STATISTICAL COLOR TEXTURE DESCRIPTORS FOR HISTOLOGICAL IMAGES ANALYSIS

Nicolas Hervé[a], Aude Servais[b], Eric Thervet[b], Jean-Christophe Olivo-Marin[a] and Vannary Meas-Yedid[a]

(a) Institut Pasteur, Quantitative Image Analysis Unit, URA CNRS 2582, 75015 Paris, France - www.bioimageanalysis.org
(b) Departments of Nephrology and Renal Transplantation, Necker Hospital, 75015 Paris, France

CONTEXT

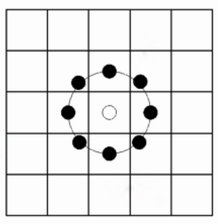
Texture and color low-level features are an important part of microscopy image analysis

- the quality of low-level features is essential for all image analysis processes
- how should we combine color and statistical texture informations ?
- particular case of histological datasets : color plays a specific role due to the staining process
- two main approaches : joint or separate assessment

APPROACHES

Local Binary Pattern

- gray scale image $\mathbf{G}$ of $w \times h$ pixels
- the neighbourhood of a given pixel (x, y) is defined by a number P of equally spaced pixels on a circle of radius R.
- $N_p(x,y) = \left(x + Rcos(\frac{2\pi p}{P}), y - Rsin(\frac{2\pi p}{P})\right), p \in [0, P-1]$
- intensities of neighbour pixels $\mathbf{G}(N_p(x,y))$ are obtained by bilinear interpolation



P = 8, R = 1

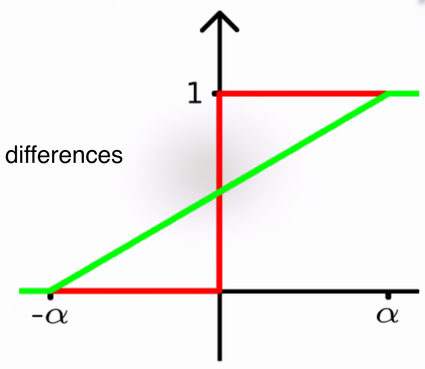
$$LBP_{P,R}(\mathbf{G}, x, y) = \sum_{p=0}^{P-1} s\left(\mathbf{G}(x,y) - \mathbf{G}(N_p(x,y))\right) 2^p$$

$$H(\mathbf{G}, i) = \sum_{x,y} \delta(i, LBP_{P,R}(\mathbf{G}, x, y)), i \in [0, 2^P - 1]$$

Fuzzy/Soft version

Improved version : soft thresholding approach for the intensity differences

$$f_\alpha(z) = \begin{cases} 0, & z < -\alpha \\ \frac{1+\frac{z}{\alpha}}{2}, & |z| \leq \alpha \\ 1, & z > \alpha \end{cases}$$



$$SLBP(\mathbf{G}, x, y, \alpha, i) = \prod_{p=0}^{P-1} \left[(2b_p(i) - 1) f_\alpha(\mathbf{G}(x,y) - \mathbf{G}(N_p(x,y))) + 1 - b_p(i)\right]$$

$$H_\alpha(\mathbf{G}, i) = \sum_{x,y} SLBP(\mathbf{G}, x, y, \alpha, i), i \in [0, 2^P - 1]$$

Proposed variants

- extend the rotation invariant and uniform approach to the soft LBP version via a look-up table : better texture representation, lower dimensionality

$$H_{\alpha,riu}(\mathbf{G}, i) = \sum_{x,y,j} SLBP(\mathbf{G}, x, y, \alpha, j), j \in LUT(i)$$

- apply SLBP on color quantization membership images
- we have a set $\mathbf{Q}_n = \{q_b\}$ of n representative colors and we define n membership images

$$\mathbf{M}^b(\mathbf{C}, x, y) = \frac{1}{d(\mathbf{C}(x,y), q_b) \sum_{k=1}^{n} \frac{1}{d(\mathbf{C}(x,y), q_k)}}$$

$$SQCLBP_\alpha(\mathbf{C}, i) = \bigoplus_{b=1}^{n} H_{\alpha,riu}(\mathbf{M}^b(\mathbf{C}), i)$$

Other tested approaches

- Gabor wavelet features : normalized mean and standard deviation of the magnitude
- Haralick contrast measure on co-occurence matrices for quantized images

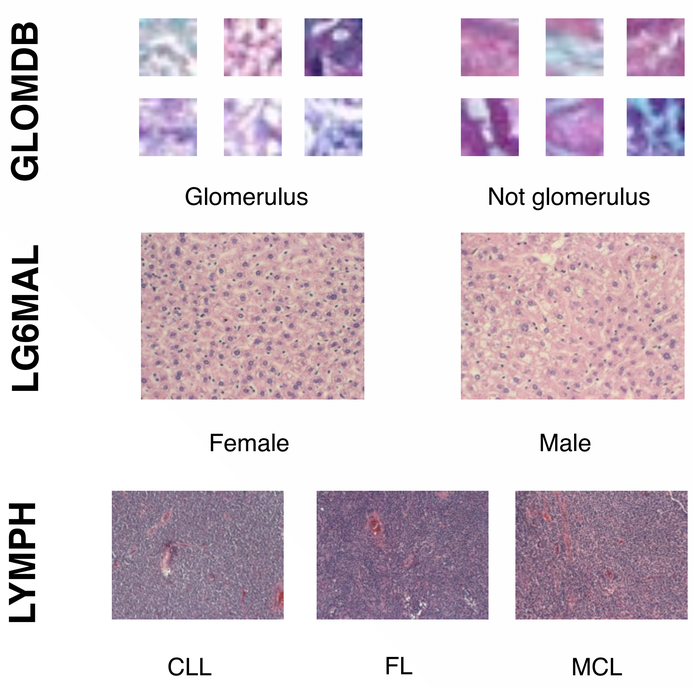
$$COM_{P,R}(\mathbf{C}_{Q_n}, a, b) = \frac{1}{w \times h} \sum_{x=1}^{w} \sum_{y=1}^{h} \sum_{p=0}^{P-1} \delta\left(a, \mathbf{C}_{Q_n}(x,y)\right) \times \delta\left(b, \mathbf{C}_{Q_n}(N_p(x,y))\right)$$

$$CCOM_{P,R}(\mathbf{C}_{Q_n}, a) = \sum_{b=1}^{n} COM_{P,R}(\mathbf{C}_{Q_n}, a, b) \times d(q_a, q_b)$$

EVALUATION

Datasets

- three diversified histological datasets
- different organ tissues, purposes, staining, imaging, variability
- available publicly (Bonus)
- classification task



	Desc.	GLOMDB	LG6MAL	LYMPH
	Random	**0.503**	**0.572**	**0.341**
Color	$I1H2H3_3$	0.850	0.736	0.546
	$I1H2H3_5$	0.886	**0.820**	0.578
	$I1H2H3_{10}$	0.911	0.784	0.594
	SM_8	0.899	0.757	0.532
	SM_{16}	0.904	0.791	0.577
	SM_{20}	**0.917**	0.777	0.580
	SM_{32}	0.913	0.776	0.590
	SM_{64}	0.909	0.775	**0.604**
Texture	*Gabor*	0.863	0.922	0.517
	LBP	0.705	0.945	0.529
	LBP_{riu}	0.723	0.922	0.506
	SLBP	0.919	0.949	0.535
	$SLBP_{riu}$	**0.922**	**0.954**	**0.540**
Sep.	$I1H2H3 \oplus SLBP_{riu}$	0.946	**0.875**	0.617
	$SM \oplus SLBP_{riu}$	**0.952**	0.842	**0.631**
Join.	$Gabor, I1H2H3$	0.894	0.962	0.583
	$SLBP_{riu}, I1H2H3$	**0.974**	**0.973**	0.576
	SQCLBP	0.937	0.954	**0.632**
	CCOM	0.933	0.825	**0.633**

- soft margin SVM with triangular kernel
- only a few training examples
- Mean Average Precision measure (MAP)
- $I1H2H3$ color space : $I1 = \frac{R+G+B}{3}$, $H2 = R - G$ and $H3 = \frac{R+G}{2} - B$.

Conclusions

- SLBPriu is the best texture feature on grayscale images
- limited variability of the dataset (GLOMDB, LG6MAL) : extract color and texture features jointly
- high variability (LYMPH) : extract color and texture features separately and concatenate

Toy plugin available for the ICY image analysis software

- free and open source
- SLBPriu implementation
- semi-supervised texture segmentation plugin