



Kick off Presentation

SLAM based on the spotlight for retinal surgery

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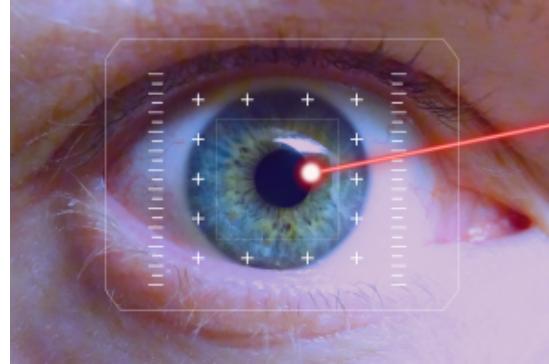


Introduction of robot-aided retinal surgery

Retinal Surgery Challenges

High Requirements

- High Precision
- Controlled Movements



Many Limitations

- Unwanted Movements (patients) → Robot filter out hand tremors
- Hand tremor (surgeon) → Spotlight localizes the instrument
- Bad visibility

Robot-assisted and Spotlight-based Retinal Surgery is of good significance.

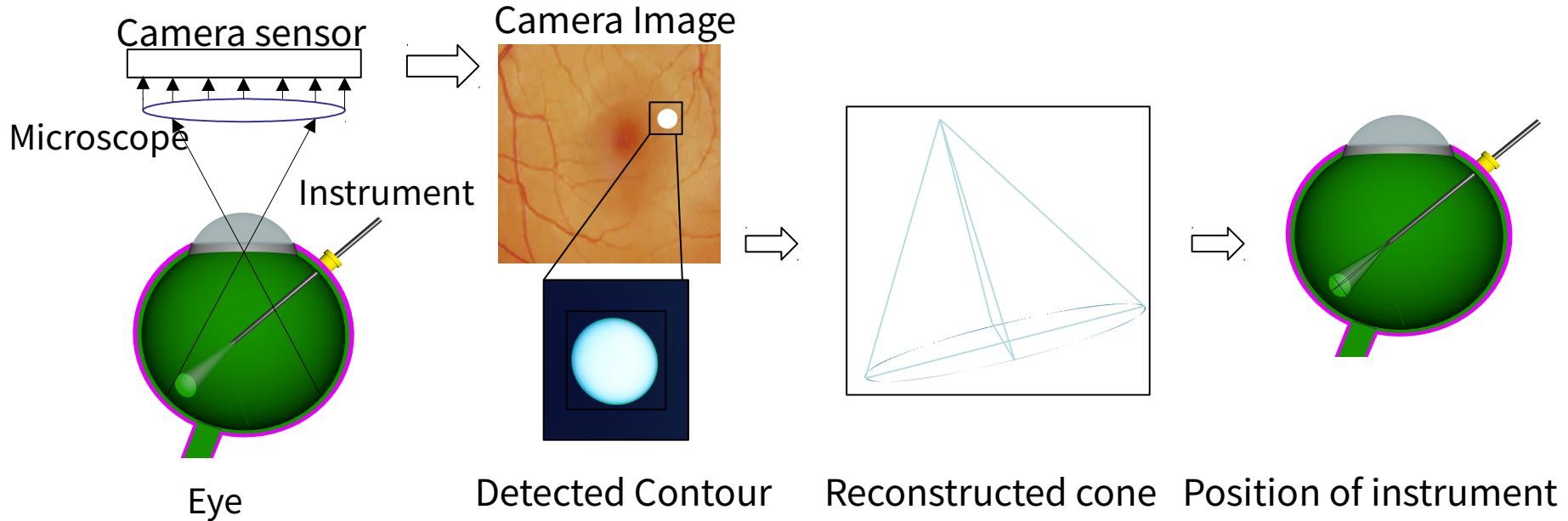




Related work of localization of Spotlight for retinal surgery

Spotlight-based Localization

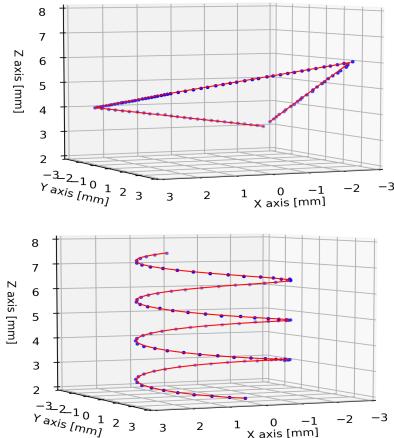
previous work: Workflow



Resource: Mingchuan Zhou , Felix Hennerkes,Nassir Navab "Theoretical Error Analysis of Spotlight-based Instrument Localization for Retinal Surgery" RAL-ICRA (2021).

Spotlight-based Localization

previous work: Summary



	Average Error [mm]	Maximum Error [mm]
Square (single)	0.026	0.100
Helix (single)	0.031	0.133

- + Good localization accuracy
- - lack mapping, which can guarantee the safety of eyeball
- **SLAMapping** ← What will be done in the research



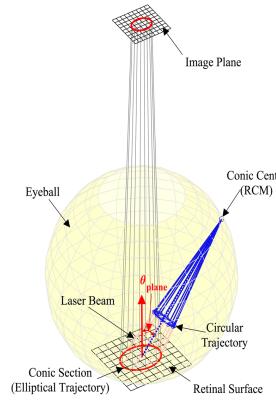
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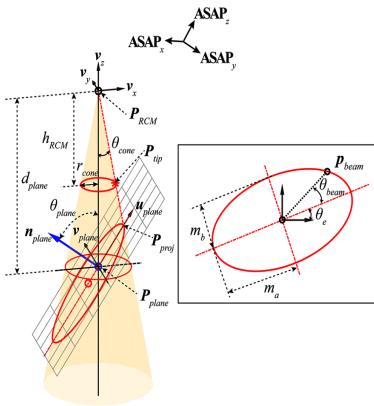
Related work of mapping and retinal reconstruction

Retinal surface estimation using monocular vision

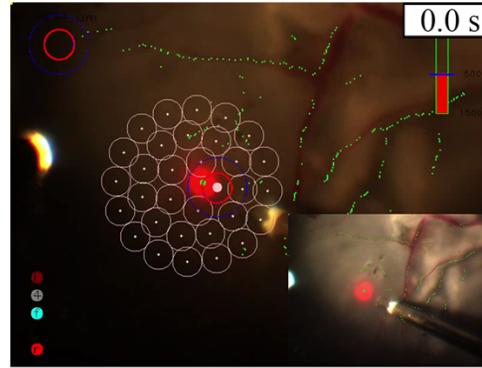
Surface Estimation using Projective Geometry



Conic section projects
on retinal surface



Cone beam analysis&
retinal surface estimation



Demonstration of intraocular laser surgery
on estimated retinal surface



Resource: S. Yang, J. N. Martel, L. A. Lobes Jr, and C. N. Riviere, "Techniques for robot-aided intraocular surgery using monocular vision," The International journal of robotics research, vol. 37, no. 8, pp. 931–952, 2018.

Retinal surface estimation using monocular vision

Experiments: Summary



(a)



(b)



(c)

(a) Eye phantom filled with water and covered with a contact lens.

(b) Dissected porcine eye placed inside the eye phantom without lens;

(c) Intact porcine eye with cornea for ex-vivo test

Work with image visual serving	Average localization error [um]
Eye phantom	>50
Placed with dissected porcine eye	>70
Intact porcine eye	>70

- + can achieve good accuracy when work with image visual serving
- - accuracy of surface estimation alone is very poor (>600um)
- - the estimated retina surface is just a plane, far different from realistic
- **3D Point Cloud Mapping**

Resource: Mingchuan Zhou , Felix Hennerkes,Nassir Navab “Theoretical Error Analysis of Spotlight-based Instrument Localization for Retinal Surgery” RAL-ICRA (2021).



What will be done?

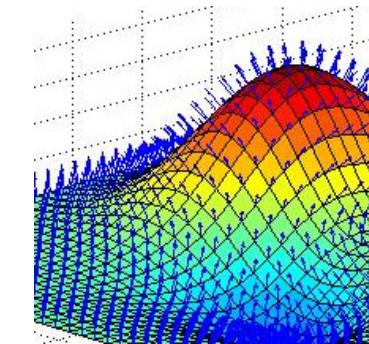
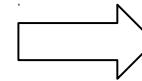
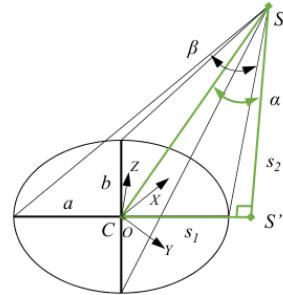
SLAM based on the spotlight for retinal surgery



Instruments' position
and pose (given by
robot platform)

+

Relative position of
projected ellipse
center



Coordinates of
points on surface
relative to world



Resources

Sources

- [1] Mingchuan Zhou , Felix Hennerkes,Nassir Navab “Theoretical Error Analysis of Spotlight-based Instrument Localization for Retinal Surgery” RAL-ICRA (2021)..
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- [3] B. O. Community. Blender - a 3D modelling and rendering package. Blender Foundation. Stichting Blender Foundation, Amsterdam, 2018.
- [4] W. H. Organization. World report on vision. Tech. rep. World Health Organization, 2019.
- [5] A. Routray, R. A. MacLachlan, J. N. Martel, and C. N. Riviere. “Real-Time Incremental Estimation of Retinal Surface Using Laser Aiming Beam.” In: 2019 International Symposium on Medical Robotics (ISMR). 2019, pp. 1–5. 59 Bibliography
- [6] S. Yang, J. N. Martel, L. A. Lobes Jr, and C. N. Riviere. “Techniques for robotaided intraocular surgery using monocular vision.” In: The International journal of robotics research 37.8 (2018), pp. 931–952.
- [7]Braun D, Yang S, Martel JN, et al. EyeSLAM: Real-time localization and mapping of retinal vessels during intraocular microsurgery. International Journal of Medical Robotics and Computer Assisted Surgery 14(1): e1848.(2018)
- [8]Yang S, MacLachlan RA, Martel JN, et al. Comparative evaluation of handheld robot-aided intraocular laser surgery. IEEE Transactions on Robotics 32(1): 246–251.(2016)

