Ocular Biometrics in the Visible Spectrum: A Survey

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Ocular Biometrics in the Visible Spectrum: A Survey

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Abstract

Ocular biometrics encompasses the imaging and use of characteristic features extracted from the eyes for personal recognition. Ocular biometric modalities in visible light have mainly focused on iris, blood vessel structures over the white of the eye (mostly due to conjunctival and episcleral layers), and periocular region around eye. Most of the existing studies on iris recognition use the near infrared spectrum. However, conjunctival vasculature and periocular regions are imaged in the visible spectrum. Iris recognition in the visible spectrum is possible for light color irides or by utilizing special illumination. Ocular recognition in the visible spectrum is an important research area due to factors such as recognition at a distance, suitability for recognition with regular RGB cameras, and adaptability to mobile devices. Further these ocular modalities can be obtained from a single RGB eye image, and then fused together for enhanced performance of the system. Despite these advantages, the state-of-the-art related to ocular biometrics in visible spectrum is not well known. This paper surveys this topic in terms of computational image enhancement, feature extraction, classification schemes and designed hardware-based acquisition set-ups. Future research directions are also enumerated to identify the path forward.

Keywords:
Biometrics, Ocular Biometrics, Mobile Biometrics, Iris, Conjunctival Vasculature, Periocular Biometrics, Visible Spectrum

1. Introduction

Biometrics is the science of establishing identity of individuals using physical (such as face, fingerprint and iris) or behavioral traits (such as voice and gait) [58, 123]. Among others, significant advancement has been observed in ocular biometrics over the past few years. Ocular biometrics is a sub-field of biometrics focused on regions in the eye and those around it. Iris has traditionally been considered as the most popular and widely accepted ocular biometrics due to its high accuracy and stability over individual's lifetime [93, 36, 75, 78]. Virtually all existing commercial iris recognition systems operate in near-infrared (NIR) illumination, and many use constrain acquisition protocols in order to minimize the impact of intra-class variations due to pose, distance, illumination changes, and occlusion from eyeglasses, eyelashes and specular reflections [79].

Academic research groups have reported some advances in iris recognition under visible spectrum (VIS) [103, 97]. However the richness of iris texture is not always well captured in a VIS image due to melanin content in darker iris images. In fact, studies suggest that NIR iris images significantly outperform VIS iris images from a matching accuracy perspective [20]. Nevertheless, iris recognition in the visible spectrum may facilitate recognition when NIR iris captures are lacking or inadequate e.g., due to distance. Further, VIS iris captures can potentially assist in classification and indexing based on iris macro features (e.g., moles, freckles and nevi), and eye color [93, 104].

Apart from *iris*, human eyes carry other distinguishable patterns such as *conjunctival vasculature* [41][28][35], *periocular* [93] and *retinal* biometrics [47] which have been used for personal recognition. Figure 1 shows an RGB eye image with its iris, conjunctival vasculature and periocular region. The blood vessel from the conjunctiva and episclera seen atop of the avascular white of the eye (sclera), and henceforth called conjunctival vasculature for brevity, is distinct to each individual, and can be non-intrusively acquired in the visible wavelengths [41, 28].