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Textual-Content-Based Classification of Bundles of Untranscribed Manuscript Images

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Outline

Motivation

- Document Classification
  - Classify bundles of handwritted images
  - Very difficult to transcribe

Carabela Corpus Sample Pages

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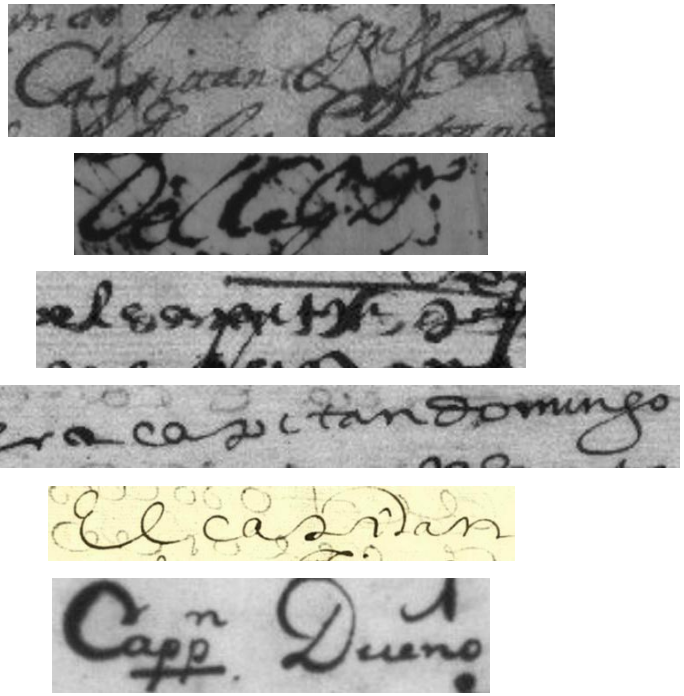
Carabela Corpus Sample Pages



Examples of important difficulties exhibited by Carabela

Background - PrIx

- The Probabilistic Indexing (PrIx) framework was proposed to deal with the intrinsic word-level uncertainty of handwritten text

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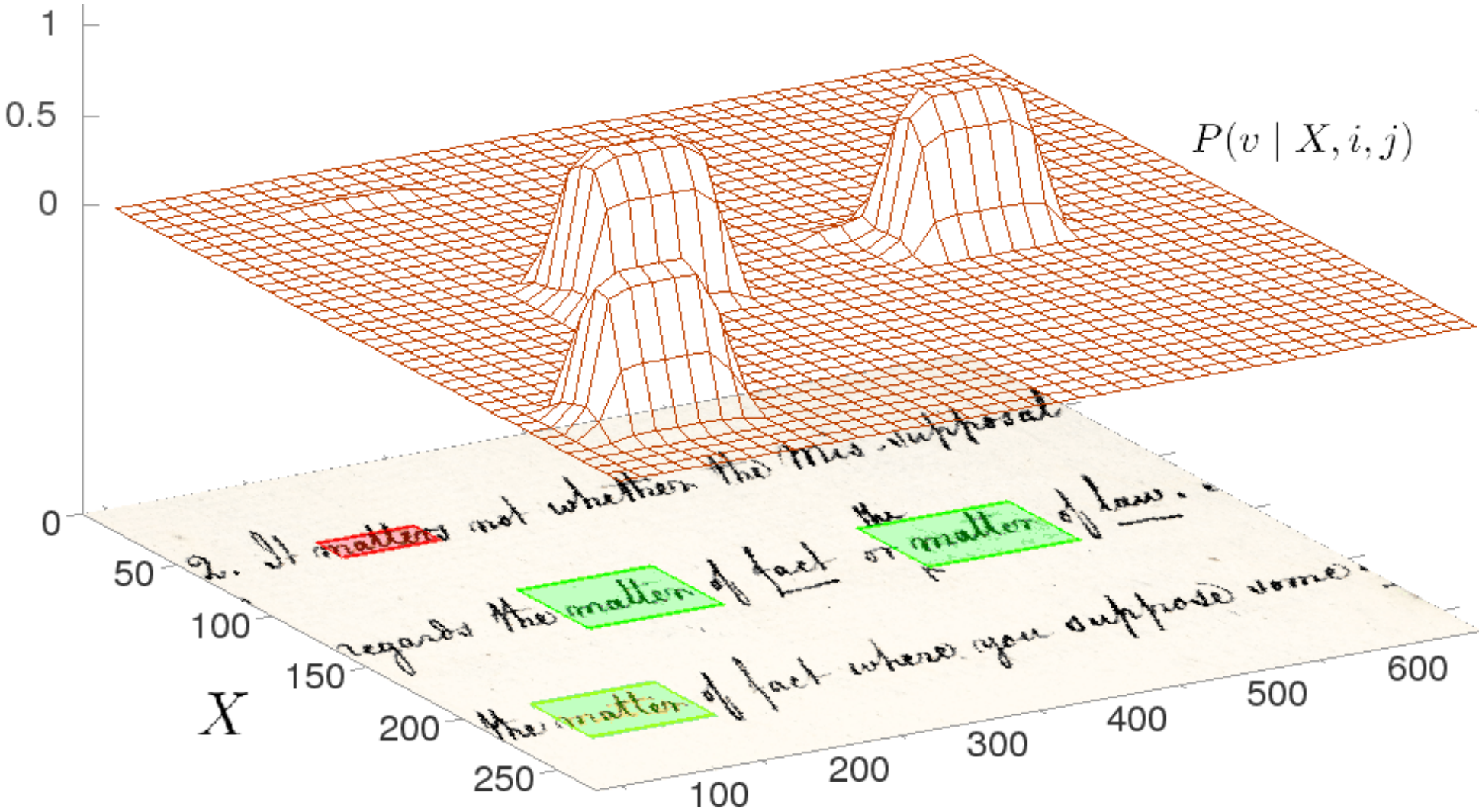
- The Probabilistic Indexing (PrIx) framework was proposed to deal with the intrinsic word-level uncertainty of handwritten text
- Text elements are referred to as *"pseudo-words spots"*
- Relevance probability (RP), $P(R|X, v)$ of each image X for each pseudo-word v

$$P(R \mid X, v) = \sum_{i,j} P(R, i, j \mid X, v) \approx \max_{i,j} P(v \mid X, i, j) \approx \max_{b \in X} P(v \mid X, b)$$

Background - PrIx



Background - Representation

- The Bag of Words model is assumed
- Information Gain to select most relevant words, based on the following frequencies:
  - $f(t_v)$: the number of documents in D which contain v
  - $f(c, t_v)$: the number of documents of class c which contain v
- Tf·Idf which is based on the following frequencies
  - $f(t_v)$ as in Information Gain
  - $f(D)$: the total number of words in D
  - $f(v, D)$: the number of times v appears in D

Estimating Word and Document Frequencies from PrIx

Word and document frequecies needed to compute IG and Tf·Idf are estimated from image Relevance Probabilities as follows:

$$f(D) \equiv n(X)$$

$$f(t_v) \equiv m(v, \mathcal{X})$$

$$f(c, t_v) \equiv m(v, \mathcal{X}_c)$$

$$f(v, D) \equiv n(v, X)$$

$$E[n(X)] = \sum_{x \in X} \sum_{v} P(R \mid x, v)$$

$$E[n(v, X)] = \sum_{x \in X} P(R \mid x, v)$$

$$E[m(v, \mathcal{X})] = \sum_{X \in \mathcal{X}} \max_{x \in X} P(R \mid x, v)$$

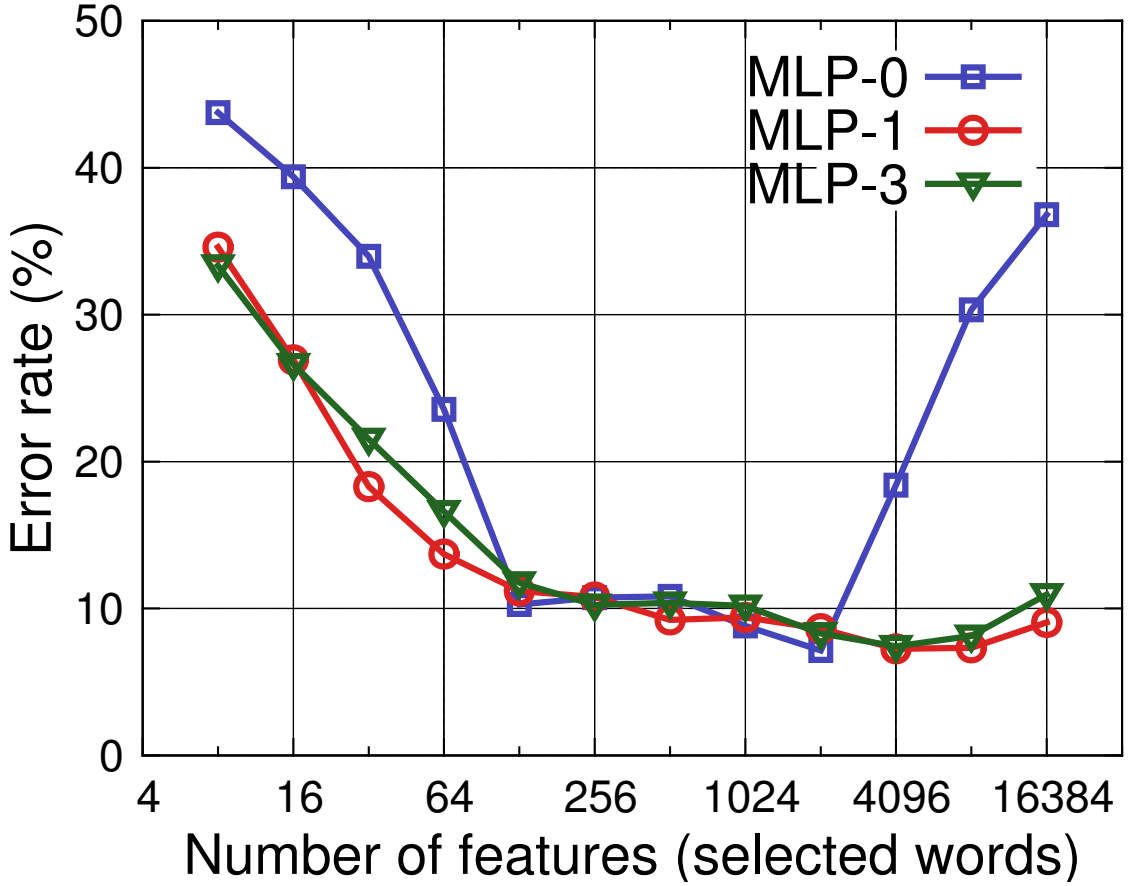
Document Image Classification

Optimal prediction of the class of an image document X is achieved by the maximum class posterior.

- Document Image Representation: Bag of Words model based on words and documents frequencies esimated from PrIx
- Multinomial Naive Bayes: A linear classifier equivalent to a (plain) perceptron
- Multilayer Perceptrons trained with cross entropy loss
  - MLP-0: 0-hidden-layers MLP
  - MLP-1: a proper MLP including one hidden layer with 64 ReLU neurons and batch normalization
  - MLP-3: 3 hidden layers including 16, 32 and 64 ReLU neurons and batch normalization

Results - MLPs

Classification error rate for three MLP classifiers



Best classification error rate (7.1%) obtained by the plain perceptron (MLP-0), for a relatively large vocabulary of the 2048 words with largest Information Gain.

Results - MLP & MNB

Classification error rates using C-MNB, compared with MLP-0, for increasing sizes of the vocabulary selected using Information Gain.

	Number of Features							
Error (%)	16	64	256	1024	2048	4096	9192	16384
C-MNB	42.6	44.5	26.5	20.0	16.1	14.8	15.5	20.6
MLP-0	39.4	23.6	10.7	8.8	7.1	18.4	30.3	36.8

All MLP based methods provide, in general, better results than the C-MNB method.

Conclusions

- Presented an approach that is able to perform textual-content-based document classification directly on documents of untranscribed handwritten text images.
- Overcomed the need to explicitly transcribe manuscripts, which is generally unfeasible for large collections

Future Works

- Better representation using geometric information of pseudo-words
- Improvise the term selection method to get accurate results with smaller vocabularies.