Image processing and semantic technologies in digital humanities: The NOTAE experience

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The NOTAE Project

• NOTAE: NOT A writtEn word but graphic symbols
  – H2020 ERC Advanced, PI Antonella Ghignoli
  – www.notae-project.eu

• Investigate the presence of **graphic symbols** in documentary records from Late Antiquity to early medieval Europe

• Graphic symbols meant as graphic signs
  – drawn as a visual unit in a written text
  – representing something other than a word

• Capture all the possible historical implications
Digital Humanities in NOTAE Project

• Support to the main activity of the NOTAE ERC project → NOTAE System
  – A back-office web application allowing experts to store information about graphic symbols
  – A web application, soon available to the public, to let people outside the project explore these data
NOTAE Geographical Analytics

• Geolocalization of material supports and original documents in space
• Different filters available for analysis
NOTAE Knowledge Graph

- Data stored in the NOTAE database is organized in a knowledge graph
- Possibility to use concepts to connect to other knowledge graphs
  - E.g., places
  - Knowledge graph will be exposed by NOTAE Public website
Go Beyond Simple Visualization

• Contribution from computer science to humanities is often limited to mere visualization purposes
  – E.g., Support to information data entry, visual analytics and querying, VR and AR, Digital reproduction, image enhancement

• Moving from Digital Humanities to «Computational Humanities»
  – Computer science providing automatic suggestions to humanists, i.e., automatically extract information
    • E.g., Handwritten Text Transcription (HTT)
  – Define ways to evaluate the actual usefulness of such tools for humanists
    • Methods based on AI and Computer Vision are (currently) far from being perfect
    • Are they perceived as an aid or a distraction for the humanist?
    • Employing expert feedback for improvement
Graphic Symbol Detection in NOTAE

• Given a digital reproduction of a document finding graphic symbols

• Three-step approach
  – Image enhancement
  – Image segmentation → finding «boxes» potentially containing graphic symbols
  – Box classification as «graphic symbols» or «not»

• Systems trained using symbols previously identified from experts
  – The expert gets suggestions about potential symbols
  – The expert confirms/discards the suggestion from the system and add symbols not identified by the system
  – System gets better while used (active learning)
Dataset augmentation

• Basic dataset is composed by symbols manually identified by experts on analyzed documents
• In order to augment the dataset, we generated symbols by using the Set Transformer neural network architecture
  – Producing geometrical representations of symbols
Classifying Symbols

• Problem with the dataset
  – Only positive examples available
  – Need to produce negative examples

• Intuition:
  – Using a Generative Adversarial Network to
    • generate negative examples
    • train the discriminator as a classifier
Classification Results

<table>
<thead>
<tr>
<th>Classifier</th>
<th>Test 1 AUC</th>
<th>Test 2 AUC</th>
<th>Mean AUC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nearest Neighbors</td>
<td>0.644</td>
<td>0.605</td>
<td>0.625</td>
</tr>
<tr>
<td>Linear SVM</td>
<td>0.652</td>
<td>0.618</td>
<td>0.635</td>
</tr>
<tr>
<td>Radial Basis Function SVM</td>
<td>0.761</td>
<td>0.738</td>
<td>0.750</td>
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<tr>
<td>Gaussian Process</td>
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<td>0.746</td>
<td>0.756</td>
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<tr>
<td>Decision Tree</td>
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<td>0.628</td>
<td>0.592</td>
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<tr>
<td>Random Forest</td>
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<td>0.540</td>
<td>0.561</td>
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<tr>
<td>Neural Net</td>
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<td>0.624</td>
<td>0.639</td>
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<tr>
<td>AdaBoost</td>
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<td>0.585</td>
<td>0.612</td>
</tr>
<tr>
<td>Naive Bayes</td>
<td>0.721</td>
<td>0.656</td>
<td>0.689</td>
</tr>
<tr>
<td>Quadratic Discriminant Analysis</td>
<td>0.628</td>
<td>0.638</td>
<td>0.633</td>
</tr>
<tr>
<td>Ours</td>
<td>0.834</td>
<td>0.735</td>
<td>0.785</td>
</tr>
</tbody>
</table>

Mean AUC: 0.677, Nearest Neighbors
Mean AUC: 0.641, Linear SVM
Mean AUC: 0.764, RBF SVM
Mean AUC: 0.774, Gaussian Process
Mean AUC: 0.591, Decision Tree
Mean AUC: 0.599, Random Forest
Mean AUC: 0.647, Neural Net
Mean AUC: 0.630, AdaBoost
Mean AUC: 0.714, Naive Bayes
Mean AUC: 0.644, QDA
Mean AUC: 0.495, Ours@Checkpoint50
Mean AUC: 0.785, Ours@Checkpoint200
Potential Symbol Detection

HOG Features

Image Enhancement

Template Matching

Object Classification
Potential Symbol Detection Results

- Obtained results are only suggestions for the expert
  - System improves while new symbols are added but perfection is no the final goal
- Usefulness of the approach must be evaluated from the point of view of final user satisfaction
Future Work

• Automatic suggestion of symbol category
• Automatic description of symbol category in terms of traits and geometric forms
• Detecting association rules between employment of specific symbols and historical context
Relation with DiDip

• We need an environment where humans and machines work together
  – Humans contribute their creativity and the ability to “understand” other people, as well as to draw meaningful insights from their experience ...
  – The machine can process large amounts of data quickly, applying rules as well as learning new ones.
Thanks for your attention

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Stay tuned on http://www.notae-project.eu/