Title: Half-face detector for enhanced performance of flash-eye filter

Author(s): Corcoran, Peter; Bigioi, Petronel

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Abstract-- Red-eye and flash-eye defects in still photography continue to cause problems for digital imaging devices. New variants of flash-eye defects have appeared as cameras and camera sub-systems get smaller in size. This paper describes advanced techniques to improve the detection of flash-eye defects using a novel half-face detector. In addition to improving the detection rate, the inherent symmetries of many of the haar-like classifiers used for such a face detector allow compression of the classifier chain providing benefits for resource constrained consumer electronics devices.

I. INTRODUCTION

In a recent article Corcoran et al. have provided a detailed overview of a wide range of techniques employed in the detection and correction of red-eye and flash-eye defects in digital images [1]. In particular these authors have examined techniques that can be adapted within a digital camera, primarily to improve the detection of such flash defects. Flash defects are also extended to cover classes of non-red or part-red (hybrid) defects.

The analysis, detection and confirmation of these classes of flash-eye defects is invariably more onerous than simple red-eye artifacts and thus it is important to reduce the number and size of regions in an image where such algorithms are applied, particularly if the goal is to achieve a real-time detection in a consumer imaging device.

II. FACE DETECTOR WITH RED-EYE FILTER

One approach takes advantage of the fact that the majority of non-red artifacts typically occur in a pair with a conventional red-eye artifact. Thus, after a basic red-eye algorithm is applied to find all standard flash defects it is likely in a state-of-art consumer camera that a face detection result for the currently imaged scene will be available at the end of each preview frame [3]. This combination of (real-time) face tracking with basic red-eye filter enables a determination of faces that have a paired set of red-eye, and those which have a single, unpaired, red-eye.

By applying a more inclusive filter, or using a non-red algorithm it is practical to determine “missing” eye artifacts [2] as the areas of the image that must be scanned are very significantly reduced. Thus many undetected eye defects can be found by application of more sophisticated analytic techniques and additional confirmation steps in the detection process. A simple flowchart is provided in Figure 1.

III. HALF-FACE DETECTOR TECHNIQUES

Another interesting use of incomplete face regions for red-eye detection arises from the symmetries that occur in the classifiers employed in many state-of-art face detectors. Some classifiers only apply to one side of the face - a selection of left-hand face classifiers are shown in the two left-hand side columns of Figure 2 below. The first column shows the classifier located within the scanning window used to transverse the main image scene; the second illustrates its relationship to the detected face region.

![Figure 1: Eye-pair technique to optimize the workflow tasks [2].](image1)

![Figure 2: Predicted face candidate regions for next preview frame [4-7].](image2)

Note that each of these three example half-face classifiers can also be applied to right-hand face regions if they are flipped horizontally within the scanning window. Thus, although these classifiers are asymmetric within their scanning window they can be applied within a classifier cascade to detect either left-hand, or right-hand face regions through a...
simple horizontal flipping transformation as explained by Nanu, Petrescu, Gagnea, Capata, Ciuc, Zamfir et al [4], [5], [6] and [7]. This implies that the number of stored classifiers can be reduced.

The second category of face classifier is a symmetric classifier shown in the two right-hand columns of Figure 2. Again the third column shows the classifier located within its scanning window, while the fourth column of images shows the classifier applied to a face region. Note that these symmetric classifiers apply to an entire face region and will return an error if a complete face region is not present.

Figure 3 shows the very first classifier of Figure 2 as applied to (a) a left-hand half face; (b) a full-face, and (c) a right-hand half face. Clearly this particular, left-face classifier will successfully detect both left-face and full face regions, but will reject the right-face region. This observation leads to the concept of a left-face classifier chain that positively detects both left-face and full-face regions, a right-face classifier chain that detects right-face and full-face regions and a full-face classifier chain that detects only complete face regions.

Note that a conventional face detector cascade will contain essentially the same classifiers but they will be ordered randomly according to their detection rates as deduced from the training process. Our training process differs as it trains independently for half-faces and full faces. The independently determined classifier sets are subsequently re-organized, removing unnecessary left- or right-face classifiers from the full face chain.

By ordering these classifiers according to their asymmetric or symmetric nature we retain the same capabilities as the conventional detector, with the additional benefit of being able to also detect right- and left-faces. An example workflow is shown in Figure 4 that implements a combined half-face and full-face detector.

IV. CONCLUSIONS

Now the advantage of this approach can be appreciated - in addition to confirming eye-pairs using detected full-faces it is now also possible to confirm single-eyes using detected half-faces. This ensures that we avoid rejecting single-eye flash defects where they occur in partial face regions. It also may suggest additional half-face regions of the image which should have a more thorough analysis applied to ensure that a difficult eye-defect has not been overlooked.

In addition to its uses for enhanced red-eye and flash-eye defect detection this partitioning of the face detection process has many potential applications in image enhancement of scenes containing face regions. These and additional details on half-face detector techniques will be presented in an expanded version of this paper.

REFERENCES