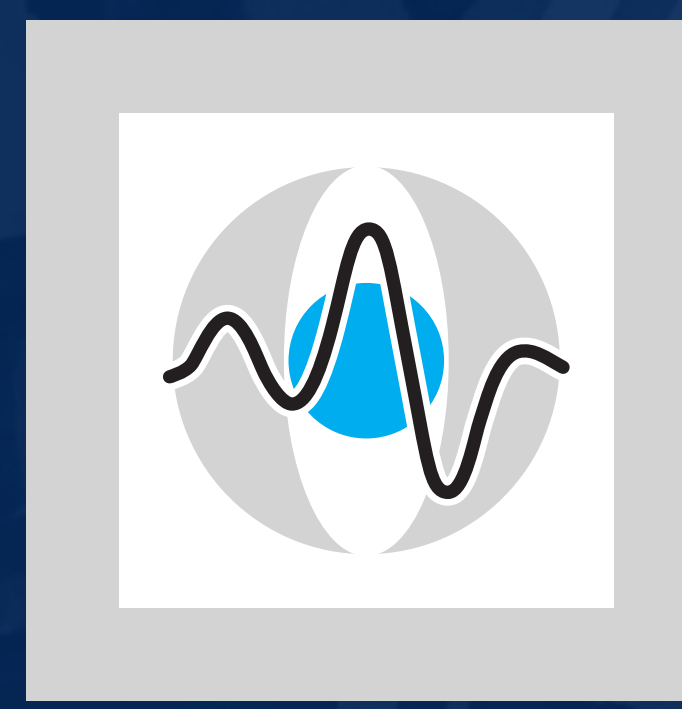# Writer Identification Using VLAD Encoded Contour-Zernike Moments
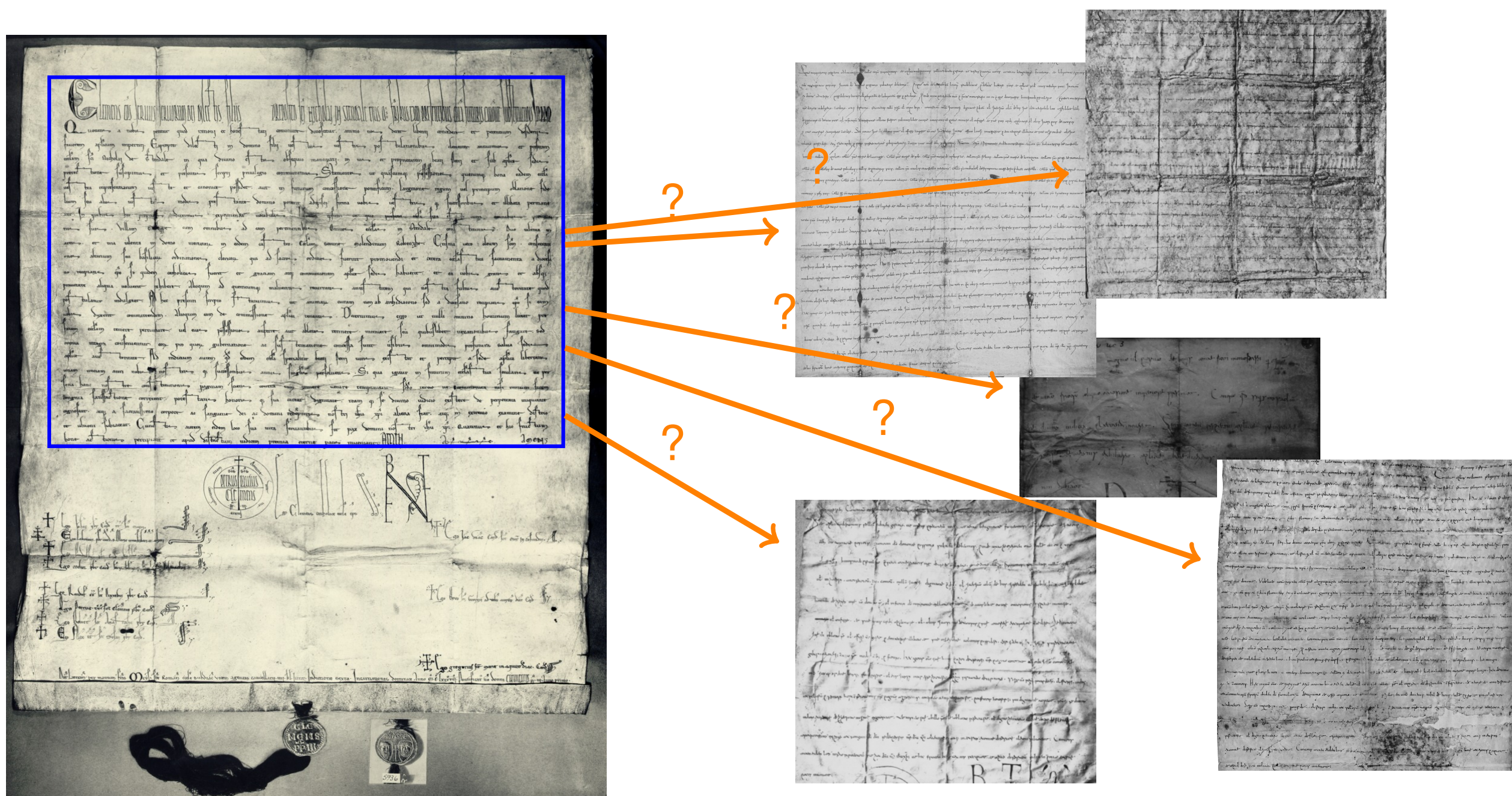
Pattern Recognition Lab (CS 5)
University of Erlangen-Nuremberg, Germany

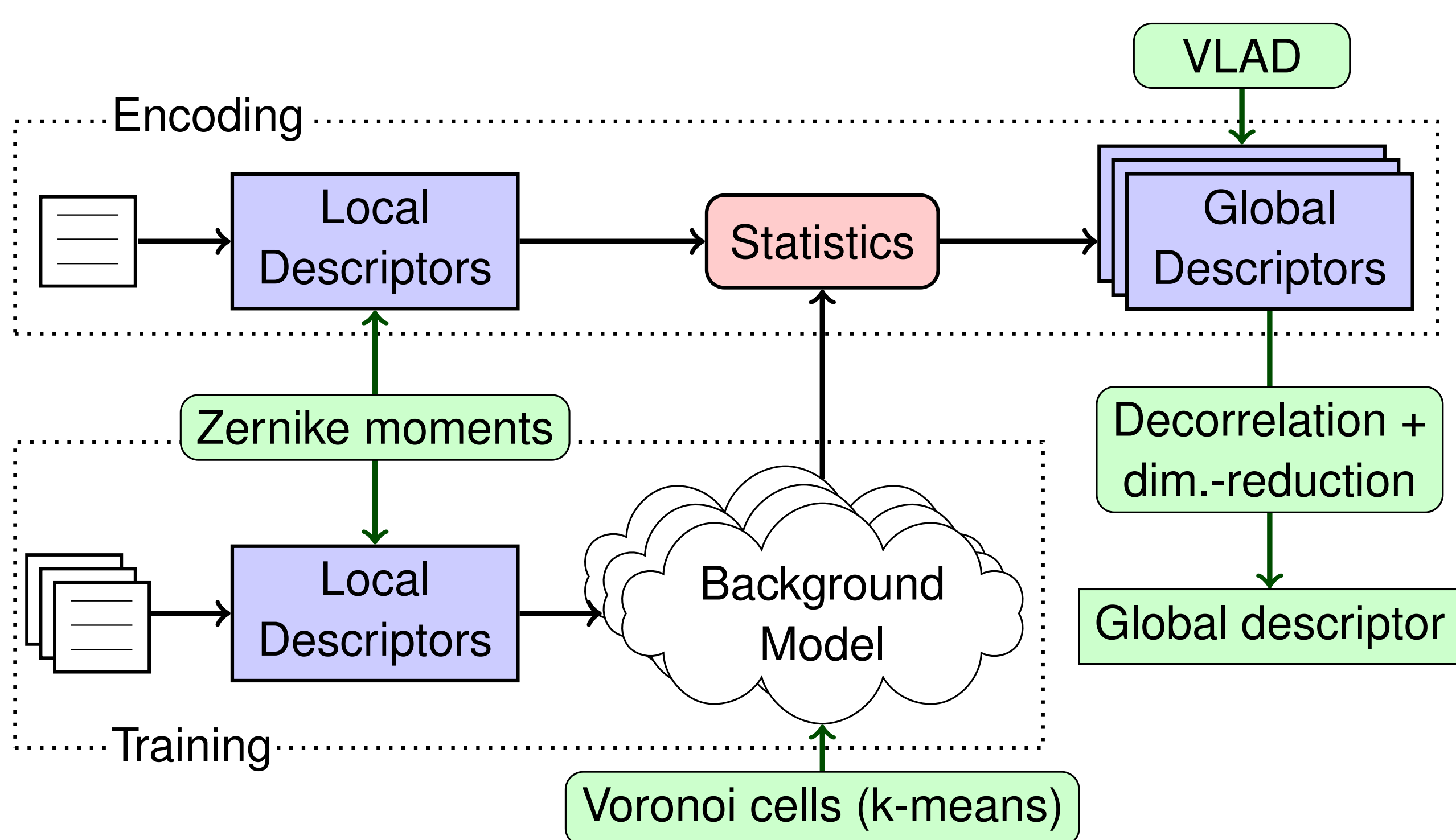Vincent Christlein, David Bernecker, Elli Angelopoulou

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Motivation

[Image source: Göttingen Academy of Sciences and Humanities]

Method Overview

Feature Extraction

- Evaluate Zernike moments [1] at the writing contour

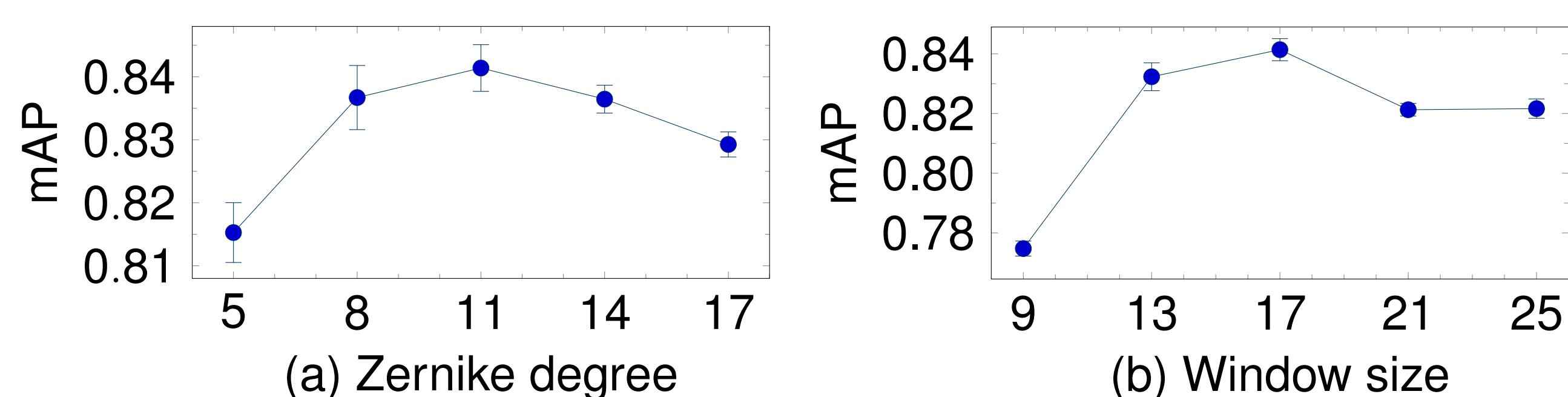$$A_{nm} = \frac{n+1}{\pi} \iint_{x^2+y^2 \leq w/2} f(x, y) V_{nm}^*(x, y) \, \mathrm{d}x\mathrm{d}y$$

$$V_{nm}(\rho, \theta) = R_{nm}(\rho) \mathrm{e}^{im\theta}$$

$$R_{nm}(\rho) = \sum_{s=0}^{(n-|m|)/2} \frac{(-1)^s [(n-s)!] \rho^{n-2s}}{s! \left(\frac{n+|m|}{2} - s\right)! \left(\frac{n-|m|}{2} - s\right)!}$$

$n \in \mathbb{Z}^+$ order $n \geq |m|$; $n - |m| = 2k, k \in \mathbb{Z}$
$m \in \mathbb{Z}$ repetition
$w \in \mathbb{Z}^+$ diameter

- Use A_{nm} directly $\rightarrow$ rotation invariance not needed
- Use only positive $m \rightarrow$ 84 features instead of 156 (for degree 11)

Parameter Evaluation

(a) Zernike degree

(b) Window size

Encoding

Vectors of locally aggregated descriptors (VLAD) [2]

Local Descriptors: $X = \{x_1, \ldots, x_T\}$; learned Dictionary: $D = \{\mu_1, \ldots, \mu_K\}$

$$v_k = \sum_{x_t: \, \mathrm{NN}(x_t=k)} (x_t - \mu_k), \quad \text{NN: nearest neighbor of } x_t \text{ in } D$$

Postprocessing

- Intra-normalization
- Joint dimensionality reduction and whitening

Datasets

CVL

- 310 writers (training: 27, test: 283)
- 5 forms (1 German, 4 English)

ICDAR13

- 350 writers (training: 100, test: 250)
- 4 forms (2 English / 2 Greek)

Evaluation

Hard criterion and mAP evaluated on ICDAR13 (test set)

	TOP-1	TOP-2	TOP-3	mAP
SV [3]	97.1	42.8	23.8	67.1
RootSIFT + VLAD + W.-full	96.1	51.7	29.1	70.7
SURF + VLAD + W.-full	95.6	50.6	28.2	70.5
Proposed	97.5	70.7	48.1	80.8
Proposed + W.-256	99.3	79.8	59.6	87.3
Proposed + W.-full	**99.4**	**81.0**	**61.8**	**88.0**

Hard criterion and mAP evaluated on CVL (test set)

	TOP-1	TOP-2	TOP-3	TOP-4	mAP
Comb. [4]	**99.4**	98.3	94.8	82.9	96.9
SV [3]	99.2	98.1	95.8	88.7	97.1
Proposed	98.8	97.6	95.3	86.2	96.0
Proposed + W.-256	99.2	98.7	97.5	92.5	97.8
Proposed + W.-full	**99.4**	**98.9**	**97.4**	**92.7**	**97.9**

Conclusion

- Outperforms s. o. t. a. on ICDAR13 and CVL
- Winning algorithm of the "ICDAR2015 Competition on Multi-script Writer Identification using QUWI Database"
- Using only a few components (256) is sufficient for comparable results $\rightarrow$ enables large scale writer identification

References

[1] F. Zernike. "Beugungstheorie des Schneidenverfahrens und seiner verbesserten Form, der Phasenkontrastmethode". In: *Physica* 1.7 (1934), pp. 689–704.

[2] Hervé Jégou et al. "Aggregating Local Image Descriptors into Compact Codes". In: *Pattern Analysis and Machine Intelligence, IEEE Transactions on* 34.9 (2012), pp. 1704–1716.

[3] Vincent Christlein et al. "Writer Identification and Verification using GMM Supervectors". In: *Applications of Computer Vision, IEEE Winter Conference on*. 2014, pp. 998–1005.

[4] Rajiv Jain and David Doermann. "Combining Local Features for Offline Writer Identification". In: *Frontiers in Handwriting Recognition, 14th International Conference on*. 2014, pp. 583–588.