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Survey of Applications of Pupil Detection Techniques in Image and Video Processing

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***Abstract*— This paper presents a variety of applications of the pupil detection techniques in image and Video processing. Moreover, the robust pupil detection techniques are also discussed. The purpose of this paper is to provide some background knowledge for new researchers in pupil detection area.**

***Index Terms*—Pupil detection, robust techniques, Iris recognition system, and Diabetic retinopathy.**

I. INTRODUCTION

Pupil detection has drawn significant attention because of the wide application of pupil detection techniques. Each application of pupil detection may pose some new challenges for current pupil detection techniques and may need us to develop new pupil detection techniques. To help new researchers to understand various applications of the pupil detection techniques, this paper surveys different applications of the pupil detection techniques. Moreover, robust pupil detection techniques are also discussed to help readers understand some new techniques in this area.

II. APPLICATIONS OF PUPIL DETECTION

Pupil detection techniques can find many applications. For example, pupil detection can be used for screening diabetic retinopathy, personal identification system, diagnosing of neuropsychiatric disorders, Cataract surgery, cataract assessment, and liveness detection. Those applications will be discussed in details.

Diabetic retinopathy is a reason for blindness, especially among elderly people [1]. Earlier detection of diabetic retinopathy is important to treat this disease. Accurate pupil features are crucial in diagnosing diabetic retinopathy [1]. To facilitate diabetic retinopathy detection, authors in [1] presented a method to estimate important pupil features, such as pupil radius and pupil center. This method uses advanced signal processing techniques to estimate pupil size in different scenarios. Simulation results showed that the presented method could get satisfactory results.

In Iris recognition system, pupil detection also plays important roles [2]. Some pupil detection methods require a detection threshold. Other pupil detection methods assume the pupil outline is a circle. However, the detection method using a threshold suffers from the intensity change while the pupil boundary is not an exact circle.

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Moreover, eye rotation and head rotation make the detection task even more difficult. To circumvent those problems, the authors in [2] proposed to use mean intensity and minimum intensity of pupil to determine the pupil boundary. Details can be found in [2]. A robust pupil boundary detection method was also presented in [3]. Interesting readers can find the details of this method in [3].

Pupil detection can also find applications in neuropsychiatric disorders [4]. The authors in [4] assumed pupil boundary is a circle and used a fitting method to estimate the position and radius of pupil. Then, this method is used for three groups of people. Finally, a pattern recognition algorithm is used to separate disorder people from normal people. Pupil detection is also important in ophthalmology, especially in Cataract surgery. In Cataract surgery, pupil detection can be used as a supplementary technique to provide pupil boundary information [5]. Usually, surgery requires very high accurate pupil boundary detection. Therefore, pupil detection techniques used in other areas may not satisfy the unique requirements of pupil detection in surgery. To address this unique problem, authors in [5] proposed a new detection technique, which can execute in high speed with quick response time. Details can be found in [5]. Similarly, pupil detection is also important in cataract assessment. Cataract assessment poses some challenges for pupil detection. Authors in [6] proposed a new pupil detection technique to meet those new challenges. Details can be found in [6].

Another interesting application of pupil detection is for liveness detection [7]. Many current liveness detection methods based on pupil detection rely on appearance difference to distinguish fake irises from real irises. The authors in [7] proposed a new detection technique based on pupil constriction. Experiments showed that this new method is highly effective. Details can be found in [7].

III. ROBUST PUPIL DETECTION

Robust pupil detection techniques are also important research areas because robust techniques can improve performance if errors or mismatch happen [8]-[10]. For example, some people have used two light sources in together with image difference method to detect pupil [8]. However, there may be a time interval between the arrival of the bright image and the arrival of the dark image. If the pupil position changes quickly, this time interval will degrade the performance of the image difference method. In [8], authors proposed three solutions to this problem.

Wireless sensor networks have drawn significant attentions [11]-[22]. If the pupil detection techniques can be integrated with wireless sensor networks, we can use pupil detection techniques in remote health care. This has tremendous potential impacts.

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IV. CONCLUSION

Pupil detection is an interesting research area with many emerging techniques. Understanding the applications of pupil detection techniques can help us to understand the pupil detection techniques designed for different applications.

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