

Chapter 37

A Low Cost Pupillometry Approach

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ABSTRACT

The need for low-cost health monitoring is increasing with the continuous increase of the elderly population. In this context, unobtrusive audiovisual monitoring methods can be of great importance. More particularly, the diameter of the pupil is a valuable source of information, since, apart from pathological cases, it can reveal the emotional state, the fatigue and the ageing. To allow for unobtrusive monitoring to gain acceptance, one should seek for efficient methods of monitoring using common low-cost hardware. This paper describes a method for monitoring pupil sizes using a common, low-cost web camera in real time. The proposed approach detects the face and the eyes area at first stage. Subsequently, optimal iris and sclera location and radius, modeled as ellipses, are found using efficient spatial filtering. As a final step, the pupil center and radius is estimated by optimal filtering within the area of the iris. Experimental results show both the efficiency and the effectiveness of our approach.

MOTIVATION

The continuous increase of the elderly population during the last decades, especially in the developed countries, has generated the need for alternative low-cost health services focusing on the elderly. In particular, computerized health monitoring can provide useful information to clinicians and carers. Unobtrusive every day health monitoring can be of important use for the elderly population. In particular, pupil size may be a valuable source of information, since, apart from pathological cases, it can reveal the emotional state, the fatigue and the ageing. To allow for unobtrusive monitoring to gain acceptance, one

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should seek for efficient methods of monitoring using common low-cost hardware. A low cost camera that monitors the user while in front of a laptop or behind a mirror (Poh et al., 2011) falls into this scenario. Detecting pupils and pupil sizes in this context is of great importance. Namely, pupil sizes may be a valuable source of information, since, apart from pathological cases, it can reveal the emotional state (Partala and Surakka, 2003), the fatigue (Morad et al., 2000) and the ageing (Winn et al., 1994) of the subject under monitoring.

Towards this end, this work presents a method for detecting iris and pupils, including both their centers and sizes, from low resolution visible-spectrum images, using a robust unsupervised filter-based approach. Iris detection performance outperforms most state of the art methods compared, and is competitive with few others. With respect to pupil detection, to our knowledge, detecting pupil sizes detection is not reported elsewhere in the related literature. Using a dataset compiled in particular for this purpose, we show that our method is accurate enough to provide significant information for everyday long-term monitoring.

PUPILLOMETRY

The task of detecting eyes in images or videos is crucial and challenging in many computer vision applications. First, eye detection is a vital component of most face recognition systems, where eyes are used for feature extraction, alignment, face normalization, etc.. In addition, eye tracking is widely used in human computer interaction (gaze tracking). Eye detection systems can be categorized according to the adopted data acquisition method in (a) visible imaging and (b) infrared imaging. According to the first (Jesorsky et al., 2001a; Zhou, 2004; Asteriadis et al., 2006; Hassaballah et al., 2011; Valenti and Gevers, 2008; Cristinacce et al., 2004; Hamouz et al., 2005), ambient light reflected from the eye area is captured, hence the task is rather difficult, due to the fact that captured information can contain multiple specular and diffuse components. On the other hand, infrared-based approaches (Li et al., 2005; Villanueva et al., 2009) manage to eliminate specular reflections and lead to better and accurate pupil detection. Differences between eye detection approaches are also due to the distance of the recording device: (a) head-mounted and (b) remote systems. Needless to say, head-mounted approaches can lead to more accurate systems. However, under particular requirements of low cost and low level of obstruction, remote sensing is the only acceptable solution.

METHOD

Face and Eye Bounding Box Detection

The overall scheme of the proposed method is presented in Figure 1. At a first stage, the face is detected. Face detection is a well-studied problem in machine vision (Viola and Jones, 2001) and there exist now several commercial tools that achieve high accuracy with high speed. For our purposes, we have used SHORETM (Sophisticated High-speed Object Recognition Engine) which achieves face detection at a frame rate greater than 50fps.

The same engine, also provides directly as a rough estimate of the two eyes area, which we have used to initiate iris and pupil detection.

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