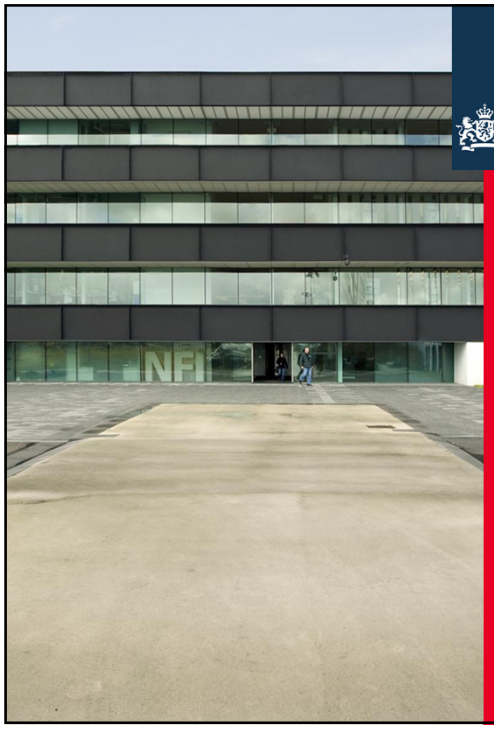

Nederlands Forensisch Instituut
Ministerie van Veiligheid en Justitie

Authorship Verification with Compression Features

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Motivation for Authorship Verification

- Forensic context
  - –Disputed document verification
  - –Author can be anyone (besides suspect)
  - –From suspect several documents available

Problem Properties in Machine Learning Perspective

- Few reference samples
  - –Makes modeling of intra-author variance hard
  - –Makes setting of decision threshold hard
- Suitable feature representation required
  - –documents from same author have similar feature values
  - –documents from different authors have different feature values
  - –Invariant for specific topic

Unsupervised Learning Approach

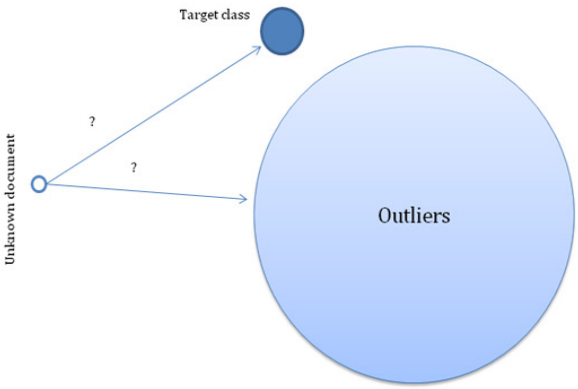
- Outlier detection or one-class classification
  - –Model normal/reference class
- Reference class contains 1-10 documents
  - –Outlier is ill-defined

Supervised Learning Approach

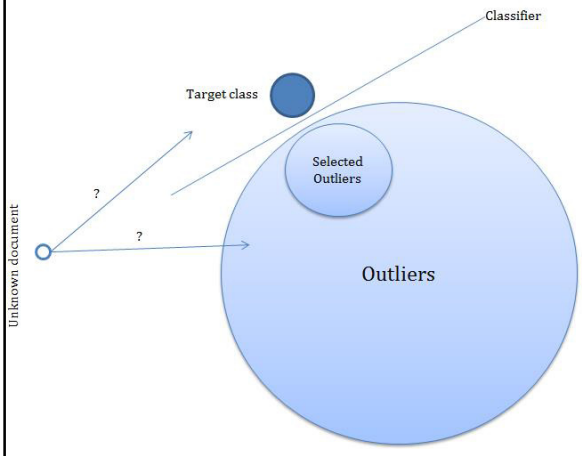
- Separate reference documents from constructed outlier class
- Reference class contains 1-10 documents
  - –Small sample size problem
- Data collection for outlier class
  - –Leads to strong class imbalance (1:100~1000)

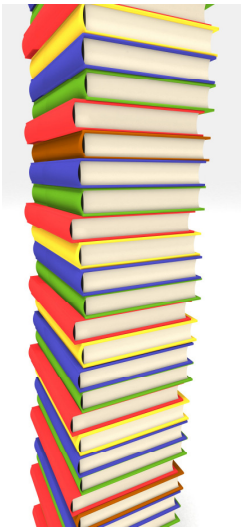
Data Collection: Uninformed

- Virtually impossible to represent outlier class



Data Collection: Same Style





Data Collection Procedure

- Reference documents are parts (~1000 words) of engineering text books
- Searched for similar books using substrings
- Found 70 books by 50 authors
- Preprocessed similarly to given reference documents
  - –Documents of ~1000 words
  - –2-75 documents per book

Feature extraction

- Distance between documents: Compression-based Dissimilarity Method (CDM)

$$CDM(x,y) = \frac{C(xy)}{C(x) + C(y)}$$

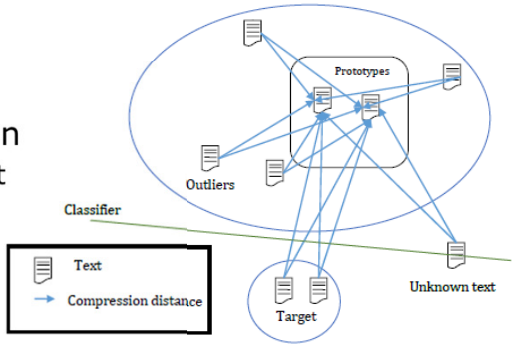
- $C(x)$ is the length of text x after compression by the PPMd method (best available text compressor)

Submission 1 (**S1**)

- Straightforward compression distances
- Decision rule: if the nearest document (CDM) is from the reference class then the documents are written by the same author, otherwise different author

Submission 2 (**S2**)

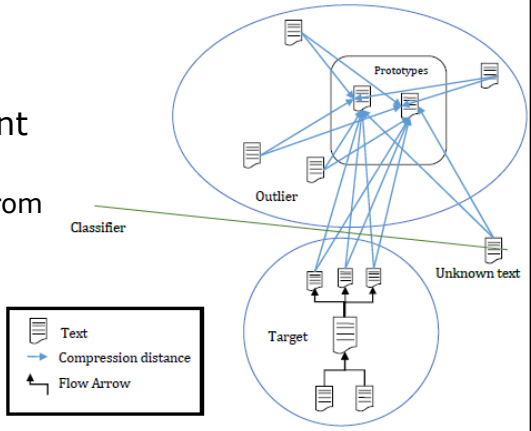
- Risk of overfit in **S1**
- Feature representation
  - distances to prototype set
  - 200 random documents



- LESS classification method
  - Sparse classifier
  - Weights both classes equally
  - Related to L_1-SVM

Submission 3 (**S3**)

- Underrepresentation of reference class in **S2**
- Boostrapped document samples
  - 50 documents sampled from concatenated reference documents



Results

- On collected data
  - **S1**: 0.94
  - **S2**: 0.79
- In PAN Lab evaluation
  - English task only
  - Highest score
- In **S2** and **S3** the (sparse) LESS model often uses only 2-3 features to separate reference from outlier class

Submission	English		
	F_1	Precision	Recall
zhenshi13	0.800	0.800	0.800
seidman13	0.800	0.800	0.800
layton13	0.767	0.767	0.767
moreau13	0.767	0.767	0.767
jankowska13	0.733	0.733	0.733
ayala13	0.733	0.733	0.733
halvani13	0.700	0.700	0.700
feng13	0.700	0.700	0.700
ghaeini13	0.691	0.760	0.633
petmanson13	0.667	0.667	0.667
bobicev13	0.644	0.655	0.633
sorin13	0.633	0.633	0.633
vandam13	0.600	0.600	0.600
jayapal13	0.600	0.600	0.600
kern13	0.533	0.533	0.533
baseline	0.500	0.500	0.500
gillam13	0.500	0.500	0.500
vladimir13	0.467	0.467	0.467
grozea13	0.400	0.400	0.400

Conclusion

- Labour intensive approach (data collection)
- Compression features simple and generic
- Robust method
  - Limited sensitivity to number of prototypes and LESS hyper parameter
- All submissions have high performance cross-validated on collected data and on PAN Lab test data

Appendix: LESS Classification Method

$$min \sum_{j=1}^{p} w_j + C\left(\sum_{i=1}^{n_t} \xi_{ti} + \sum_{i=1}^{n_o} \xi_{oi}\right)$$

Subject to:

$$\begin{cases} x \in X_t,\ \sum_{j=1}^{p} w_j f(x,j) \geq 1 - \xi_{ti} \\ x \in X_o, \sum_{j=1}^{p} w_j f(x,j) < -1 + \xi_{oi} \end{cases}$$

Where $f(x,j) = (x_j - \mu_{tj})^2 - (x_j - \mu_{oj})^2$, $w_j \geq 0$, $\xi_{ti} \geq 0$, , $\xi_{oi} \geq 0$.