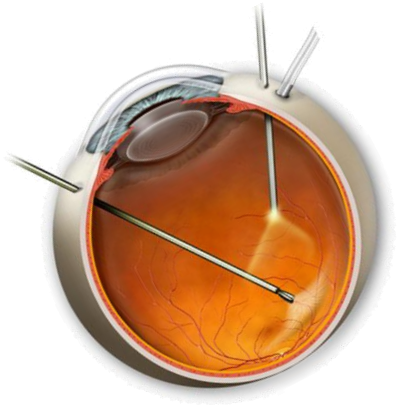

Intraocular Robotic Interventional Surgical System (IRISS): Mechanical Design, Evaluation, and Master–slave Manipulation

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Presented by Ali Ebrahimi
Group 7

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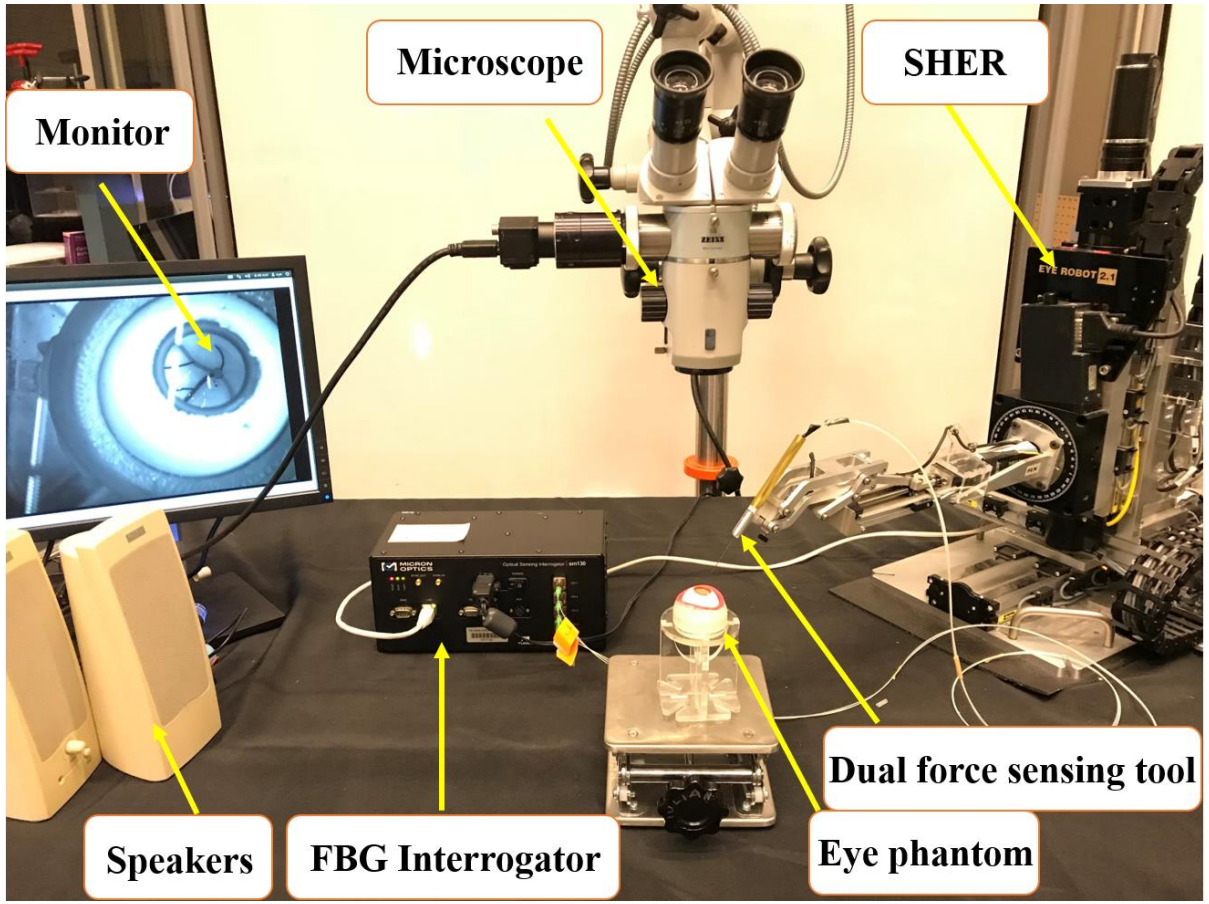
Project title: Steady-Hand Eye Robot Control Algorithm Based on Force-sensing Tool Information

1. Implementing a variable admittance control scheme to increase the robot resistance when the sclera force is increasing a fixed upper level threshold

2. Using the expert's force-depth variation curve to apply another variable admittance control which helps operator to manipulate the eye

3. Applying these control schemes on the Eye-Robot and performing several experiments with different subjects



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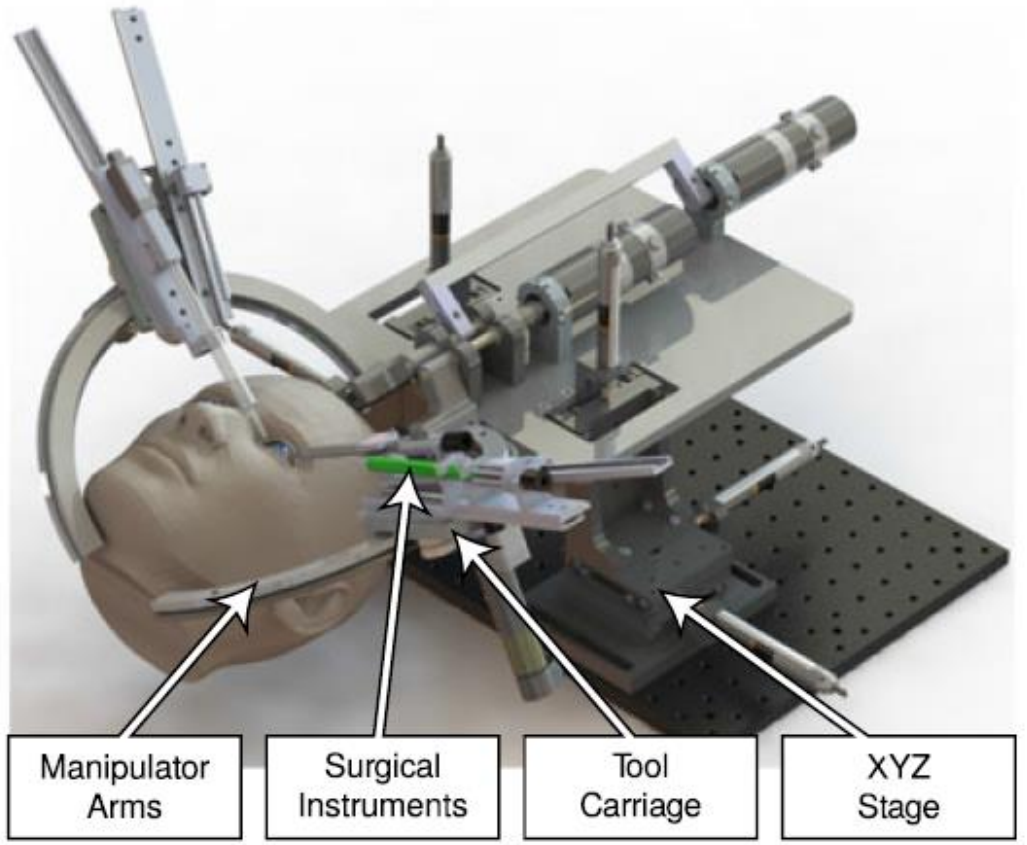
Paper Selection

Title: Intraocular Robotic Interventional Surgical System (IRISS): Mechanical Design, Evaluation, and Master–slave Manipulation

- Describes the mechanical design of the IRISS
- Discusses the hardware–software interface and the method of control
- Evaluates the performance of the robot both mechanically and in a clinical trial



CAD model for IRISS

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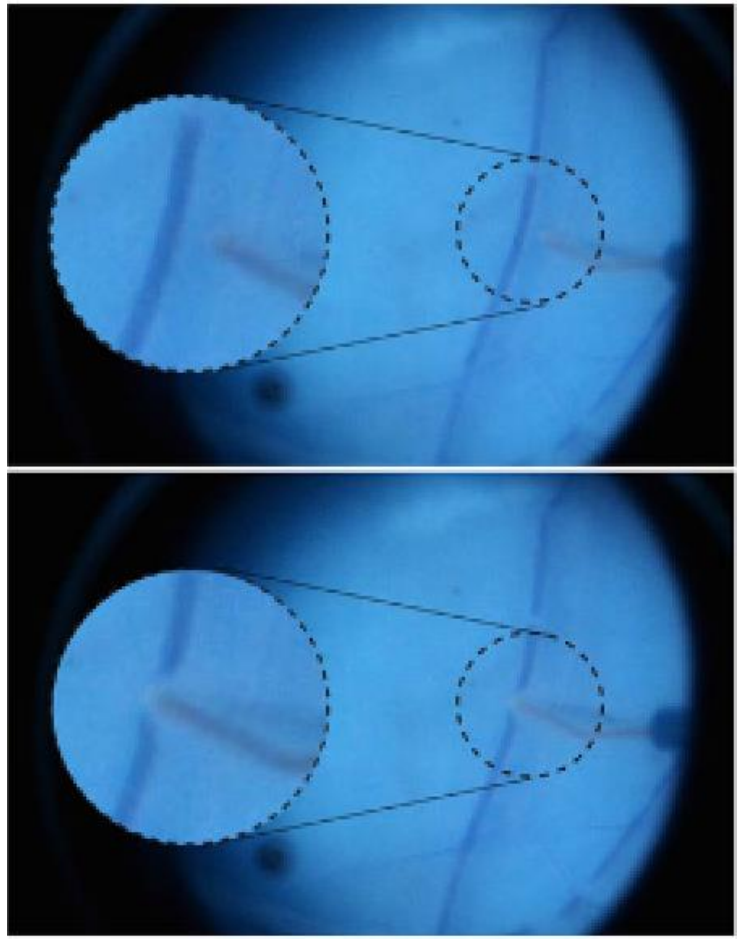
Key Result and Significance

- Remotely operated and fully automated intraocular robotic system
- Adjustable RCM point aiming at performing safe manipulation
- Designed compatible to clinical requirements
- Simultaneously employ two tools inside the eye

Most significant achievement: robotic retinal vein cannulation



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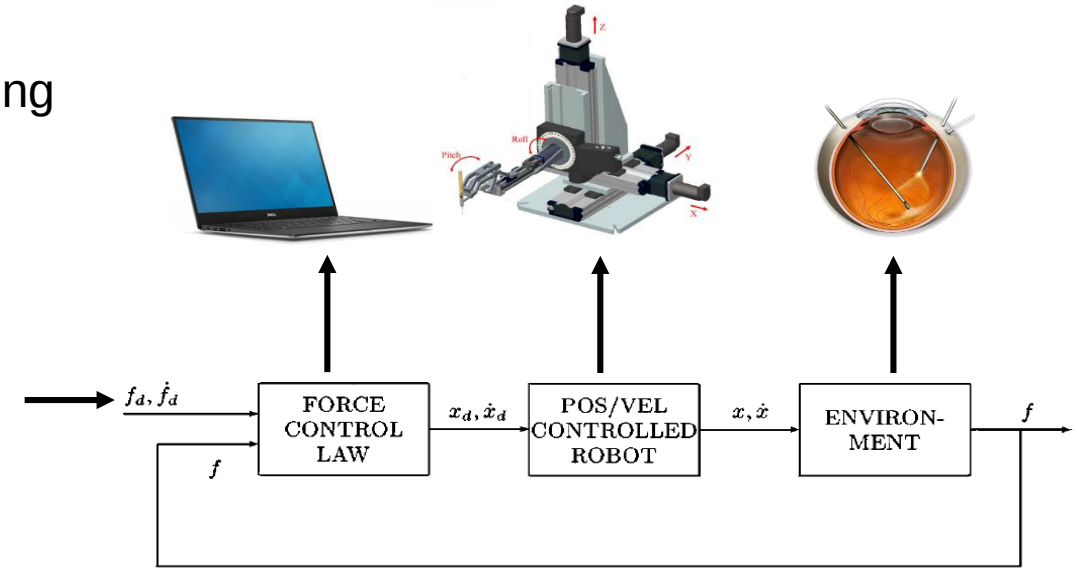
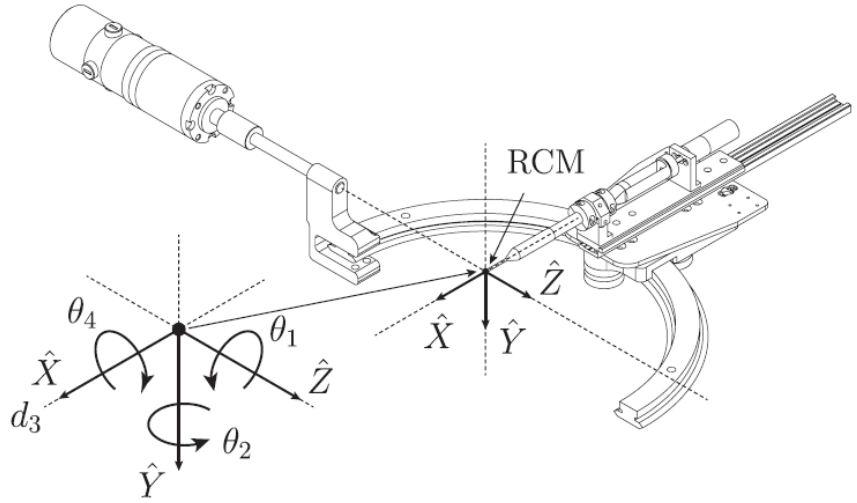
Background Information

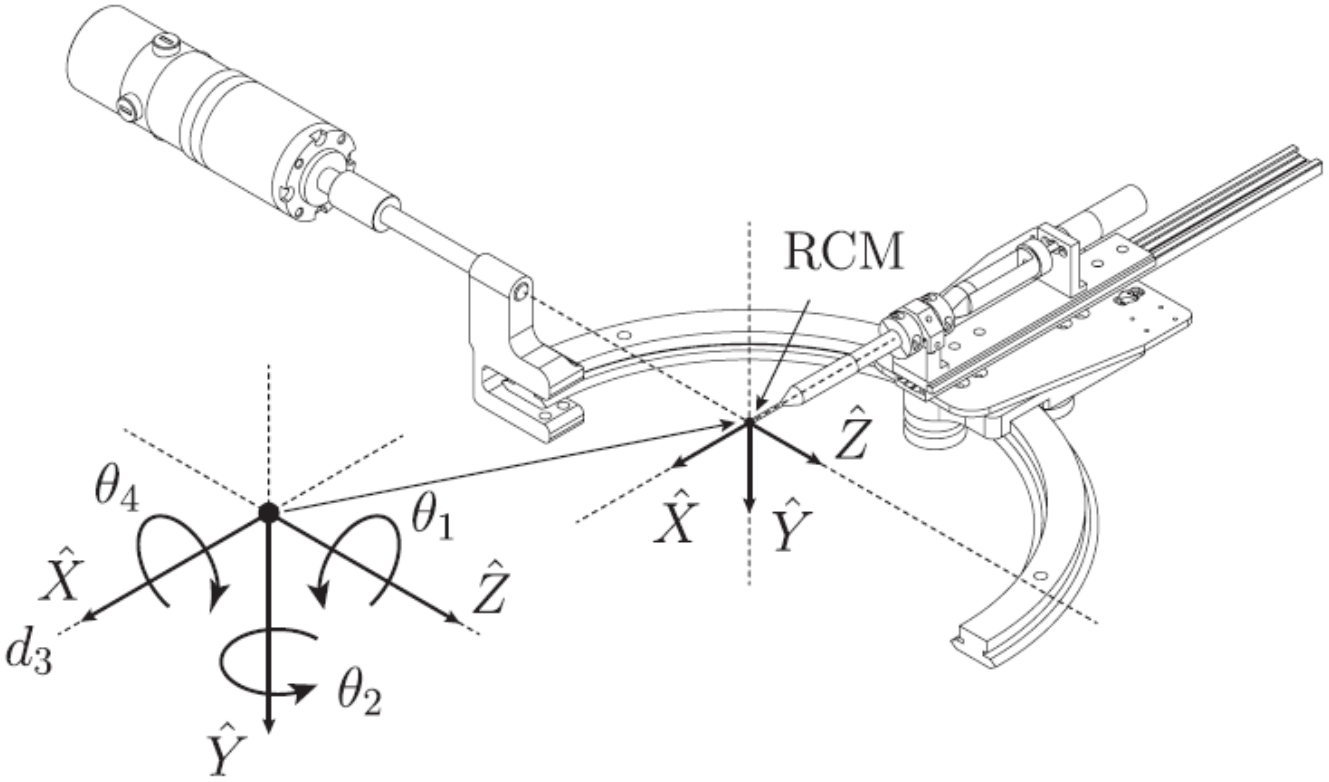
Two methods exists for reducing stress at the eye entry site during surgery:

- Using active software enforcement with visual or force-based feedback control to minimize tool-induced stress

- Physically constraining the surgical instrument about its incision point in the eye

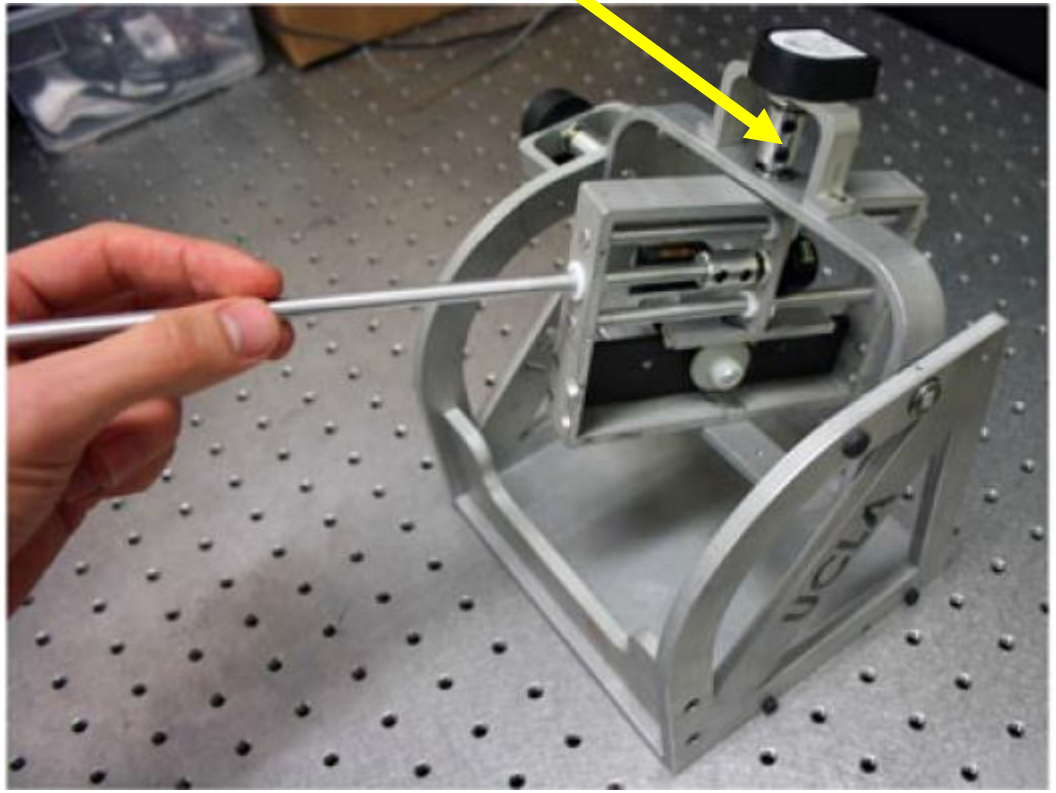




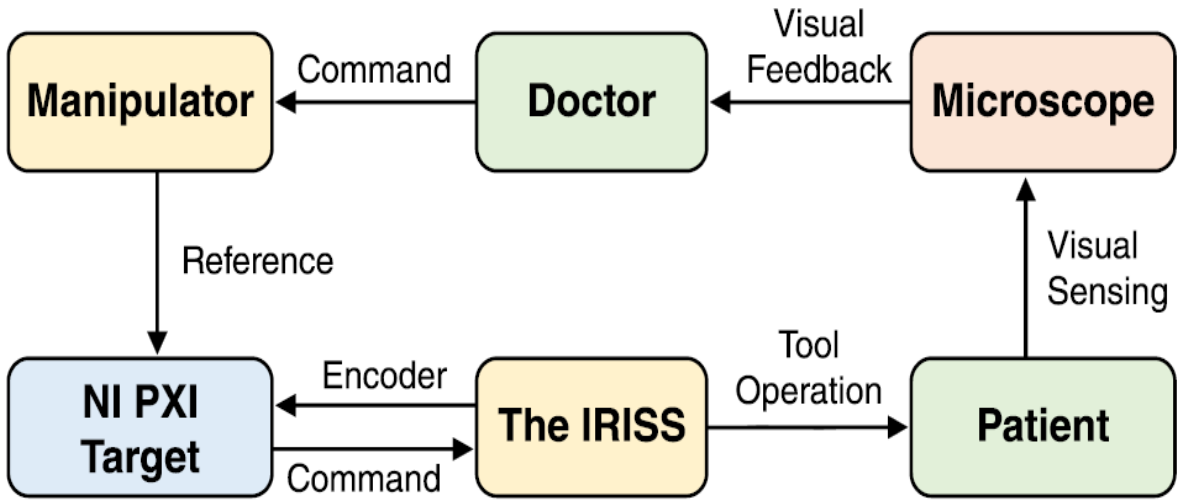


Slave robot with 6-DOF

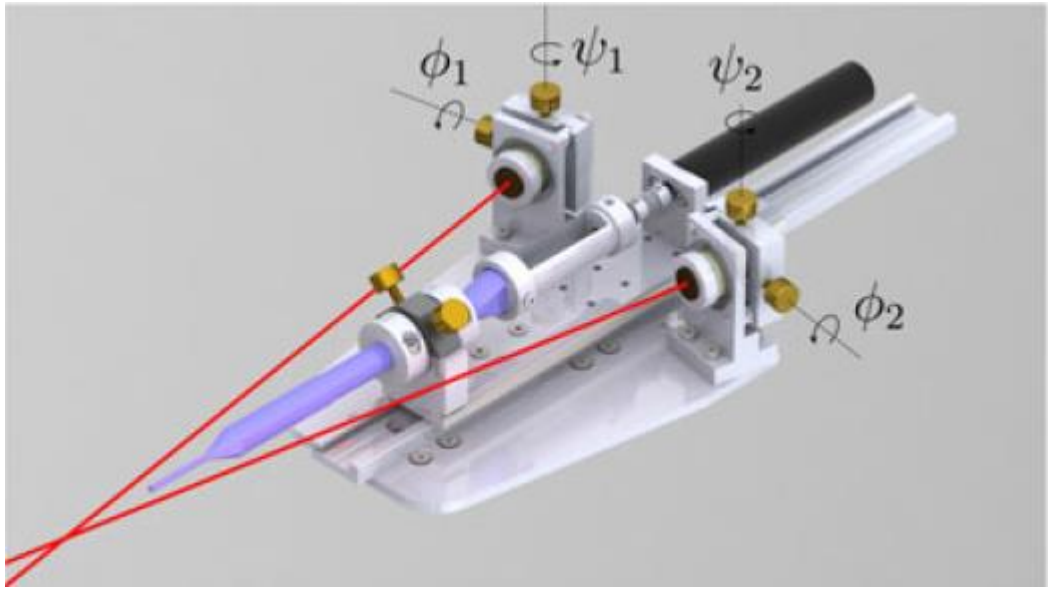
2 DOF gimbal mechanism



Master robot with 3 DOF

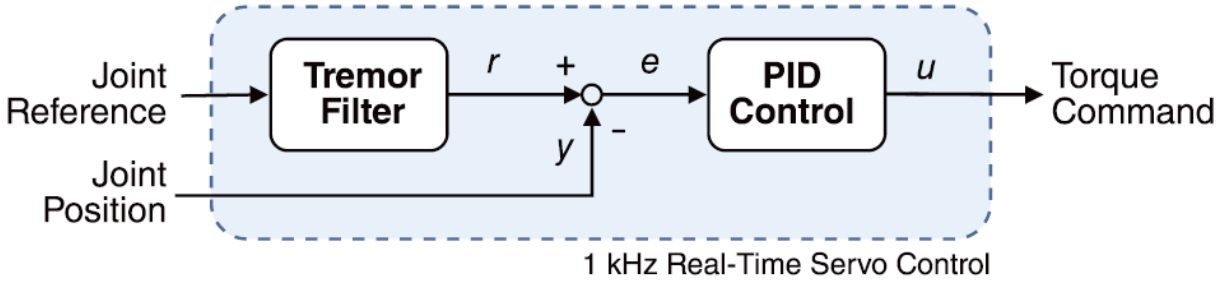


system architecture



CAD model of the RCM laser tool holder

alignment of the RCM to the incision point with computer-vision guidance by searching the minimal detected area of laser points



The data acquisition of the master manipulators and control for the IRISS are implemented on a National Instruments PXI real-time target with sampling rate of 1 kHz

Quantitative Results

resolution of optical joint encoders for each DOF

Joint	Count/Rev.	Gear ratio	Resolution
θ_1	4000	100:1	0.90 mdeg/count
θ_2	2048	588:1	0.30 mdeg/count
d_3	1024	60:1	1.26 μm/count
θ_4	1024	17:1	20.7 mdeg/count

statistical results of precision test

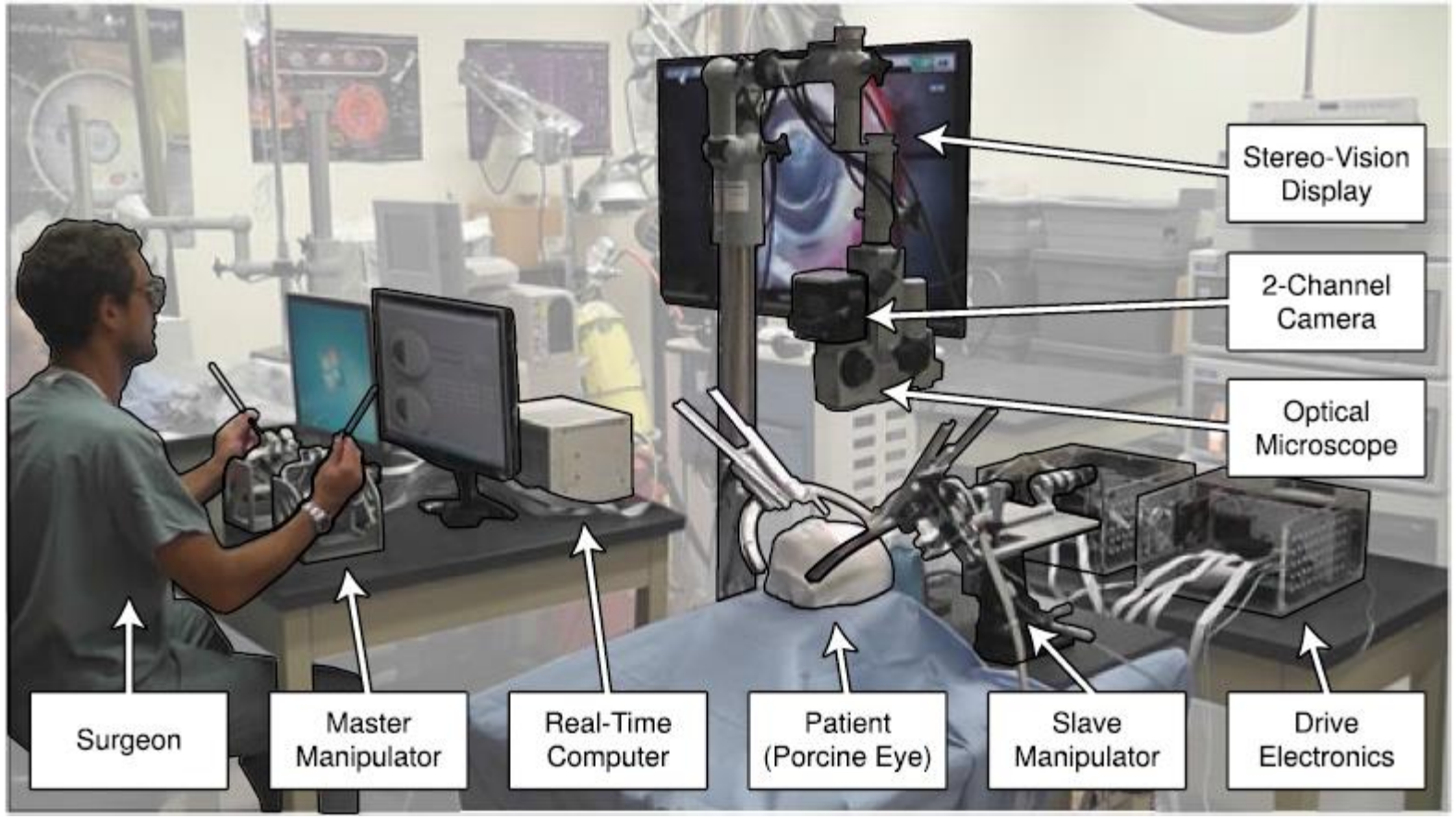
	RMS	SE	Max.	*n*
Point A	0.027	0.002	0.045	14
Point B	0.030	0.002	0.047	15

All values are in units of mm.

point A (at $\theta_1 = 15°, \theta_2 = 15°$ and $d_3 = -2.55$ mm).

point B (at $\theta_1 = 5°, \theta_2 = -5°$ and $d_3 = -2.10$ mm).

Surgery tasks performed



experimental setup for surgical tests on porcine eyes

- The IRISS was able to perform the following surgical procedures:

1. anterior lens capsulorhexis

2. viscoelastic injection

3. hydro-dissection

4. lens aspiration

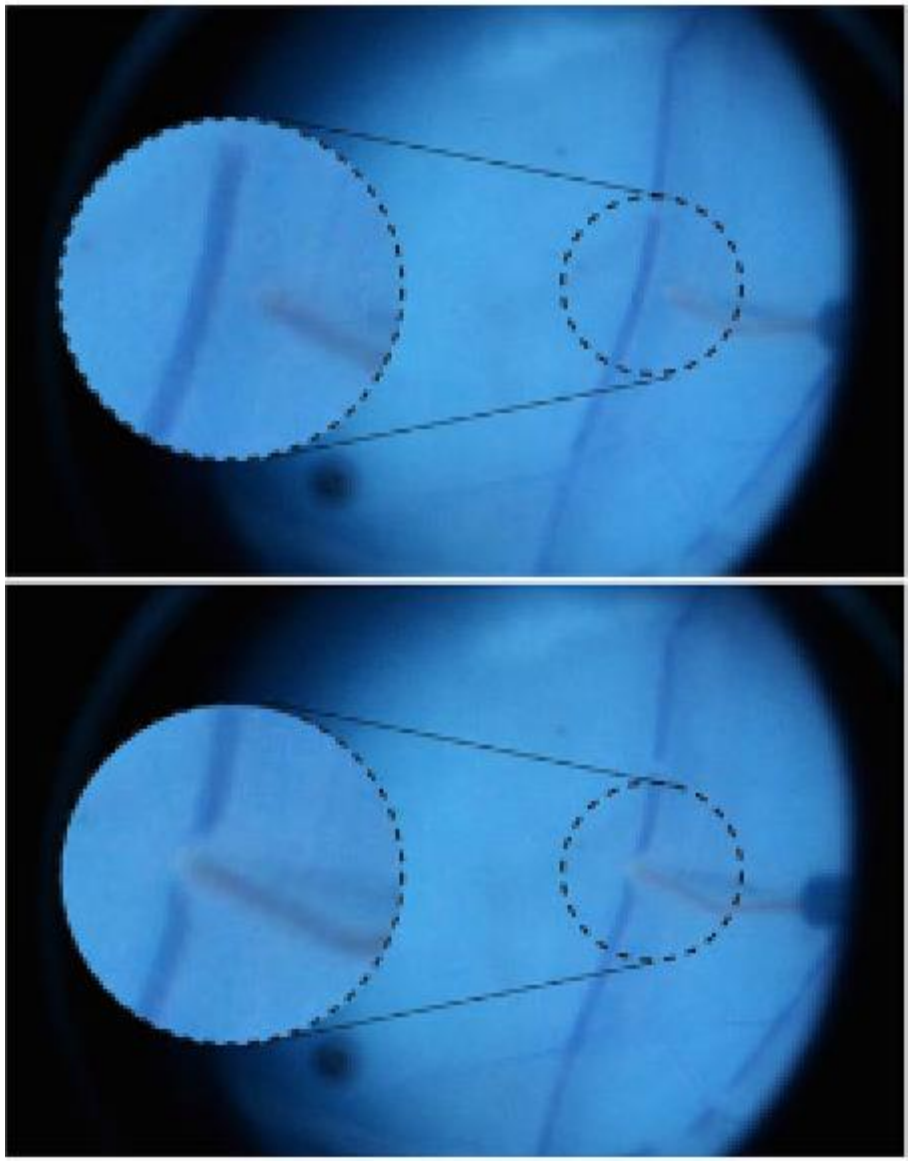
5. **retinal vein cannulation** (requires a tool-positioning accuracy of 10 µm)

6. vitrectomy.

Surgery tasks performed

View of the surgical field through the microscope moments

- before retinal vein cannulation →
- during retinal vein cannulation →



Assessment

- **Pros**
  - Developing software and hardware components for a remote robotic master-slave retinal surgery
  - Many technical approaches to increase the precision
  - Laser-based RCM positioning
  - Performing many in vivo advanced surgery tasks
- **Cons**
  - They have not attached a force sensing tool to the robot for active force control (sclera or tip) – online sclera monitoring is not possible
  - Surgeons mostly rely on visual or force feedback cues (collaborative controlled robots seem more advantageous)

Conclusion

- Developing an active force control at sclera can still be a novel study
- It would be a great study to compare the sclera safety with the 2 methods mentioned.
- The same studies also can be done on tip force instead of sclera force

Citation

- J. T. Wilson, M. J. Gerber, S. W. Prince, C.-W. Chen, S. D. Schwartz, J.-P. Hubschman, and T.-C. Tsao, "Intraocular robotic interventional surgical system (iriss): Mechanical design, evaluation, and master–slave manipulation," The International Journal of Medical Robotics and Computer Assisted Surgery, 2017.