Fused Photoacoustic and White-light Microscopic Imaging with Cross-modality Representation and Registration (Accepted by Medical Image Analysis 2025)

IEEE ISBI 2026

Poster No. 1571239205

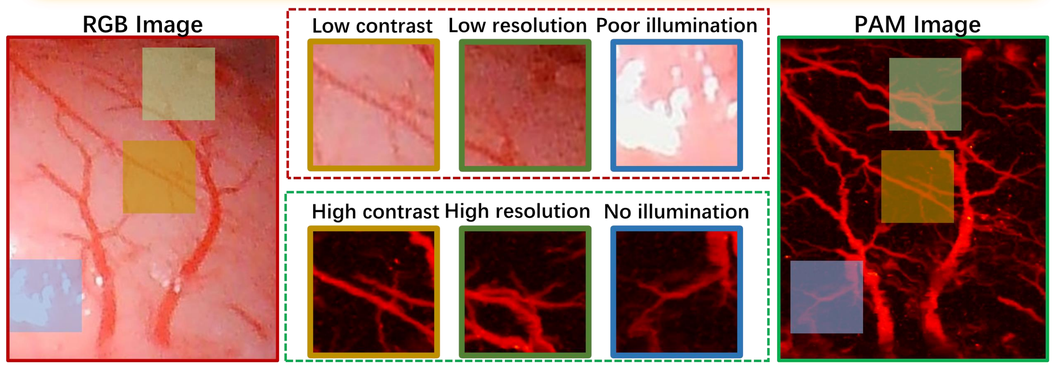
Yuxuan Liu, Yao Guo, Guang-Zhong Yang

Shanghai Key Laboratory of Flexible Medical Robotics, Shanghai Jiao Tong University, China

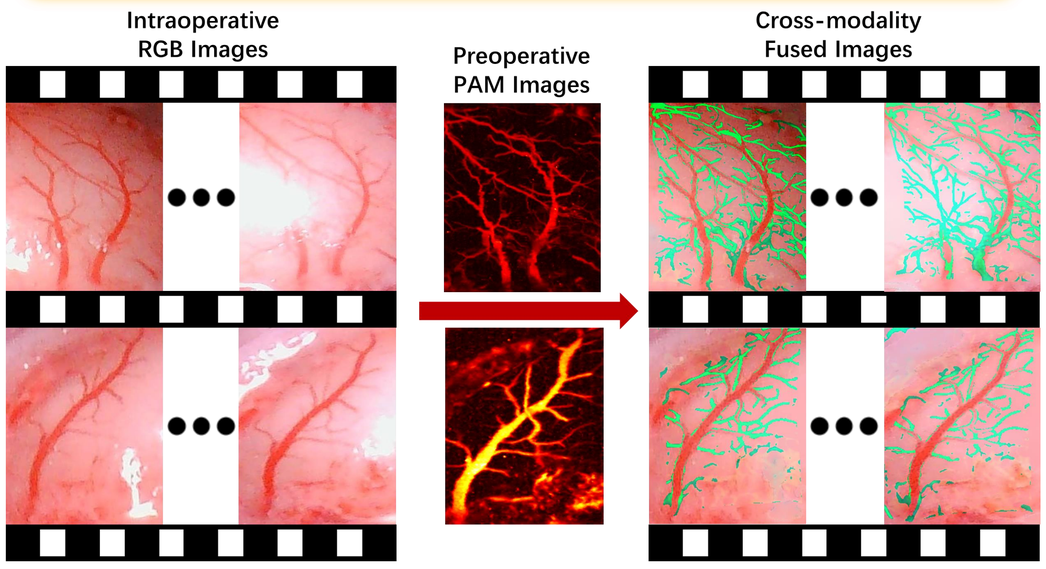
Institute of Medical Robotics, School of Biomedical Engineering, Shanghai Jiao Tong University, China

Problem Statement

Difference between two imaging modalities



Problem definition

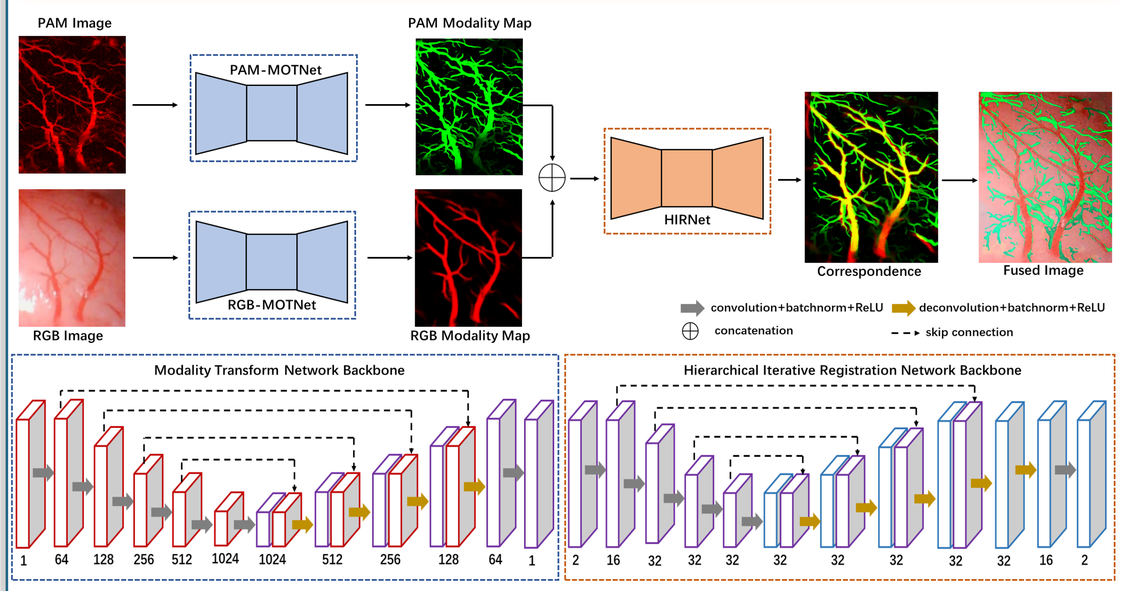


$$F_{\theta^*} = \arg\min_{\theta} L(\phi^{p\to c} \circ I_p, I_c), \phi^{p\to c} = F(I_p, I_c)$$

where I_p and I_c represent the PAM image and RGB image

Methodology

Overview of the proposed network architecture



- The modality transform network (MOTNet) is designed to extract the feature maps for a unified representation of micro-vessels that is invariant across modalities.

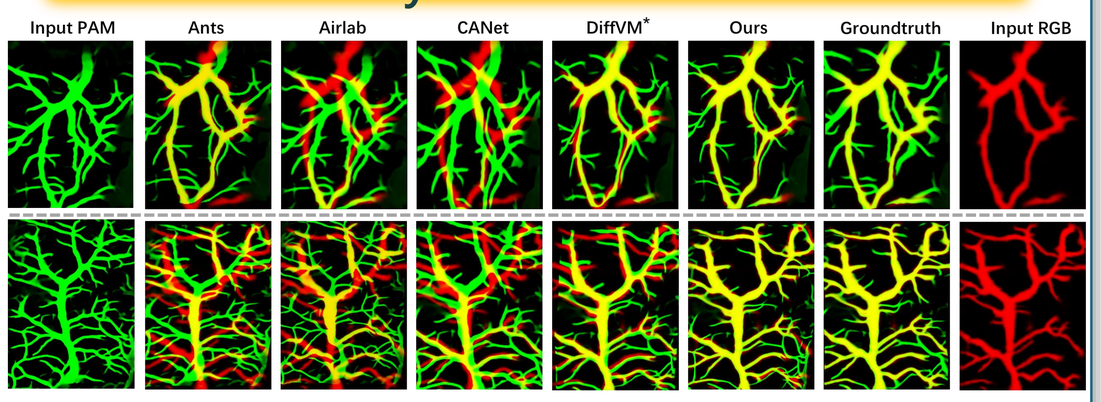
$$\{R_p, R_c\} = F_m(I_p, I_c), L_p^m = BCE(R_p, M_p), L_c^m = BCE(R_c, M_c)$$

- The hierarchical iterative registration network (HIRNet) is proposed to establish the cross-modality correspondence in a coarse-to-fine manner between intraoperative white-light microscopic images and preoperative PAM images.

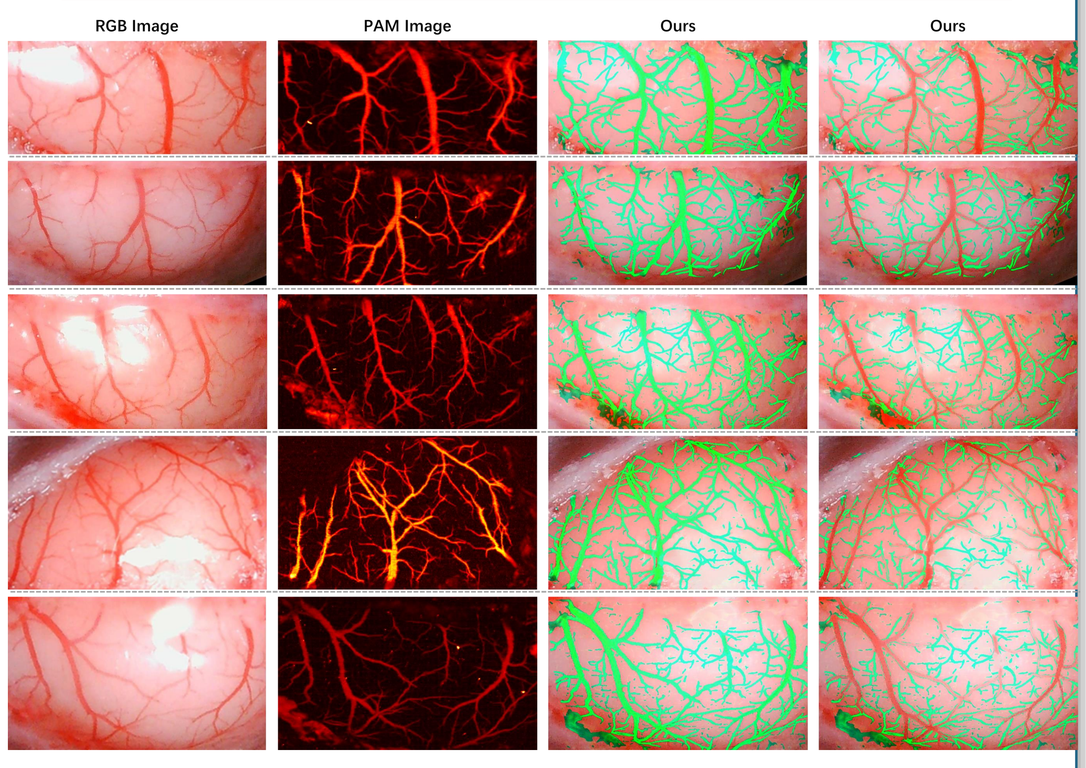
$$\phi = \uparrow \circ \phi^1 + \uparrow \circ \phi^2 + \uparrow \circ \phi^3, L^r = \sum MSE(R_p^{i*}, R_c^i) + \left|\left|\nabla \phi^i\right|\right|^2$$

Results

On synthetic dataset



On in-vivo dataset



Conclusion

- This work proposes a fused microscopic imaging scheme to improve the imaging quality of intraoperative white-light microscopic vision via establishing the correspondence of images between RGB and PAM modalities.
- The proposed method consists of two sub-networks to extract the unified feature representation of cross-modality microvasculature images and perform registration in an coarse-to-fine manner.
- A pipeline is developed to generate synthetic paired PAM and RGB images with ground truth correspondence.
- Both quantitative and qualitative results on synthetic and in-vivo datasets demonstrate the superior performance of our method and its potential application of clinical use.

Reference

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上海市柔性医疗机器人重点实验室

生物医学工程学院 School of Biomedical Engineering

上海交通大學 SHANGHAI JIAO TONG UNIVERSITY