eCodicology

Algorithms for the Automatic Tagging of Medieval Manuscripts

# Development of New Technologies for the Automatic Analysis of Medieval Manuscripts

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Bundesministerium
für Bildung
und Forschung

Kompetenzzentrum
für elektronische Erschließungs- und Publikationsverfahren in den Geisteswissenschaften

KIT
Karlsruher Institut für Technologie

TECHNISCHE
UNIVERSITÄT
DARMSTADT

# Project and Motivation

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*What is eCodicology?*

A BMBF funded joint research project of

- Technical University Darmstadt
- Trier Center for Digital Humanities
- Karlsruhe Institute for Technology

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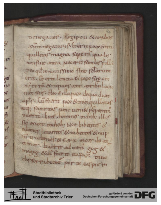
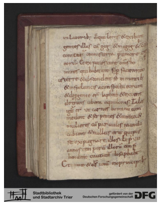
*What is eCodicology for?*

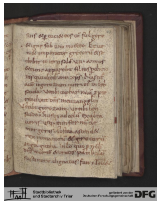
- Automatic identification of macro and micro structural layout elements
- Quantitative Codicology: Statistical analysis of reproducible features
- To identify hidden relationships

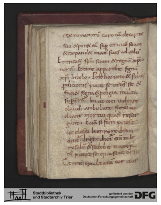
# How to Publish a Library?

Virtual Scriptorium St. Matthias









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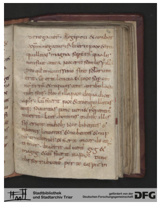

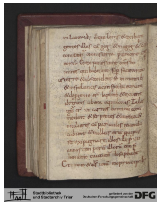

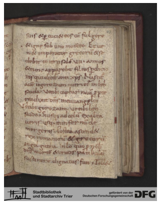

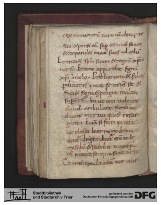

| | |
|---|---|
| Scope: | 440 codices online |
| Period: | 8th to 16th century |
| Contents: | Liturgica, Bible, patristics, mysticism, philosophy, poetry, law, charters, etc. |

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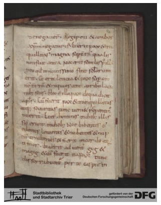

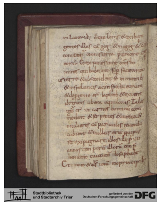

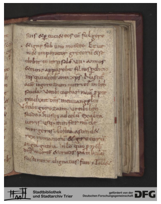

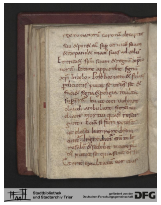

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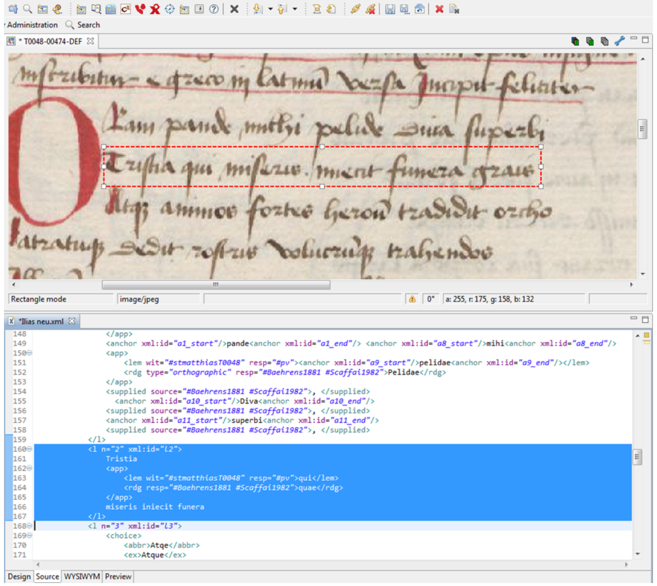
## TextGrid



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            <rdg type="orthographic" resp="#Baehrens1881 #Scaffai1982">Pelidae</rdg>
        </app>
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          <anchor xml:id="a10_start"/>Diva<anchor xml:id="a10_end"/>
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        <anchor xml:id="a11_start"/>superbi<anchor xml:id="a11_end"/>
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    </l>
    <l n="2" xml:id="l2">
        Tristia
        <app>
            <lem wit="#stmatthiasT0048" resp="#pv">qui</lem>
            <rdg resp="#Baehrens1881 #Scaffai1982">quae</rdg>
        </app>
        miseris iniecit funera
    </l>
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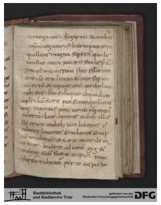
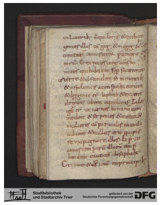
            <ex>Atque</ex>
```

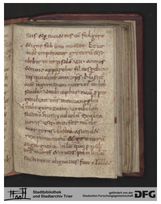
# How to Publish a Library?

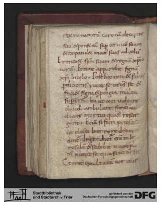
Virtual Scriptorium St. Matthias

TextGrid









Scope: 440 codices online

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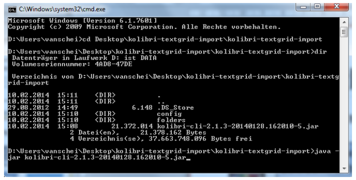


```
Microsoft Windows [Version 6.1.7601]
Copyright (c) 2009 Microsoft Corporation. Alle Rechte vorbehalten.

D:\Users\vanschei>cd Desktop\kolibri-textgrid-import\kolibri-textgrid-import

D:\Users\vanschei\Desktop\kolibri-textgrid-import\kolibri-textgrid-import>dir
 Datenträger in Laufwerk D: ist DATA
 Volumeseriennummer: 4AD8-47DE

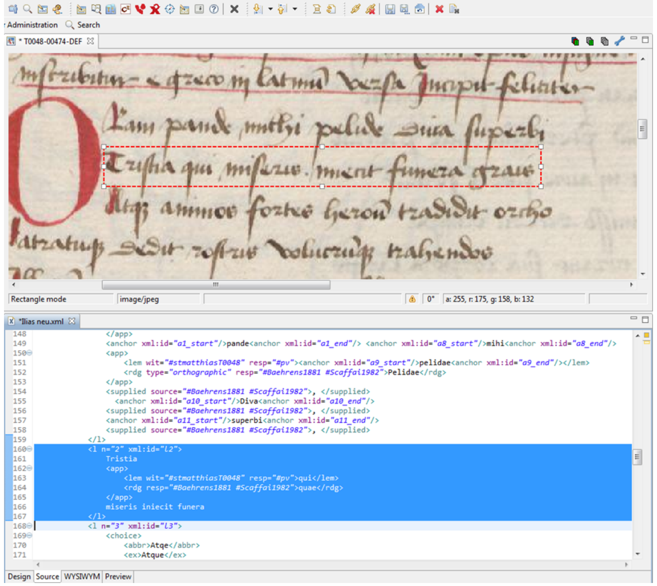
 Verzeichnis von D:\Users\vanschei\Desktop\kolibri-textgrid-import\kolibri-textg
rid-import

10.02.2014  15:11    <DIR>          .
10.02.2014  15:11    <DIR>          ..
29.08.2012  14:49             6.148 .DS_Store
10.02.2014  15:10    <DIR>          config
10.02.2014  15:10    <DIR>          folders
10.02.2014  15:08        21.372.014 kolibri-cli-2.1.3-20140128.162010-5.jar
               2 Datei(en),     21.378.162 Bytes
               4 Verzeichnis(se), 37.663.748.096 Bytes frei

D:\Users\vanschei\Desktop\kolibri-textgrid-import\kolibri-textgrid-import>java -
jar kolibri-cli-2.1.3-20140128.162010-5.jar_
```

KoLibRi

Mass Ingest



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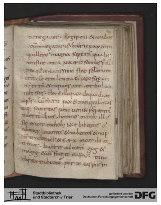

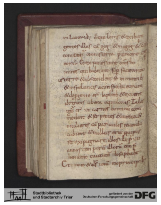

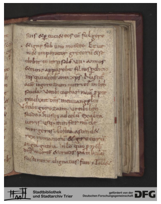

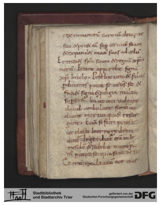

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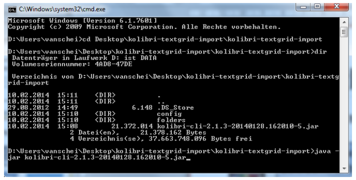

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KoLibRi

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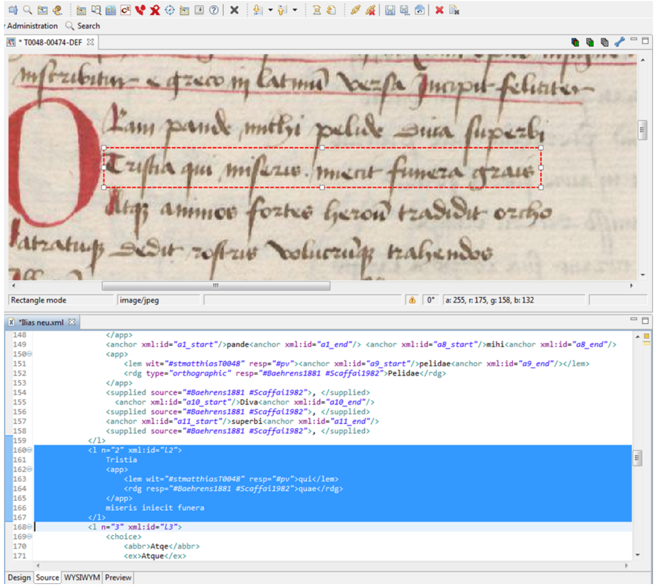

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                </app>
                <anchor xml:id="a1_start"/>pande<anchor xml:id="a1_end"/> <anchor xml:id="a8_start"/>mihi<anchor xml:id="a8_end"/>
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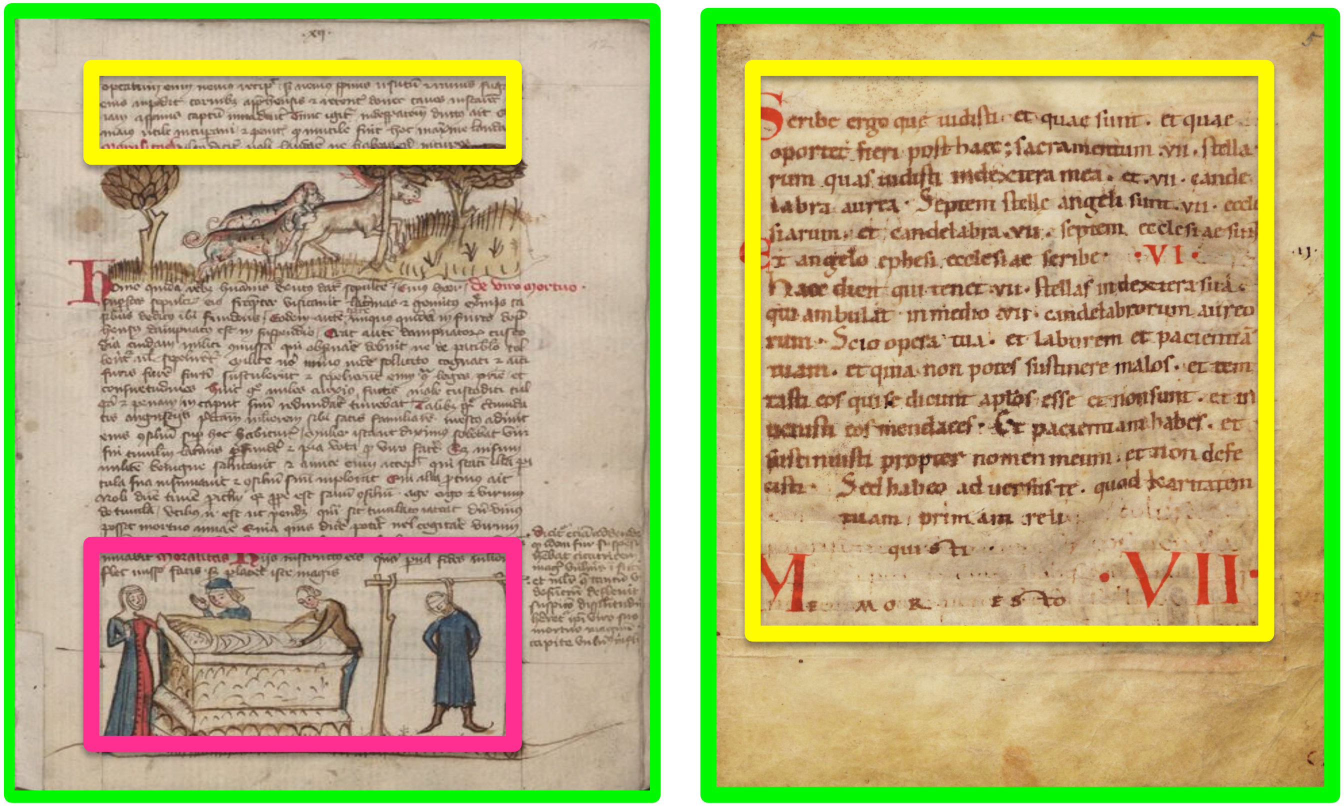
            </l>
            <l n="3" xml:id="l3">
                <choice>
                    <abbr>Atqe</abbr>
                    <ex>Atque</ex>
```

- PID Handling by GWDG
- Exploration of material by human researchers, eg. Critical editions

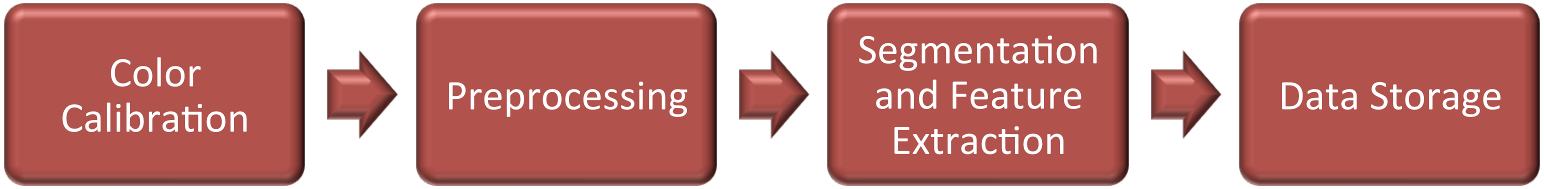
# Feature Extraction

- **Feature:** Individual measurable property of phenomenon observed



🟩 page size, 🟨 written size, 🟥 pictorial space

# How to Extract Layout Features?

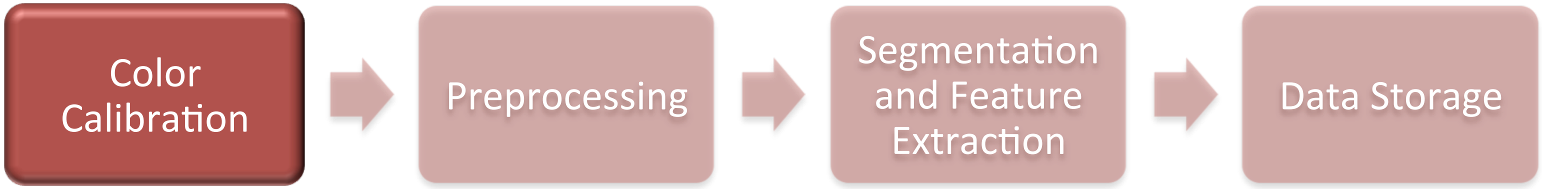


Color Calibration

Preprocessing

Segmentation and Feature Extraction

Data Storage



Color Calibration

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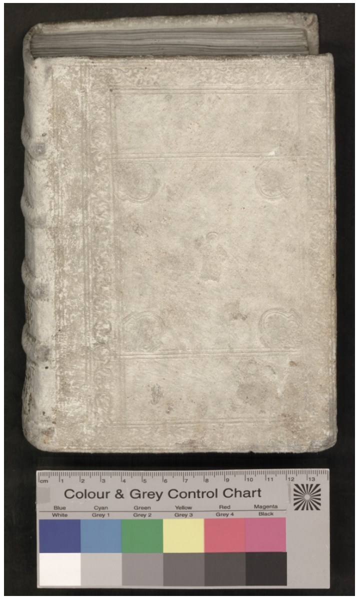
Data Storage

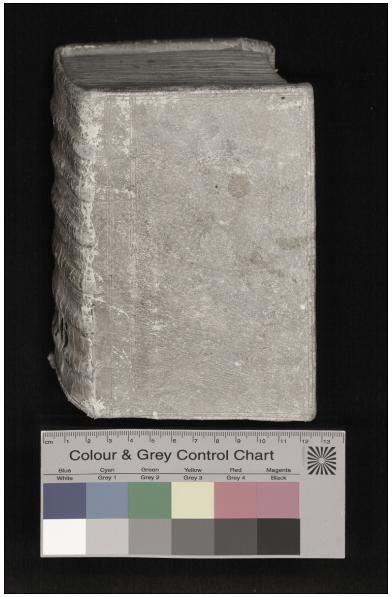
# Color Calibration

- Adjusting different color spaces to similar color space according to a standard color chart



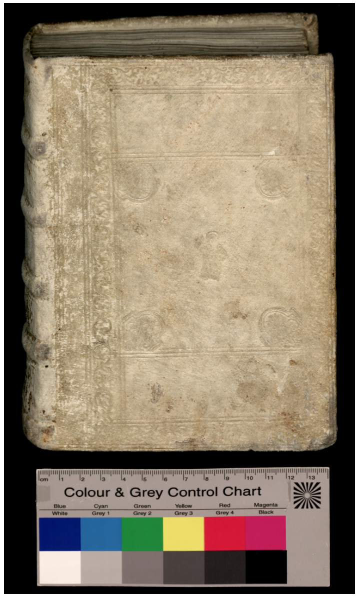
Before Calibration

Scanner 1



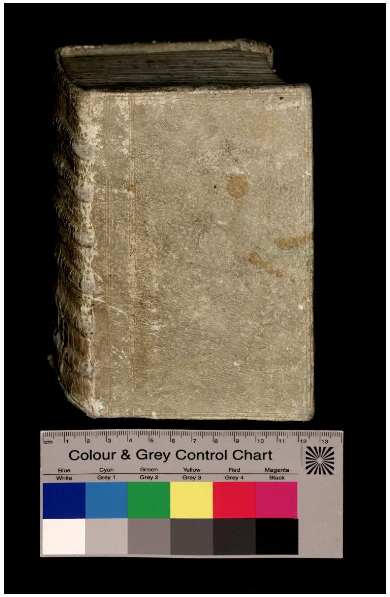
Before Calibration

Scanner 2



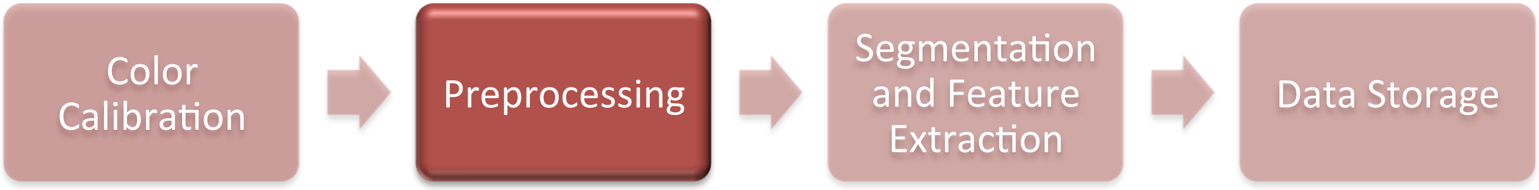
After Calibration

Scanner 1



After Calibration

Scanner 2



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# Preprocessing

- To increase accuracy of the digital data for feature extraction
  - Spatial Calibration - Adjusting different resolutions to same resolution
  - Filtering - Removing low frequency background noise
  - Scaling and Duplication – Scaling images to different resolutions

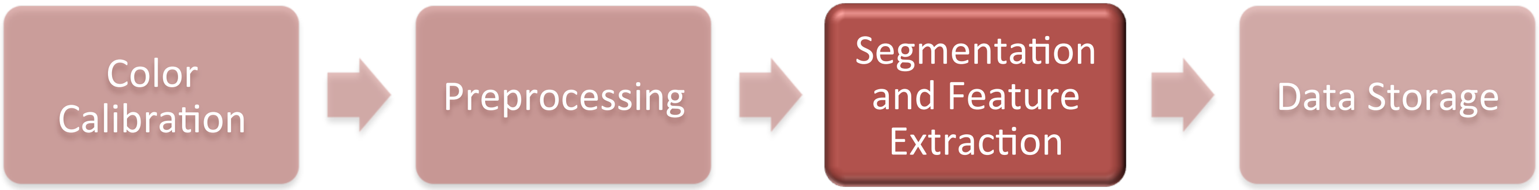
300 dpi

400 dpi

Different Resolutions

Spatial Calibrated Image

Filtered Image



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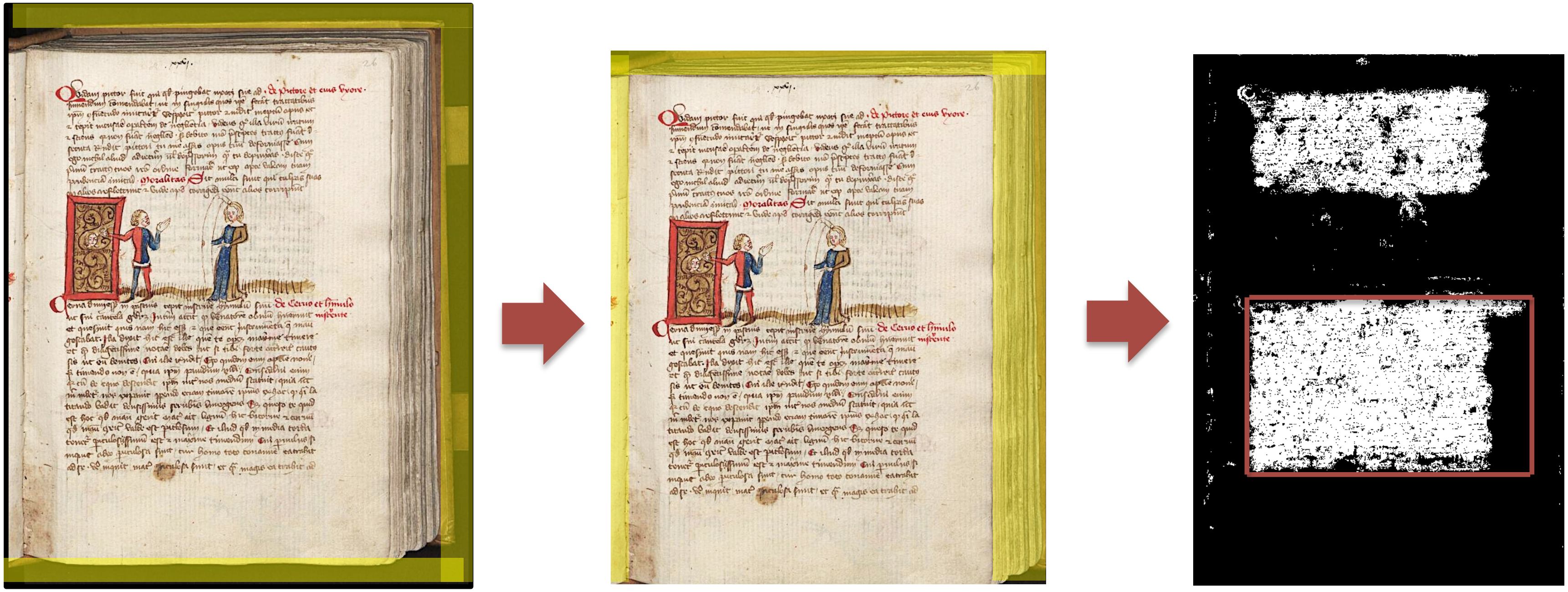
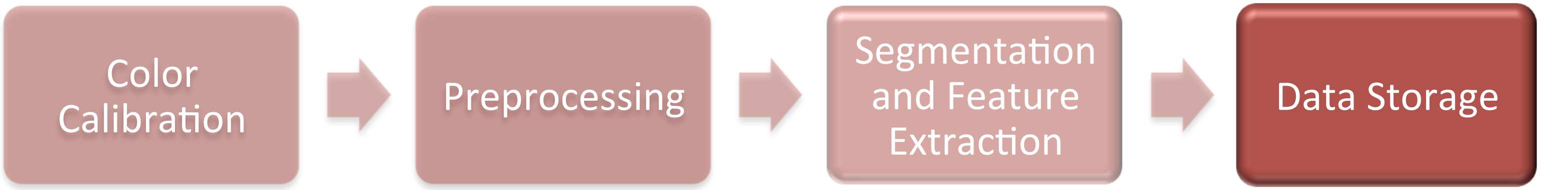
# Segmentation

- Divide image into regions with similar properties
- Determine region of interest





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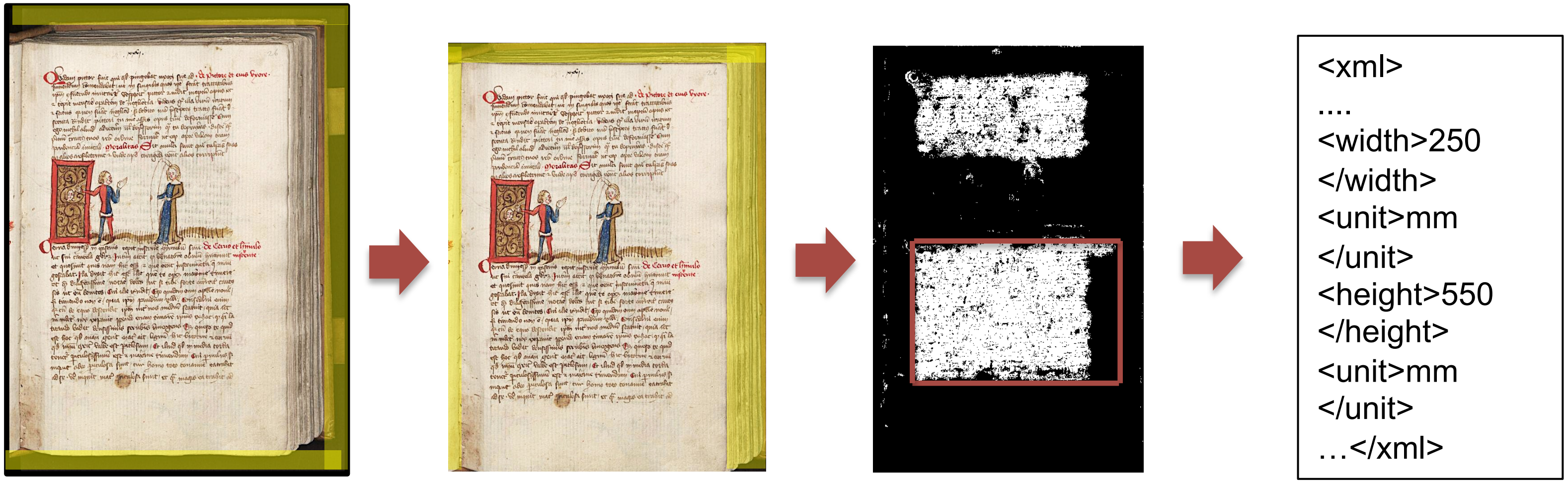
# Data Storage

- Extracted features are stored in XML file



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<xml>
....
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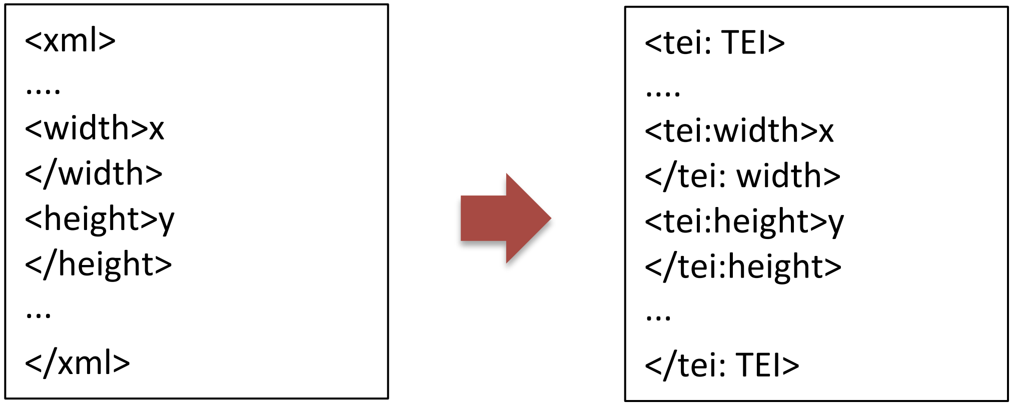
</width>
<unit>mm
</unit>
<height>550
</height>
<unit>mm
</unit>
…</xml>
```

# Feature Extraction….In a nutshell

- Automatic layout analysis of manuscript images is challenging due to different color spaces, heavy noise etc.
- Suitable preprocessing and segmentation methodology are very essential steps for feature extraction
- Accuracy and convergence rate of such techniques must be significantly high in order to ensure the success of subsequent steps

# Metadata Management

- Customization of TEI, using TEI ODD – One Document Does It All
- Preferable schema language for output: RelaxNG + Schematron
- Special focus on measurements, written and pictorial spaces, e.g. marginalia, pictorial elements



```
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....
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</width>
<height>y
</height>
...
</xml>
```

```
<tei: TEI>
....
<tei:width>x
</tei: width>
<tei:height>y
</tei:height>
...
</tei: TEI>
```

# Metadata Management

TEI XML Example for Manuscript Description:

```
<tei:TEI>
    <tei:teiHeader>
    …
        <tei:msDesc>
        …
            <tei:supportDesc>

                <tei:extent>
                    <tei:measure type="leaves">44</tei:measure>
                    <tei:measure type="format">8°</tei:measure>
                </tei:extent>
                …
            </tei:supportDesc>
            <tei:layoutDesc>
                <tei:layout>
                    <tei:dimensions type="written" corresp="#written1">
                        <tei:height quantity="250" unit="mm" min="249" max="251" confidence="0.8">250mm</tei:height>
                        <tei:width quantity="100" unit="mm" min="98" max="101" confidence="0.77">100mm</tei:width>
                    </tei:dimensions>
                    <tei:dimensions type="image" facs="#image1"/>
                </tei:layout>
                <tei:layout columns="1" writtenLines="26 30"/>
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            </tei:objectDesc>
            …
            <tei:additions>
                <tei:note type="gloss" place="gutter"/>
            </tei:additions>
            …
        </tei:msDesc>
        …
    </tei:teiHeader>
    <tei:facsimile>
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            <tei:graphic url="0099-00005.jpg"/>
            <tei:zone type="image" ulx="20" uly="20" lrx="70" lry="70" xml:id="image1"/>
            <tei:zone  type="written" ulx="20" uly="20" lrx="90" lry="90" xml:id="written1"/>
        </tei:surface>
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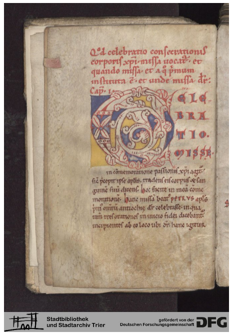
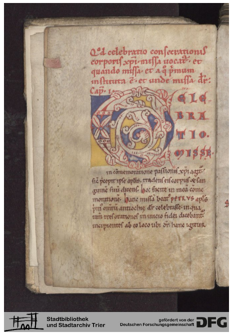
</tei:TEI>
```

# How to analyze the results?

+

=


Stadtbibliothek und Stadtarchiv Trier
gefördert von der Deutschen Forschungsgemeinschaft DFG


Stadtbibliothek und Stadtarchiv Trier
gefördert von der Deutschen Forschungsgemeinschaft DFG

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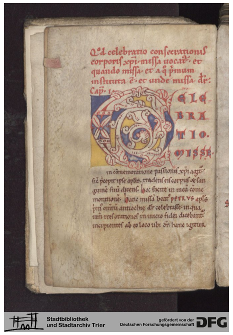
Stadtbibliothek und Stadtarchiv Trier
gefördert von der Deutschen Forschungsgemeinschaft DFG

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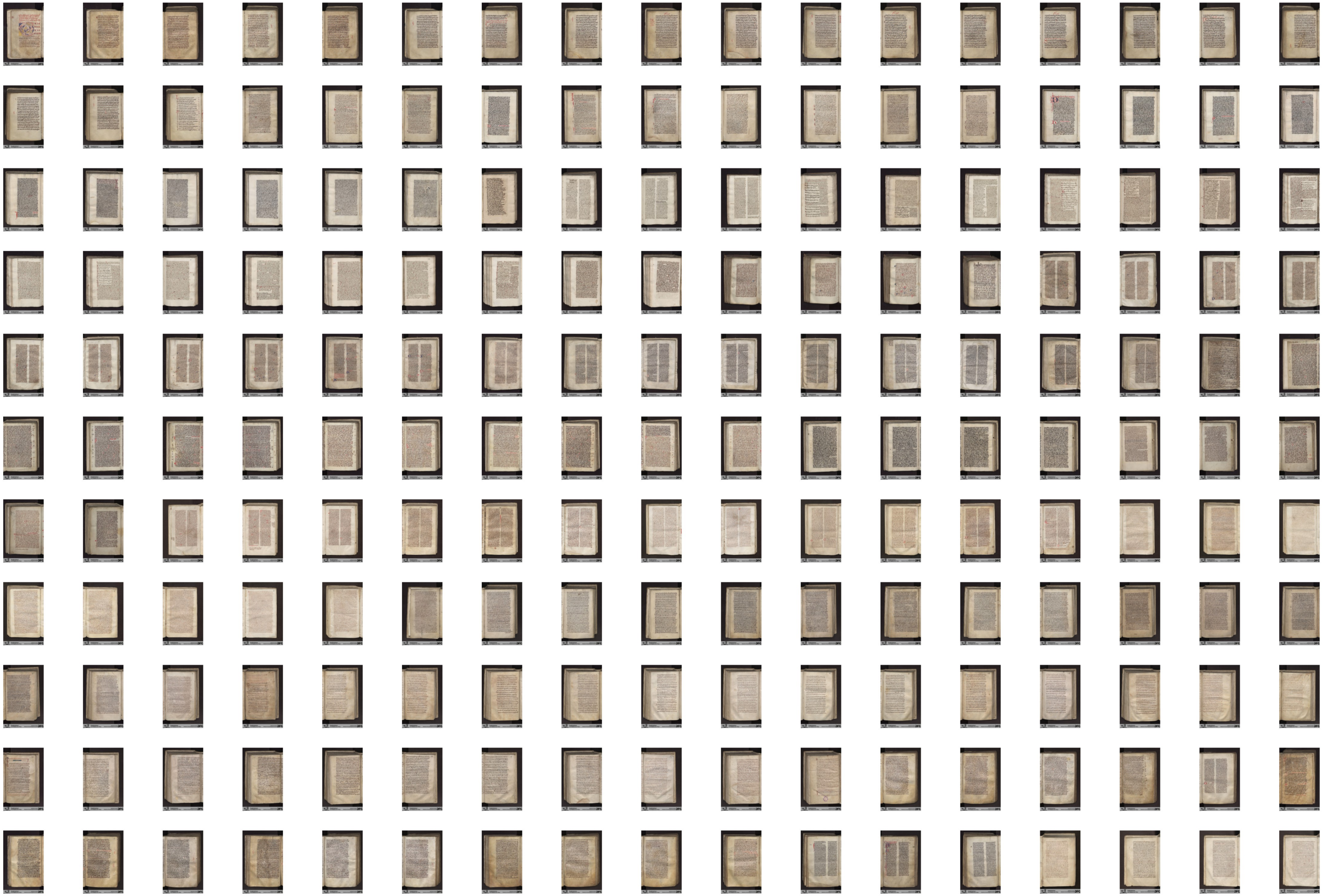
# Quantitative Codicology



# Current Case Study (100 codices)

eCodicology

Numerical variables (absolute values)

A) page dimensions (height x width)

B) number of columns

} 20 randomly selected pages

C) number of folios

D) number of blank pages within a codex

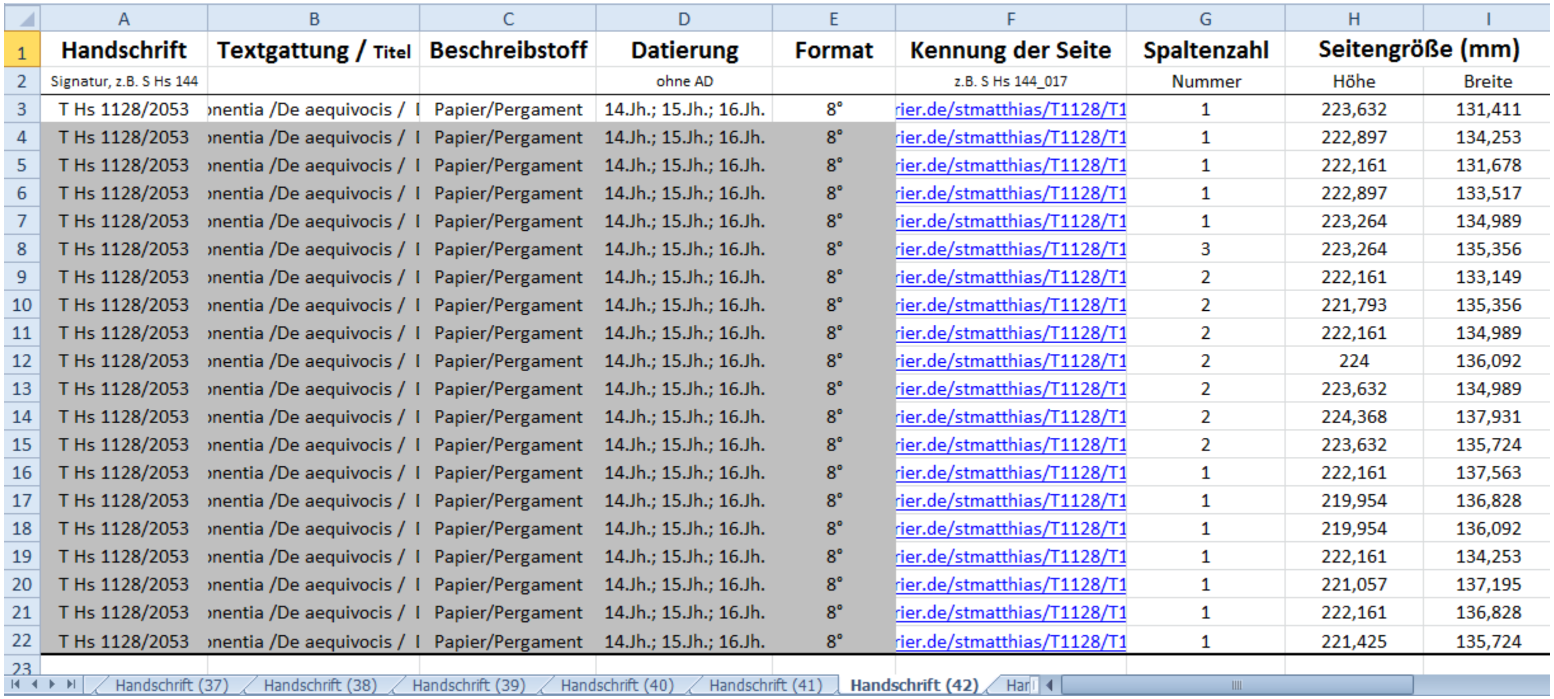
Categorial variables

E) codex format (2°; 4°; 8°)

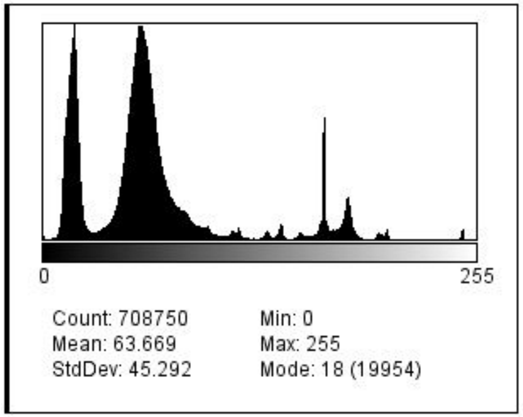
F) dating

G) text genre

H) writing material (parchment; paper; both) eCodicology



| | A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Handschrift | Textgattung / Titel | Beschreibstoff | Datierung | Format | Kennung der Seite | Spaltenzahl | Seitengröße (mm) | |
| 2 | Signatur, z.B. S Hs 144 | | | ohne AD | | z.B. S Hs 144_017 | Nummer | Höhe | Breite |
| 3 | T Hs 1128/2053 | ›nentia /De aequivocis / I | Papier/Pergament | 14.Jh.; 15.Jh.; 16.Jh. | 8° | rier.de/stmatthias/T1128/T1 | 1 | 223,632 | 131,411 |
| 4 | T Hs 1128/2053 | ›nentia /De aequivocis / I | Papier/Pergament | 14.Jh.; 15.Jh.; 16.Jh. | 8° | rier.de/stmatthias/T1128/T1 | 1 | 222,897 | 134,253 |
| 5 | T Hs 1128/2053 | ›nentia /De aequivocis / I | Papier/Pergament | 14.Jh.; 15.Jh.; 16.Jh. | 8° | rier.de/stmatthias/T1128/T1 | 1 | 222,161 | 131,678 |
| 6 | T Hs 1128/2053 | ›nentia /De aequivocis / I | Papier/Pergament | 14.Jh.; 15.Jh.; 16.Jh. | 8° | rier.de/stmatthias/T1128/T1 | 1 | 222,897 | 133,517 |
| 7 | T Hs 1128/2053 | ›nentia /De aequivocis / I | Papier/Pergament | 14.Jh.; 15.Jh.; 16.Jh. | 8° | rier.de/stmatthias/T1128/T1 | 1 | 223,264 | 134,989 |
| 8 | T Hs 1128/2053 | ›nentia /De aequivocis / I | Papier/Pergament | 14.Jh.; 15.Jh.; 16.Jh. | 8° | rier.de/stmatthias/T1128/T1 | 3 | 223,264 | 135,356 |
| 9 | T Hs 1128/2053 | ›nentia /De aequivocis / I | Papier/Pergament | 14.Jh.; 15.Jh.; 16.Jh. | 8° | rier.de/stmatthias/T1128/T1 | 2 | 222,161 | 133,149 |
| 10 | T Hs 1128/2053 | ›nentia /De aequivocis / I | Papier/Pergament | 14.Jh.; 15.Jh.; 16.Jh. | 8° | rier.de/stmatthias/T1128/T1 | 2 | 221,793 | 135,356 |
| 11 | T Hs 1128/2053 | ›nentia /De aequivocis / I | Papier/Pergament | 14.Jh.; 15.Jh.; 16.Jh. | 8° | rier.de/stmatthias/T1128/T1 | 2 | 222,161 | 134,989 |
| 12 | T Hs 1128/2053 | ›nentia /De aequivocis / I | Papier/Pergament | 14.Jh.; 15.Jh.; 16.Jh. | 8° | rier.de/stmatthias/T1128/T1 | 2 | 224 | 136,092 |
| 13 | T Hs 1128/2053 | ›nentia /De aequivocis / I | Papier/Pergament | 14.Jh.; 15.Jh.; 16.Jh. | 8° | rier.de/stmatthias/T1128/T1 | 2 | 223,632 | 134,989 |
| 14 | T Hs 1128/2053 | ›nentia /De aequivocis / I | Papier/Pergament | 14.Jh.; 15.Jh.; 16.Jh. | 8° | rier.de/stmatthias/T1128/T1 | 2 | 224,368 | 137,931 |
| 15 | T Hs 1128/2053 | ›nentia /De aequivocis / I | Papier/Pergament | 14.Jh.; 15.Jh.; 16.Jh. | 8° | rier.de/stmatthias/T1128/T1 | 2 | 223,632 | 135,724 |
| 16 | T Hs 1128/2053 | ›nentia /De aequivocis / I | Papier/Pergament | 14.Jh.; 15.Jh.; 16.Jh. | 8° | rier.de/stmatthias/T1128/T1 | 1 | 222,161 | 137,563 |
| 17 | T Hs 1128/2053 | ›nentia /De aequivocis / I | Papier/Pergament | 14.Jh.; 15.Jh.; 16.Jh. | 8° | rier.de/stmatthias/T1128/T1 | 1 | 219,954 | 136,828 |
| 18 | T Hs 1128/2053 | ›nentia /De aequivocis / I | Papier/Pergament | 14.Jh.; 15.Jh.; 16.Jh. | 8° | rier.de/stmatthias/T1128/T1 | 1 | 219,954 | 136,092 |
| 19 | T Hs 1128/2053 | ›nentia /De aequivocis / I | Papier/Pergament | 14.Jh.; 15.Jh.; 16.Jh. | 8° | rier.de/stmatthias/T1128/T1 | 1 | 222,161 | 134,253 |
| 20 | T Hs 1128/2053 | ›nentia /De aequivocis / I | Papier/Pergament | 14.Jh.; 15.Jh.; 16.Jh. | 8° | rier.de/stmatthias/T1128/T1 | 1 | 221,057 | 137,195 |
| 21 | T Hs 1128/2053 | ›nentia /De aequivocis / I | Papier/Pergament | 14.Jh.; 15.Jh.; 16.Jh. | 8° | rier.de/stmatthias/T1128/T1 | 1 | 222,161 | 136,828 |
| 22 | T Hs 1128/2053 | ›nentia /De aequivocis / I | Papier/Pergament | 14.Jh.; 15.Jh.; 16.Jh. | 8° | rier.de/stmatthias/T1128/T1 | 1 | 221,425 | 135,724 |
| 23 | | | | | | | | | |



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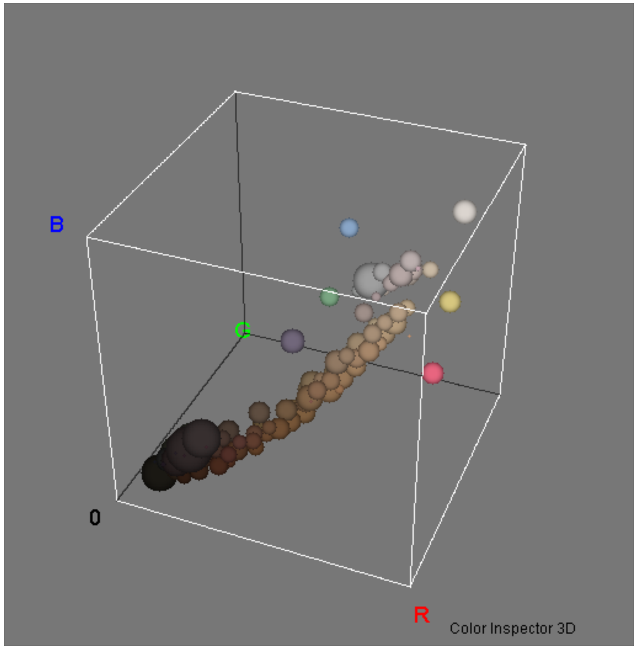

# Conclusion

Our goals are …

to build correlations between different parameters within groups of **codices with common features** (for ex. dating / text genre / writing material)

to make comparisons between groups of **codices with different similarities** (for ex. codices made of parchment vs. codices made of paper or handwritten codices vs. incunables)

The eCodicology project is associated to

DARIAH-DE