEDIEVAL MUSIC



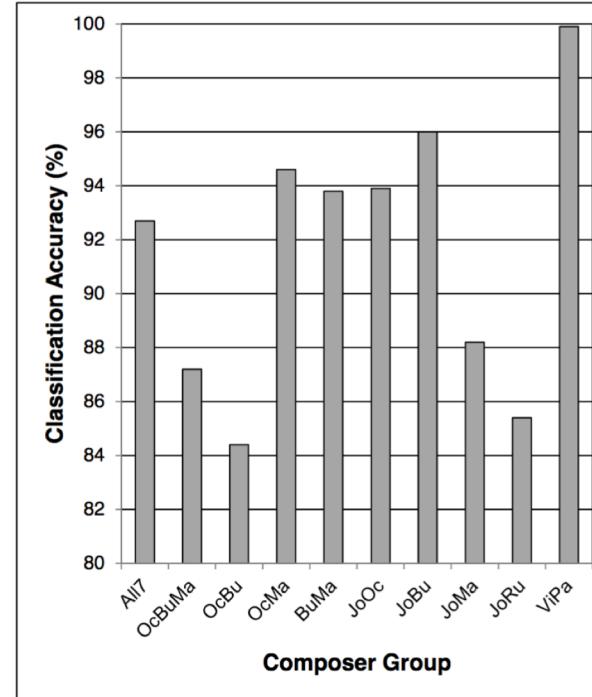
Arthur, Claire, Julie Cumming, and Peter Schubert. “Computer-Assisted Modal Identification.” Presented at the 46th Medieval and Renaissance Music Conference, Maynooth, Ireland, July 2018.

Melodic Data, with comparison sets		
Regression model	Mode	Mode family
test data: leaps and outlines	36%	67%
comparison set 1: remainder notes	39%	68%
comparison set 2: pc distributions	45%	71%
Experiment w/ experts		
experiment 1: pc tallies	35%	65%
experiment 2: pitch, interval size & direction	39%	61%
Full score experiment	67.5%	100%

Machine learning and composer identification

McKay, Cory, Tristano Tenaglia, Julie Cumming, and Ichiro Fujinaga. "Using Statistical Feature Extraction to Distinguish the Styles of Different Composers." Presented at the Medieval and Renaissance Music Conference, Prague, Czech Republic, July 4, 2017.

Composer Group	Classification Accuracy
All 7	92.7%
Ockeghem / Busnoys / Martini	87.2%
Ockeghem / Busnoys	84.4%
Ockeghem / Martini	94.6%
Busnoys / Martini	93.8%
Josquin / Ockeghem	93.9%
Josquin / Busnoys	96.0%
Josquin / Martini	88.2%
Josquin / La Rue	85.4%
Victoria / Palestrina	99.9%



Thank you!

<https://simssa.ca/>
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@simssaproject
@e_a_hopkins



Social Sciences and Humanities
Research Council of Canada

Conseil de recherches en
sciences humaines du Canada



Schulich School of Music
École de musique Schulich

DDMAL

DISTRIBUTED DIGITAL MUSIC
ARCHIVES & LIBRARIES LAB

C I R
M M T Centre for Interdisciplinary Research
in Music Media and Technology

*Fonds de recherche
Société et culture*

Québec



compute | calcul
canada | canada

WEST GRID