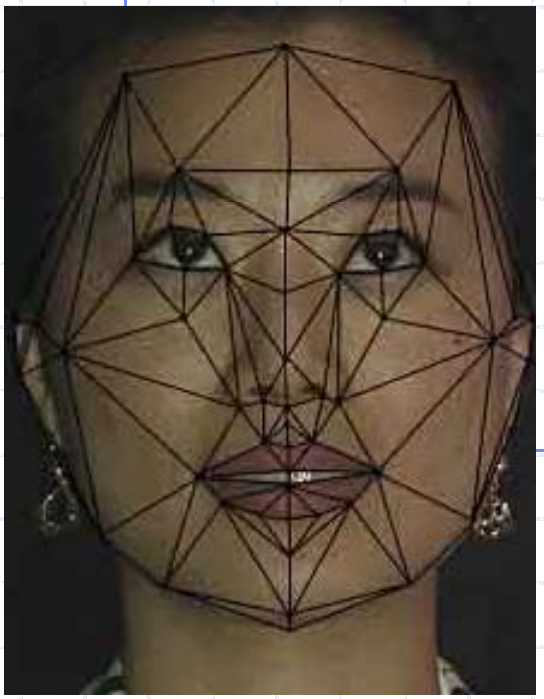
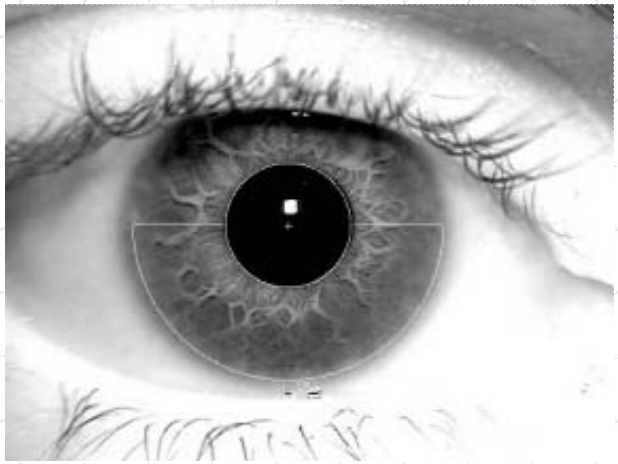
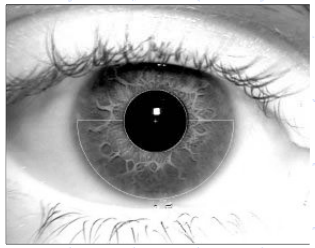
Face normalisation



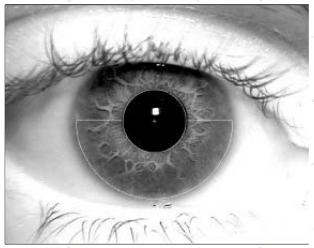


Face Recognition and Biometric Systems

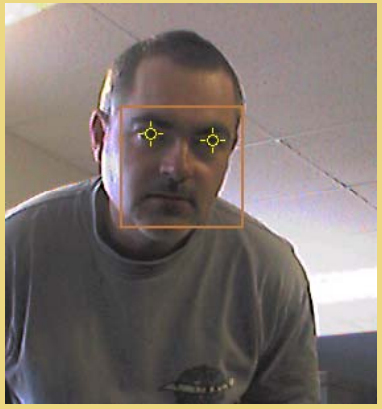


Plan of the lecture

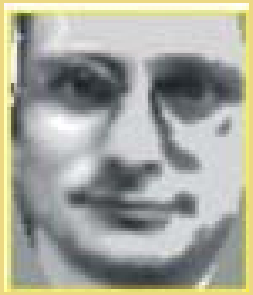
- Normalisation – task definition
  - testing issues
- Geometric normalisation
- Lighting normalisation
- Advanced normalisation issues



Face recognition process



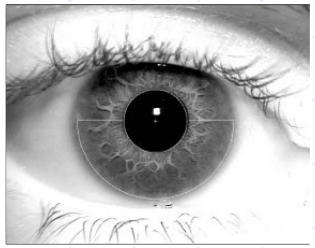
Detection



Normalisation

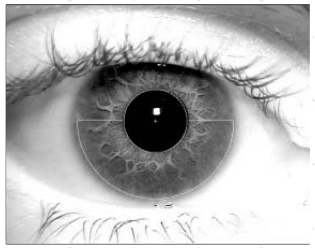
Feature extraction

Feature vectors comparison



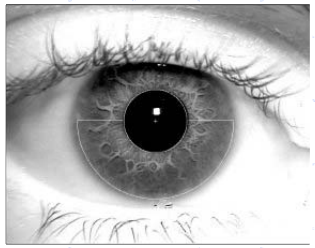
Normalisation – general

- Image preparation for feature extraction
  - similar properties of generated images
    - geometry
    - conditions (e.g.: lighting, expression)
    - occlusions
- Intra-class differences minimised
- Extra-class differences not influenced



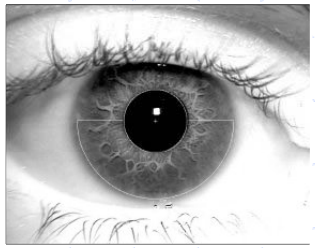
Normalisation – general

- Effectiveness criteria
  - visual effect
  - recognition performance
- Detection error influences normalisation result



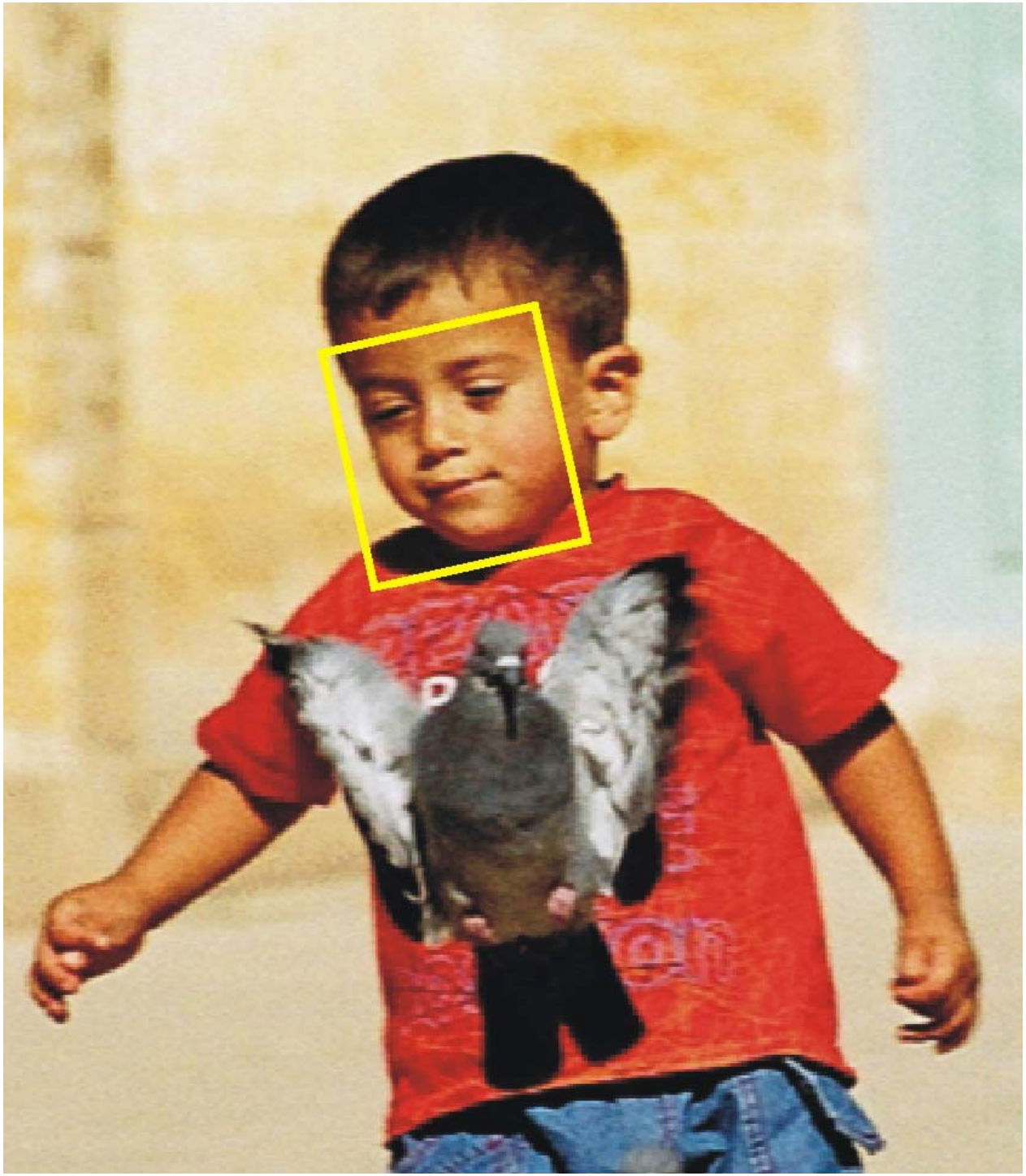
Normalisation – general

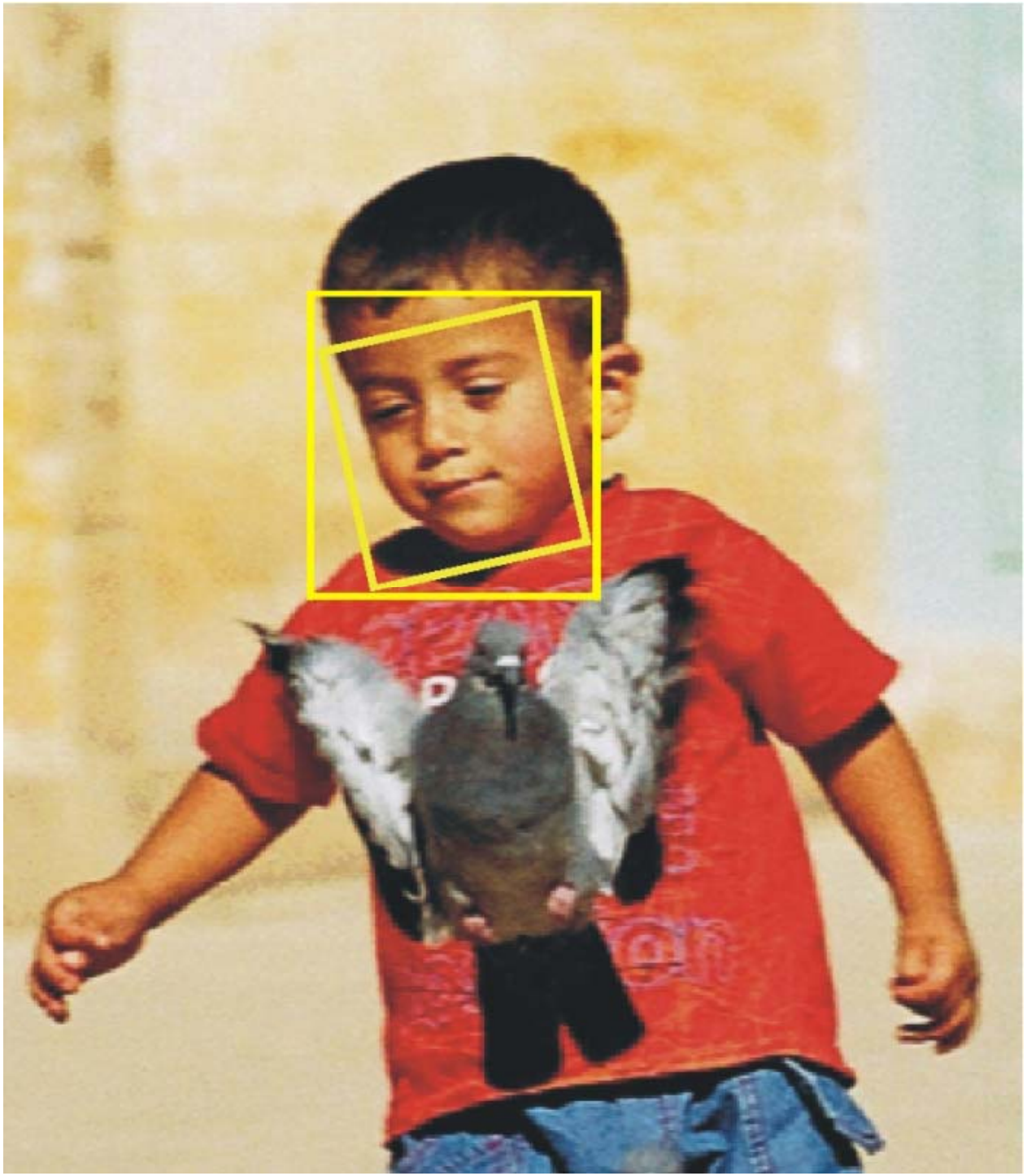
- Perfect detection
  - real location of face and facial features
  - data input by human
- Elimination of detection error propagation
- Better assessment of subsequent recognition stages

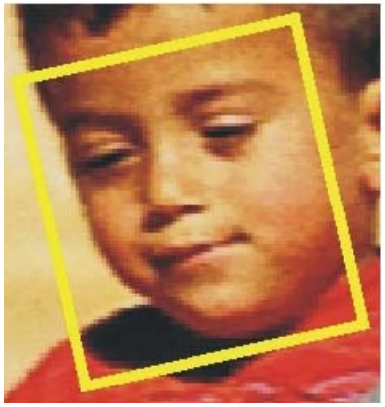


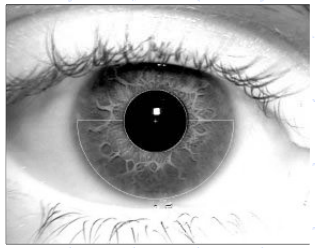
Geometric normalisation

- Requirements:
  - constant image size
  - fixed eye positions
  - frontal orientation (soft requirement)
- Frontal faces – goal:
  - given positions of eyes
  - affine transform
- Actions:
  - clipping
  - rotation
  - scaling
- Time for example



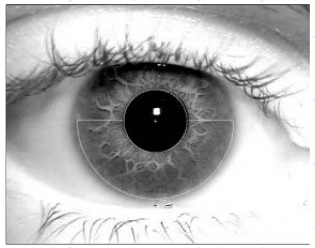






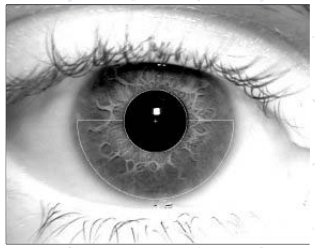
Geometric normalisation

- Speed optimisation
  - larger image = more time consumed
- Optimal algorithm:
  1. Calculate rotation angle
  2. Find and clip the ROI
  3. Rotate the clipped image
  4. Clip again
  5. Scale to the defined size



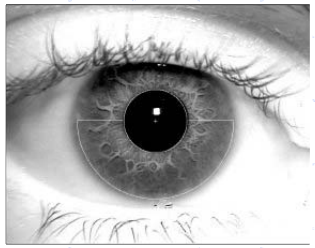
Laboratory reference (ex 2)

- Function parameters
- Eye positions:
  - left (49, 24)
  - right (15, 24)
- IPP reference
  - RotateCenter
  - Resize
- Operations...



Lighting normalisation

- Lighting codnitions affect effectiveness
- Normalisation techniques:
  - global filtering
  - local modifications
- Histogram modifications:
  - stretching
  - equalisation
  - fitting to the average face histogram
- Filtering



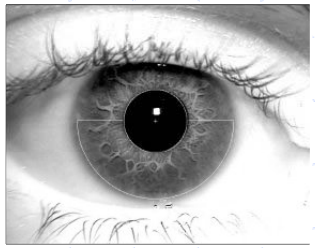
Lighting normalisation

- Average face

$$\boldsymbol{\mu} = \frac{1}{M}\sum_{i=1}^{M}\mathbf{x}_i$$

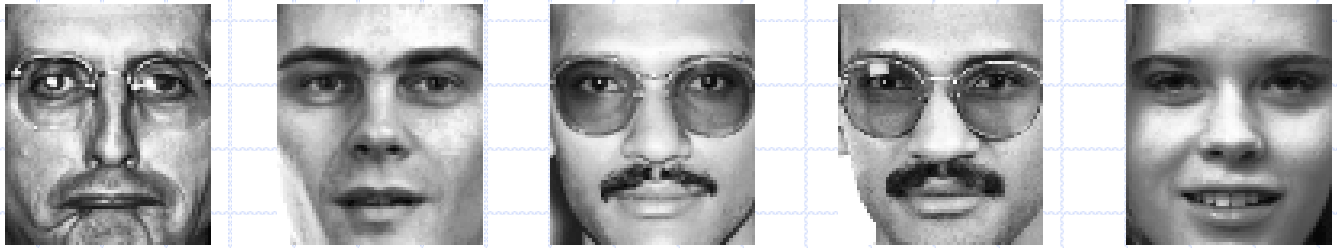
M – number of faces in a set

x – a single face vector

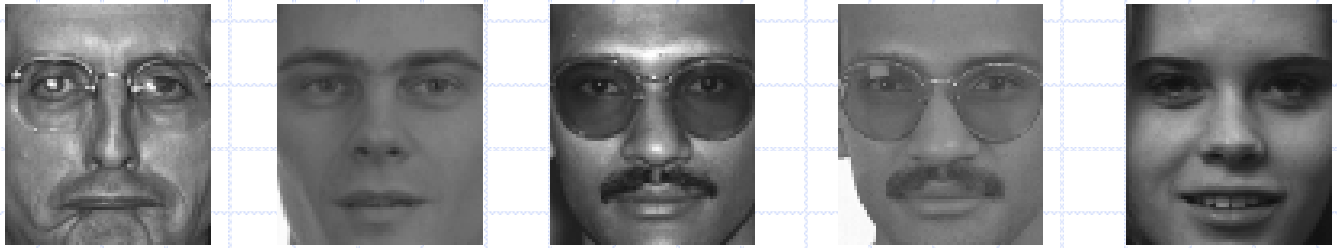


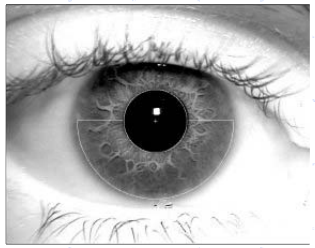
Lighting normalisation

- With histogram fitting:

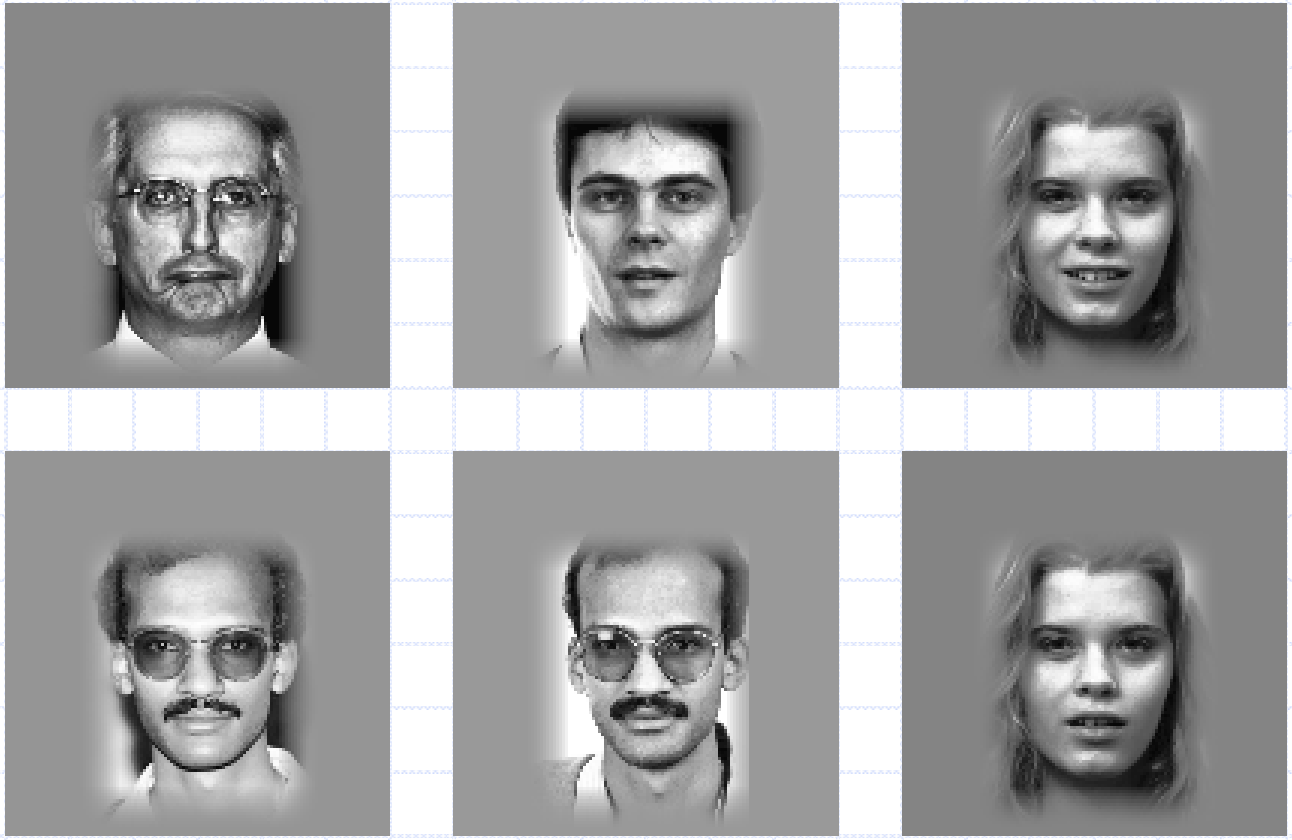


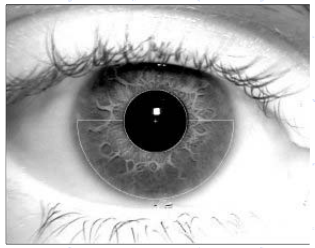
- Without histogram fitting:





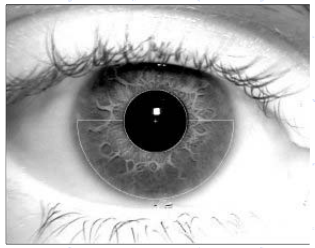
Lighting normalisation





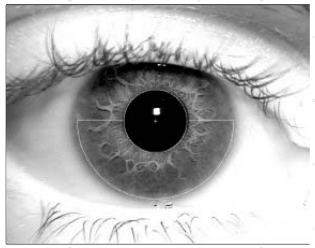
Lighting normalisation

- Brightening filters – example of effects

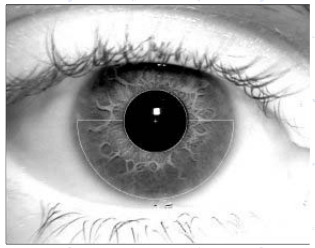


Lighting normalisation

- Directional lighting:
  - strong influence on the image
  - recognition effectiveness much worse
- Light direction normalisation:
  - light angle detection
  - compensation to the frontal light conditions

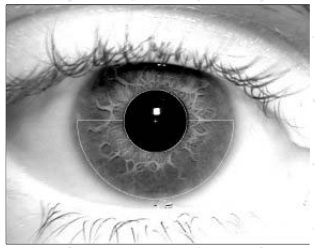


Lighting normalisation



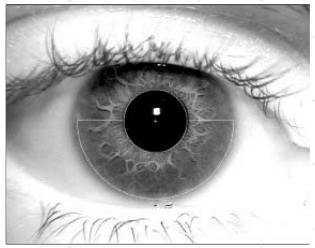
Lighting normalisation

- Mirror reflection
- Lighting compensation masks:
  - lighting symmetrisation
  - compensation to the average
  - model-based mask
- Filtering based on lighting model
- Compensation based on lighting model



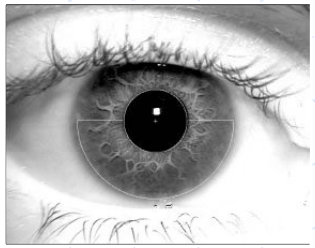
Lighting normalisation

- Mirror reflection
  - Condition: no information in one image half
  - Image half recovery
  - Applicable to frontal faces only
  - Brightness and angle thresholding



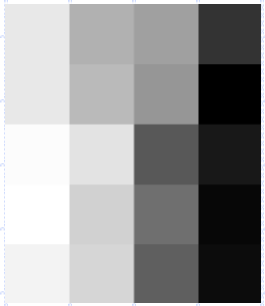
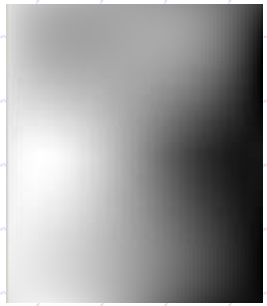
Lighting normalisation - masks

- Image-based lighting compensation masks
  - dark areas lightened
  - highlights darkened
- Mask imposition on the original image:
  - addition
  - multiplication
  - advanced imposition – to be investigated...



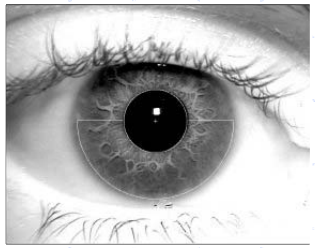
Lighting normalisation - masks

- Symmetric mask

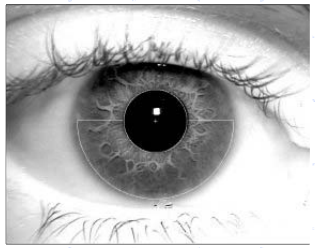

- Compensation to the average



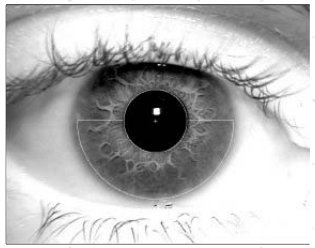
Lighting normalisation

- Lighting compensation – face model
- Detection of lighting direction
  - based on average 3D face model
  - classifiers (SVM, PCA)
- Compensation based on 3D model
  - mask generation
- Works correctly for artificial data



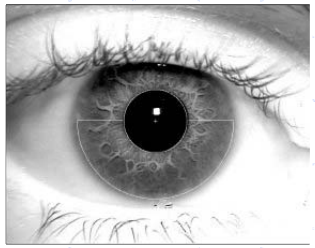
Lighting normalisation

- Lighting-model based compensation
- Initial object (ambient light):
  - a[m,n]
- Illuminated object:
  - c[m,n] = a[m,n] • I[m,n]



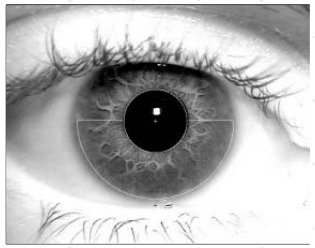
Lighting normalisation

- Light – low frequencies in the image
- Low frequencies elimination:
  - $\ln(c[m,n]) = \ln(I[m,n]) + \ln(a[m,n])$
  - $HP\{\ln(c[m,n])\} \approx \ln(a[m,n])$
  - $a'[m,n] = \exp\{HP\{\ln(c[m,n])\}$
- Theory seems nice...



Advanced normalisation

- Head rotation normalisation
  - frontal image desired
- Face expression normalisation
  - neutral expression
  - expression detection
- Elimination of occlusions
  - glasses
  - beard and moustache

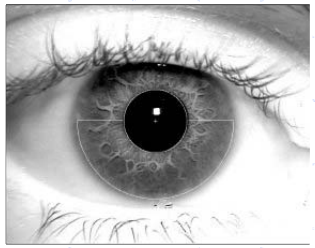


Non-frontal images



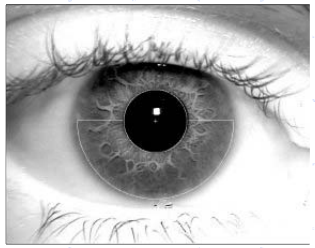


- Significant influence on recognition effectiveness
- Normalisation (rotation):
  - 3D
  - 2D + depth map
- The most serious problem: angle detection



Summary

- Normalisation – important step in face recognition process
- Tasks:
  - size and position normalisation
  - image properties normalisation
- Many areas for further research



Thank you for your attention!