

CLASSIFICATION OF SD-OCT VOLUMES WITH LBP: APPLICATION TO DME DETECTION

MICCAI-OMIA
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G. Lemaître, M. Rastgoo, J. Massich,
S. Shrinivasan, F. Mériauudeau, and D. Sidibé

Université de Bourgogne & Universitat de Girona



1 Introduction

Diabetic Macular Edema
State-of-the-art

2 DME detection

Framework
Image pre-processing
Mapping
Local Binary Pattern
Feature representation

3 Experiments

Datasets

4 Conclusion

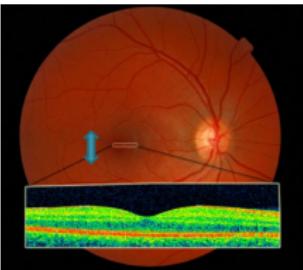


Introduction Diabetic Macular Edema (DME)

DME

- ▶ Breakdown of the blood-retinal barrier
- ▶ Leads to fluid leakage
- ▶ Damage the photo-receptors

SD-OCT



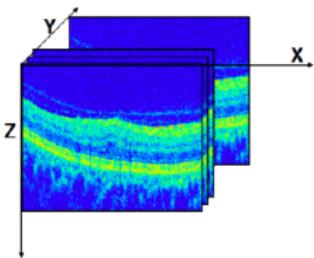


Introduction Diabetic Macular Edema (DME)

DME

- ▶ Breakdown of the blood-retinal barrier
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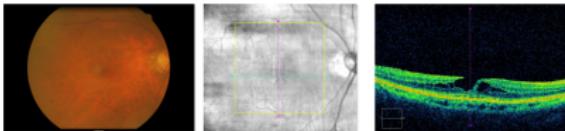
SD-OCT



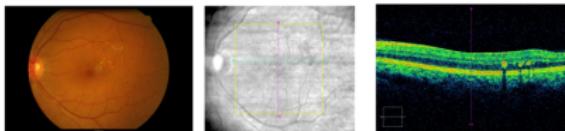


Introduction DME

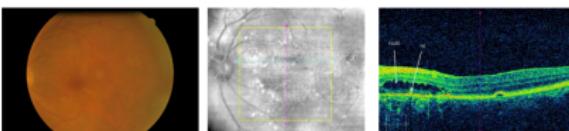
Cyst



Hard Exudates



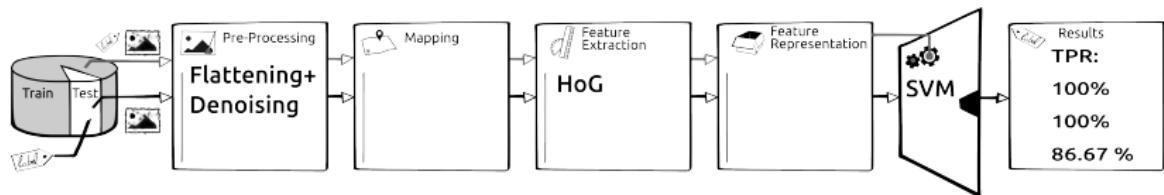
Sub Retinal Fluid





Introduction State-of-the-art

Srinivasan *et al.*¹

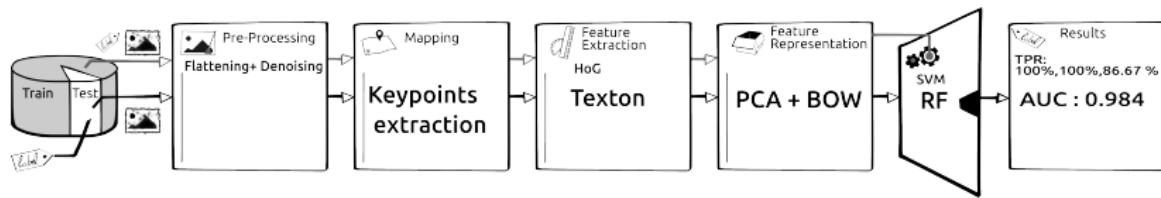


¹P. P. Srinivasan, L. A. Kim, P. S. Mettu, S. W. Cousins, G. M. Comer, J. A. Izatt, and S. Farsiu. "Fully automated detection of diabetic macular edema and dry age-related macular degeneration from optical coherence tomography images". In: *Biomedical Optical Express* 5.10 (2014), pages 3568–3577.



State of the Art

Venhuizen *et al.*²

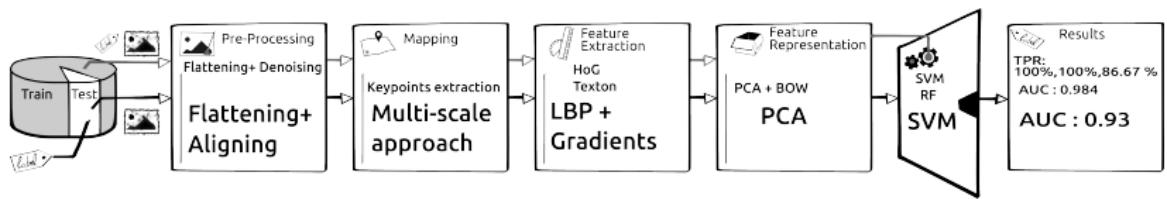


²F. G. Venhuizen, B. van Ginneken, B. Bloemen, M. J. P. P. van Grisven, R. Philipsen, Hoyng. C., T. Theelen, and C. I. Sanchez. "Automated age-related macular degeneration classification in OCT using unsupervised feature learning". In: *SPIE Medical Imaging*. Volume 9414. 2015, page 94141l.



State of the Art

Liu *et al.*³

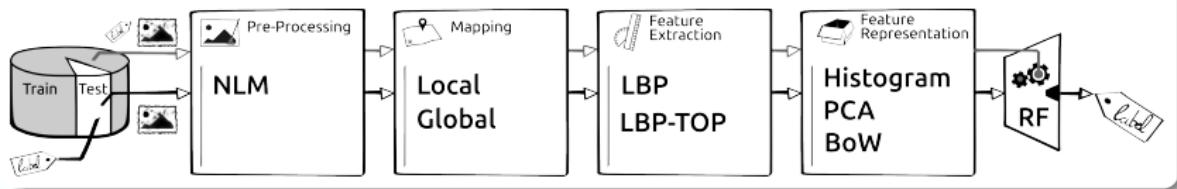


³Y.-Y. Liu, M. Chen, H. Ishikawa, G. Wollstein, J. S. Schuman, and Rehg. J. M. "Automated macular pathology diagnosis in retinal OCT images using multi-scale spatial pyramid and local binary patterns in texture and shape encoding". In: *Medical Image Analysis* 15 (2011), pages 748–759.



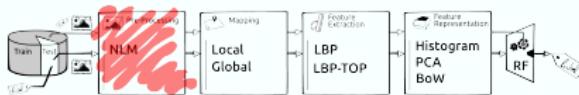
DME detection Framework

Overview

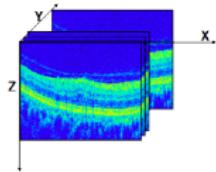




DME detection Image pre-processing



Reference system

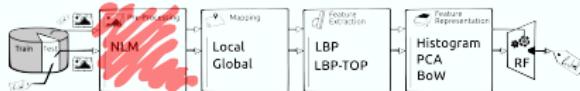


- ▶ OCT images corrupted with speckle noise
- ▶ Denoising for each B-scan ($x - z$ slice)
- ▶ **Non-Local Means**⁴

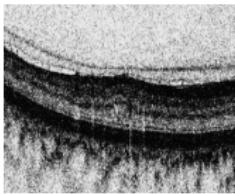
⁴P. Coupe, P. Hellier, C. Kervrann, and C. Barillot. "Nonlocal means-based speckle filtering for ultrasound images". In: *IEEE Transactions in Image Processing* (Oct. 2009), pages 2221–2229.



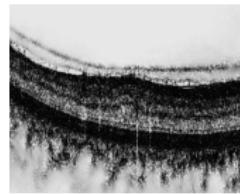
DME detection Image pre-processing



Qualitative results



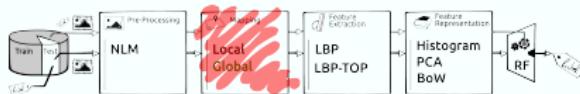
Raw image



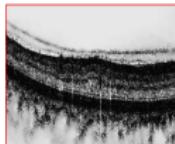
NLM denoising



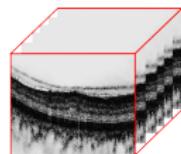
DME Detection Mapping



Global mapping



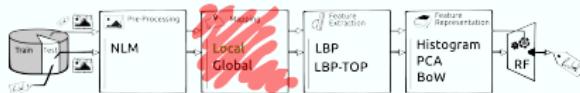
2D



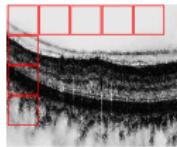
3D



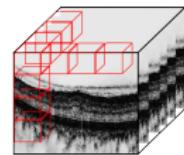
DME Detection Mapping



Local mapping



2D



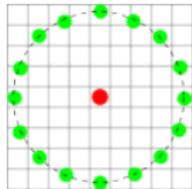
3D



DME Detection Local Binary Pattern (LBP)



LBP



$$LBP_{P,R} = \sum_{p=0}^{P-1} s(g_p - g_c) 2^p, \quad s(\cdot) = \begin{cases} 1 & \text{if } (g_p - g_c) \geq 0 \\ 0 & \text{otherwise} \end{cases},$$

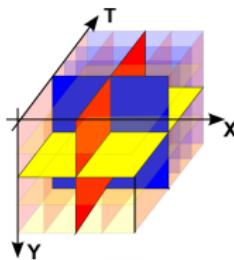
► Select uniform and rotation invariant



DME Detection LBP



LBP-Three Orthogonal Plane (TOP)



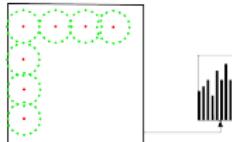


DME Detection Feature representation

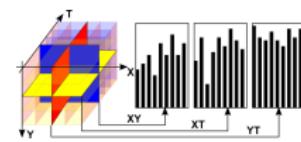


Low-level representation

→ Compute the histogram of the LBP codes



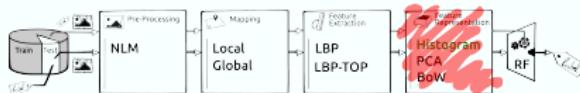
LBP histogram



LBP-TOP histogram



DME Detection Feature representation

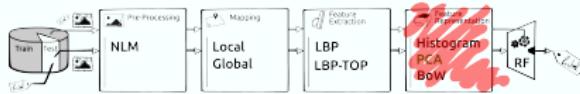


Global *versus* local mapping

- ▶ 1 LBP histogram per *B-scan* later concatenated
- ▶ 1 LBP-TOP histogram per *volume*
- ▶ 1 LBP histogram per *window* later concatenated
- ▶ 1 LBP-TOP histogram per *sub-volume* later concatenated



DME Detection Feature representation

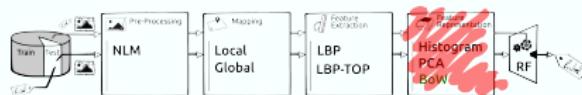


High-level representation — PCA

- ▶ Reduce the number of feature dimensions by finding a space where the data variance is maximized

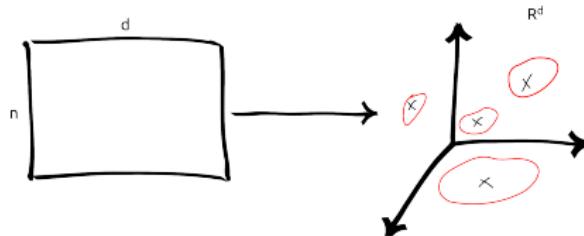


DME Detection Feature representation



High-level representation — BoW

- ▶ Reduce the complexity of the feature space by clustering samples together



- ▶ A codebook is learnt through k-means

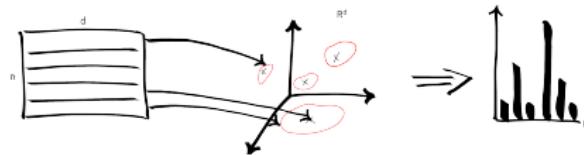


DME Detection Feature representation



High-level representation — BoW

- ▶ Reduce the complexity of the feature space by clustering samples together



- ▶ A codebook is learnt through k-means
- ▶ Each sample is assigned to a specific cluster/word (i.e., hard-voting)
- ▶ Histogram by calculating the frequency of occurrences of each word



Experiments Datasets

SERI dataset

- ▶ 32 SD-OCT images with 16 DME cases and 16 healthy cases
- ▶ Each volume has 128 B-scans with a resolution of 512×1024 pixels

Duke dataset

- ▶ 30 SD-OCT images with 15 DME cases and 15 healthy cases
- ▶ Volumes were denoised and cropped with different sizes



Experiments Parameters

Local mapping

- ▶ Window of 7×7 pixels and Sub-volume of $7 \times 7 \times 7$ pixels

LBP generation

- ▶ Radius of 1, 2, and 3 pixels
- ▶ 8, 16, and 24 neighbours

High-level representation

- ▶ PCA keeping eigenvectors with the 99 % cumulative eigenvalues
- ▶ Codebook of 32 words

Classification

- ▶ Leave-One-Patient-Out cross-validation
- ▶ Random Forest classifier with 100 trees



Experiments

Experiment #1

- ▶ SERI dataset
- ▶ 2D B-scan and 3D volumes, local and global mapping
- ▶ Low and high feature representation

Experiment #2

- ▶ Duke dataset
- ▶ No PCA representation

Experiment #3

- ▶ Comparison between our based approaches and the method of Venhuizen *et al.*^a

^aVenhuizen, Ginneken, Bloemen, Grisven, Philipsen, C., Theelen, and Sanchez, "Automated age-related macular degeneration classification in OCT using unsupervised feature learning".



Results

Obtained results using SERI datasets

Features	8 ^{riu2}		16 ^{riu2}		24 ^{riu2}	
	SE	SP	SE	SP	SE	SP
LBP	43.75	43.75	37.50	50.00	50.00	62.50
LBP-TOP	56.25	62.50	87.50	75.00	68.75	68.75
LBP+PCA	50.00	62.50	56.25	37.50	68.75	68.75
LBP+BoW	50.00	81.25	57.50	68.75	50.00	50.00
LBP+BoW+P	75.00	87.50	81.25	75.00	68.75	62.5
LBP-TOP+BoW+P	62.50	68.75	56.25	37.50	37.50	43.75

Obtained results using Duke datasets

Features	8 ^{riu2}		16 ^{riu2}		24 ^{riu2}	
	SE	SP	SE	SP	SE	SP
LBP-TOP	80.00	93.33	73.33	86.67	73.33	86.67
LBP+BoW+P	80.00	86.67	86.67	100	93.33	86.67
LBP-TOP+BoW+P	80.00	86.67	86.67	86.67	60.00	80.00



Results

Comparison with Venhuizen *et al.* on SERI and Duke

Data sets	SERI		Duke	
	SE	SP	SE	SP
Venhuizen <i>et al.</i> ^a	61.53	58.82	71.42	68.75
{LBP+BoW+P}, 16 ^{riu2}	81.25	75.00	86.67	100.00
{LBP-TOP}, 16 ^{riu2}	87.50	75.00	73.33	86.76

^aVenhuizen, Ginneken, Bloemen, Grisven, Philipsen, C., Theelen, and Sanchez, "Automated age-related macular degeneration classification in OCT using unsupervised feature learning".



Conclusion

Summary

- ▶ LBP with high-level representation and local mapping
- ▶ LBP-TOP with low-level representation and global mapping
- ▶ Radius of 2 and 16 neighbours

Future works

- ▶ Study the invariance of LBP
- ▶ Study the pre-processing of SD-OCT
- ▶ Classification scheme