Analyzing Images Through Texture Descriptors

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Motivation

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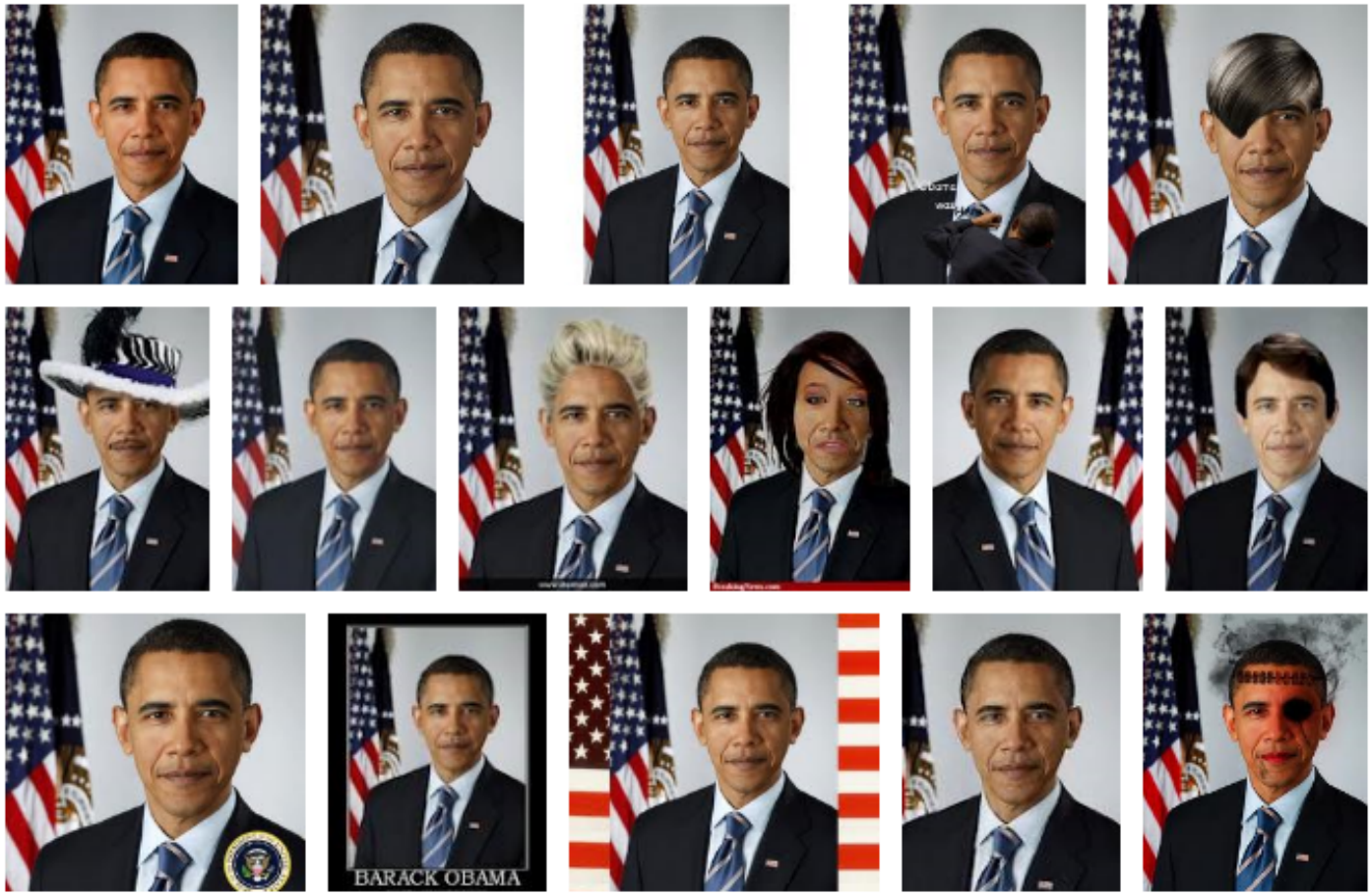


Image Descriptors

$$\Rightarrow \begin{pmatrix} 135 \\ 94 \\ . \\ . \\ 102 \end{pmatrix}$$

$$\Rightarrow \begin{pmatrix} 132 \\ 91 \\ . \\ . \\ 103 \end{pmatrix}$$

$$\Rightarrow \begin{pmatrix} 32 \\ 59 \\ . \\ . \\ 10 \end{pmatrix}$$

$$\begin{pmatrix} 135 \\ 94 \\ . \\ . \\ 102 \end{pmatrix} \overset{?}{\approx} \begin{pmatrix} 132 \\ 91 \\ . \\ . \\ 103 \end{pmatrix}$$

$$\begin{pmatrix} 135 \\ 94 \\ . \\ . \\ 102 \end{pmatrix} \overset{?}{\approx} \begin{pmatrix} 32 \\ 59 \\ . \\ . \\ 10 \end{pmatrix}$$

Image Descriptors

Basic division

- Local vs. global

- Descriptors based on comparing
  - color
  - texture
  - shape

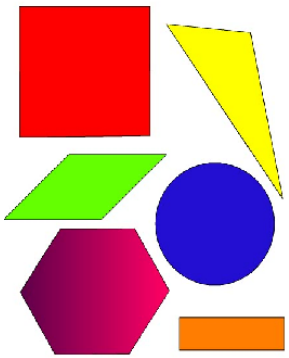


Image Descriptors

Selected Descriptors

- Haralick features
- Zernike features
- Tamura features
- Local Binary Patterns (LBP)
- MPEG-7 descriptors
- SIFT, SURF, ...
- ...

Haralick features

- Introduced in 1973 by Haralick
- Based on co-occurrence matrix

0	0	1	1
0	0	1	1
0	2	2	2
2	2	3	3

a) Original image

#(0,0)	#(0,1)	#(0,2)	#(0,3)
#(1,0)	#(1,1)	#(1,2)	#(1,3)
#(2,0)	#(2,1)	#(2,2)	#(2,3)
#(3,0)	#(3,1)	#(3,2)	#(3,3)

b) General form of GTSD matrix for image a)

4	2	1	0
2	4	0	0
1	0	6	1
0	0	1	2

c) Horizontal part of GTSD matrix

- Vector length is not fixed
- Expansion to 3D in 2007 (Tesař)

Local Binary Patterns

- First publication in 1994 (Ojala)
- We get the vector by applying these steps:
  - each pixel compare to its 8 neighbors
  - where the center pixel's value is greater, write 1
  - otherwise, write 0

7	1	12
2	5	5
5	3	0

0	1	0
1		0
0	1	1

Local Binary Patterns

- We get the vector by applying these steps:
  - convert 8 digit binary number to decimal

0	1	0
1		0
0	1	1

$*$

128	64	32
1		16
2	4	8

$=$

0	64	0
1		0
0	4	8

$1 + 4 + 8 + 64 = 77$

  - compute the histogram of the frequency of each number
  - concatenate normalized histogram values gives us the feature vector

Task

- design and implement pattern recognition system
- able to classify the pre-segmented cells
- 6 categories

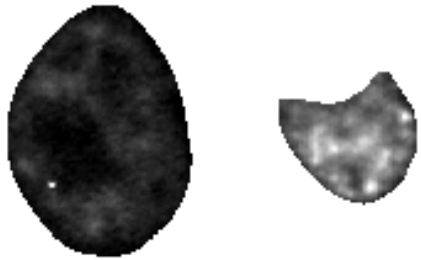
Evaluation

- winner = highest value of the accuracy

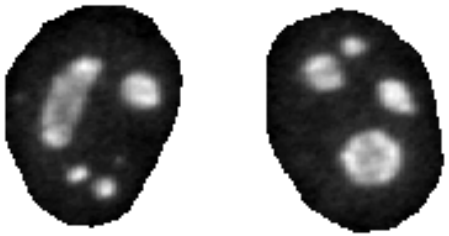
Homogeneous: stain is diffused in the cell nuclei

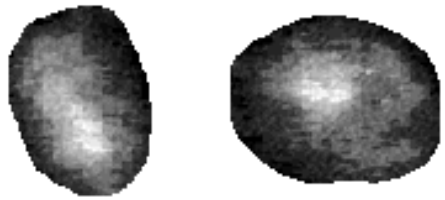
Fine speckled: staining protein is in the cell nucleus but outside small nuclei

Coarse speckled: similar to fine speckled, but the granularity is more significant



Nucleolar: staining protein is located in small nuclei





Cytoplasmatic: staining protein is in the cytoplasm, not in the nucleus

Centromere: staining is applied on centromeres (small structures in chromatin)

Used descriptors

- MPEG-7 (Color Structure)
- Local Binary Patterns (LBP)
- Haralick features
- Granulometry
- TSurf

Others: SIFT, Tamura features, Mask Shape, Circular averaging (RDisc), Dots detection, ...

Aggregation of desctiptors

- Color Structure + Granulometry
- LBP + Haralick features
- Color Structure + Haralick features
- ...

Combination of classifications

- sum
- multiply
- naive Bayes
- multiply with zero suppression
- naive Bayes with zero suppression
- harmonic mean
- geometric mean

- Zero suppression: 20 neighbours, if all negative -> 21st set as positive.
- Naive Bayes: $\frac{ab}{ab+(1-a)(1-b)}$

Actual results

- Centromere: 98,0% [204/208 images]
- Coarse speckled: 100% [109/109 images]
- Cytoplasmatic: 94,8% [55/58 images]
- Fine speckled: 86,1% [81/94 images]
- Homogeneous: 90,7% [136/150 images]
- Nucleolar: 94,1% [96/102 images]

- Average performance: 94,4% [681/721 images]