

The SIMSSA Project: Search as access to digital music libraries

Emily Hopkins
SIMSSA Project Manager, McGill University

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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

N-13752
Bibliothèque nationale de France

Zur gef. Rechtung:
Das Abschriften einzelner Lieder nachdrücklich in weiteren handschriftlichen oder gedruckten Sammlungen zu verwenden. Wohl die wertvollste Lieder aus diesem Heft would wir uns des Schriftes in seinem Verlage rechtlichen Gesamtrechtes, ist nach dem Willen des Gebers auch als Methodische Abschrift für den Gebrauch im Unterricht und der Freizeit, jedoch vor Übertreibung in seiner Verwendung, da ich jahr. Averschen Vorsicht haben zur Kenntnis der Staatsanwaltschaft bringen werde.
N. SIMROCK

NOTICE:
The copying of single songs, or entire sets of them, published by my firm, is piracy according to the law, and punishable as such. I hereby give notice that I shall prosecute any person who infringes my copyright.
N. SIMROCK.

2 Songs, Op.91
The Internet Archive

a vent, tout Ménage de Musique de l'Orchestre de Naples et toute sorte d'Instruments à Paris Palais du Tribunal Galerie de Pierre Napoléon du Pérou

METHODES	BONATES	Vibrato correcte dans les deux voix clarinette	PONT-POURRI
Methodes à Violoncelle, 1790	Bonates à Violoncelle, 1790	Violoncelle à Violoncelle, 1790	Violoncelle à Violoncelle, 1790
Methodes à Violon, 1790	Bonates à Violon, 1790	Zimmermann violon	Violoncelle à Violon, 1790
Methodes à Flûte, 1790	Bonates à Flûte, 1790	Zimmermann violon	Violon à Violon, 1790
GAMME	DUO-pianoforte	Violoncelle à Violoncelle, 1790	Violon à Violoncelle, 1790

GAMME
DUO-pianoforte

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[SIMSSA](#) | Single Interface for Music Score Searching and Analysis

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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)

The image shows a page from a musical score. At the top, the tempo is marked 'Langsam.'. The first staff is labeled 'Singstimme.' and contains lyrics: 'V. 1. Du', 'V. 2. Wie', 'V. 3. So', and 'V. 4. Wie'. The second staff is labeled 'Pianoforte.' and has a dynamic marking 'p'. Both staves are in common time (indicated by '2' over '4') and have three sharps in the key signature. The music is written on five-line staves.

```
<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.

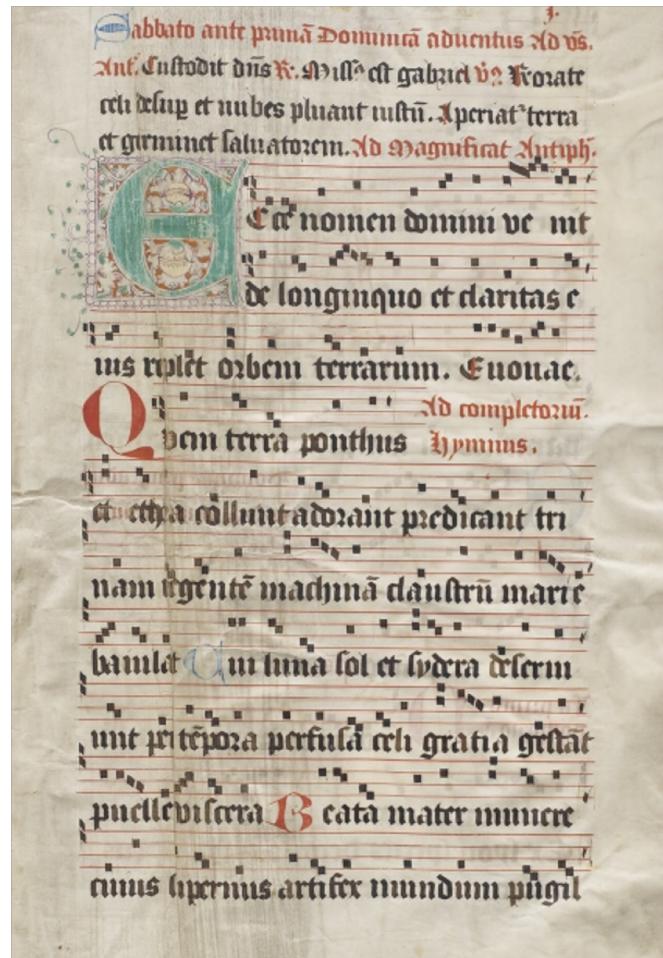
(Componirt im September 1828.)

Molto moderato.

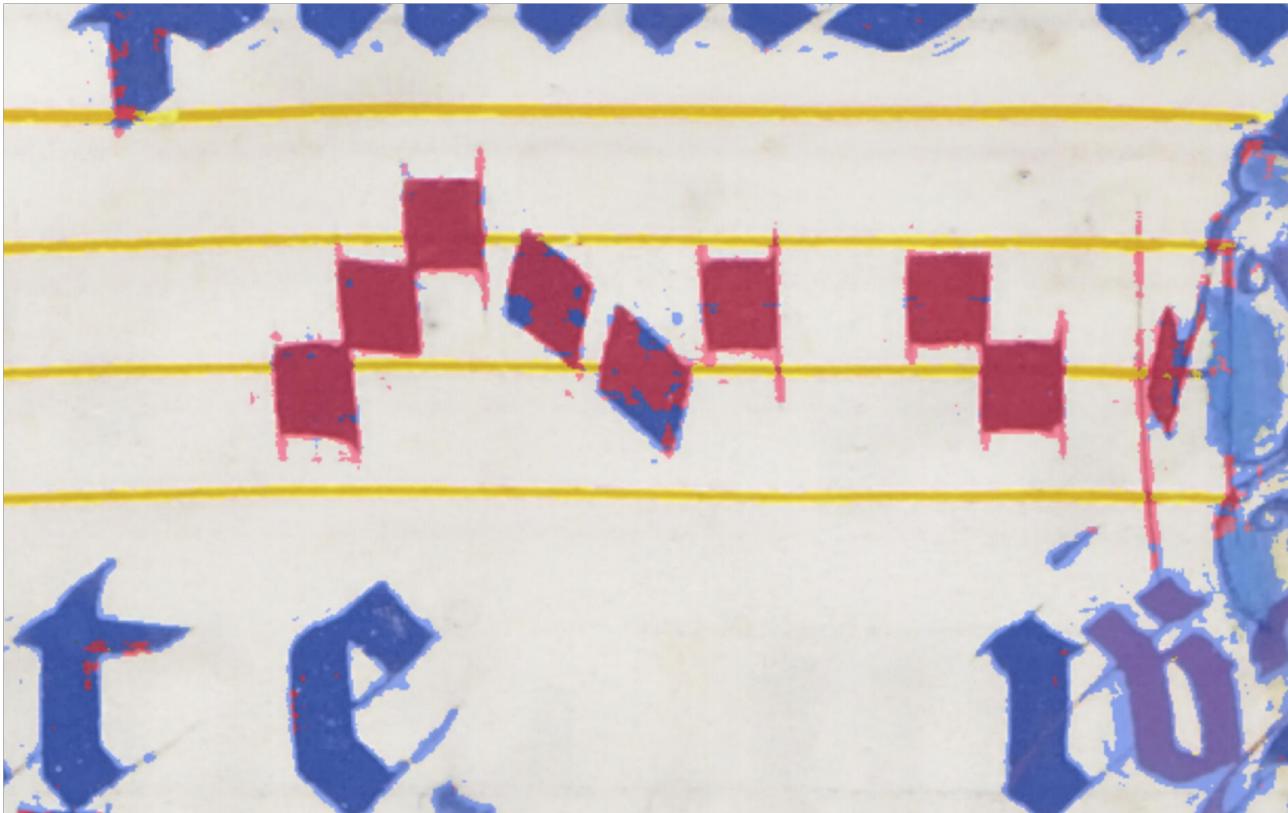
The musical score is for a piano sonata in B major, composed by Franz Schubert. It features two staves: a treble staff and a bass staff. The key signature is one flat (B-flat). The time signature is common time (indicated by 'C'). The tempo is 'Molto moderato'. The dynamics are marked as 'pp ligato' (pianissimo with ligato style) and 'tr.' (trill). The score is divided into measures, with measure numbers 2 and 6 visible at the start of each staff. The music consists of a series of chords and harmonic progressions. The bass staff provides harmonic support with sustained notes and rhythmic patterns. The overall style is characteristic of Schubert's early piano writing.

Salzinnes Antiphonal CDN Hsmu M2149.L4

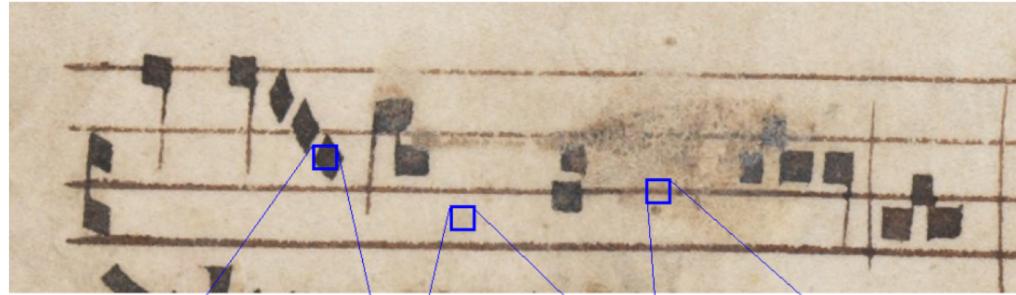
<http://cantus.simssa.ca>



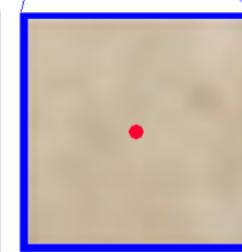
Pixel.js: Making ground truth data



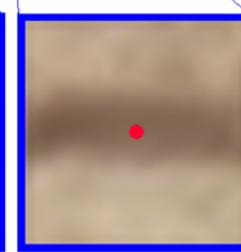
Pixelwise Classification



Symbol



Background



Staff

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** Update

Splitting Split x Split

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 | DDMA

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 ma tempus miserendi eius quia

venit tempus Misereberis syon. Hymno.

O eis creator. ola. Korate

celi desup. Ad Magnificat. Ant.

et unicas

maria inuenisti gratiam apud domi

num ecce concipies et paries filium alle

Scoring-up Tool

Superius



Tenor



Contratenor



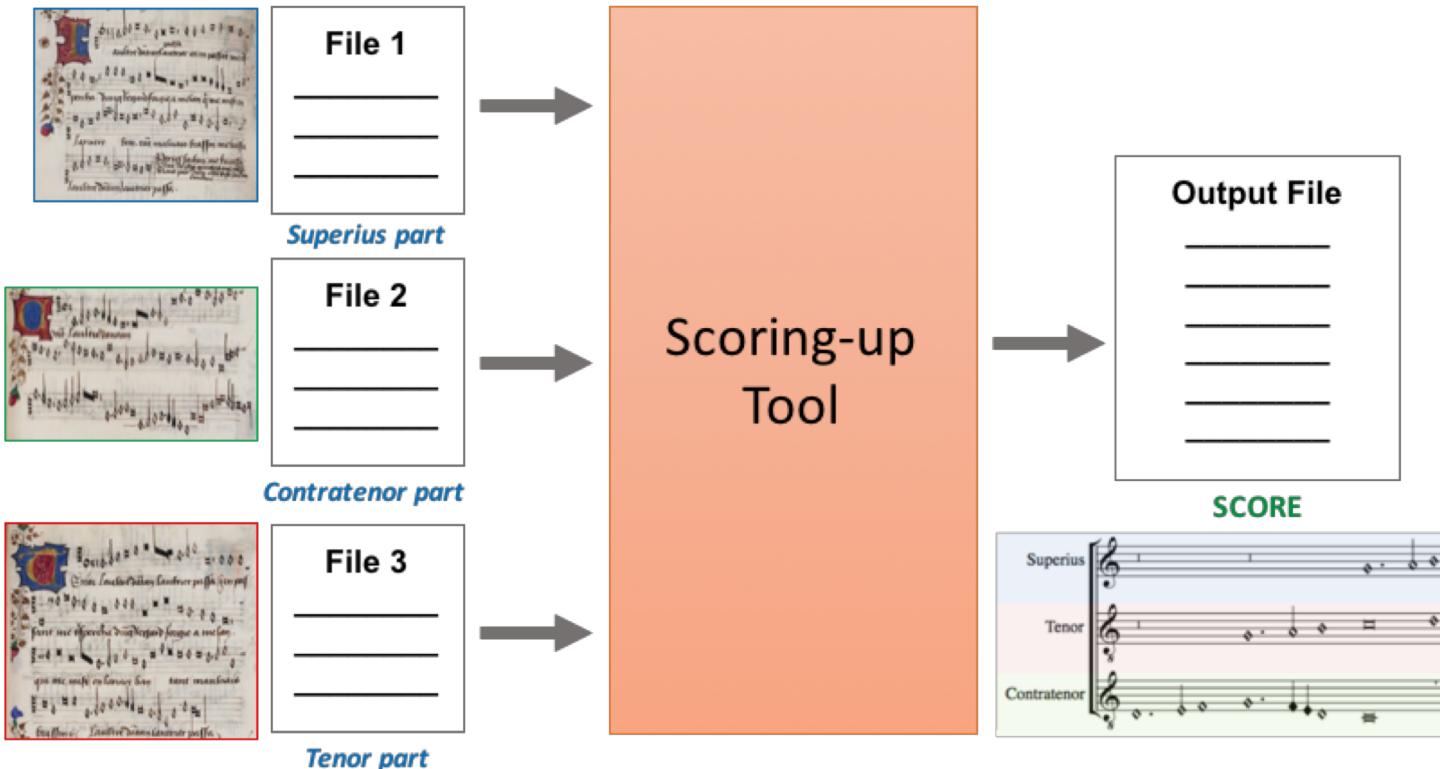
Beinecke Rare Book & Manuscript Library

Mellan Chansonnier (MS 91), 25v-26r

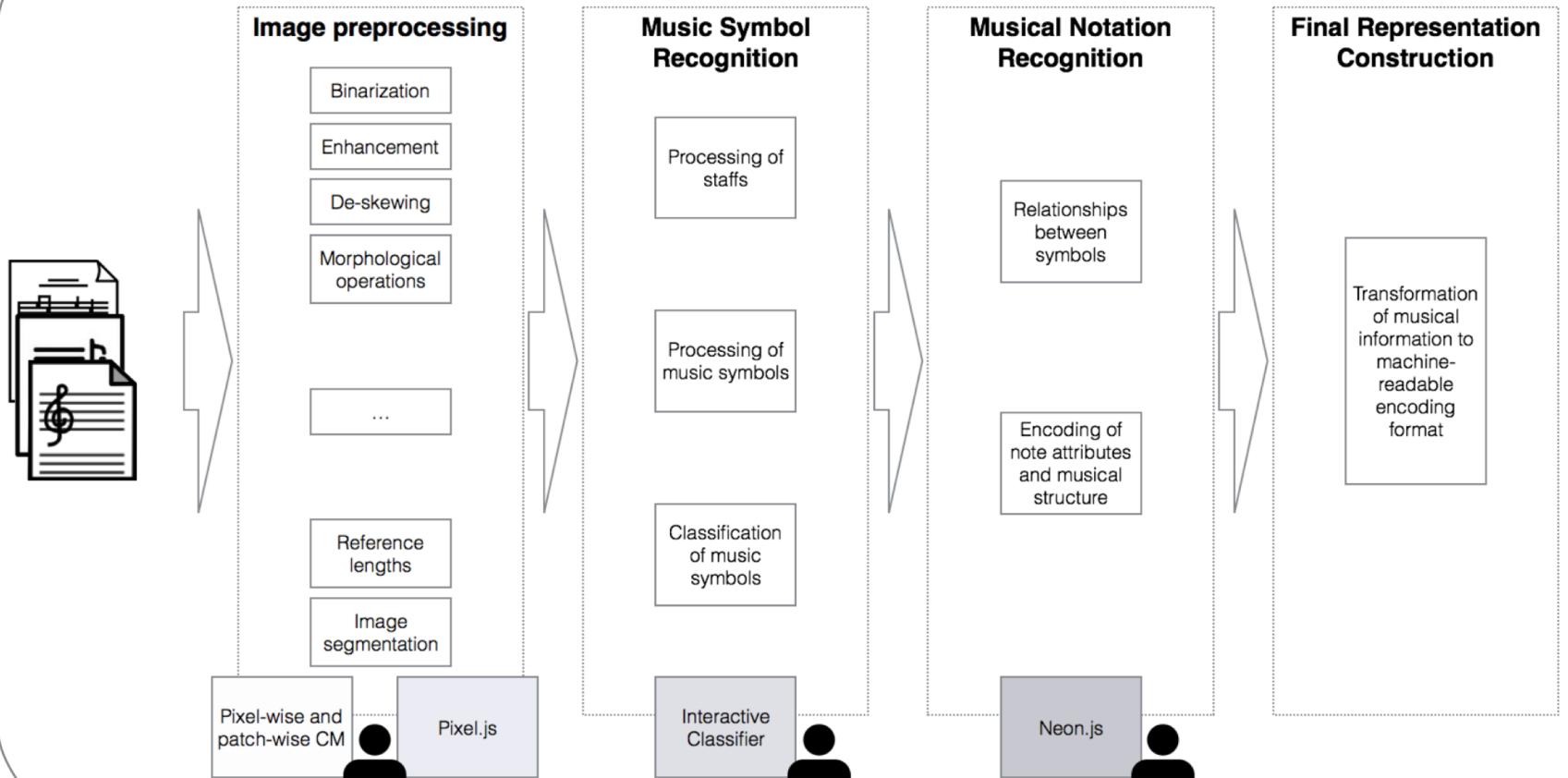
2

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



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.



RODAN: Web-based distributed OMR workflow system (Hankinson 2014)

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 figure shows a musical score fragment with a treble clef, a 4/4 time signature, and a key signature of one sharp (F#). A red arrow points up from the table to the 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 by David Garfinkle

```
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

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 the associated slider controls.

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.

[*Motion of upper voice:* +5 +4 +3 +2]

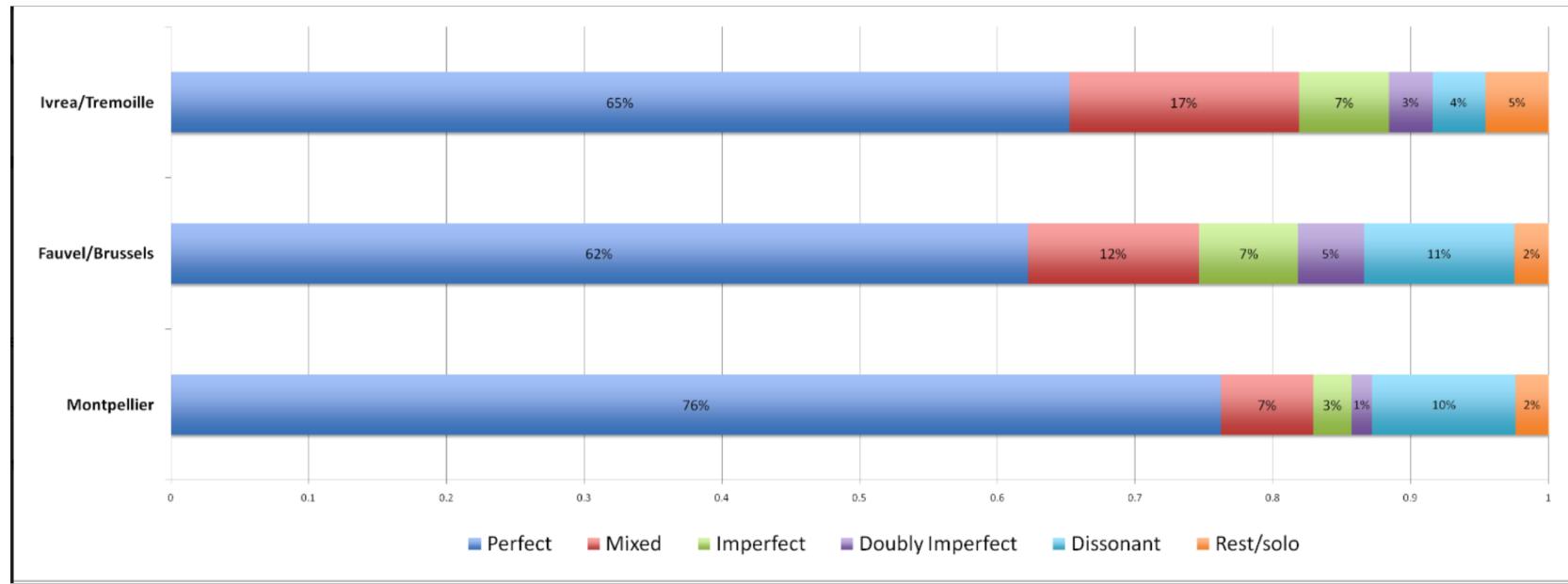
Exempla

Intervals:
Motion of lower voice:

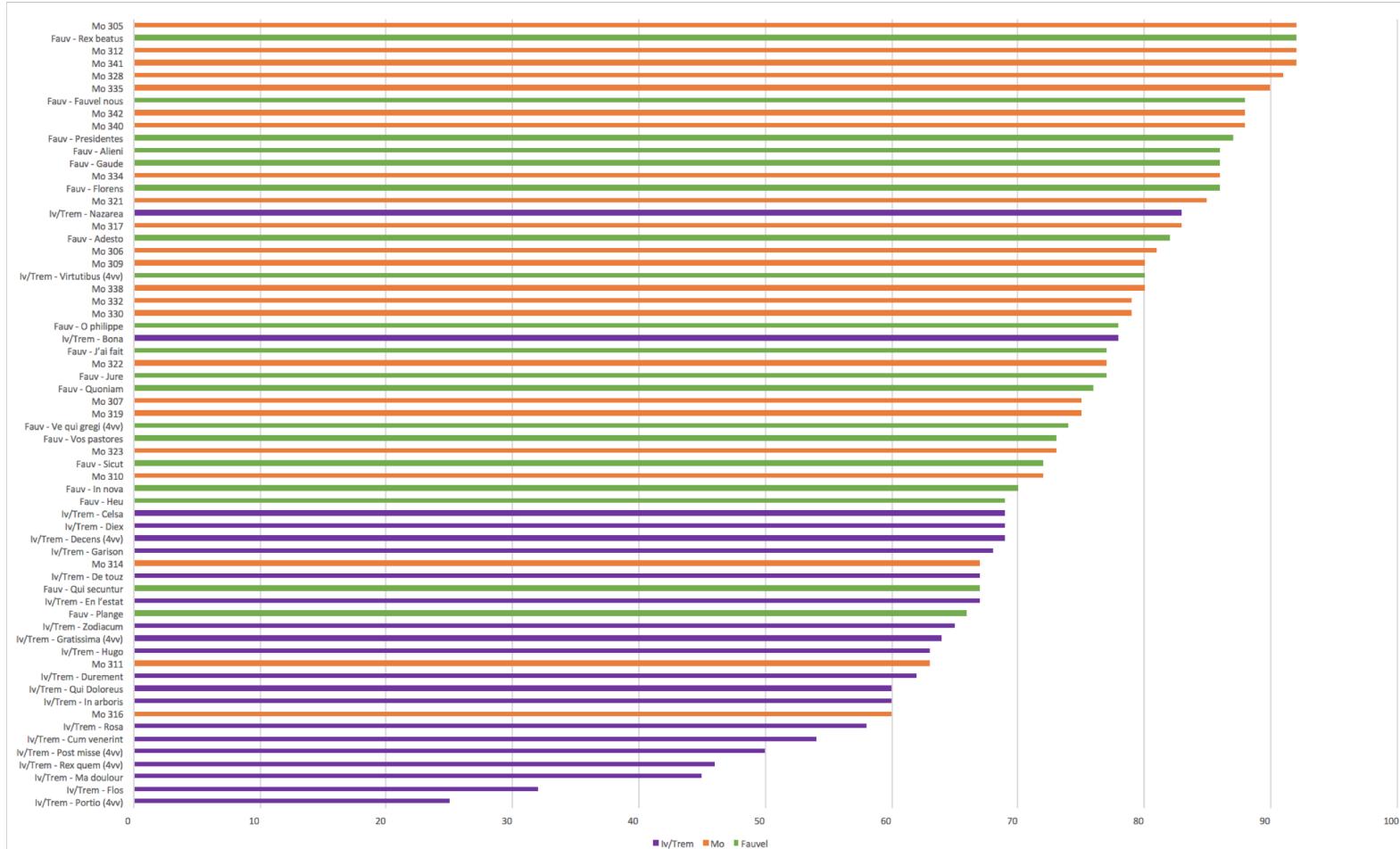
A musical 'word' or 2-gram: 2 vertical intervals linked by a melodic motion of the lower voice (upper voice implied).

The diagram illustrates a musical 'word' or 2-gram. It shows four measures of music with implied upper voices. The first measure has an implied upper voice of +5. The second measure has an implied upper voice of +4. The third measure has an implied upper voice of +3. The fourth measure has an implied upper voice of +2. Below the music, there are four triangles representing vertical intervals. The first triangle has 1 at the top and -2 at the bottom. An arrow points from this triangle to the second measure's implied upper voice of +4. The second triangle has 1 at the top and -3 at the bottom. The third triangle has 1 at the top and -4 at the bottom. The fourth triangle has 1 at the top and -5 at the bottom.

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



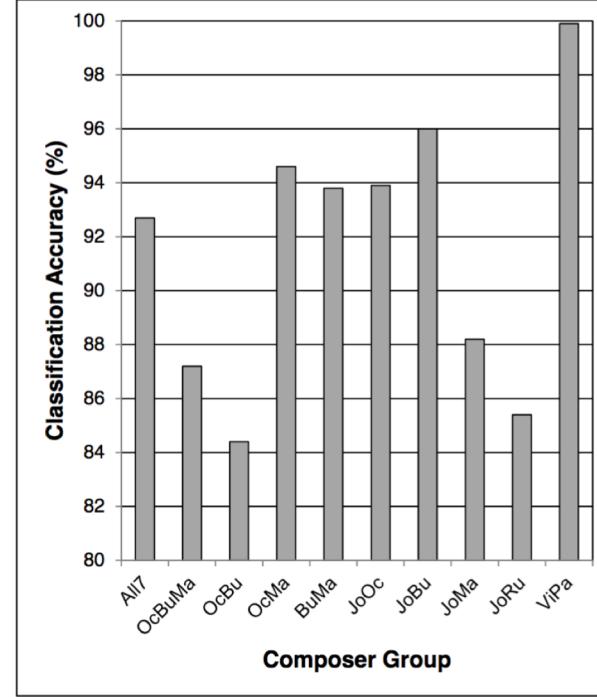
Arthur, Claire, Julie Cumming, and Peter Schubert. “Computer-Assisted Modal Identification.” Presented at the 46th Medieval and Renaissance Music Conference, Maynooth, Ireland, July 2018.

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/>
emily.hopkins@mcgill.ca

@simssaproject
@e_a_hopkins



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M M T

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in Music Media and Technology

Fonds de recherche
Société et culture

Québec



compute | calcul
canada | canada



WEST GRID