

Musicología digital: Trabajando en la intersección entre musicología y tecnología

Martha E. Thomae Elías

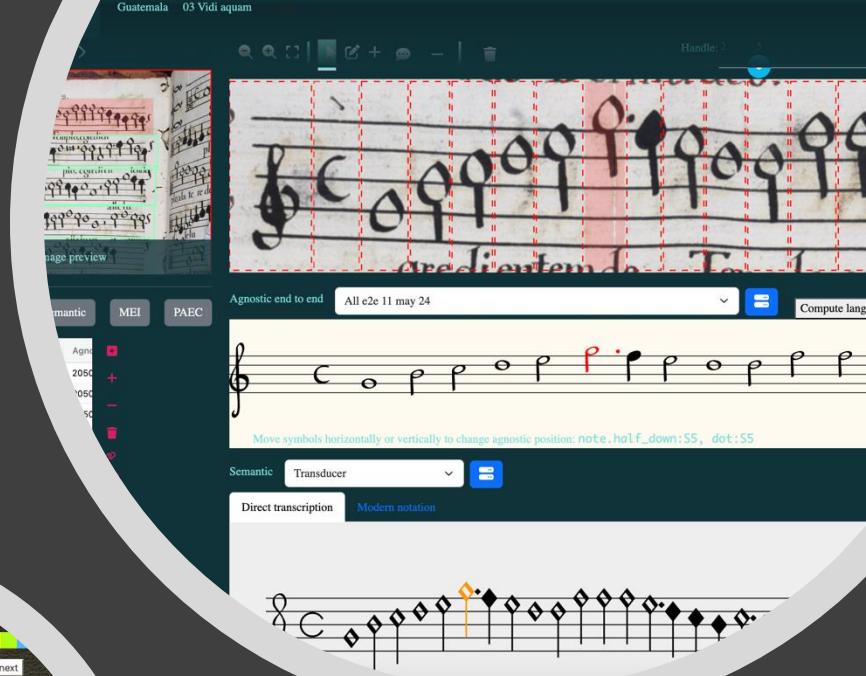
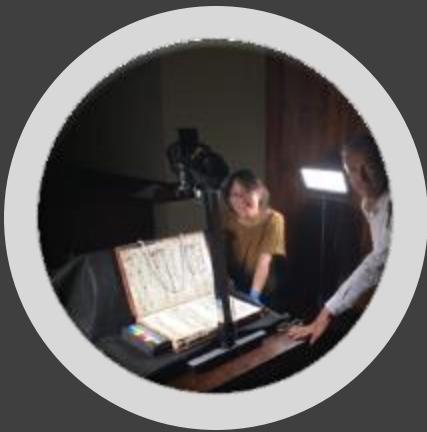
Dra. tecnología musical (McGill University)

Centro de Estudios de Sociología e Estética Música (CESEM)

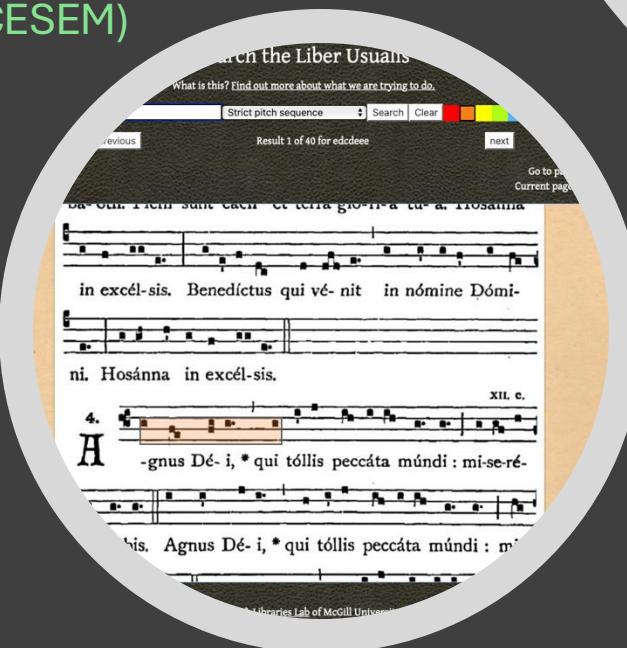
Universidade NOVA de Lisboa

Institut d'Estudis Catalans

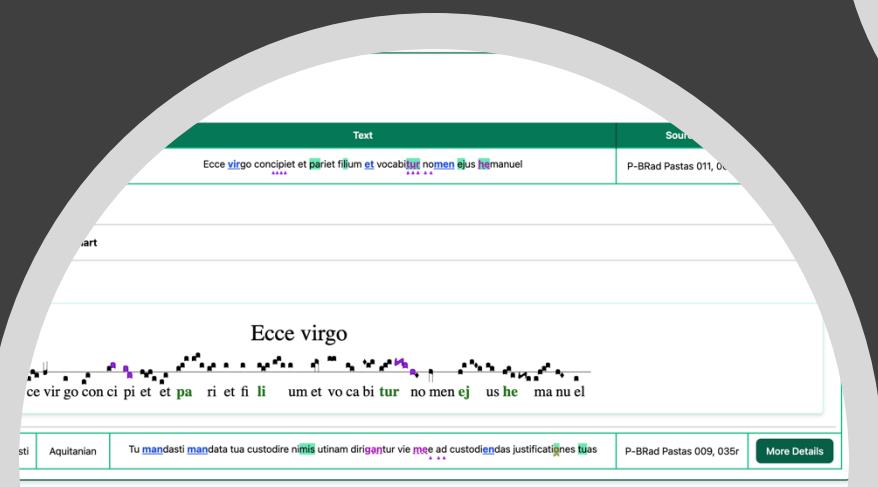
25 de Febrero del 2025



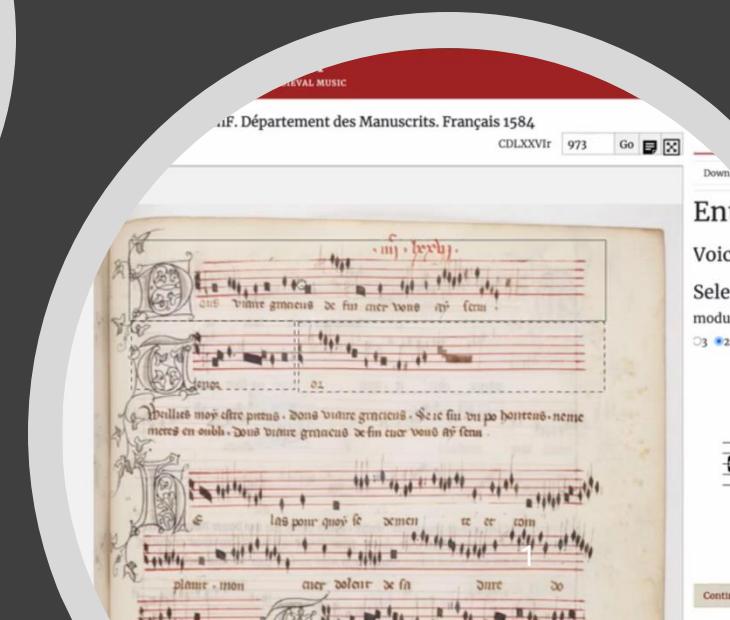
The screenshot shows a digital interface for music transcription. At the top, there's a toolbar with various icons. Below it, a header bar displays "Guatemala 03 Vidi aquam" and "Handle: 2". The main area contains a musical score with several staves. Red dashed boxes highlight specific notes across different staves, likely indicating points of interest for analysis. On the left side, there's a sidebar with tabs for "Agnostic", "MEI", and "PAEC". At the bottom, there are buttons for "Semantic" and "Transducer", and dropdown menus for "Direct transcription" and "Modern notation".



This screenshot shows a digital manuscript viewer displaying a page from the "Liber Usualis". The page features Gregorian chant notation on four-line red staves. The Latin text of the chant is written below the staves. A small orange circle highlights a specific note in the fourth staff. The interface includes a search bar at the top and navigation buttons like "previous" and "next".



This screenshot shows a digital manuscript viewer displaying a page from the "Brad Pastas". The page contains musical notation on red staves and Latin text. A specific note in the first staff is highlighted with a blue box. The interface includes a "Text" tab at the top where the Latin text "Ecce virgo concepit et pariet filium et vocabili nomen eius Emmanuel" is displayed. There are also tabs for "Source" and "Part".



This screenshot shows a digital manuscript viewer displaying a page from the "Département des Manuscrits. Français 1584". The page features musical notation on red staves and Latin text. A specific note in the first staff is highlighted with a blue box. The interface includes a "Text" tab at the top where the Latin text "Dons virum gracieus de fin tuer venu ay feru" is displayed. There are also tabs for "Source" and "Part".

Objetivo

- Compartir mi experiencia trabajando en la intersección de los campos de **musicología** y **tecnología**
- Explorar cómo estas tecnologías transforman el estudio y preservación del repertorio de música antigua
 - Canto llano
 - Notación neumática
 - Notación cuadrada
 - Polifonía (período de transición entre el Ars antiqua y Ars nova, el Renacimiento)
 - Notación mensural (negra y blanca)

Enforcar en tres experiencias

- Asistente de investigación en el proyecto **Single Interface for Music Score Searching and Analysis (SIMSSA)** en el laboratorio de investigación **Distributed Digital Music Archives and Libraries (DDMAL, McGill University)** **PI: Ichiro Fujinaga**
- Mi propia investigación de doctorado: digitalización y codificación de los libros de polifonía de la Catedral de Guatemala
- Experiencia postdoctoral para el proyecto **Echoes from the Past: Unveiling a Lost Soundscape with Digital Analysis** (Universidade NOVA de Lisboa) **PI: Elsa De Luca**

**Experiencia trabajando en el
SIMSSA Project en el DDMAL
Lab (Universidad de McGill)**

SIMSSA Project

“Single Interface for Music Score Searching and Analysis”

- Proyecto financiado por el Social Sciences and Humanities Research Council (SSHRC) de Canadá
- Una interface que permita la búsqueda de piezas por su contenido musical (Google Books para música)
 - OCR = Optical Character Recognition
- Tecnologías de reconocimiento óptico de caracteres musicales (OMR = Optical Music Recognition)
- Enfoque: notación antigua (no está protegida por derechos de autor)

<https://simssa.ca>

Search the Liber Usualis

What is this? Find out more about what we are trying to do.

edcdeee Strict pitch sequence Search Clear

previous

Result 1 of 40 for edcdeee

next

Go to page Go

Current page: 157 of 2340

in excél-sis. Benedíctus qui vé-nit in nómine Dómi-ni. Hosánna in excél-sis.

XII. c.

4. **A**gnus Dé-i, * qui tollis peccáta móndi : mi-se-ré-re nóbis. Agnus Dé-i, * qui tollis peccáta móndi : mi-

Ejemplo: Liber usualis
<https://liber.simssa.ca/>

Search the Liber Usualis

What is this? Find out more about what we are trying to do.

edcdeee

Strict pitch sequence

Search

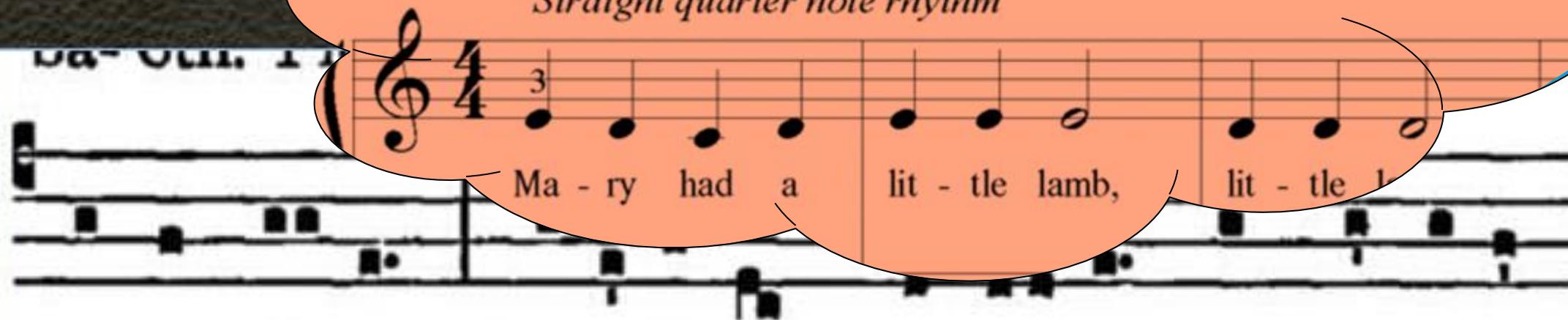
Clear

previous

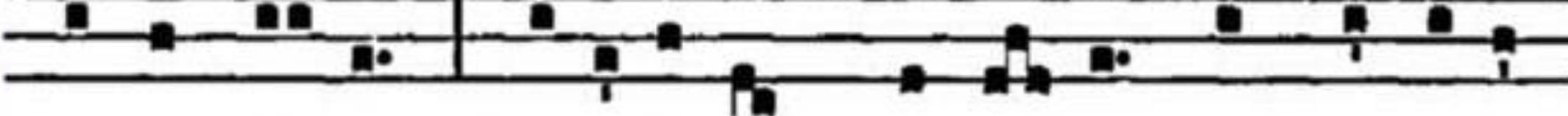
Mary Had a Little Lamb

Tradit

Straight quarter note rhythm



in excél-sis. Benedíctus qui vé- nit in nómine I



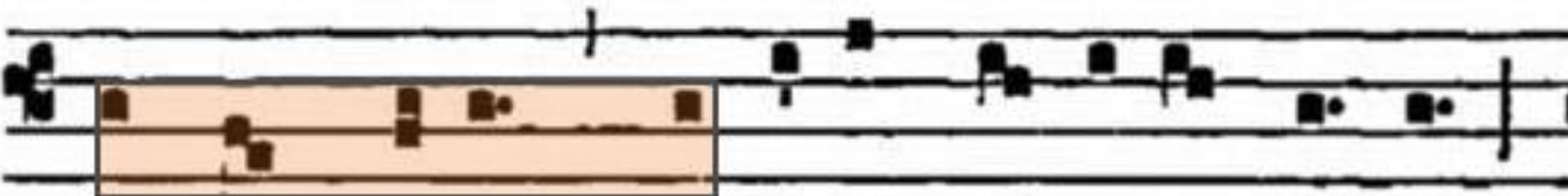
in excél-sis. Benedíctus qui vé-nit in nómine I



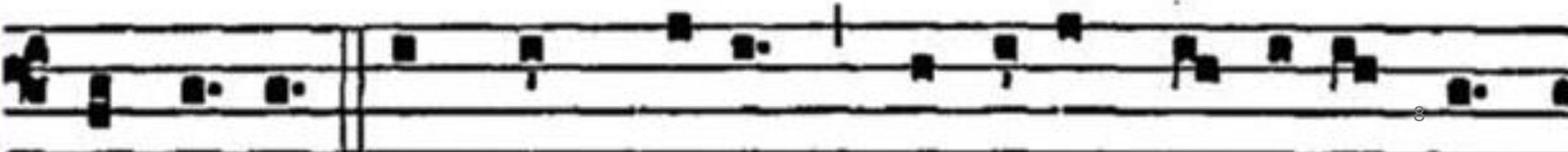
ni. Hosánnna in excél-sis.

4.

A

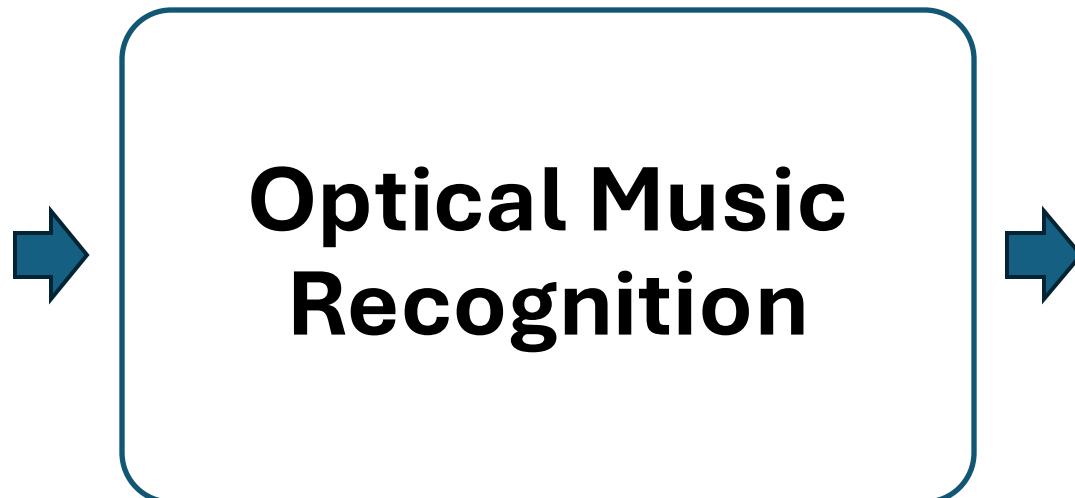


-gnus Dé-i, * qui tollis peccáta mundi : m



Reconocimiento óptico en música

- OMR = Optical **M**usic Recognition
- OCR = Optical **C**haracter Recognition
→ Se utiliza en **textos** digitales
- El OMR se usa en documentos de música digitales



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      <title>Missa sobre las voces</title>
      <composer>Cristobal de Morales</composer>
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    <pubStat>
    </pubStat>
  </fileDesc>
  <music>
    <body>
      <div>
        <score>
          <scoreDef>
            <staffGrp n="1" lines="5" label="superius" notationType="mensural">
              <clef Line="2" shape="G"/>
              <ensur sign="C" tempus="2" prolation="2"/>
            </staffGrp>
            <scoreDef>
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                  <rest dur="semibrevis" loc="4"/>
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                  <note dur="minima" pname="b" oct="4"/>
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                  <note dur="minima" pname="d" oct="5"/>
                </layer>
              </staff>
            </scoreDef>
          </score>
        </div>
      </score>
    </body>
  </music>

```

Reconocimiento óptico en música

- **Entrada:** Imágenes digitales de documentos musicales
- **Salida:** Representación simbólica
 - Legible por el ordenador
- **Formatos simbólicos:** MIDI, MusicXML, MEI
- **MEI:** notación antigua, conexión con facsimiles



Optical Music
Recognition

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  <meiHead>
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            </staff>
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      </div>
    </body>
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```

Reconocimiento óptico en música

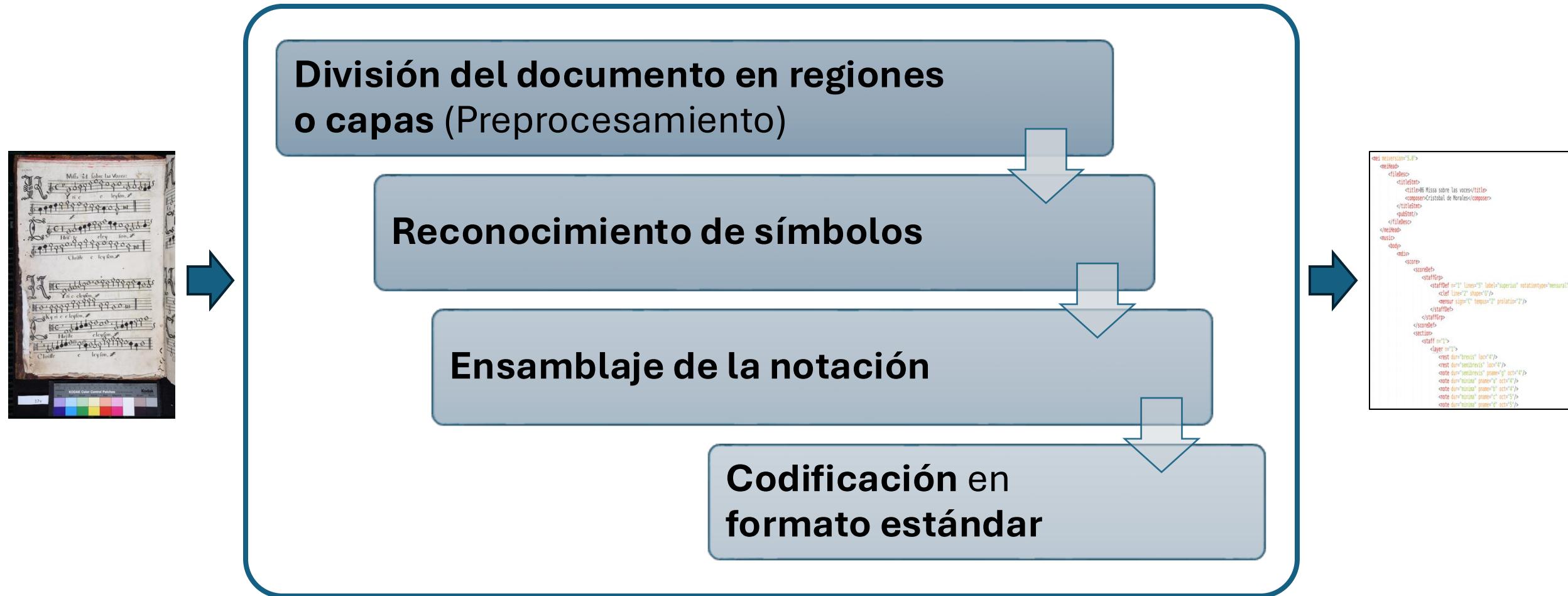


Optical Music
Recognition

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    <composer>Cristobal de Morales</composer>
  </fileDesc>
</meiHead>
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      <score>
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          <note dur="minima" pname="b" oct="4"/>
          <note dur="minima" pname="c" oct="5"/>
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        </layer>
      </staff>
    </div>
  </body>
</music>
```

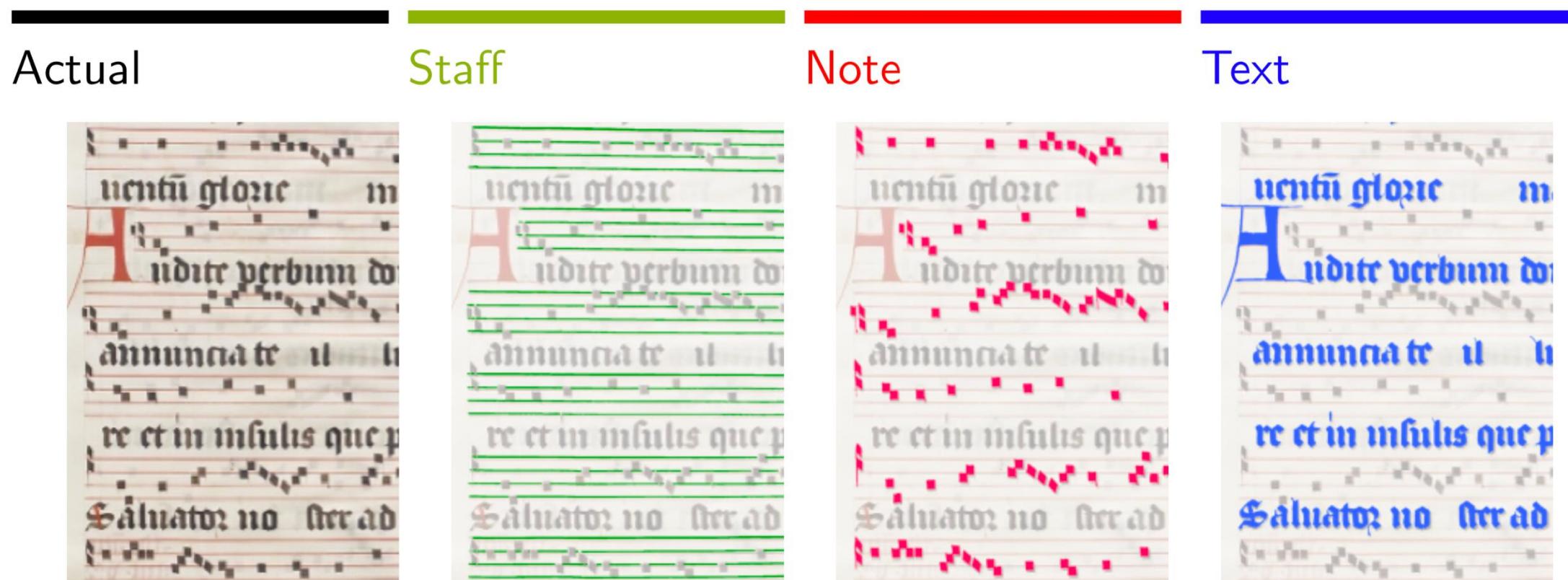
- Es un proceso de varios pasos

Reconocimiento óptico en música

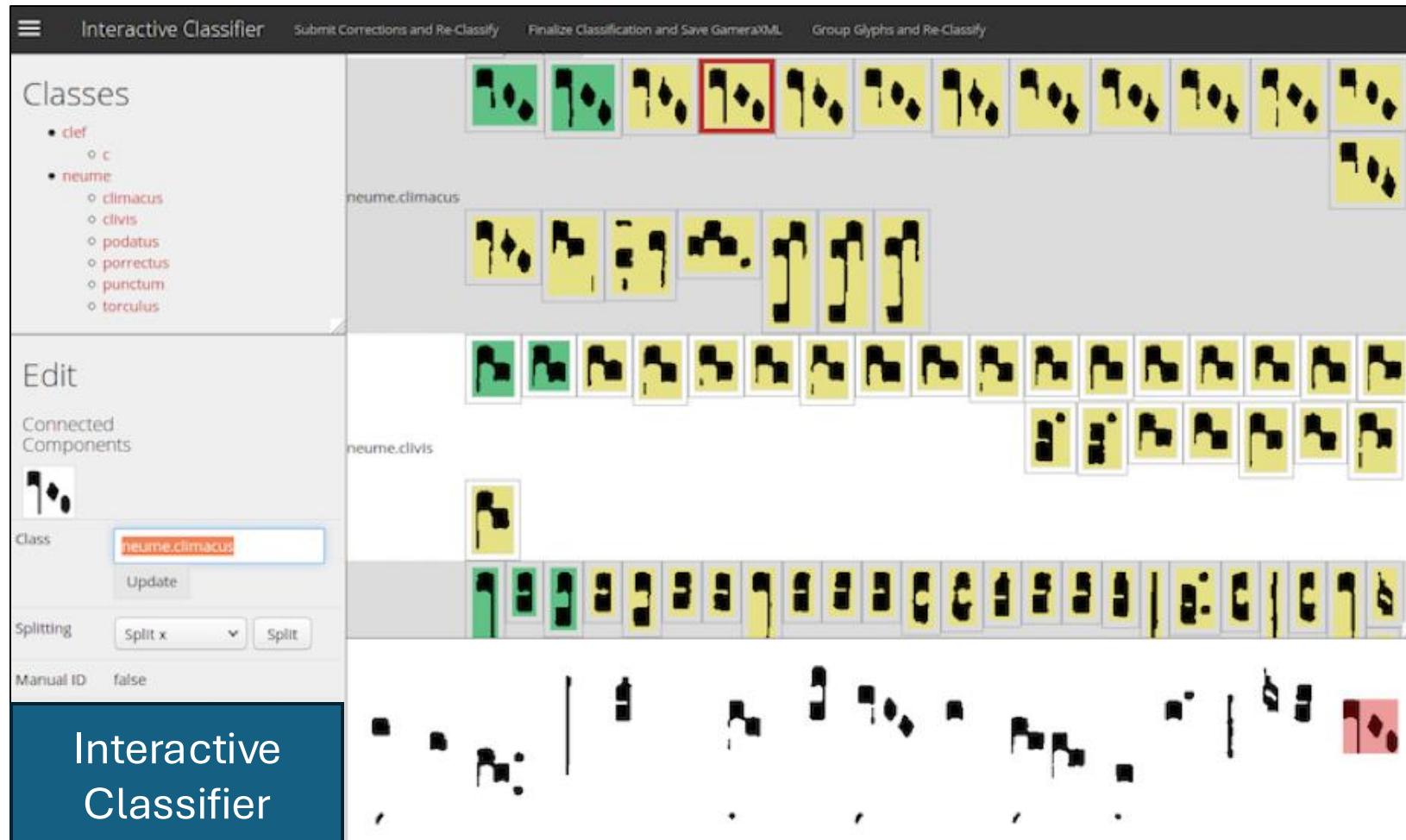


1. Preprocesamiento

División del documento en regiones o capas
(para su posterior procesamiento)



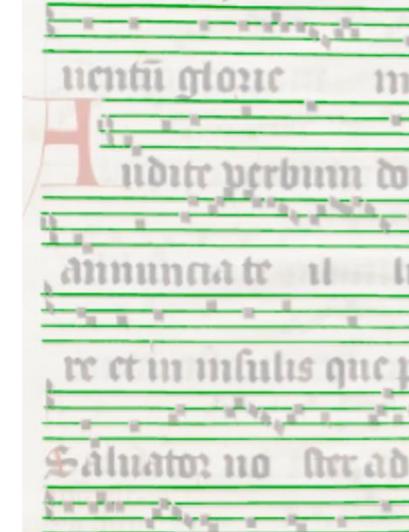
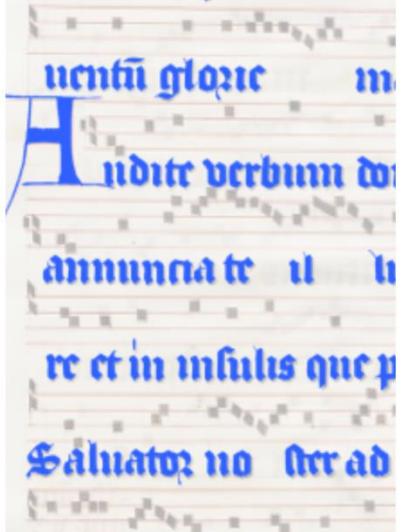
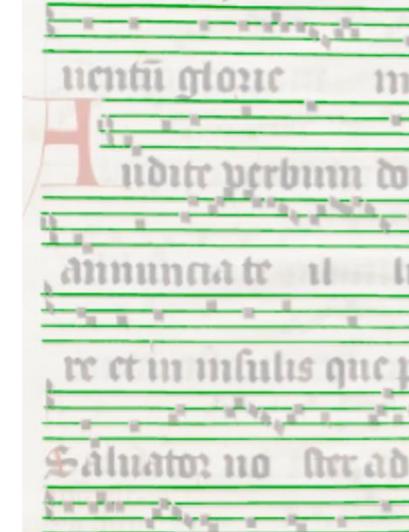
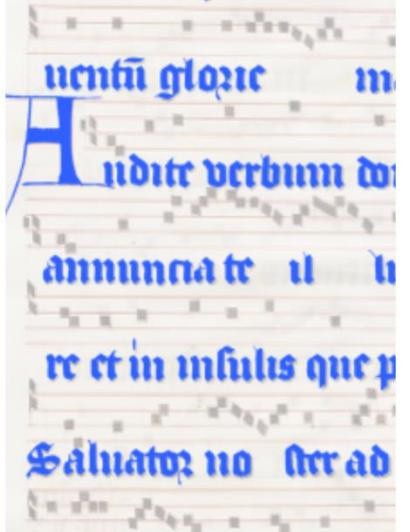
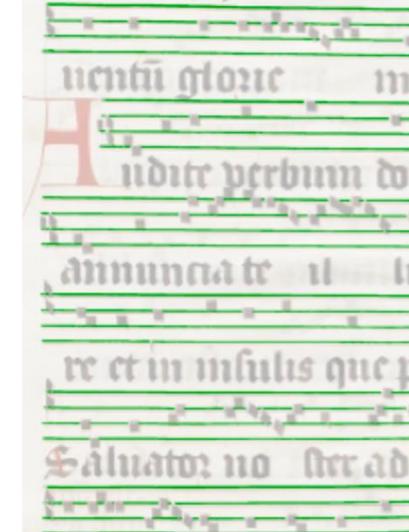
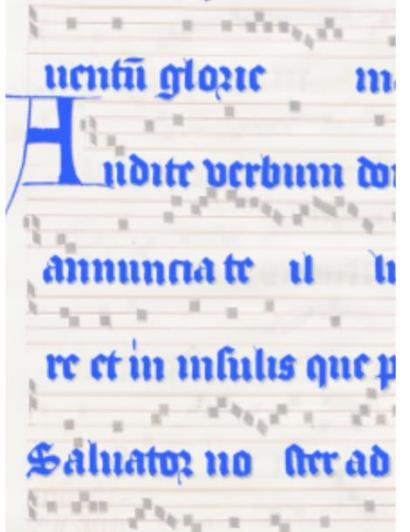
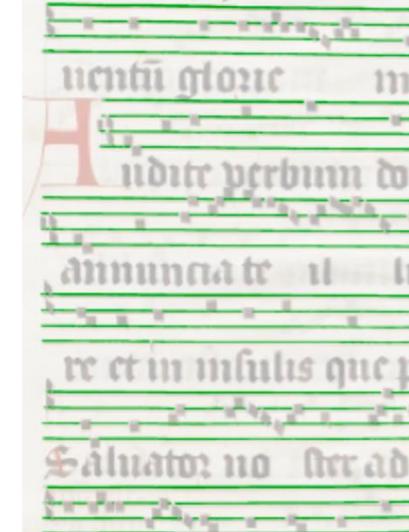
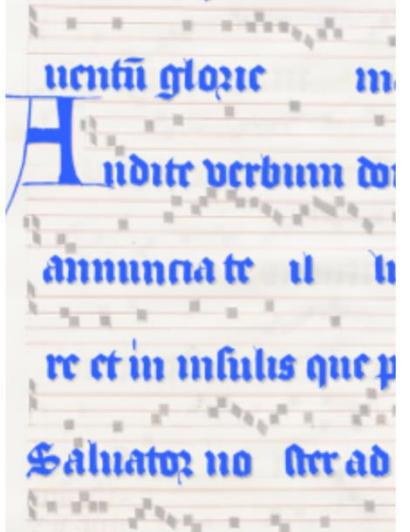
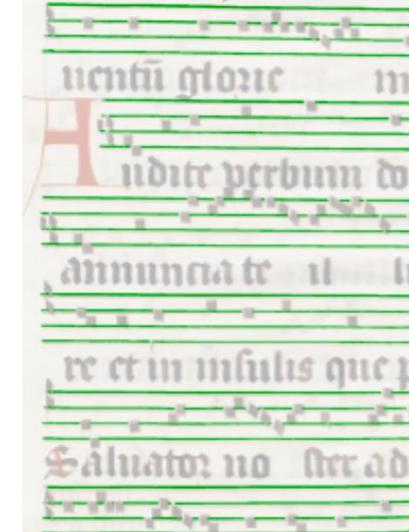
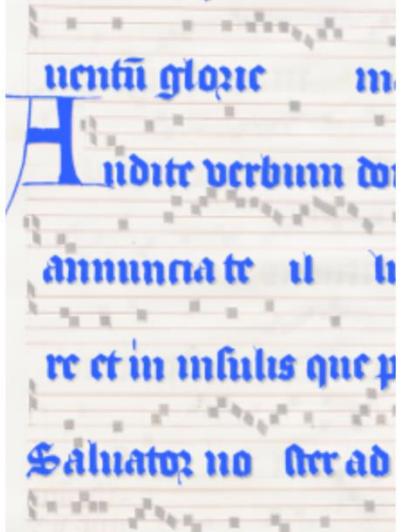
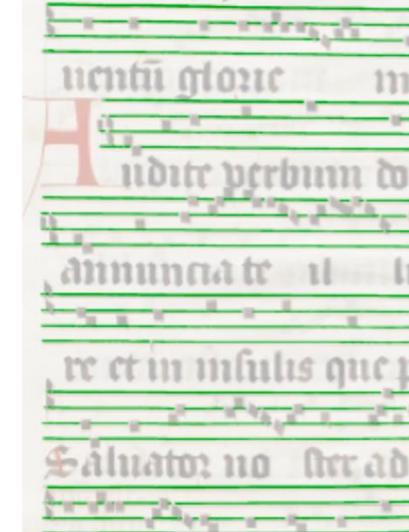
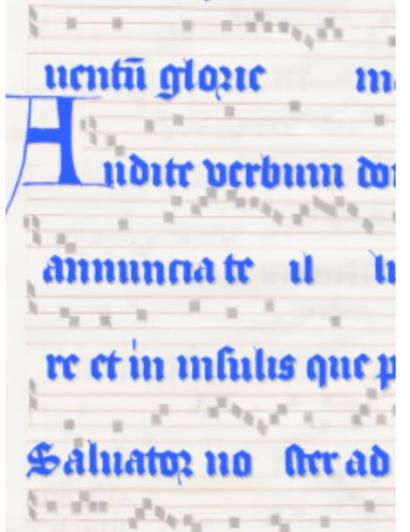
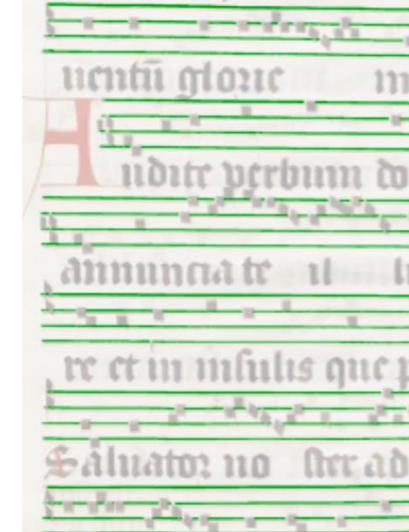
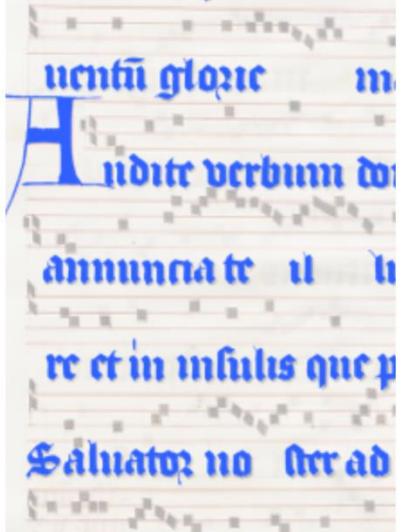
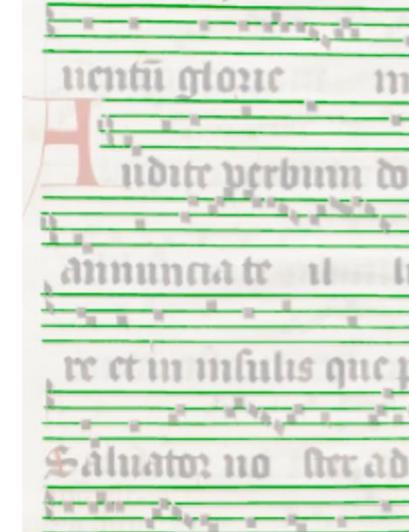
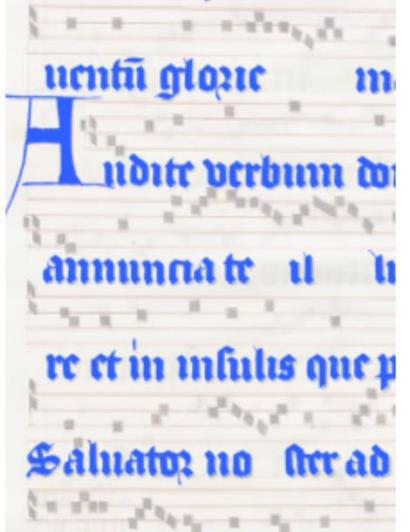
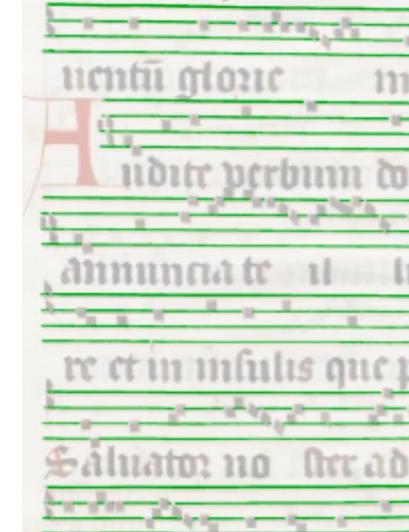
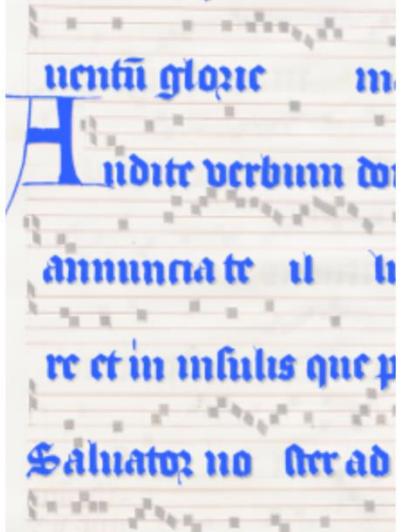
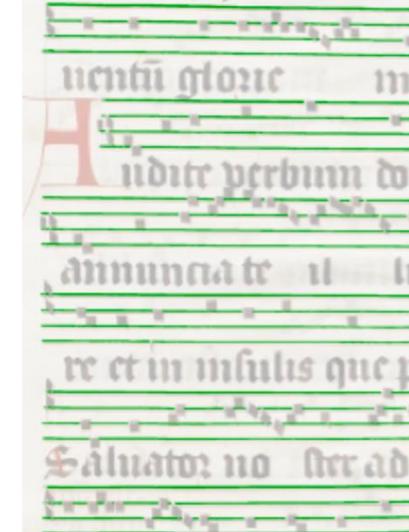
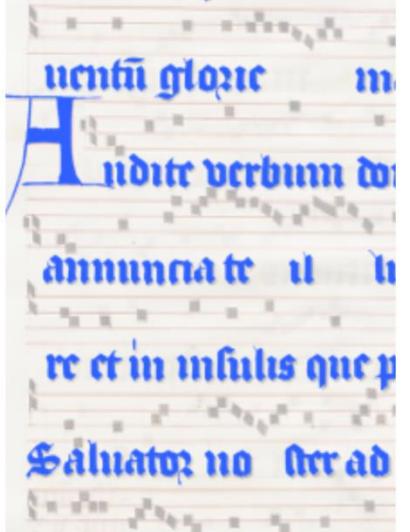
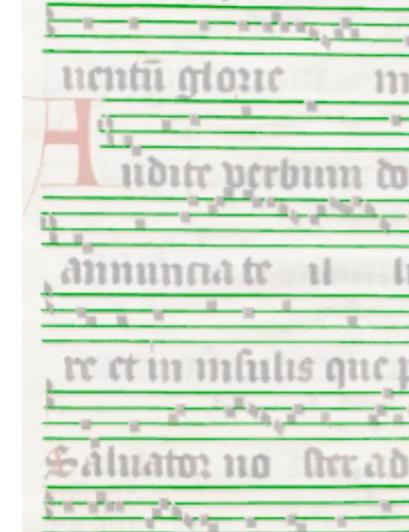
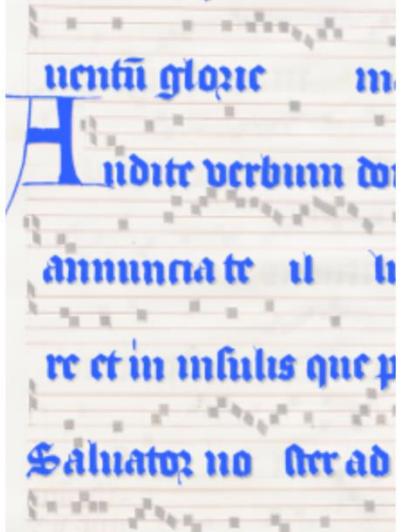
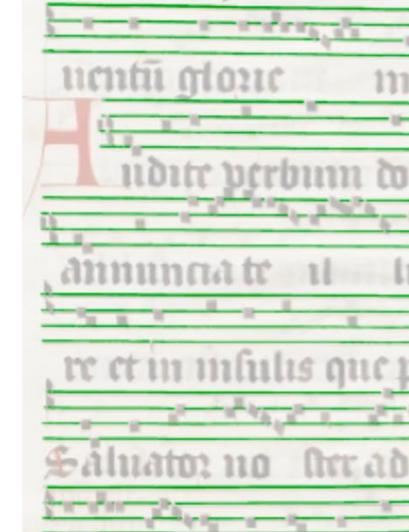
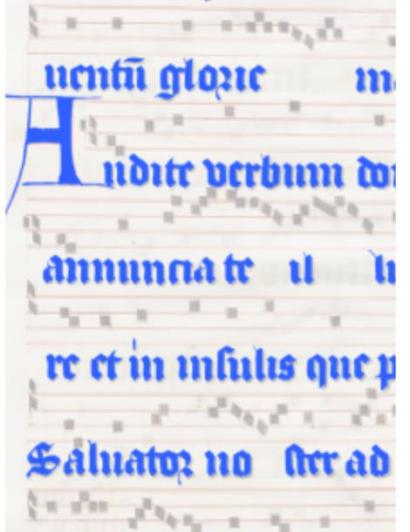
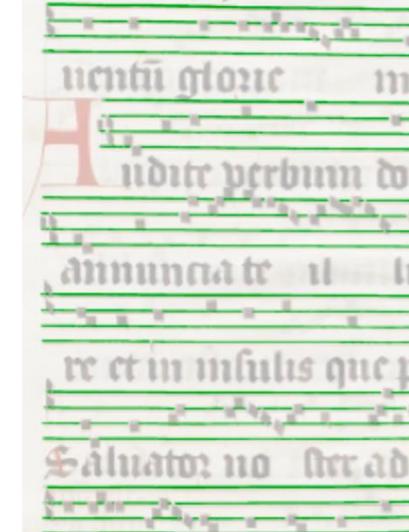
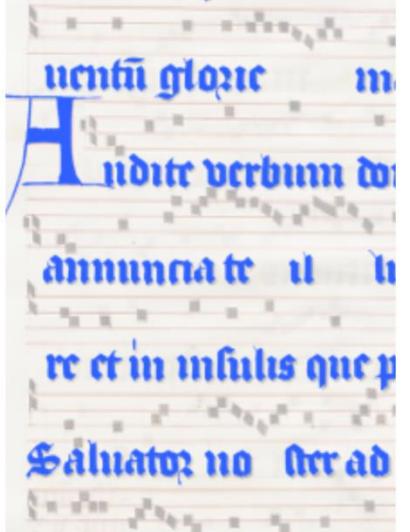
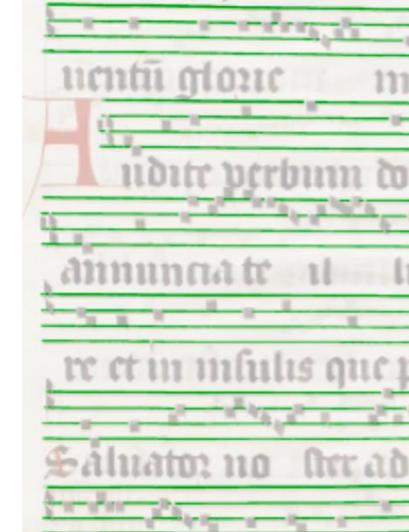
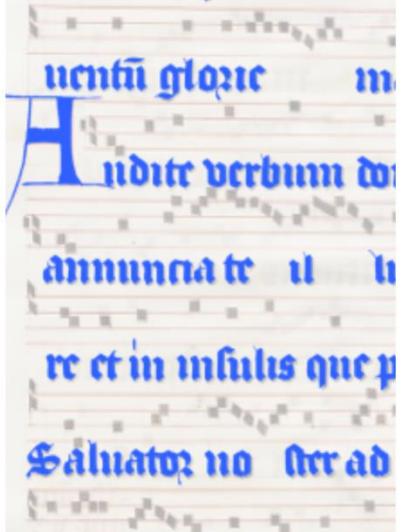
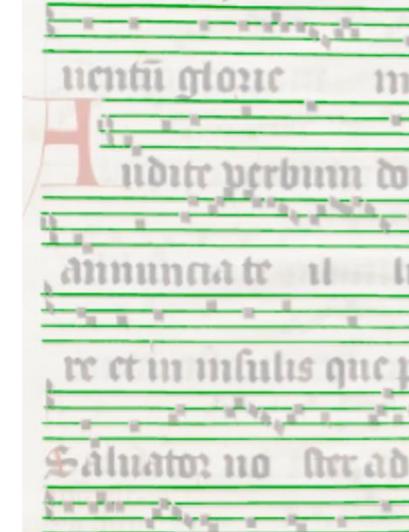
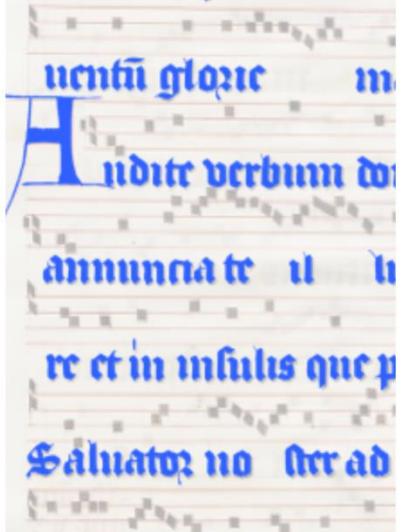
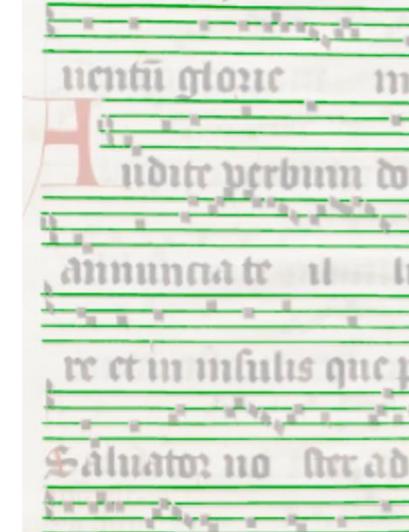
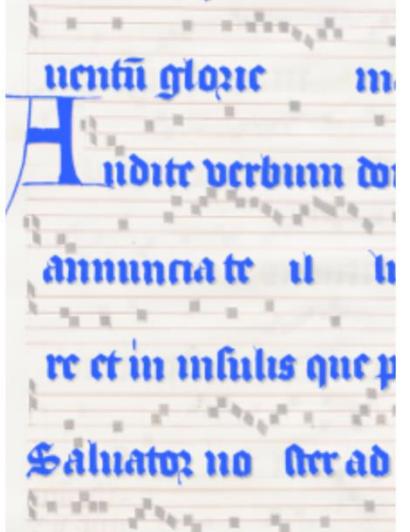
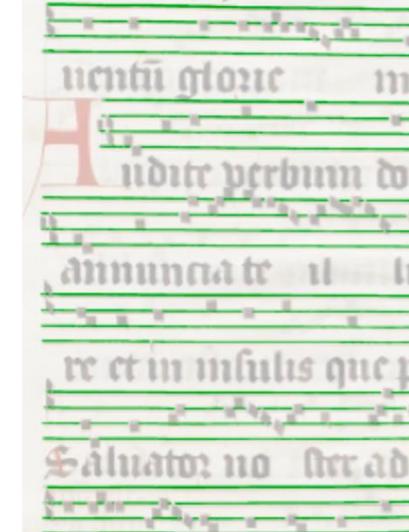
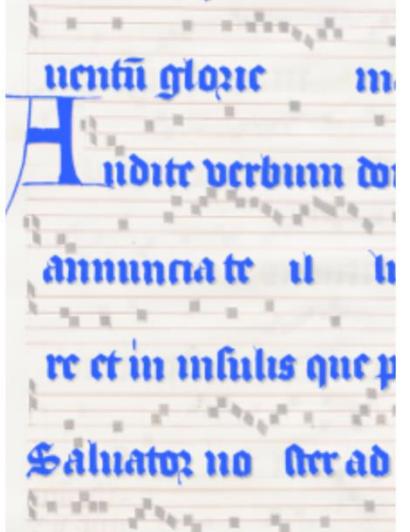
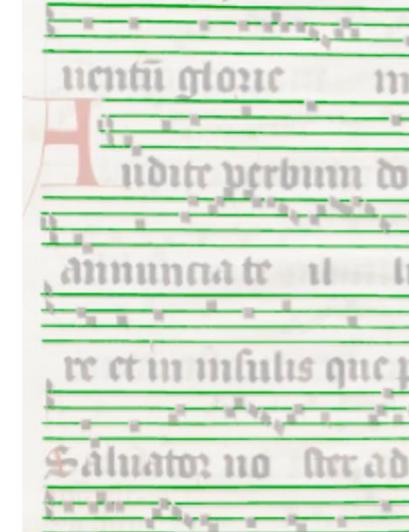
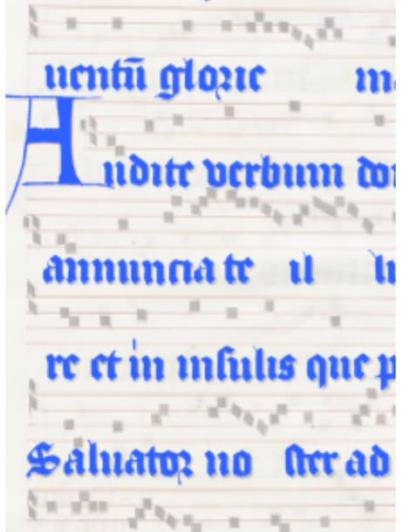
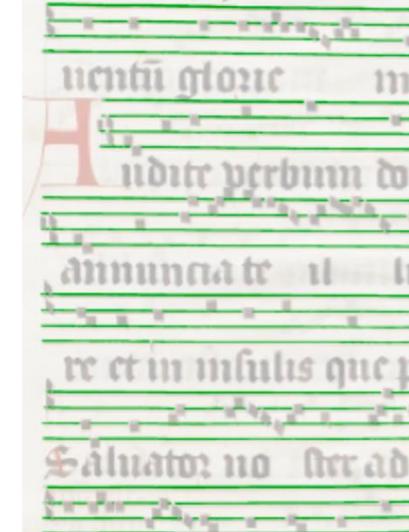
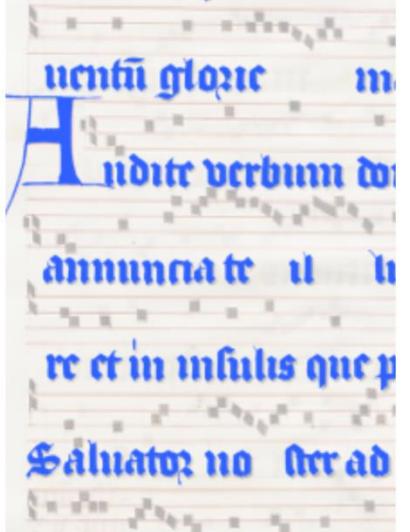
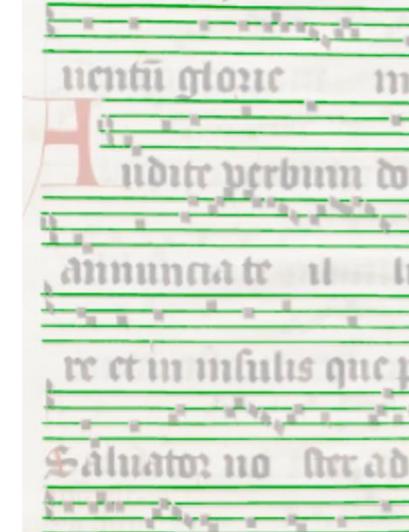
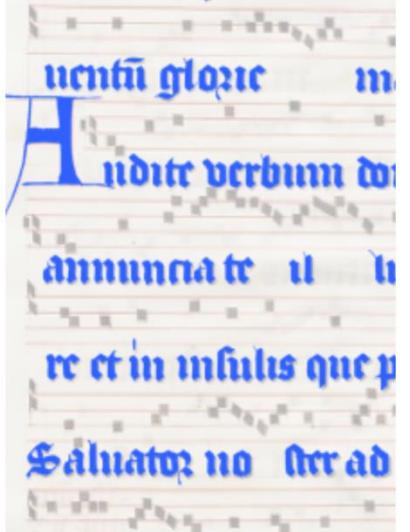
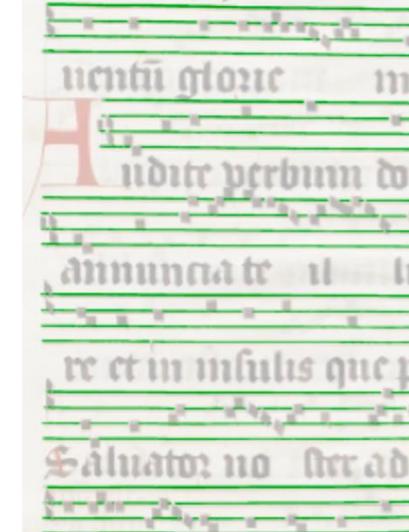
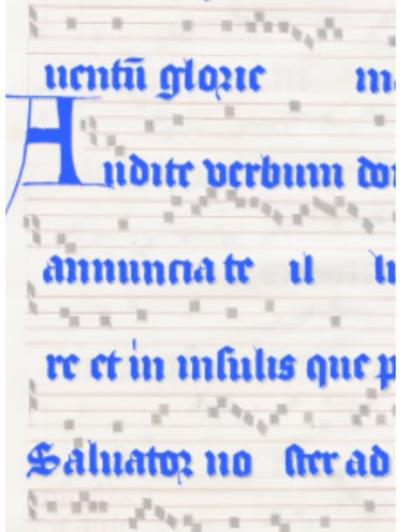
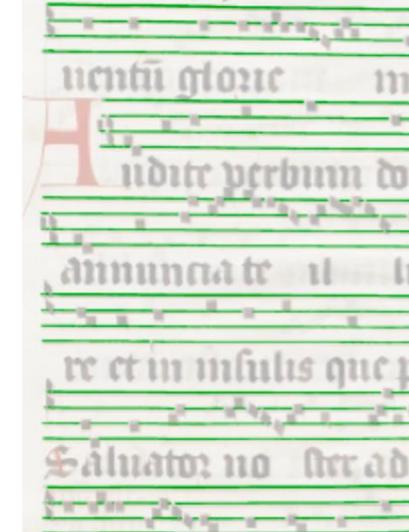
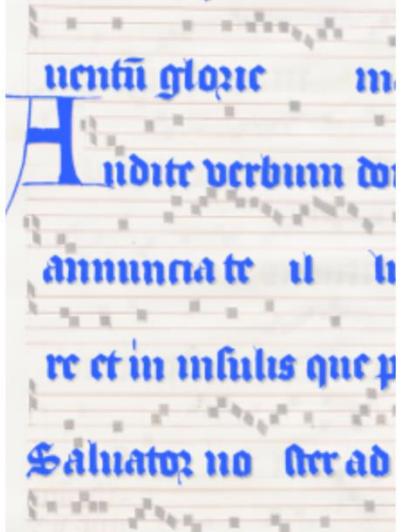
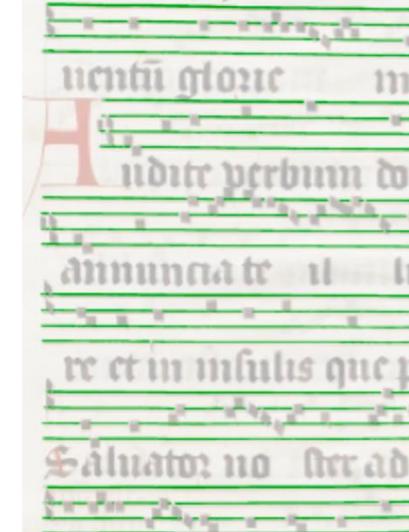
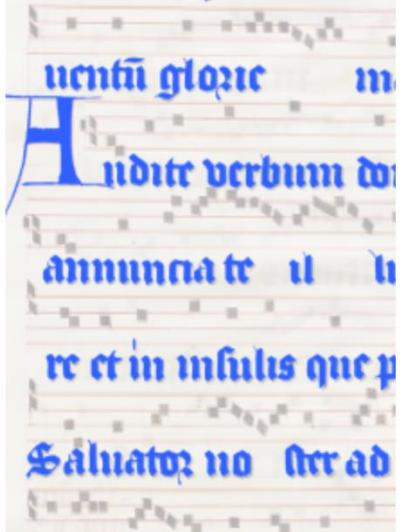
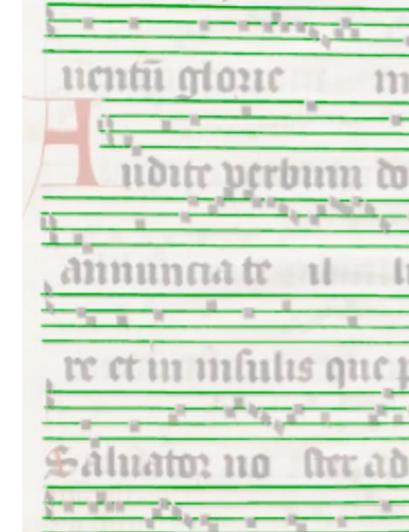
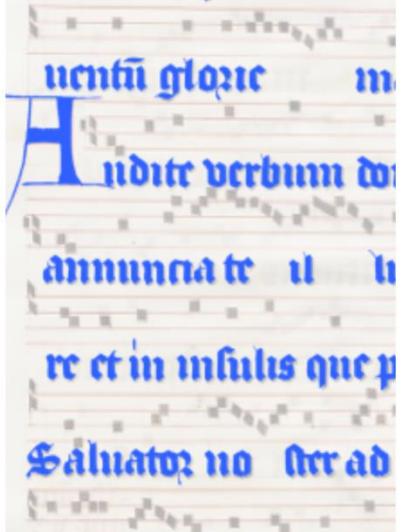
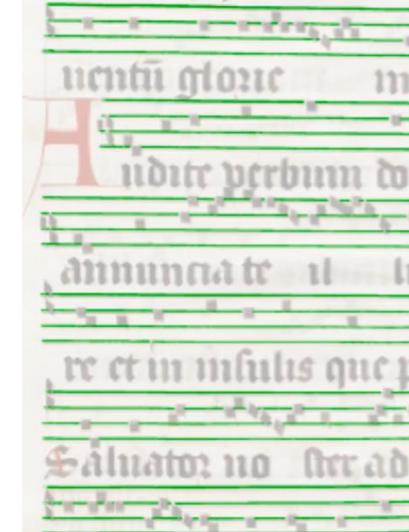
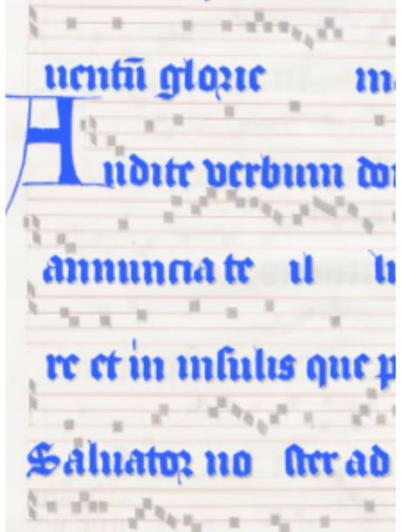
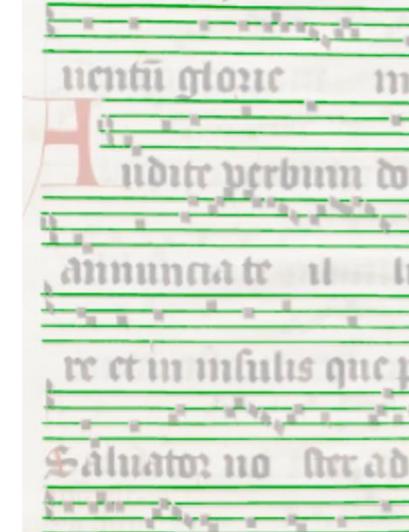
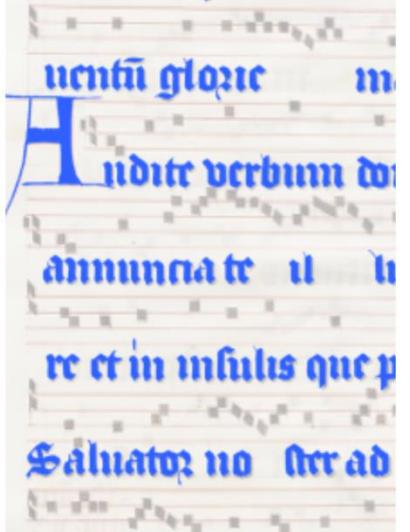
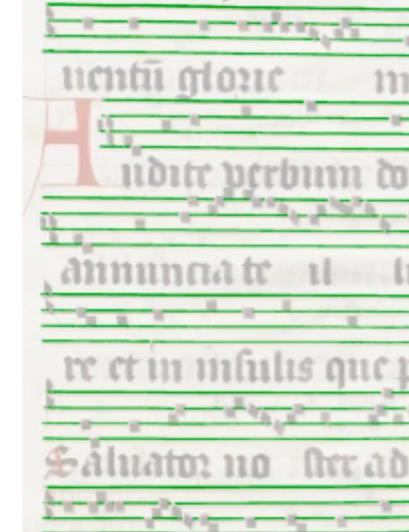
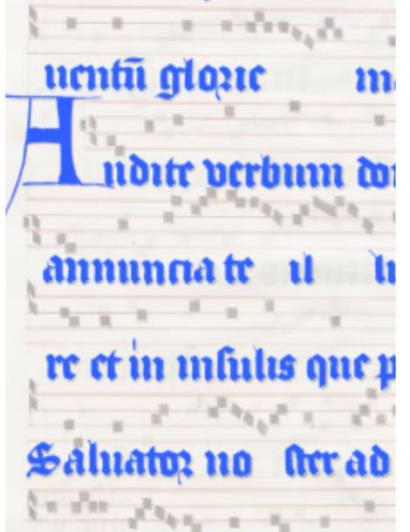
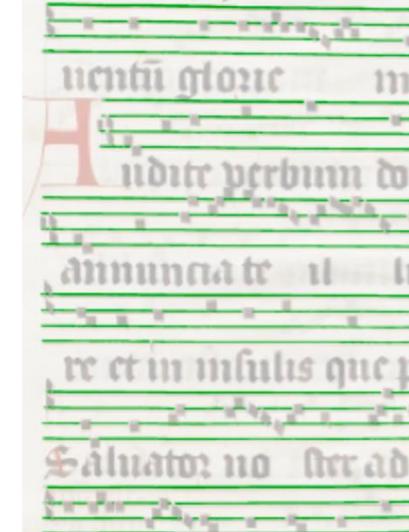
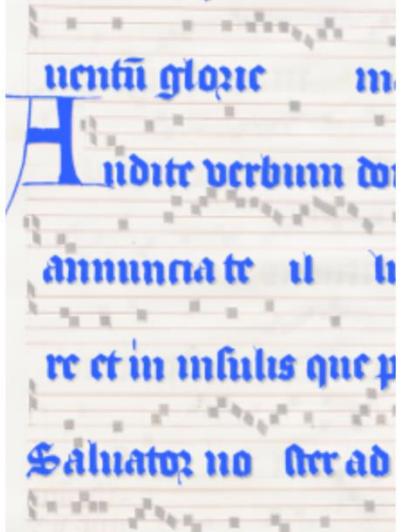
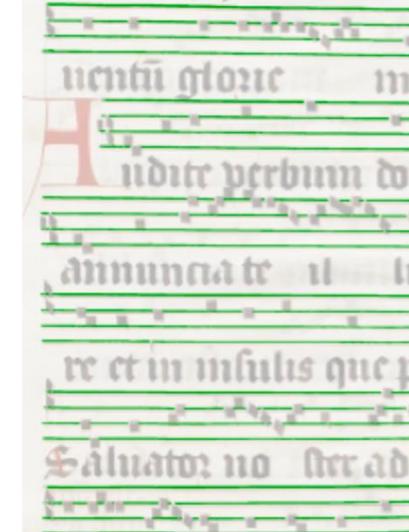
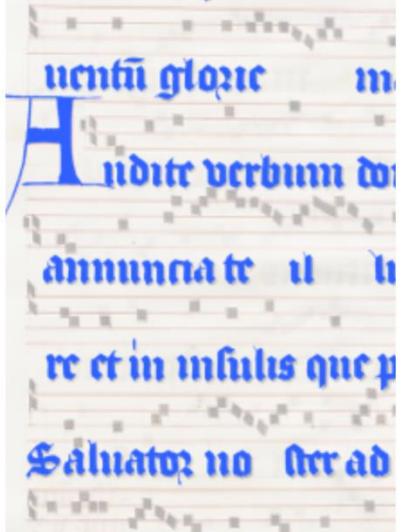
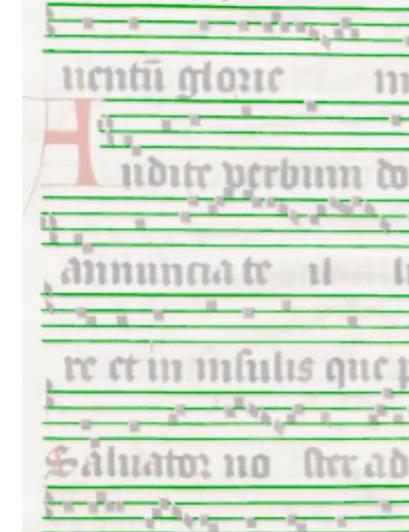
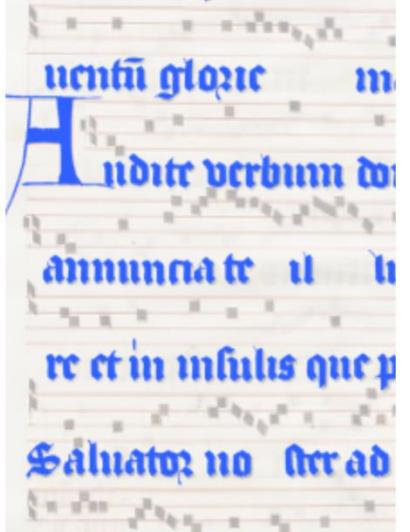
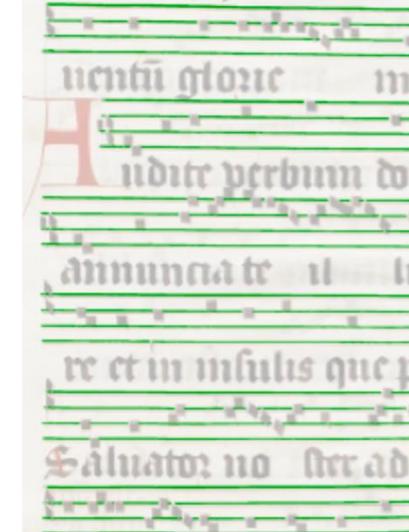
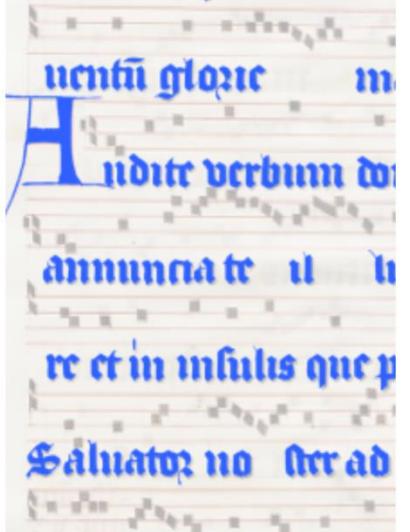
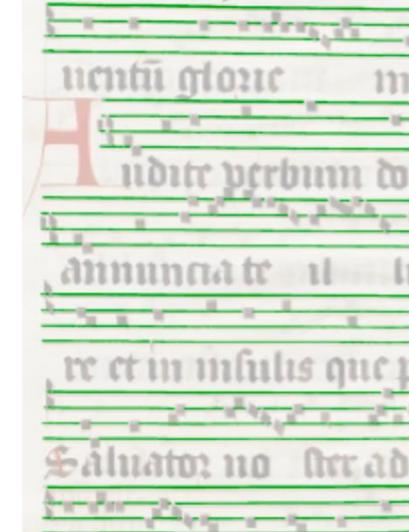
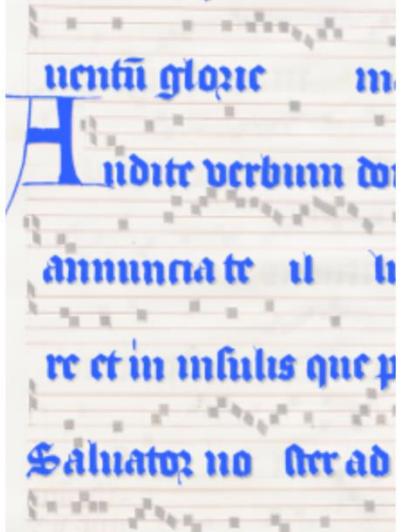
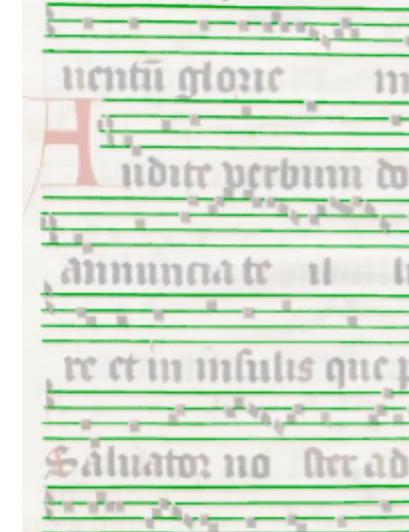
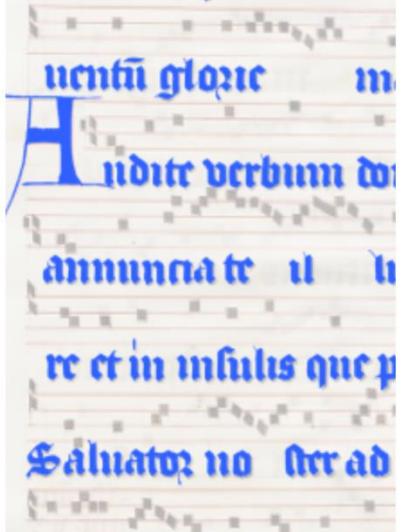
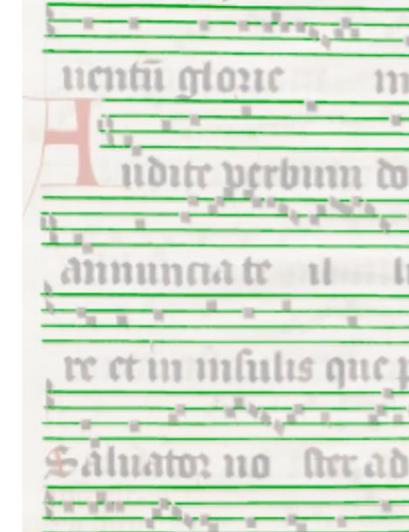
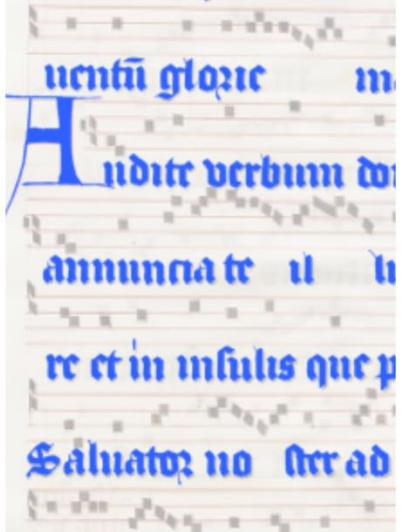
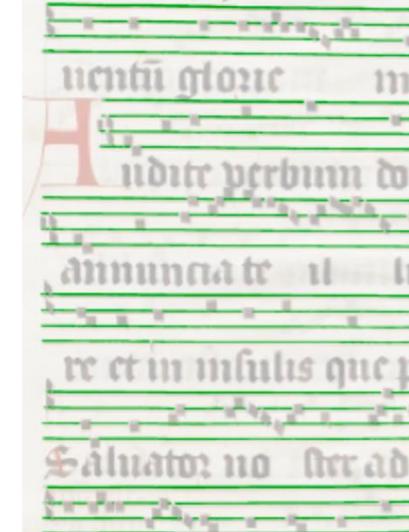
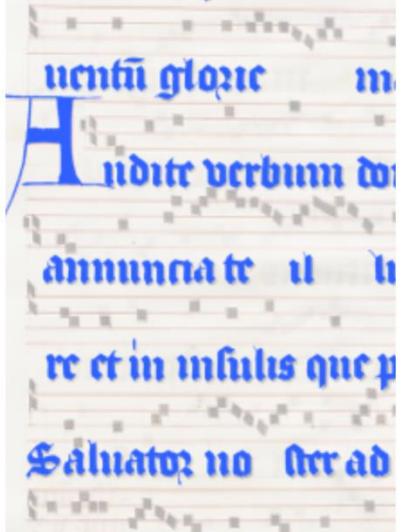
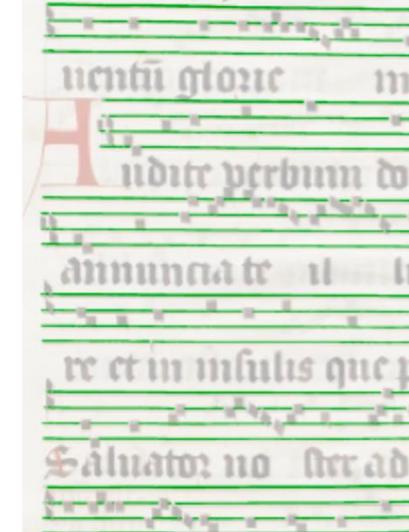
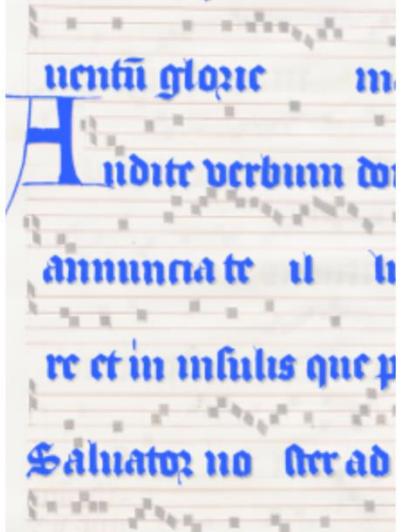
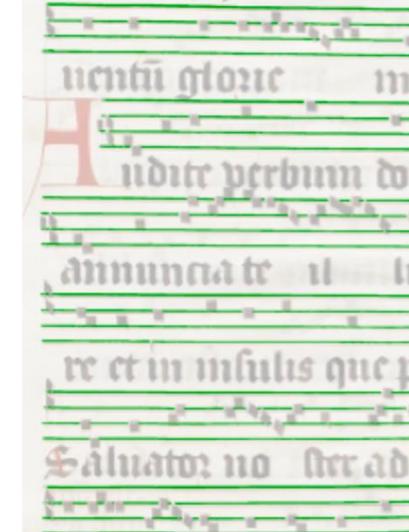
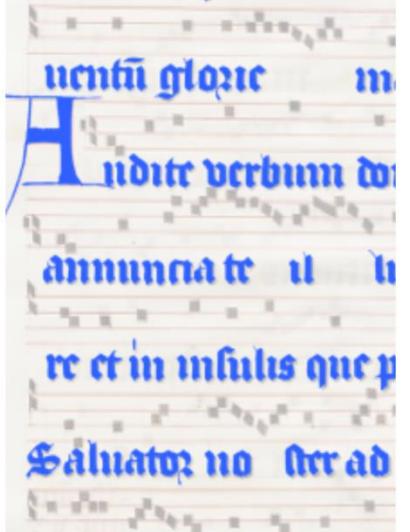
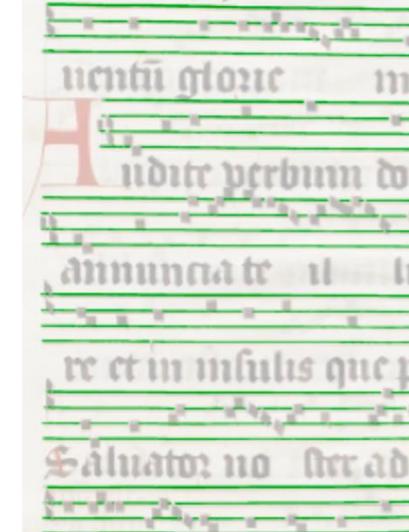
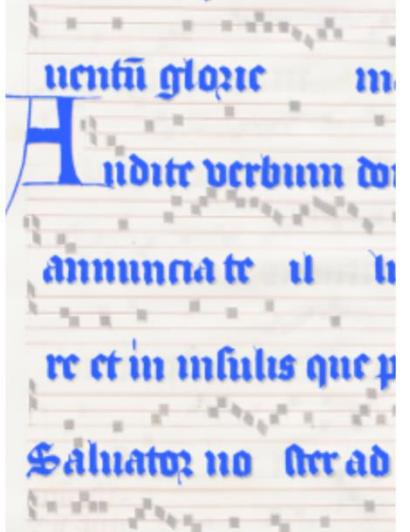
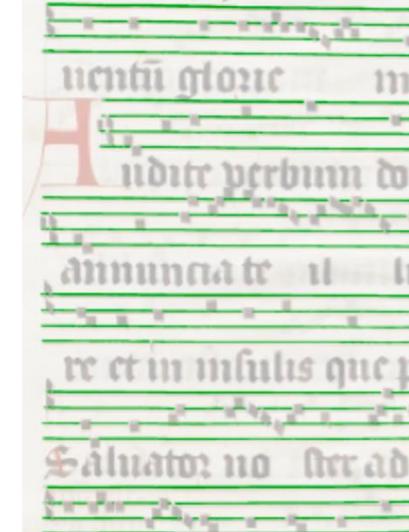
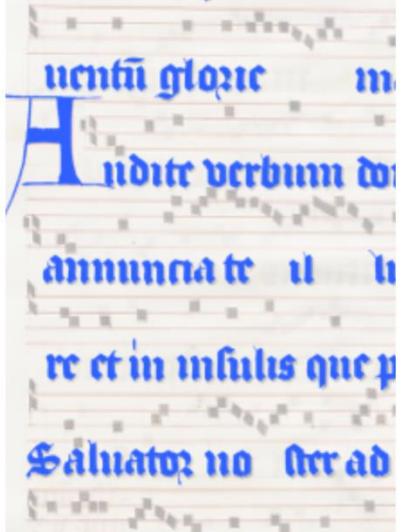
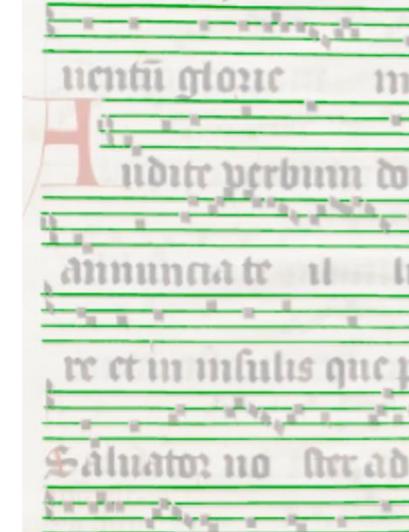
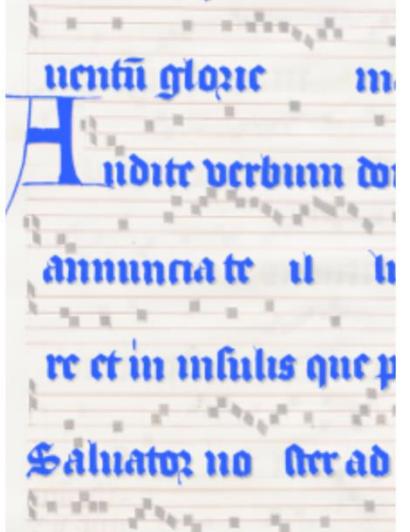
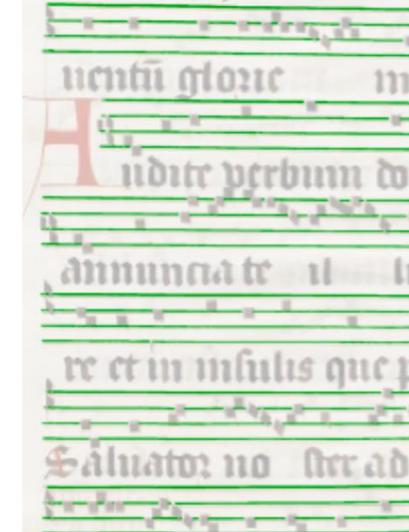
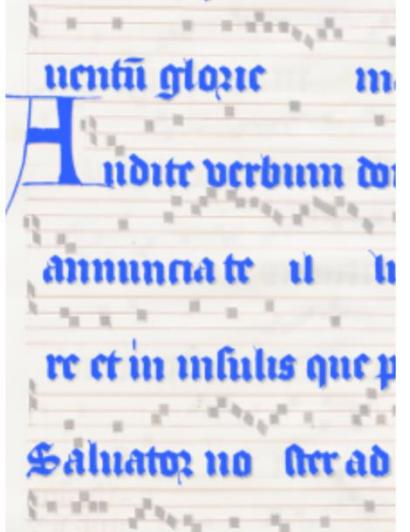
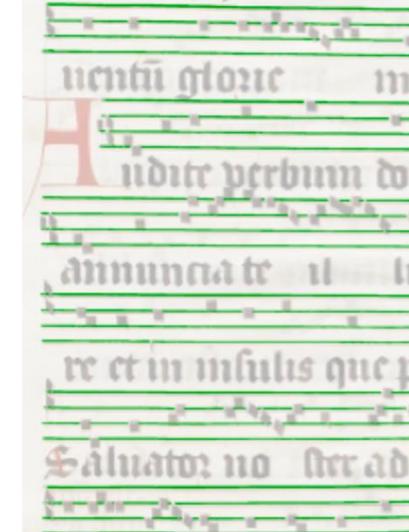
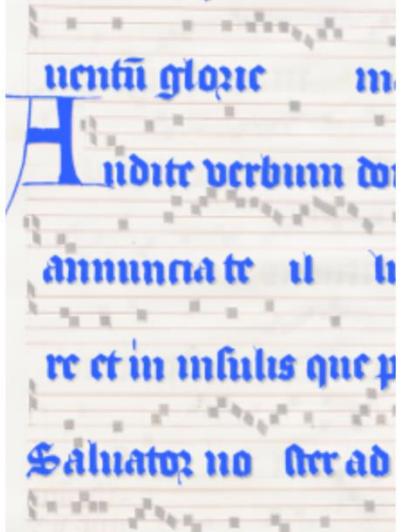
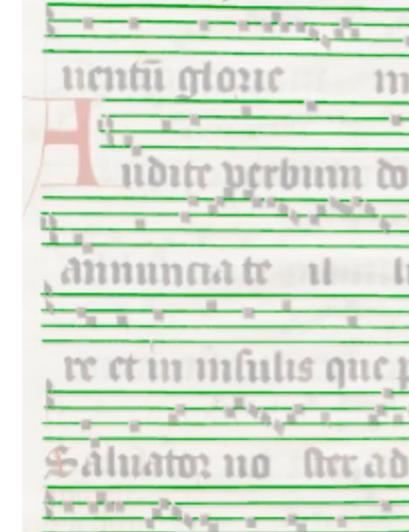
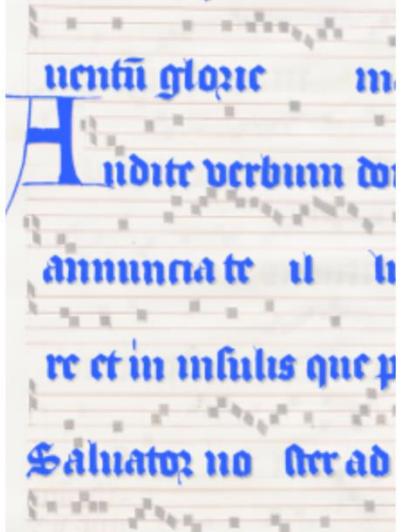
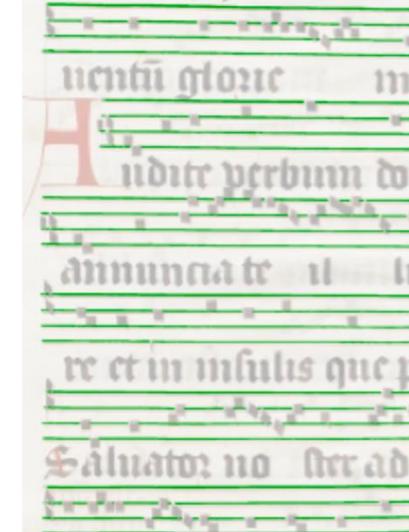
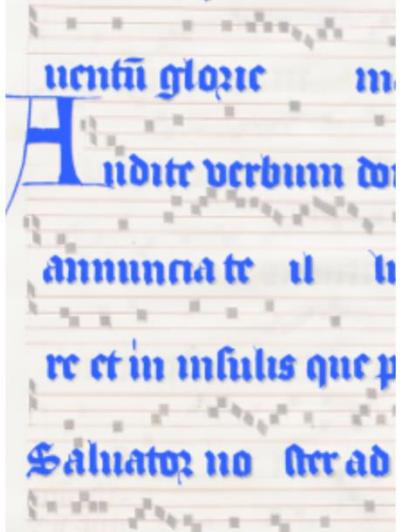
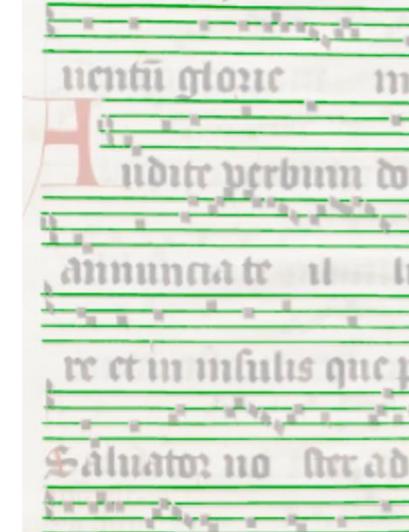
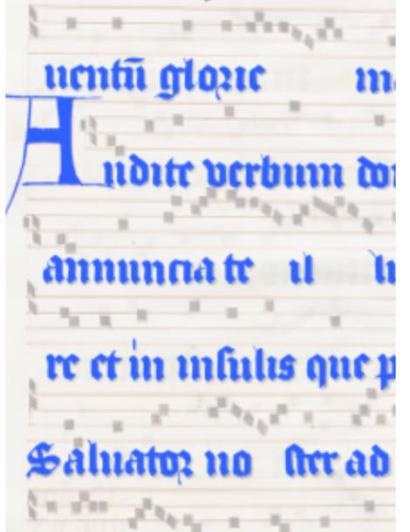
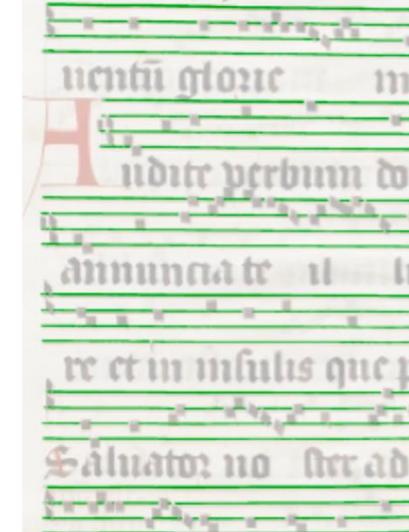
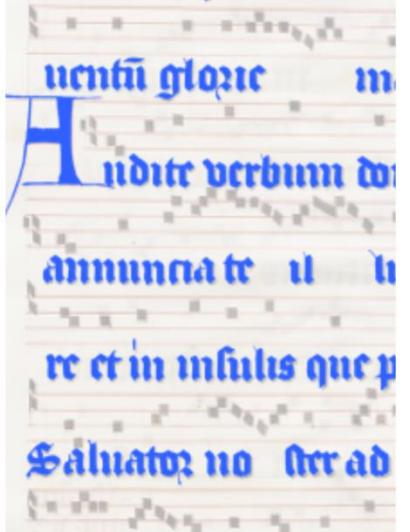
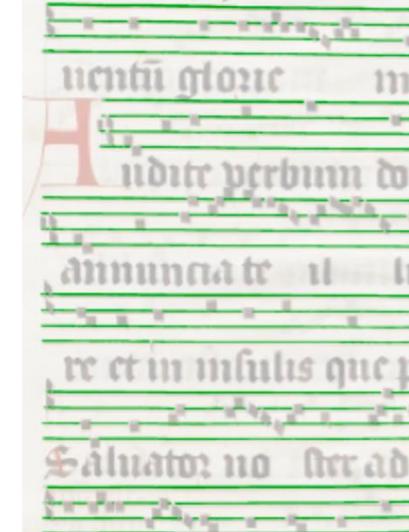
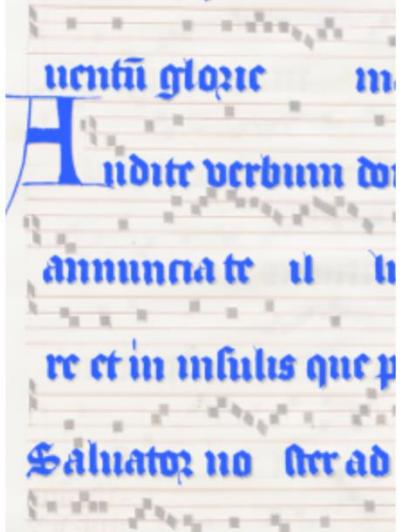
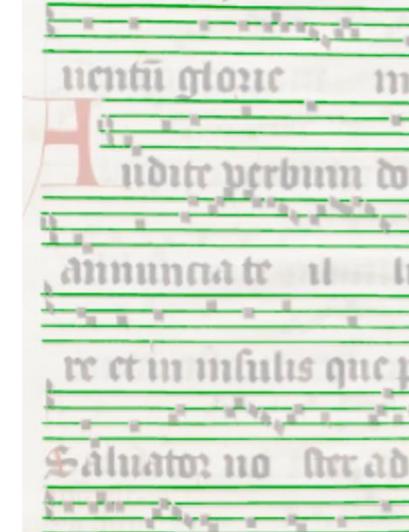
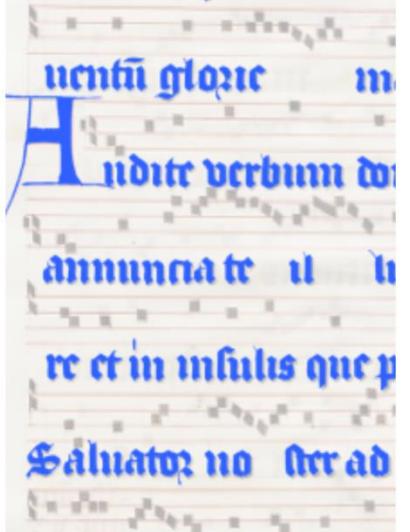
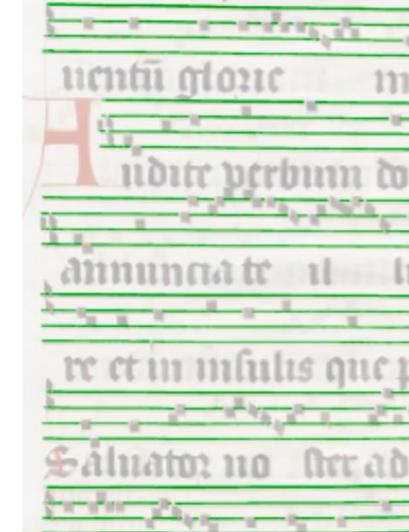
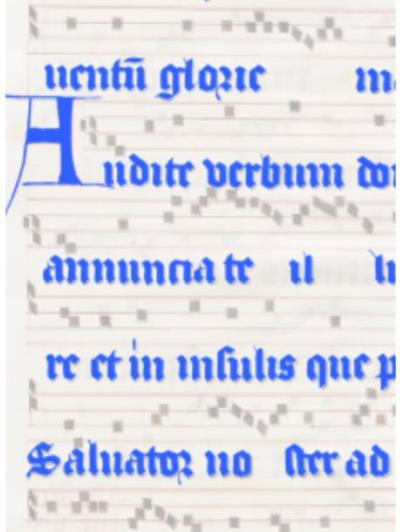
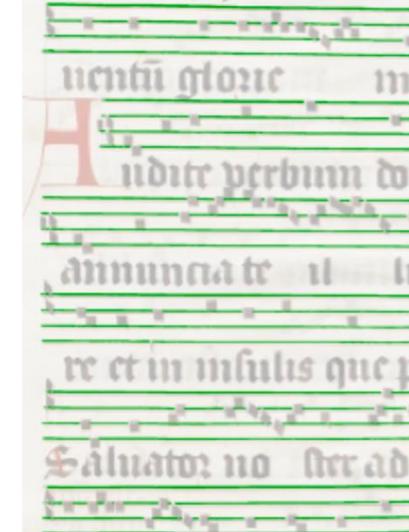
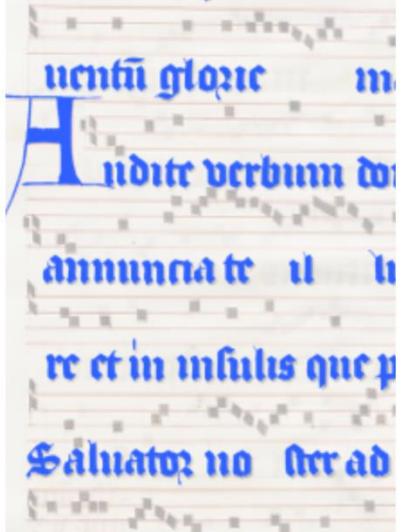
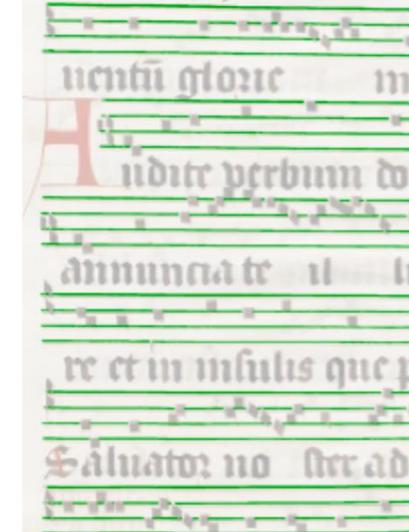
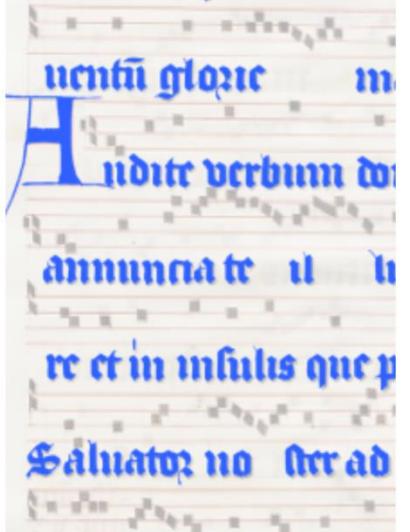
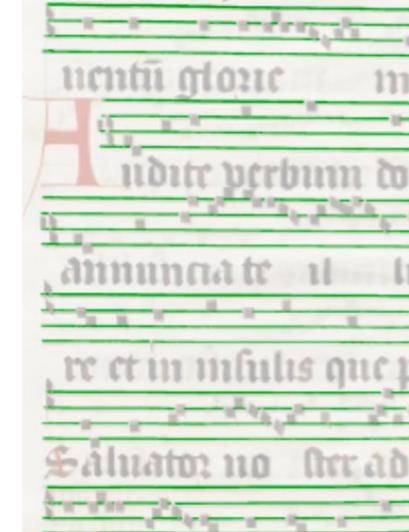
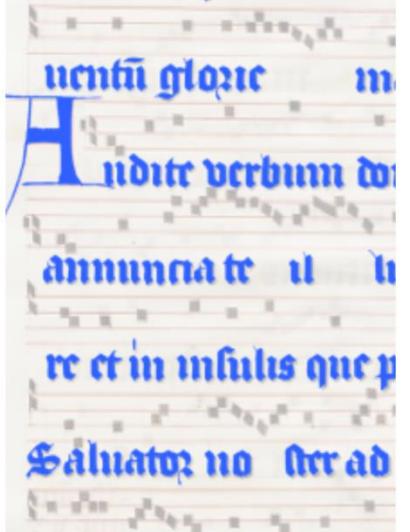
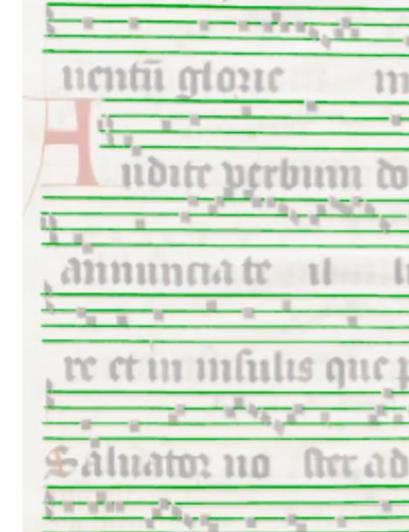
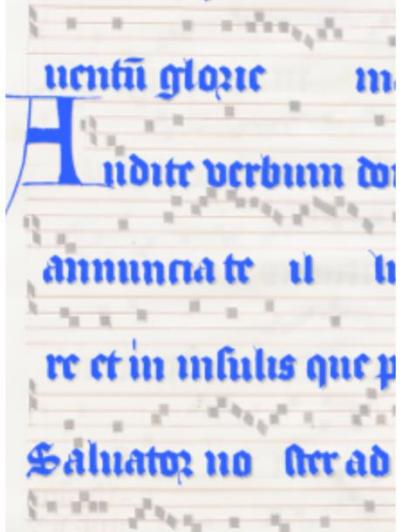
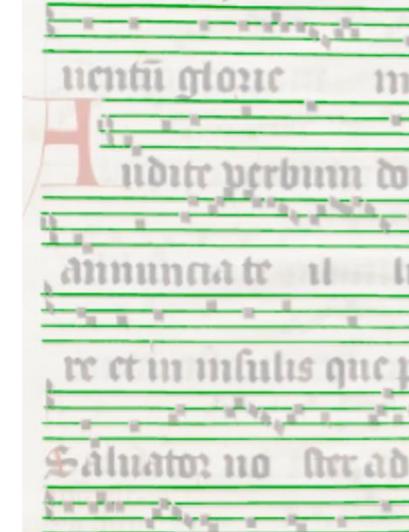
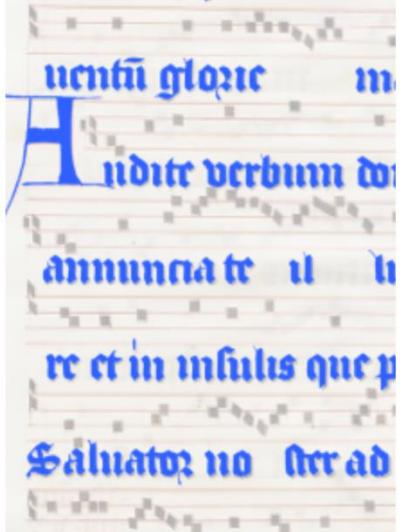
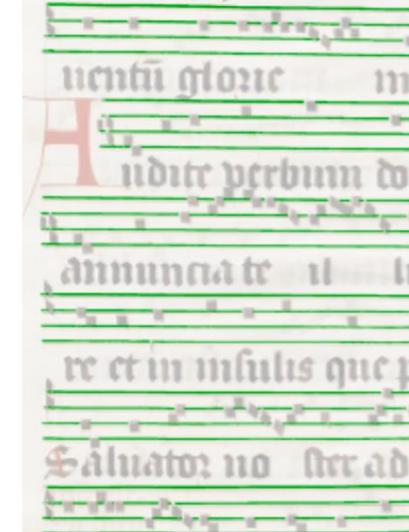
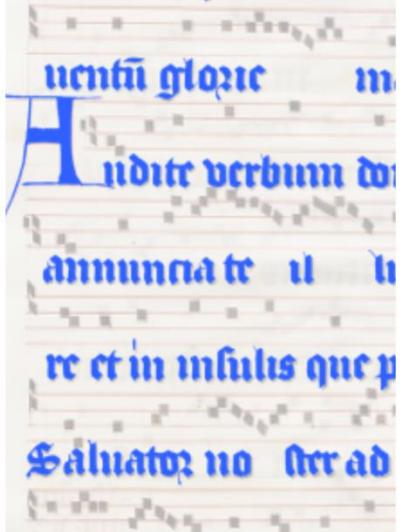
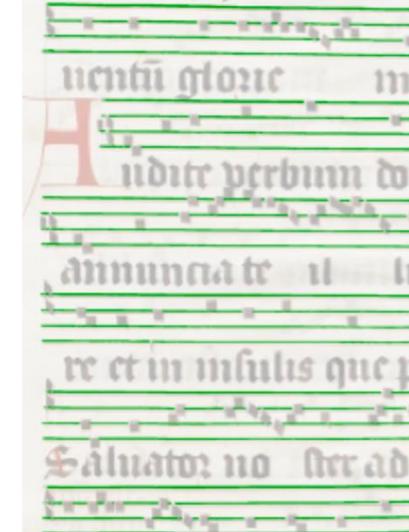
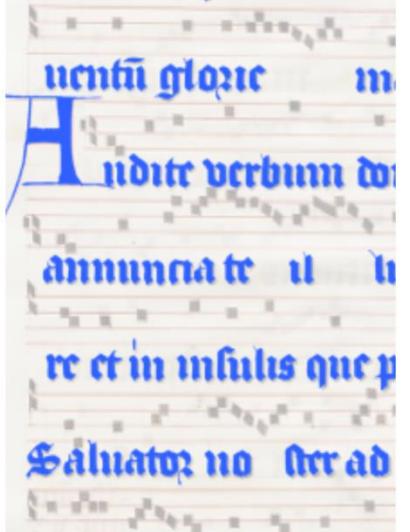
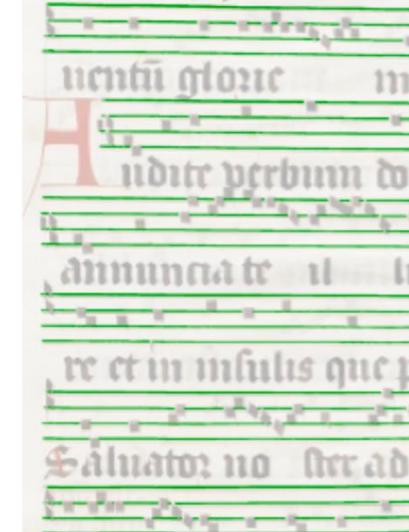
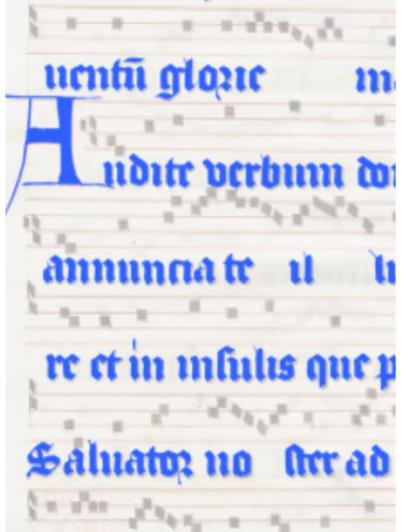
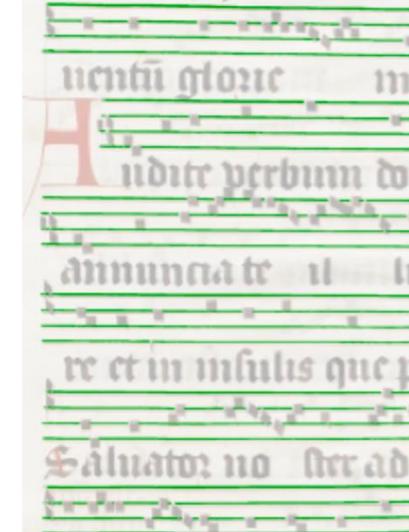
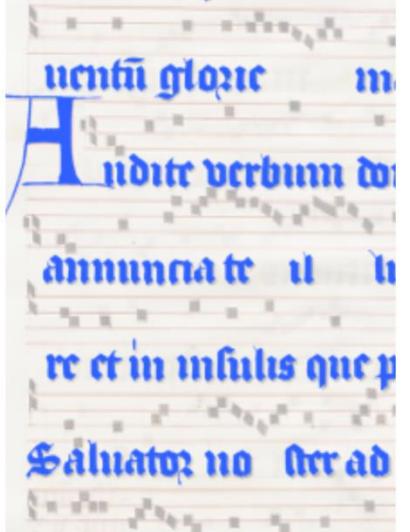
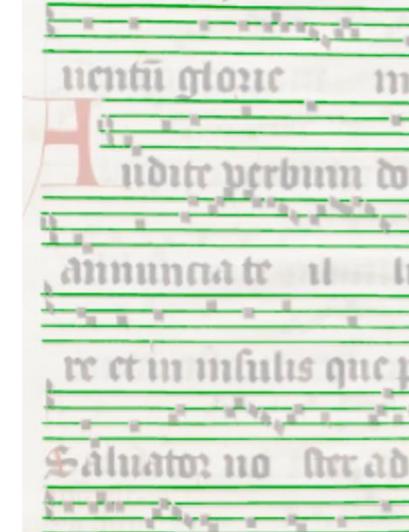
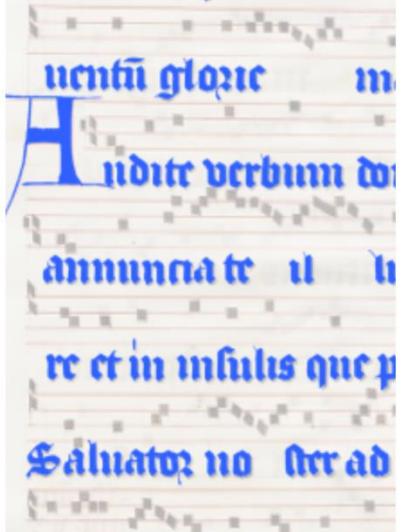
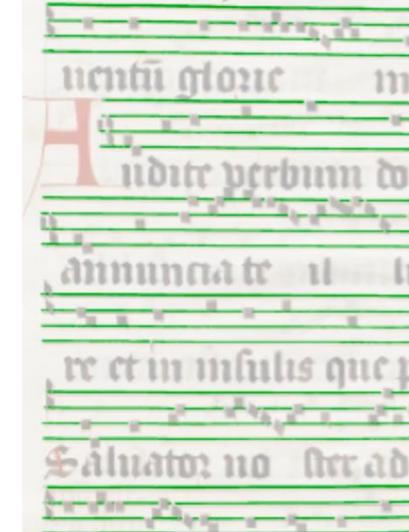
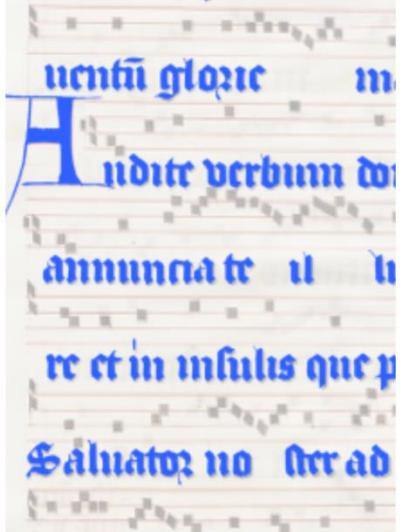
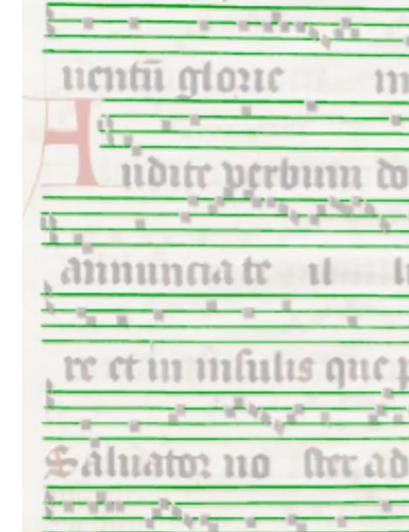
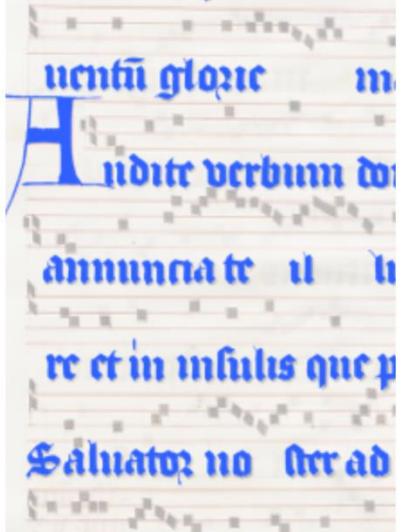
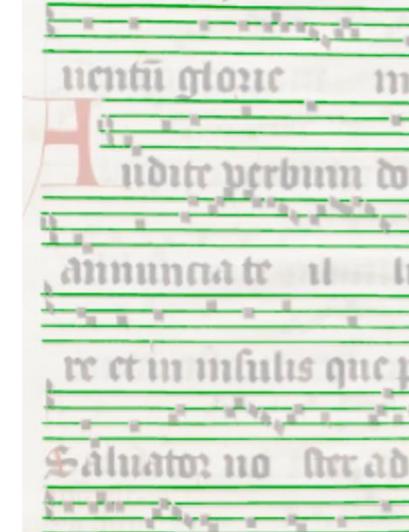
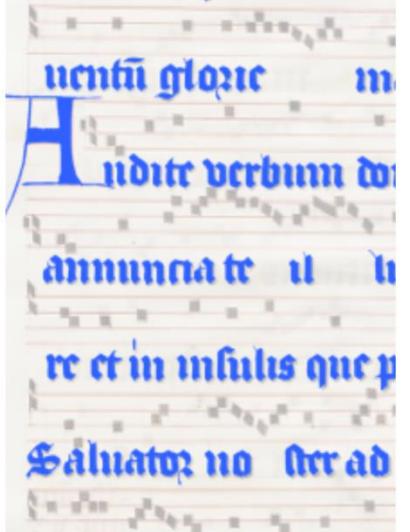
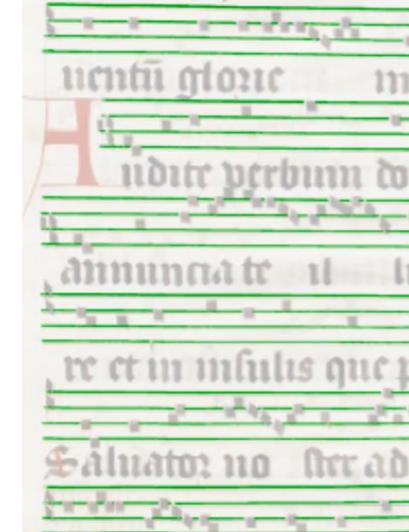
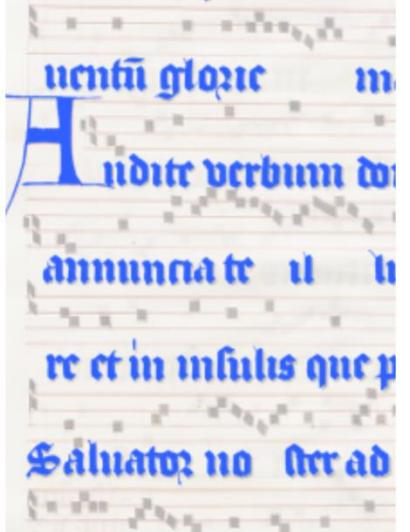
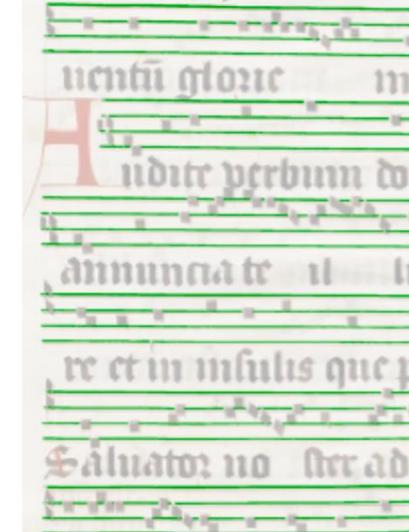
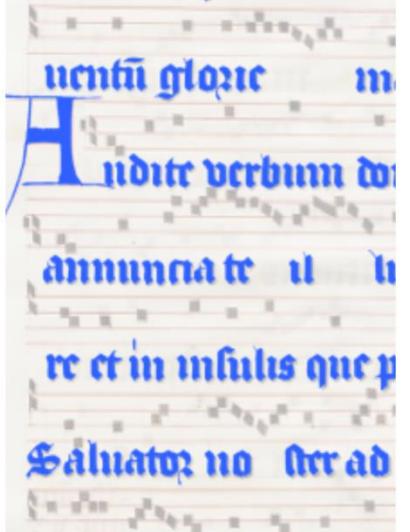
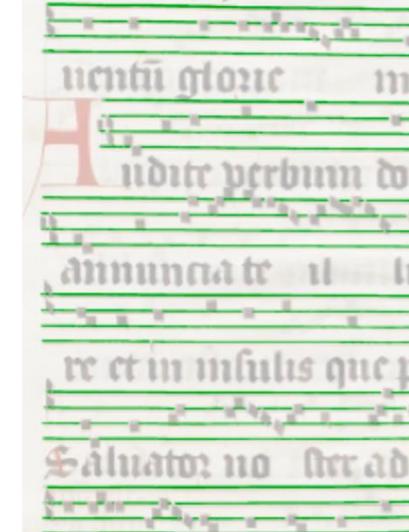
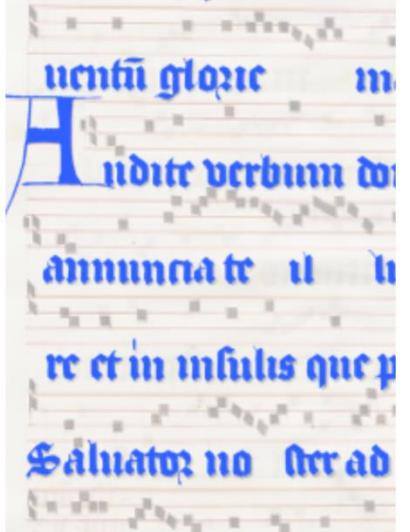
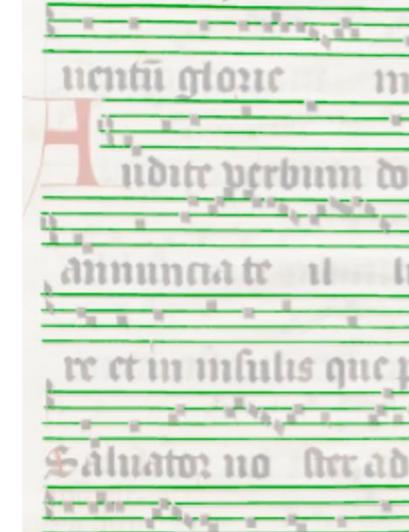
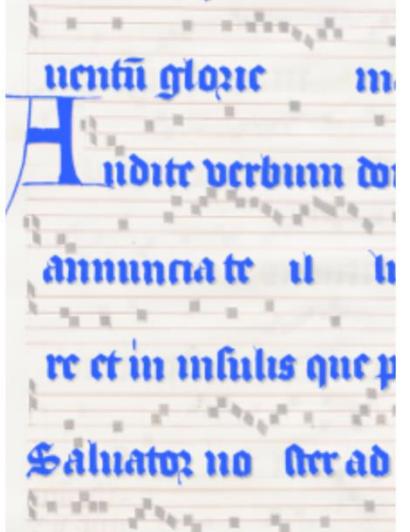
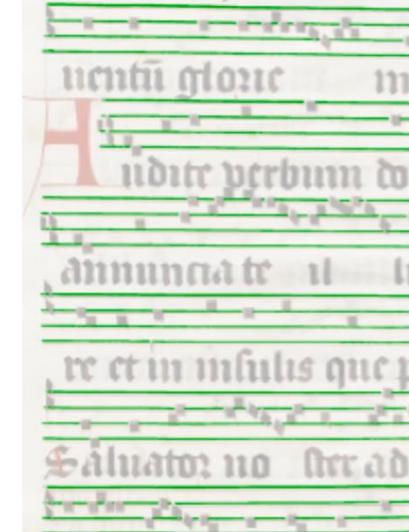
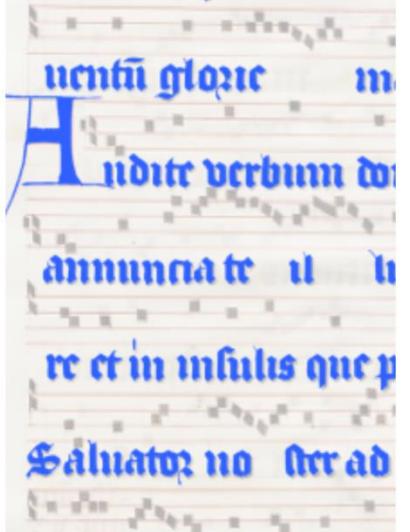
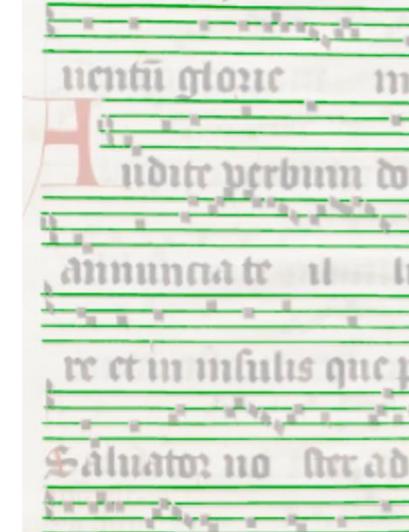
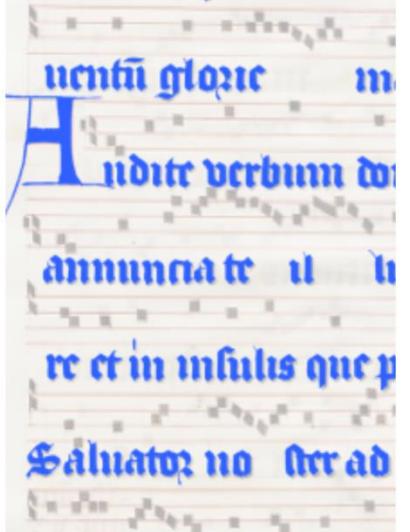
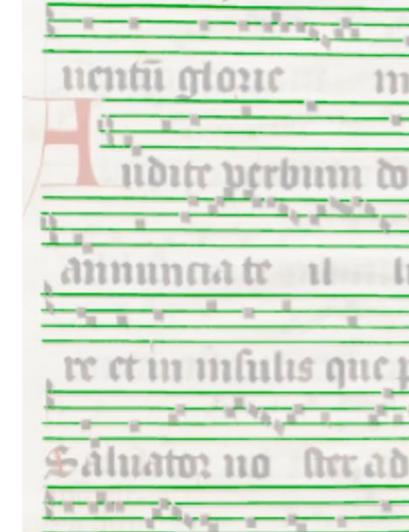
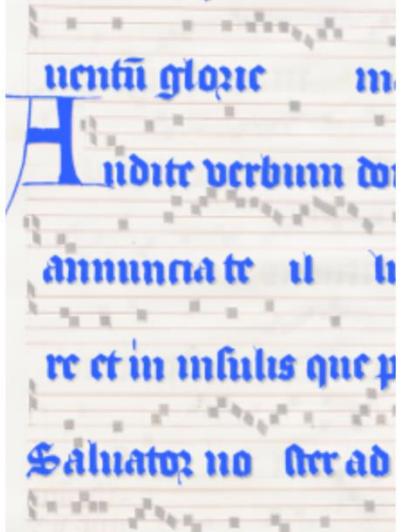
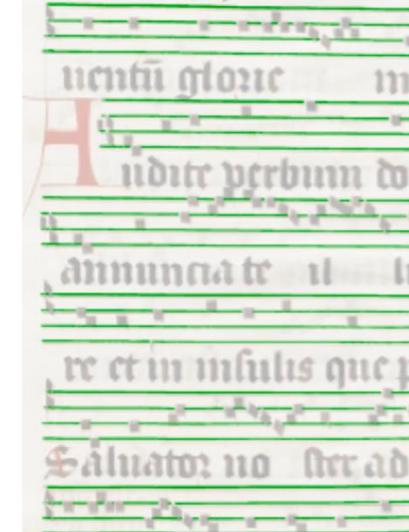
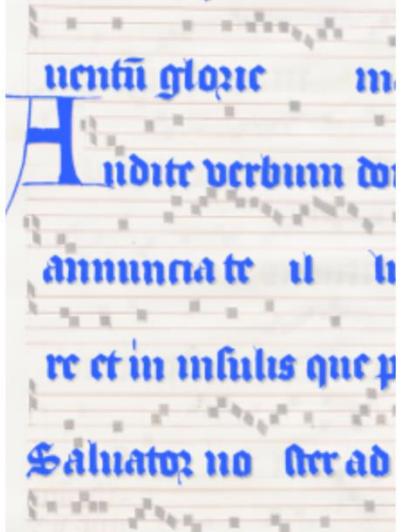
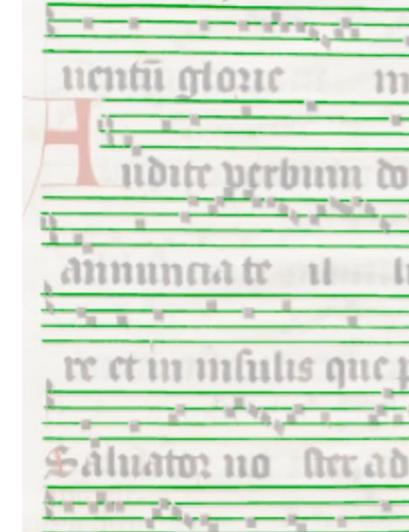
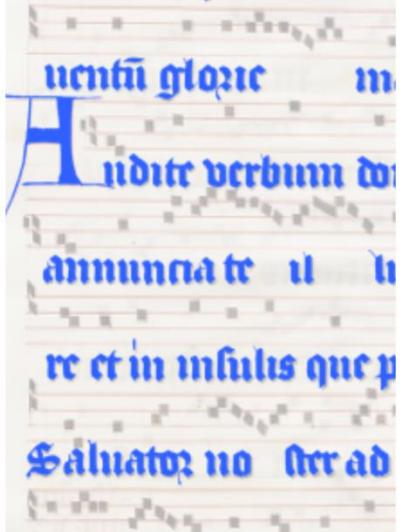
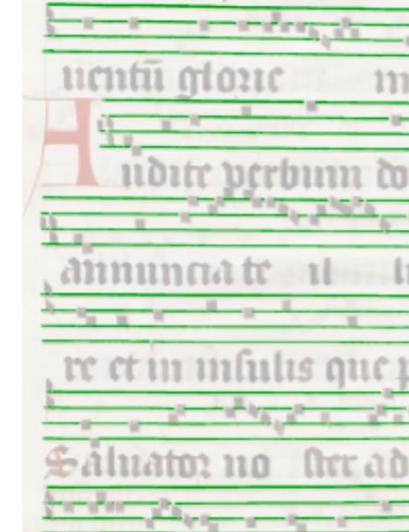
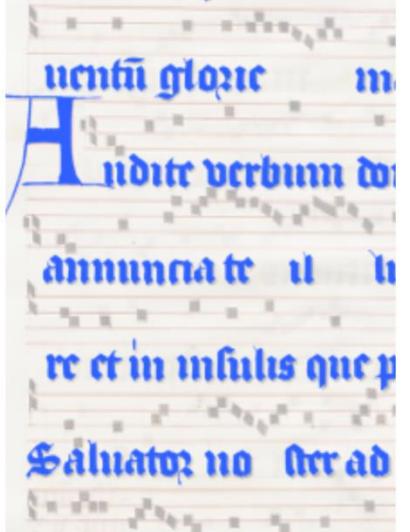
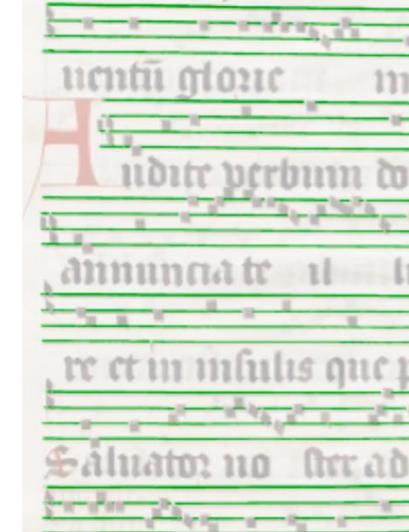
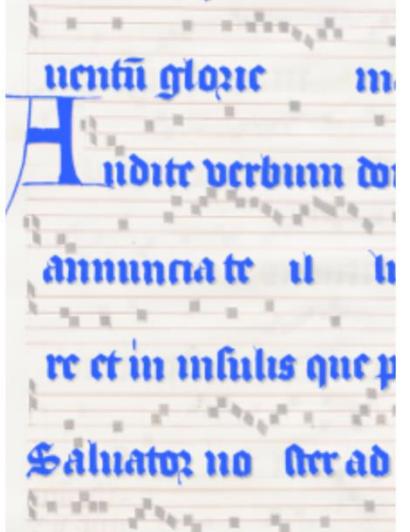
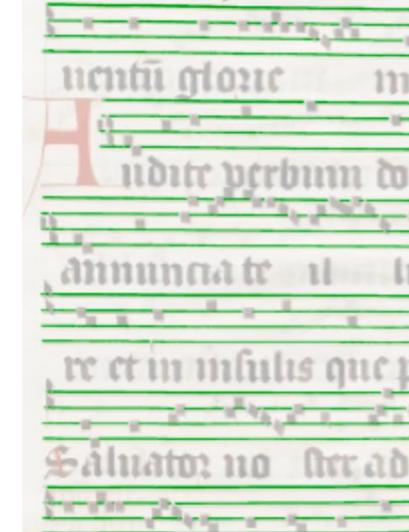
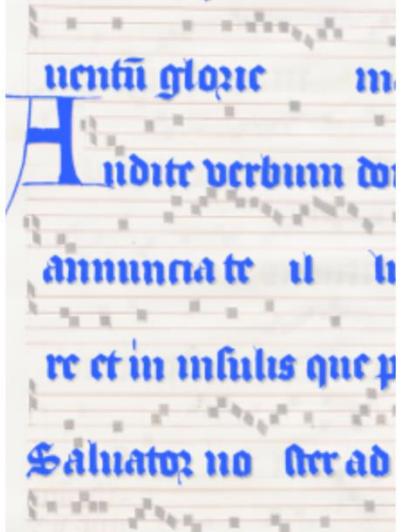
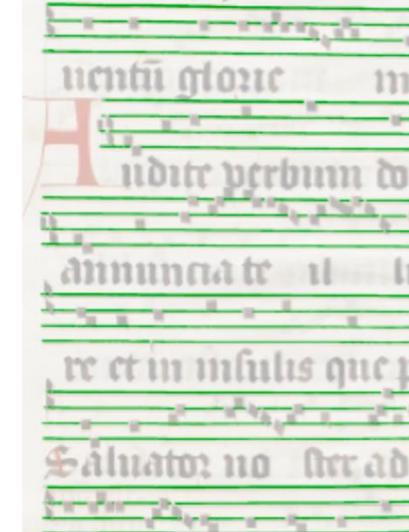
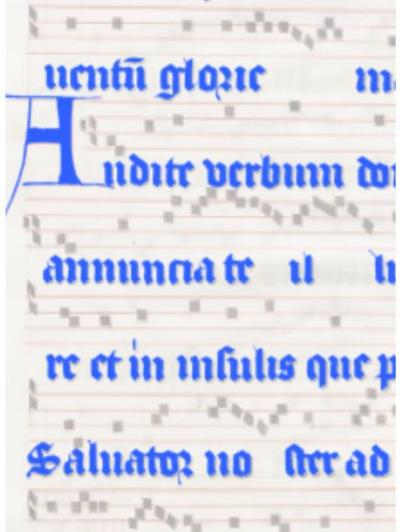
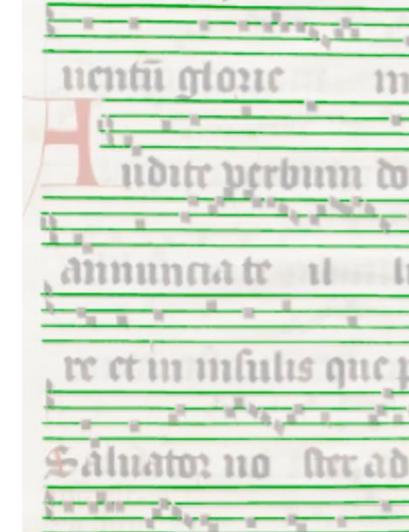
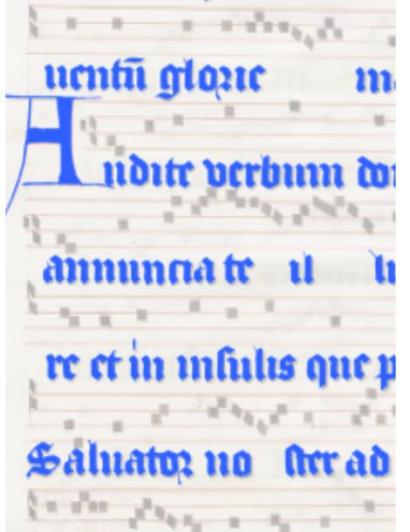
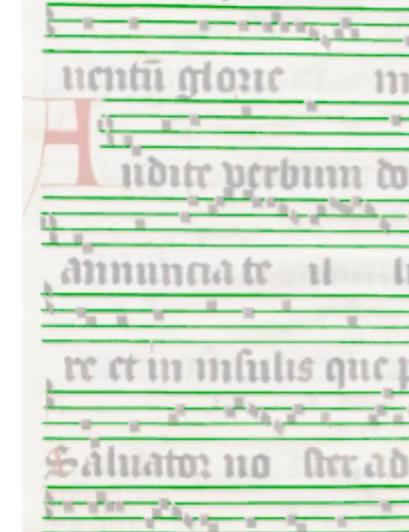
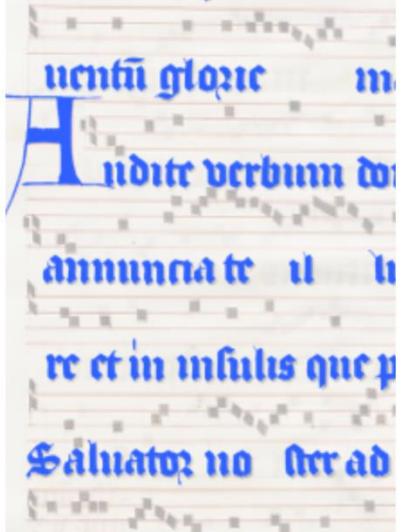
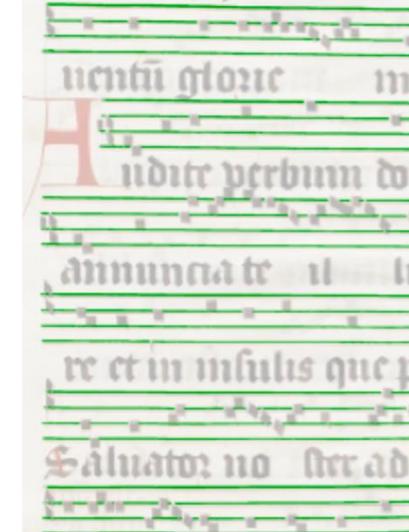
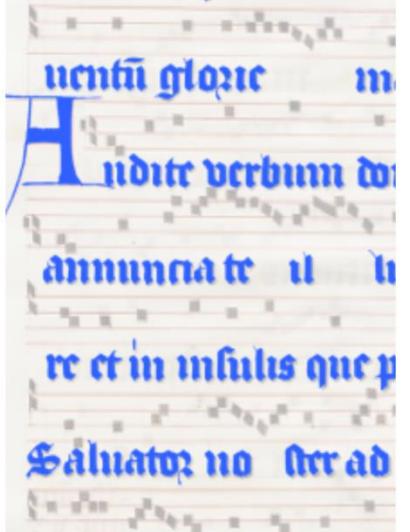
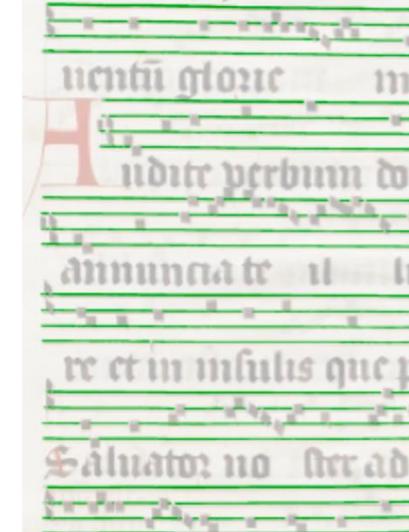
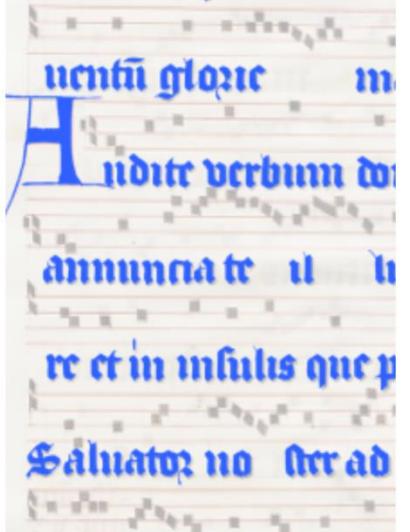
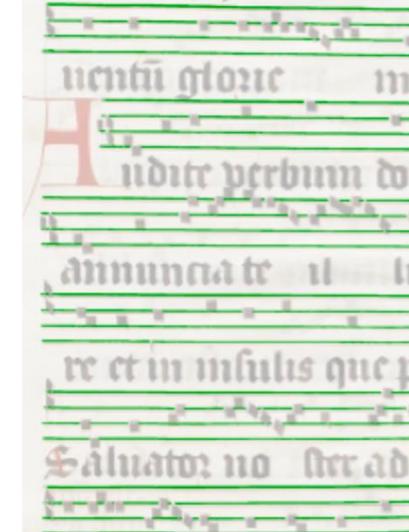
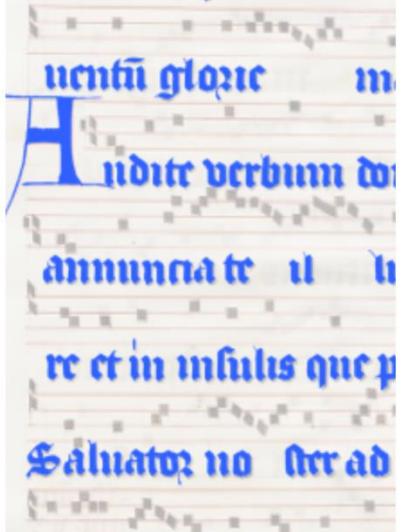
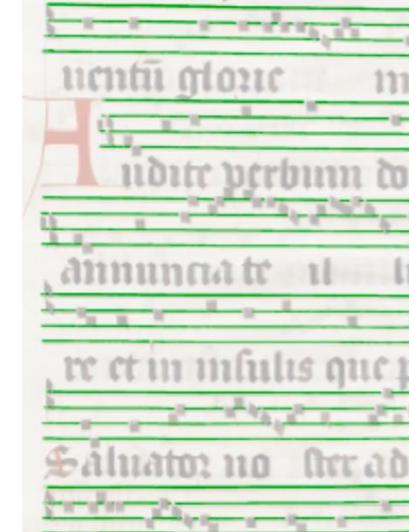
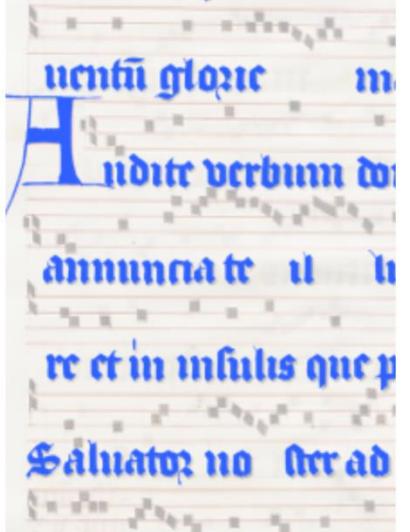
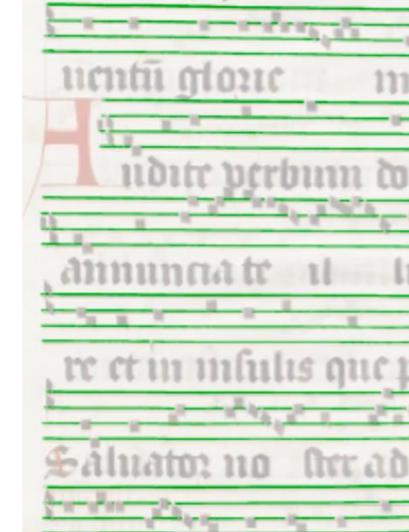
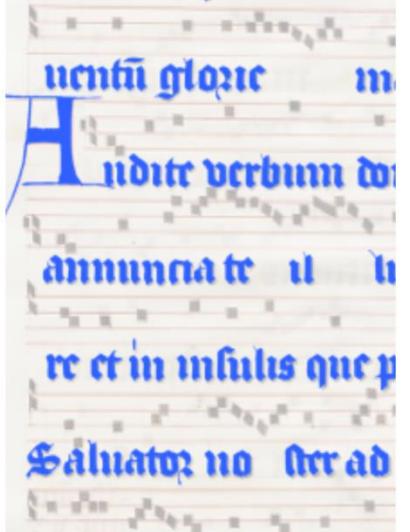
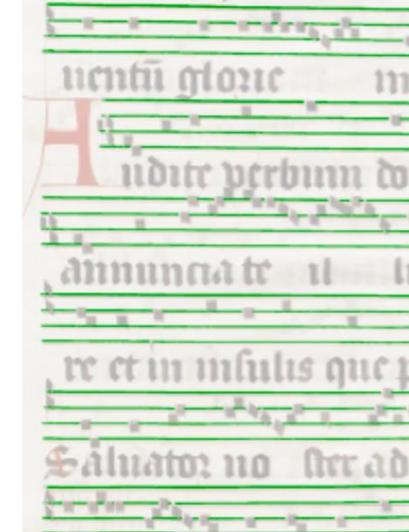
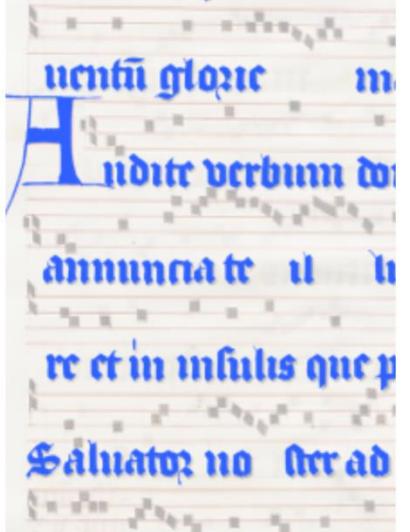
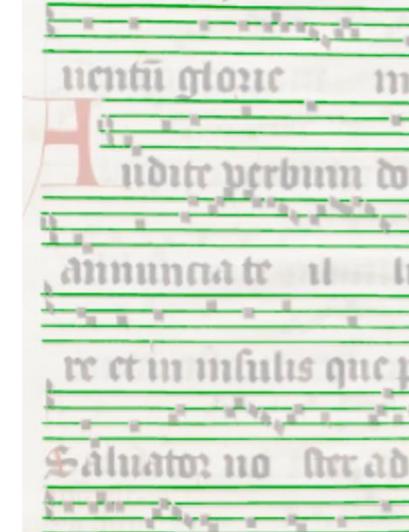
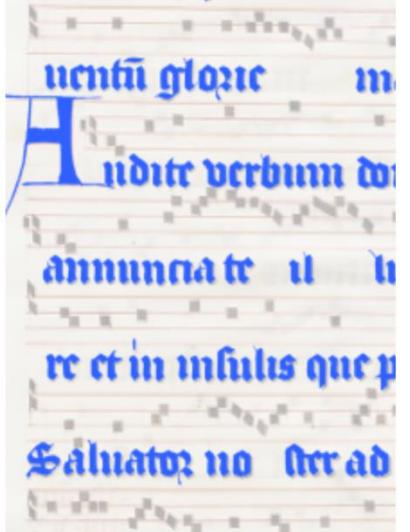
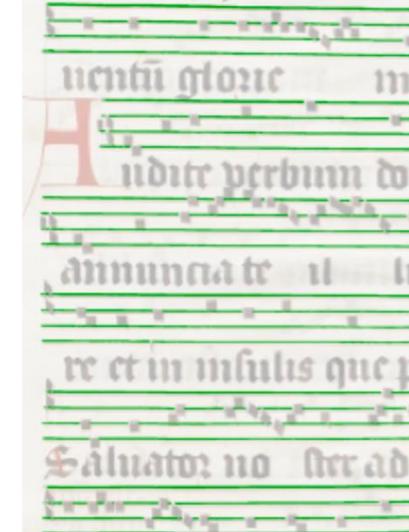
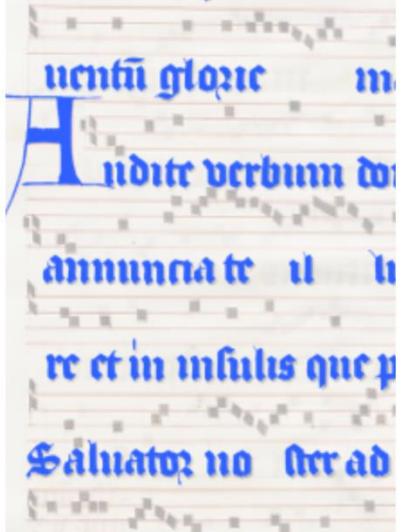
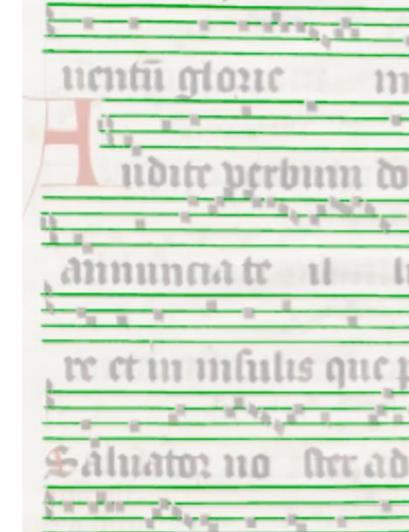
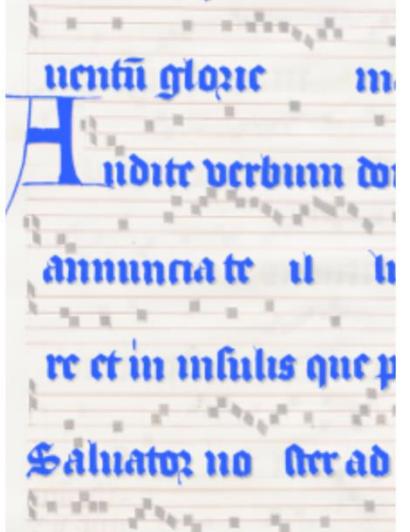
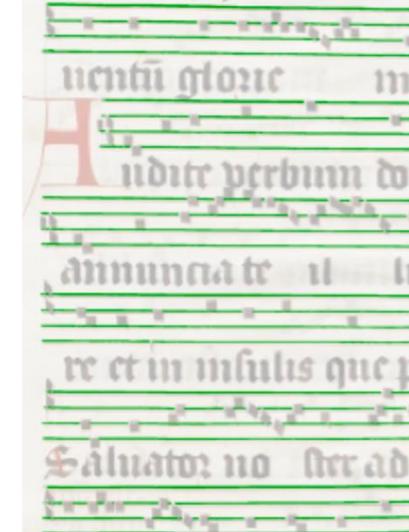
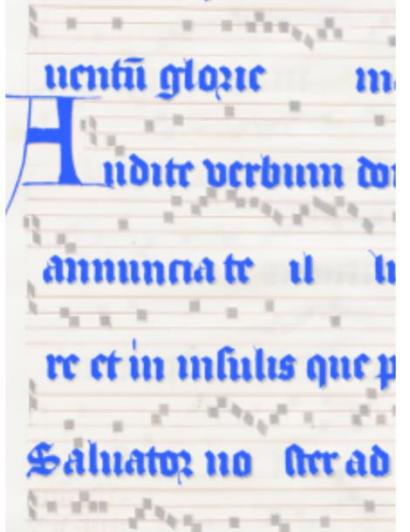
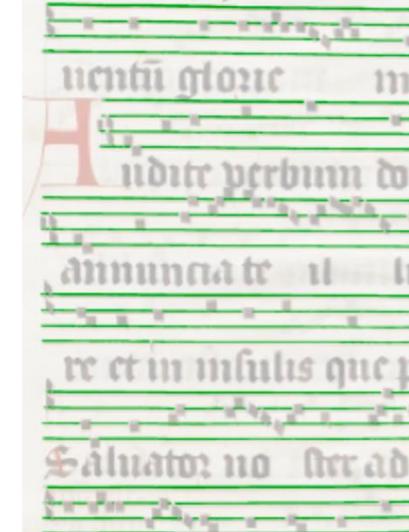
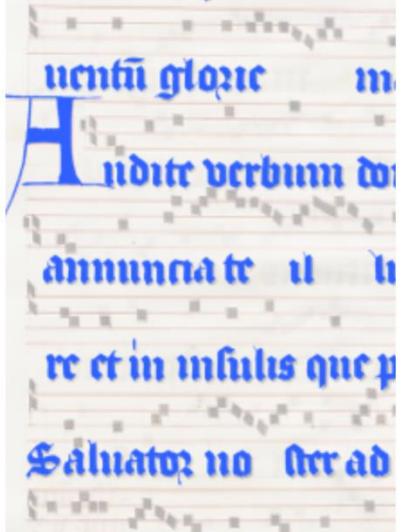
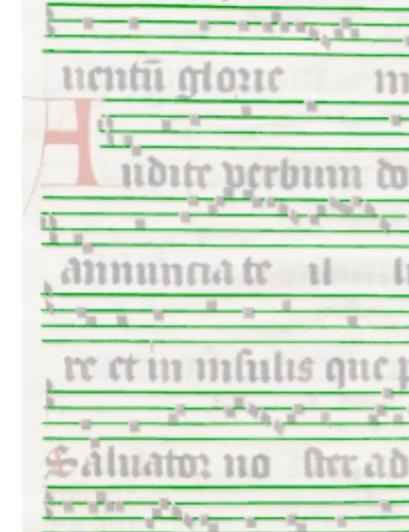
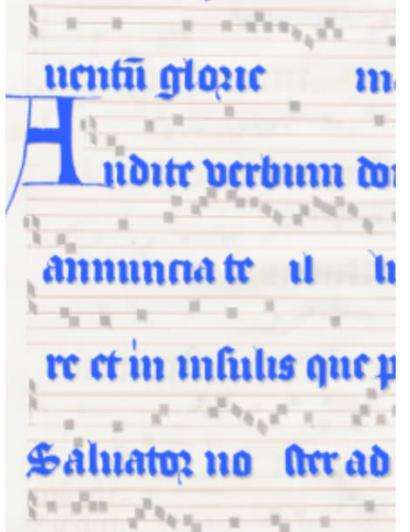
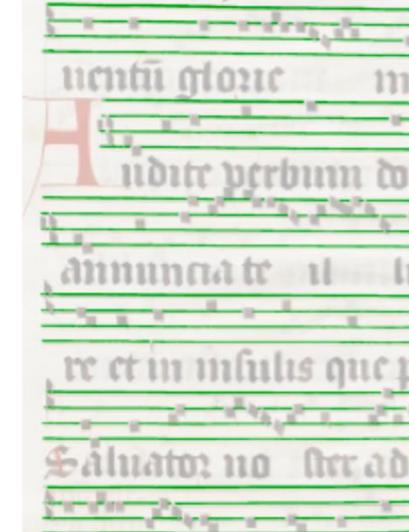
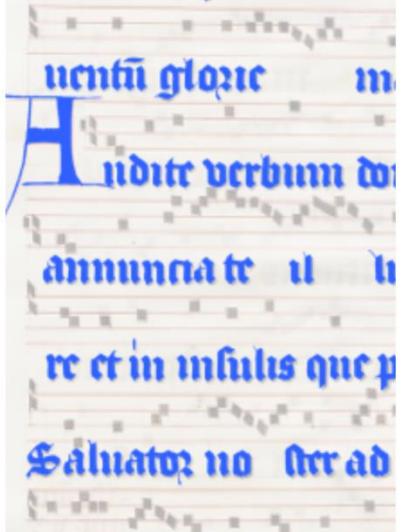
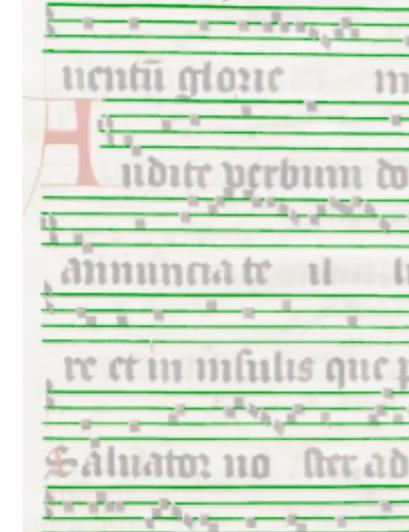
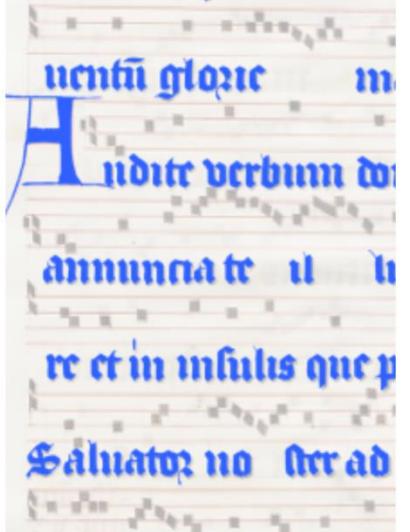
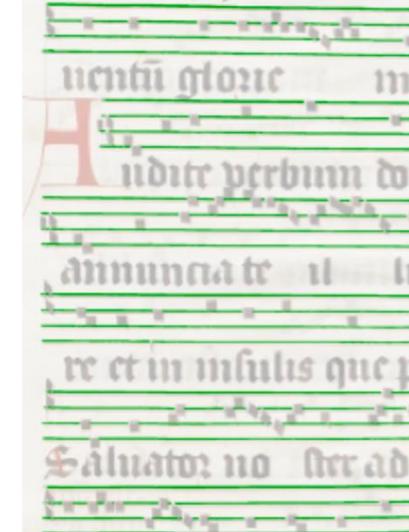
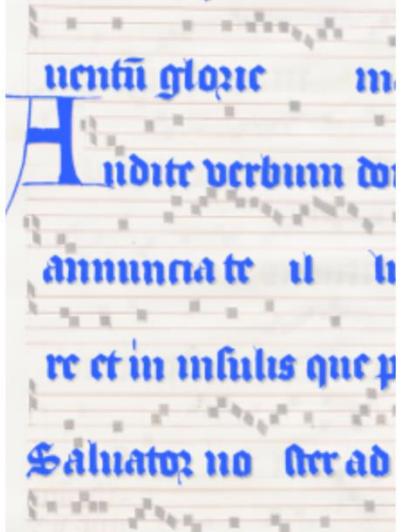
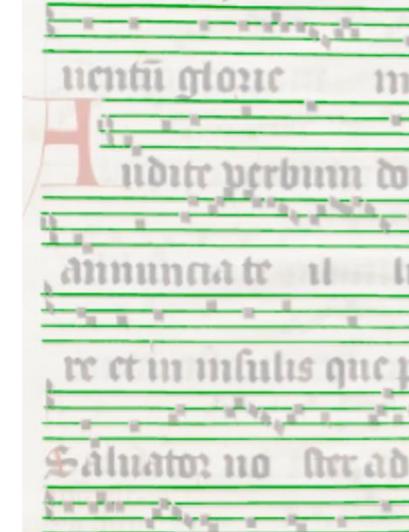
2. Reconocimiento de los símbolos



3. Ensamblaje de la notación

Combinación de la información para reconstruir la notación (el significado) musical

- Interpretación de la nota musical (símbolo + posición en pentagrama + clave)
- Asignación de las sílabas del texto a los grupos de notas

Staff	Note	Text
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		
		<img alt="Text 'H' in blue above the staff." data-bbox="785

4. Codificación en un formato estándar

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      <layer xml:id="layer-L6F1N1" n="1">
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        </triplet>
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    </staff>
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      </layer>
    </staff>
  </measure>
</section>
```

- Exportar la música a un formato estándar de codificación musical (e.g., MEI)
- En ocasiones, se han desarrollado interfaces para corregir el MEI con mayor facilidad

4. Codificación en un formato estándar

The screenshot shows the Neon.js Neume Editor Online interface. On the left, a manuscript page from Salzинnes, CDN-Hsmu M2149.L4, Folio 011r, is displayed. The page contains four-line red staves with black neumes. Below the staves, Gothic-style text is written in two columns. The first column reads: "omnis homo quia ec", "a et. u. t prepara bi tur in mi", "solium e uis et sedebit super", and "cans in equita te. Tunc". The second column starts with a large blue initial letter "A". On the right side of the interface, there is a toolbar with various icons for file operations like Open, Save, Print, and Export. Below the toolbar is a "Display" panel with sliders for "Glyph Opacity" and "Image Opacity", both set to 100%. It also includes checkboxes for "Display Text", "Display Info", and "Highlight - Syllable". The "MEI Status" is shown as "VALID". Under the "Insert" section, there are buttons for Neume, Grouping, Clef, and System. The "Edit" panel at the bottom has buttons for "Select By: Syllable, Neume, Neume Component, Staff", "Delete", "Undo", and "Redo". A blue banner at the bottom right of the editor area contains the text "Neon.js Neume Editor Online".

Ejemplo en otro sistema de OMR

MuRET = Music Recognition Encoding and Transcription

Desarrollado en la Universidad de Alicante

Principalmente por **David Rizo Valero**

Page

Author

Capital

Chord

Drawing

Empty staff

Lyrics

Marginalia

Multiple lyrics

Multiple text

No music content staff

 Part name Staff Lyrics Multiple lyrics

1. Preprocesamiento

División del documento en regiones o capas (para su posterior procesamiento)

Page

Author

Capital

Chord

Drawing

Empty staff

Lyrics

page 593/H. 1.3

A 4. Author Petrus Bermudes.

capital staff

lyrics si autem de Templo, et ceterum ienit

lyrics sic templo, sic item pio, et ceterum ienit

lyrics pio, alia in nuncius

autem

lyrics'''

affe in ym et omnes

lyrics si spernunt, qui spernunt, et omnes ad quos spernunt

capital staff

I lyrics a ceterum

lyrics

2. Reconocimiento de los símbolos

MURET

Guatemala 03 Vidi aquam

Logout as martha

The screenshot shows the MURET software interface. At the top left is the logo 'MURET'. To its right is the title 'Guatemala 03 Vidi aquam'. On the far right is a link 'Logout as martha'. The main area displays a manuscript page with musical notation and Latin text. A green box highlights a section of the text 'tempore tempore tunc pio, egeriam iudea' and the number 'A 4. Petrus Bermudes.'. Below the manuscript is a transcription tool with various editing icons (magnifying glass, eraser, etc.) and a handle slider set to 2. A red dashed box highlights a specific section of the manuscript's musical staff. At the bottom, there's a 'Clefs!Meters' section showing various musical symbols, a transcription dropdown ('Agnostic end to end All e2e 11 may 24'), a 'Compute language model probabilities' button, and a modern notation editor with a staff and a note being moved.

A 4. Petrus Bermudes.

tempore tempore tunc pio, egeriam iudea

External reference (option)

Handle: 2 5 20

Enlarge image preview

Clefs!Meters Notes Beams Ligature Rests | Accids. Other

Agnostic **skm Semantic MEI PAEC

Agnostic end to end All e2e 11 may 24 Compute language model probabilities Move pitch L5 L4 L3 L2 L1 S4 S3 S2 S1

Move symbols horizontally or vertically to change agnostic position: metersign.Ct:L3

Semantic Transducer Direct transcription Modern notation Special notation type: Same as whole document

Agnostic end to end

All e2e 11 may 24

v



AFC

Other

A musical staff in G clef. The first note is a red 'C'. The second note is a white open circle. The third note is a white filled circle with a vertical stem. The fourth note is a white filled circle with a vertical stem. The fifth note is a white open circle. The sixth note is a white filled circle with a vertical stem. The seventh note is a white filled circle with a vertical stem. The eighth note is a white open circle. The ninth note is a white filled circle with a vertical stem.

Semantic

Transducer



Direct transcription

Modern notation

Agnostic ****skm** **Semantic** **MEI** **PAEC**

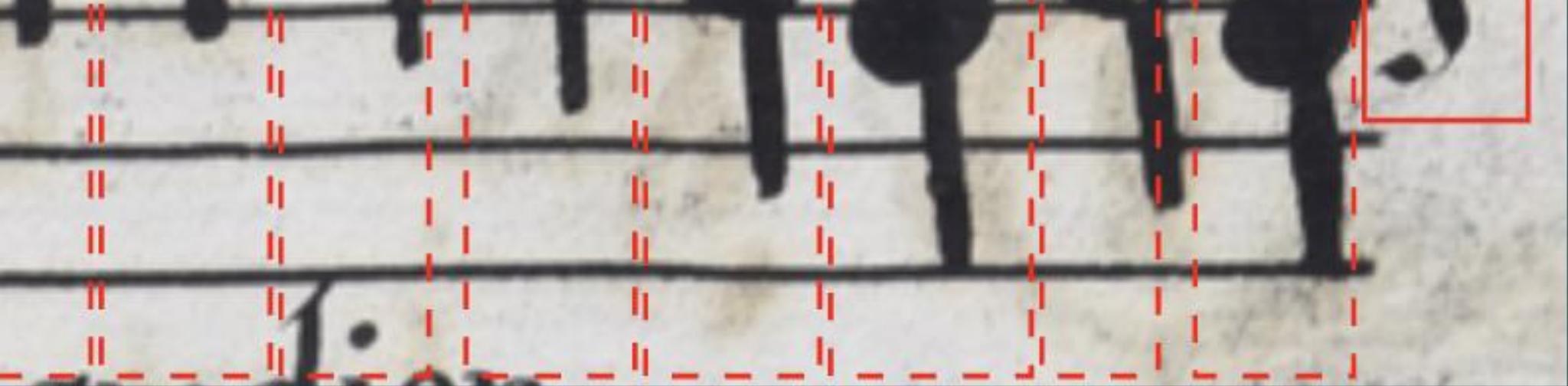
Clefs|Meters Notes Beams Ligature Rests | Accids. Other

Agnostic end to end **All e2e 11 may 24**

Move symbols horizontally or vertically

Semantic **Transducer**

Direct transcription **Modern notation**



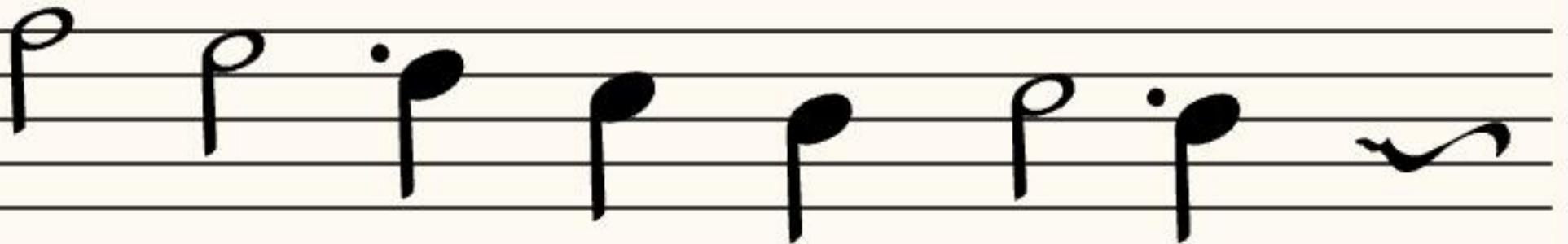
language model probabilities



Move pitch



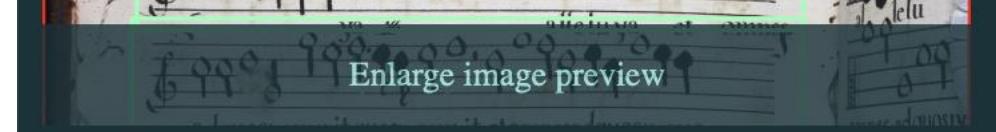
L5 L4 L3 L2 L1
S4 S3 S2 S1



3. Ensamblaje de la notación

The screenshot displays the MURET software interface for assembling musical notation. The top left shows a thumbnail of a manuscript page with the title "A 4. Petrus Bermudes." and lyrics. The main workspace shows a photograph of a manuscript page with red dashed boxes highlighting specific notes. Below the image is a modern musical staff with corresponding note heads. A sidebar on the left lists various symbols and their agnostic values, such as clefs, metrical signatures, and dynamic markings. The bottom right shows a second modern musical staff with a different set of note heads. The interface includes various tools and dropdown menus for managing the transcription process.

Combinación de la información para reconstruir la notación (significado) musical



Agnostic **skm Semantic MEI PAEC

	Agno
**skm	2050
*clefG2	2050
*met(C)	2050
sg	2050
Mb\	2050
Mcc	2050
sdd	2050
Mee	2050
M.gg	2050
mff	2050
Mee	2050
sdd	2050
Mdd	2050
Mff	2050

Agnostic end to end All e2e 11 may 24

Move symbols horizontally or vertically to change agnostic position: note.half_down:S5,

Semantic Transducer

Direct transcription Modern notation

Combinación de la información para reconstruir la notación (significado) musical

4. Codificación en formato estándar

Guatemala

7v.jpg

superius
-
tenor
-

8r.jpg

alt
-

bas

9r.jpg

superius
-
altus
-
bassus
-

9v.jpg

superius
-
tenor
-

10r.jpg

10v.jpg

11r.jpg

Engrave and export (MEI...) (selected)

Export to Basic MEI...

Export Tonos (temp.)...

Hide

Propagate document analysis and parts

Propagate just parts

Move to section:

Reconocimiento óptico en música

Producto final: Archivo simbólico

Una representación simbólica en un formato estándar (e.g., MEI)

¿Cuál es la utilidad de esto?

Permite la **búsqueda** de piezas **no solo por metadata** (e.g., título y compositor)
si no también por **contenido musical** (e.g., melodía)

Resumen de mi experiencia

- A través del proyecto SIMSSA en DDMAL, tuve mi primer acercamiento a las **tecnologías** desarrolladas para la **codificación** de documentos de **música antigua** en **formatos simbólicos**
- Implicaciones:
 1. Mejorar el acceso
 - A. Facilita la búsqueda (melódica)
 - B. Reproducción de audio y transcripción automática a notación moderna
 2. Facilitar el análisis musical
- El **OMR** facilita todo esto al permitir la **codificación de la música de una forma semiautomática**
- **Otras tecnologías** que también **colaboran** en la **codificación semiautomática** de la **música antigua** (específicamente, para notación **mensural**)

Experiencia durante el trabajo de maestría y disertación

Trabajo en polifonía

Tecnologías específicas para la notación mensural (su interpretación rítmica:
sistema experto en los *principios de imperfección y alteración*, editores
gráficos y herramientas de análisis de contrapunto)

Primero, una introducción al corpus de música

Trabajo en polifonía

Tecnologías específicas para la notación mensural (su interpretación rítmica: sistema experto en los *principios de imperfección y alteración*, editores gráficos y herramientas de análisis de contrapunto)

Libros de polifonía de la Catedral de Guatemala



- Seis libros de polifonía
- Manuscritos
- Notación mensural
- Copiados en los siglos XVII y XVIII
- Música Renacentista del siglo XVI
- La mayor parte por compositores españoles (algunos pocos de otras partes de Europa, otros criollos y bastantes anónimos)
- Se encuentran en el Archivo Histórico Arquidiocesano, Ciudad de Guatemala ([GCA-Gaha](#))
- **Sigla:** GuatC (census catalogue), GCA-Gc ([antiguo siglum en RISM](#)), GCA-Gaha ([nuevo siglum en RISM](#))

Composers Represented in the GuatC 1–6 Choirbooks

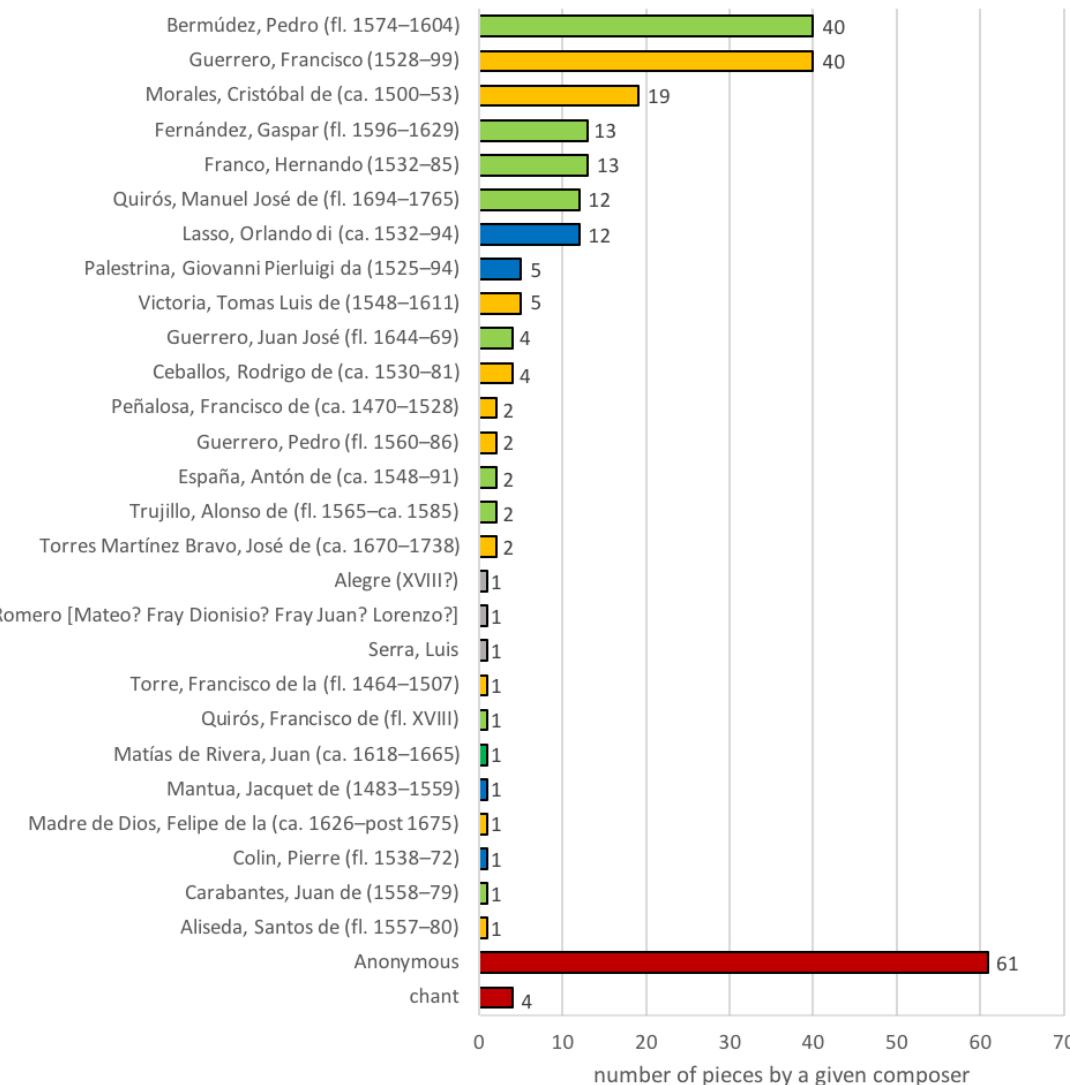
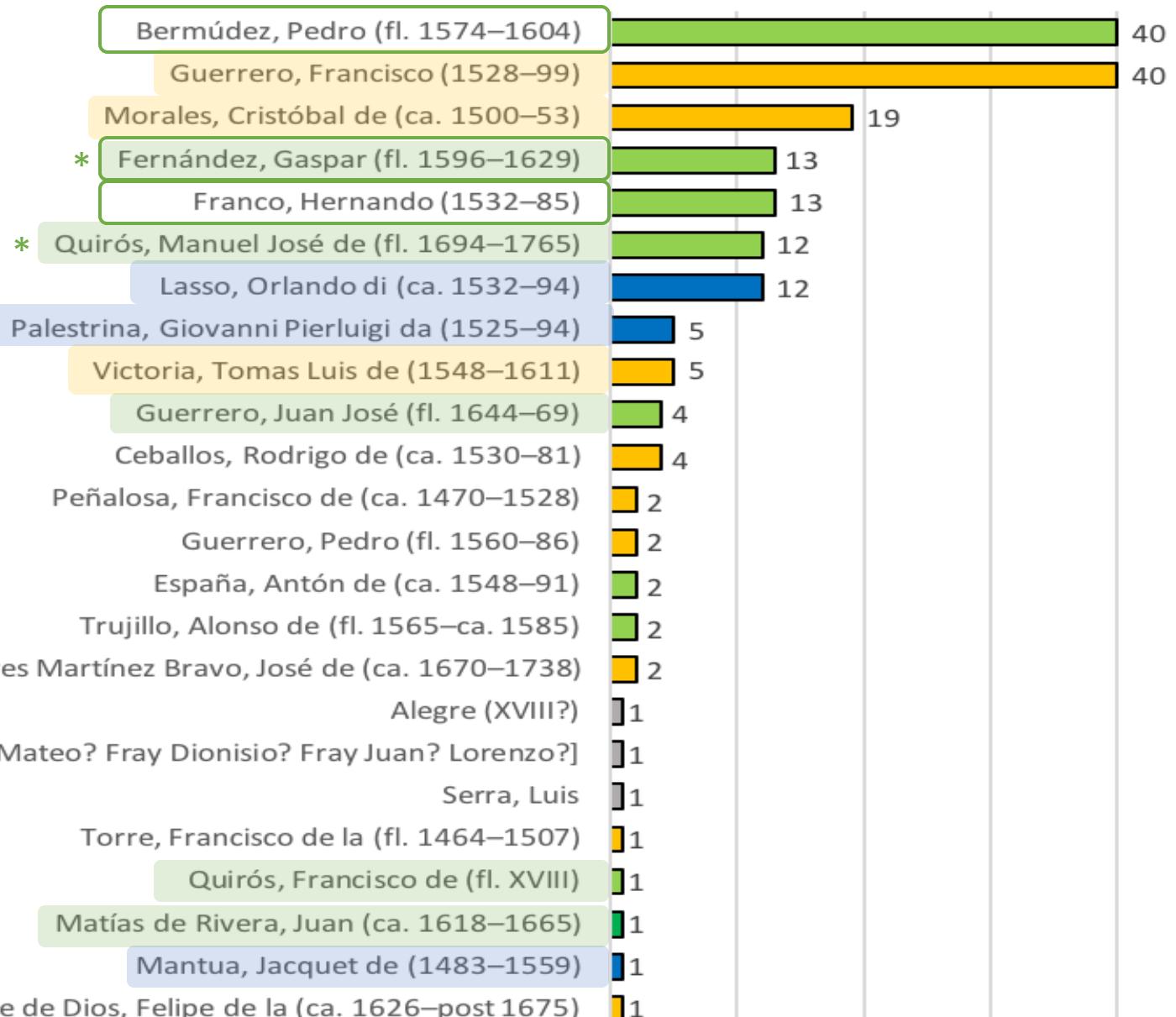


Gráfico basado en la información
proveída por Morales Abril
(2015, 119–120)

Composers Represented in the GuatC 1–6 Choirbooks



KEY:

- Compositores de la Península Ibérica que nunca viajaron a las Américas
- Compositores activos en el Vicerreinato de Nueva España
- Otros compositores europeos

Gráfico basado en la información proveída por Morales Abril (2015, 119–120)

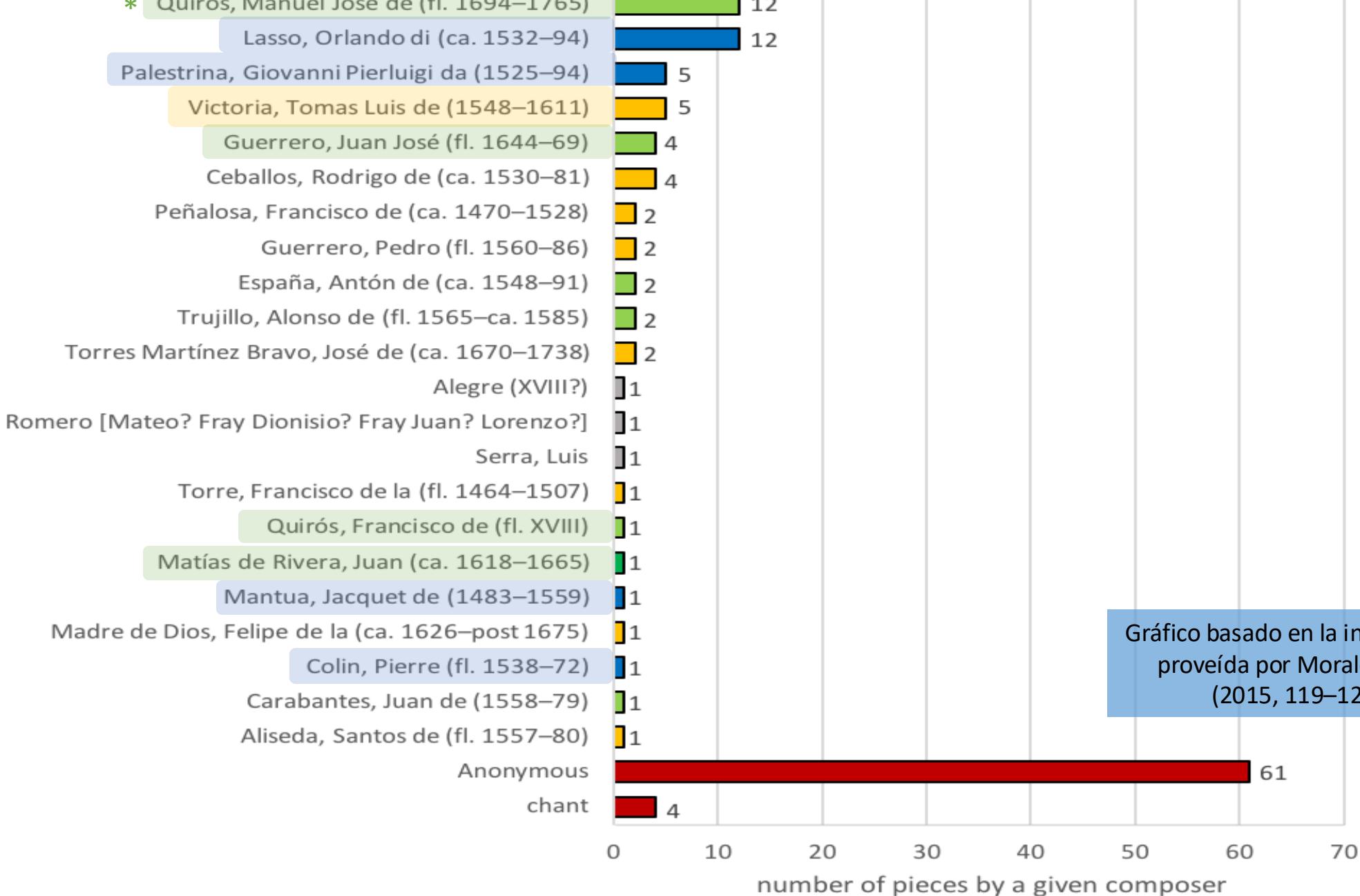
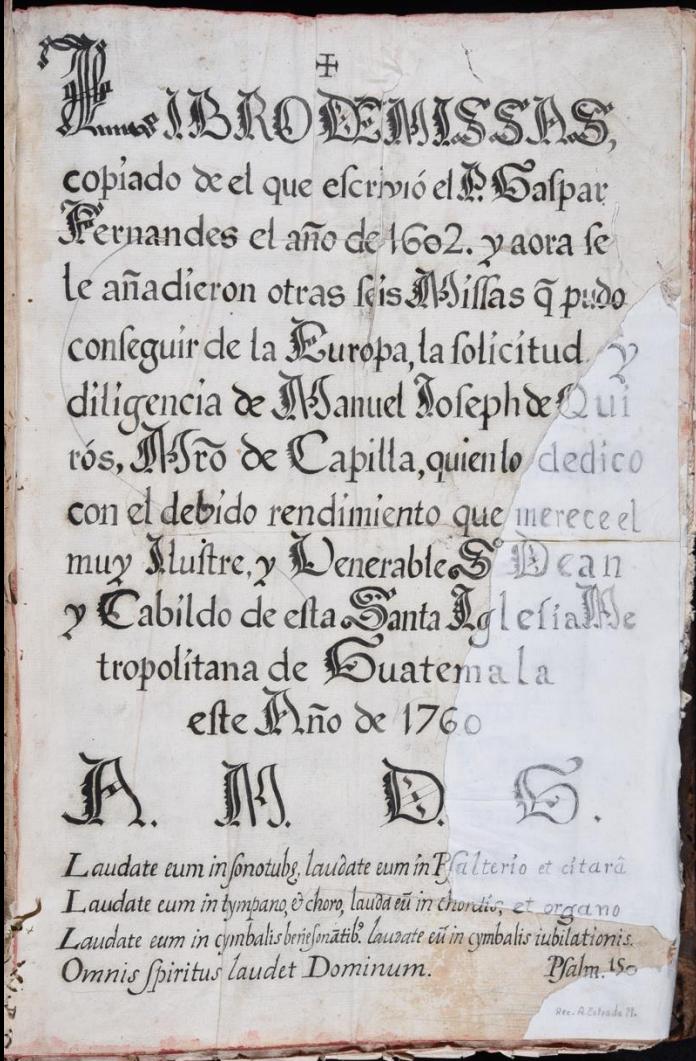


Gráfico basado en la información
proveída por Morales Abril
(2015, 119–120)

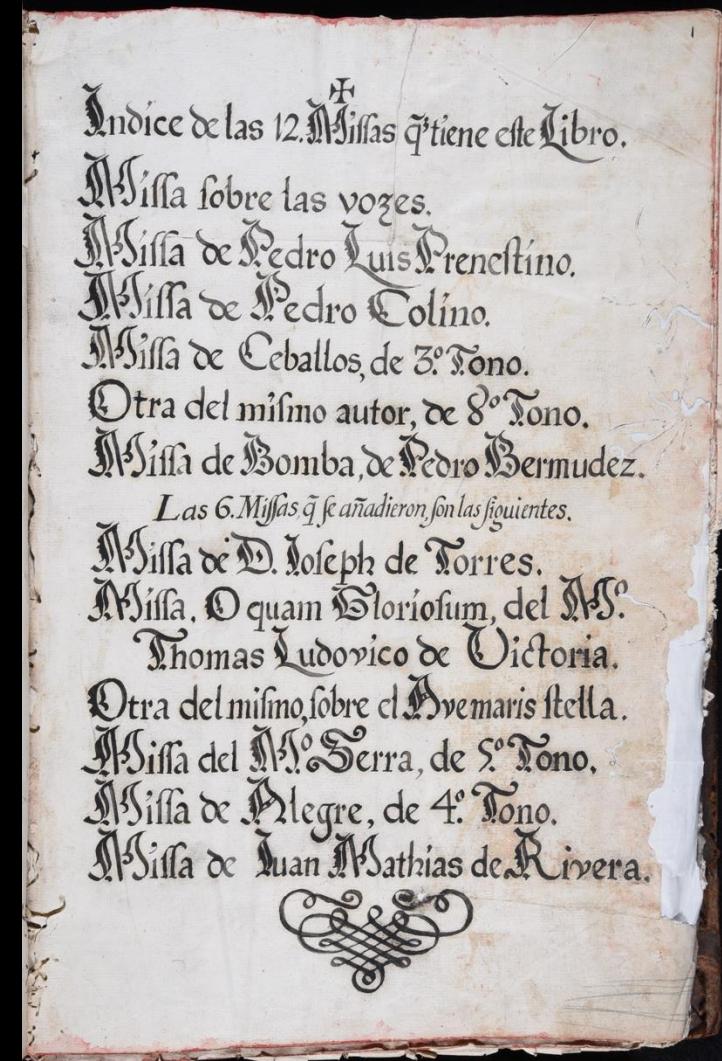


GuatC 1, folio Or

PROYECTO PILOTO

Libro 1 Libro de Misas

- 12 misas
- 15 piezas litúrgicas breves (añadidas en el s. XVIII, pero de compositores del s. XVI)



GuatC 1, folio 1r

Libros de polifonía de la Catedral de Guatemala



“Una de las **características más notables** de la colección de libros de polifonía de la catedral de Guatemala es la **perdurabilidad** de un repertorio que se **recopiló en los primeros años del siglo XVII** y que mantuvo su **vigencia al menos hasta principios del siglo XIX**.

Esta recopilación echó mano de la música de mediados del siglo XVI, en uso en la propia catedral de Guatemala ”

Morales Abril, Omar "Música local y música foránea en los libros de polifonía de las Catedrales de Guatemala y México." *troja. Jahrbuch für Renaissancemusik* 14 (2015): 95-124.

Ahora, hablemos de la parte de tecnología

Trabajo en polifonía

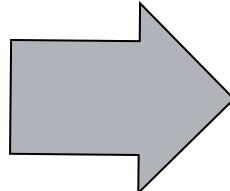
Tecnologías específicas para la notación mensural (su interpretación rítmica: sistema experto en los *principios de imperfección y alteración*, editores gráficos y herramientas de análisis de contrapunto)

Herramientas específicas para la notación mensural

- Hemos hablado del OMR
- La notación mensural requiere un paso más allá del OMR para tratar con un aspecto específico de la notación
 - **la interpretación de la duración de las notas**
- **Herramientas específicas para notación mensural** y cómo estas pueden ser utilizadas junto con los resultados del OMR para facilitar el proceso de codificación semiautomática de la música mensural

Herramientas específicas para la notación mensural

- Hemos hablado del OMR
 - La notación mensural requiere un paso más allá del OMR para tratar con un aspecto específico de la notación
- **la interpretación de la duración de las notas**



Herramientas específicas para la notación mensural

- 1. Editor de notación mensural**
 - Su integración con el **OMR**
- 2. Sistema experto para la interpretación rítmica** de la notación mensural (según los principios de imperfección y alteración)
- 3. Herramienta de análisis de contrapunto** aplicada a detección de errores

Herramientas específicas para la notación mensural

1. **Editor de notación mensural**

➤ Su integración con el **OMR**

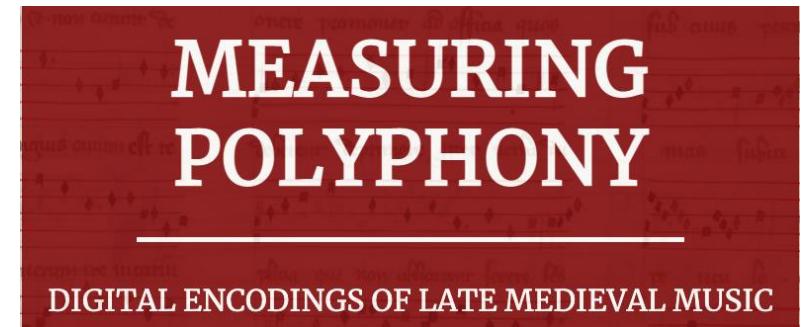
2. **Sistema experto para la interpretación rítmica** de la notación mensural (según los principios de imperfección y alteración)

3. **Herramienta de análisis de contrapunto** aplicada a detección de errores

1. Editor de notación mensural

MEASURING POLYPHONY (MP) EDITOR

- Editor de música mensural en línea
- Dos interfaces:
 - **Editor de entrada:** el usuario ingresa las notas con el teclado de su ordenador
 - **Editor de partitura:** la duración de las notas ingresadas es interpretada automáticamente (dándoles valores de *imperfecta* / *perfecta* / *altera*) y las voces son alineadas en partitura



The screenshot shows the Measuring Polyphony interface. At the top, there's a header bar with the logo, "MEASURING POLYPHONY", "DIGITAL ENCODINGS OF LATE MEDIEVAL MUSIC", and links for "BROWSE", "TRANSCRIBE", and "ABOUT". Below the header, the main area has tabs for "Music Input", "General Help", and "Music Input Help". A sub-header says "Enter Music" with a dropdown menu set to "cantus". It includes sections for "Select Initial Mensuration" with radio buttons for "modus" (3, 2, ON/A), "tempus" (3, 2, ON/A), and "prolatio" (3, 2, ON/A). On the right, a musical staff shows notes being entered. In the center, a manuscript page from the BnF Département des Manuscrits, Français 1584, is displayed with musical notation and Latin text. At the bottom, a transcription of the music is shown with lyrics like "Dous vi ai re graci eus de fin".

Karen Desmond (Brandeis University, ahora Maynooth)

- Desarrolladoras: Juliette Regimbal (principal) y Martha Thomae (algoritmo de interpretación rítmica)
- Colaboradores: Laurent Pugin (Verovio), Craig Sapp (Humdrum), Andrew Hankinson (IIIF y DIAMM)

MuRET Editor editor.measuringpolyphony.org/#/ CAQ McGill's Services... Software to Download Verovio Editor Manuscriptorium MEI Garage Verovio MEI Viewer MuRET Editor MEC 2019 VHV W... MEC 2019 Tutorial... Welcome to PEM |... Welcome to Spani... Welcome to Spanish Other Bookmarks

MEASURING POLYPHONY
DIGITAL ENCODINGS OF LATE MEDIEVAL MUSIC

BROWSE TRANSCRIBE ABOUT

Load a manuscript

Manuscript Repository: URL:

For example, to transcribe a piece from the famous *Roman de Fauvel* manuscript, choose *Gallica* in the dropdown and paste this URL:
<https://gallica.bnf.fr/ark:/12148/btv1b8454675g>

Load an .mei file

Compatible Parts-MEI File: No file chosen

The Measuring Polyphony Music Editor (the MP Editor), funded by the [National Endowment for the Humanities](#), is a prototype web application that allows users with no expertise in music encoding to transcribe and digitally encode transcriptions of polyphony in mensural notation, and create links between these music transcriptions to zones of the digital images of the original medieval manuscripts. To download a White Paper on the MP Editor, click [here](#). For more information about the Measuring Polyphony project, click [here](#).

Project Team

Karen Desmond, Brandeis University, Massachusetts, USA: Principal Investigator & Project Director
Juliette Regimbal, McGill University, Canada: Prototype developer
Martha Thomae, McGill University, Canada: Prototype developer
Andrew Hankinson, RISM, Switzerland: Consultant on diva.js, MEI
Laurent Pugin, University of Bern & RISM, Switzerland: Consultant on Verovio, MEI
Craig Sapp, Stanford University, California, USA: Consultant on Humdrum, MEI

Student Research Assistants

Caelan Gadweh-Meaden, Brandeis University, USA
Zen Kuriyama, Brandeis University, USA
Daniel Shapiro, Brandeis University, USA

With thanks also to Julie Cumming and her music palaeography students at McGill University - Christina Colanduoni, Mayu Egan, Geneviève Gates-Panneton, Namgon Lee, and Celia Morin - for testing the MP Editor in December 2020.

Advisory Board

Julie Cumming, McGill University, Canada
Julia Craig McFeely, University of Oxford, UK

Editor

gpolyphony.org/#/

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YPHONY
MEDIEVAL MUSIC

BROWSE

Load a manuscript

Manuscript Repository: Gallica URL:

For example, to transcribe a piece from the famous *Roman de Fauvel* manuscript, choose *Gallica* in the dropdown and paste this URL:
<https://gallica.bnf.fr/ark:/12148/btv1b8454675g>

Load an .mei file

Compatible Parts-MEI File: No file chosen

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Project Team

Karen Desmond, Brandeis University, Massachusetts, USA: Principal Investigator & Project Director



BnF. Département des Manuscrits. Français 146



Zoom level: 3

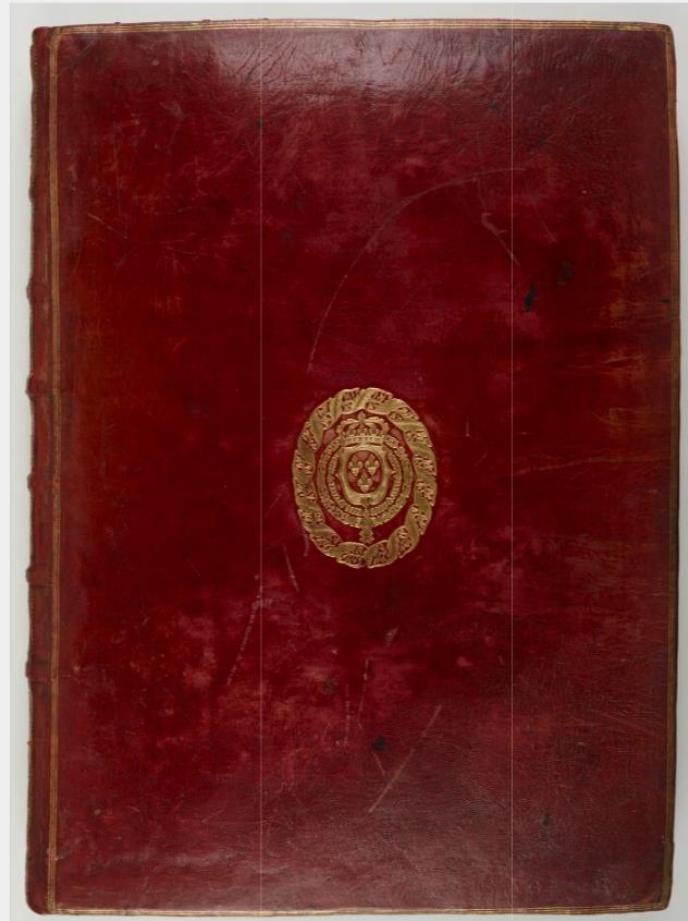
plat supérieur – contreplat sup.



Metadata Input

General Help

Music Input Help



Enter Metadata

Short title:

Composer name:

Notation:

Manuscript Siglum:

Genre:

Add Contributor

Continue to Music Input



BnF. Département des Manuscrits. Français 146



Zoom level: 3

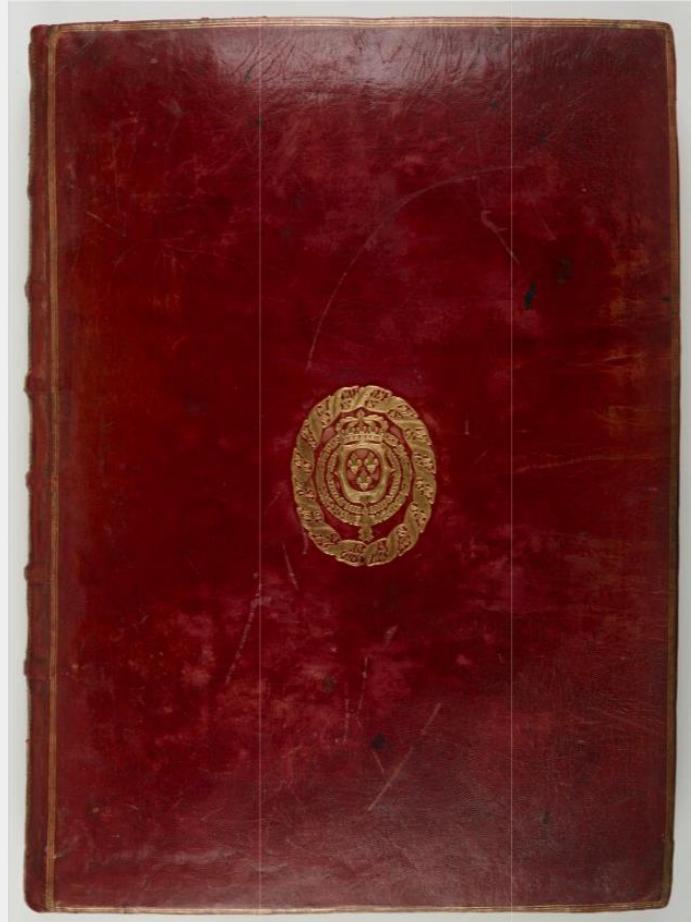
plat supérieur - contreplat sup.



Metadata Input

General Help

Music Input Help



Enter Metadata

Short title:

Composer name:

Notation:

Black Mensural — Ars antiqua

Black Mensural — Ars nova

White Mensural

Manuscript Siglum:

Genre:

Add Contributor

Continue to Music Input



BnF. Département des Manuscrits. Français 146

Zoom level: 5 45r 45r Go

Music Input General Help Music Input Help

[Download MEI File](#) [Delete Staff](#) [Save/Load My Work](#)

Enter Music

Voice:

triplum motetus tenor contratenor

Select Mensuration:

modus tempus prolation

3 2 N/A 3 2 N/A 3 2 N/A

Quant ie se wi ou vointe der wlen
tiers mi uueil acorder et puis chante
de cuer der. ce chans ueust bone.
Tenant fina bien deus
Fauuel qui na agiu fin
En ce monde car tout ob
I sent aslu tout a sole
E obe nous a tout en solein
E o sole en nous destobam
I l fineta car toiz iourz
A e pourra pas. a faut mo
S econt. dieu en gre le reco
C ai ses. il est temps que
E ryliac explitcat
lude scriptor cat.
Est en tour de vni dex quar le me domez

[Continue to Score Editor](#)

Herramientas específicas para la notación mensural

1. Editor de notación mensural

➤ Su integración con el OMR

2. Sistema experto para la interpretación rítmica de la notación mensural (según los principios de imperfección y alteración)
3. Herramienta de análisis de contrapunto aplicada a detección de errores

Editor

gpolyphony.org/#/

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PYTHON
E MEDIEVAL MUSIC

BROWSE

Load a manuscript

Manuscript Repository: URL:

For example, to transcribe a piece from the famous *Roman de Fauvel* manuscript, choose *Gallica* in the dropdown and paste this URL:

<https://gallica.bnf.fr/ark:/12148/btv1b8454675g>

Load an .mei file

Compatible Parts-MEI File: No file chosen

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Project Team

Karen Desmond, Brandeis University, Massachusetts, USA: Principal Investigator & Project Director

Editor

gpolyphony.org/#/

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PYPHONY
E MEDIEVAL MUSIC

BROWSE

Load a manuscript

Manuscript Repository: URL:

For example, to transcribe a piece from the famous *Roman de Fauvel* manuscript, choose *Gallica* in the dropdown and paste this URL:

<https://gallica.bnf.fr/ark:/12148/btv1b8454675g>

Load an .mei file

Compatible Parts-MEI File: No file chosen

The Measuring Polyphony Music Editor (the MP Editor), funded by the [National Endowment for the Humanities](#), is a prototype web application that allows users with no expertise in music encoding to transcribe and digitally encode transcriptions of polyphony in mensural notation, and create links between these music transcriptions to zones of the digital images of the original medieval manuscripts. To download a White Paper on the MP Editor, click [here](#). For more information about the Measuring Polyphony project, click [here](#).

Project Team

Karen Desmond, Brandeis University, Massachusetts, USA: Principal Investigator & Project Director

MuRET Editor

editor.measuringpolyphony.org/#/input/iiif/https%25253A%25252F%25252Fmuret.dlsi.ua.es%25252Fiiif%25252F6%25252F223%25252Fmanifest.json

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MEASURING POLYPHONY DIGITAL ENCODINGS OF LATE MEDIEVAL MUSIC

Pedro Bermudez

166r.jpg - 167r.jpg 166v Go

BROWSE TRANSCRIBE ABOUT

Zoom level: 3

Music Input General Help Music Input Help

Download MEI File Download System Humdrum Delete Staff

Enter Music

Voice: superius

Select Initial Mensuration:

modus tempus prolatio

3 2 N/A 3 2 N/A 3 2 N/A

Mensuration Sign: C3

166v.jpg, p1, s1

KODAK Color Control Patches

Continue to Score Editor

The screenshot shows a web-based application for digitizing medieval musical manuscripts. On the left, a photograph of a double-page spread from a manuscript is displayed. The top page (166r) contains musical notation on four-line red staves with black note heads. The bottom page (167r) has similar notation. A color calibration strip at the bottom of the image shows various color patches. On the right, a transcription interface allows users to input musical data. It includes dropdown menus for 'Voice' (set to 'superius'), 'Modus' (set to '3'), 'Tempus' (set to '2'), and 'Prolatio' (set to 'N/A'). A 'Mensuration Sign' dropdown is set to 'C3'. Below these controls is a preview area showing a single staff of music with a C3 sign and two measures of notes. At the bottom of the interface is a button labeled 'Continue to Score Editor'.

modus tempus prolation
 3 2 N/A 3 2 N/A 3 2 N/A

Mensuration Sign: **C3** ▾



166v.jpg, p1, s1

Continue to Score Editor

Herramientas específicas para la notación mensural

1. Editor de notación mensural

➤ Su integración con el OMR

2. Sistema experto para la interpretación rítmica de la notación mensural (según los principios de imperfección y alteración)

3. Herramienta de análisis de contrapunto aplicada a detección de errores

2. Sistema experto de interpretación rítmica de notación mensural

- Sistema experto (conjunto de reglas)
- De interpretación de la duración de las notas en notación mensural
- Según los principios de imperfección y alteración
- Esto permite transcribir las voces a partitura

→ **Integré este sistema dentro del Measuring Polyphony Editor**

modus tempus prolation
 3 2 N/A 3 2 N/A 3 2 N/A

Mensuration Sign: **C3** ▾



166v.jpg, p1, s1

Continue to Score Editor

MuRET Editor editor.measuringpolyphony.org/#/score/iiif/https%25253A%25252F%25252Fmuret.dlsi.ua.es%25252Fiiif%25252F6%25252F223%25252Fmanifest.json

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MEASURING POLYPHONY
DIGITAL ENCODINGS OF LATE MEDIEVAL MUSIC

Pedro Bermudez

Zoom level: 3 152v.jpg - 153r.jpg Go

Score Editor Score Editor Help

Return to Music Input Download MEI File(s) Copy MEI Score to Clipboard

16 Missa de Bomba

superius C3 166v.jpg_p1_s1 166v.jpg_p1_s2 166v.jpg_p1_s3

altus C3 167r.jpg_p1_s1 167r.jpg_p1_s2 167r.jpg_p1_s3

tenor C3 166v.jpg_p1_s4 166v.jpg_p1_s5 166v.jpg

bassus C3 167r.jpg_p1_s4 167r.jpg_p1_s5

KODAK Color Control Patches Blue Open Green Yellow Red Magenta White 200mpg Black

Bar by: none Switch to Modern Clef Add Dissonance Labels Continue in Editorial Mode

MuRET Editor

editor.measuringpolyphony.org/#/score/iiif/https%25253A%25252F%25252Fmuret.dlsi.ua.es%25252Fiiif%25252F6%25252F223%25252Fmanifest.json

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MEASURING POLYPHONY
DIGITAL ENCODINGS OF LATE MEDIEVAL MUSIC

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Zoom level: 3 152v.jpg - 153r.jpg Go

Score Editor Score Editor Help

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Missá de Bomba, à 4.

Y ri e leyfón, Kyri

ley fón, Hrifte leyfón,

Chritte leyfón,

Christe leyfón,

superius

16 Missa de Bomba

166v.jpg_p1_s1 166v.jpg_p1_s2 1

167r.jpg_p1_s1 167r.jpg_p1_s2 1

166v.jpg_p1_s4 166v.jpg_p1_s5

167r.jpg_p1_s4 167r.jpg_p1_s5

altus

tenor

bassus

KODAK Color Control Patches

Bar by: semibreve Switch to Modern Clefs Add Dissonance Labels

Continue in Editorial Mode

MuRET Editor

editor.measuringpolyphony.org/#/score/iiif/https%25253A%25252F%25252Fmuret.dlsi.ua.es%25252Fiiif%25252F6%25252F223%25252Fmanifest.json

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Zoom level: 3 166r.jpg - 167r.jpg Go

Score Editor Score Editor Help

Return to Music Input Download MEI File(s) Copy MEI Score to Clipboard

16 Missa de Bomba

superius
166v.jpg_p1_s1 166v.jpg_p1_s2 1
altus
167r.jpg_p1_s1 167r.jpg_p1_s2 1
tenor
166v.jpg_p1_s4 166v.jpg_p1_s5
bassus
167r.jpg_p1_s4 167r.jpg_p1_s5

KODAK Color Control Patches

Bar by: semibreve ▾ Switch to Modern Clefs □ Add Dissonance Labels □ Continue in Editorial Mode

The screenshot shows a dual-pane interface. On the left, a photograph of a medieval manuscript page (166v) is displayed, featuring four-line musical notation and Latin text lyrics. A color calibration strip at the bottom is labeled 'KODAK Color Control Patches'. On the right, a digital score for '16 Missa de Bomba' is shown in a staff-based format. The score is divided into four voices: superius, altus, tenor, and bassus. Each voice has a corresponding staff with black note heads. The score is annotated with file names (e.g., 166v.jpg_p1_s1, 167r.jpg_p1_s1) and bar numbers (e.g., 1). The top navigation bar includes links for CAQ, McGill's Services..., Software to Download, Verovio Editor, Manuscriptorium, MEI Garage, Verovio MEI Viewer, MuRET, Editor, MEC 2019 VH..., MEC 2019 Tutorial..., Welcome to PEM ..., Welcome to Spani..., and Other Bookmarks. The title 'MEASURING POLYPHONY' and subtitle 'DIGITAL ENCODINGS OF LATE MEDIEVAL MUSIC' are at the top left, and 'BROWSE TRANSCRIBE ABOUT' are at the top right.

MuRET Editor editor.measuringpolyphony.org/#/score/iiif/https%25253A%25252F%25252Fmuret.dlsi.ua.es%25252Fiiif%25252F6%25252F223%25252Fmanifest.json

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MEASURING POLYPHONY
DIGITAL ENCODINGS OF LATE MEDIEVAL MUSIC

BROWSE TRANSCRIBE ABOUT

Pedro Bermudez

Zoom level: 3 166r.jpg - 167r.jpg Go

Score Editor Score Editor Help

Return to Music Input Download MEI File(s) Copy MEI Score to Clipboard

16 Missa de Bomba

superius
altus
tenor
bassus

166v.jpg_p1_s1 166v.jpg_p1_s2
167r.jpg_p1_s1 167r.jpg_p1_s2
166v.jpg_p1_s4 166v.jpg_p1_s5
167r.jpg_p1_s4 167r.jpg_p1_s5

KODAK Color Control Patches

Bar by: semibreve ▾ Switch to Modern Clefs □ Add Dissonance Labels □ Continue in Editorial Mode

The screenshot shows the MuRET Editor interface. On the left, there is a photograph of a medieval manuscript page (166v) with musical notation and Latin text. Below the manuscript is a color calibration strip with various colored patches. On the right, a digital score for four voices (superius, altus, tenor, bassus) is displayed. The title '16 Missa de Bomba' is at the top. The score consists of two staves from different pages: 166v (measures s1-s2) and 167r (measures s1-s2). The tenor voice has a red marker on the fourth measure of the 166v staff. At the bottom, there are options to change the bar length, switch to modern clefs, add dissonance labels, and continue in editorial mode.

MuRET Editor editor.measuringpolyphony.org/#/score/iiif/https%25253A%25252F%25252Fmuret.dlsiu.es%25252Fiiif%25252F6%25252F223%25252Fmanifest.json

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MEASURING POLYPHONY
DIGITAL ENCODINGS OF LATE MEDIEVAL MUSIC

BROWSE TRANSCRIBE ABOUT

Pedro Bermudez

Zoom level: 3 166r.jpg - 167r.jpg Go

Score Editor Score Editor Help

Return to Music Input Download MEI File(s) Copy MEI Score to Clipboard

16 Missa de Bomba

superius
altus
tenor
bassus

166v.jpg_p1_s1 166v.jpg_p1_s2
167r.jpg_p1_s1 167r.jpg_p1_s2
166v.jpg_p1_s4 166v.jpg_p1_s5
167r.jpg_p1_s4 167r.jpg_p1_s5

KODAK Color Control Patches

Bar by: semibreve ▾ Switch to Modern Clefs □ Add Dissonance Labels □ Continue in Editorial Mode

The screenshot shows the MuRET Editor interface. On the left, there is a photograph of a medieval manuscript page (166v) with musical notation on four-line red staves and Latin text below it. A color calibration strip at the bottom is labeled 'KODAK Color Control Patches' and includes color patches for Blue, Cyan, Green, Yellow, Red, Magenta, Black, and White. On the right, a digital score for '16 Missa de Bomba' is displayed with four voices: superius, altus, tenor, and bassus. Each voice has a staff with black note heads. The score is divided into measures labeled 166v.jpg_p1_s1 through 167r.jpg_p1_s5. The interface includes various toolbars and buttons for editing, searching, and navigating between music input and score editor.

MuRET Editor

editor.measuringpolyphony.org/#/score/iiif/https%25253A%25252F%25252Fmuret.dls.u...%25252Fiiif%25252F6%25252F223%25252Fmanifest.json

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MEASURING POLYPHONY
DIGITAL ENCODINGS OF LATE MEDIEVAL MUSIC

Pedro Bermudez

Zoom level: 3 166r.jpg - 167r.jpg Go

Score Editor Score Editor Help

Return to Music Input Download MEI File(s) Copy MEI Score to Clipboard

16 Missa de Bomba

superius
166v.jpg_p1_s1 166v.jpg_p1_s2

altus
167r.jpg_p1_s1 167r.jpg_p1_s2

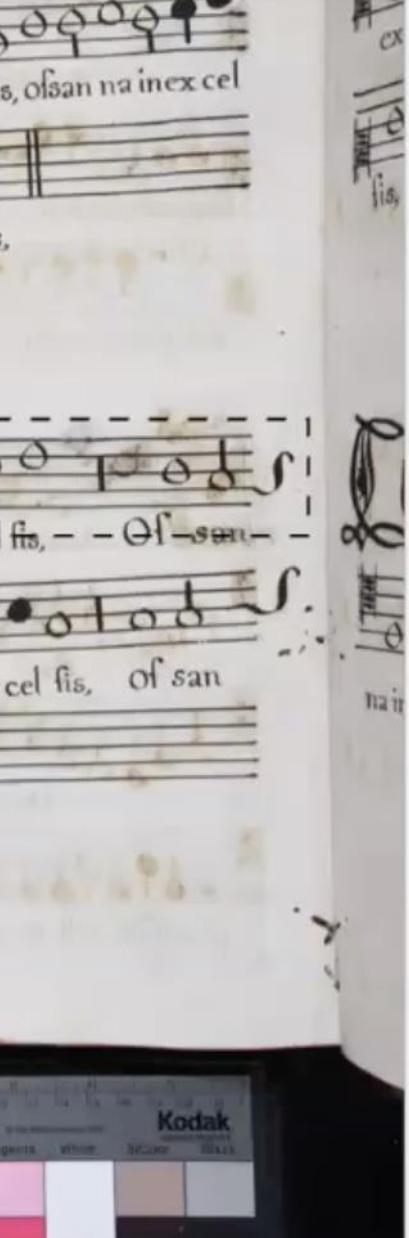
tenor
166v.jpg_p1_s4 166v.jpg_p1_s5

bassus
167r.jpg_p1_s4 167r.jpg_p1_s5

KODAK Color Control Patches

Bar by: semibreve Switch to Modern Clefs Add Dissonance Labels Continue in Editorial Mode

The screenshot shows a digital edition of a medieval manuscript. On the left, a photograph of folio 166v is displayed, showing two staves of musical notation in square neumes on four-line red staves. The notation is in common time, with a key signature of one sharp. The text below the music is in a Gothic script. A color calibration strip at the bottom of the image shows various color patches. On the right, a modern musical score for four voices (superius, altus, tenor, bassus) is shown. The score uses diamond-shaped neumes on five-line staves. The tenor part includes a red vertical bar with a small arrow pointing upwards. Below the score, there are buttons for changing the bar length, switching to modern clefs, adding dissonance labels, and continuing in editorial mode.



superius

166v.jpg, p1, s1 166v.jpg, p1, s2

altus

167r.jpg, p1, s1 167r.j

tenor

166v.jpg, p1, s4 166v.

bassus

167r.jpg, p1, s4 167r.jpg, p1, s5

Bar by: Switch to Modern Clefs Add Dissonance Labels

2. Sistema experto de interpretación rítmica de notación mensural

- Sistema experto (conjunto de reglas)
- De interpretación de la duración de las notas en notación mensural
- Según los principios de imperfección y alteración
- Esto permite transcribir las voces a partitura

→ **Integré este sistema dentro del Measuring Polyphony Editor**

- Se puede seguir editando la partitura (añadir / remover / cambiar notas)
- Todos estos cambios tienen efecto en el alineamiento de las voces
- También se pueden guardar estos cambios como “correcciones editoriales”

MuRET Editor

editor.measuringpolyphony.org/#/score/iiif/https%25253A%25252F%25252Fmuret.dls.u...%25252Fiiif%25252F6%25252F223%25252Fmanifest.json

CAQ McGill's Services... Software to Down... Verovio Editor Manuscriptorium MEI Garage Verovio MEI Viewer MuRET Editor MEC 2019 VHV W... MEC 2019 Tutorial... Welcome to PEM |... Welcome to Spani... Other Bookmarks

MEASURING POLYPHONY
DIGITAL ENCODINGS OF LATE MEDIEVAL MUSIC

Pedro Bermudez

Zoom level: 3 166r.jpg - 167r.jpg Go

Score Editor Score Editor Help

Return to Music Input Download MEI File(s) Copy MEI Score to Clipboard

16 Missa de Bomba

superius
166v.jpg_p1_s1 166v.jpg_p1_s2

altus
167r.jpg_p1_s1 167r.jpg_p1_s2

tenor
166v.jpg_p1_s4 166v.jpg_p1_s5

bassus
167r.jpg_p1_s4 167r.jpg_p1_s5

KODAK Color Control Patches

Bar by: semibreve Switch to Modern Clefs Add Dissonance Labels Continue in Editorial Mode

x +

https://25253A%25252F%25252Fmuret.dlsi.ua.es%25252Fiiif%25252F6%25252F223%25252Fmanifest.json



Verovio Editor Manuscriptorium MEI Garage Verovio MEI Viewer MuRET Editor MEC 2019 VHV W... MEC 2019 Tutorial... Welcome to PEM |... Welcome to Spani...

BROWSE TRAN

167r.jpg

Go

Score Editor

Score Editor Help

Return to Music Input

Download MEI File(s)

Copy MEI Score to Clipboard

16 Missa de Bomba

superius

A musical score for the superius part of 'Missa de Bomba'. The score consists of two staves. The top staff starts with a soprano clef and a C3 note. The bottom staff starts with an alto clef and a C3 note. Both staves have a common time signature. The music features various note heads, including diamonds and diamonds with stems, indicating different pitch levels. Measure numbers 166v.jpg, p1, s1 and 166v.jpg, p1, s2 are indicated below the staves.

altus

A musical score for the altus part of 'Missa de Bomba'. It consists of two staves, continuing from the superius part. The top staff starts with a soprano clef and a C3 note. The bottom staff starts with an alto clef and a C3 note. Both staves have a common time signature. The music features various note heads, including diamonds and diamonds with stems. Measure numbers 167r.jpg, p1, s1 and 167r.jpg, p1 are indicated below the staves.

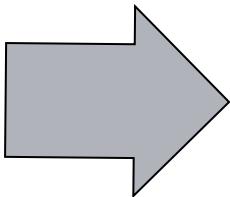
Transcripción semiautomática de la música mensural a partir de imágenes digitales

Reconocimiento óptico de caracteres

Optical music recognition (OMR)



Imágenes digitales



Alineamiento automático de voces en partitura y correcciones editoriales



A musical score for four voices: Superius (purple), Altus (light green), Tenor (pink), and Bassus (yellow). The lyrics "Os - san-na - in - ex - cel - sis" are written below each voice part, with the notes corresponding to the neumes in the score.

Archivo “MEI Score”
interpretación de la duración de las notas y alineamiento de las voces en partitura

Herramientas específicas para la notación mensural

- 1. Editor de notación mensural**
 - Su integración con el OMR
- 2. Sistema experto para la interpretación rítmica de la notación mensural (según los principios de imperfección y alteración)**
- 3. Herramienta de análisis de contrapunto aplicada a detección de errores**

3. Herramienta de análisis de contrapunto

- Junto con **Craig Sapp** (desarrollador de *humlib*) y **Juliette Regimbal** (desarrolladora del *MP Editor*)
- Tomamos una **herramienta de análisis musical**, específicamente **contrapunto**
- Y la integramos dentro del MP Editor
- **Objetivo:** Facilitar la ubicación de errores del escriba y la corrección de estos
- La herramienta integrada es el ***Dissonant Filter***
- Herramienta pre-existente desarrollado por **Alex Morgan**

3. Herramienta de análisis de contrapunto

¿Qué hace el *dissonant filter*?

Marca las notas disonantes según su función (e.g., notas de paso) con una etiqueta

<https://doc.verovio.humdrum.org/filter/dissonant/#dissonance-summaries>

Label	Meaning	Label	Meaning
P	rising passing tone	p	downward passing tone
N	upper neighbor	n	lower neighbor
D	double neighbor upper then lower	d	double neighbor lower then upper
E	upper échappée	e	lower échappée
C	ascending short nota cambiata	c	descending short nota cambiata
K	ascending long nota cambiata	k	descending long nota cambiata
A	rising anticipation	a	descending anticipation
I	reverse ascending nota cambiata	i	reverse descending nota cambiata
J	reverse upper échappée	j	reverse lower échappée
S	ternary suspension	s	binary suspension
G	ternary suspension agent	g	binary suspension agent
F	fake susp. approached by step up	f	fake susp. approached by step down
x	resolution against suspension dissonance	r	suspension repeated note
M	suspension missing agent approached by step up	m	suspension missing agent approached by step down
o	purely ornamental suspension	h	chanson idiom
Q	dissonant 3rd quarter rising passing tone	q	dissonant 3rd quarter falling passing tone
B	dissonant 3rd quarter upper neighbor	b	dissonant 3rd quarter lower neighbor
T	appoggiatura approached from below	t	appoggiatura approached from above
V	ascending accented passing tone	v	descending accented passing tone
W	accented upper neighbor	w	accented lower neighbor
Y	only dissonant against known dissonance asc.	y	only dissonant against known dissonance desc.
Z	unclassified dissonance, 2nd or 7th interval	z	unclassified dissonance, 4th interval

3. Herramienta de análisis de contrapunto

¿Cómo lo adaptamos para trabajar en el MP Editor?

MuRET Editor editor.measuringpolyphony.org/#/score/iiif/https%25253A%25252F%25252Fmuret.dlsi.ua.es%25252Fiiif%25252F6%25252F223%25252Fmanifest.json

CAQ McGill's Services... Software to Downl... Verovio Editor Manuscriptorium MEI Garage Verovio MEI Viewer MuRET Editor MEC 2019 VHV W... MEC 2019 Tutorial... Welcome to PEM J... Welcome to Spani... Other Bookmarks

MEASURING POLYPHONY
DIGITAL ENCODINGS OF LATE MEDIEVAL MUSIC

Pedro Bermudez

Zoom level: 3 152v.jpg - 153r.jpg Go

Score Editor Score Editor Help

Return to Music Input Download MEI File(s) Copy MEI Score to Clipboard

16 Missa de Bomba

superius C3 166v.jpg_p1_s1 166v.jpg_p1_s2 166v.jpg_p1_s3

altus C3 167r.jpg_p1_s1 167r.jpg_p1_s2 167r.jpg_p1_s3

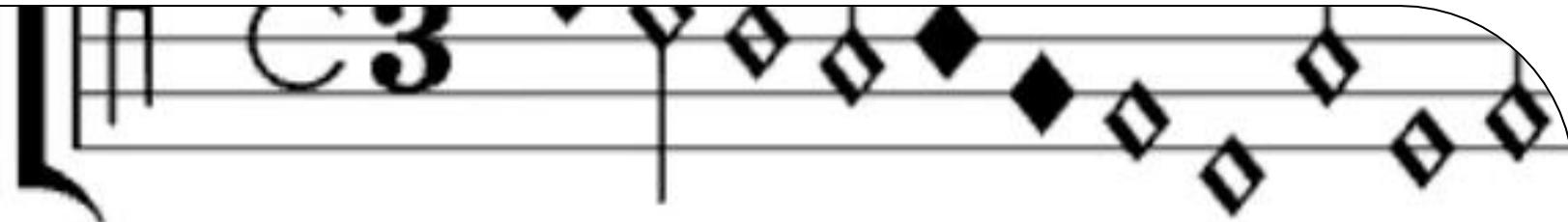
tenor C3 166v.jpg_p1_s4 166v.jpg_p1_s5 166v.jpg

bassus C3 167r.jpg_p1_s4 167r.jpg_p1_s5

KODAK Color Control Patches Blue Open Green Yellow Red Magenta White 200mpg Black

Bar by: none Switch to Modern Clef Add Dissonance Labels Continue in Editorial Mode

bassus



167r.jpg, p1, s4

Bar by: none



Switch to Modern Clef



Add Dissonance Labels

Continue in Editorial Mode

superius

altus

tenor

bassus

superius

altus

tenor

bassus

z g

p l p

s

a Z g P g v

P/p: nota de paso (ascendente/descendente)

N/n: nota vecina (superior/inferior)

s: suspensión

g: agente de la suspensión

Z/z: disonancia con función desconocida (2^{da} o 7^{ma} / 4^a)

I: disonancia con función desconocida en movimiento paralelo

Disonancias cuya función es “conocida” vs. aquellas con función “desconocida”

(las etiquetas vienen del dissonance filter de humlib, desarrollado por Alex Morgan y Craig Sapp para el Josquin Research Project)

3. Herramienta de análisis de contrapunto

¿Con qué objetivo?

- (1) Facilitar la **ubicación** de errores del copista
- (2) y la **corrección** de los mismos

1. Facilita la ubicación de errores → reduce la región de búsqueda

superius

altus

tenor

bassus

141v.jpg_p1_s1

141v.jpg_p1_s2

z g

g Z

142r.jpg_p1_s1

g

142r.jpg_p1_s2

p s

p l p w V W Z

141v.jpg_p1_s5

141v.jpg_p1_s6

s

g s n p l v 141v.jpg_p1_s7

v p s s

142r.jpg_p1_s6

p

142r.jpg_p1_s7

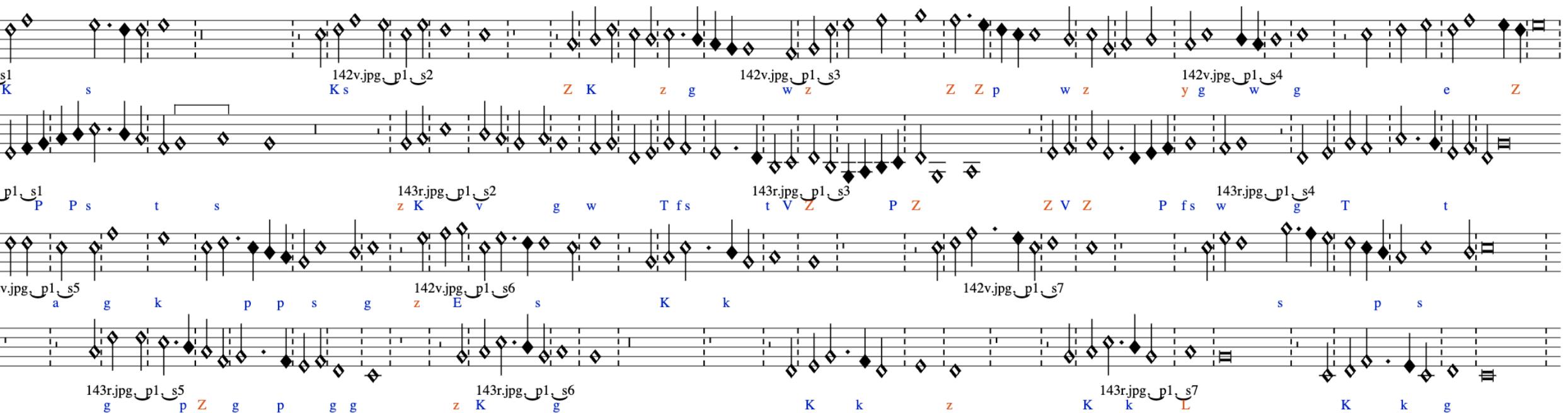
P g

a Z g P g

142r.jpg_p1_s8

v p v v g Z

1. Facilita la ubicación de errores → reduce la región de búsqueda



1. Facilita la ubicación de errores → reduce la región de búsqueda

superius

altus

tenor

bassus

141v.jpg_p1_s1 141v.jpg_p1_s2 z g g Z

142r.jpg_p1_s1 g p P s w V W Z

141v.jpg_p1_s5 141v.jpg_p1_s6 s g s n p l v 141v.jpg_p1_s7 v p s s

142r.jpg_p1_s6 p 142r.jpg_p1_s7 P g a Z g P g 142r.jpg_p1_s8 v p v v g Z

Region to look at for an error

1st orange label

2. Facilita la corrección de los errores →

Actualización de etiquetas luego de la corrección

The musical score consists of four staves (superius, altus, tenor, bassus) in common time, C major. The superius staff has a red arrow pointing to a note in measure 141v.jpg_p1_s2. A purple dashed box highlights a section from measure 142r.jpg_p1_s1 to 142r.jpg_p1_s3. A blue arrow points to a note in measure 141v.jpg_p1_s7. A purple dashed line at the bottom indicates a region to look at for an error. Various labels are placed above notes: 'z' and 'g' in orange, 'p' and 'P' in blue, 's' and 'n' in black, 'v' and 'p' in blue, and 'a' and 'g' in orange.

Region to look at for an error

1st orange
label

Cadence does not line up;
alto is a minim too long

2. Facilita la corrección de los errores → Actualización de etiquetas luego de la corrección

The image displays a musical score for four voices: superius, altus, tenor, and bassus. The music is written on five-line staves. The superius voice is at the top, followed by altus, tenor, and bassus at the bottom. The score includes various musical markings such as clefs, time signatures, and dynamic markings (p, f, g, s, n). Articulation marks like 'z' and 'fs' are also present. Performance instructions like '141v.jpg_p1_s1' are placed above certain notes. A red arrow points to a specific note in the altus part, likely indicating a point of interest or an error for correction. The vocal parts are labeled on the left side of the staves.

superius

altus

tenor

bassus

141v.jpg_p1_s1

141v.jpg_p1_s2

g

g

142r.jpg_p1_s1

142r.jpg_p1_s2

142r.jpg_p1_s3

z

p

Z

P

g

p

p

s

c

141v.jpg_p1_s5

141v.jpg_p1_s6

141v.jpg_p1_s7

141v.jpg_p1_s8

142r.jpg_p1_s6

142r.jpg_p1_s7

142r.jpg_p1_s8

f s

a

P

g

s

n

p

p

s

p

g

p

g

2. Facilita la corrección de los errores → Actualización de etiquetas luego de la corrección

A musical score for four voices: superius, altus, tenor, and bassus. The score consists of four staves, each with a key signature of C major (one sharp) and common time. The vocal parts are represented by diamond-shaped note heads on a five-line staff. Annotations are present in several measures:

- Measure 1:** The superius part has a file name '141v.jpg_p1_s1' below it.
- Measure 2:** The altus part has a file name '142r.jpg_p1_s1' below it.
- Measure 3:** The altus part has a 'g' label above a note. The tenor part has a 'p' label above a note. A green arrow points to a note in the altus part.
- Measure 4:** The altus part has a 'z' label above a note. The tenor part has a 'p' label above a note. The bassus part has a 'p' label above a note.
- Measure 5:** The superius part has a file name '141v.jpg_p1_s5' below it.
- Measure 6:** The altus part has a 's' label above a note. The tenor part has a file name '141v.jpg_p1_s6' below it.
- Measure 7:** The altus part has a 'g' label above a note. The tenor part has a 's' label above a note. The bassus part has a 'P' label above a note.
- Measure 8:** The altus part has a 'n' label above a note. The tenor part has a 'p' label above a note. The bassus part has a 'v' label above a note.
- Measure 9:** The altus part has a 'w' label above a note. The tenor part has a 'l p' label above a note. The bassus part has a 'v' label above a note.
- Measure 10:** The altus part has a 'z' label above a note. The tenor part has a 'w' label above a note. The bassus part has a 'p s' label above a note.
- Measure 11:** The altus part has a 'V' label above a note. The tenor part has a 'p' label above a note. The bassus part has a 'v' label above a note.
- Measure 12:** The altus part has a 'W' label above a note. The tenor part has a 'p' label above a note. The bassus part has a 'p v v g' label above a note.
- Measure 13:** The altus part has a 'z' label above a note. The tenor part has a 'g' label above a note. The bassus part has a 'g' label above a note.
- Measure 14:** The altus part has a 'g' label above a note. The tenor part has a 'g' label above a note. The bassus part has a 'g' label above a note.

Annotations for error correction include:
- A purple dashed box at the bottom left labeled "Region to look at for an error".
- An orange arrow pointing to a note in measure 3 labeled "1st orange label".
- A purple dashed box in measure 8 labeled "Cadence does not line up; alto is a minim too long".

Region to look at for an error

1st orange
label

Cadence does not line up;
alto is a minim too long

2. Facilita la corrección de los errores → Actualización de etiquetas luego de la corrección

superius

141v.jpg_p1_s1 141v.jpg_p1_s2

altus

142r.jpg_p1_s1 g
p p s c

tenor

141v.jpg_p1_s5 141v.jpg_p1_s6 s s n p 141v.jpg_p1_s7 p s

bassus

142r.jpg_p1_s6 p 142r.jpg_p1_s7 P g a P g 142r.jpg_p1_s8 g p g

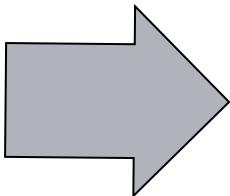
Cadence lining up

Tecnologías para la transcripción semiautomática de la música mensural a partir de imágenes digitales

Reconocimiento óptico de caracteres
Optical music recognition (OMR)



Imágenes digitales



Alineamiento automático de voces en partitura y correcciones editoriales



```
<mei>
  <music>
    <staff n="1">
      <clef line="2" shape="G"/>
      <note dur="semibrevis" pname="g" oct="5"/>
      <note dur="semibrevis" pname="d" oct="5"/>
      <dot/>
      <note dur="minima" pname="c" oct="5"/>
      <ligature form="recta">
        <note dur="semibrevis" pname="d" oct="5"/>
        <note dur="semibrevis" pname="g" oct="4"/>
      </ligature>
      <note dur="brevis" pname="b" oct="4"/>
    </staff>
  </music>
</mei>
```

Archivo “MEI Parts” codifica los símbolos de cada parte o voz en las imágenes

Archivo “MEI Score”
interpretación de la duración de las notas y alineamiento de las voces en partitura

Mayor acceso

Superius
Altus
Tenor
Bassus

Os - san-na - in - ex - cel - sis

Os - san-na - in - ex - cel - sis

Os - san-na - in - ex - cel - sis

Os - san-na - in - ex - cel - sis

Os - san-na - in - ex - cel - sis - Os - san-na - in - ex - cel - sis

Representación simbólica (i.e., **legible por un ordenador**) de las voces en **partitura** con la **duración de las notas interpretada**

Reproducción
de audio

Transcribir
automáticamente la
partitura a **notación moderna**

Facilitar estudios
de concordancias

Paso previo: digitalización

Digitalización
(fotografiar folios)



Reconocimiento óptico de
caracteres
Optical music recognition (OMR)



Alineamiento automático de
voces en partitura
interpretación de la notación mensural
y correcciones editoriales



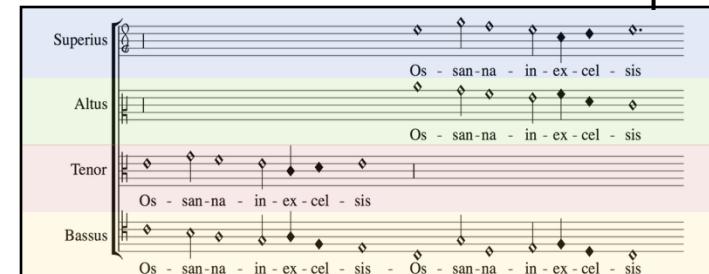
Manuscrito



Imágenes digitales

```
<mei>
<music>
<staff n="1">
<clef line="2" shape="G"/>
<note dur="semibrevis" pname="g" oct="5"/>
<note dur="semibrevis" pname="d" oct="5"/>
<dot/>
<note dur="minima" pname="c" oct="5"/>
<ligature form="recta">
<note dur="semibrevis" pname="d" oct="5"/>
<note dur="semibrevis" pname="g" oct="4"/>
</ligature>
<note dur="brevis" pname="b" oct="4"/>
</staff>
</music>
</mei>
```

Archivo “MEI Parts”
codifica los **símbolos** de cada
parte o voz en las imágenes



Archivo “MEI Score”
interpretación de la duración de
las notas y alineamiento de las
vozes en partitura

Resumen de mis experiencias

- Primer acercamiento a **tecnologías** desarrolladas para la **codificación** de documentos de **música antigua** en **formatos simbólicos**
- Implicaciones:
 1. Mejorar el acceso
 - A. Facilita la búsqueda (melódica)
 - B. Reproducción de audio y transcripción automática a notación moderna
 2. Facilitar el análisis musical
- El **OMR** facilita todo esto al permitir la **codificación de la música de una forma semiautomática**
- **Otras tecnologías** que también **colaboran** en la **codificación semiautomática** de la **música antigua** (específicamente, para notación **mensural**)

Experiencia postdoctoral

Canto llano

Notación aquitana y notación cuadrada

Herramientas de búsqueda de información para asistir el análisis musicológico

Proyecto ECHOES

El Proyecto ECHOES tiene el objetivo de entender la historia y evolución del canto llano en Braga (región en el norte de Portugal) durante los siglos XI al XVII. La idea es explorar el proceso de creación y transmisión musical de dos estilos de notación utilizados en este periodo (Aquitana—utilizada hasta el siglo XV—y cuadrada) por medio de herramientas digitales de análisis musical.

<https://echoes.fcsh.unl.pt>

Proyecto ECHOES

- Potencial de la música codificada
- Una vez codificada la música, es posible la **búsqueda, extracción y procesamiento de la información** para su posterior **análisis musicológico**
- ECHOES cuenta con un prototipo de herramienta para el análisis musical de canto llano codificado en MEI

Search Filters

Filter chants with the following music script(s):

Aquitanian Square

Filter chants that have ornamental figure(s):

(No selection will display all chants)

[Liquescent](#) [Quilisma](#) [Oriscus](#)

Filter chants by melodic pattern



Pitch (wildcards) [i](#)

Contour (melodic intervals) [i](#)

-1 -2

Excluding patterns with ascending liquescences

Excluding patterns with descending liquescences

Other options

Enable [melisma highlighting](#)

Melisma(s) with at least notes in a syllable

Show pitch/location with each syllable

Show Aquitanian in pitch value (only available for
chants with detected mode)

Enable modern rendition of chants (Verovio)

Filter chants by finalis (the last note) [i](#)

e.g.: '-1' or 'a'

Filter chants by metadata

(*Title, Source, Cantus ID*)

Search by a title

Search by a chant's source

Search by Cantus ID

Filter chants by text [i](#)

e.g.: 'dominici'

Search

Reset

Clear results

**Herramientas de búsqueda del
“ECHOES MEI Analyser” para
facilitar el análisis por parte de los expertos**

Search Filters

Filter chants with the following music script(s):

Aquitanian Square

Filter chants that have ornamental figure(s):

(No selection will display all chants)

[Liquescent](#) [Quilisma](#) [Oriscus](#)

Filter chants by melodic pattern



Pitch (wildcards) [i](#)

Contour (melodic intervals) [i](#)

-1 -2

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(*Title, Source, Cantus ID*)

Search by a title

Search by a chant's source

Search by Cantus ID

Filter chants by text [i](#)

e.g.: 'dominici'

Search

Reset

Clear results

Search Results

Found 2 chants from the search options.

Title	Music Script	Text	Source	Options
Ecce virgo	Aquitanian	Ecce virgo concipiet et pariet filium et vocabi tur no men ejus he manuel 	P-BRad Pastas 011, 007r	More Details
Tu mandasti	Aquitanian	Tu man dasti man data tua custodire nimis utinam dirigan tur vie mee ad custodiend as justificati on es tuas 	P-BRad Pastas 009, 035r	More Details

Search Filters

Filter chants with the following music script(s):

Aquitanian Square

Filter chants that have ornamental figure(s):

(No selection will display all chants)

[Liquescent](#) [Quilisma](#) [Oriscus](#)

Filter chants by melodic pattern



Pitch (wildcards) [i](#)

Contour (melodic intervals) [i](#)

-1 -2

Other options

Enable melisma highlighting

Melisma(s) with at least notes in a syllable

Search Results

Found 2 chants from the search options.

Title	Music Script	Text	Source	Options
Ecce virgo	Aquitanian	Ecce <i>virgo</i> concipiet et pariet filum <i>et</i> vocab <i>itur</i> no <i>m</i> en <i>e</i> jus <i>he</i> manuel	P-BRad Pastas 011, 007r	More Details

Chant Information

Neume Distribution Chart

Modern Rendition

Ecce virgo

Ec ce vir go con ci pi et et pa ri et fi li um et vo ca bi tur no men ej us he ma nu el

Tu mandasti

Aquitanian

Tu *mandasti* *ma*data tua custodire *nimis* utinam dir*igantur* vie *mee* ad custodiendas justificati*on*es *tuas*

P-BRad Pastas 009, 035r

[More Details](#)

Title	Music Script	Text	Source	Options
Ecce virgo	Aquitianian	Ecce virgo concipiet et pariet filium et vocabitur nomen eius he manuel ▲▲▲ ▲▲▲▲	P-BRad Pastas 011, 007r	More Details

Chant Information

Title: Ecce virgo

Source: P-BRad Pastas 011, 007r

Cantus ID: 503007

PEM Database URL: <https://pemdatabase.eu/gallery-item/14498>

Music Script: Aquitanian

Possible Mode(s): 1

Mode Analysis:

- The **finalis** is located 2 steps below the line (position -2).
- The **rhomboidal punctum** can be found exclusively three steps above the line (+3) or one step below the line (-1).

Possible mode(s) include mode 1. The pitch of the line is 'F'.

For more information, see [Mode Detection for Aquitanian Script \(github.com\)](#)

MEI File: [009_C09_ecce-virgo_pem84548_aquit_AQUIT.mei \(GitHub\)](#)

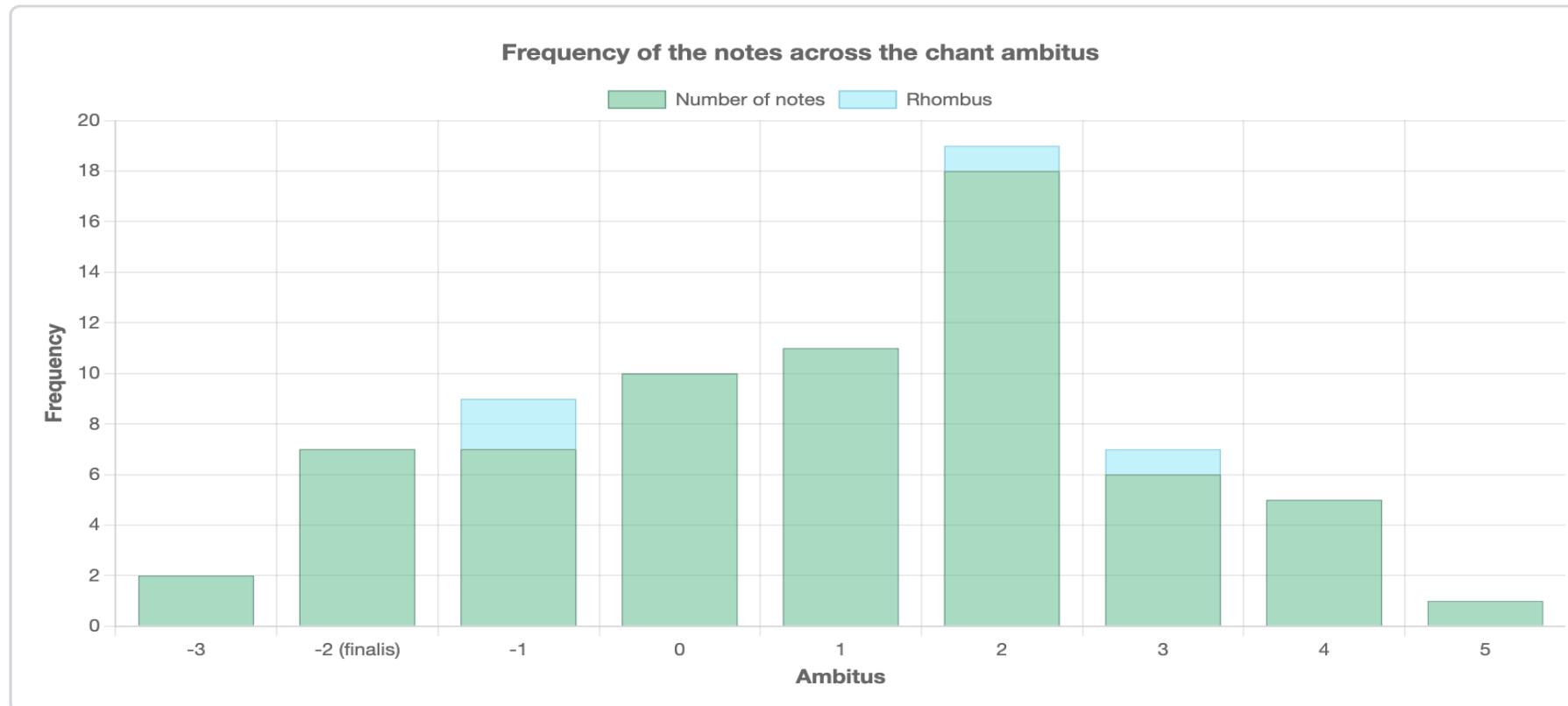
Neume Distribution Chart

Modern Rendition

Title	Music Script	Text	Source	Options
Ecce virgo	Aquitanian	Ecce virgo concipiet et pariet filium et vocabitur nomen ejus hemanuel	P-BRad Pastas 011, 007r	More Details

Chant Information

Neume Distribution Chart



Modern Rendition

Análisis computacional

- Una vez codificada la música, es posible la **búsqueda, extracción y procesamiento de la información** para su posterior análisis
- En el futuro, con más datos codificados, se usará esta herramienta para estudiar jor la evolución del canto llano en el periodo y región en cuestión (siglos XI a XVII en Braga)
- Observando cambios en los cantos escritos en notación aquitana (más antigua) vs. cuadrada (más “moderna”)

Análisis computacional

- Las herramientas de análisis computacional pueden permitir el análisis a macro escala
 - La máquina puede procesar una mayor cantidad de información en menor tiempo que un humano
 - El experto es quien solicita a la máquina la información a procesar y quien interpreta los resultados
- Capacidad de potenciar la investigación musicológica

Conclusiones

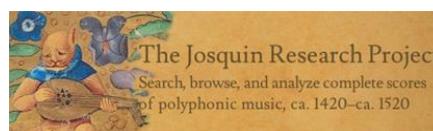
Conclusiones

- Aplicación de tecnologías digitales al estudio de la música antigua
- Cómo la codificación de la música contribuye a su:
 - **Preservación**
 - **Acceso** → búsqueda, transcripción moderna, reproducción en audio
 - **Análisis** → extracción de información por un ordenador, la cuál puede ser analizada por el experto o por el mismo ordenador dependiendo de la cantidad de información a procesar
- Tecnologías: OMR, editores gráficos de notación, sistemas expertos en la interpretación de notación mensural, herramientas de análisis musical y extracción de información
- Importancia de la **colaboración entre tecnólogos y musicólogos** para el desarrollo de estas herramientas

¡Muchas gracias!

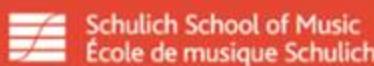
marthathomae@fcs.h.unl.pt

<https://martha-thomae.github.io/projects/guatemala.html>



Social Sciences and Humanities
Research Council of Canada

Conseil de recherches en
sciences humaines du Canada



Centre for Interdisciplinary Research
in Music Media and Technology



SIMSSA | Single Interface for Music
Score Searching and Analysis

CENTRO DE ESTUDOS DE
SOCIOLOGIA E ESTÉTICA
MUSICAL



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FACULDADE DE CIÊNCIAS SOCIAIS E HUMANAS
UNIVERSIDADE NOVA DE LISBOA



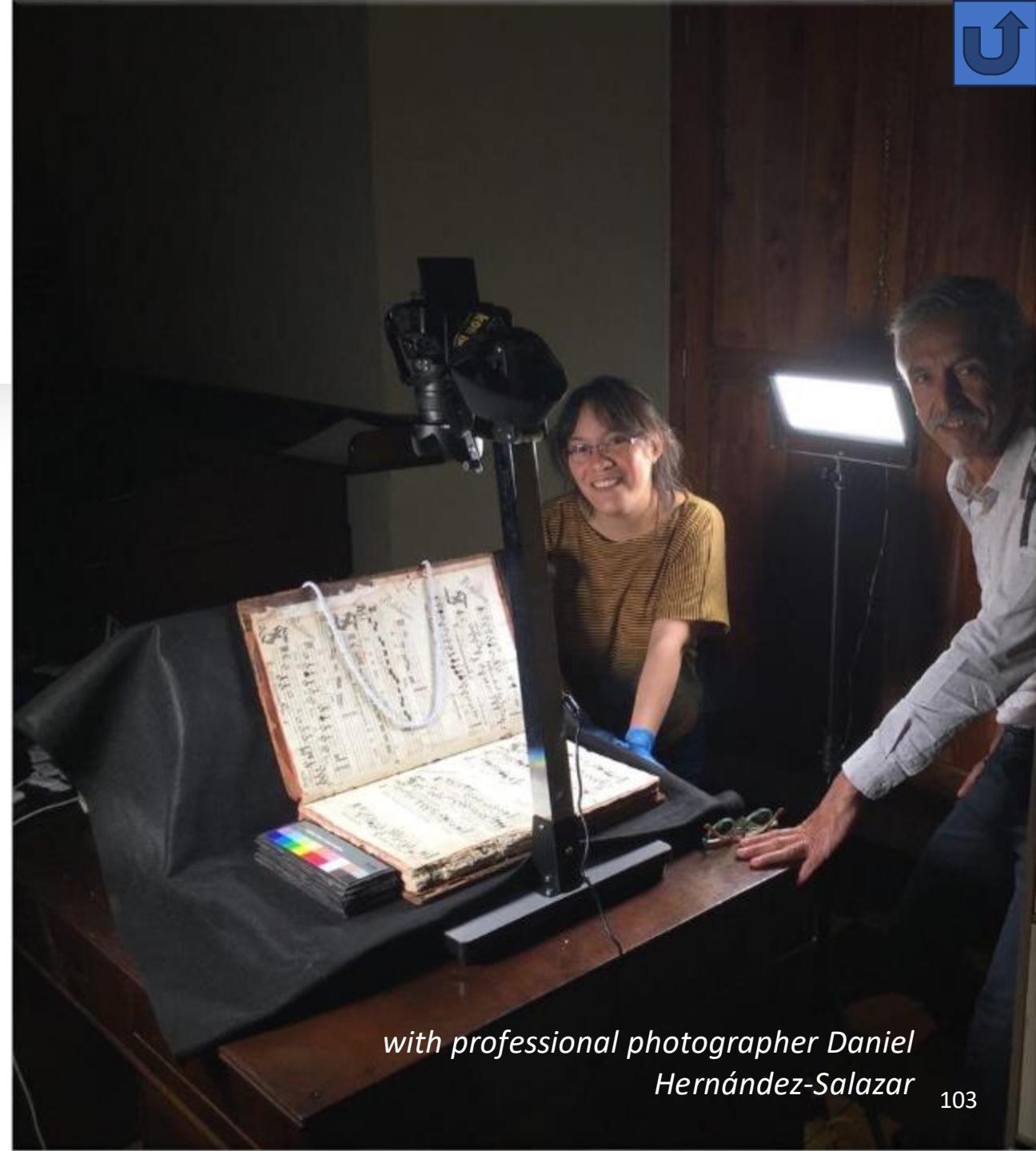
Fundação
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Diapositivas Extras

Tecnologías utilizadas

Escáner de libros DIY (do it yourself)

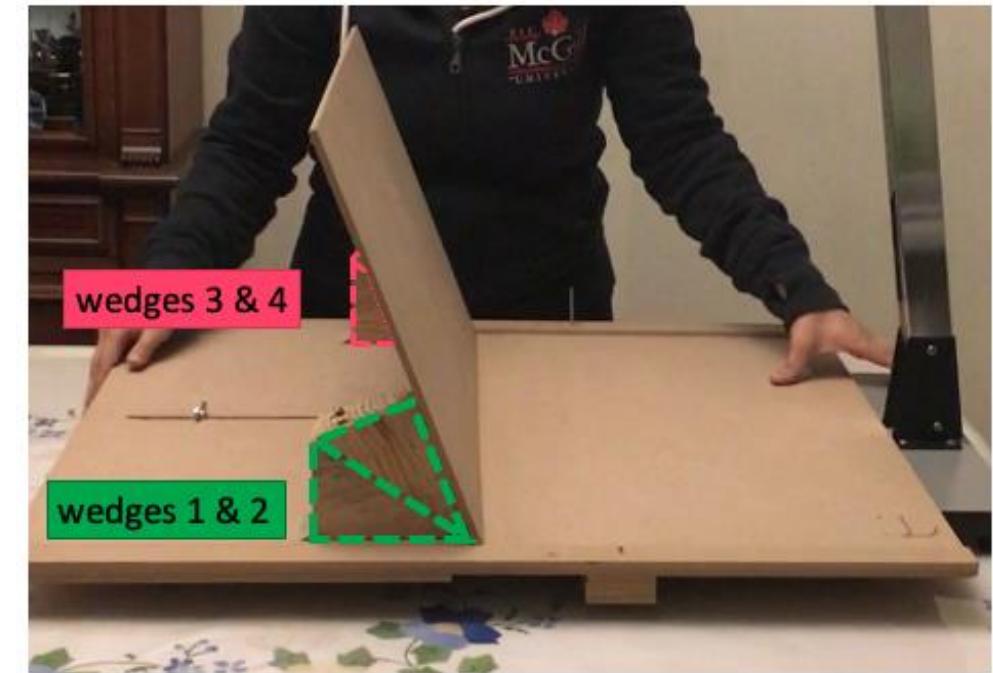
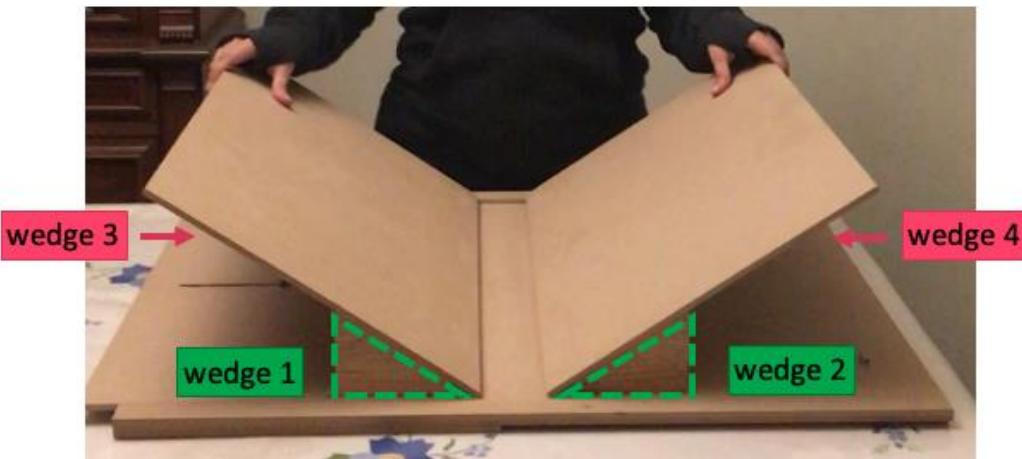
- Con partes **prestadas** (cámara y luces) o **construidas** (soporte / cuna del libro)
- Bajo el consejo de varias instituciones con experiencia en el campo de digitalización de colecciones especiales, incluidos *Digital Image Archive of Medieval Music* (DIAMM)



with professional photographer Daniel Hernández-Salazar

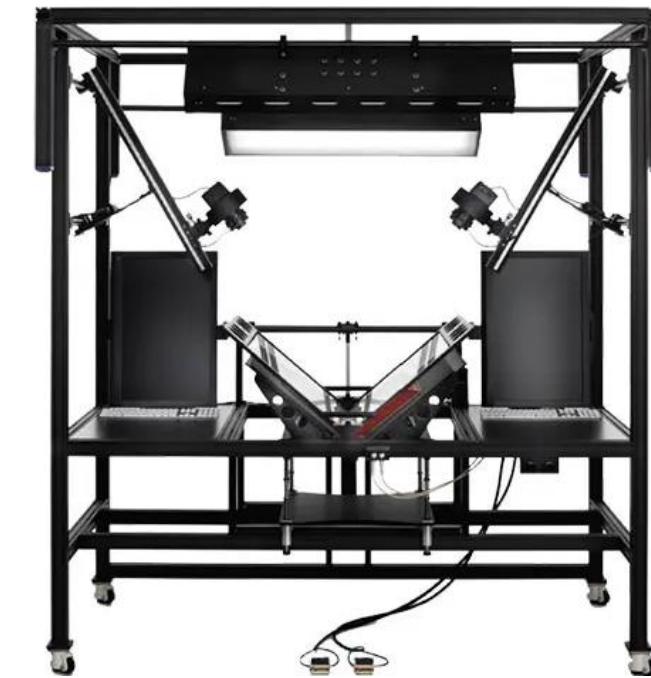
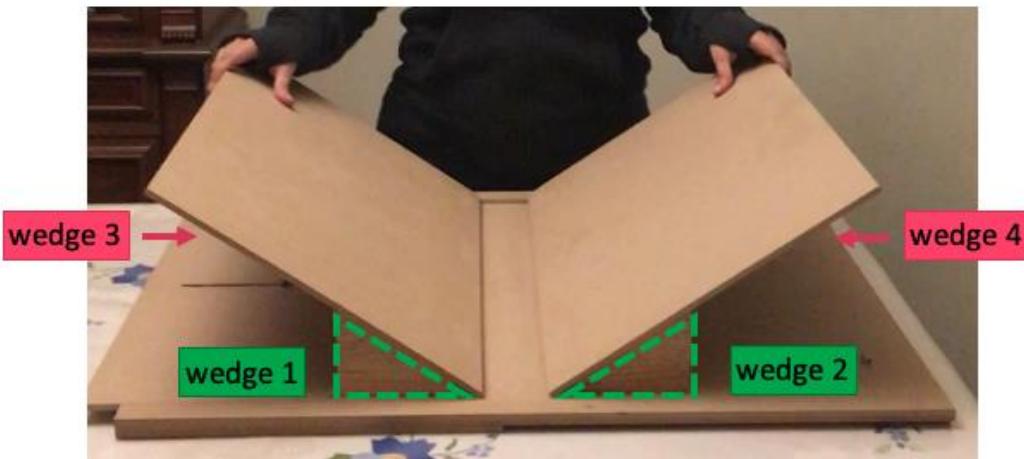
Configuraciones de la cuna de libro

Mantienen el libro abierto a 110°
usando cuatro cuñas de 35° cada una



Configuraciones de la cuna de libro

Mantienen el libro abierto a 110º
usando cuatro cuñas de 35º cada una

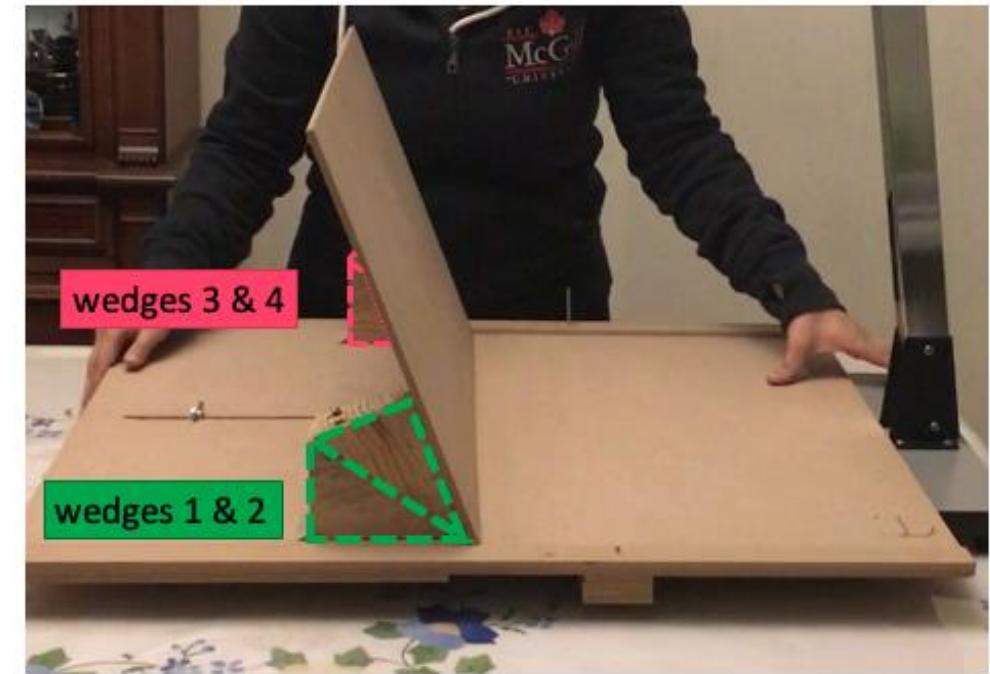


Configuraciones de la cuna de libro

Mantienen el libro abierto a 110º
usando cuatro cuñas de 35º cada una



[https://www.telescopiomania.eu/
9161-reproduction-table-
bresser-br-cst-copy-stand-
40x48-cm-4007922033389.html](https://www.telescopiomania.eu/9161-reproduction-table-bresser-br-cst-copy-stand-40x48-cm-4007922033389.html)



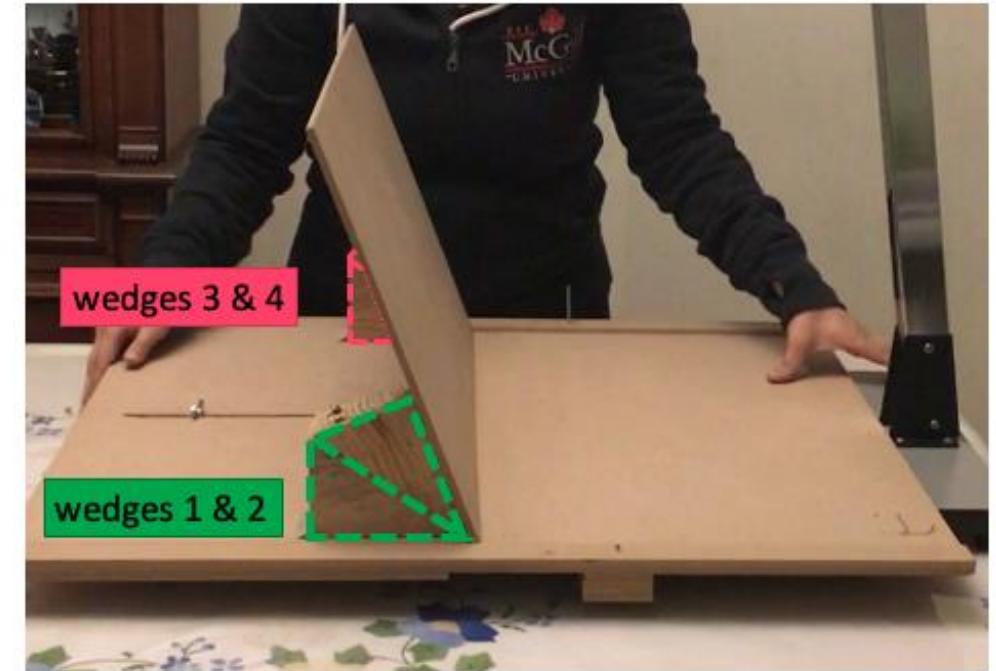
German Thomae

Configuraciones de la cuna de libro

Mantienen el libro abierto a 110º
usando cuatro cuñas de 35º cada una



<https://www.bsb-muenchen.de/einblicke/vom-buch-zum-byte-digitalisierung-an-der-bayerischen-staatsbibliothek>



German Thomae



Proceso de digitalización

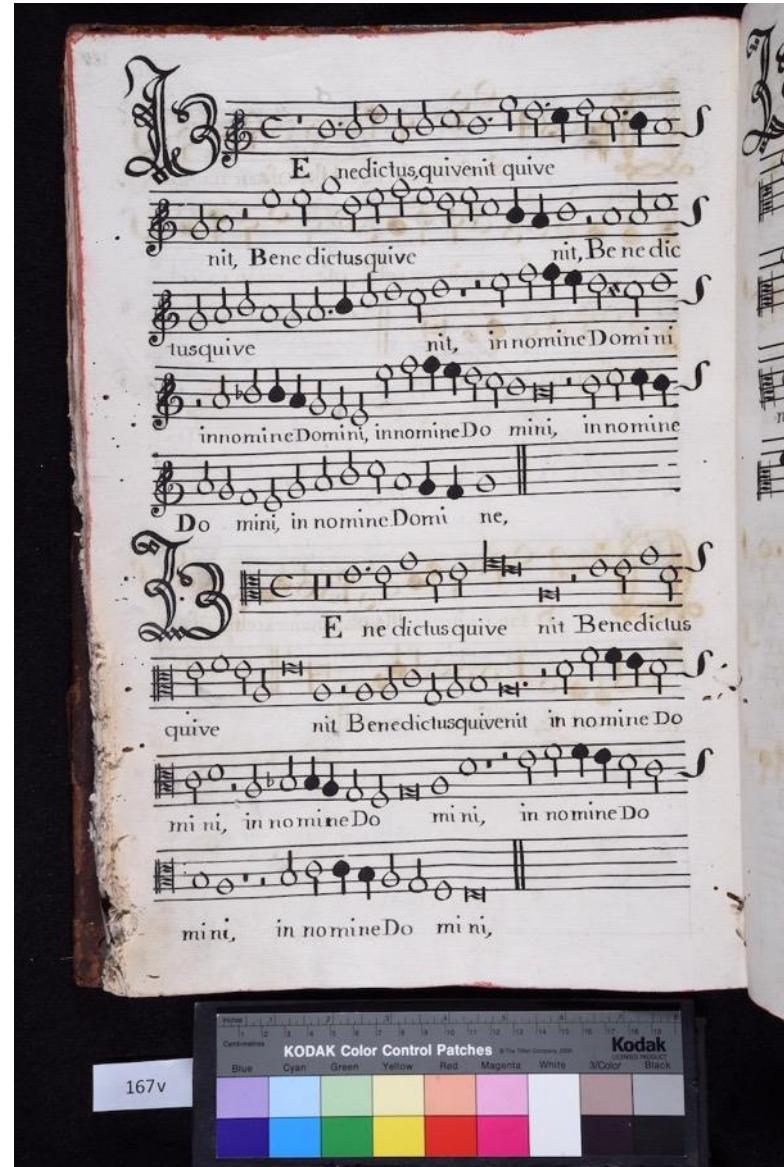
Idea clave: “asequibilidad”

- **Equipo:** Escáner de libro DIY
- **Labor de conservación:** conducida por una institución externa, no lucrativa
- **Labor de digitalización:** conducido por mí con el ayuda de un fotógrafo profesional contratado para ajustar los parámetros de la cámara

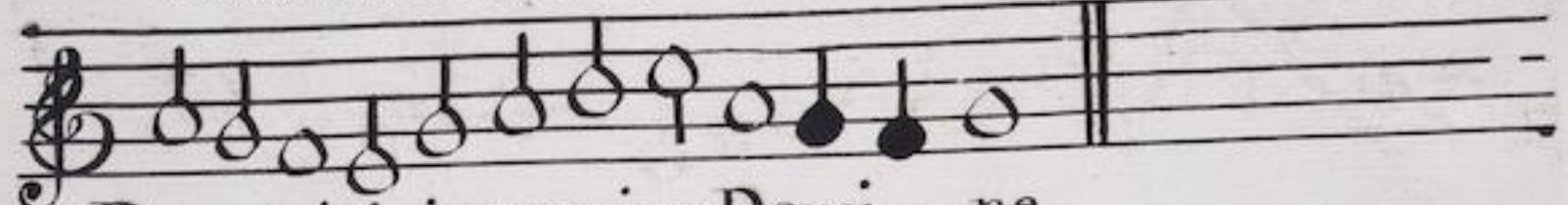


con el fotógrafo Guatemalteco Daniel Hernández-Salazar

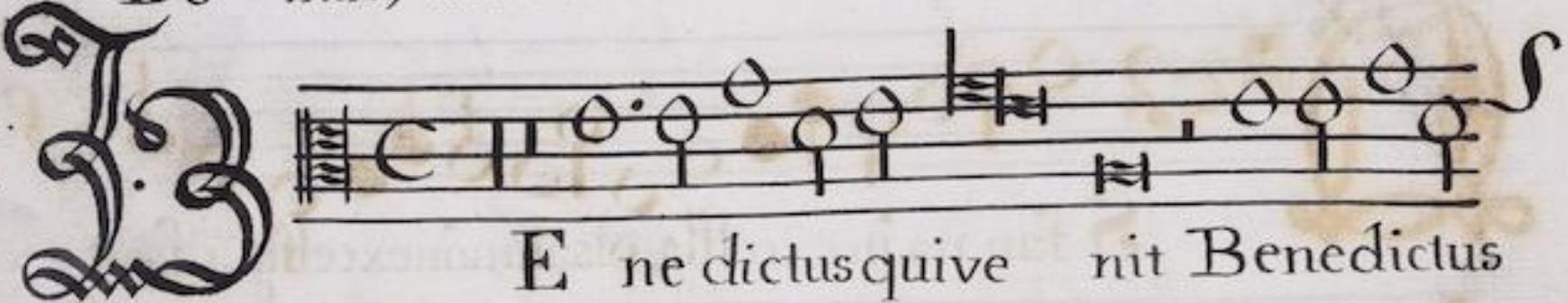
Resultados



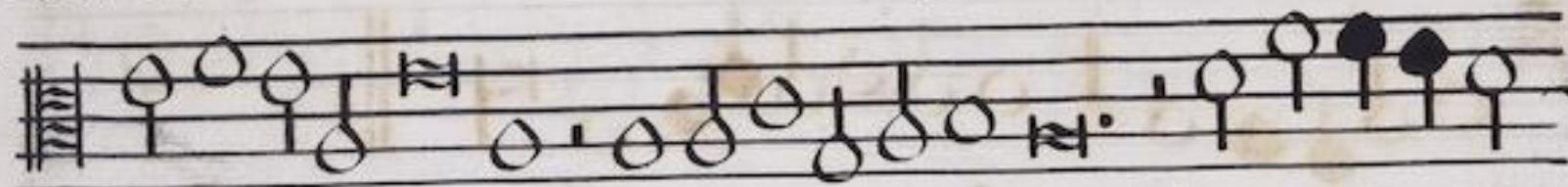
in nomine Domini, in nomine Do mini, in nomine



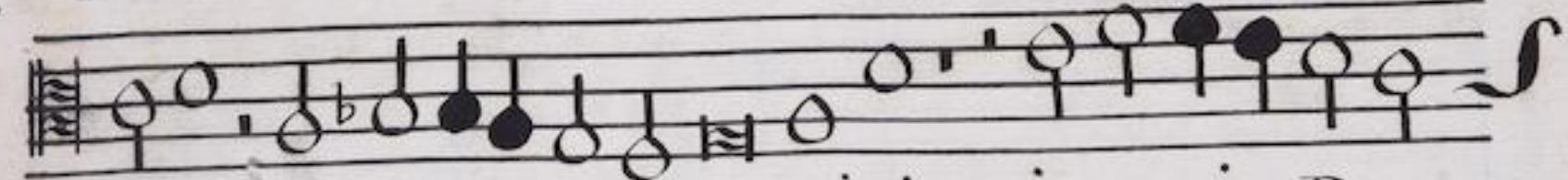
Do mini, in nomine Domi ne,



E ne dictus quive nit Benedictus



quive nit Benedictus qui venit in nomine Do



mi ni, in nomine Do mi ni, in nomine Do

