Offer

Type: Master's Thesis
Form: constructive, practical, experimental
Submodule Drive Unit

Design and engineering of robotic submodules for a modular robot-assisted eye surgery system and co-development of a novel surgical robot system architecture and workflow.

Project Background

Robot-assisted surgical systems are transforming ophthalmic surgery by enabling enhanced precision and stability beyond human manual capabilities. At MAPS at Hospital of the Technical University of Munich (TUM Klinikum), a system for robot-assisted eye surgery is under development. A critical aspect of this system is that it integrates seamlessly into the existing surgical workflows of the ophthalmology operating room. That is precisely why it is important to document and analyze existing workflows, expectations, and standards in traditional manual eye surgery, and to use this knowledge to define the requirements for a robotic surgical system. The focus for this project is on the interaction between the robot technician & runner, the surgical assistant and the robotic system in the preparation phase („pre-operative phase"): the time frame from cleaning the OR just until the moment the surgeon enters the room.

The existing robotic device employs a Remote Center of Motion (RCM) mechanism, with its workspace designed to replicate the range of motion used in conventional manual surgical procedures inside the eye. However, the current system divided in its submodules – utilizing a 5 DoF high precision arm interfaced with a surgical tool, a 4 DoF positioning stage and a Mecanum wheel drive unit – presents several limitations that compromise the use in a real operation room environment:

- temporal and spacial constraints of the traditional components of the surgical workflow as well as the standards regarding the sterile zone and aseptic techniques of the OR personnel are not considered fully yet preventing the system to be used in a simulated or real OR environment
- the system's approaching, positioning and locking during the preparation phase and its interfacing to the operation table isn't clear yet resulting in workflow distortion
- suboptimal mechanical stability of the submodules introducing unwanted movement or vibrations at the tip of the surgical instrument which needs micrometer precision
- the draping and wiring process of the robot is not considered fully impacting ergonomics and aseptic standards in interaction between robot technician & runner, the surgical assistant and the robotic system which results in increased time requirements, thereby undermining the goal of designing a time-saving, safe, and user-friendly surgical system

Thesis Objective

The primary goal of this thesis is to investigate and implement alternative positioning and preparation strategies regarding the drive stage and the macroscopic interfacing to other submodules regarding wiring and physical interfaces. The 5 DoF arm and the 4 DoF positioning stage are out of the scope.
Potential solutions include, but are not limited to, caster-driven or „Omniwheel"-driven systems powered by battery.

The redesigned mechanisms should deliver a user experience comparable to conventional eye surgery workflows while preserving the existing device kinematics and accuracy on the tool tip.

Scope of Work

1. Literature Review and Requirements Extraction: Conduct a comprehensive review of state-of-the-art positioning and preparation (e.g. draping) mechanisms in surgical robotics.
2. Analyse the existing workflow and the traditional components of the surgical workflow as well as the standards regarding the sterile zone and aseptic techniques of the OR personnel using the captured data of simulated eye surgery from the perspective of surgeon, assistant and robot.

3.* Conceptual Design: Develop and evaluate alternative drive unit submodule concepts based on defined requirements.

4.* CAD Modeling: Create detailed 3D models of the proposed mechanisms.

5.* Validation of the robotic submodule concepts before manufacturing: Perform tests based on the OR user workflow in a simulated OR environment using rapid prototyping techniques to validate design performance.

*) Step 3, 4 and 5 are iterative steps and part of several iteration loops finding the best solution

6. CAD Modelling of final Prototype and Fabrication (externally): Manufacture a functional prototype for experimental evaluation.
7. User Study: Conduct a final validation user study to assess the redesigned device.

Candidate Profile and Required Qualifications

- Strong proficiency in mechanical design and CAD
- Strong collaborative and open-mindset approach in deep-tech development projects
- Hands-on experience with rapid prototyping (FDM & SLA printers, Laser Cutter, 1:1 model making)
- Practical experience or training in fields such as precision mechanics, machining, model making or similar is advantageous
- Interest in robotics, human factors engineering, medicine and precision surgery
- Very good German and English skills

What we offer

- Work on real robotic systems within a team of computer scientists, robotic and medical engineers, designers and clinicians. We provide state of the art rapid prototyping tools and a physical 1:1 scale research OR environment to validate designs within real surgical workflows and contexts. Opportunity to contribute to publishable results targeting major robotic and AI venues.

How to apply

- Please send application including your CV to Mario Weisser, M.Sc., mario.weisser(at)tum.de and Prof. M. Ali Nasseri, ali.nasseri(at)mri.tum.de

More information

https://augenklinik.mri.tum.de/de/Forschung-und-Lehre/MAPS

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