Personal Detection and Recognition Based on Facial Information

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Vetenskapsrådet

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MARIE CURIE ACTIONS

SEVENTH FRAMEWORK PROGRAMME

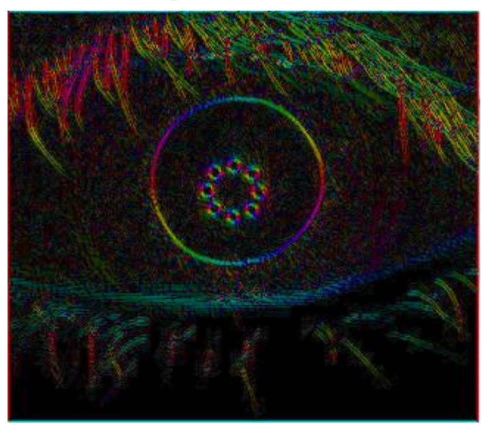
Detection of Iris Boundaries

PROPOSED APPROACH: SEGMENTATION USING THE GENERALIZED STRUCTURE TENSOR (GST) THEORY

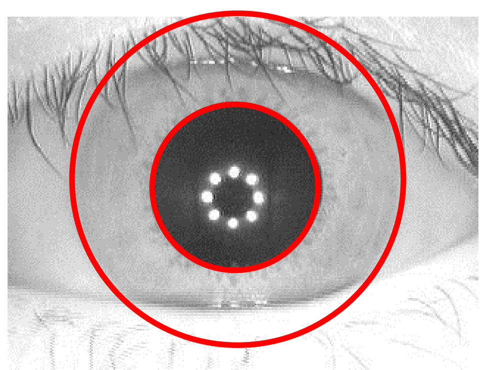
$$I_{20} = \sum_p c[p]\,(f_x[p]+if_y[p])^2 \qquad I_{11} = \sum_p |c[p]|\,|(f_x[p]+if_y[p])|^2$$

(complex) circular filter

image derivatives



detected boundaries



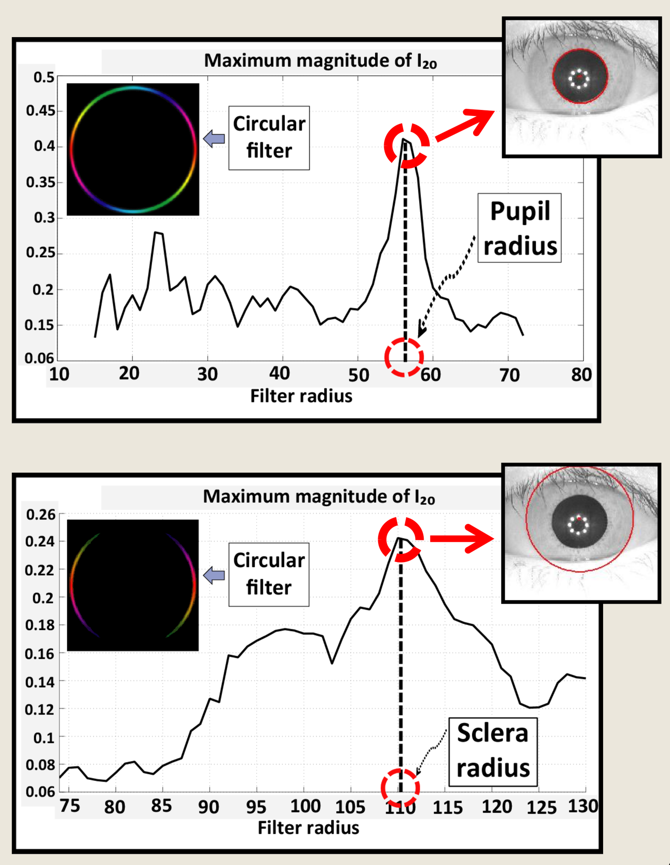
when the circular filter "finds" edges in the image
AND
the local orientation of those edges "agree" with the directions encoded by the filter

- ✓ A high response is observed in $|I_{20}|$
- ✓ Zero argument is obtained in I_{20}
- ✓ Both magnitudes $|I_{20}|$ and I_{11} are equal $(|I_{20}| = I_{11})$

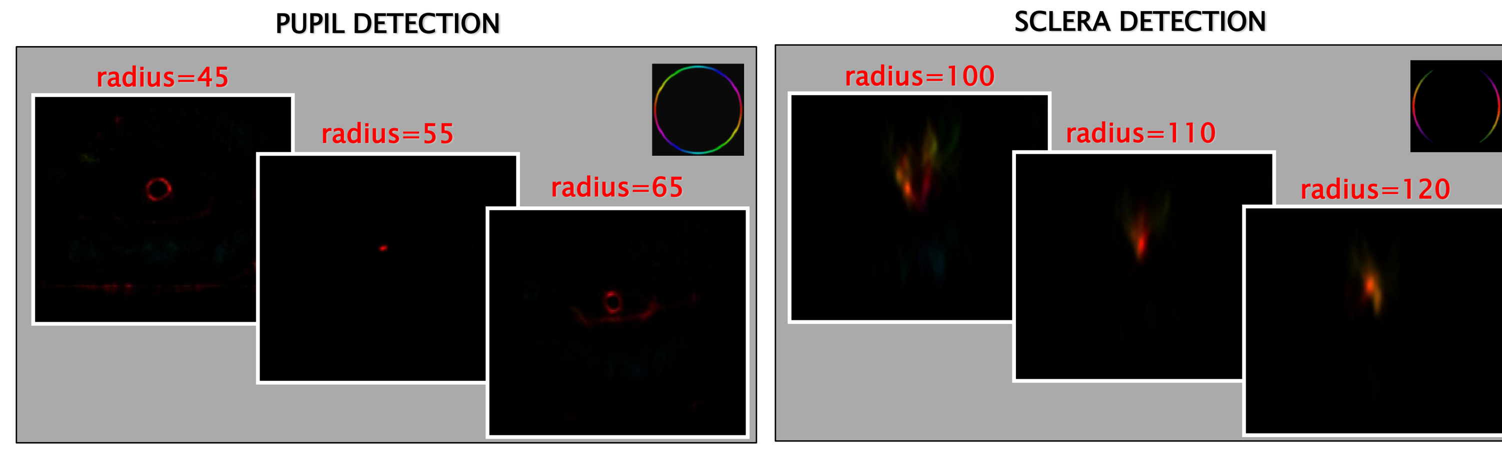
Magnitudes I_{20} and I_{11} encode evidence of the sough symmetry

Finding iris circles:

Detection of maxima in $|I_{20}|$



How filter output looks like with different filter radius



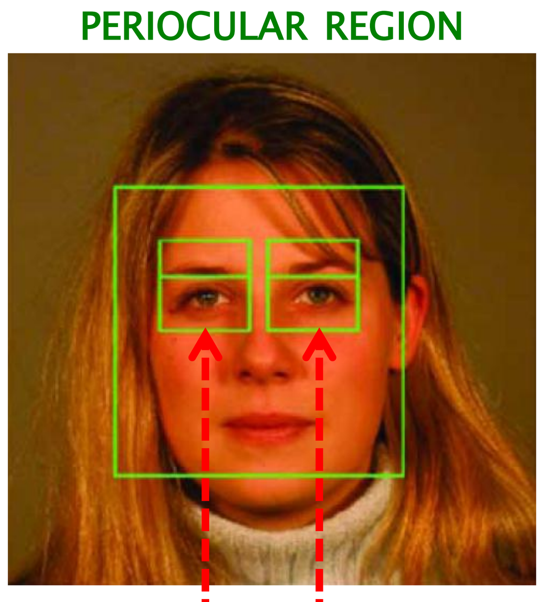
OUR RESULTS

- Apart from correlation of edge magnitudes, the circular filter used takes into account the direction of edges (by encoding its expected orientation), so any disagreement in the direction will be penalized
- This is not exploited by other popular edge-based methods (Daugman, Wildes), where all boundary pixels contribute equally to (do not penalize) the detection of circles
- Reported results show the effectiveness of the GST algorithm, with similar performance than the others in pupil detection, and clearly better performance in sclera detection. These results show the validity of our proposed approach and demonstrate that the GST constitutes an alternative to classic iris segmentation approaches.
- Segmentation experiments under different degrees of image defocus and motion blur also show that comparatively, our GST algorithm always gets top performance for all levels of degradation.

Recognition Using Periocular Information

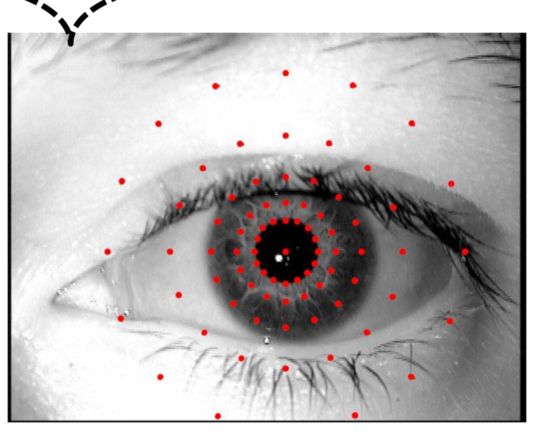
PROPOSED APPROACH: RETINOTOPIC SAMPLING AND GABOR DECOMPOSITION OF THE SPECTRUM

PERIOCULAR REGION

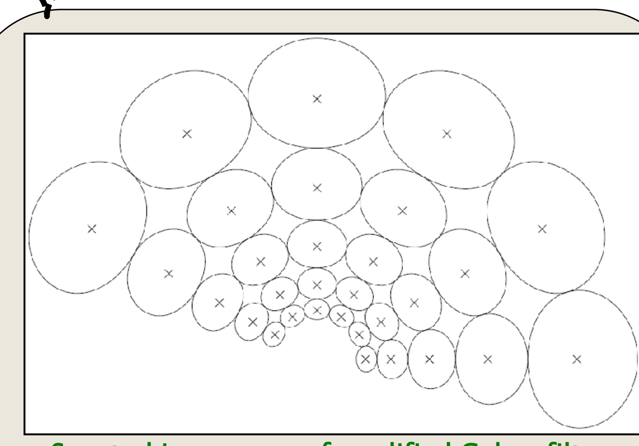


face region in the immediate vicinity of the eye, (including eyes, eyelids, eyelashes and eyebrows)

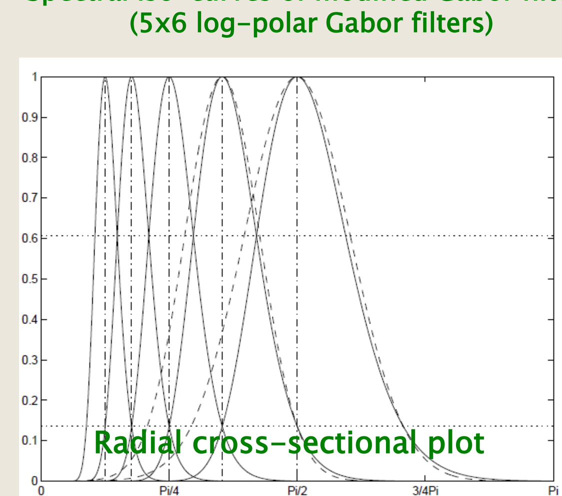
- ✓ Easily obtained with existing setups for face and iris acquisition
- ✓ Available over a wide range of acquisition distances, even when iris cannot be reliably obtained (low resolution, off-angle, etc.) or face is partially occluded (close distances, obstacles, criminal scenarios, etc.)



Circular sampling grid
(5 concentric circles, 16 points/circle)



Spectral iso-curves of modified Gabor filters
(5x6 log-polar Gabor filters)



Radial cross-sectional plot

BACKGROUND

- Existing periocular systems have mostly used Local Binary Patterns (LBPs) and, to a lesser extent, Gradient Orientation (GO) histograms and Scale-Invariant Feature Transform (SIFT) keypoints for recognition. The best performance in the few published studies is consistently given by GO from SIFT keypoints (rank-one accuracy: 81-94%, EER: 7%), LBPs (rank-one: 74-87%, EER: 19%) and finally GO (rank-one: 67-90%, EER: 22%).
- Comparison and/or fusion of periocular features with face and iris modalities is also done in some studies.

OUR RESULTS

Our system achieves competitive verification rates compared with other periocular recognition approaches (EER ~15%)

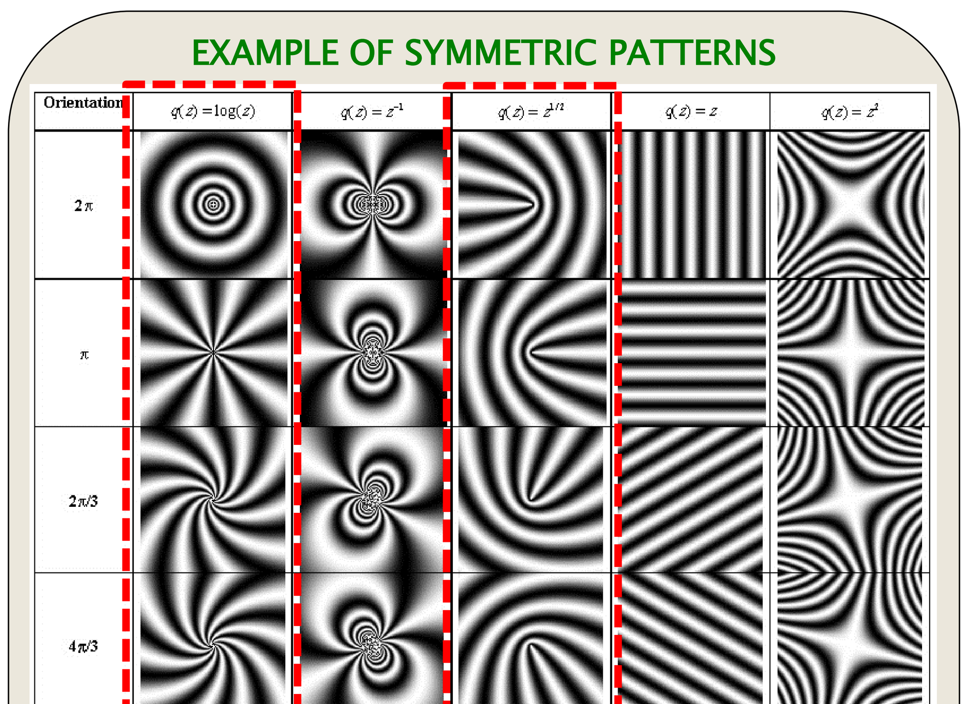
A number of aspects are also studied, including:

- Rotation compensation: negligible effect in the Gabor magnitude, but greatly improvement with phase vectors (up to 50-70% in EER)
- Gabor magnitude vs. phase vectors: magnitude without rotation compensation still performs equal or better than phase vectors with rotation compensation, so this step could be supressed
- Size of the grid: adapted to dimensions of the target eye vs. constant size
  - ✓ Performance not affected substantially with grids of fixed dimensions, so no accurate iris detection is needed, meaning that the only requirement is the availability of the eye center and (in some cases) of the pupil radius (both expected to be available even when the iris texture is difficult to extract)

Facial Detection and Recognition Resilient to Physical Image Deformations

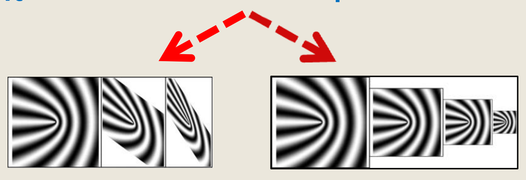
DETECTION OF FACIAL LANDMARKS

EXAMPLE OF SYMMETRIC PATTERNS



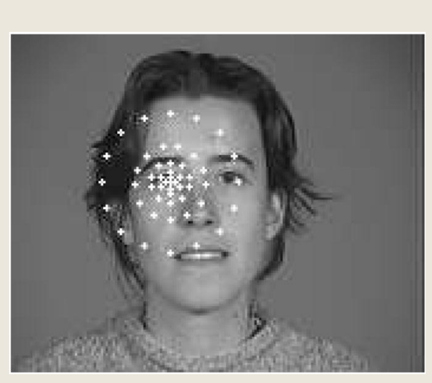
Rotation and scale invariant

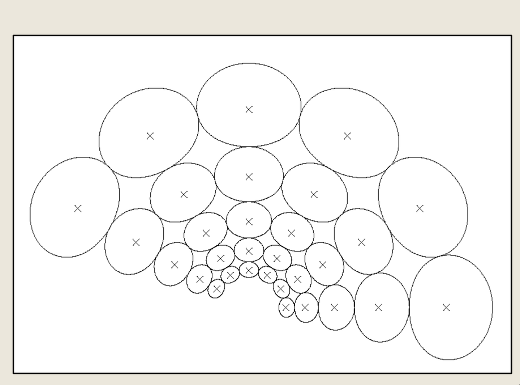
Maintains its appearance under scale and in-depth rotations



PERSONAL RECOGNITION

LOG-POLAR SAMPLING GRIDS AND GABOR FILTERS MIMICKING RETINA PHOTORECEPTORS AND VISUAL CORTEX CELLS





OUR TARGET: FACE TECHNOLOGIES APPLICABLE TO REAL-WORLD DATA

- To detect facial landmarks (eyes, nose, mouth) and recognize individuals under image perturbations found in real-world conditions (scale, rotation)
  - ✓ Facial detection with families of symmetric patterns resilient to these perturbations
  - ✓ Use of scale-invariant patterns to avoid time-consuming image pyramids, which is the traditional approach to deal with scale changes
  - ✓ Separate detection of each facial landmark, coping efficiently with facial occlusion and view changes, which is where current face detection methods fail
  - ✓ User authentication by using separate machine experts that extract Gabor features in the facial region surrounding each (available) landmark
- This will contribute to increase user convenience and comfort by reducing the cooperation level required and by allowing the use of their own device and natural interaction patterns to communicate with the system

LOW COST DEVICES

DISTANT ACQUISITION

UNCONTROLLED BACKGROUND AND LIGHTNING

cost EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

HÖGSKOLAN HALMSTAD