Writer Identification and Verification Using GMM Supervectors

Pattern Recognition Lab (CS 5)

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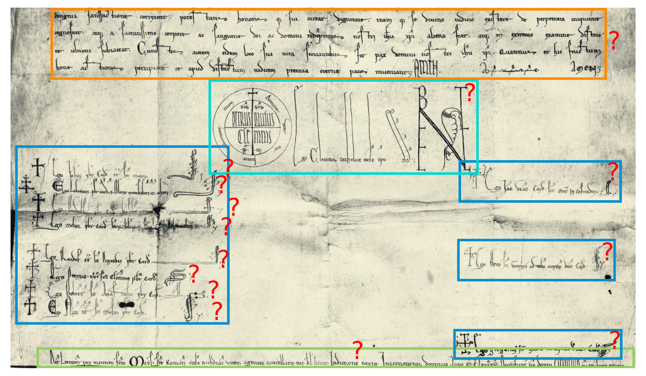
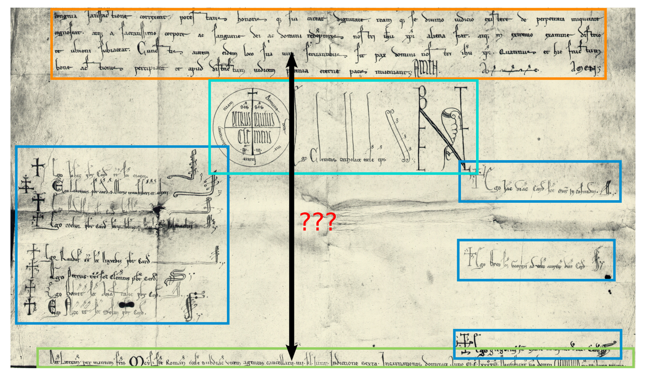
Motivation

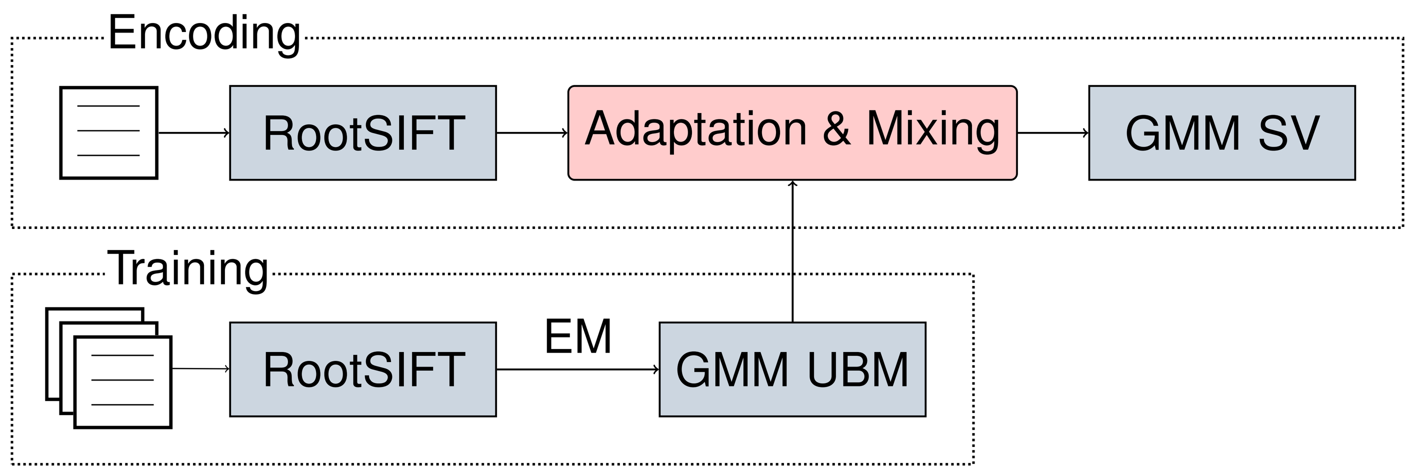
Writer Identification



Writer Verification

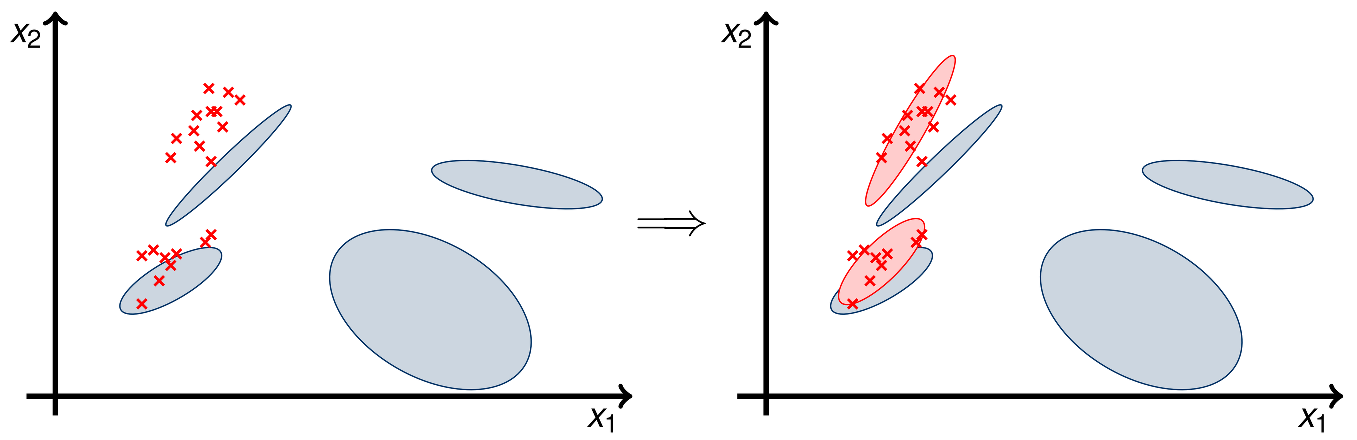


Method Overview



GMM Adaptation

A universal background model (UBM) using a Gaussian Mixture Model is created from the training data. New data is represented as an adaptation to the UBM.



Adaptation and Mixing:

$$\hat{w}_i = \alpha_i(r)\frac{1}{M}\sum_{j=1}^{M}\pi_j(i) + (1-\alpha_i(r))w_i$$

$$\hat{\boldsymbol{\mu}}_i = \alpha_i(r)\frac{\sum_{j=1}^{M}\pi_j(i)\boldsymbol{x}_j}{\sum_{j=1}^{M}\pi_j(i)} + (1-\alpha_i(r))\boldsymbol{\mu}_i$$

$$\hat{\boldsymbol{\sigma}}_i = \alpha_i(r)\frac{\sum_{j=1}^{M}\pi_j(i)\boldsymbol{x}_j\odot\boldsymbol{x}_j}{\sum_{j=1}^{M}\pi_j(i)} + (1-\alpha_i(r))(\boldsymbol{\sigma}_i\odot\boldsymbol{\sigma}_i + \boldsymbol{\mu}_i\odot\boldsymbol{\mu}_i) - \hat{\boldsymbol{\mu}}_i\odot\hat{\boldsymbol{\mu}}_i$$

$\odot$ element-wise vector multiplication
r relevance factor
$\pi(i)$ posterior probability for mixture i
$\alpha_i(r)$ mixing function
M number of descriptors per document

GMM Supervector

Supervector (SV): Stacking of the adapted GMM parameters:

$$\boldsymbol{s} = (\hat{w}_1, \ldots, \hat{w}_N, \hat{\boldsymbol{\mu}}_1^T, \ldots, \hat{\boldsymbol{\mu}}_N^T, \hat{\boldsymbol{\sigma}}_1^T, \ldots, \hat{\boldsymbol{\sigma}}_N^T)^T$$

Other Encoding Methods:

- Fisher Vectors (FV) [5]
- Vector of Locally Aggregated Descriptors (VLAD) [4]

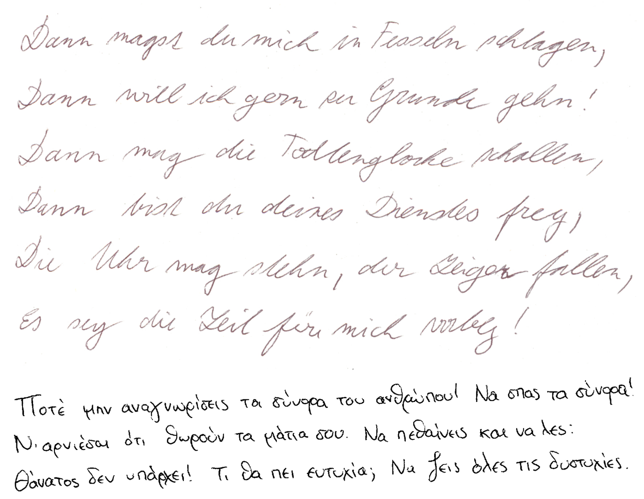
Datasets

CVL

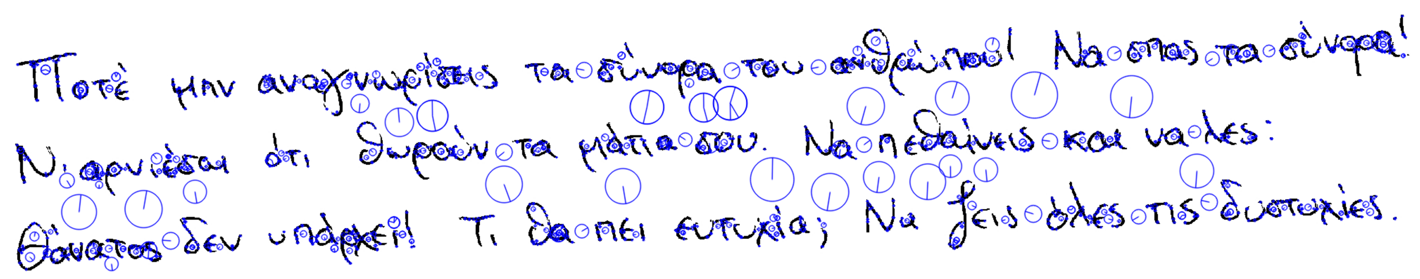
- 309 writers
- 5 forms (1 German, 4 English)

ICDAR

- Training: 100, test-set: 250
- 4 forms (2 English / 2 Greek)



SIFT vs. RootSIFT



[Top-1]	SV	FV	VLAD
SIFT	0.943	0.828	0.861
RootSIFT [1]	0.972	0.945	0.931

RootSIFT: hellinger normalized version of SIFT

References

[1] R. Arandjelovic and A. Zisserman. Three things everyone should know to improve object retrieval. In *CVPR*, 2012.

[2] S. Fiel and R. Sablatnig. Writer Identification and Writer Retrieval using the Fisher Vector on Visual Vocabularies. In *ICDAR*, 2013.

[3] R. Jain and D. Doermann. Writer Identification Using an Alphabet of Contour Gradient Descriptors. In *ICDAR*, 2013.

[4] H. Jégou and M. Douze. Aggregating local descriptors into a compact image representation. In *CVPR*, 2010.

[5] F. Perronnin and C. Dance. Fisher kernels on visual vocabularies for image categorization. In *CVPR*, 2007.

Evaluation

Writer Identification (Hard Criterion):

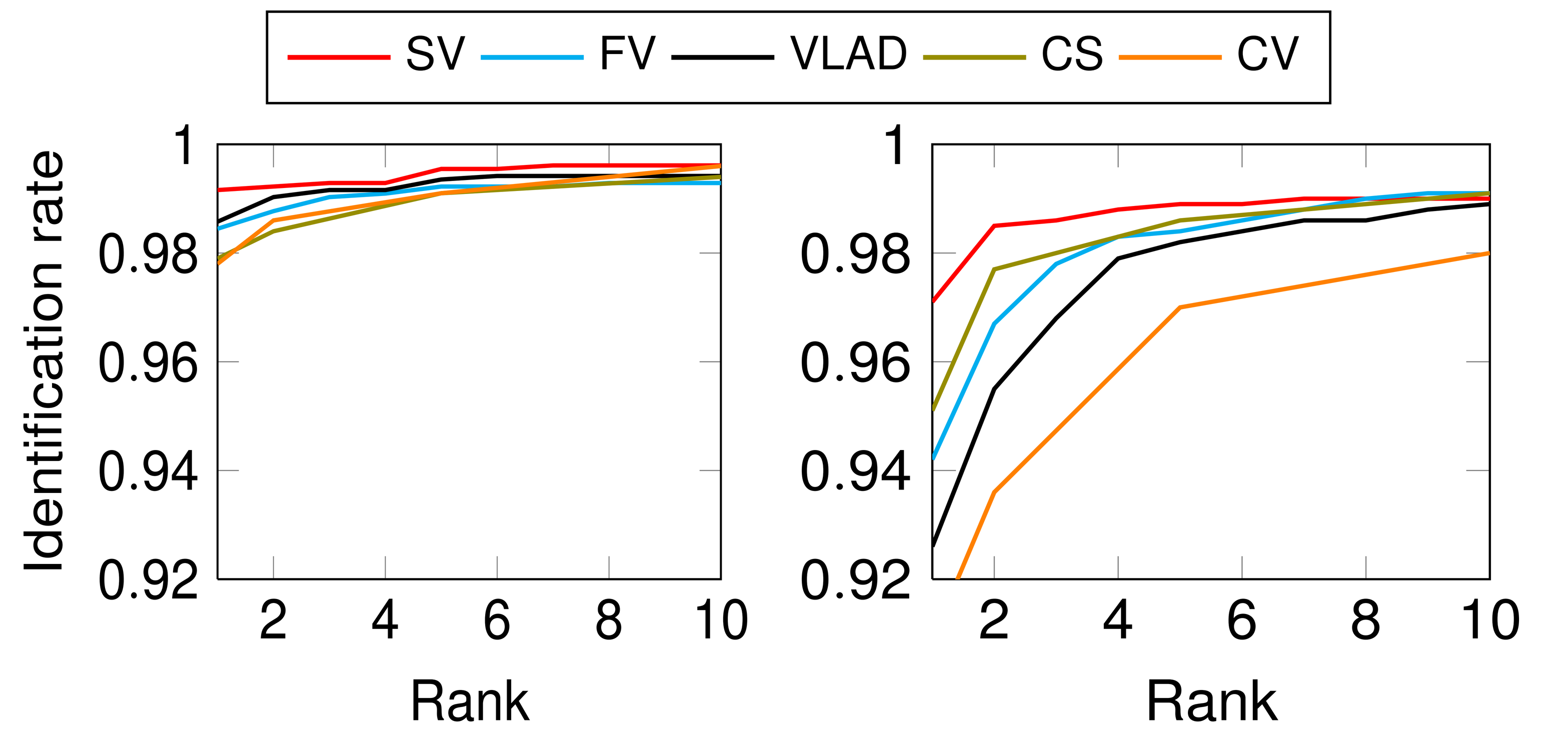
CVL

	Top-1	Top-4	mAP
CV [2]	0.978	0.758	–
CS [3]	0.979	0.483	–
VLAD	0.986	0.720	0.936
FV	0.984	0.756	0.940
SV	**0.992**	**0.887**	**0.971**

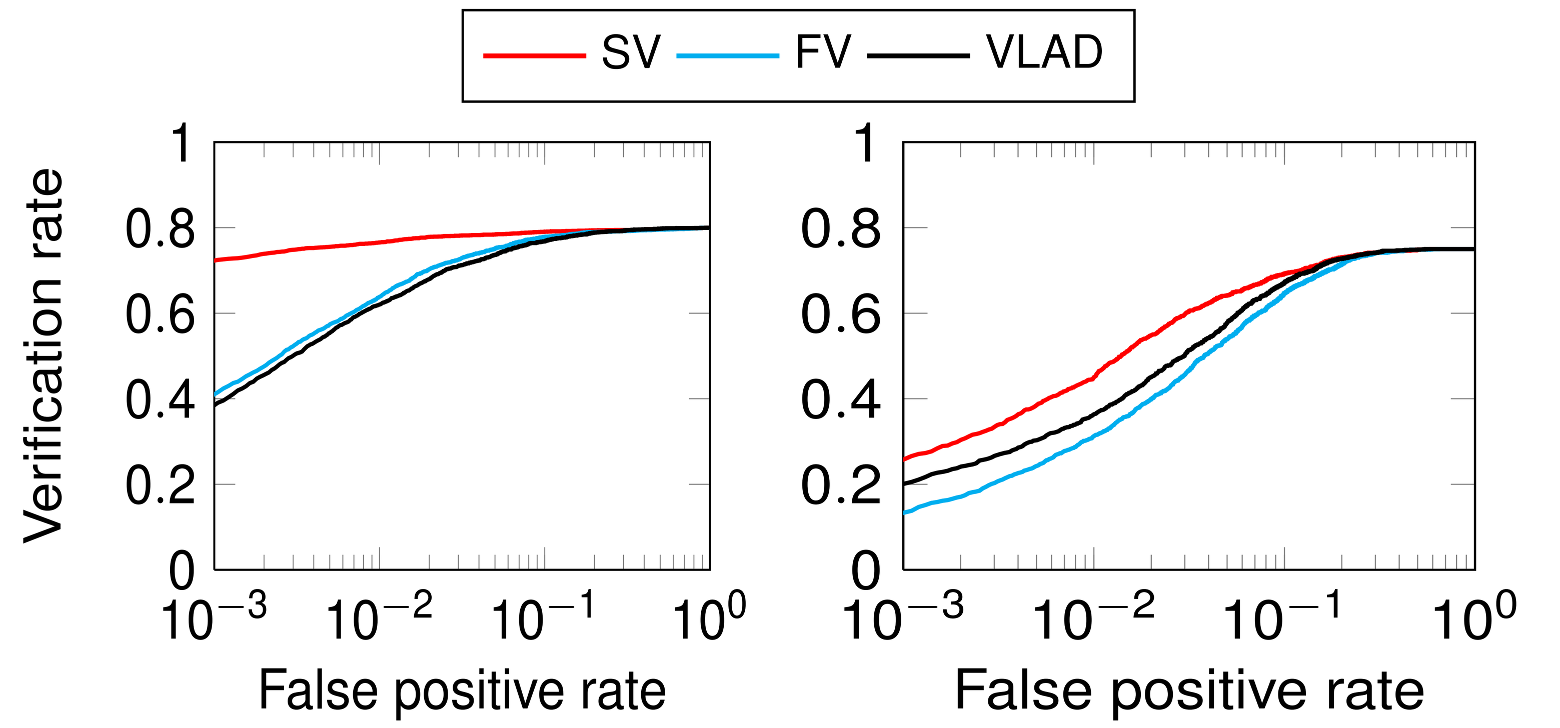
ICDAR

	Top-1	Top-3	mAP
CV	0.909	0.245	–
CS	0.951	0.071	–
VLAD	0.926	0.248	0.651
FV	0.942	**0.25**	**0.677**
SV	**0.971**	0.238	0.671

Writer Identification (Soft Criterion):



Writer Verification:



Conclusion

- RootSIFT improves encoding methods over SIFT
- GMM Supervectors outperform the current state of the art in writer identification / verification
- Overall, GMM Supervectors outperform other adaptation methods