A REPORT

ON

ACCURATE EYE CENTRE LOCALISATION BY MEANS OF GRADIENTS

By

Names	ID Nos.
Shrenik Borad	2013B3A8678P
Ajinkya Gaikwad	2013B4A8529P

.

Prepared in partial fulfillment of the

Submitted to

Dr. K.K Gupta

BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE,

PILANI

Description

The estimation of the eye centres is used in several computer vision applications such as face recognition or eye tracking. Especially for the latter, systems that are remote and rely on available light have become very popular and several methods for accurate eye centre localisation have been proposed. Nevertheless, these methods often fail to accurately estimate the eye centres in difficult scenarios, e.g. low resolution, low contrast, or occlusions. We therefore propose an approach for accurate and robust eye centre localisation by using image gradients. We derive a simple objective function, which only consists of dot products. The maximum of this function corresponds to the location where most gradient vectors intersect and thus to the eye's centre. Although simple, our method is invariant to changes in scale, pose, contrast and variations in illumination.

Procedure

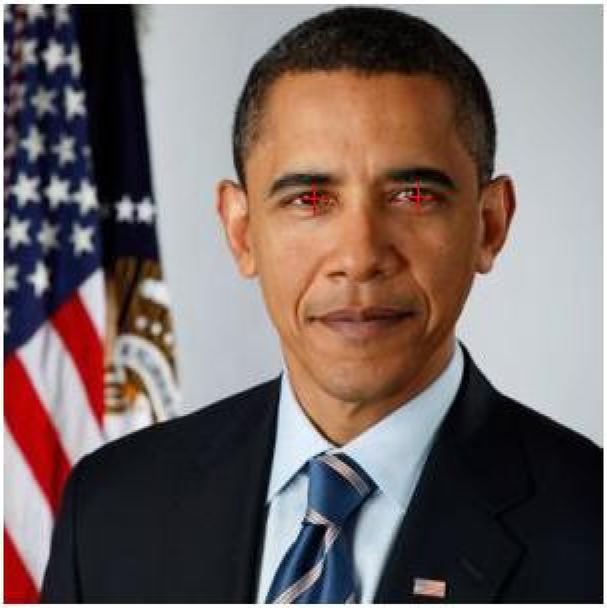
we also analyse the vector field ofimage gradients but derive a novel mathematical formulation of the vector field characteristics. Therefore,we mathematically describe the relationship between a possible centre and the orientations of all image gradients. Let c be a possible centre and g i the gradient vector at position x i . Then, the normalised displacement vector d i should have the same orientation (except for the sign) as the gradient g i (see Fig. 2). If we use the vector field of (image) gradients, we can exploit this vector field by computing the dot products between the normalised displacement vectors (related to a fixed centre) and the gradient vectors g i . The optimal centre c ∗ of a circular object in an image with pixel positions x i , i ∈ {1, ..., N}, is then given by

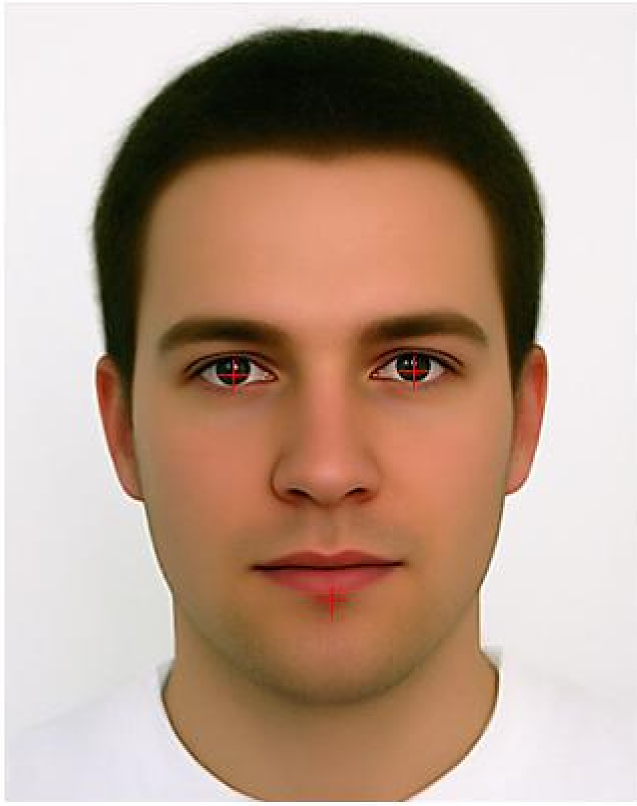
$$\mathbf{c}^* = \arg\max_{\mathbf{c}} \left\{ \frac{1}{N} \sum_{i=1}^{N} \left(\mathbf{d}_i^T \mathbf{g}_i \right)^2 \right\} , \qquad (1)$$

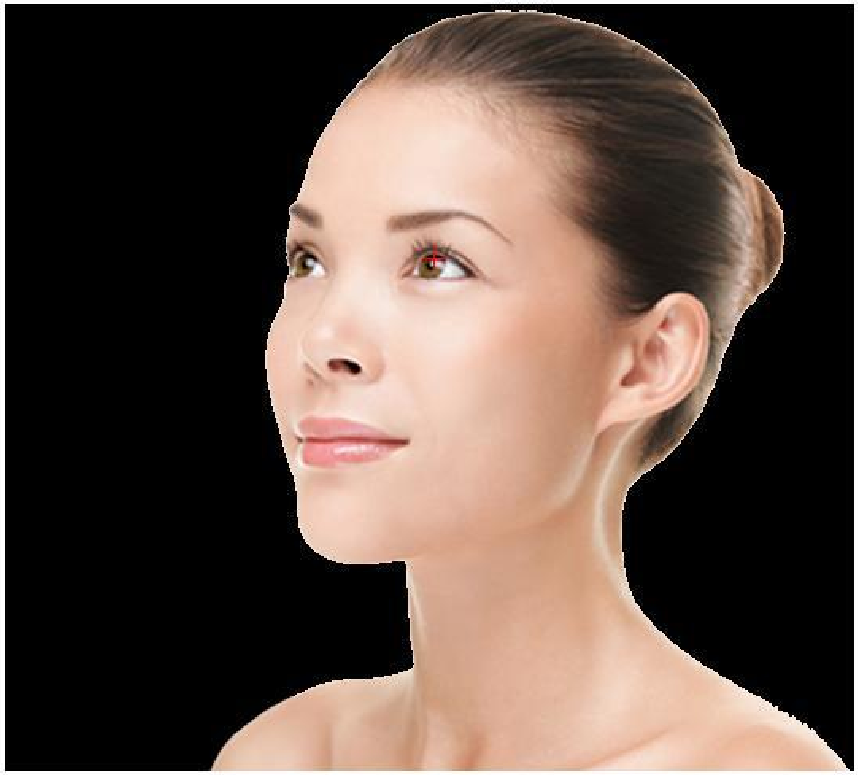
$$\mathbf{d}_i = \frac{\mathbf{x}_i - \mathbf{c}}{\left\| \mathbf{x}_i - \mathbf{c} \right\|_2} , \quad \forall i : \left\| \mathbf{g}_i \right\|_2 = 1 . \qquad (2)$$

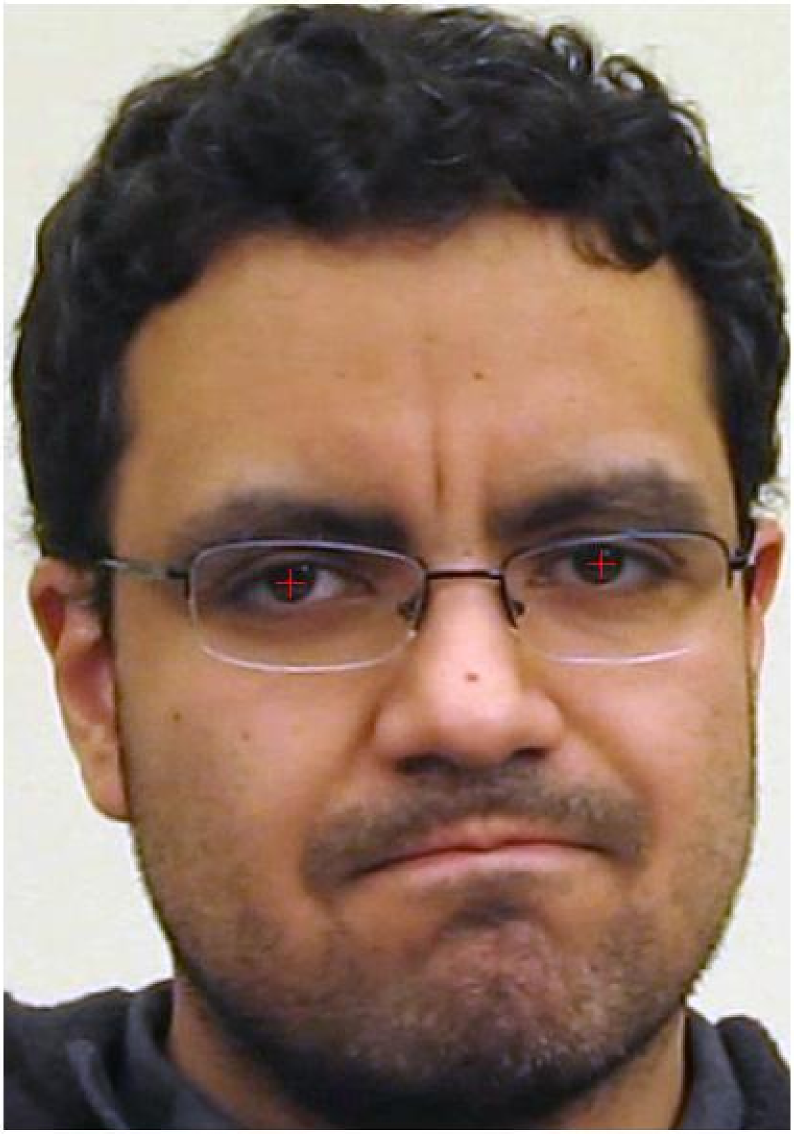
The displacement vectors d i are scaled to unit length in order to obtain an equal weight for all pixel positions. In order to improve robustness to linear changes in lighting and contrast the gradient vectors should also be scaled to unit length. An example evaluation of the sum of dot products for different centres is shown in Fig. 3, where the objective function yields a strong maximum at the centre of the pupil. Computational complexity can be decreased by considering only gradient vectors with a significant magnitude, i.e. ignoring gradients in homogeneous regions. In order to obtain the image gradients, we compute the partial derivatives g i = (∂I(x i ,y i) / ∂x i , ∂I(x i ,y i) / ∂y i) T , but other methods for computing image gradients will not change the behaviour of the objective function significantly.

Images









Results

The qualitative results of the proposed approach are shown . It can be observed that our approach yields accurate centre estimations not only for images containing dominant pupils, but also in the presence of glasses, shadows, low contrast, or strands of hair. This demonstrates the robustness and proves that our approach can successfully deal with several severe problems that arise in realistic scenarios. Our approach yields inaccurate estimations if the eyes are (almost) closed or strong reflections on the glasses occur (last row). Then, the gradient orientations of the pupil and the iris are affected by “noise” and hence their contribution to the sum of squared dot products is less than the contribution of the gradients around the eyebrow or eyelid.

Conclusion

For every pixel, we compute the squared dot product between the displacement vector of a centre candidate and the image gradient. The position of the maximum then corresponds to the position where most image gradients intersect. Our method yields low computational complexity and is invariant to rotation and linear changes in illumination. Compared to several state of the art methods, our method yields a very high accuracy for special scenarios such as pupil localisation.

References

1. Hansen, D. and Ji, Q. (2010). In the eye of the beholder: A survey of models for eyes and gaze. IEEE Trans. on PAMI, 32(3):478–500

2.Kothari, R. and Mitchell, J. (1996). Detection of eye locations in unconstrained visual images. In Proceedings of the IEEE ICIP, volume 3, pages 519–522. IEEE.

3.Viola, P. and Jones, M. (2004). Robust real-time face detection. IJCV, 57(2):137–154.

4.Zhou, Z. and Geng, X. (2004). Projection functions for eye detection. Pattern Recognition, 37(5):1049–1056.