DopUS-Net: Quality-Aware Robotic Ultrasound Imaging based on Doppler Signal

Zhongliang Jiang*, Felix Duelmer* and Nassir Navab

Computer Aided Medical Procedures, Technical University of Munich, Germany

*Contributed equally

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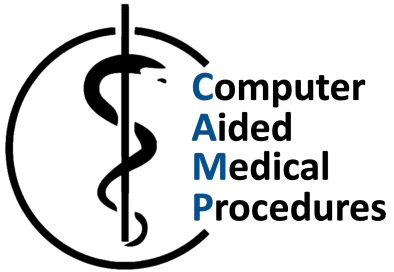
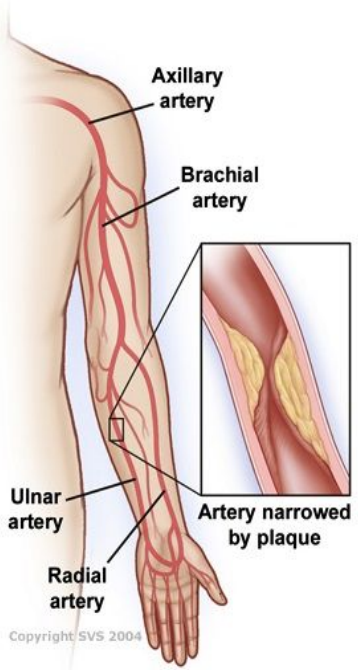


Clinical Motivation

- Peripheral Artery Disease (PAD) describes an abnormal narrowing of an artery due to a collection of plaque which is associated with:
  - Increased risk of cardiovascular morbidity and mortality
  - Reduced functional capacity
- It is estimated that >200 million people have PAD worldwide [1]
- Although regular screening procedures are recommended, current methods are:
  - resource intensive (medical staff, expensive equipment, etc.)
  - sometimes use radiation techniques (CTA)

An automatic, robust and non-ionizing screening method is needed!



[2]

[1] Shu, J. & Santulli, G. (2018) Update on peripheral artery disease: Epidemiology and evidence-based facts. *Atherosclerosis*. 275, 379–381.

[2] Arm artery disease. Arm Artery Disease | Society for Vascular Surgery. (n.d.). https://vascular.org/patients-and-referring-physicians/conditions/arm-artery-disease#resource-85

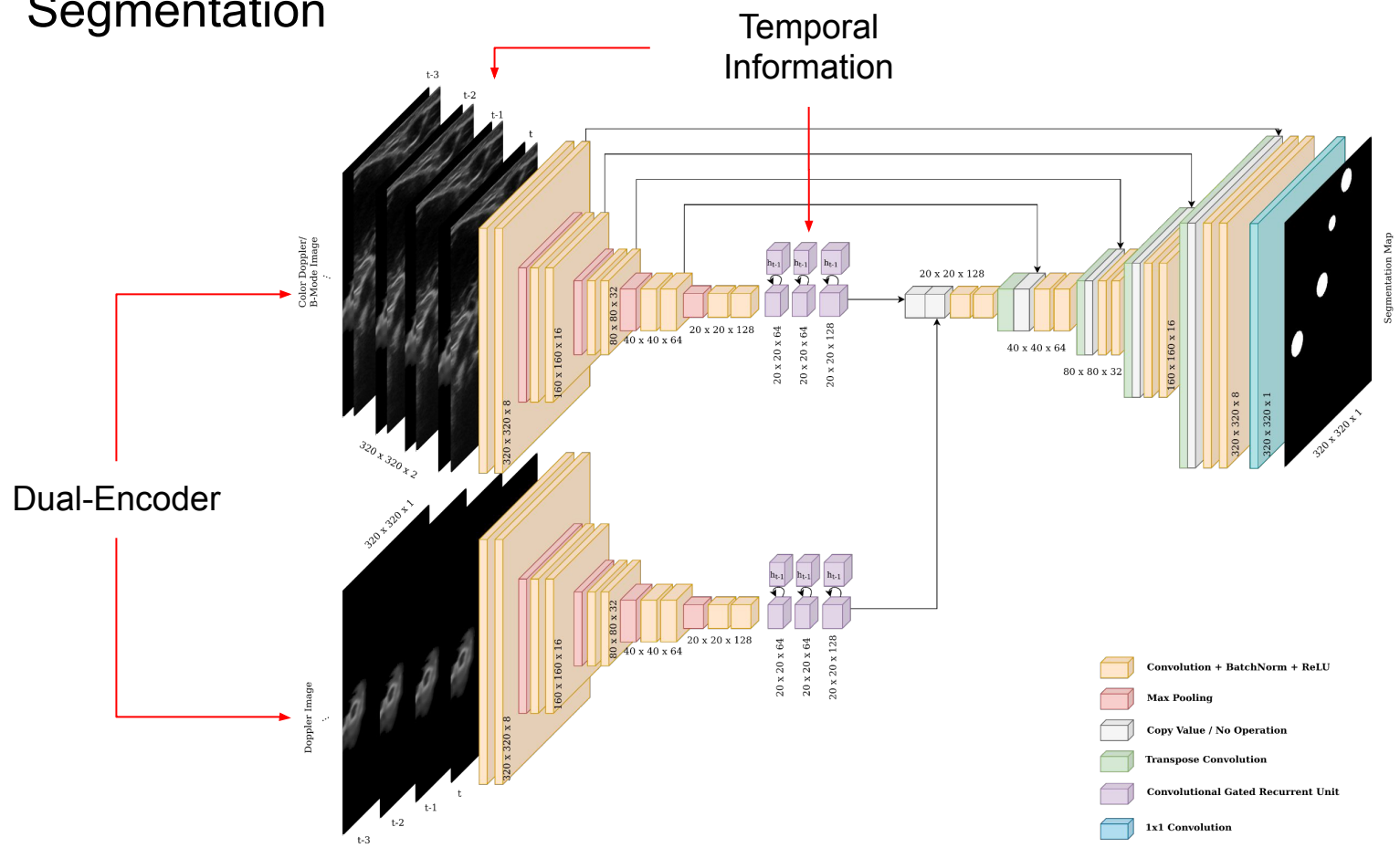
Contributions

We propose a robust quality-aware robotic Ultrasound screening using Doppler information for autonomous peripheral artery segmentation and 3D reconstruction:

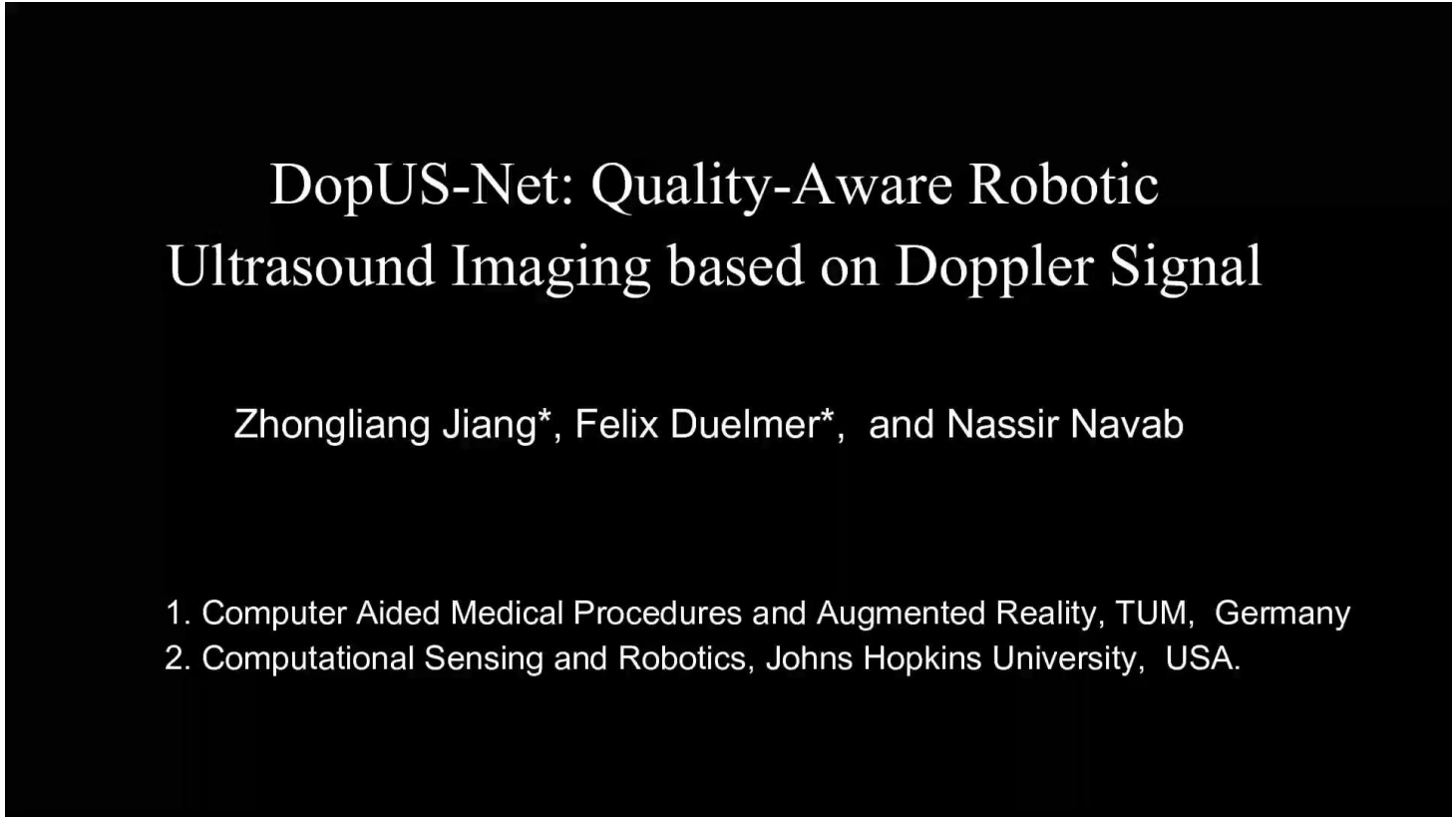
- DopUS-Net: novel segmentation network leveraging Doppler and continuity information for superior segmentation performance

- Quality-aware scanning: Doppler re-identification procedure for robust reconstruction performance using a closed-loop control scheme

Segmentation

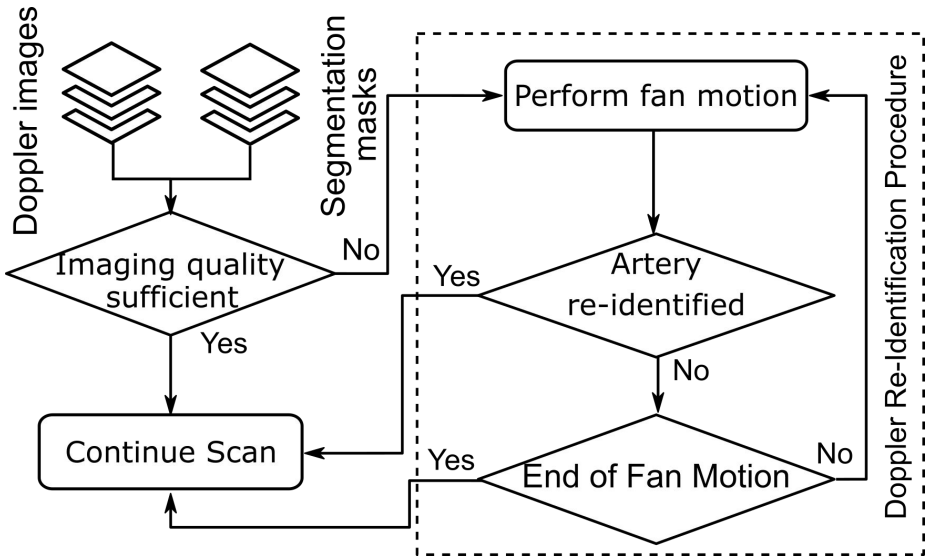


Segmentation

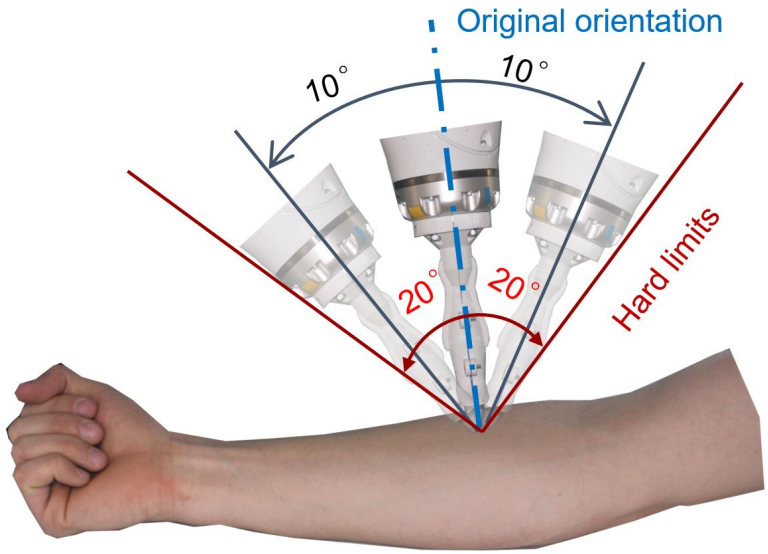


[1] Jiang, B., Chen, A., Bharat, S., Zheng, M. (2021). Automatic Ultrasound Vessel Segmentation with Deep Spatiotemporal Context Learning. In: Noble, J.A., Aylward, S., Grimwood, A., Min, Z., Lee, SL., Hu, Y. (eds) Simplifying Medical Ultrasound. ASMUS 2021. Lecture Notes in Computer Science(), vol 12967. Springer, Cham. https://doi.org/10.1007/978-3-030-87583-1_1
[2] Ronneberger, Olaf, Philipp Fischer, and Thomas Brox. "U-net: Convolutional networks for biomedical image segmentation." Medical image computing and computer-assisted intervention–MICCAI 2015: 18th international conference, Munich, Germany, October 5-9, 2015, proceedings, part III 18. Springer International Publishing, 2015.

Doppler Re-Identification

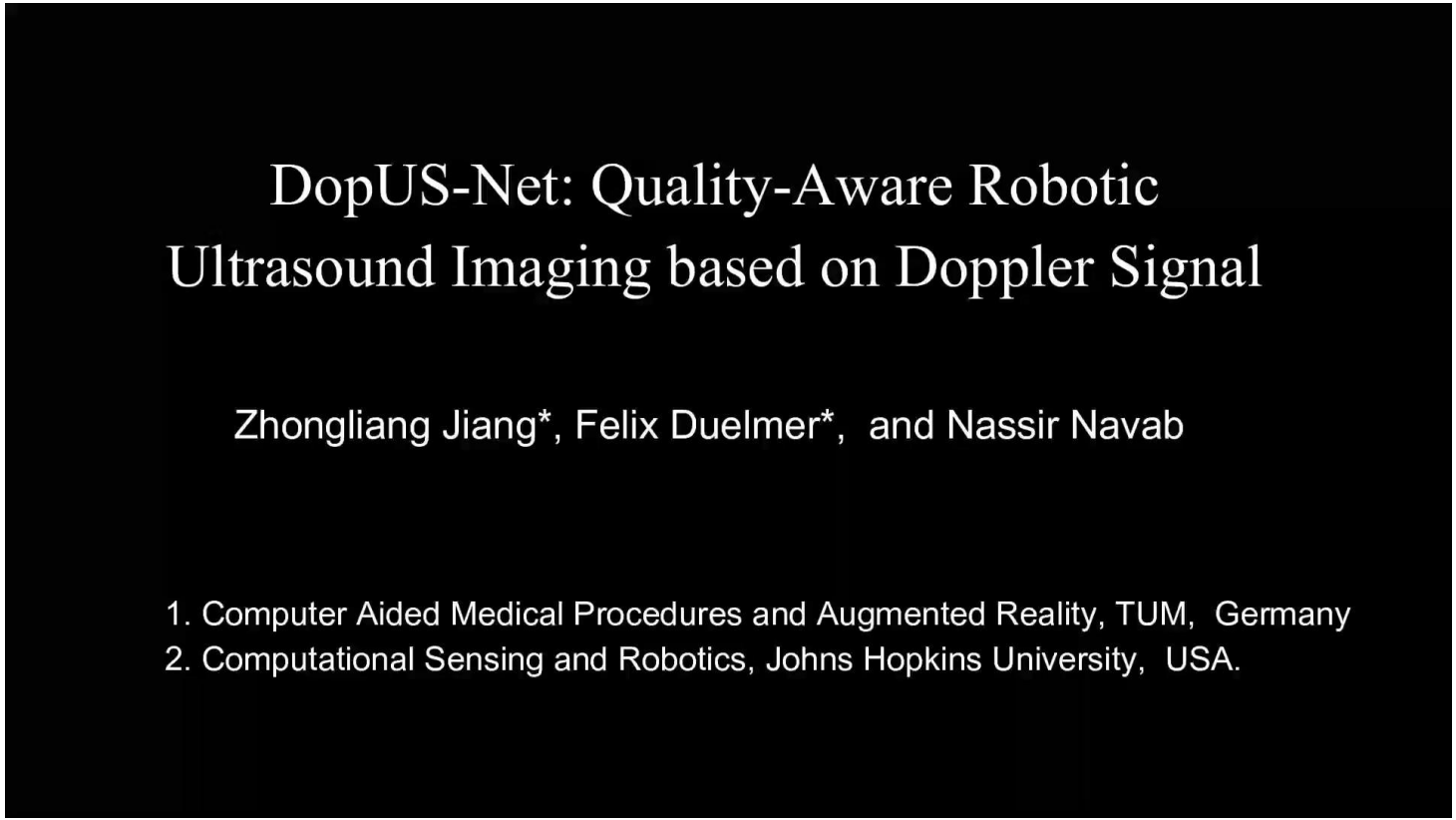


Flow Chart for Re-Identification



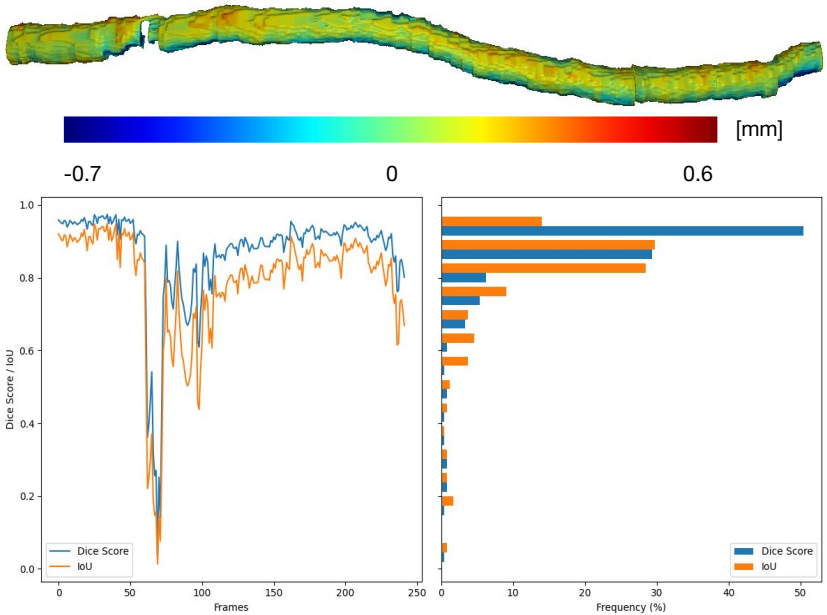
Visualization of Re-Identification

Doppler Re-Identification

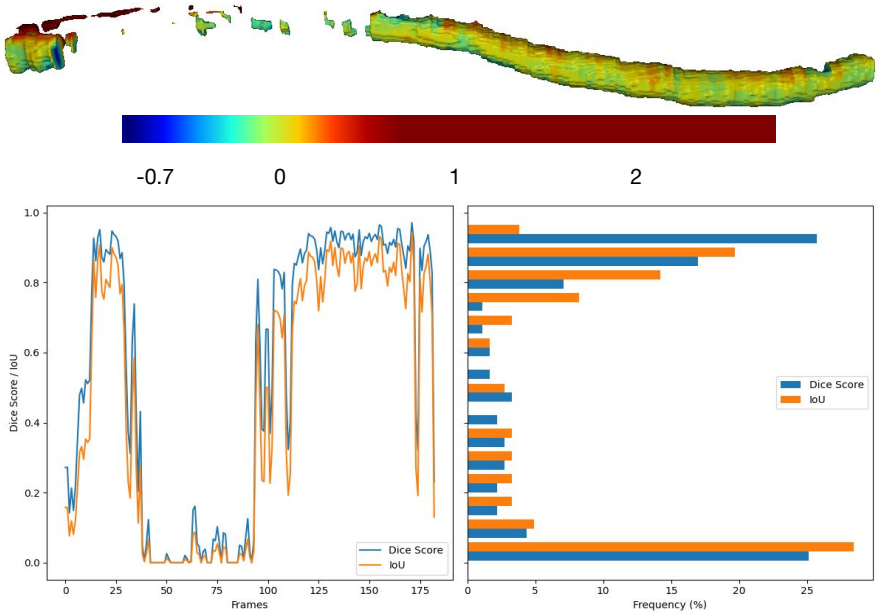


Artery Compounding

Doppler Re-Identification Enabled



Doppler Re-Identification Disabled



Results:

Avg. Dice Score:	0.867	Avg. Dice Score: 0.540
Avg. IoU:	0.785	Avg. IoU: 0.469

Conclusion

- Introduction of the DopUS-Net for enhanced vessel segmentation
- Novel quality-aware Doppler re-identification procedure for increased robustness
- Improved screening procedure for point-of-care Ultrasound systems
- Code publicly available

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Paper

Code

Video

https://github.com/Felixduelmer/DopUs

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