Online implicit eye-tracking recalibration for surgery

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Abstract

A.A.Kogkas and G.P.Mylonas proposed a novel framework [1] using wearable eye-trackers that can provide unrestricted and simultaneous 3D eye-tracking in the operating theater. To improve the usability and flexibility of wearable eye trackers, this project intends to develop an online implicit eye-tracking recalibration method for seamless hands-free interactions and behavioral analysis in the operating theatre.

Introduction

Background: The operating theatre remains an environment where the latest technological developments have not been fully exploited towards patient safety. To improve patient safety, eye-tracking methodology is expected to improve the collaboration among staff during surgery.

Motivation: The wearable eye-tracking devices provide more flexibility to the surgeon's movements, but unexpected slippage of glasses during surgery would affect the accuracy of the eye tracker. An online implicit eye-tracking recalibration method is expected to allow seamless use of wearable eye-trackers in the operating theater.

Methods

-Use the wearable eye-tracker to estimate gaze

- Typical wearable eye tracker contains eye cameras and a scene camera
- Unique characteristics of human eyes require the eye trackers to be calibrated before use

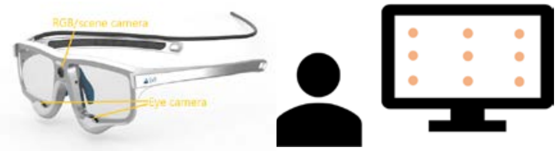

Fig. 1 – (a) SMI eye-tracking glasses; (b)Typical calibration process[2]

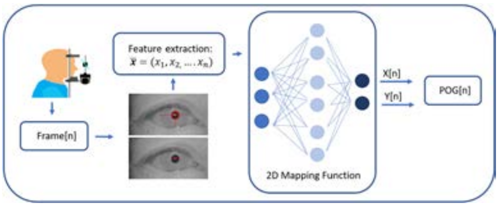

Fig. 2 – Diagram of a standard eye tracker with 2D mapping method[2]

-Detect drifts and errors

- The magnitude of drifts and errors determines whether to apply the recalibration procedure
- The ground truth of the gaze can be estimated through specific feature points such as the tip of a scalpel.

-Acquire recalibration reference points

- If the error exceeds a certain threshold value, the recalibration process will start to acquire reference points through gaze fixations.

-Construct a mapping function

- The calibration mapping incorporated in the algorithm is a thin plate spline (TPS) based radial basis function (RBF) mapping.

Preliminary Results

- Calibration marker that is easy to be focused for users
- Detected marker and visualized gaze estimated by the eye tracker are shown by red cross and green cross, respectively.

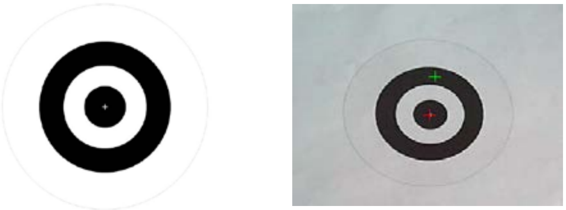

Fig. 3 – (a) Calibration marker; (b)Tracked marker and estimated gaze;

- Thin plate spline (TPS) mapping
- The blue across represents the corrected gaze points

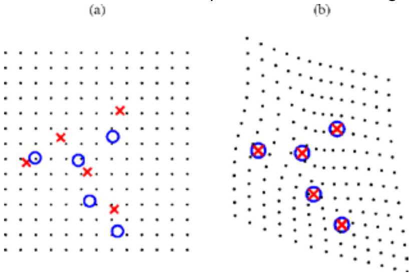

Fig. 4 – TPS mapping[3]

Fig. 5 – Corrected result

Discussion and Future plans

-Discussion of preliminary results

- The TPS mapping can work on recalibration process, but its precision significantly relies on the quality of collected gaze data.
- Sometimes the mapping results are not stable enough.
- All the recalibration procedures are performed offline.
- The location of the marker may not be the ground truth of gaze.

-Future plans

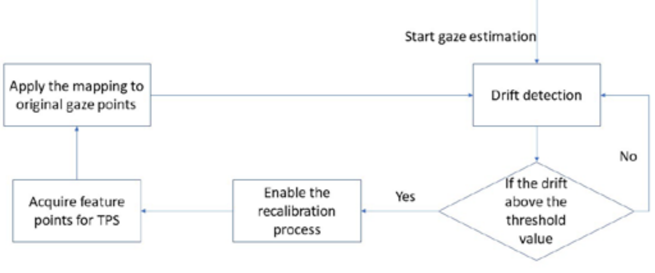

Fig. 6 – Diagram of the project frame

References

[1] A. Kogkas, M. Sodergren, A. Darzi, and G. Mylonas, "Macro-and micro-scale 3d gaze tracking in the operating theatre," 2016.
[2] Larrazabal A J, Cena C E G, Martínez C E. Video-oculography eye tracking towards clinical applications: A review[J]. Computers in biology and medicine, 2019, 108: 57-66.
[3] Donato, Gianluca, and Serge J. Belongie. Approximation methods for thin plate spline mappings and principal warps. Department of Computer Science and Engineering, University of California, San Diego, 2003.