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学位論文の概要及び要旨

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題　　目 Gaze Estimation from Remote RGB-D Camera and Head-Mounted Eye Camera

(遠隔 RGBD カメラ及びヘッドマウントアイカメラによる視線推定)

学位論文の概要及び要旨

This thesis focuses on the topic of gaze estimation from cameras. Gaze estimation is an important topic in computer vision in such areas as driver behavior analysis, security monitoring, behavior investigation, and human-computer interfaces. In particular, gaze information can offer a new means of communication with machines, such as determining a human's region of interest. In addition, there are two big categories in this area: one is gaze estimation from a remote camera, which is placed in front of an observer, and the observer would not have any direct bindings with the remote camera. The other is gaze estimation from a head-mounted eye camera, which is placed on the observer's head. The camera can have a direct view of the eye. This thesis proposes novel methods of gaze estimation based on an eye model for the remote camera and the head-mounted camera, and is composed by two parts as follows.

Part I (Gaze estimation from remote camera): The most crucial factors in the eye-model-based approach to gaze estimation are the three-dimensional (3D) positions of the eyeball and iris centers. In the proposed method, a RGB-D camera, Kinect sensor, is used to obtain the head pose as well as the eye region of the color image. Because the ray from the

eyeball center to target and the ray from the eyeball center to the iris center should meet a relationship. Based on the knowledge, our method sets up a model to calibrate the eyeball center by gazing at the center of the color image camera. Then, to estimate the 3D position of the iris center, the 3D contour of the iris is projected onto the color image with the known head pose obtained from color and depth cues of an RGB-D camera. Thus, the ellipse of the iris in the image can be described using only two parameters: the yaw and pitch angles of the eyeball in the iris coordinate system, rather than the conventional five parameters of an ellipse. The proposed method can fit an iris that is not complete due to eyelid occlusion. The average errors of vertical and horizontal angles of the gaze estimation for seven subjects are 5.9 degrees and 4.4 degrees in experiments, respectively. However, for lower resolution and poor illumination images, as tested on the public database EYEDIAP, the performance of the proposed eye-model-based method is inferior to that of the-state-of-the-art appearance-based method.

Part II (Gaze estimation from head-mounted camera): As introduced in Part I. Gaze estimation is based on the eyeball center and the iris center, so in this proposed method, we divide the continuous gaze estimation of a head-mounted eye camera into two phases. One phase, known as the calibration phase, is used to estimate the eyeball center position in relation to the coordinate system of the head-mounted eye camera. The other phase is used to fit the iris contour in 2D images employing only two parameters for gaze estimation. Based on an eye-model, iris can be extracted in a more efficient and accurate manner by projecting the 3D iris contour onto a 2D space. Given the calibrated 3D eyeball center and estimated 3D iris center, the gaze tracking can be achieved. As seen from the experimental results, the proposed method demonstrates both credible eyeball center estimation and an accurate iris contour estimation in comparison with the conventional approach using five unknown parameters. At the end, the accuracy of our gaze estimation method and other existed methods using targets on a screen was evaluated.