

# Music Retrieval Tools

## Optical Music Recognition (OMR) and Music Analysis

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Research Seminars Series  
“Musicologists and Their Sources: The Alchemy of Turning Parchment into Pixels”

NOVA University of Lisbon,  
Portugal, 24 June 2024

# Music Information Retrieval Tools

1. Optical music recognition (OMR) *Martha E. Thomae*
2. Music search & analysis *Antoine Phan*

**Focus:** Early music written in neumatic and mensural scripts

# Optical Music Recognition (OMR)

- Similar to Optical **Character** Recognition (OCR)
  - Where the characters of a digital text document are readable by the computer
  - It allows to perform content-based searches
- For music: Optical **Music** Recognition (OMR)
  - The **music** characters (and text) are readable by the computer
  - Therefore, in addition to search music pieces by their metadata (e.g., composer, title of the piece, and date)
  - The music content is searchable (e.g., ask the computer to look for a melody → melodic search)
  - Moreover, perform computational music analysis

# The Traditional OMR Pipeline

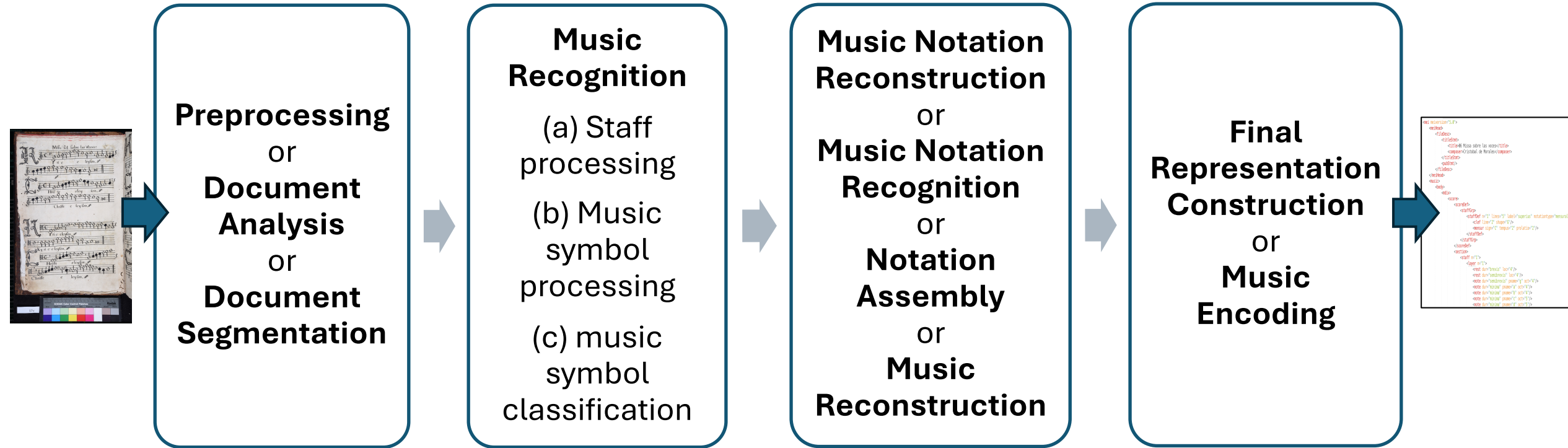


**Optical Music Recognition**

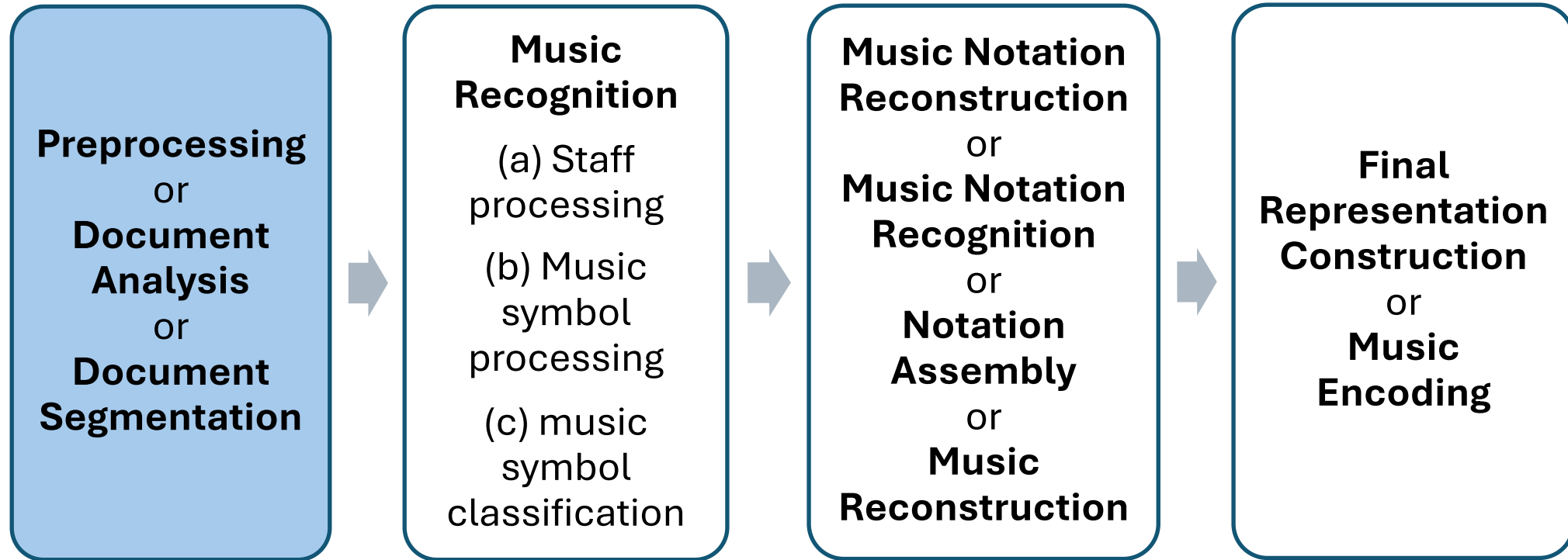


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<?xml version="5.0"?>
<meiHead>
  <fileDesc>
    <titleStm>
      <title>06 Missa sobre las voces</title>
      <composer>Cristobal de Morales</composer>
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  </fileDesc>
</meiHead>
<music>
  <body>
    <div>
      <score>
        <staffGrp>
          <staffDef n="1" lines="5" label="superius" notationtype="mensural">
            <lef line="2" shape="G"/>
            <mensur sign="C" tempus="2" prolatum="2"/>
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          <staffGrp>
            </staffGrp>
          </scoreDef>
        </scoreDef>
        <section>
          <staff n="1">
            <layer n="1">
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              <rest dur="semibrevis" loc="4"/>
              <note dur="semibrevis" pname="g" oct="4"/>
              <note dur="minima" pname="a" oct="4"/>
              <note dur="minima" pname="b" oct="4"/>
              <note dur="minima" pname="c" oct="5"/>
              <note dur="minima" pname="d" oct="5"/>
            </layer>
          </staff>
        </section>
      </div>
    </body>
  </music>
</mei>
```

# The Traditional OMR Pipeline



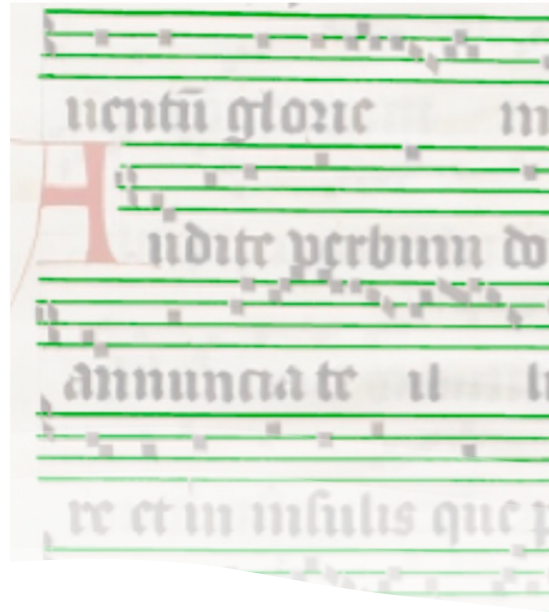
# Step 1: Preprocessing or Document Analysis



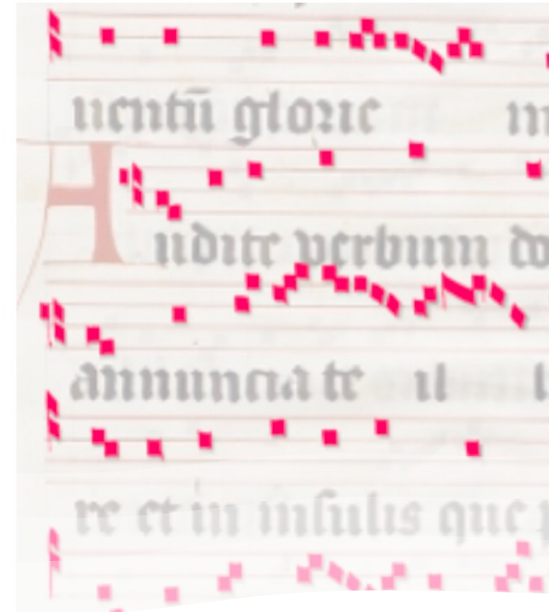
Actual



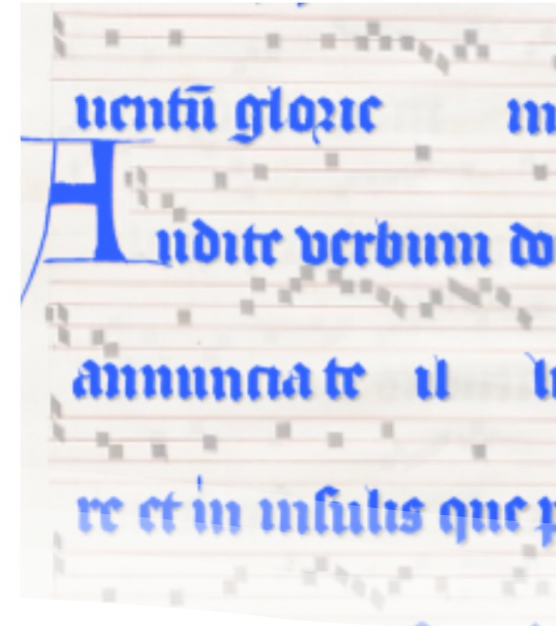
Staff



Note



Text



## Step 1: Preprocessing or Document Analysis or Document Segmentation

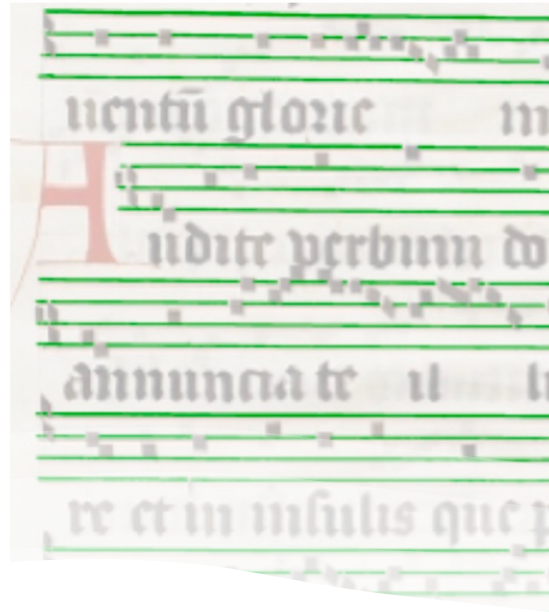
- There is always a **pre-processing step** that **prepares the data** needed for the **following steps** in the pipeline
- Normally, this step segments the document into layers: music symbols & staves & text layers



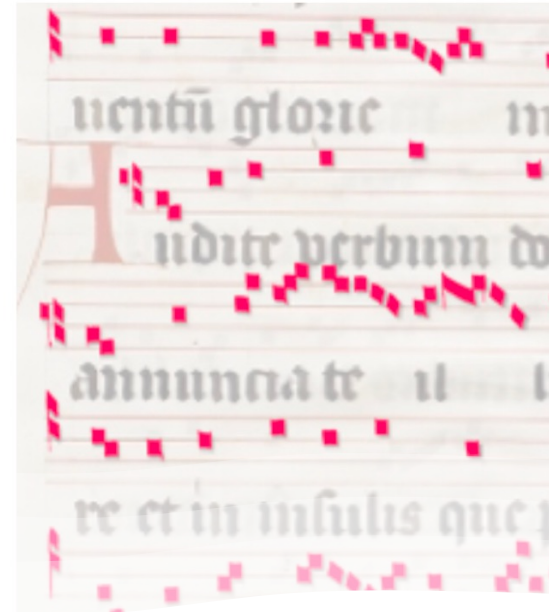
Actual



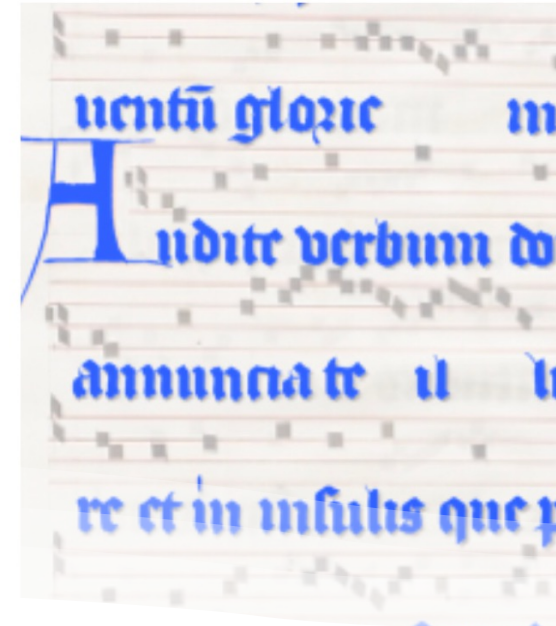
Staff



Note



Text



## Step 1: Preprocessing or Document Analysis or Document Segmentation

- There is always a **pre-processing step** that **prepares the data** needed for the **following steps** in the pipeline
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- Sometimes the music symbols are not separated from their staff and the staff regions (with their music) are used for the next step



FEAST OF THE BLESSED SACRAMENT.  
**CORPUS CHRISTI.**  
*Double of the First Class with Octave.*  
 AT FIRST VESPERS.  
*All as at second Vespers, p. 956, except the following :*

At Magn.  
 Ant. 6. F

mi-ne, spi-  
 ri-tus in fi-li-os de-  
 monstrá-res, páne su-a-vís-simo de caélo  
 praesti-to, esu-ri-éntes réples bónis,

ARUSPIX

## Step 1: Preprocessing or Document Analysis or Document Segmentation

CANTO

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ARUSPIX

## Step 1: Preprocessing or Document Analysis or Document Segmentation

MURET Guatemala / 15 Missa Simile est regnum caelorum / 147v.jpg / Document analysis Classification server status: ON Logout as martha Training sets Report an issue About

Go to: Agnostic Semantic

Page Undefined Staff Title Text Author Empty staff Lyrics Multiple lyrics Other Chord

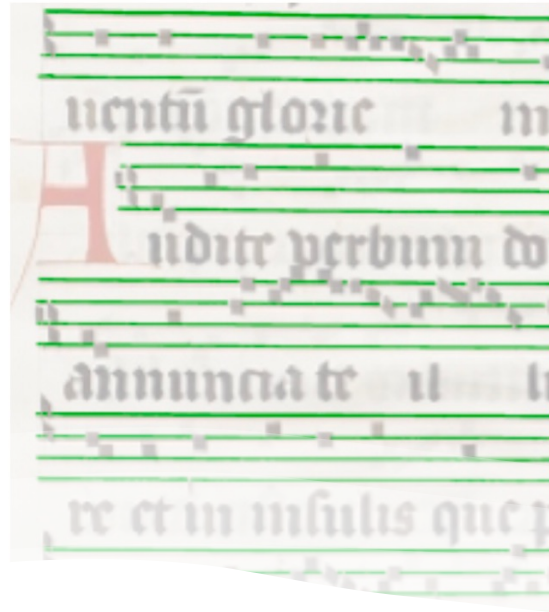
MURET

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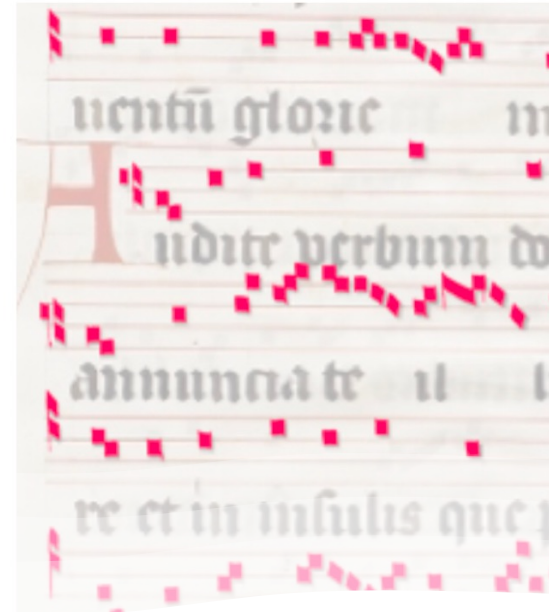
Actual



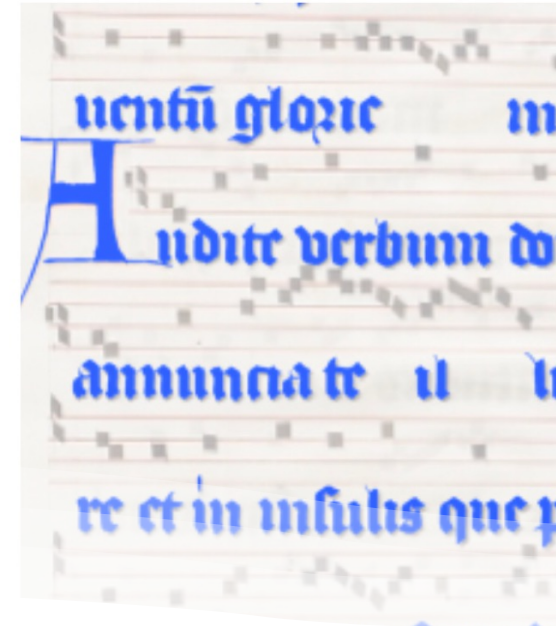
Staff



Note



Text



## Step 1: Preprocessing or Document Analysis or Document Segmentation

- There is always a **pre-processing step** that **prepares the data** needed for the **following steps** in the pipeline
- Normally, this step segments the document into layers: music symbols & staves & text layers
- **Train the computer to do this layer separation**



Pixel.js x Ichiro

132.206.14.203

Apps SIMSSA Keep Pixel Kayak Horwitz McGill 307 TD imdb Dict Ich Other Bookmarks

Salzannes, CDN-Hsmu M2149.L4

Zoom level: 3

Undo Redo Delete selected layer Create new layer

- Texts
- Stafflines
- Neumes
- Background

brush rectangle grab erase select

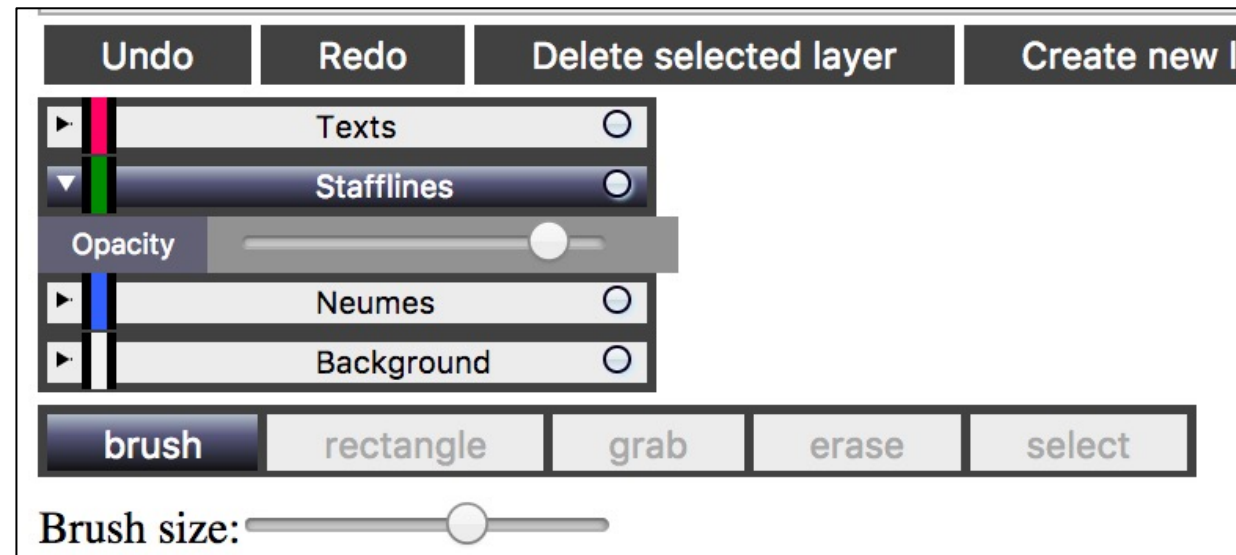
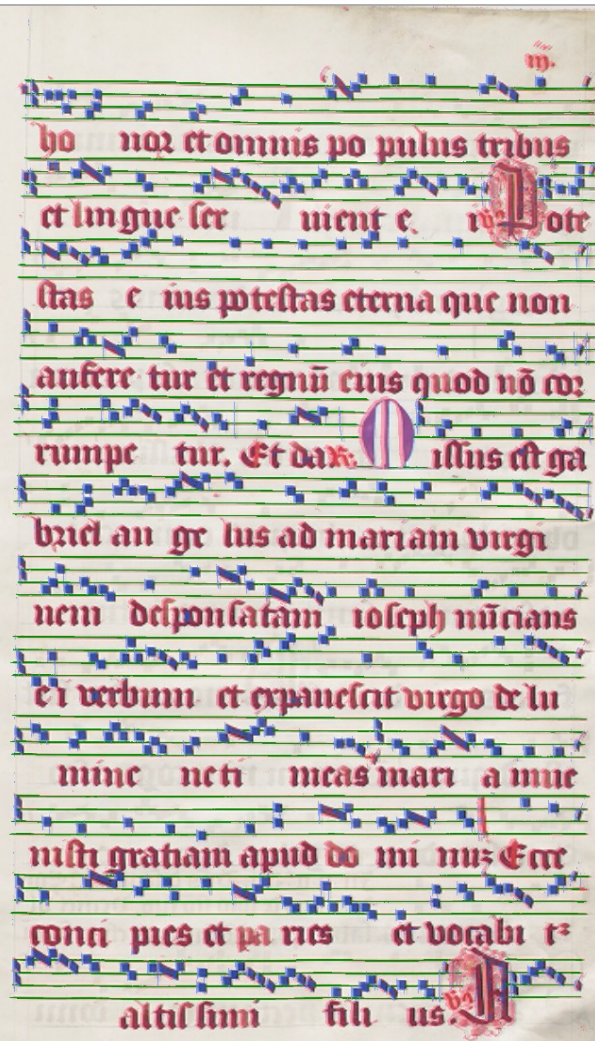
Brush size:

Export as CSV Export as PNG Export as image Data PNG Choose File CF-010\_3.png

How to use Keyboard shortcuts

Pixel.js

- There is always a **pre-processing step** that **prepares the data** needed for the **following steps** in the pipeline
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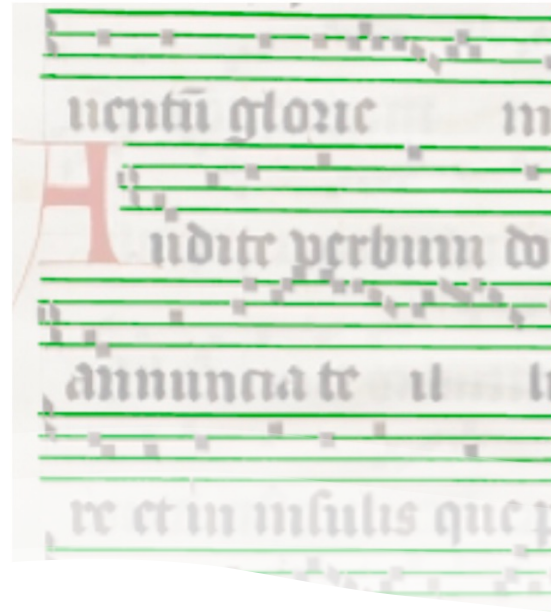
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Actual



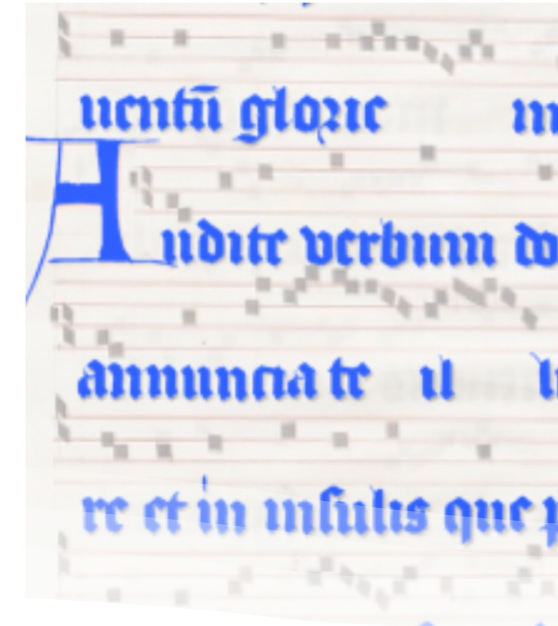
Staff



Note



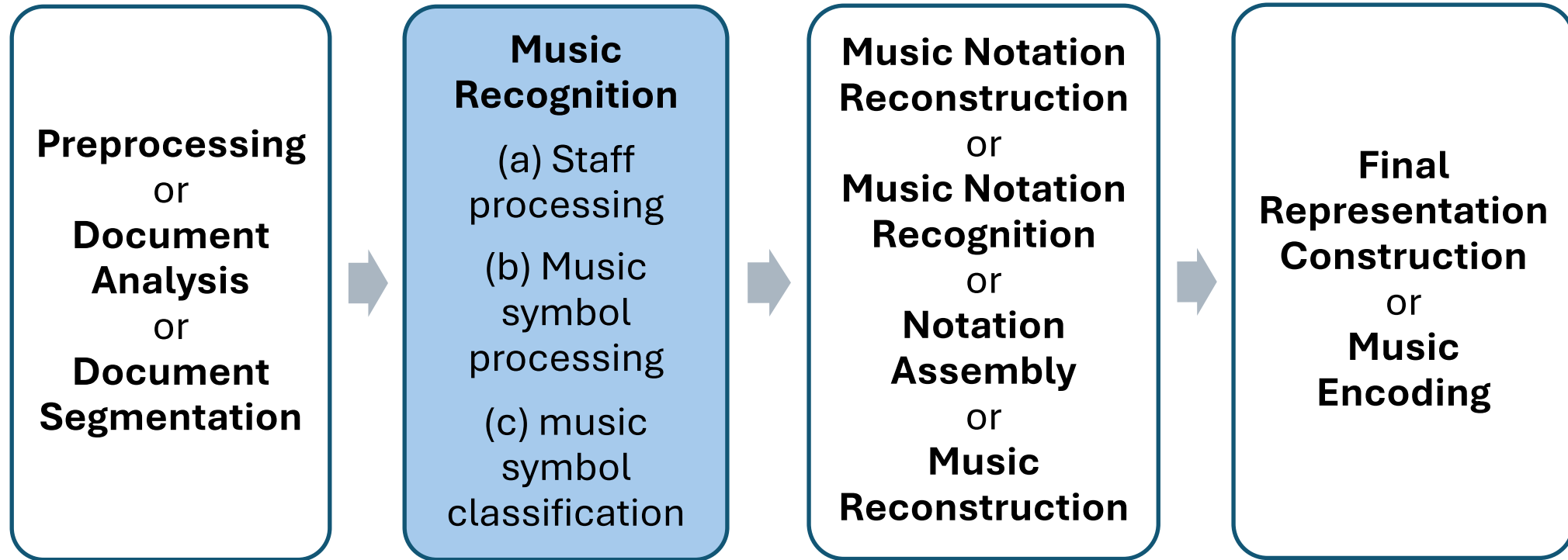
Text



## Step 1: Preprocessing or Document Analysis or Document Segmentation

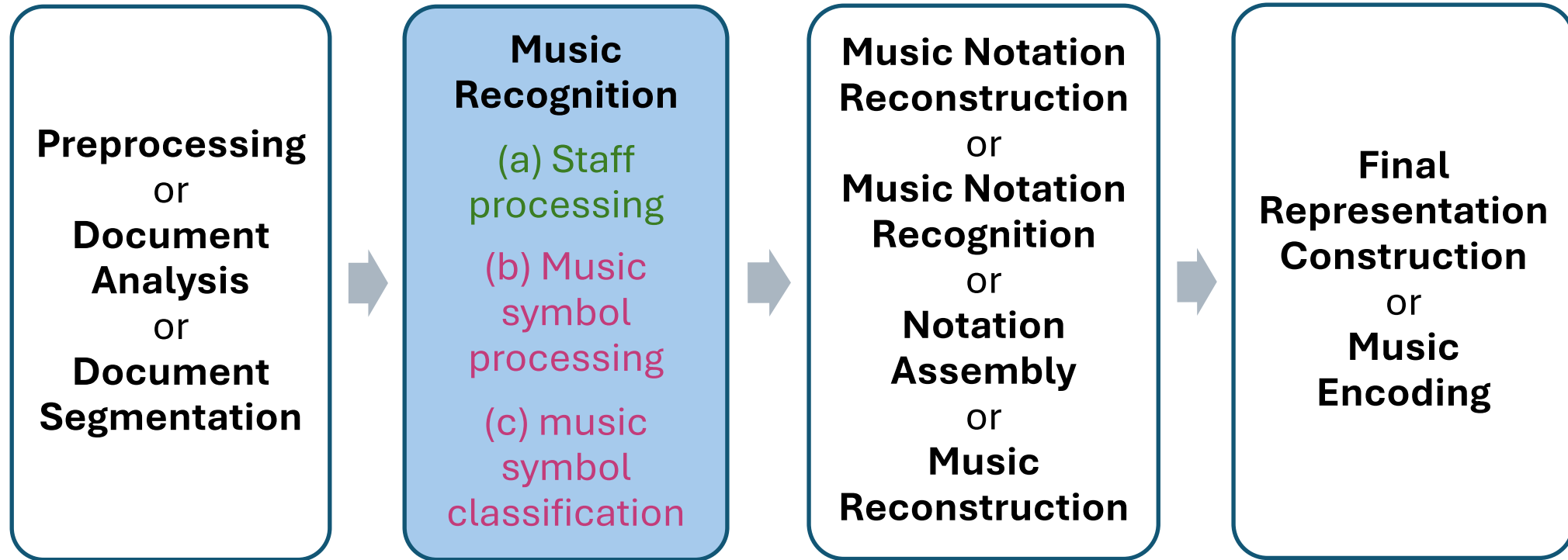
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- Train the computer to do this layer separation

# Step 2: Music Recognition

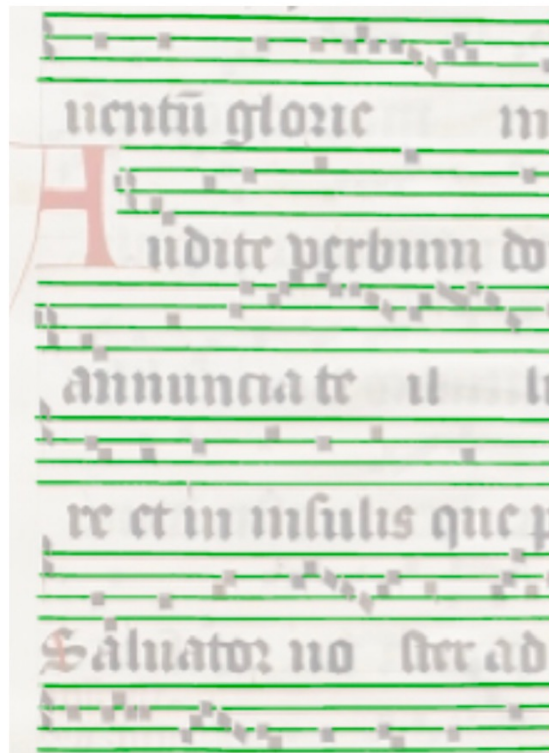




# Step 2: Music Recognition



## Staff



## Note



## Step 2: Music Recognition

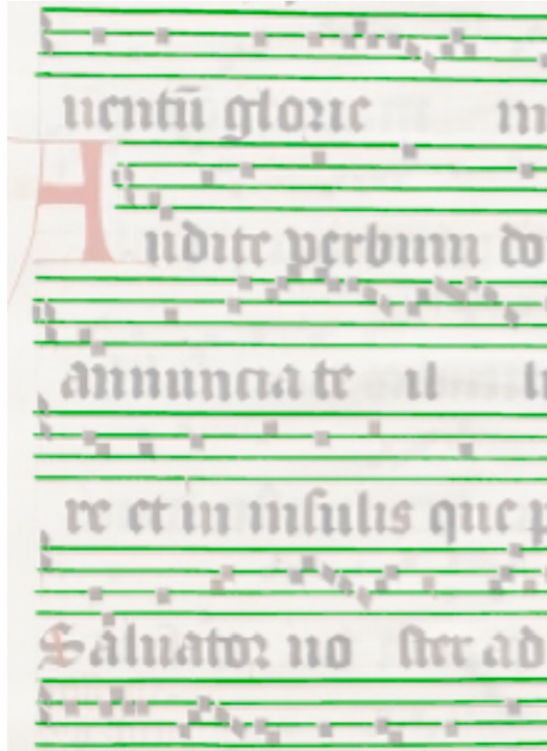
(a) Staff processing

(b) Music symbol processing &

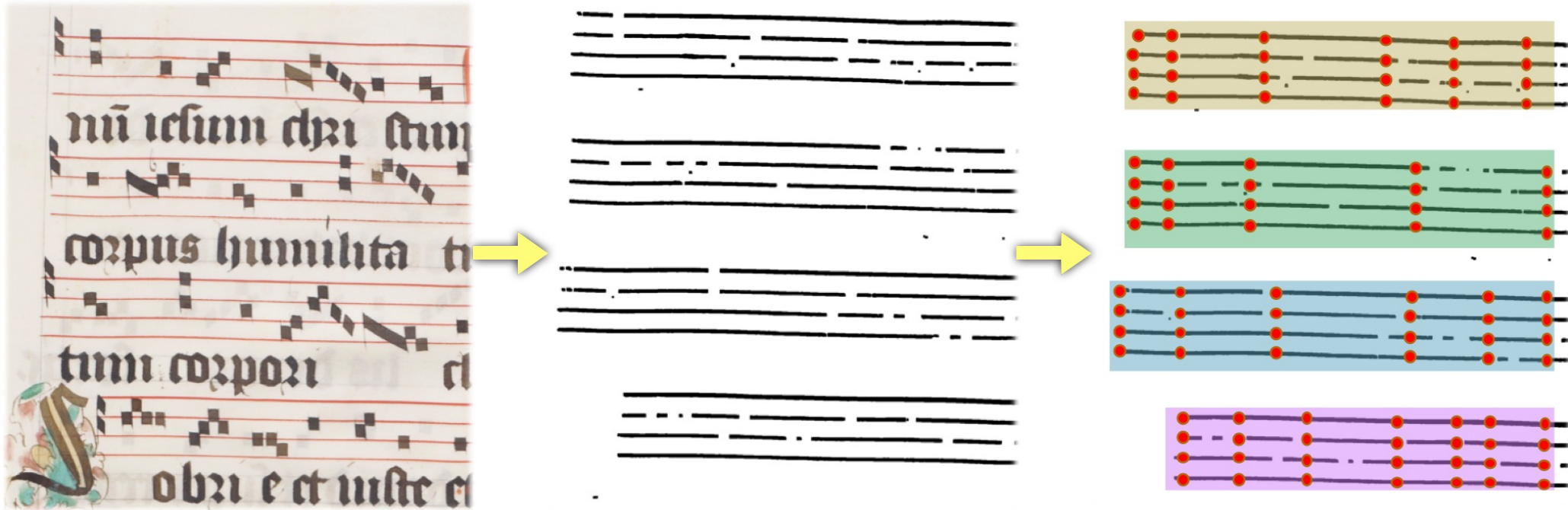
(c) Music symbol classification

---

# Staff



**Step 2: Music Recognition** (a) Staff processing



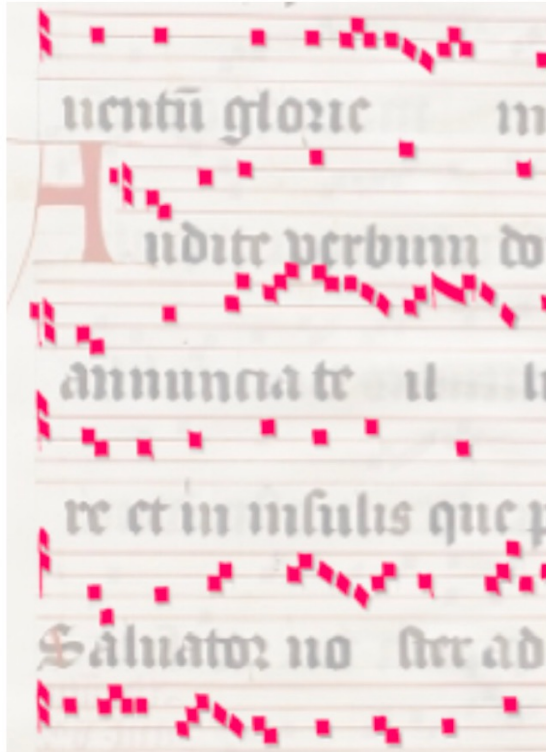
## Step 2: Music Recognition

(a) Staff processing

- Track the staff line path

---

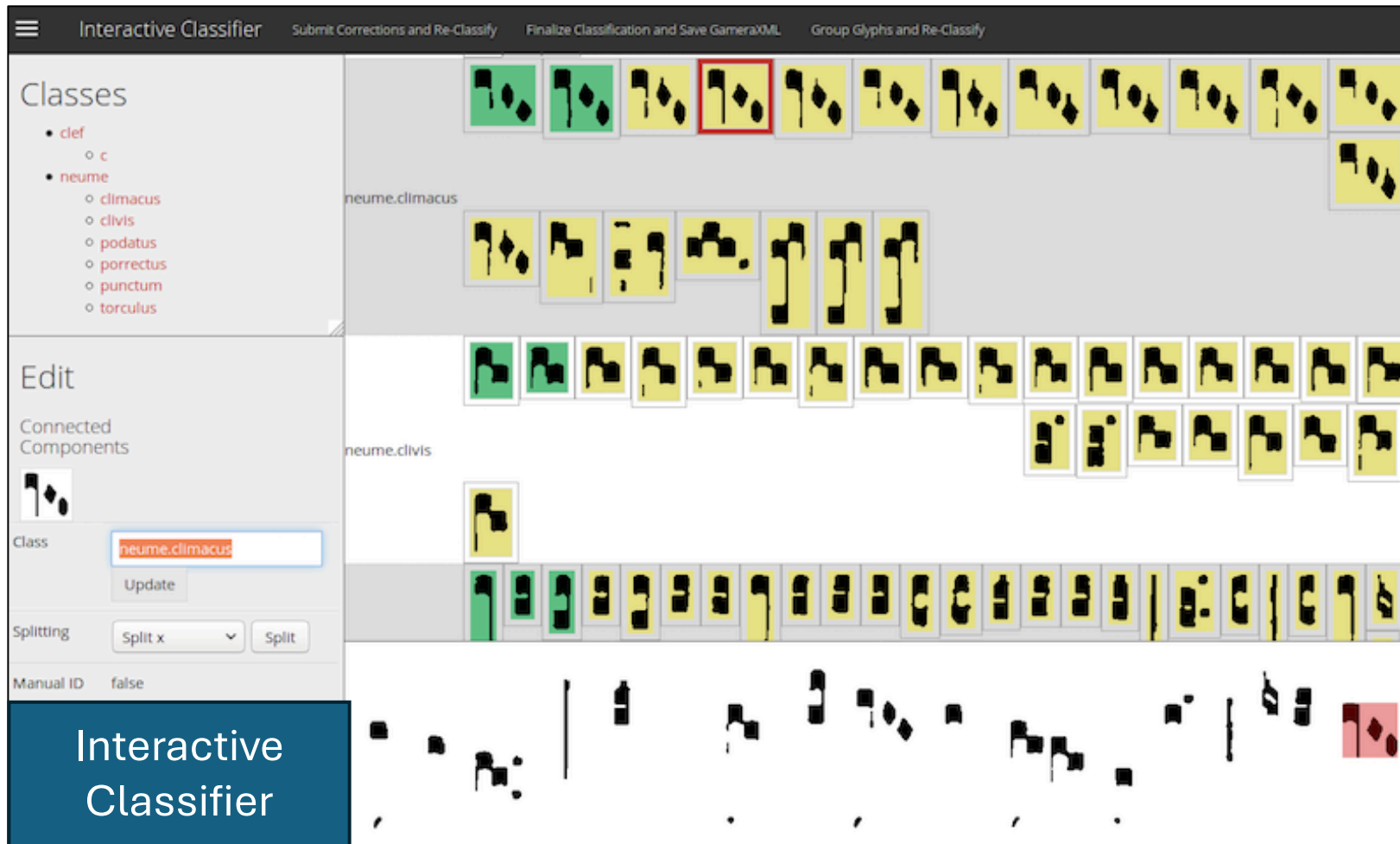
## Note



## Step 2: Music Recognition

(b) Music symbol processing

- “Detection” of music symbols



Interactive  
Classifier

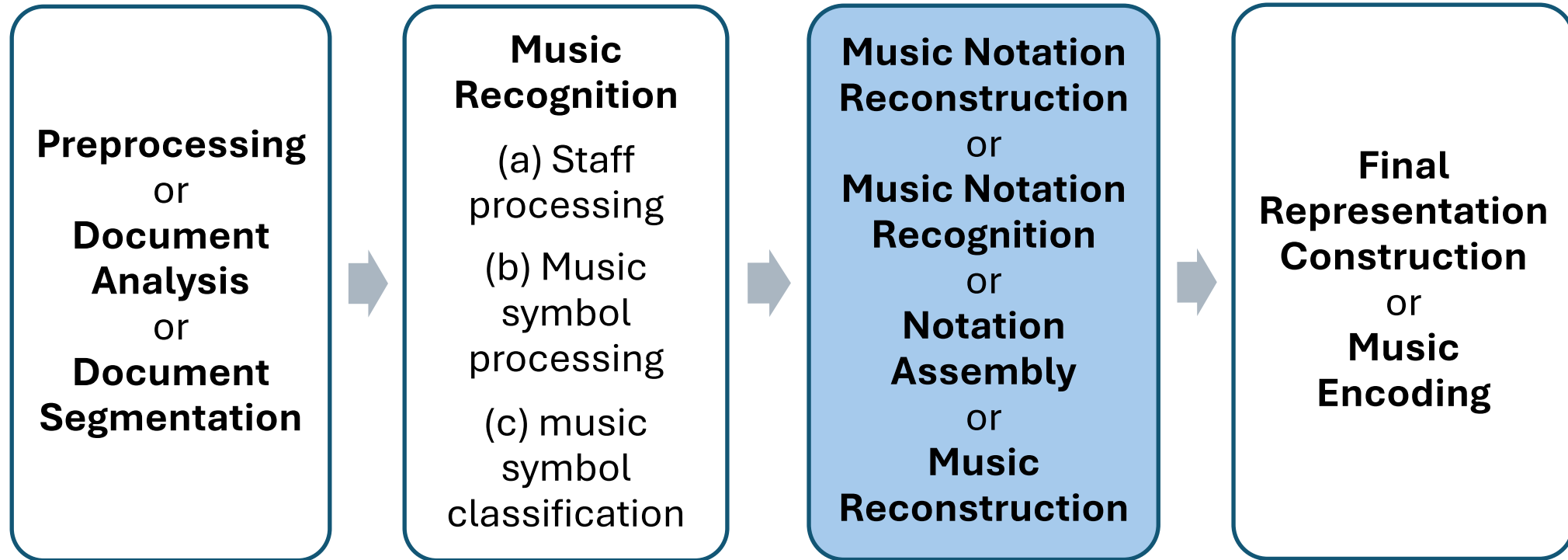
## Step 2: Music Recognition

(b) Music symbol processing

- “Detection” of music symbols

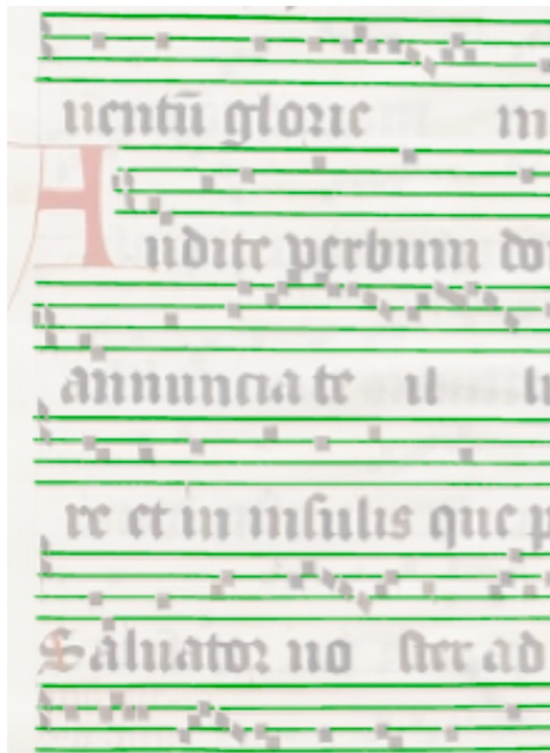
(c) Music symbol **classification**

# Step 3: Music Notation Reconstruction

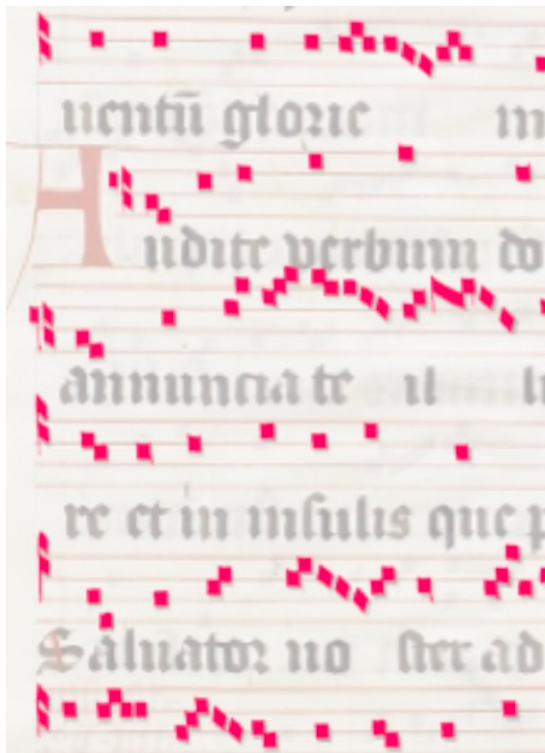




## Staff



## Note



**Step 3:** Music Notation Reconstruction  
*also known as “notation assembly” or  
“music reconstruction”*

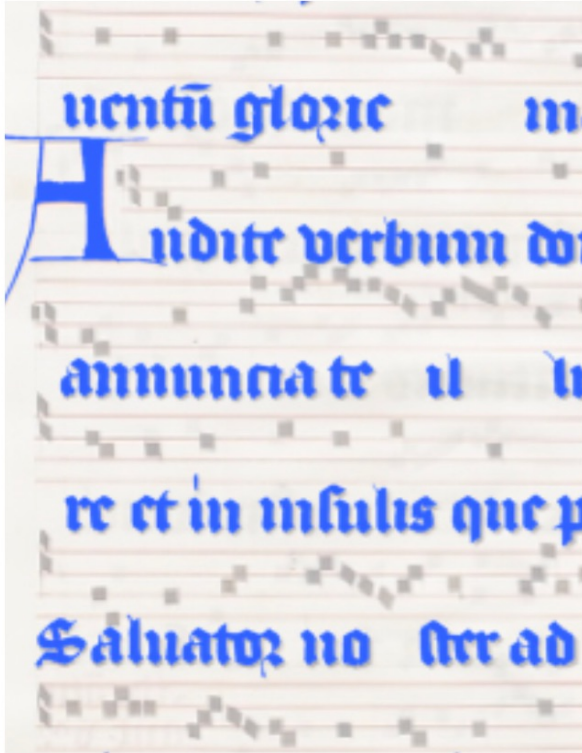
Take the various individual sources of information recognized on previous steps (e.g., music symbols and staff lines) and bring them together to reconstruct the “music notation” (or “music semantics”)

### → Pitch detection

Overlay the symbols on top of the staff lines and use the tracked staff lines path to interpret the pitch of each symbol

---

Text

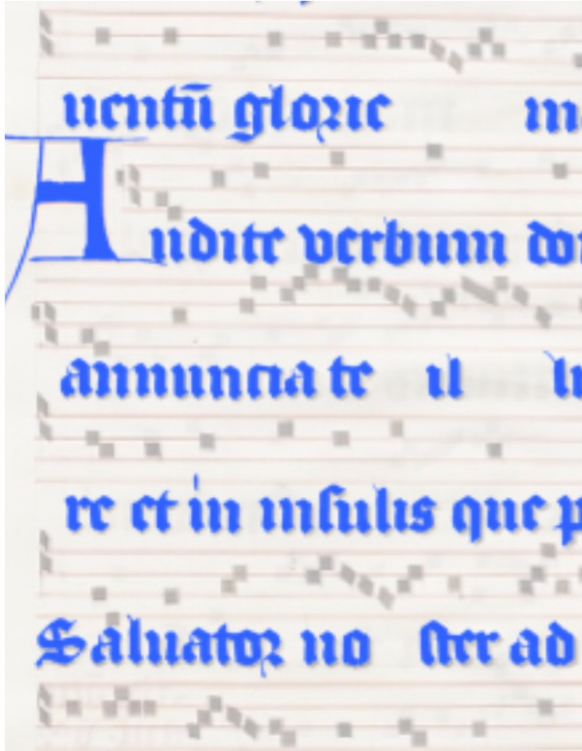


# What about text?

**Step 3:** Music Notation Reconstruction  
*also known as “notation assembly” or  
“music reconstruction”*

---

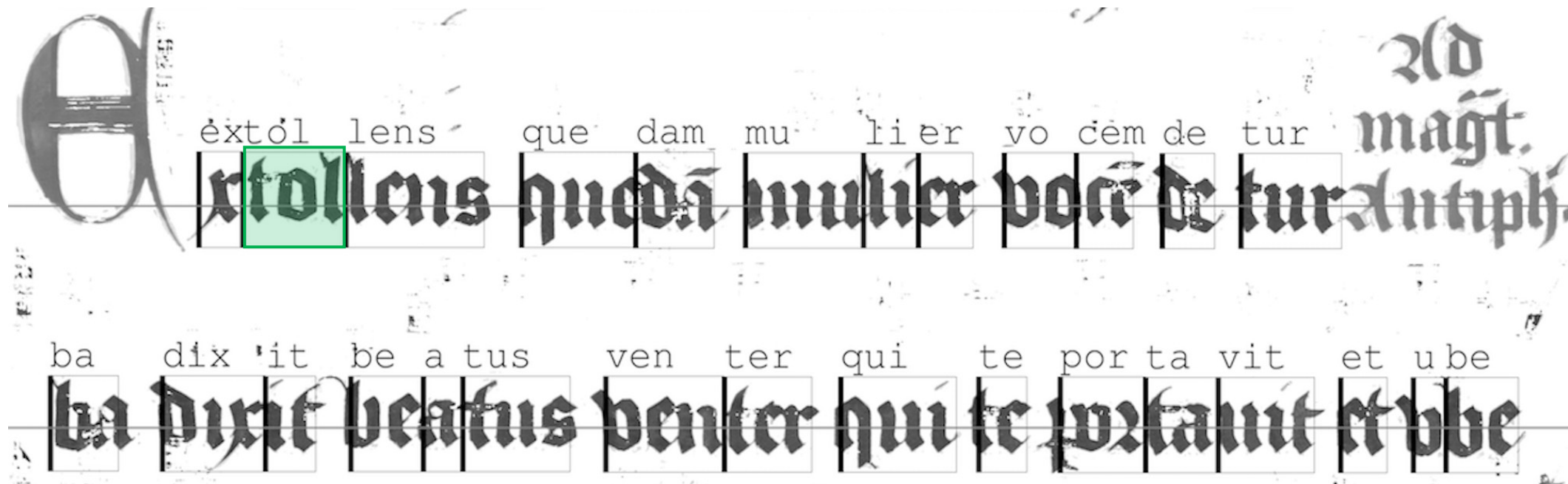
Text



# What about text?

**Step 3:** Music Notation Reconstruction  
*also known as “notation assembly” or  
“music reconstruction”*

- OCR has issues with recognizing handwritten text



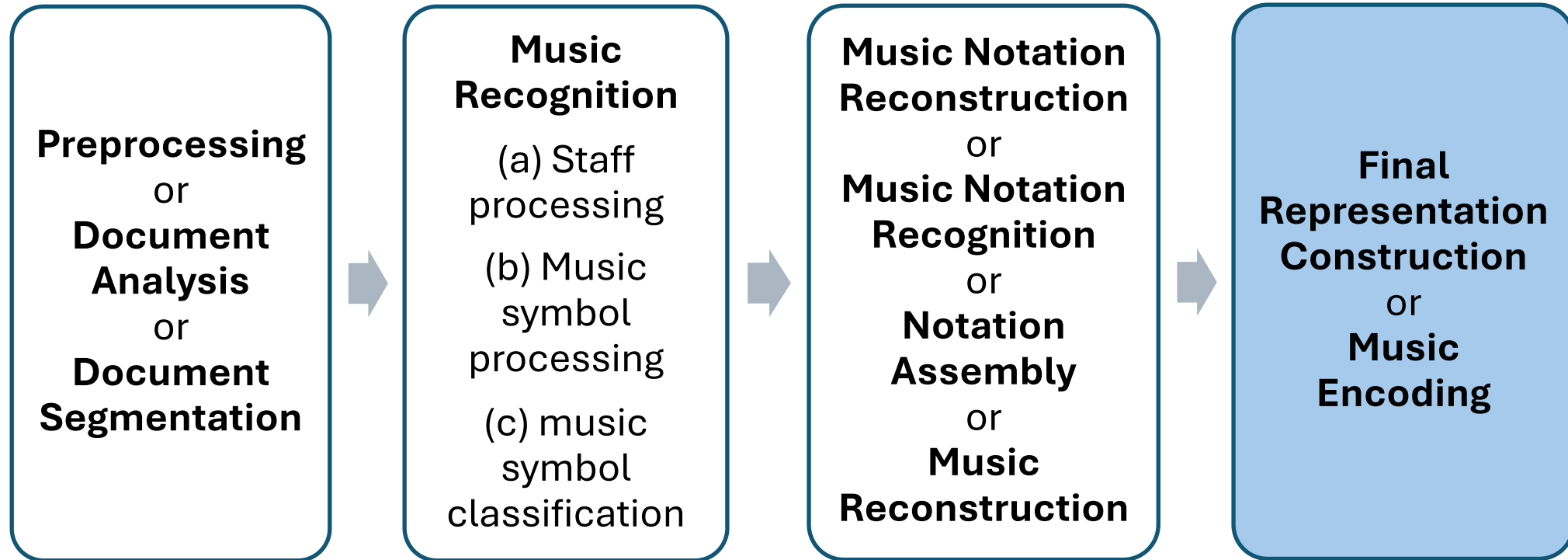
From Cantus Database

Extollens quaedam mulier vocem de tur-  
ba dixit beatus venter qui te portavit et ube...

**Step 3:** Music Notation Reconstruction  
*also known as “notation assembly” or  
“music reconstruction”*

- OCR has issues with recognizing handwritten text

# Step 4: Final Representation or Music Encoding



```

<section xml:id="section-0000001229415468">
  <measure xml:id="measure-L6" n="1">
    <staff xml:id="staff-L6F2N1" n="1">
      <layer xml:id="layer-L6F2N1" n="1">
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        <note xml:id="note-L11F2" dur="2" oct="4" pname="g" accid="n" />
      </layer>
    </staff>
    <staff xml:id="staff-L6F1N1" n="2">
      <layer xml:id="layer-L6F1N1" n="1">
        <note xml:id="note-L7F1" dots="1" dur="4" oct="3" pname="c" accid="n" />
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          <beam xml:id="beam-L8F1-L10F1">
            <note xml:id="note-L8F1" dur="16" oct="3" pname="d" accid="s" />
            <note xml:id="note-L9F1" dur="16" oct="3" pname="e" accid="ff" />
            <note xml:id="note-L10F1" dur="16" oct="3" pname="f" accid="x" />
          </beam>
        </tuplet>
        <note xml:id="note-L11F1" dur="4" oct="3" pname="a" accid="n" />
        <note xml:id="note-L12F1" dur="4" oct="3" pname="a" accid="n" />
      </layer>
    </staff>
    <fermata xml:id="fermata-L10F1" staff="2" startid="#note-L10F1" place="above" />
    <tie xml:id="tie-L11F1-L12F1" startid="#note-L11F1" endid="#note-L12F1" />
    <slur xml:id="slur-L11F2-L16F3N1" staff="1" startid="#note-L11F2" endid="#note-L16F3" />
    <tie xml:id="tie-L12F1-L15F1" startid="#note-L12F1" endid="#note-L15F1" />
  </measure>
  <measure xml:id="measure-L13" n="2">
    <staff xml:id="staff-L13F2N1" n="1">
      <layer xml:id="layer-L13F2N1" n="1">
        <note xml:id="note-L15F3" dur="2" oct="4" pname="b" accid="n" />
        <note xml:id="note-L16F3" dur="2" oct="5" pname="d" accid="n" />
      </layer>
    </staff>
    <staff xml:id="staff-L13F1N1" n="2">
      <layer xml:id="layer-L13F1N1" n="1">
        <note xml:id="note-L15F1" dur="1" oct="3" pname="a" accid="n" />
      </layer>
      <layer xml:id="layer-L15F2N2" n="2">
        <note xml:id="note-L15F2" dur="2" oct="2" pname="b" accid="n" />
        <note xml:id="note-L16F2" dur="2" oct="2" pname="a" accid="n" />
      </layer>
    </staff>
    <fermata xml:id="fermata-L16F3" staff="1" startid="#note-L16F3" place="above" />
  </measure>
  <measure xml:id="measure-L18" right="end" n="3">
    <staff xml:id="staff-L18F2N1" n="1">
      <layer xml:id="layer-L18F2N1" n="1">
        <note xml:id="note-L19F2" dur="4" oct="5" pname="c" accid="n">
          <artic xml:id="artic-L19F2" artic="marc" />
        </note>
        <note xml:id="note-L20F2" dur="4" oct="5" pname="d" accid="n">

```

## Step 4: Final Representation Construction (or Music Encoding)

- The music is encoded in a standard music-encoding format (e.g., MusicXML and MEI)



```

<section xml:id="section-0000001229415468">
  <measure xml:id="measure-L6" n="1">
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        <rest xml:id="rest-L7F2" dur="2" fermata="above" />
        <note xml:id="note-L11F2" dur="2" oct="4" pname="g" accid.ges="n" />
      </layer>
    </staff>
    <staff xml:id="staff-L6F1N1" n="2">
      <layer xml:id="layer-L6F1N1" n="1">
        <note xml:id="note-L7F1" dots="1" dur="4" oct="3" pname="c" accid.ges="n" />
        <tuplet xml:id="tuplet-L8F1-L10F1" num="3" numbase="2" num.format="count">
          <beam xml:id="beam-L8F1-L10F1">
            <note xml:id="note-L8F1" dur="16" oct="3" pname="d" accid="s" />
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            <note xml:id="note-L10F1" dur="16" oct="3" pname="f" accid="x" />
          </beam>
        </tuplet>
        <note xml:id="note-L11F1" dur="4" oct="3" pname="a" accid.ges="n" />
        <note xml:id="note-L12F1" dur="4" oct="3" pname="a" accid.ges="n" />
      </layer>
    </staff>
    <fermata xml:id="fermata-L10F1" staff="2" startid="#note-L10F1" place="above" />
    <tie xml:id="tie-L11F1-L12F1" startid="#note-L11F1" endid="#note-L12F1" />
    <slur xml:id="slur-L11F2-L16F3N1" staff="1" startid="#note-L11F2" endid="#note-L16F3" />
    <tie xml:id="tie-L12F1-L15F1" startid="#note-L12F1" endid="#note-L15F1" />
  </measure>
  <measure xml:id="measure-L13" n="2">
    <staff xml:id="staff-L13F2N1" n="1">
      <layer xml:id="layer-L13F2N1" n="1">
        <note xml:id="note-L15F3" dur="2" oct="4" pname="b" accid.ges="n" />
        <note xml:id="note-L16F3" dur="2" oct="5" pname="d" accid.ges="n" />
      </layer>
    </staff>
    <staff xml:id="staff-L13F1N1" n="2">
      <layer xml:id="layer-L13F1N1" n="1">
        <note xml:id="note-L15F1" dur="1" oct="3" pname="a" accid.ges="n" />
      </layer>
      <layer xml:id="layer-L15F2N2" n="2">
        <note xml:id="note-L15F2" dur="2" oct="2" pname="b" accid.ges="n" />
        <note xml:id="note-L16F2" dur="2" oct="2" pname="a" accid.ges="n" />
      </layer>
    </staff>
    <fermata xml:id="fermata-L16F3" staff="1" startid="#note-L16F3" place="above" />
  </measure>
  <measure xml:id="measure-L18" right="end" n="3">
    <staff xml:id="staff-L18F2N1" n="1">
      <layer xml:id="layer-L18F2N1" n="1">
        <note xml:id="note-L19F2" dur="4" oct="5" pname="c" accid.ges="n">
          <artic xml:id="artic-L19F2" artic="marc" />
        </note>
        <note xml:id="note-L20F2" dur="4" oct="5" pname="d" accid.ges="n">

```

## Step 4: Final Representation Construction (or Music Encoding)

- The music is encoded in a standard music-encoding format (e.g., MusicXML and MEI)
- For early music notation → MEI



Neon File Help

Salzannes, CDN-Hsmu M2149.L4

Folio 011r

Zoom level: 5

Display

Glyph Opacity 100

Image Opacity 100

Display Text:  Display Info:  Highlight - Syllable

MEI Status: VALID

Insert

Neume Grouping Clef System

Edit

Select By: Syllable Neume Neume Component Staff

Delete

Undo Redo

Neon.js  
Neume Editor Online

## Step 4: Final Representation Construction (or Music Encoding)

- The music is encoded in a standard music-encoding format
- For early music notation → MEI
- Interfaces for correction of the resulting MEI file (e.g., Neon for neume notation)

# Some OMR Frameworks for **Neume Scripts**



OMMR4all

# Rodan and the **Single Interface for Music Score Searching & Analysis (SIMSSA)** Project

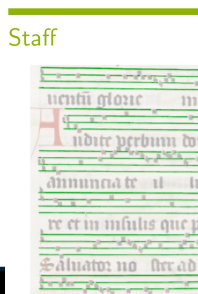
*Workflow manager created by **Andrew Hankinson**, used for OMR in the **SIMSSA** project, led by **Ichiro Fujinaga** (McGill)*

# Rodan and the **Single Interface for Music Score Searching & Analysis (SIMSSA)** Project

*Workflow manager created by **Andrew Hankinson**, used for OMR in the **SIMSSA** project, led by **Ichiro Fujinaga** (McGill)*

**Document  
Segmentation**

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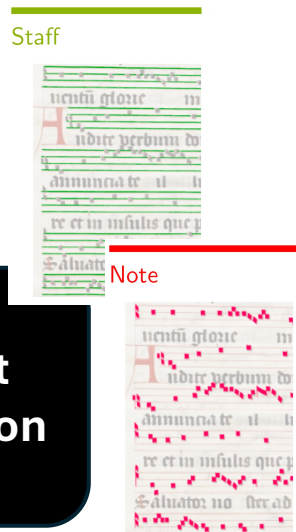


**Document  
Segmentation**

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# Rodan and the **Single Interface for Music Score Searching & Analysis (SIMSSA)** Project

*Workflow manager created by **Andrew Hankinson**, used for OMR in the **SIMSSA** project, led by **Ichiro Fujinaga** (McGill)*

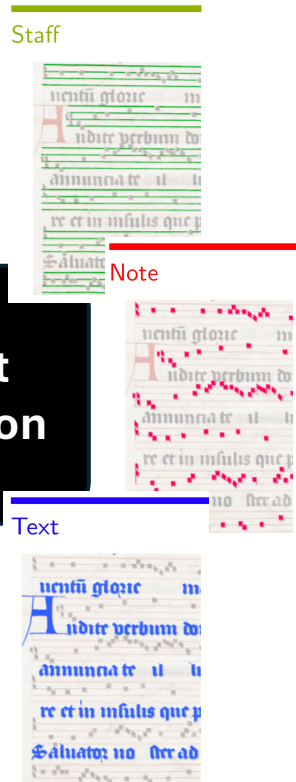


**Document Segmentation**

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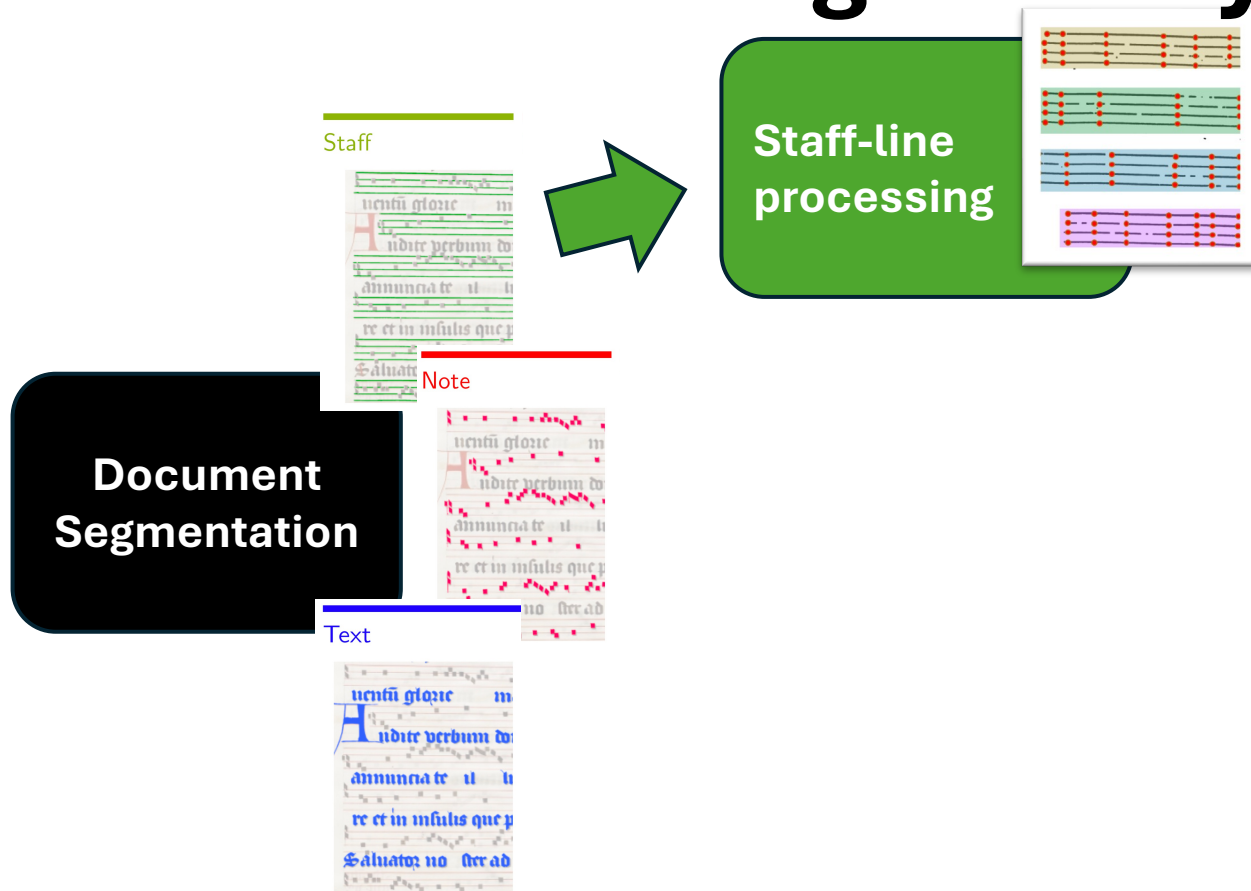
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**Document Segmentation**



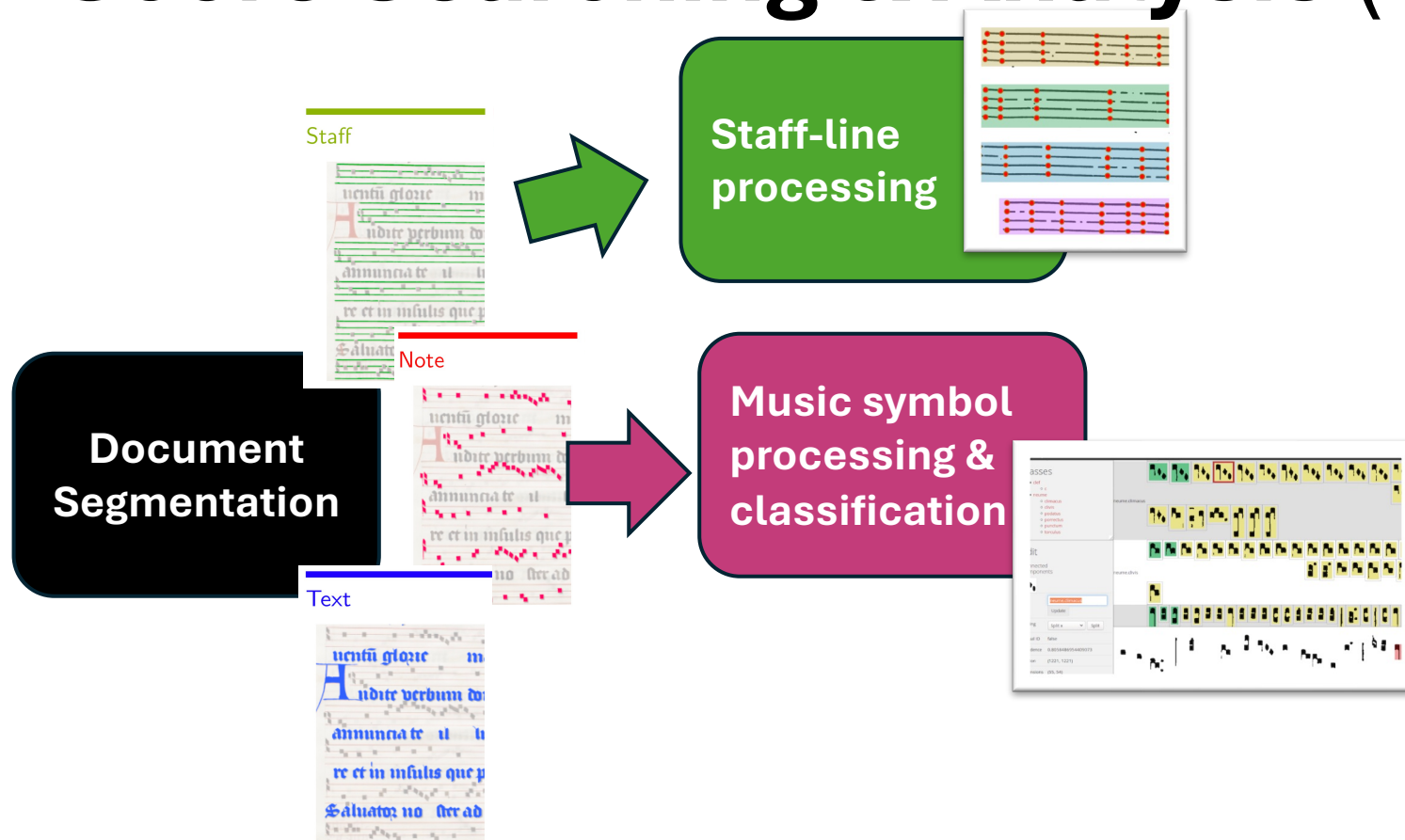


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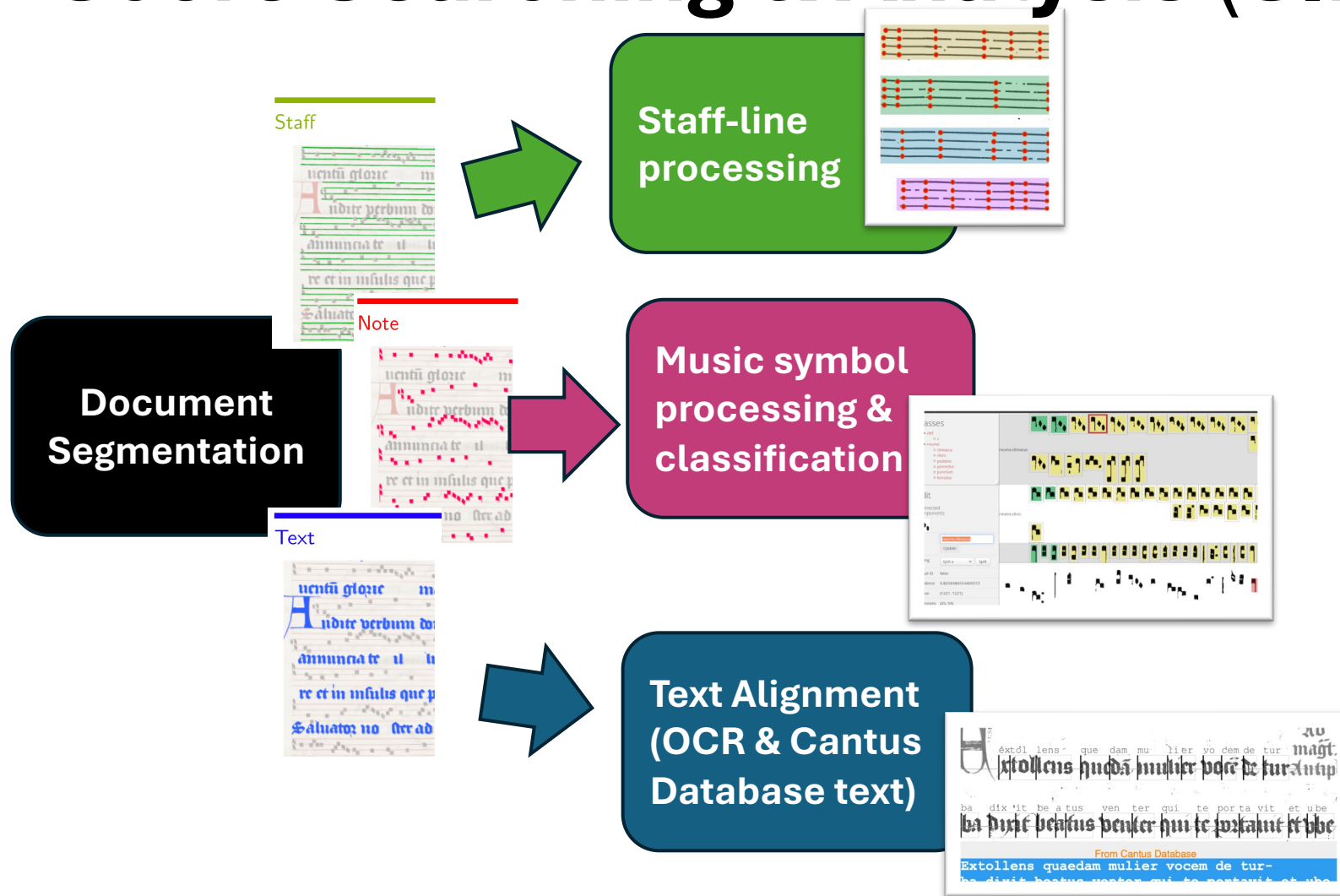
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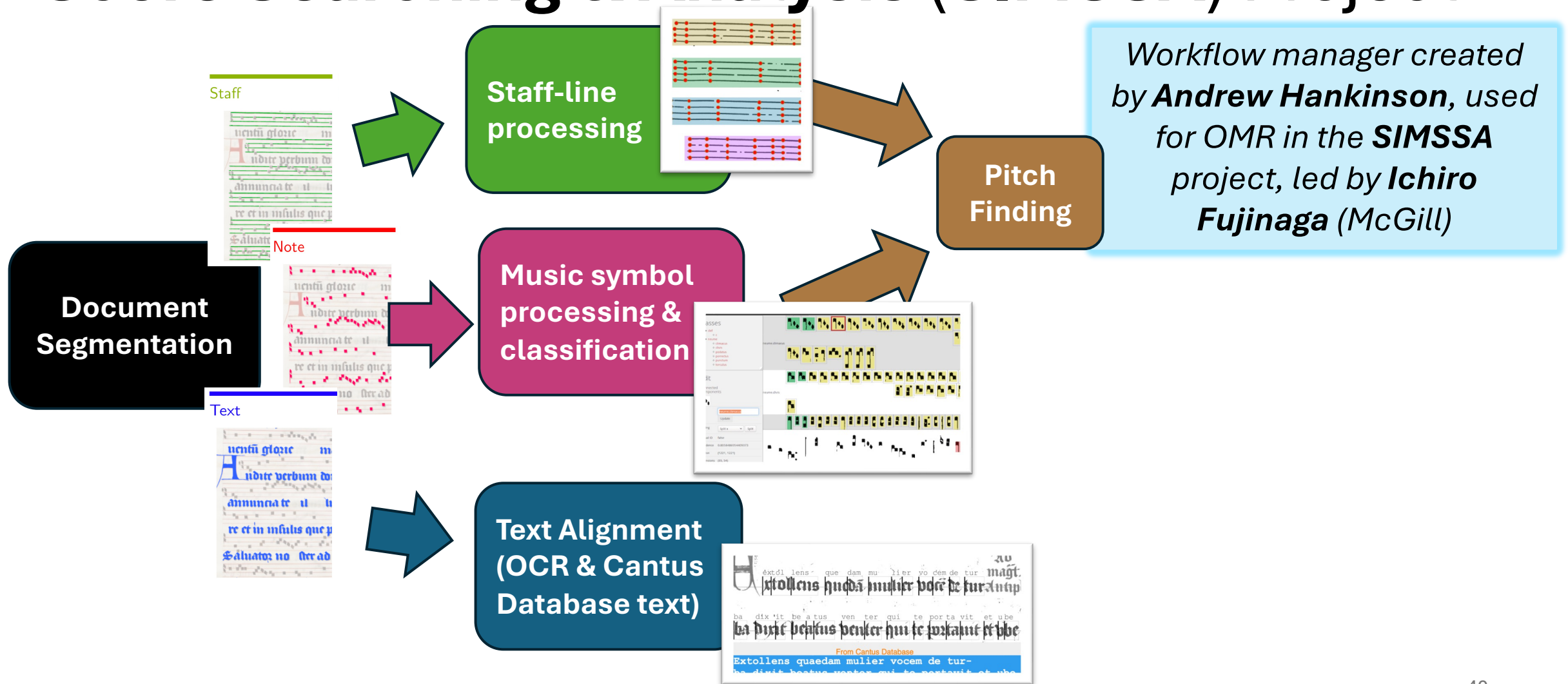
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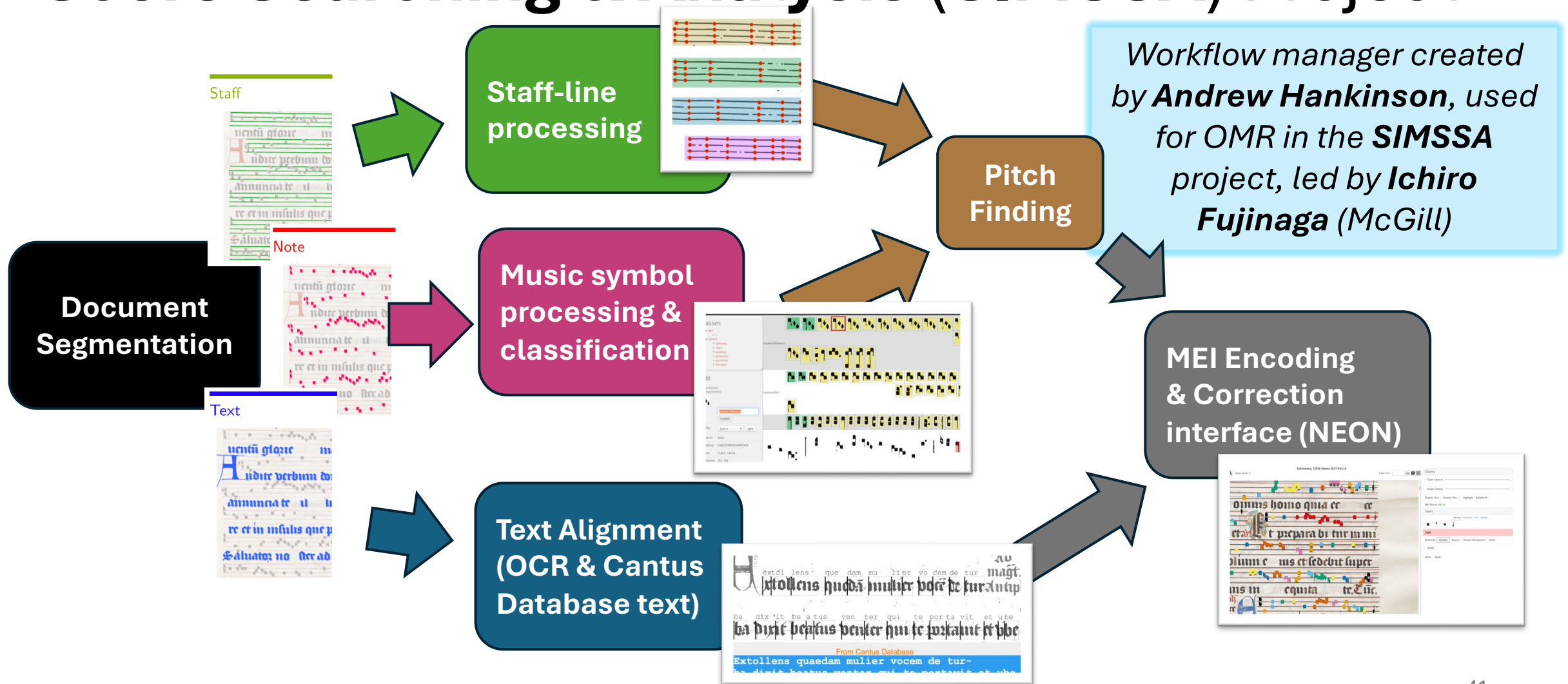


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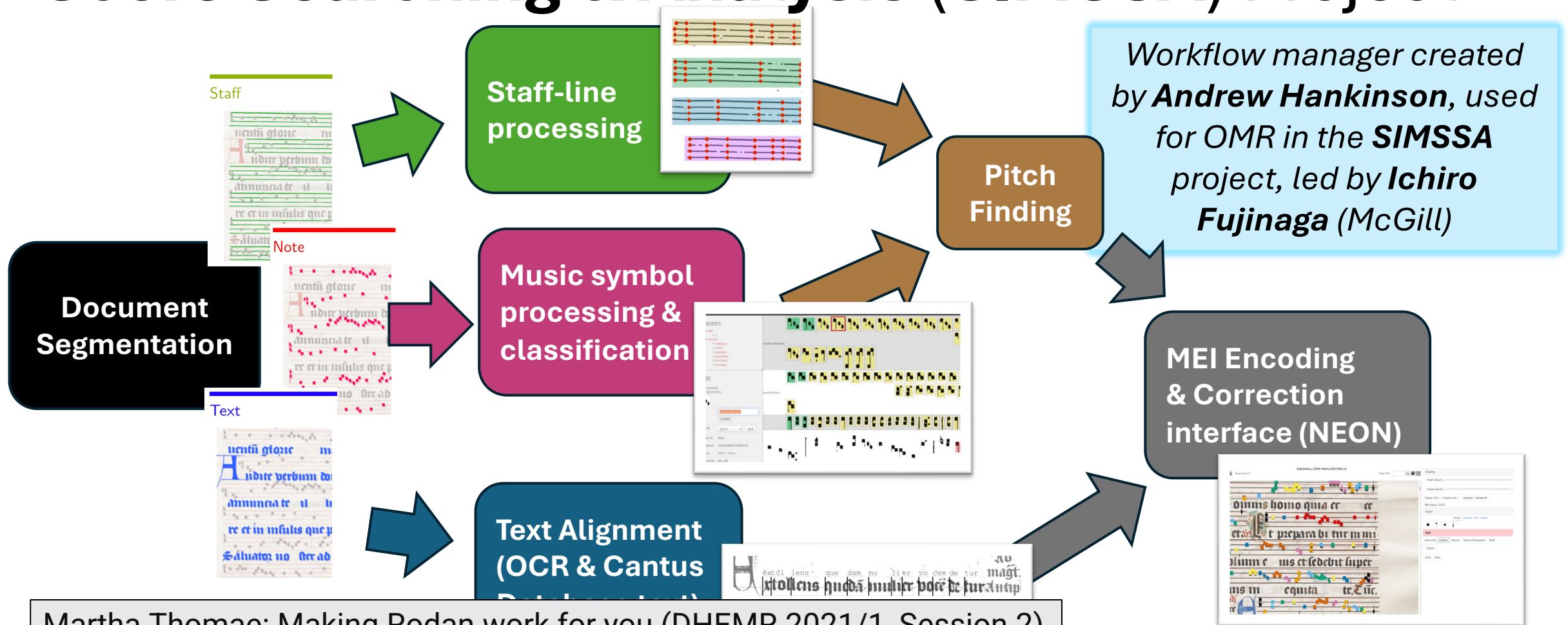


# Rodan and the **Single Interface for Music Score Searching & Analysis (SIMSSA)** Project





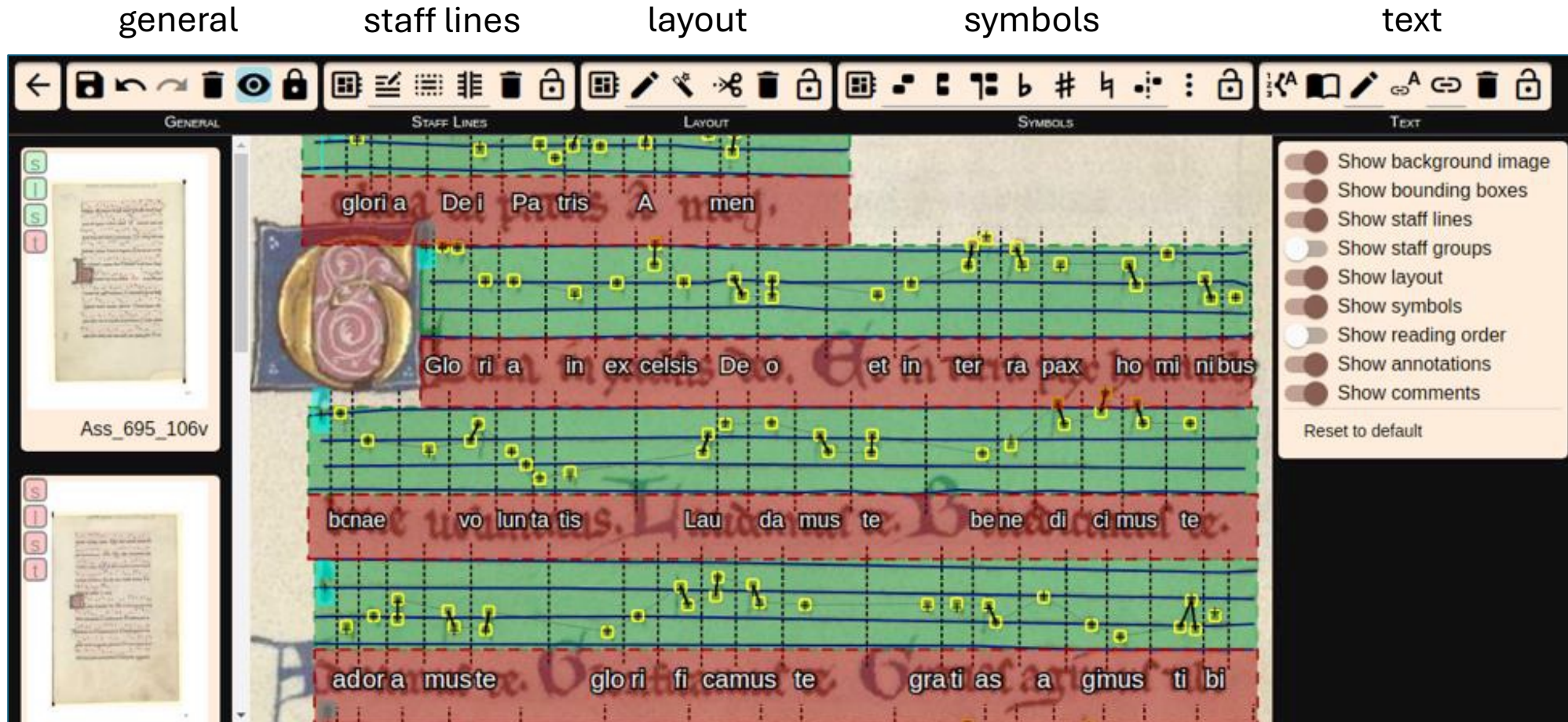
# Rodan and the **Single Interface for Music Score Searching & Analysis (SIMSSA)** Project



Martha Thomae: Making Rodan work for you (DHEMR 2021/1, Session 2)  
[https://youtu.be/\\_TeGXG9Fh2M?si=v\\_IQOBysIGi7GtLL](https://youtu.be/_TeGXG9Fh2M?si=v_IQOBysIGi7GtLL)

# OMMR4All

Created by **Cristopher Wick** (University of Würzburg), and it is being used in the **Corpus Monodicum** project



Alexander Hartelt & Jan Hajič: Collaborative digital editions with OMMR4All (DHEMR 2021/1 sess. 3): <https://youtu.be/hX9pGOdfbZ8?feature=shared>



# OMR Frameworks for Neume Notation

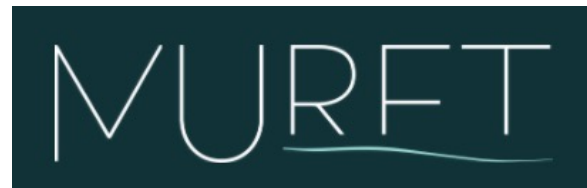
- **Old Myths, New Facts (OMNF).** Recordings available from first Digital Humanities in Early Music Research workshop of 2021.

<https://www.smnf.cz/en/news/Recordings-available-from-first-Digital-Humanities-in-Early-Music-Research-workshop-of-2021/>

The project “Old Myths, New Facts: Czech Lands in Center of 15-century Music Developments” (Czech Science Foundation EXPRO 19-28306X) focuses on the study of music repertory from 15th century Bohemia and its reflection in modern Czech music culture.

- **Ichiro Fujinaga:** Large-scale OMR for neumes with Rodan (DHEMR 2021/1, Session 1).  
<https://www.youtube.com/watch?v=FXkKrwatlwM>
- **Martha Thomae:** Making Rodan work for you (DHEMR 2021/1, Session 2).  
<https://www.youtube.com/watch?v=TeGxG9Fh2M>
- **Alexander Hartelt & Jan Hajič:** Collaborative digital editions with OMMR4All (DHEMR 2021/1 session 3). <https://www.youtube.com/watch?v=hX9pGOdfbZ8>

# Some OMR Frameworks for Mensural Scripts



# MuRET

## The Piece Interface

**Music Recognition Encoding and Transcription (MuRET)**  
OMR framework developed by **David Rizo (University of Alicante)**

MuRET

Guatemala / 07 Missa sine nomine

Unassigned to section

New section...

Move all to default section...

(#0 images)

31v.jpg  
superius  
-  
tenor  
-

32r.jpg  
-  
altus  
-  
bassus

32v.jpg  
superius  
-  
tenor  
-

33r.jpg  
-  
altus  
-  
bassus

33v.jpg  
superius  
-  
tenor  
-

34r.jpg  
-  
altus  
-  
bassus


34v.jpg  
superius  
-  
tenor  
-


35r.jpg  
-  
altus  
-  
bassus

46

# MuRET

## The Page Interface

MuRET  Guatemala / 7 Missa sine nomine / 31v.jpg Logout as ma



Missa sine nomine, cum 4. vocibus.




Yrie e leyson, /

Kyrie leyson;

Hris te e leyson, /

Chris te e leyson;

Yrie e

- Document analysis: 
- Parts: 
- Score transcription: 

Comments

- [Next image in collection](#)

Staff  Lyrics  Select all/none

[Show more...](#)



# MuRET

## OMR Stage 1: Preprocessing or Document Analysis

The screenshot displays the MuRET web application interface. At the top, the page title is "Guatemala / 7 Missa sine nomine / 31v.jpg". The main content area shows a manuscript page with the title "Missa sine nomine, cum 4. vocibus." and four staves of musical notation with lyrics: "Yrie e leyson, /", "Kyrie leyson;", "Hris te e leyson, /", and "Chris te e leyson;". The word "Hris" is misspelled as "Hris" in the image. The interface includes a top navigation bar with search, zoom, and editing tools, and a left sidebar with a "Staff" selection menu. The bottom control bar contains various analysis options.

Page

Author

Chord

Drawing

Empty staff

Lyrics

Marginalia

Multiple lyrics

Multiple text

No music content staff

Number

Other

**Staff**

Text

Title

Undefined

Staff

Lyrics

Select all/none

Show less...

Undefined

Title

Text

Author

Empty staff

Multiple lyrics

Other

Chord

No music content staff

Number

Marginalia

Multiple text

# MuRET OMR Stage 2: Music Symbol Recognition

The screenshot displays the MuRET OMR Stage 2 interface. At the top, it shows the document path "Guatemala / 7 Missa sine nomine / 31v.jpg" and a "Logout as martha" link. The main workspace features a large image of a handwritten musical score with red dashed bounding boxes around the notes. Below this, a "Semantic" section shows the recognized notes as a modern musical staff. The interface includes a toolbar with search, zoom, and edit tools, and a sidebar with a thumbnail of the document and a list of symbols for selection. The sidebar is organized into categories: "Agnostic" (Guatemala End2End), "MEI", and "PAEC". Under "Agnostic", there are sub-categories: "Clefs | Meters", "Notes", "Beamed notes", "Rests | Accidentals", and "Other". The "Notes" category is selected, showing various note symbols. The "Semantic" section includes a dropdown menu for "Agnostic to semantic transducer" and a "Special notation type" dropdown set to "Same as whole document".



# MuRET OMR Stage 3: Music Notation Reconstruction

The screenshot displays the MuRET OMR Stage 3 interface for music notation reconstruction. The main window shows a scanned image of a musical score with red dashed bounding boxes around the notes. Below the image, there are three panels: Agnostic, Semantic, and a list of musical symbols.

**Agnostic Panel:** Shows the original scanned image with red dashed bounding boxes. Below it, a reconstructed agnostic notation is shown with standard musical symbols. A tooltip indicates "Move symbols horizontally to change agnostic position".

**Semantic Panel:** Shows a reconstructed semantic notation with diamond-shaped symbols. A tooltip indicates "note\_quarter\_up:1,2".

**Symbol List:** A table of musical symbols and their corresponding values.

Symbol	Value
**smens/**skern	Ai
*clefC1	12
*met(C)	12
Lr_2	12
Se	12
sg	12
sf	12
me	12
mf	12
ngl	12
ma	12
mb	12
ngl	12
soc	12



# MuRET

## OMR Stage 4: Music Encoding

Guatemala / 7 Missa sine nomine

Right click on selected images for further exporting and part

31v.jpg

32r.jpg

32v.jpg

33r.jpg

33v.jpg

34r.jpg

34v.jpg

35r.jpg

35v.jpg

superius  
-  
tenor  
-

-  
altus  
-  
bassus

superius  
-  
tenor  
-

superius  
-  
altus  
-

altus  
-

superius  
-

superius  
-

altus  
-

altus  
-

altus

altus

altus

altus

altus

- Preview image...
- Engrave and export (MEI)...
- Hide
- Move to section:
- Unassign section
- Link whole image to part:
- superius
- altus
- tenor
- bassus
- Create new part...
- Unlink part

# MuRET

## Extra Step: Assignment of Voices



Link whole image to part



Missa sine nomine, cum 4. vocibus.

leyfon, /

leyfon;

c leyfon, /

Chrille c leifon;

ric

tor

Link selected to part:

- superius
- altus
- tenor
- bassus
- Create new part...
- Unlink part
- Rename part

Staff  Lyrics  Select all/none

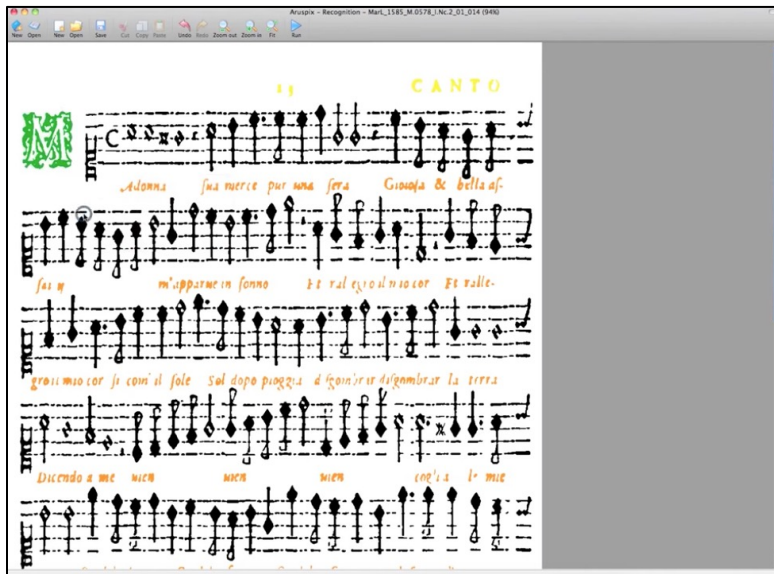
Show more...

Use right button to change the parts of the selected items

# Aruspix

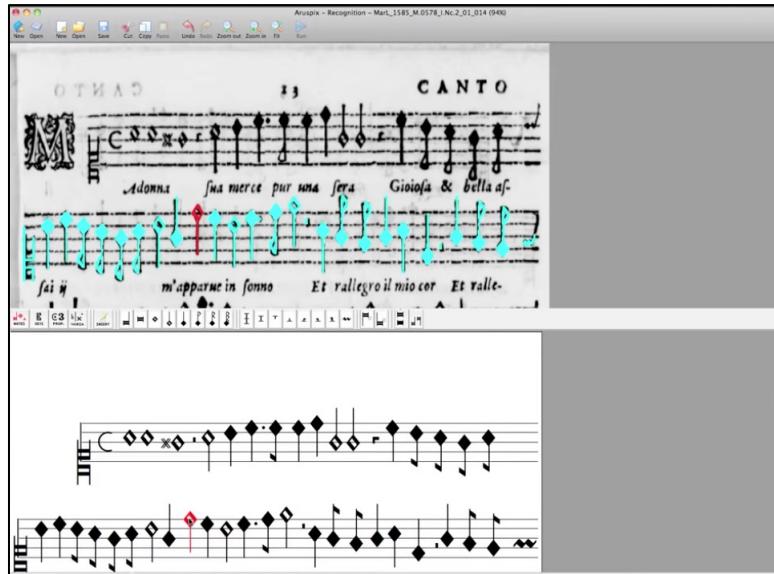
Developed by Laurent Pugin  
<http://www.aruspix.net>

- Early typographic music prints
- Music printed during the sixteenth and seventeenth centuries with **movable typefaces**



A screenshot of the Aruspix software interface. The window title is "Aruspix - Recognition - Mar\_1585\_M.0178\_Nr.2\_01\_014 (040)". The main display shows a page of a musical score with the heading "CANTO" and a large decorated initial "M". The lyrics are: "Adonna sua merce pur una sera Gioiosa & bella af-  
fai u m'appare in sonno Et rallegro il mio cor Et valle-  
grosissimo cor si con il sole Sul dopo pioggia d'ogn'irar d'ogn'embrar la terra  
dicendo a me vien vien vien con la l' mie". The software has processed the image, with some elements highlighted in green and orange. Below the screenshot is a red-bordered box containing the text "Preprocessing = Document Analysis".

Preprocessing = Document Analysis



A screenshot of the Aruspix software interface, similar to the one on the left. The window title is "Aruspix - Recognition - Mar\_1585\_M.0178\_Nr.2\_01\_014 (040)". The main display shows the same musical score page. In this view, the notes and lyrics are highlighted in cyan, and a red vertical line is positioned under the first note of the first staff. Below the screenshot is a blue-bordered box containing the text "Symbol Recognition".

Symbol Recognition



# Optical Music Recognition (OMR)



**Optical Music Recognition**



```
<?xml version="5.0"?>
<meiHead>
  <fileDesc>
    <titleStm>
      <title>06 Missa sobre las voces</title>
      <composer>Cristobal de Morales</composer>
    </titleStm>
    <pubStm>
    </pubStm>
  </fileDesc>
</meiHead>
<music>
  <body>
    <div>
      <score>
        <staffGrp>
          <staffDef n="1" lines="5" label="superius" notationtype="mensural">
            <lef line="2" shape="G"/>
            <mensur sign="C" tempus="2" prolatum="2"/>
          </staffDef>
          </staffGrp>
        </scoreDef>
        <section>
          <staff n="1">
            <layer n="1">
              <rest dur="brevis" loc="4"/>
              <rest dur="semibrevis" loc="4"/>
              <note dur="semibrevis" pname="g" oct="4"/>
              <note dur="minima" pname="a" oct="4"/>
              <note dur="minima" pname="b" oct="4"/>
              <note dur="minima" pname="c" oct="5"/>
              <note dur="minima" pname="d" oct="5"/>
            </layer>
          </staff>
        </section>
      </div>
    </body>
  </music>
</mei>
```

Now... What can we do with  
the retrieved music that is  
encoded in these machine-  
readable files?



Now... What can we do with  
the retrieved music that is  
encoded in these machine-  
readable files?

Content-based searches  
& computational music analysis