Face recognition for automatic class attendance system

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Motivation

- Attendance taking tries to increase the involvement of students
- A lot of learning time is lost:
  - 160 students -> 15 minutes
  - Posterior copy to digital system, by the teacher
- State-of-the-art face recognition systems performance is satisfactory
- Also useful for similar scenarios: assemblies, meetings, conferences...

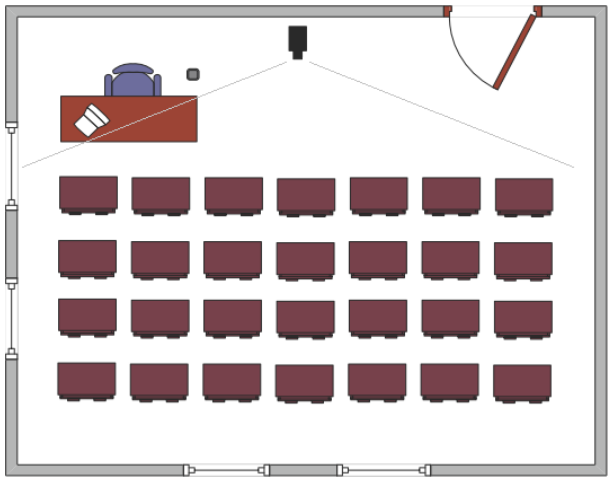
Why face recognition

Face recognition

- No contact
  - No damage
  - More hygienic
- Large groups at the same time
- May be able to use existing cameras

Cards, Biometrics, RFID

- Important initial investment
- Needs user cooperation
  - Large queues
  - Same time than taking attendance



Literature review

- More than 35 papers reviewed
- Overall bad quality
  - Incomplete
  - no results
  - plagiarized…
- Just another application

Aspects to consider

- Hardware
  - Cameras
    - N°, position, angle, resolution, zoom, movement
  - Computer
    - PC
    - Embedded
    - Server-side processing
  - Connection between cameras and computer
  - Power

Aspects to consider

- Feature extraction
- Face detection
- Pre-processing techniques
- Anti-spoofing
- Imaging: one, multiple
  - When?
- Unknown

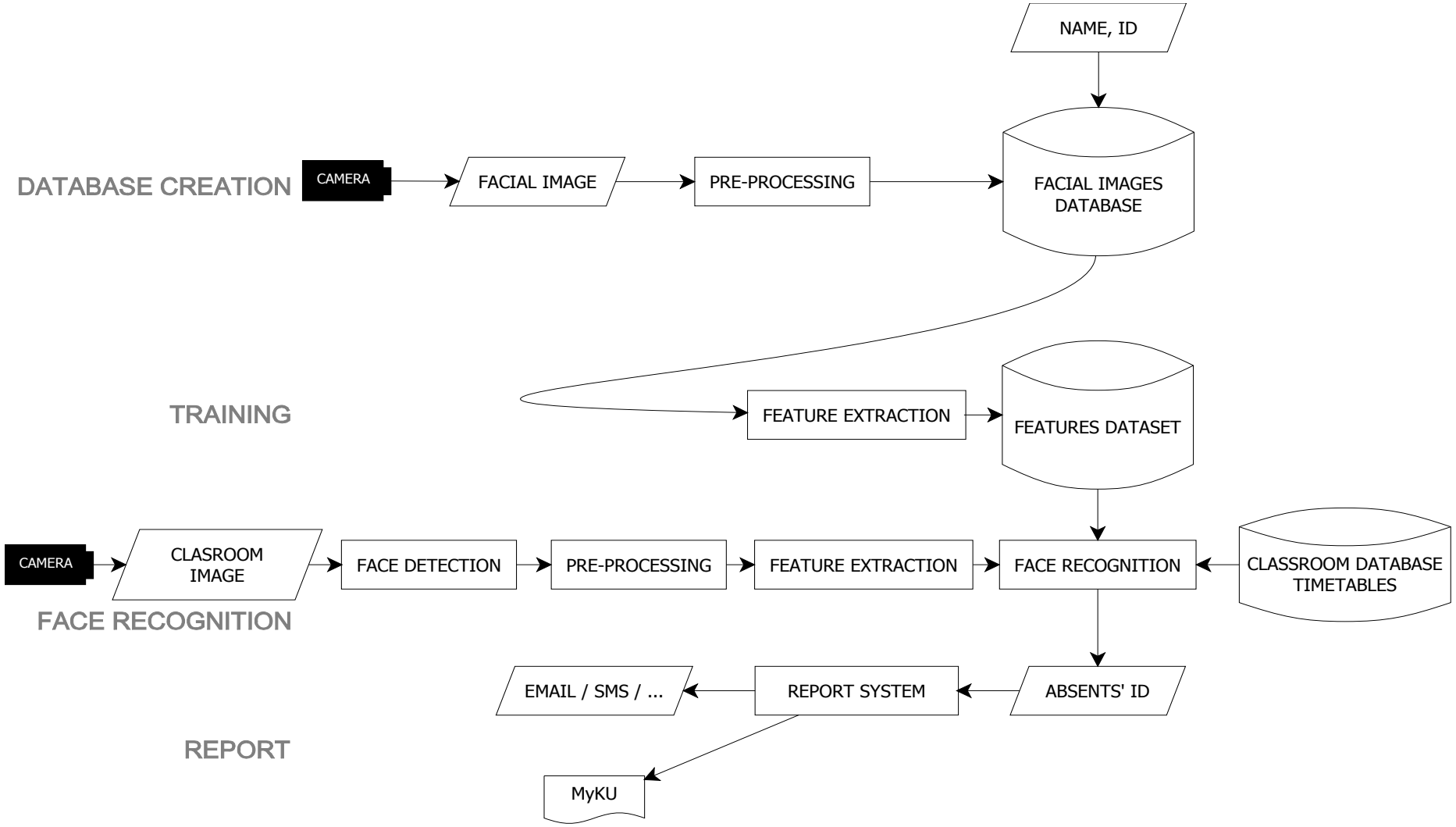
Aspects to consider

- Feedback
  - Students
  - Teacher
- Report
- GUI
- Level of automation
- Databases
  - Connection
  - Amount of faces
- Enrolling system

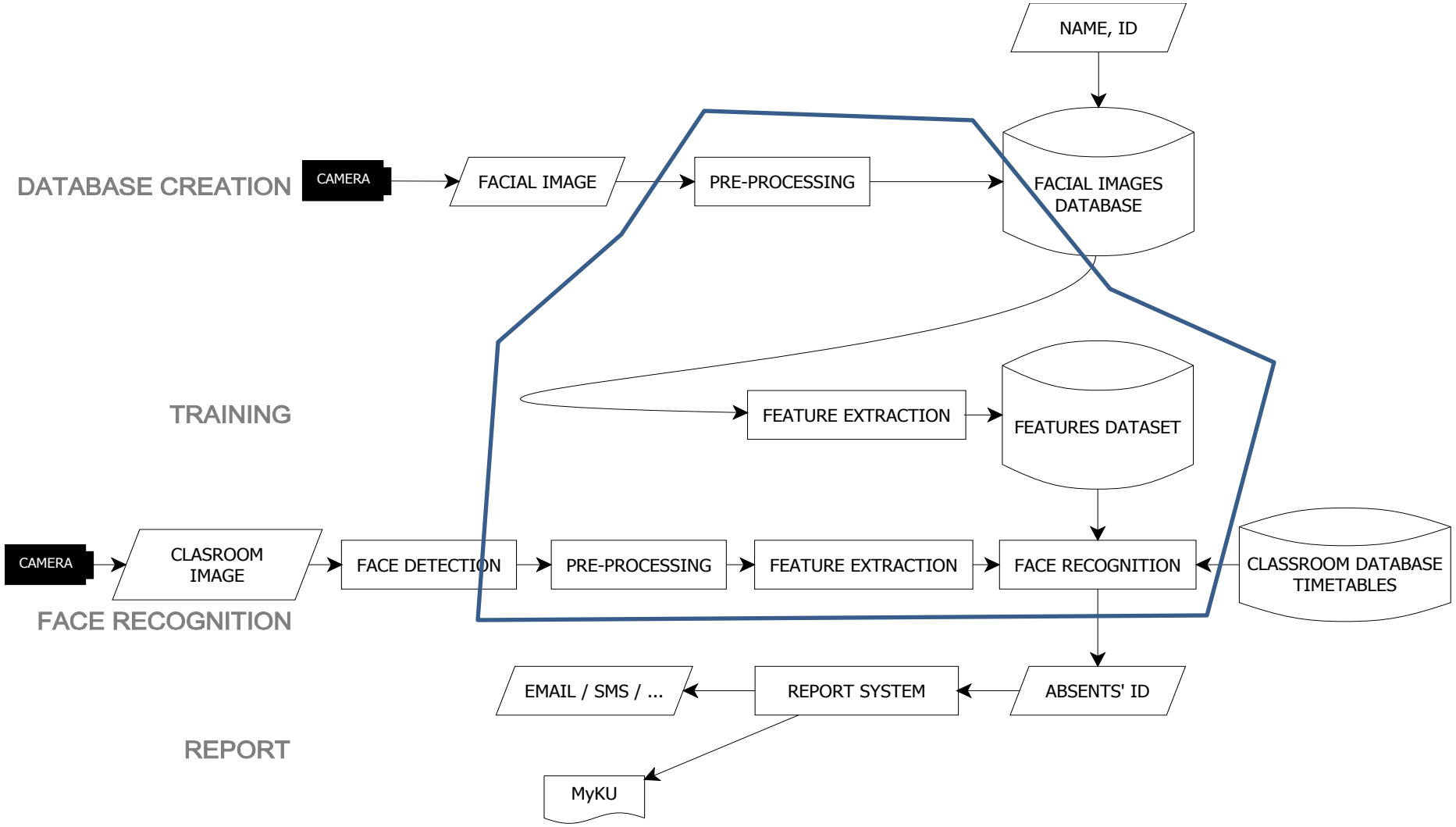
System proposal: Constraints

- One camera per classroom
  - Wide angle, high resolution
- Students will face the camera and not intentionally occlude their faces
- Viola-Jones face detector
- EigenFaces feature description
- Matlab

System proposal



System proposal



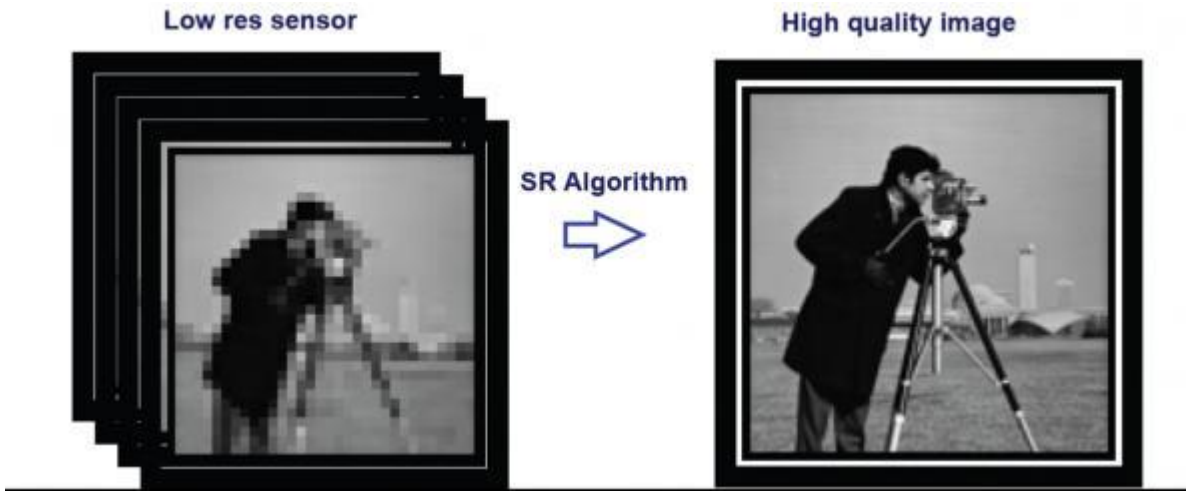
Design

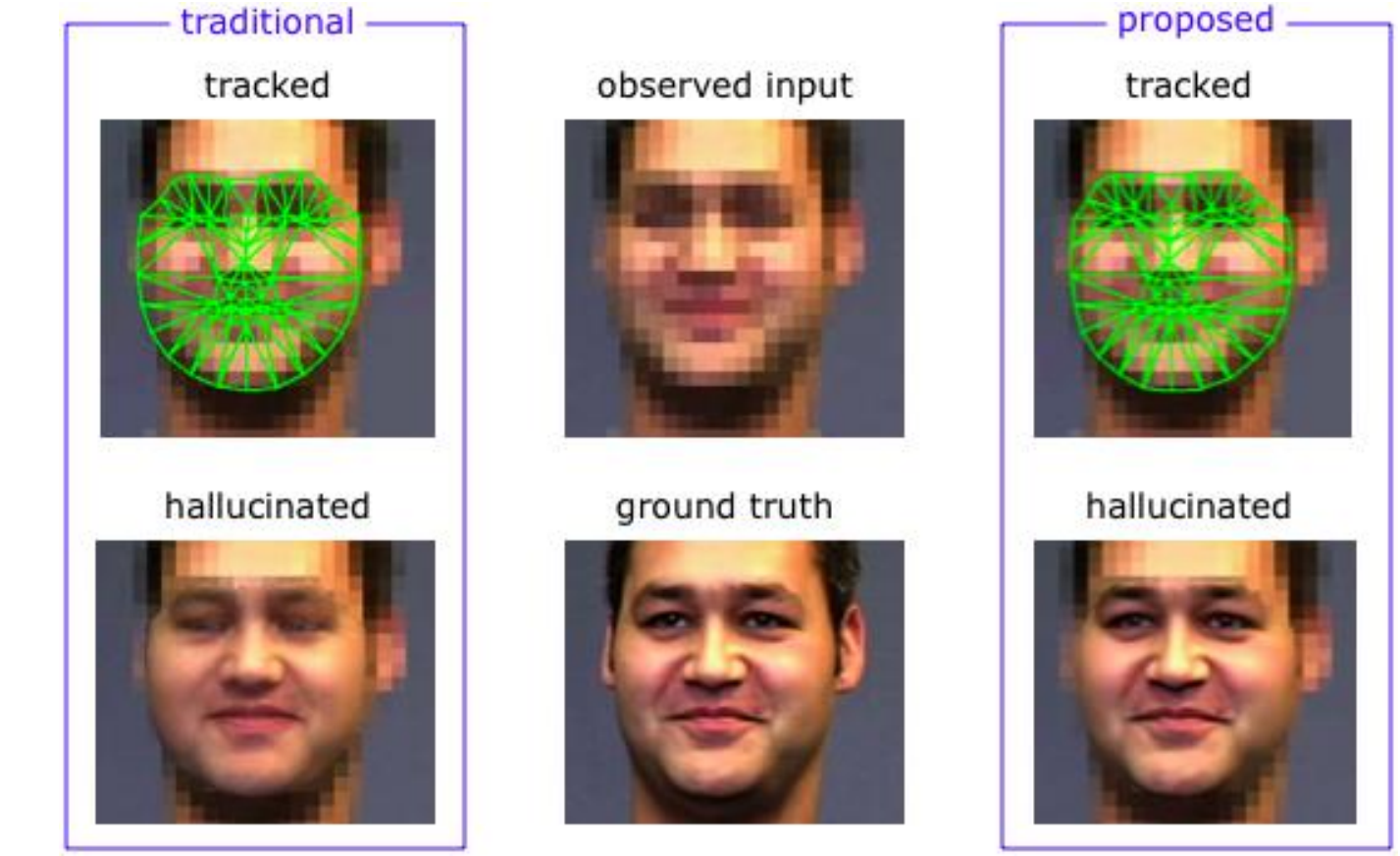
- Object oriented programming
  - Modular framework
  - Easy to upgrade

```
FeatureExtractor = Eigenfaces();
FeatureExtractor.getFeatures(image_array);
…
FeatureExtractor = LBP();
```

Design

- Super resolution
  - For images, before detection
  - For faces, before recognition : Face hallucination. Uses known information about faces.




traditional
tracked
hallucinated
observed input
ground truth
proposed
tracked
hallucinated

Design

- Face frontalization before recognition
  - Geometric normalization
  - Tal Hassner et al. (2014-2015)

Design

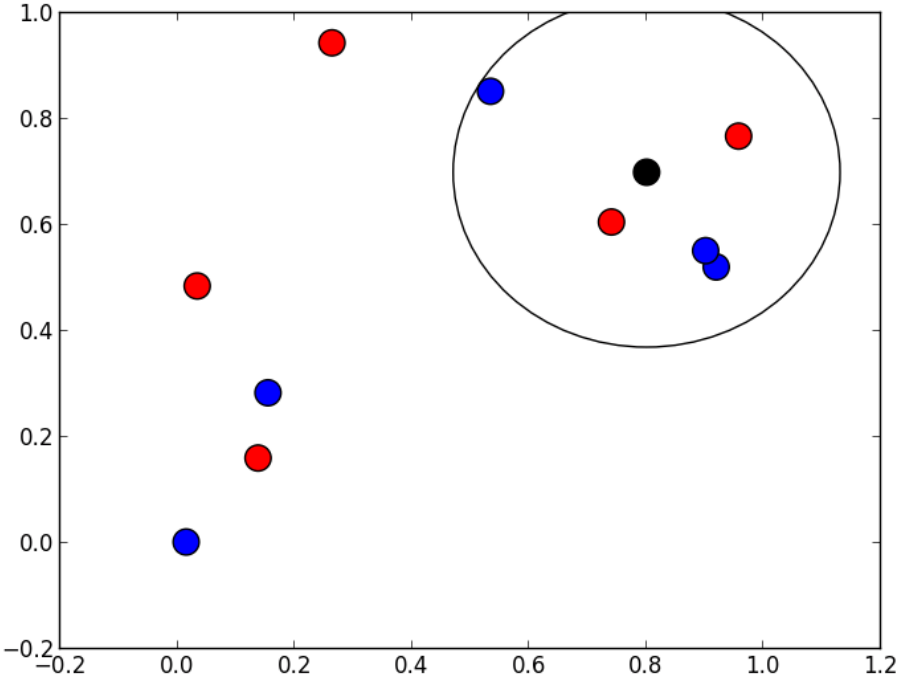
- Tan & Triggs photometric normalization

Design

- Database
  - Multiple faces for each student
    - Different angles, illumination, expressions
    - Unique ID
- Unrecognized
  - Manual verification if reliability under pre-set threshold

Design

- Classification: k Nearest Neighbours
  - Distance functions: Cityblock, Euclidean, Standardized Euclidean, Mahalanobis, Cosine, Chi Square



Main program

- Classes
  - Image
  - TestImage
  - Student
  - Class
  - ClassDatabase
  - FeatureExtractor
    - EigenFaces
  - Classifier

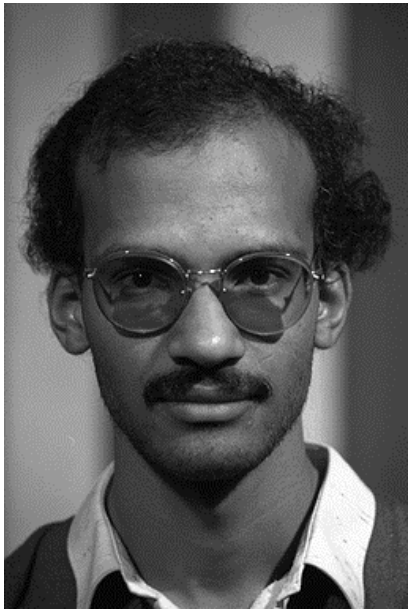
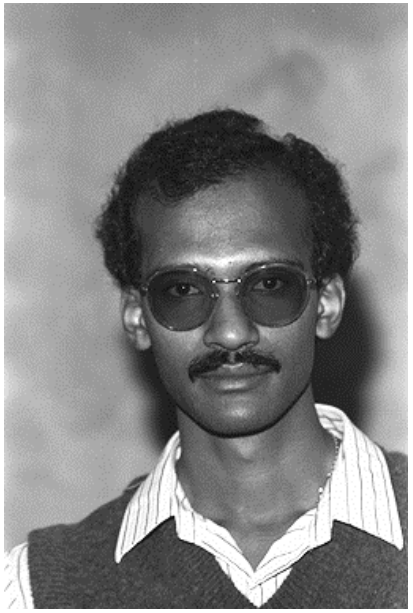
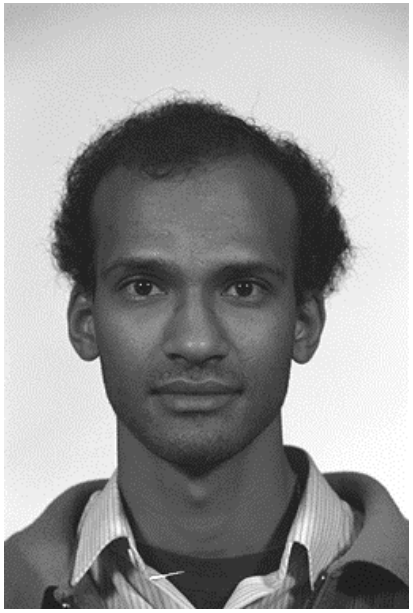
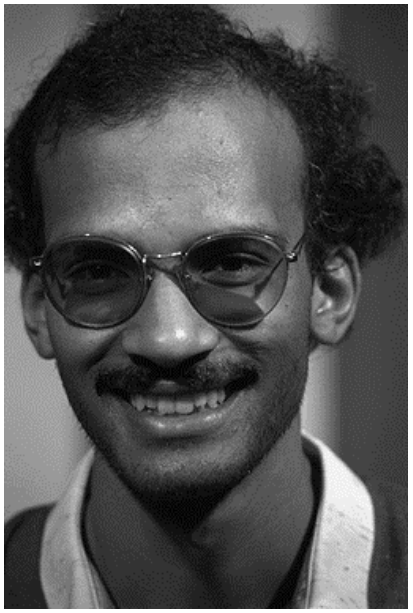
Main program

- Load photos from database. Split and save in testing and training sets.
- Preprocess and save training faces (detection, normalization)
- Class object, load IDs corresponding to that class. Load faces for that class. Train feature extractor. Train classifier
- Load test images. Preprocess. Classify and evaluate reliability

Main program

- Results:
  - 10 fold mean loss for different k nearest neighbours

Distance	knn = 1	knn = 3	knn = 5	knn = 7
Euclidean	0,22857143	0,22857143	0,21428571	0,25
Seuclidean	0,18571429	0,18571429	0,2	0,19285714
Cosine	0,22142857	0,21428571	0,19285714	0,2



Main program

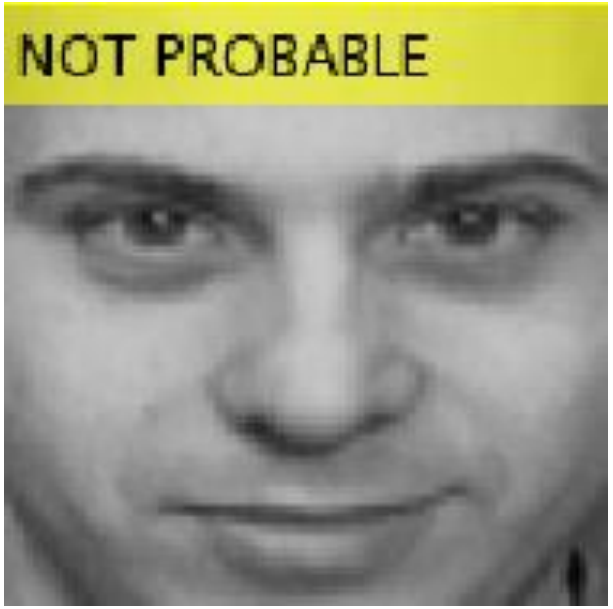
- Results:
  - Correctly recognized face

Main program

– Incorrectly recognized face

Main program

– False negative

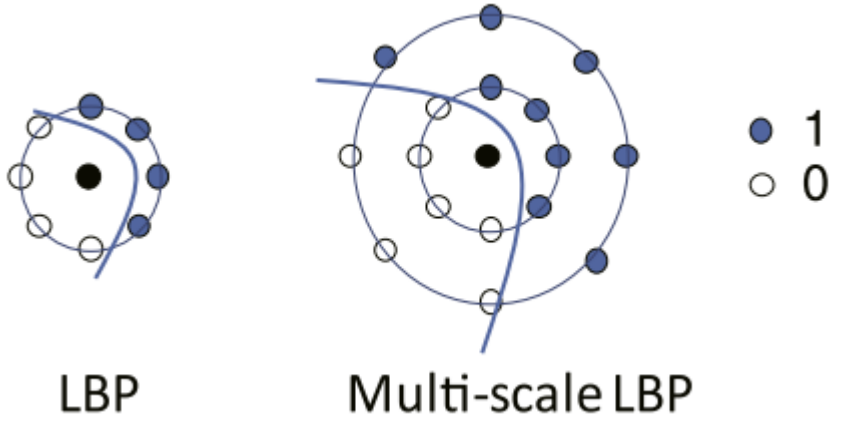


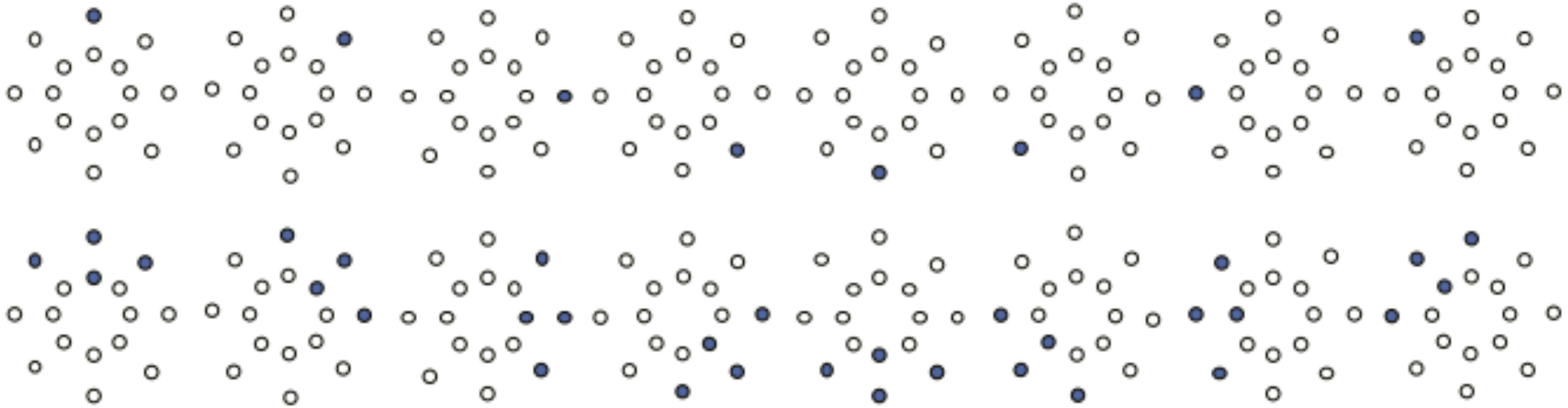
Input program

- Classes:
  - InputSequence
  - DetectedPerson
- Extract sample frames from a video
- Detect faces in frames
- All faces in the same position are assigned to the same detected person

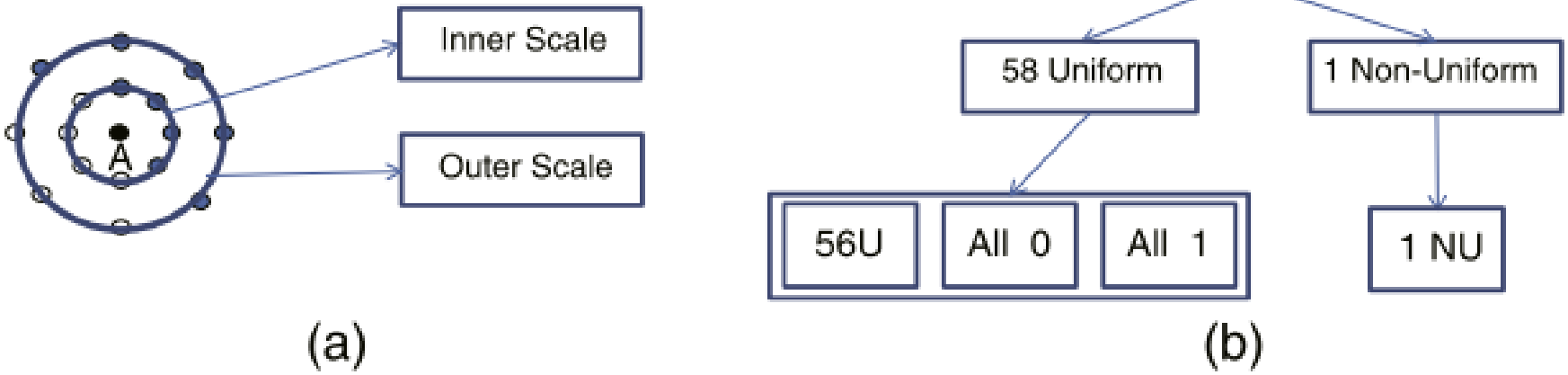
Input program

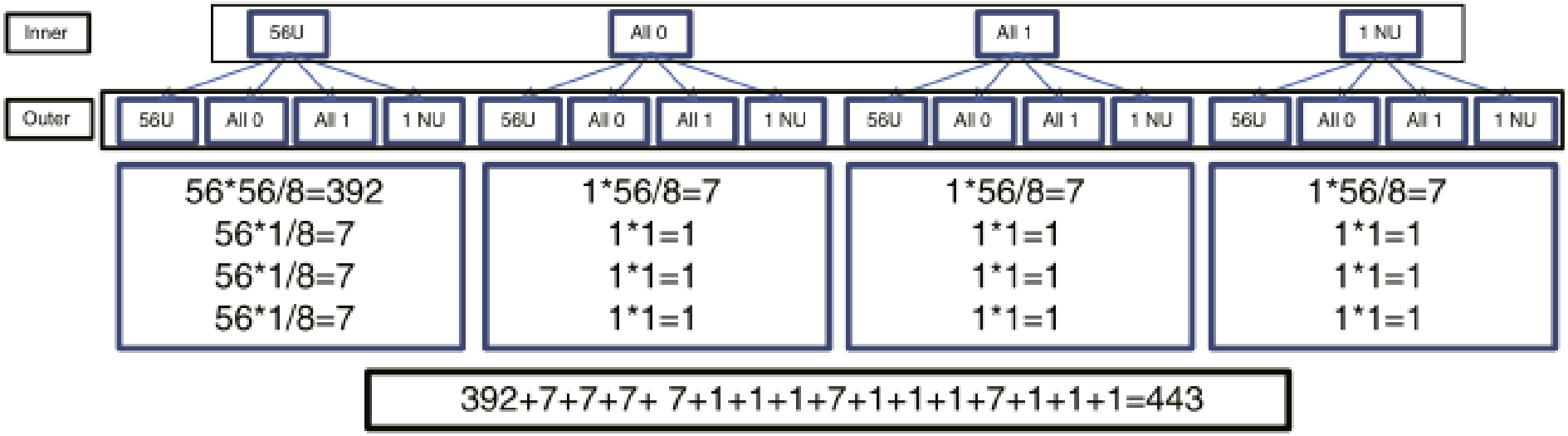
Globally rotation invariant multi-scale co-occurrence local binary pattern (MCLBP)





MCLBP


Inner Scale
Outer Scale
A
All LBP Patterns
58 Uniform
1 Non-Uniform
56U
All 0
All 1
1 NU
(a)
(b)


Inner
Outer
56U
All 0
All 1
1 NU
56*56/8=392
56*1/8=7
56*1/8=7
56*1/8=7
1*56/8=7
1*1=1
1*1=1
1*1=1
1*56/8=7
1*1=1
1*1=1
1*1=1
1*56/8=7
1*1=1
1*1=1
1*1=1
392+7+7+7+ 7+1+1+1+7+1+1+1+7+1+1+1=443

MCLPB/C

- “Completed” or “center gray level”
- Feature vector for pixels above mean pixel value
- Feature vector for pixels below mean pixel value
- 443 + 443 = 886 components

MCLBP/C

- Database: FERET
- September 96 evaluation protocol
  - FA: Gallery / Training set
  - Probe sets:
    - FB
    - FC
    - Dup1
    - Dup2

MCLBP/C

fa

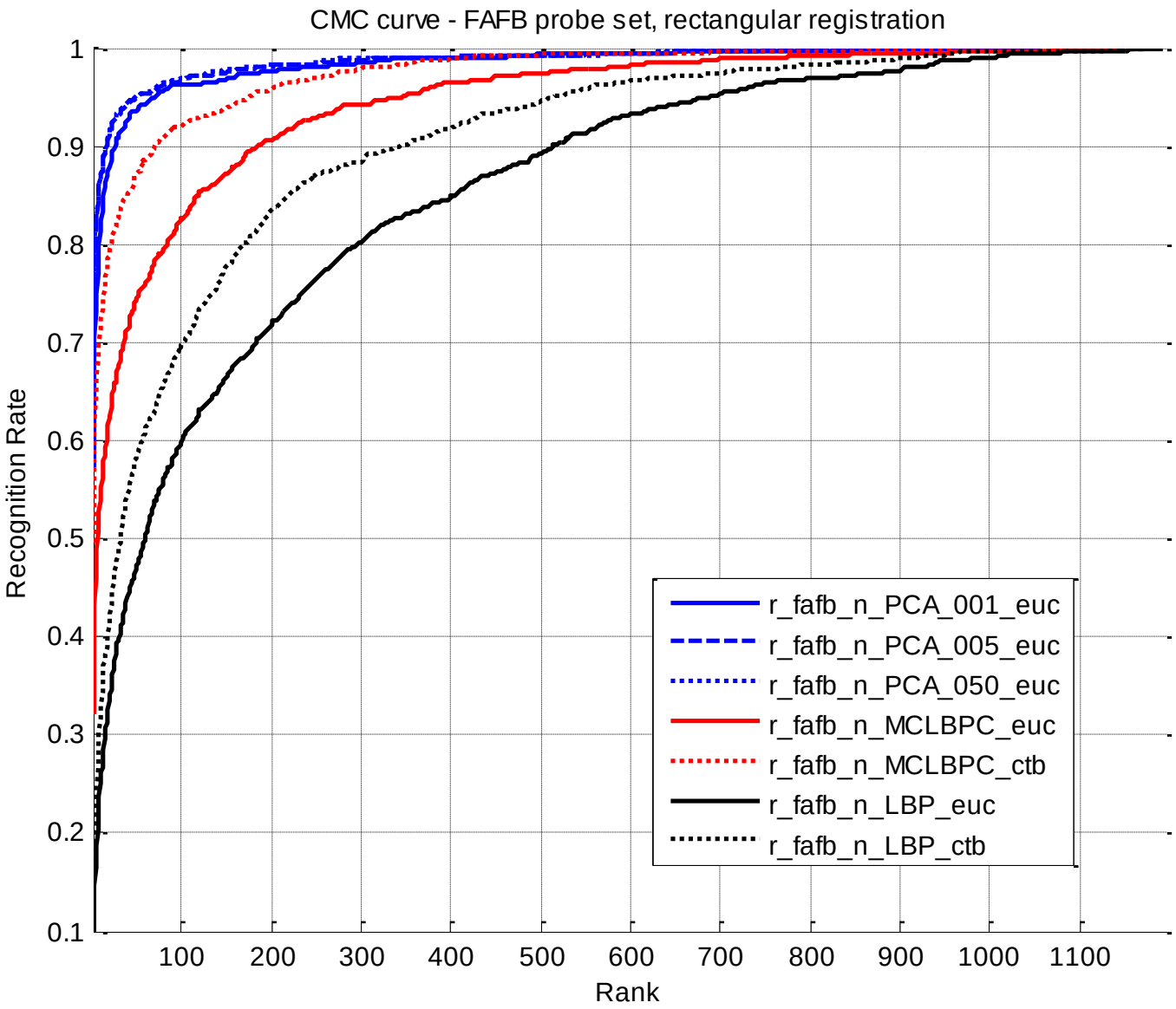
fb

duplicate I

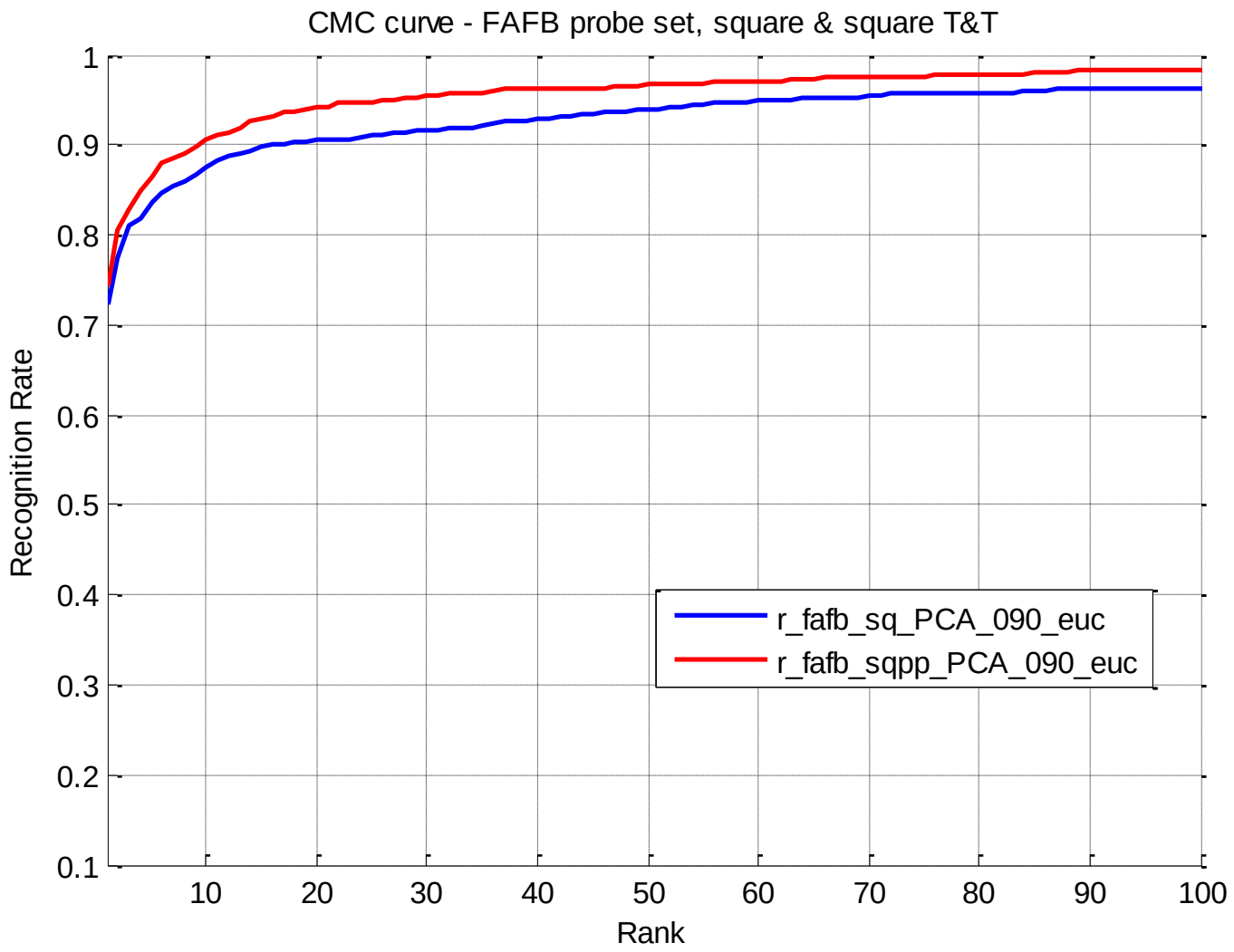
fc

duplicate II

MCLPB/C


CMC curve - FAFB probe set, rectangular registration
Recognition Rate
Rank
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
100
200
300
400
500
600
700
800
900
1000
1100
r_fafb_n_PCA_001_euc
r_fafb_n_PCA_005_euc
r_fafb_n_PCA_050_euc
r_fafb_n_MCLBPC_euc
r_fafb_n_MCLBPC_ctb
r_fafb_n_LBP_euc
r_fafb_n_LBP_ctb

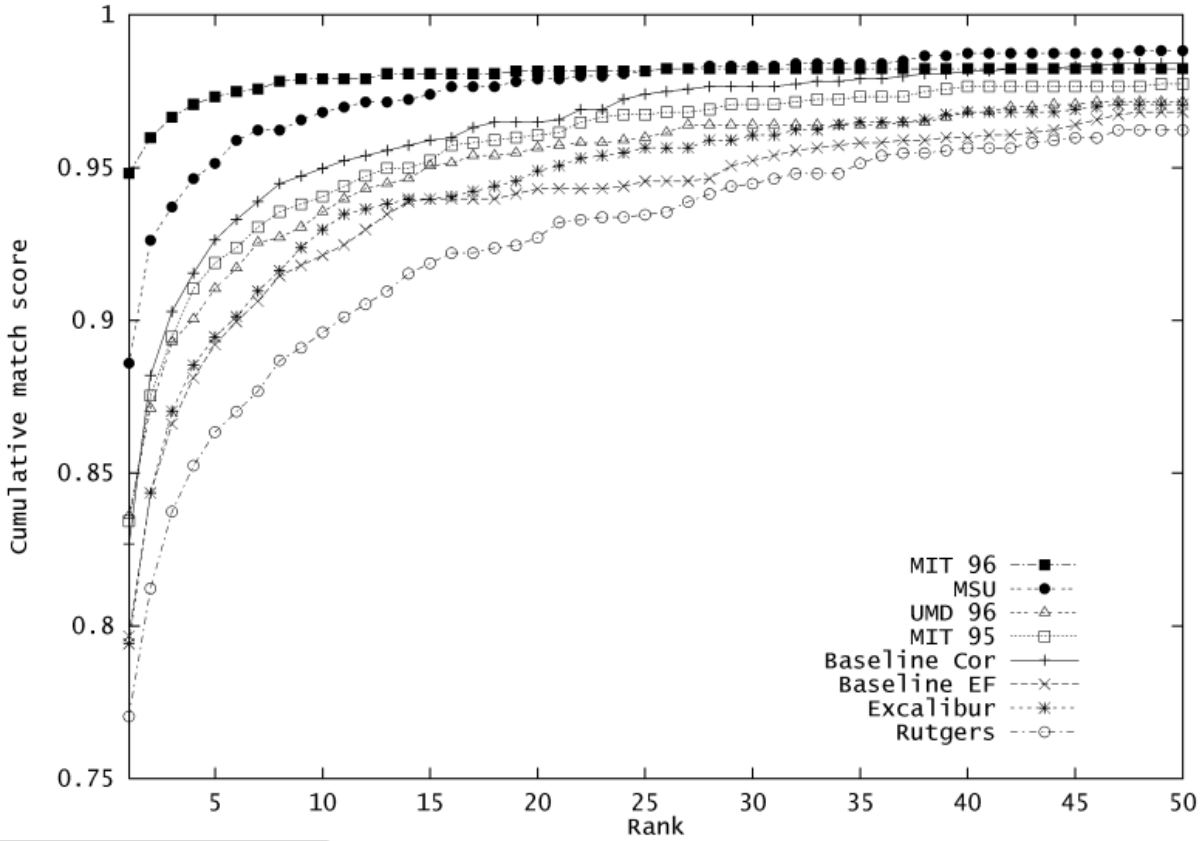
MCLPB/C


CMC curve - FAFB probe set, square & square T&T
Recognition Rate
Rank
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
10
20
30
40
50
60
70
80
90
100
r_fafb_sq_PCA_090_euc
r_fafb_sqpp_PCA_090_euc

MCLPB/C with FAFB probe set

PCA 1%	Euclidean	57
PCA 5%	Euclidean	68
PCA 50%	Euclidean	71
MCLBP/C	Euclidean	32
MCLBP/C	Cityblock	49
LBP	Euclidean	8
LBP	Cityblock	10

Our results



Phillips et al. 2000

Liu et al. 2014

Method	FB	fc	dup. I	dup. II
PCA	0.85	0.65	0.44	0.22
Fisherface	0.94	0.73	0.55	0.31
LBP	0.97	0.79	0.66	0.64
Gabor-M+FLDA	0.9615	0.7629	0.5817	0.3419
LGBP-M [4]	0.98	0.97	0.74	0.71
E-GV-LBP-M [5]	0.9841	0.9897	0.8199	0.8162
VLD-GLBP	**0.9707**	**0.9536**	**0.7230**	**0.7009**

MCLPB/C with FAFB probe set

	Results at Rank 1 (%)			
	Metric			
Projection	**L1**	**L2**	**MAH**	**COS**
		Fb		
PCA	**82.26**	*82.18*	*64.94*	*81.00*
ICA1	*81.00*	**81.51**	*64.94*	*80.92*
ICA2	*64.94*	*74.31*	*64.94*	**83.85**
LDA	*78.08*	**82.76**	*70.88*	*81.51*
		Fc		
PCA	**55.67**	*25.26*	*32.99*	*18.56*
ICA1	*18.04*	*17.53*	**32.99**	*12.89*
ICA2	*15.98*	*44.85*	*32.99*	**64.95**
LDA	*26.80*	*26.80*	**41.24**	*20.62*
		Dup1		
PCA	**36.29**	*33.52*	*25.62*	*33.52*
ICA1	**32.55**	*31.86*	*25.62*	*32.27*
ICA2	*28.81*	*31.99*	*25.62*	**42.66**
LDA	**34.76**	*32.96*	*27.70*	*33.38*
		Dup2		
PCA	**17.09**	*10.68*	*14.53*	*11.11*
ICA1	*8.97*	*7.69*	**14.53**	*8.97*
ICA2	*16.24*	*19.66*	*14.53*	**28.21**
LDA	*16.24*	*10.26*	**16.67**	*10.68*

Delac et al. 2005

Conclusions

- Real 90% recognition rate can be more than enough for earning time
  - Not state-of-the-art needed, but EigenFaces is not enough
- Field conditions should be evaluated
  - Pan/zoom/tilt camera - Super-resolution
  - Robust feature extractor
  - Photometric normalization
  - Geometric normalization

Conclusions

- Testing code needs more development
  - All system features should be previously determined
  - Object orientation is good, but classes should be reviewed
- Hardware platform should be determined for final code
- Public code was very useful for developing. Sharing code is important for research.

Conclusions

- MCLBP should be tested again, assuring that the framework is already working for PCA and LBP.
  - SVM with Chi squared kernel?