OPTIMIZATION OF LBP PARAMETERS

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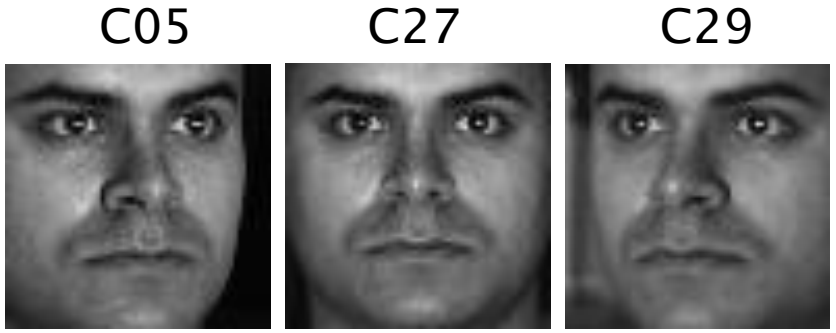
Motivation

- Comparison of three types of Local Binary Patterns (LBP) as the texture features for face recognition
  - LBP, LGP, NRLBP
- Biometric system parameters optimization
  - Genetic algorithm
- Evaluation of experimental results
  - Dimension reduction
  - Recognition accuracy

Input Data

- CMU PIE face database
  - Collected at Carnegie Mellon University
  - Pose, illumination, expression
  - 68 individuals
  - 64x64 pixels
  - 97 images per subject
  - 68*6 = 408 training samples
  - 68*91 = 6188 testing samples



Input Data

- Cropped Yale face database
  - Collected at University of California, San Diego
  - Illumination (different positions of illumination source)
  - 38 individuals
  - 192x168 pixels
  - 68 images per subject
  - 38*6 = 228 training samples
  - 38*62 = 2356 testing samples

Input Data

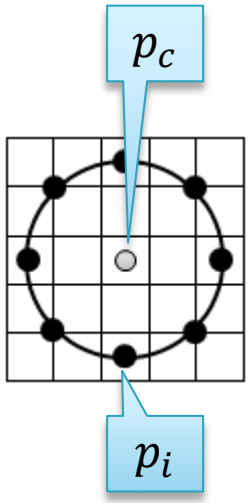
- ORL or ATT face database
  - Collected Cambridge University Computer Laboratory
  - Pose
  - 40 individuals
  - 112x92 pixels
  - 10 images per subject
  - 40*6 = 240 training images
  - 40*4 = 160 testing images

Feature extraction

- LBP – Local Binary Patterns

$$LBP_{P,R} = \sum_{i=0}^{P-1} s(p_i - p_c)2^i$$

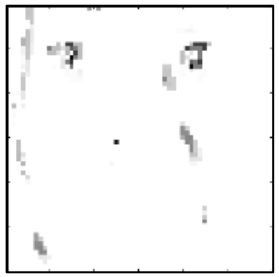
$$s(x) = \begin{cases} 1, & x \geq 0 \\ 0, & x < 0 \end{cases}$$



- LGP – Local Gradient Patterns

$$LGP_{P,R} = \sum_{i=0}^{P-1} s(g_i - \bar{g})\, 2^i$$

$$g_i = |p_i - p_c| \quad \bar{g} = \frac{1}{P}\sum_{i=0}^{P-1} g_i$$



- NRLBP – Non-redundant LBP

$$NRLBP = \min\left(LBP_{P,R}, 2^P - 1 - LBP_{P,R}\right)$$

The number of histogram bins (P=8, R=2)

Type	Patterns			
	Common (none)	Uniform (U2)	Rotation invariant (RI)	Rotation invariant Uniform (RIU2)
LBP	256	59	36	10
LGP	256	59	36	10
NRLBP	128	30	35	9

Feature classification

- L1 – Manhattan or city block distance

$$L1(x,y) = \sum_{i=0}^{N-1} |x_i - y_i|$$

- L2 – Euclidian distance

$$L2(x,y) = \sqrt{\sum_{i=0}^{N-1} (x_i - y_i)^2}$$

- χ2 – Chi-square distance

$$\chi^2 = \sum_{i=0}^{N-1} \frac{(x_i - m_i)^2}{m_i} \quad m_i = \frac{x_i - y_i}{2}$$

- EMD – Earth mover's distance for histograms

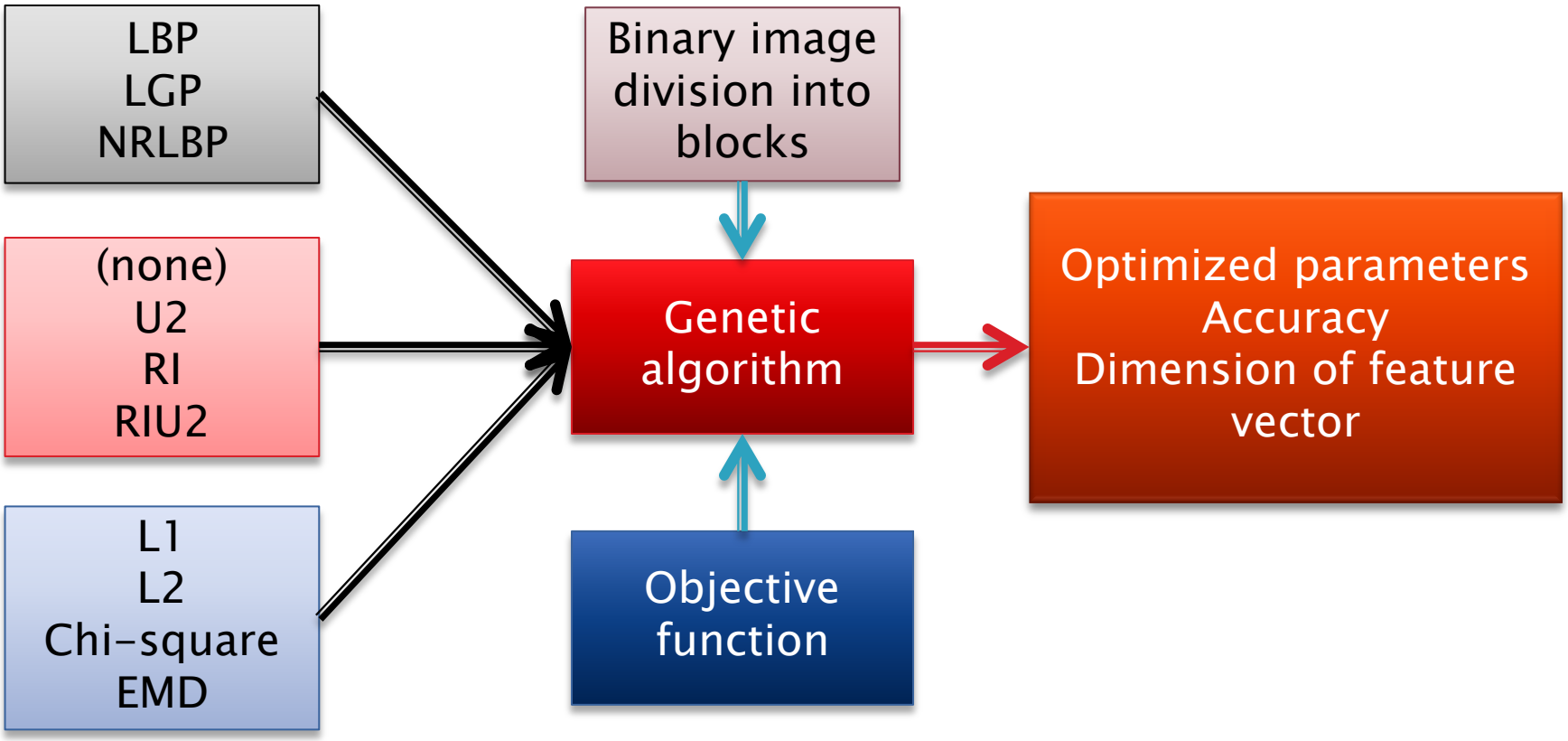
$$EMD = \min \sum_{ij} g_{ij} d_{ij}$$

$$\sum_i g_{ik} - \sum_j g_{kj} = |x(k) - y(k)|$$

Genetic algorithm

- Chromosome (sequence of values which will be optimized)
- Number of individuals in population per generation (*ps=20*)
- Number of generations (*ng=40*)
- Mutation probability (*mp=0.8*)
- Recombination probability (crossing-over) (*rp=0.5*)
- Definition of objective function – fitness
  - $f(d, x, y, acc) = 0.25\frac{d}{xy} + (1 - acc)$

Proposed methodology



Experimental Results (CMU PIE)

Image size	Feature type	Number of blocks; Size of one block	Feature dimension	Distance measure	Recognition accuracy [%]
16x16	LBP RIU2	6 blocks; 2*12pix	60	χ^2	50.323
24x24	LBP RIU2	20 blocks; 1*20pix	200	χ^2	76.131
32x32	LBP RIU2	28 blocks; 1*28pix	280	χ^2	82.708
48x48	**LBP RIU2**	**44 blocks; 1*44pix**	**440**	**L1**	**85.326**
64x64	LBP RIU2	60 blocks; 1*60pix	600	χ^2	82.902

Experimental Results (YALE)

Image size	Feature type	Number of blocks; Size of one block	Feature dimension	Distance measure	Recognition accuracy [%]
24x21	LBP RIU2	20 blocks 1*17pix	200	χ^2	80.127
48x42	**LBP RIU2**	**44 blocks 1*38pix**	**440**	**χ^2**	**94.056**
72x63	LBP RIU2	34 blocks 2*59pix	340	χ^2	93.013
96x84	LBP RIU2	46 blocks 2*80pix	460	χ^2	91.062

Experimental Results (ORL)

Image size	Feature type	Number of blocks; Size of one block	Feature dimension	Distance measure	Recognition accuracy [%]
28x23	NRLBP U2	3 blocks 8*19pix	90	L2	99.375
42x35	LBP U2	1 block 38*31pix	59	L1	99.375
56x46	**LBP U2**	**2 blocks 26*42pix**	**118**	**χ^2**	**100.000**
84x69	**NRLBP RIU2**	**20 blocks 20*13pix**	**180**	**L1, χ^2**	**100.000**
112x92	**NRLBP RIU2**	**9 blocks 12*88pix**	**81**	**χ^2**	**100.000**

Conclusion

- Oft-repeated LBP using RIU2 mapping
- Consider NRLBP using RIU2 mapping
- Binary image divided along rows
- Oft-repeated Chi-square distance
- Input image 50*50 pixels (P=8, R=2)
- EMD is not suitable distance measure
- LGP is not discriminative enough
- LGP should be combined with histogram of oriented gradients (HOG)

Thank you for your attention!