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Appearance Based Prosthetic Eye

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Abstract

This paper introduces a new approach to improve the appearance of a prosthetic eye using computer vision and graphics technology. The proposed method can synthesize realistic appearance and movement of a prosthetic eye.

Keywords: Prosthetic Eye, LCD Display, IBR, Image Analogies

1. Introduction

A prosthetic eye is used to replace the lost eye for the blind. An ocular implant used currently is static or has small movement ability. This causes unnatural appearance of the prosthetic eye since its appearance and movement do not correspond to the other natural eye.

Recently, Gu et al. have proposed a motor controlled robotic eye [1]. This enables a prosthetic eye to move, but it requires power and may lacks quick eye movements due to use of the motor.

In this paper, we propose a completely different approach using computer vision and graphics technology. Instead of embedding a robotic eye, we embed a LCD display, possibly with a curved surface, in order to give an appearance of the movable prosthetic eye. From the image of the natural eye, we synthesize an image for the prosthetic eye, which is shown on the display. This approach is based on IBR (image based rendering) technique so that its appearance can be realistic and fast as the natural eye.

2. Appearance Based Prosthetic Eye

In order to produce an image sequence of moving prosthetic eye, a video camera images the natural eye. After the motion and texture of the natural eye is obtained, the technique called "Image Analogies" [2] is applied for synthesizing image of the prosthetic eye.

2.1. Instrumentation

Fig. 1 (a) shows glasses with a small video camera attached to. A mannequin head is used for demonstration of the display corresponding to a prosthetic eye as shown in Fig. 1 (b); One of the mannequin's eyes is replaced by a LCD display.

2.2. Natural Eye Tracking

We can assume that the camera projection model to be weak perspective; orthographic projection followed by scaling. Even when the gaze direction is perpendicular to the optical axis of the camera, the diameter of the limbus is very small relative to the distance from the camera.

First, 2D location of the eyelids and limbus are tracked in the natural eye image. Next, 3D orientation of the eyeball is estimated based on anatomical characteristics.

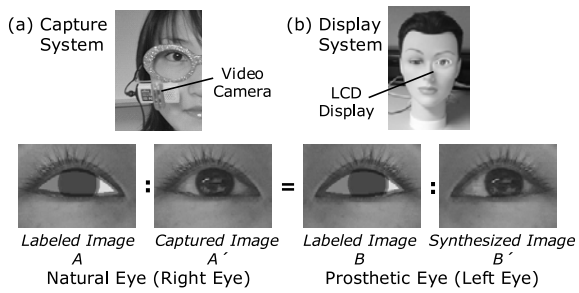

Figure 1: Appearance Based Prosthetic Eye.

2.3. Image Generation for Prosthetic Eye

Once the 3D orientation of the natural eyeball is obtained, 3D orientation of the other eyeball, corresponding to the prosthetic one, is chosen by assuming that the person is looking at a certain distance - we choose that distance to be one meter. The 2D location of the limbus is then calculated from the determined eyeball orientation. As for the eyelid location, we make it the same as the natural one.

Now that we have determined the location of limbus and eyelids, we synthesize a natural-looking image of the prosthetic eye. We apply the technique called "Image Analogies " - the technique to synthesize a new image such that each labeled region in it will have similar image statistic (color, spatial, and relational) with that of sample regions.

The particular process for our purpose is shown in Fig. 1. A given natural eye image A' is segmented into three regions: cornea, left sclera, and right sclera as shown in image A. Then, a synthetic image B' is generated for the segmentation B where image statistics is learned from A and A'. Instead of applying this process to each frame independently, we enforce some temporal consistency between current and previous frames of synthetic eye images. We can see that the resultant B' is realistic; being similar to but not identical to the natural eye as well as containing reflection.

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References

[1] J. Gu, M. Meng, A. Cook, and M. G. Faulkner. A study on natural movement of artificial eye implant. *Robotics and Autonomous Systems*, 32(2-3):153–161, 2000.

[2] A. Hertzmann, C. E. Jacobs, N. Oliver, B. Curless, and D. H. Salesin. Image analogies. *Proc. SIGGRAPH 2001.*

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