Dealing with Inaccurate Face Detection for Automatic Gender Recognition with Partially Occluded Faces

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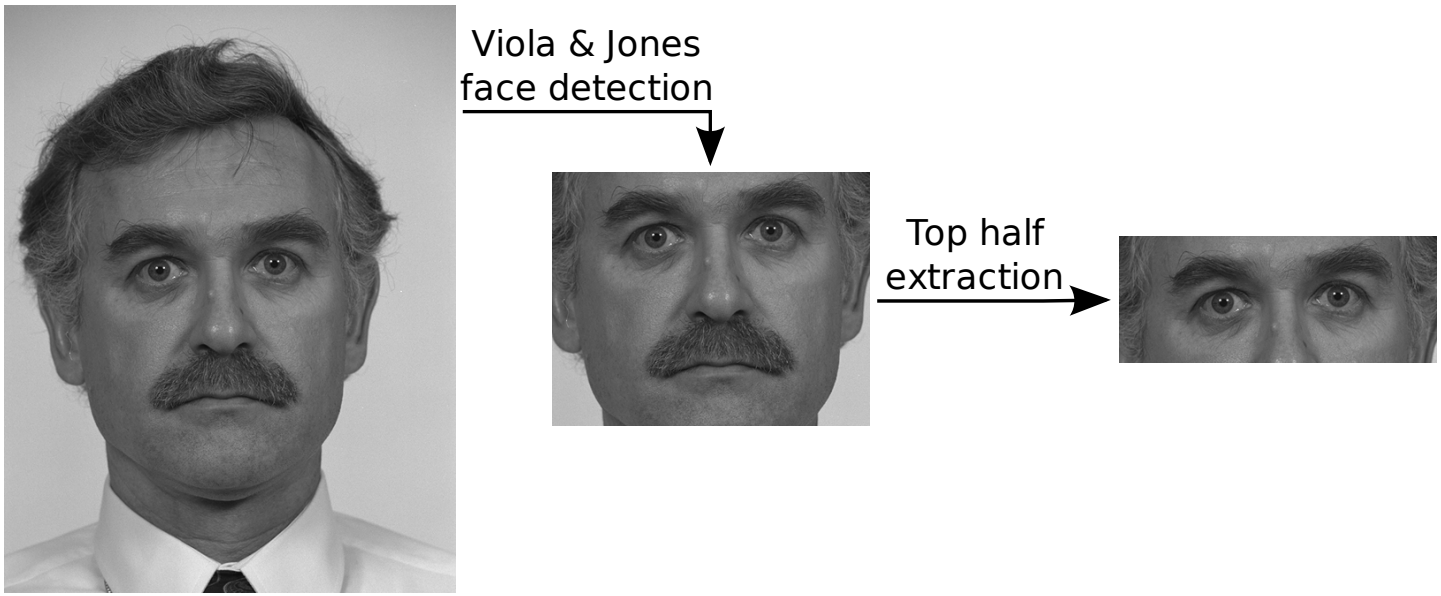
Motivation

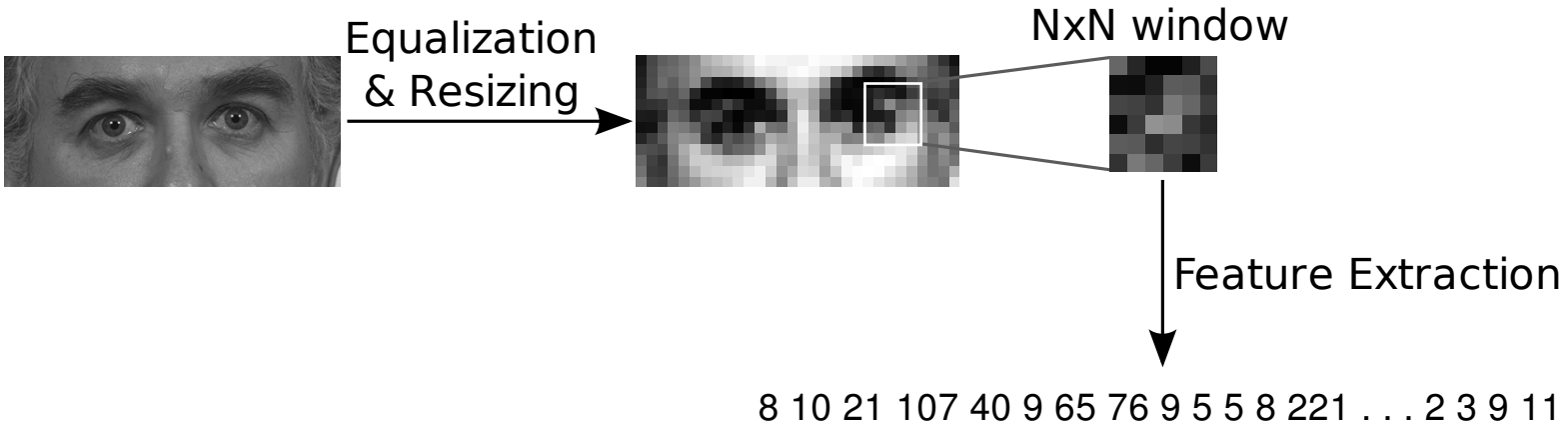
Study the gender recognition problem in situations where the face cannot be accurately detected and could be partially occluded



- Occlusions $\rightarrow$ only top half of the face is used
- Inaccurate face detections $\rightarrow$ proposed classification technique

Outline

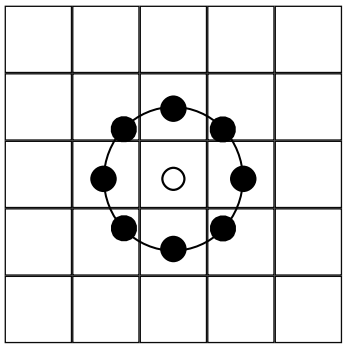
Overview



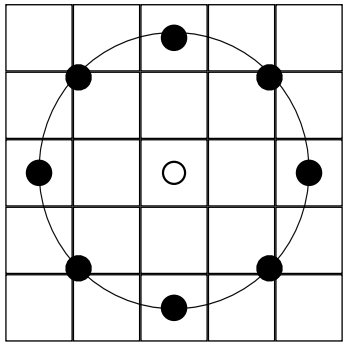
1. Preprocessing the image:
   - Top half extraction
   - Histogram equalization
   - Image size adjustment
2. Scanning the image using windows of $N \times N$ size
3. Describing the pixels inside the image (3 different face descriptions are used)

Face Descriptions: LBP & LCH

- Local Binary Patterns (LBP)



$\text{LBP}^{u}_{8,1}$



$\text{LBP}^{u}_{8,2}$

- Comparing grey levels:

  $g_c > g_p \rightarrow 0$

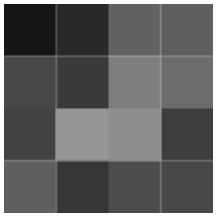
  $g_c \leq g_p \rightarrow 1$

- Concatenate digits $\rightarrow$ binary pattern
- Histogram of binary patterns
- Rotationally invariant (RI) and rotation dependent (no RI) versions

- Local Contrast Histograms (LCH)

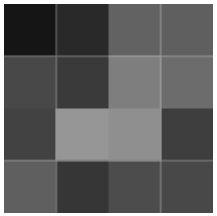
  Histogram of contrast values, same neighborhoods sizes and amount of bins as in LBPs.

Face Descriptions: Ranking Labels



Steps of this process

Face Descriptions: Ranking Labels



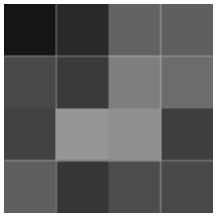
$\overrightarrow{Vectorizing}$

12	33	92	89	65	50	121	102	59	146	139	55	89	46	69	65

Steps of this process

1. A vector is created with the grey values of the pixels within the window

Face Descriptions: Ranking Labels



$\overrightarrow{Vectorizing}$

12	33	92	89	65	50	121	102	59	146	139	55	89	46	69	65

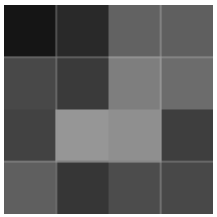
$\downarrow Sorting$

12	33	46	50	55	59	65	65	69	89	89	92	102	121	139	146

Steps of this process

1. A vector is created with the grey values of the pixels within the window
2. Sorting the vector in ascending order

Face Descriptions: Ranking Labels



$\overrightarrow{Vectorizing}$

12	33	92	89	65	50	121	102	59	146	139	55	89	46	69	65

$\downarrow Sorting$

12	33	46	50	55	59	65	65	69	89	89	92	102	121	139	146

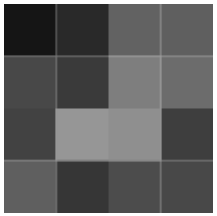
$\downarrow Label\ assignment$

1	2	3	3	4	4	5	5	5	6	6	6	7	8	9	9

Steps of this process

1. A vector is created with the grey values of the pixels within the window
2. Sorting the vector in ascending order
3. Assigning the corresponding Ranking Label to each component

Face Descriptions: Ranking Labels



$\overrightarrow{Vectorizing}$

12	33	92	89	65	50	121	102	59	146	139	55	89	46	69	65

$\downarrow Sorting$

12	33	46	50	55	59	65	65	69	89	89	92	102	121	139	146

$\downarrow Label\ assignment$

1	2	3	3	4	4	5	5	5	6	6	6	7	8	9	9

$\downarrow Unsorting$

1	2	6	6	5	3	8	7	4	9	9	4	6	3	5	5

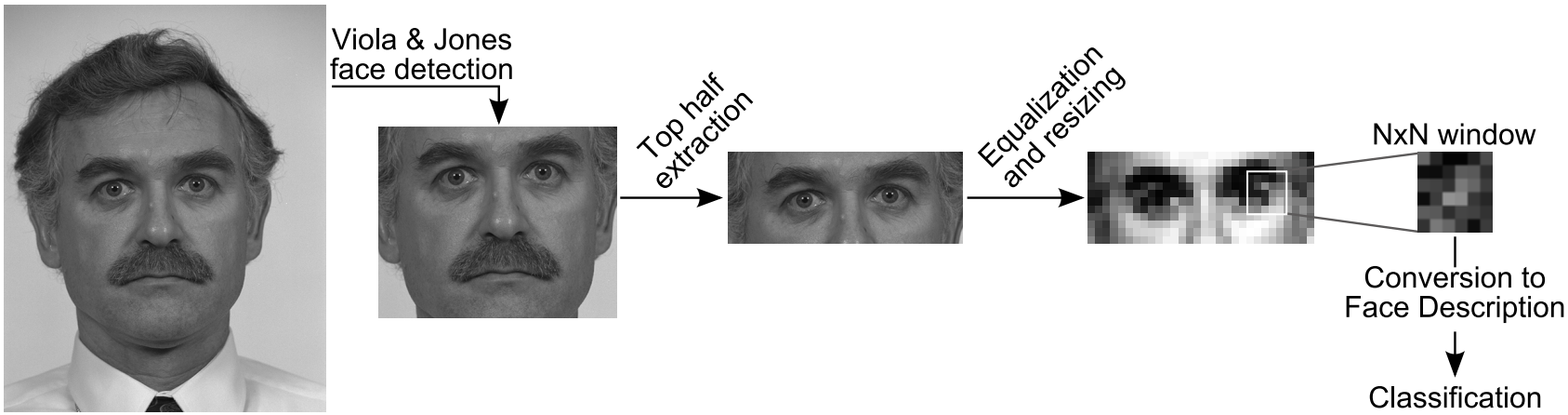
Steps of this process

1. A vector is created with the grey values of the pixels within the window
2. Sorting the vector in ascending order
3. Assigning the corresponding Ranking Label to each component
4. “Unsorting” the vector to keep the original positions of each component

Methodology

Steps of the Gender Recognition Process

1. The face is detected using the Viola & Jones algorithm (no correction of the face inclination is done)
2. The top half of the resulting image from step 1 is extracted, equalized and resized to 45 pixels width
3. A set of windows of 7×7 pixels are defined to obtain a collection of vectors that characterize the top half face
4. The face is classified as male or female



Descriptions of the Experiments

Experiment 1

- Non-overlapping windows
- Concatenation of extracted vectors
- Classification at image level

Tests how appropriate the face descriptions are for gender recognition

Experiment 2

- Overlapping windows
- Concatenation of extracted vectors
- Classification at image level

Tests how useful redundant information is for distinguishing between genders

Descriptions of the Experiments

Experiment 3

- Overlapping windows
- Several vectors describe the face
- Classification at window level inside a neighborhood
- Voting system

Tests the performance of the proposed classification technique

Experiment 4

- Result of the face detection artificially modified $\rightarrow$ simulate a non-accurate situation
- Same configuration as in experiment 3

Tests how reliable the face descriptions are in non-accurate situations

Summary

Several characterization methods

- Local Binary Patterns: $\text{LBP}^{u}_{8,1}$ and $\text{LBP}^{u}_{8,2}$
- Local Contrast Histograms: $\text{LCH}^{u}_{8,1}$ and $\text{LCH}^{u}_{8,2}$ (10 and 59 bins)
- Ranking Labels

Two different classification techniques

- **Concatenating all the vectors** $\Rightarrow$ 1-NN $\Rightarrow$ Predicted class label
- Several vectors $\Rightarrow$ 1-NN in a given neighborhood $\Rightarrow$ Several class labels $\Rightarrow$ **Majority voting** $\Rightarrow$ Predicted class label

Two different metrics are used to measure distances: χ^2 and $Euclidean$

Experiment 1

	$\mathbf{LBP}^{u}_{8,1}$		$\mathbf{LBP}^{u}_{8,2}$		$\mathbf{LBP}^{u}_{8,\{1,2\}}$	
	RI	no RI	RI	no RI	RI	no RI
χ^2	70.88	76.61	68.42	79.06	73.92	80.47
Euc	68.30	76.02	68.42	76.73	72.51	78.25

	$\mathbf{LCH}^{u}_{8,1}$		$\mathbf{LCH}^{u}_{8,2}$		$\mathbf{LCH}^{u}_{8,\{1,2\}}$	
	10 bins	59 bins	10 bins	59 bins	10 bins	59 bins
χ^2	75.44	69.36	77.89	71.81	77.89	72.98
Euc	73.57	70.64	74.27	72.05	75.44	73.80

	$\mathbf{LBP}^{u}_{8,1}$ + $\mathbf{LCH}^{u}_{8,1}$		$\mathbf{LBP}^{u}_{8,2}$ + $\mathbf{LCH}^{u}_{8,2}$		$\mathbf{LBP, LCH}^{u}_{8,\{1,2\}}$	
	RI/ 10 bins	no RI/ 59 bins	RI/ 10 bins	no RI/ 59 bins	RI/ 10 bins	no RI/ 59 bins
χ^2	75.79	79.53	80.47	79.88	82.69	81.64
Euc	77.19	77.43	77.43	77.66	80.70	79.88

	Ranking Labels
χ^2	78.95
Euc	78.60

Results

- LBP and LCH achieve good performances
- Combination of LBP and LCH with both radii reach the highest rates
- Ranking Labels recognition rates are comparable with the LBP and LCH ones
- The highest rates were obtained using the χ^2 metric

Experiment 2

	$\text{LBP}^{u}_{8,1}$		$\text{LBP}^{u}_{8,2}$		$\text{LBP}^{u}_{8,\{1,2\}}$	
	RI	no RI	RI	no RI	RI	no RI
χ^2	74.27	78.48	81.17	78.95	78.13	80.23
Euc	73.33	76.37	77.89	75.56	77.43	77.31

	$\text{LCH}^{u}_{8,1}$		$\text{LCH}^{u}_{8,2}$		$\text{LCH}^{u}_{8,\{1,2\}}$	
	10 bins	59 bins	10 bins	59 bins	10 bins	59 bins
χ^2	79.65	74.97	79.77	75.79	79.30	76.26
Euc	78.95	72.87	76.96	74.50	77.54	76.73

	$\text{LBP}^{u}_{8,1}$ + $\text{LCH}^{u}_{8,1}$		$\text{LBP}^{u}_{8,2}$ + $\text{LCH}^{u}_{8,2}$		LBP, $\text{LCH}^{u}_{8,\{1,2\}}$	
	RI/ 10 bins	no RI/ 59 bins	RI/ 10 bins	no RI/ 59 bins	RI/ 10 bins	no RI/ 59 bins
χ^2	80.23	81.17	82.46	81.40	82.81	80.82
Euc	79.65	77.89	81.17	77.08	81.40	77.19

	Ranking Labels
χ^2	80.12
Euc	79.30

Results

- All the face descriptions are suitable to discriminate between genders
- The more number of features are used, the best recognition rates are achieved
- Recognition rates were increased with respect to experiment 1

Experiment 3

	$\text{LBP}^u_{8,1}$		$\text{LBP}^u_{8,2}$		$\text{LBP}^u_{8,\{1,2\}}$	
	RI	no RI	RI	no RI	RI	no RI
χ^2	61.66	71.75	61.43	75.26	62.84	78.55
Euc	61.08	70.57	62.02	72.92	62.49	76.32

	$\text{LCH}^u_{8,1}$		$\text{LCH}^u_{8,2}$		$\text{LCH}^u_{8,\{1,2\}}$	
	10 bins	59 bins	10 bins	59 bins	10 bins	59 bins
χ^2	61.08	62.95	61.08	63.42	65.06	64.48
Euc	61.08	64.36	61.08	63.42	66.00	63.07

	$\text{LBP}^u_{8,1}$ + $\text{LCH}^u_{8,1}$		$\text{LBP}^u_{8,2}$ + $\text{LCH}^u_{8,2}$		LBP, $\text{LCH}^u_{8,\{1,2\}}$	
	RI/ 10 bins	no RI/ 59 bins	RI/ 10 bins	no RI/ 59 bins	RI/ 10 bins	no RI/ 59 bins
χ^2	66.47	79.95	69.05	82.65	74.44	85.11
Euc	67.87	75.15	69.40	77.61	71.28	78.55

	Ranking Labels
χ^2	88.54
Euc	88.54

Results

- Ranking Labels reach the best results $\rightarrow$ keep positional information
- Individual histogram features are less efficient than in previous experiments
- LBP, $\text{LCH}^u_{8,\{1,2\}}$ achieve similar results to the Ranking Labels ones $\rightarrow$ 4 times more features

Experiment 4

	$\mathbf{LBP}^{u}_{8,1}$		$\mathbf{LBP}^{u}_{8,2}$		$\mathbf{LBP}^{u}_{8,\{1,2\}}$	
	RI	no RI	RI	no RI	RI	no RI
χ^2	61.08	61.08	61.08	61.08	62.49	62.49
Euc	61.08	61.08	62.14	62.14	62.14	62.14

	$\mathbf{LCH}^{u}_{8,1}$		$\mathbf{LCH}^{u}_{8,2}$		$\mathbf{LCH}^{u}_{8,\{1,2\}}$	
	10 bins	59 bins	10 bins	59 bins	10 bins	59 bins
χ^2	61.08	64.36	61.08	63.19	64.83	65.30
Euc	61.08	65.06	61.08	64.13	64.48	63.66

	$\mathbf{LBP}^{u}_{8,1}$ + $\mathbf{LCH}^{u}_{8,1}$		$\mathbf{LBP}^{u}_{8,2}$ + $\mathbf{LCH}^{u}_{8,2}$		**LBP, LCH**$^{u}_{8,\{1,2\}}$	
	RI/ 10 bins	no RI/ 59 bins	RI/ 10 bins	no RI/ 59 bins	RI/ 10 bins	no RI/ 59 bins
χ^2	64.83	79.01	69.17	81.71	71.16	83.59
Euc	65.77	73.51	69.64	76.08	70.81	78.55

	Ranking Labels
χ^2	89.12
Euc	89.94

Results

- LBP and LCH by themselves cannot properly accomplish the recognition task $\rightarrow$ significantly influenced by the non-accurate face detection
- Ranking Labels recognition rates have not got worse while the others did
- Ranking Labels is the most reliable face description when the face detection process is inaccurate

Conclusions

- Dealing with the automatic gender classification problem in situations where the face was partially occluded and inaccurately detected
- LBPs and LCHs performed correctly when the positional information is kept (face accurately detected) by the classification method
- In general, Ranking Labels + proposed classification technique is the most stable method $\longrightarrow$ similar results when accurate face detection and same rates when no accuracy

Thank you!


MIPRCV
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