Eye Registration for cataract CAS

Project Management and Software Development
for Medical Applications

General Info

Project Title: Eye Registration for cataract CAS

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Project Abstract

Cataract surgery is the most common type of surgery worldwide. This project aims to develop an eye registration workflow to be used on an AR assistance system for the alignment of toric Intraocular lenses (IOL) during cataract surgery.

Background and Motivation

Cataracts are the leading cause of blindness worldwide, responsible for 65.2 million people with vision loss in 2019 [1]. Cataract surgery is indicated for patients whose eye lenses have opaqued. This avoids the correct transmission of light to the retina, which leads to blurry vision and finally complete vision loss [cite]. During the procedure, the opaque lens is removed and replaced by an artificial IOL. IOL selection depends on the patient's eye anatomy and is one of the key factors that determines post-surgery vision quality [2].

Astigmatism is a common vision impairment disease that causes blurred distance and near vision. Astigmatism occurs when either the front surface of the eye (cornea) or the lens inside the eye has mismatched curves. Instead of having one curve like a round ball, the surface is egg-shaped. This causes blurred vision at all distances [3]. Because of this asymmetry, astigmatic patients which undergo cataract surgery need an special type of IOL, known as toric IOL, that compensates for the distortion.

While regular IOLs are orientation agnostic, toric IOLs require to be implanted in a specific orientation to compensate for astigmatism. For that IOL orientation needs to be defined preoperatively. However, currently used procedures are suboptimal leading to an average deviation of approximately 5° with respect to the intended orientation [4]. This deviation affects significantly the effectiveness of toric IOL treatment and happens mainly because of two reasons:

1. Poor resolution of IOL target marking. Many methods are used to align the toric IOL. The most important step is the preoperative marking of the horizontal meridian (0°–180°) while the patient is sitting. Marking of the horizontal meridian can be done manually under the guidance of different methods that includes slitlamp-assisted marking with a horizontal slit beam, slitlamp-assisted marking with a pendulum-attached marker, or nonpendular marker with a surgeon's direct visualization [4].

2. Cyclorotation, which is the eye axis rotation with a patient changes from standing to lying position [5].

During the last years, computer aided surgical (CAS) systems such as Zeiss Calysto [6], Alcon Verion and True Vision [7] have been developed to improve IOL placement accuracy and therefore surgical outcomes. However, adoption of these systems has been poor due to their high cost and unclear reimbursement paths.

At Custom Surgical we aim to develop an smartphone based augmented reality (AR) application for affordable and precise toric IOL alignment. That will be connected to the surgical microscope through our MicroREC [8]. MicroREC is an optical system that allows the digitalisation of any surgical or diagnostic microscope in an extremely affordable manner using smartphones.

This project aims to define the requirements to develop such a system, and leverage Custom Surgical's proprietary detection and tracking algorithms to implement a registration workflow that can effectively map patient eye pose between preoperative and operative images, thus compensating cyclorotation.

Student's Tasks Description

As part of this project, the student will:

- Analyze the registration problem and design a workflow for accurate registration of surgical video to a preoperative reference image.
- Understand and use Custom Surgical detection and tracking algorithms to implement the proposed framework.
- Using Custom Surgical's resources and equipment, run experiments to validate the proposed framework.

During the entire process, the student is invited to our lab to test and discuss his/her findings with the engineers of the company and our clinical consultants.

The student will learn about the following topics:

1. Computer Aided Surgical systems
2. Surgical procedures in ophthalmology
3. Augmented Reality
4. Image processing
5. Microscopy

Technical Prerequisites

- Previous experience with OpenCV or other similar computer vision framework
- Previous knowledge of Python and C++
- Seek to learn new things and work on a young, dynamic environment.

References

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