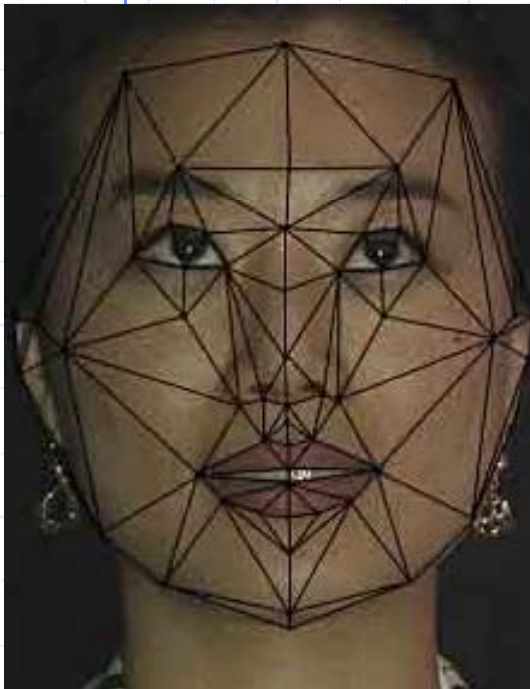
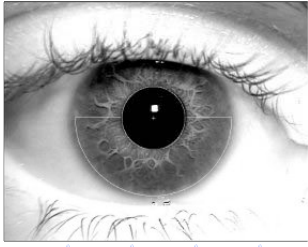




Face normalisation



Face Recognition and Biometric Systems

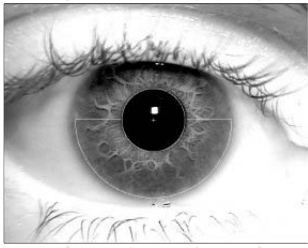


Plan of the lecture

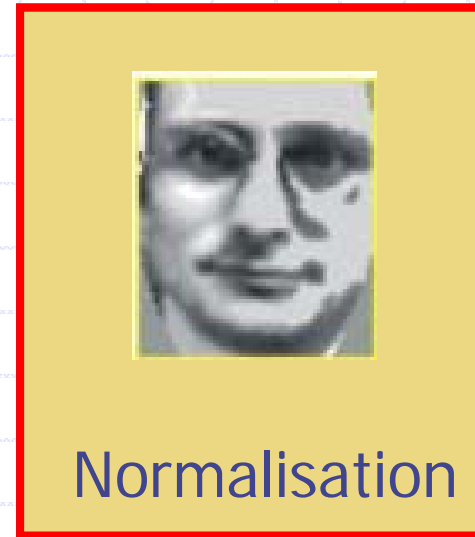
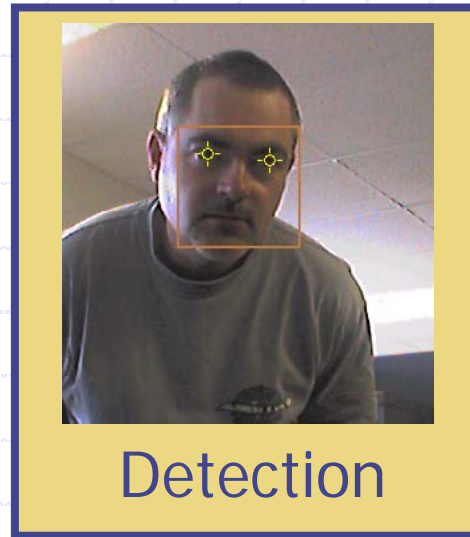


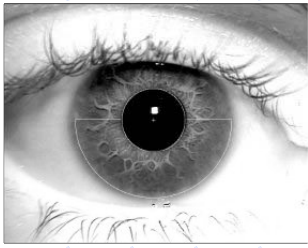
- ◆ Normalisation – task definition
 - testing issues
- ◆ Geometric normalisation
- ◆ Lighting normalisation
- ◆ Advanced normalisation issues





Face recognition process



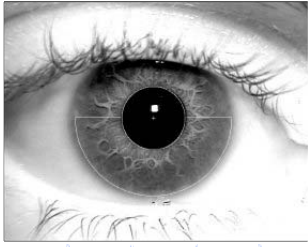


Normalisation – general



- ◆ 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



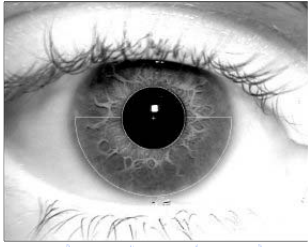


Normalisation – general



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



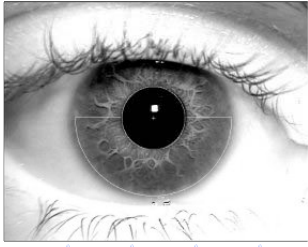


Normalisation – general



- ◆ 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

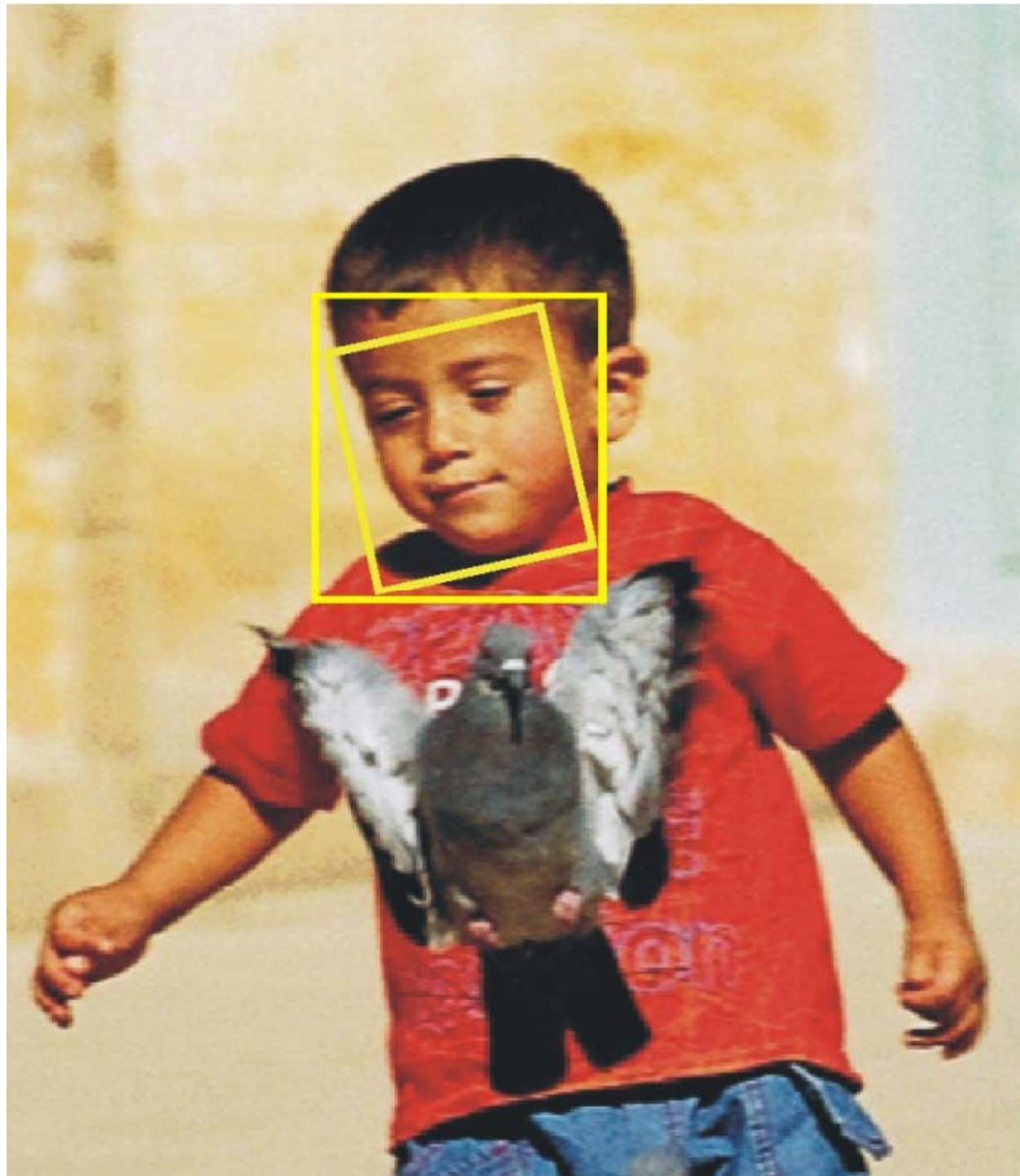
◆ Time for example

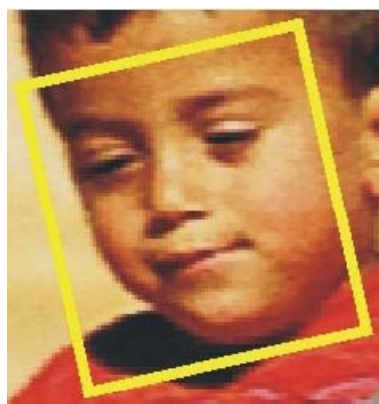






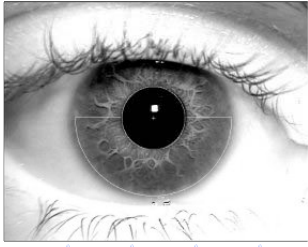










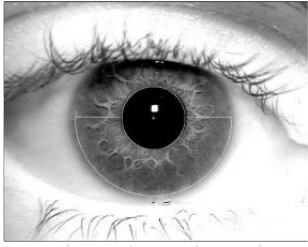


Geometric normalisation



- ◆ 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



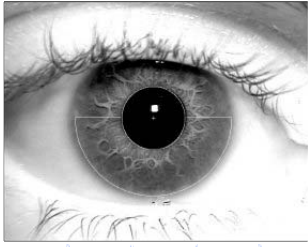


Laboratory reference (ex 2)



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



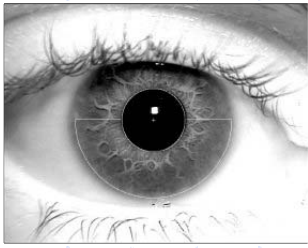


Lighting normalisation



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





Lighting normalisation



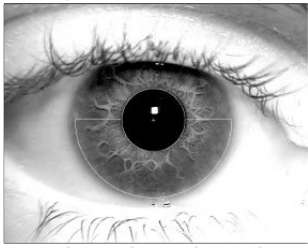
◆ Average face

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

M – number of faces in a set

\mathbf{x} – a single face vector

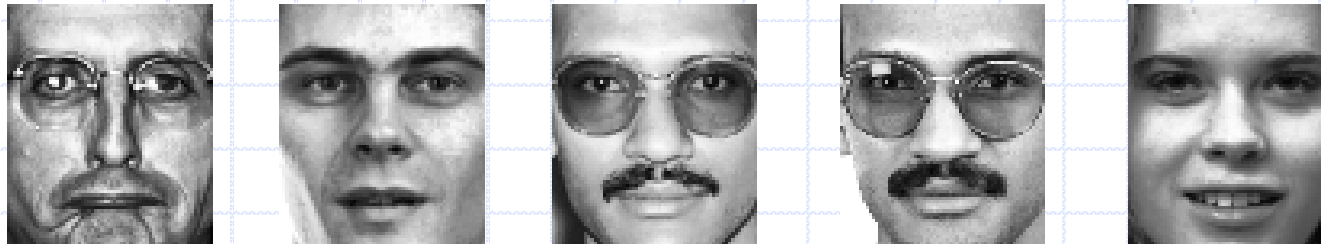




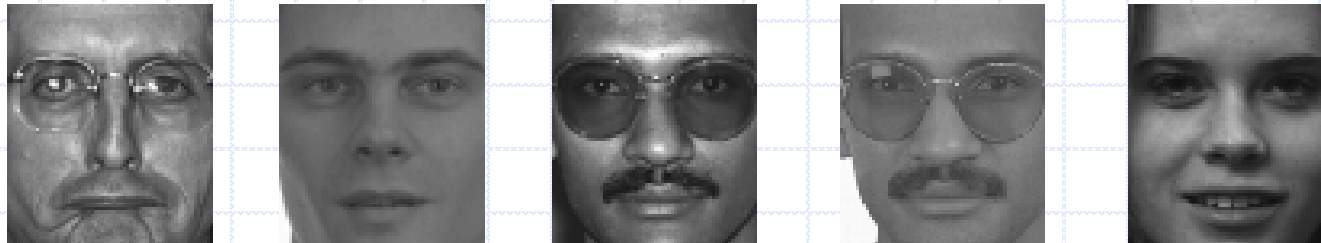
Lighting normalisation

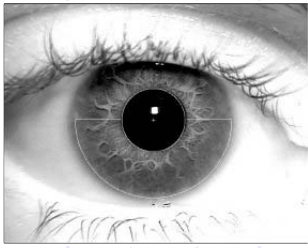


◆ With histogram fitting:

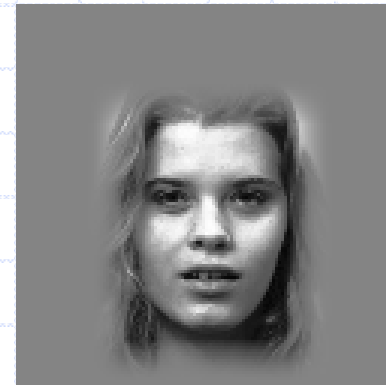
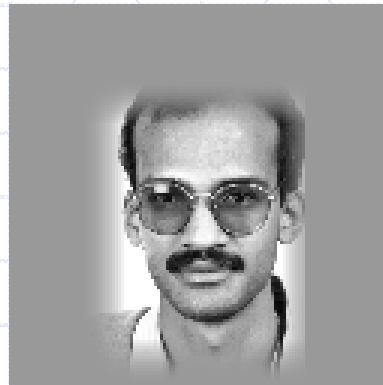
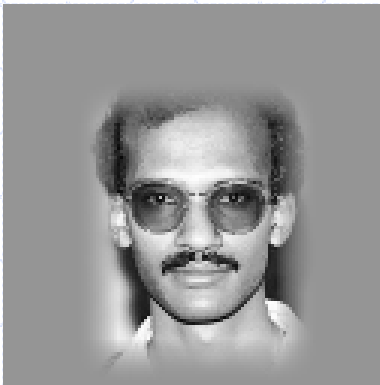
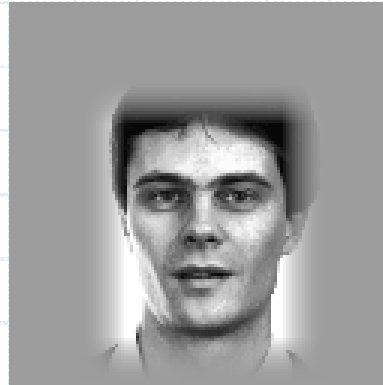
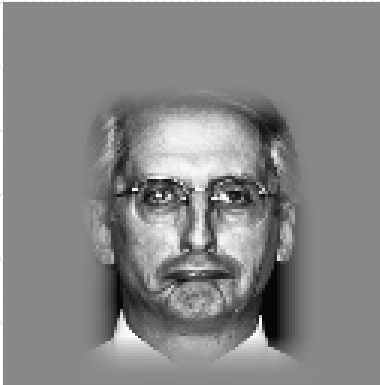


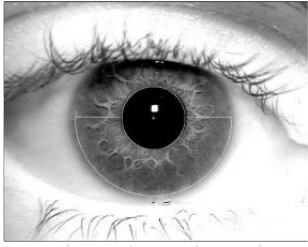
◆ Without histogram fitting:





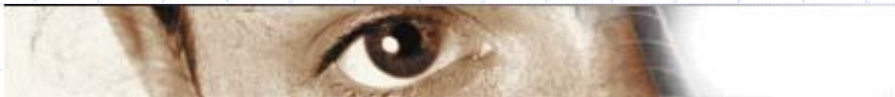
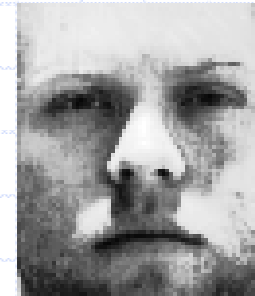
Lighting normalisation

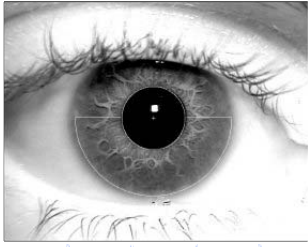




Lighting normalisation

◆ Brightening filters – example of effects



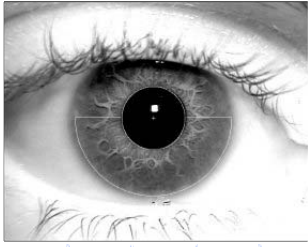


Lighting normalisation

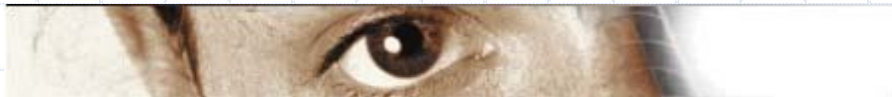


- ◆ Directional lighting:
 - strong influence on the image
 - recognition effectiveness much worse
- ◆ Light direction normalisation:
 - light angle detection
 - compensation to the frontal light conditions

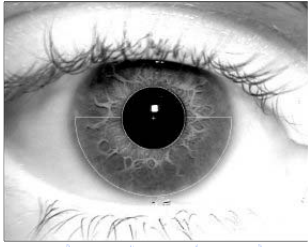




Lighting normalisation



Face Recognition and Biometric Systems

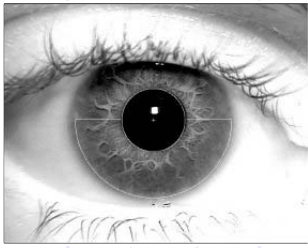


Lighting normalisation



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





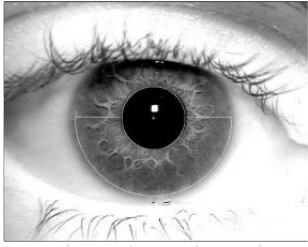
Lighting normalisation



◆ Mirror reflection

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



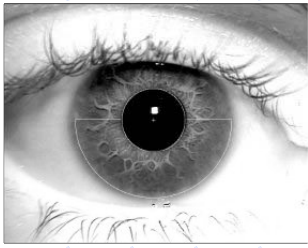


Lighting normalisation - masks



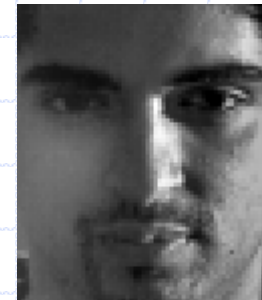
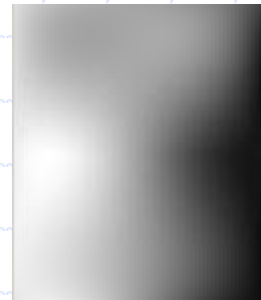
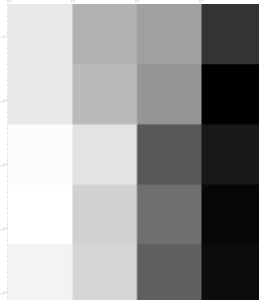
- ◆ Image-based lighting compensation masks
 - dark areas lightened
 - highlights darkened
- ◆ Mask imposition on the original image:
 - addition
 - multiplication
 - advanced imposition – to be investigated...



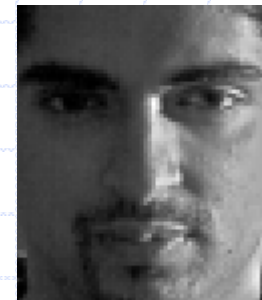
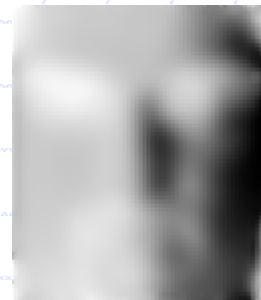


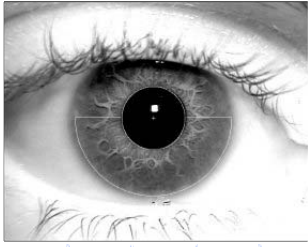
Lighting normalisation - masks

◆ Symmetric mask



◆ Compensation to the average



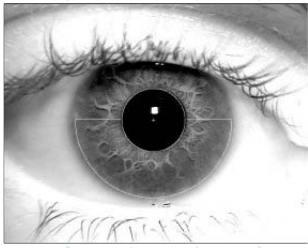


Lighting normalisation



- ◆ 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



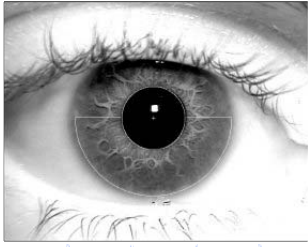


Lighting normalisation



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



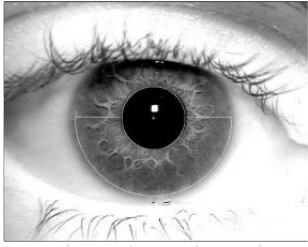


Lighting normalisation



- ◆ 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...



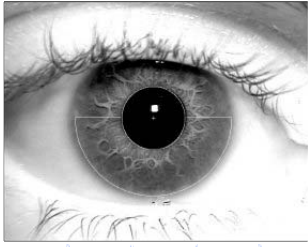


Advanced normalisation



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



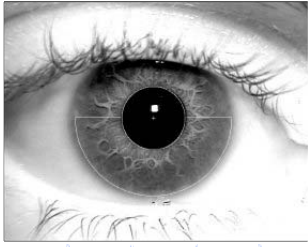


Non-frontal images



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



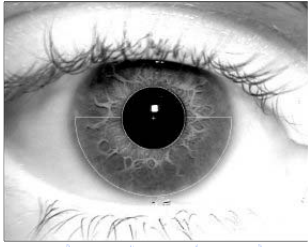


Summary



- ◆ 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!



Face Recognition and Biometric Systems