Camera-based Eye Tracking in Virtual Reality Headsets

Graduate Candidates

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Introduction: Virtual Reality opens up completely new areas of applications for many sectors as it is with the industrial partner for this project VRM-Switzerland, which develops flight simulators for helicopter pilots. At the moment, a supervisor is needed to control the behavior of the trainee pilot. For the future, it is desired that a computer can do this task. Therefore, various sets of trackers are needed. One of these trackers will be an eye tracker to verify if the pilot has checked the correct instruments before or during a maneuver. For those simulators VRM-Switzerland uses the XTAL headset, which has already a built-in eye tracker. This eye tracker had to be evaluated and tested firstly for this task. The final aim of this project is to have an eye tracker which can estimate the gaze of a person whilst in the simulator.

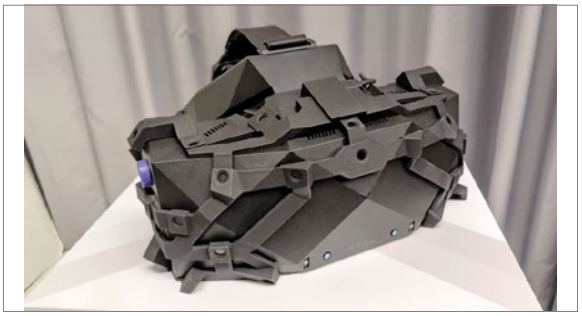
Approach: In the game engine Unity, a test scene was created to evaluate the eye tracker. It turned out that the eyes are not tracked well enough to be of use in the final product and therefore a new eye tracking had to be developed. Three approaches could be followed to design the eye tracking: With geometry, with image processing or with deep learning. The deep learning approach is used in the built-in eye tracking solution, which is not accurate enough. The geometric approach was promising because it constructs a geometric model of the eye ball in relation to the screen and can calculate directly a gaze estimation. However, this approach was later discarded as well because too many variables such as the focal length of the camera and so on were unknown. For this reason, the image processing approach was chosen to develop an eye tracker which should be at least as good as the built-in tracker.

The first goal was to detect the pupil in the image, which first had to be filtered. Afterwards, to detect the pupil the image was thresholded to find contours. The second goal was to transform the coordinates of the pupil on the camera images to the coordinates in the game for a gaze estimation. This was done with a multiple linear regression using nine reference points for the calibration. At the end, a detection of the cornea reflection (reflection of light hitting the eye) was implemented to perform a simple offset correction when the headset is shifted on the head.

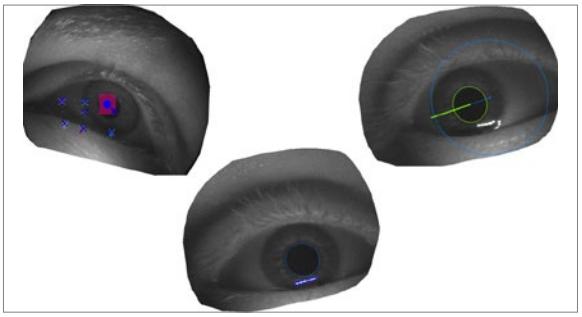
Result: It has been verified that the developed eye tracking performs better than the built-in eye tracker. Through measurements it has been shown that a decrease of the error by 0.4 degree in x and 1 degree in y of the visual field could be achieved. Although, both eye trackers are suffering from the same problem that the tracking is imprecise while the head is in motion. It has been proven that with the cornea reflection an offset correction is possible. This means that an accurate estimation of the gaze whilst in motion should be possible when the cornea reflection can be tracked continuously.

Nevertheless, with the XTAL headset this did not seem to be possible because it is unable to illuminate the eyes in the headset well enough.

XTAL 8K-Headset
Own presentment



Three different eye trackers (L: XTAL built-in with YOLO, M: developed with image processing, R: geometric model)
Own presentment



Unity test scene
Own presentment

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Subject Area
Image Processing and Computer Vision

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