ETH zürich

ARSL
Acoustic Robotics Systems Lab

Semester Project: Real-Time Ultrasound Imaging Feedback

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30th January 2024, Zürich

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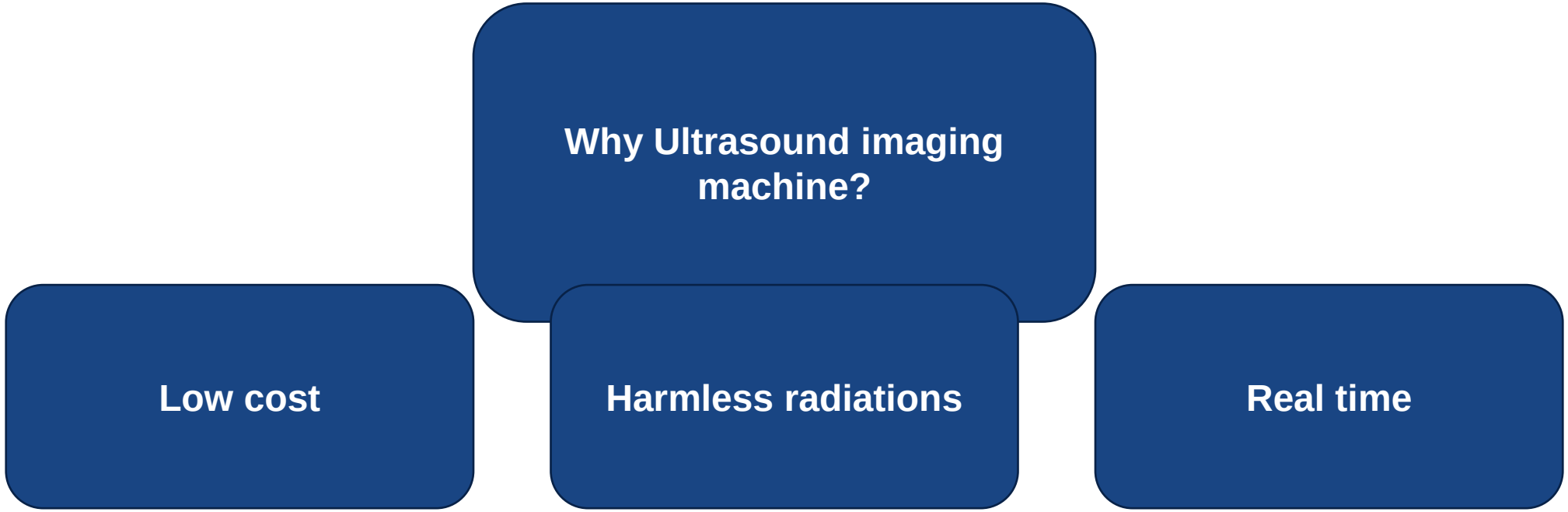
Introduction

How does Ultrasound Imaging work?

https://www.youtube.com/watch?v=JL-SB3JWmr0

Introduction

Introduction



Introduction

Why Ultrasound imaging machine?

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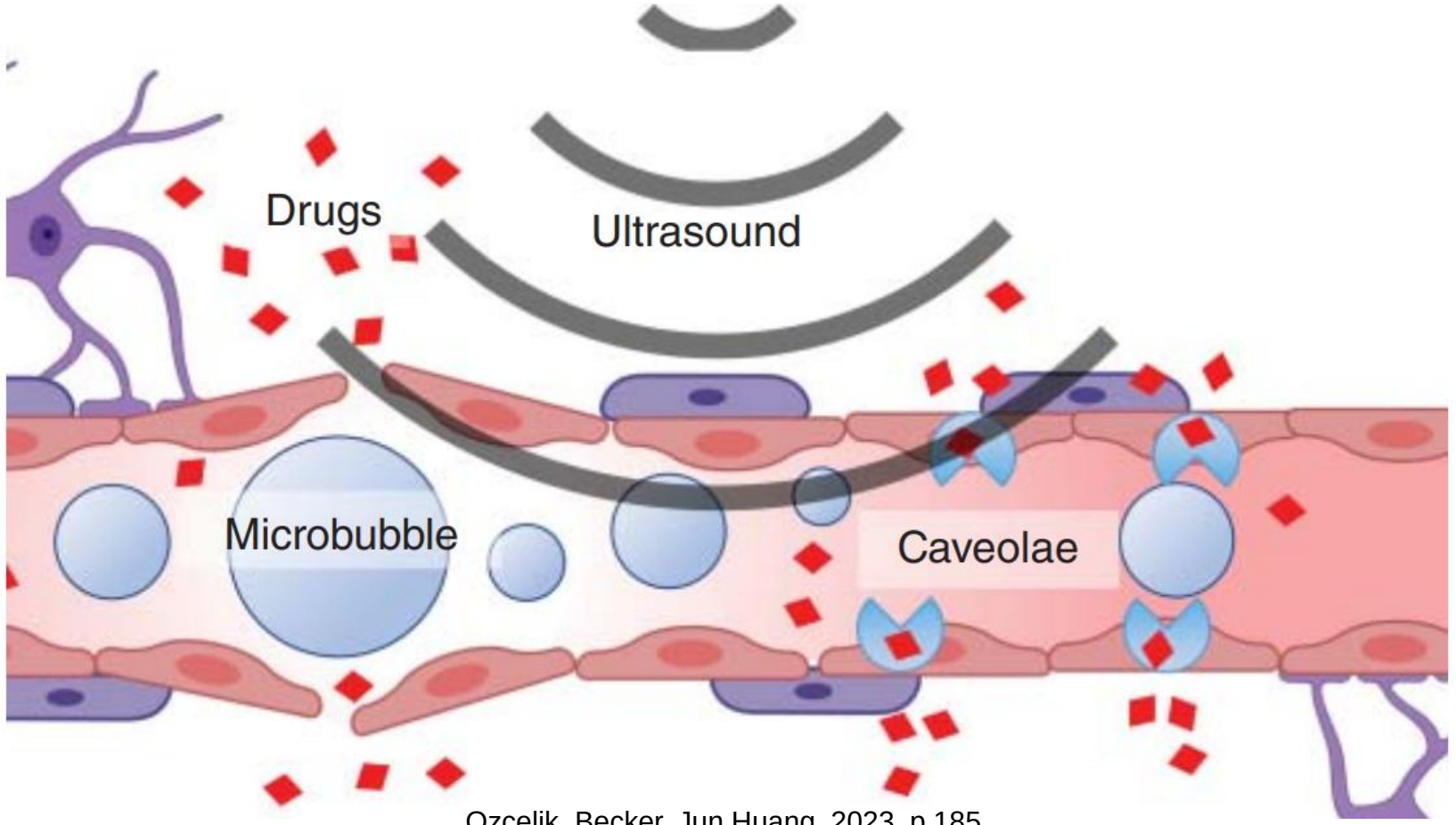
R

Harmless radiations

Introduction

Drug Delivery



Ozcelik, Becker, Jun Huang, 2023, p 185

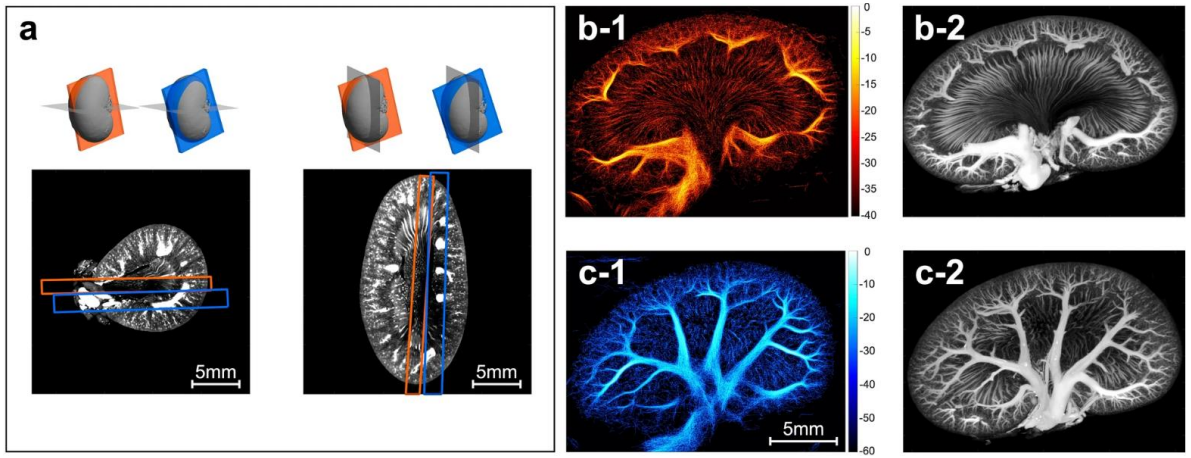
Introduction

Contrast Agent

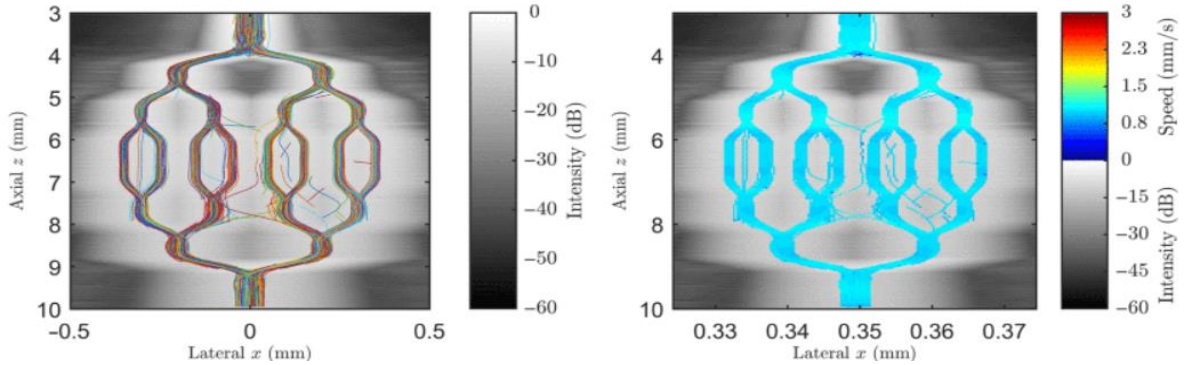
Introduction

Contrast Agent

Introduction

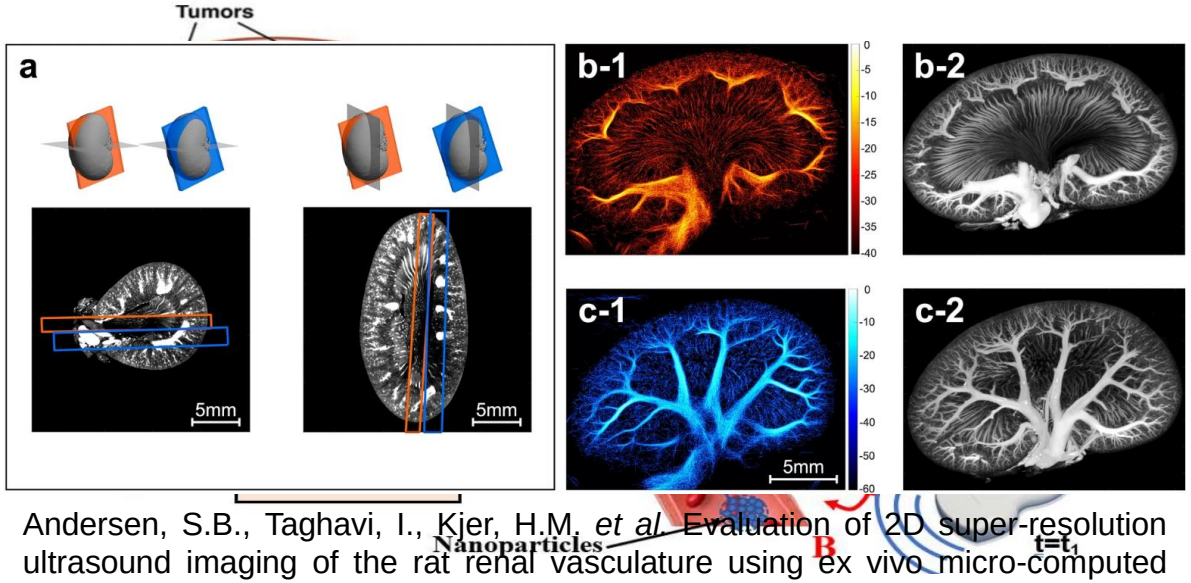


Andersen, S.B., Taghavi, I., Kjer, H.M. *et al.* Evaluation of 2D super-resolution ultrasound imaging of the rat renal vasculature using ex vivo micro-computed tomography.



Ackermann, D., & Schmitz, G. (2016). Detection and Tracking of Multiple Microbubbles in Ultrasound B-Mode Images.

Introduction



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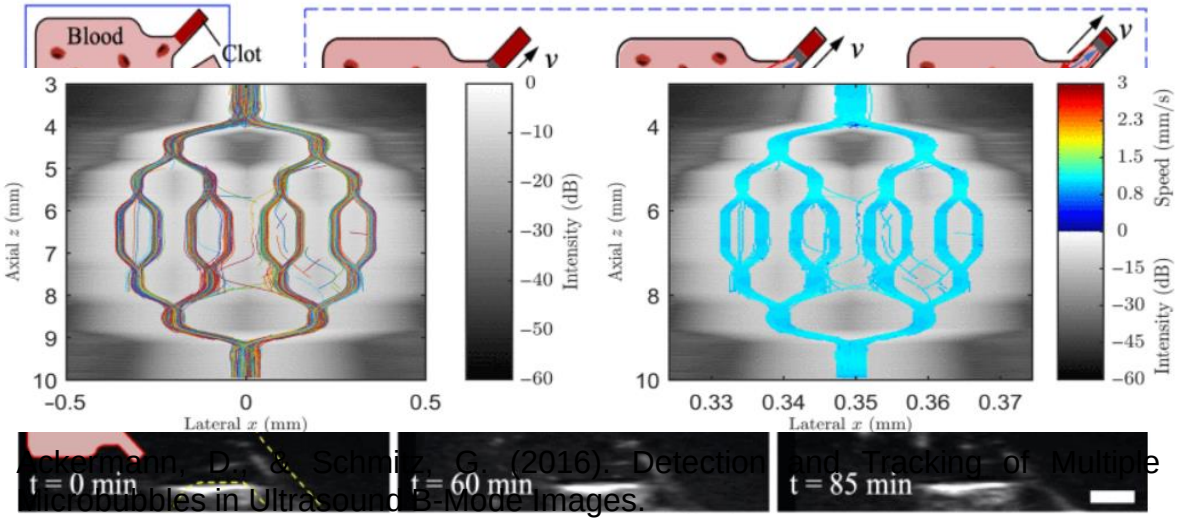
K. Bozuyla, Y. Alkhatib, D. Folio and A. Ferreira, "Fully Automatic and Real-Time Microrobot Detection and Tracking based on Ultrasound Imaging using Deep Learning,"



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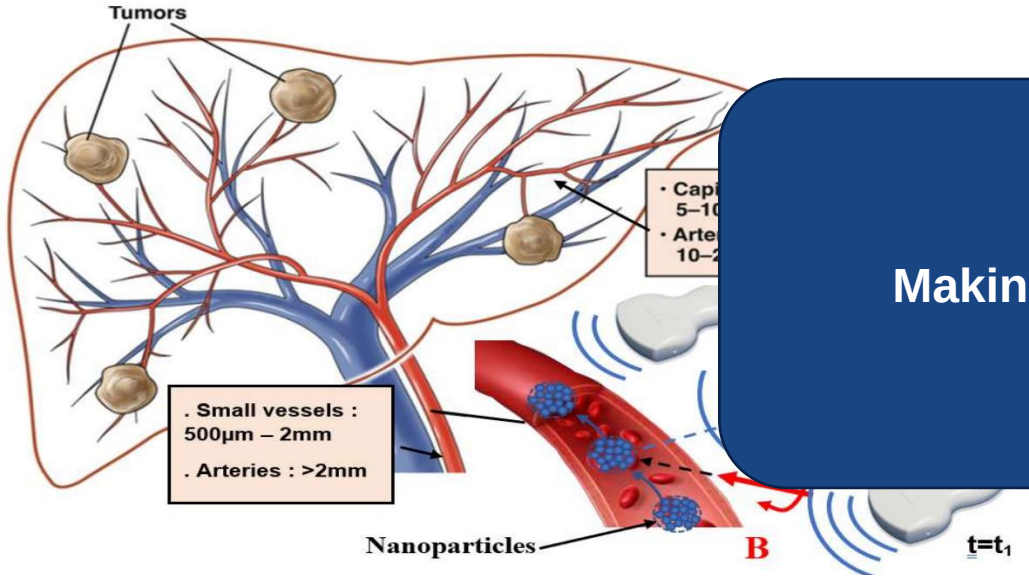
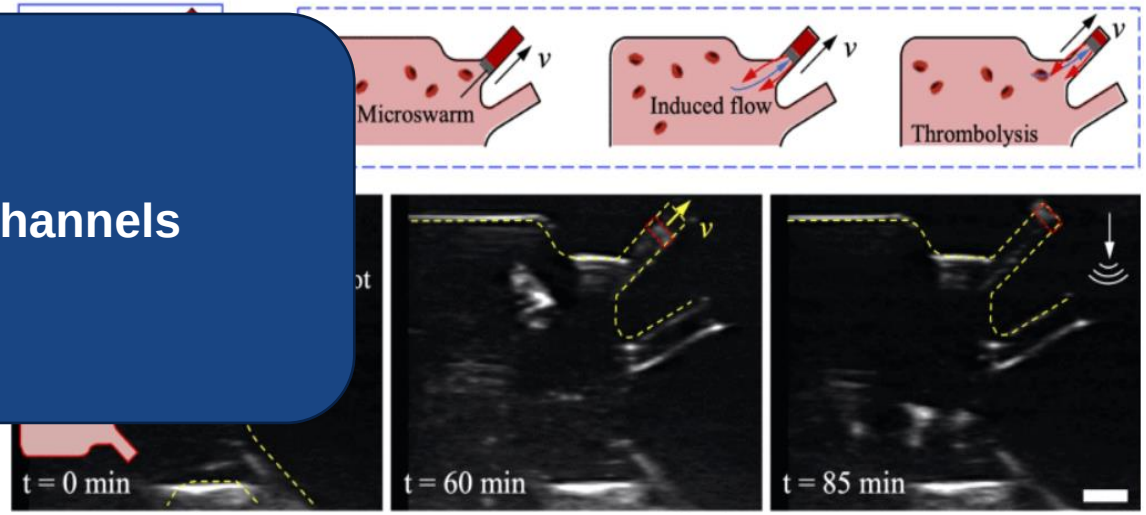
Q. Wang et al., "Reconfigurable Magnetic Microswarm for Accelerating tPA-Mediated Thrombolysis Under Ultrasound Imaging,"

Setups



K. Botros, M. Alkhatib, D. Folio and A. Ferreira, "Fully Automatic and Real-Time Microrobot Detection and Tracking based on Ultrasound Imaging using Deep Learning,"

Making of Channels



Q. Wang et al., "Reconfigurable Magnetic Microswarm for Accelerating tPA-Mediated Thrombolysis Under Ultrasound Imaging,"

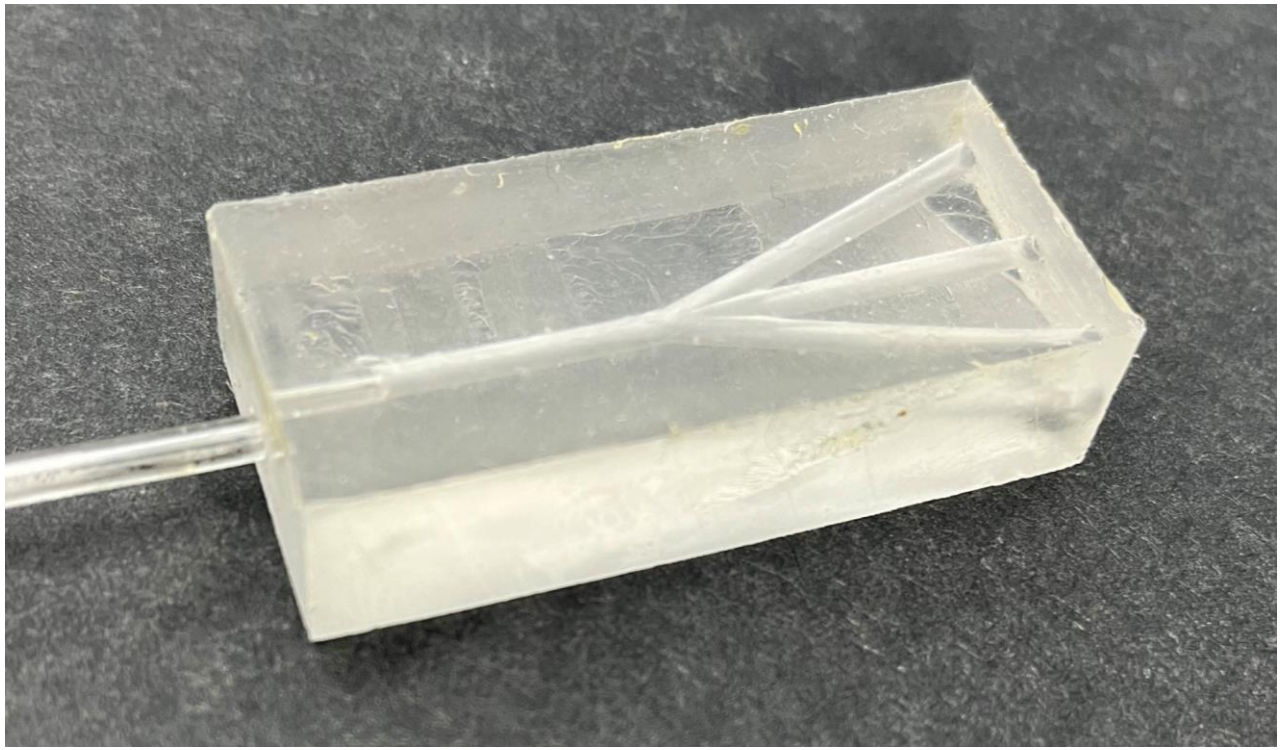
Setups

PDMS

Making of Channels

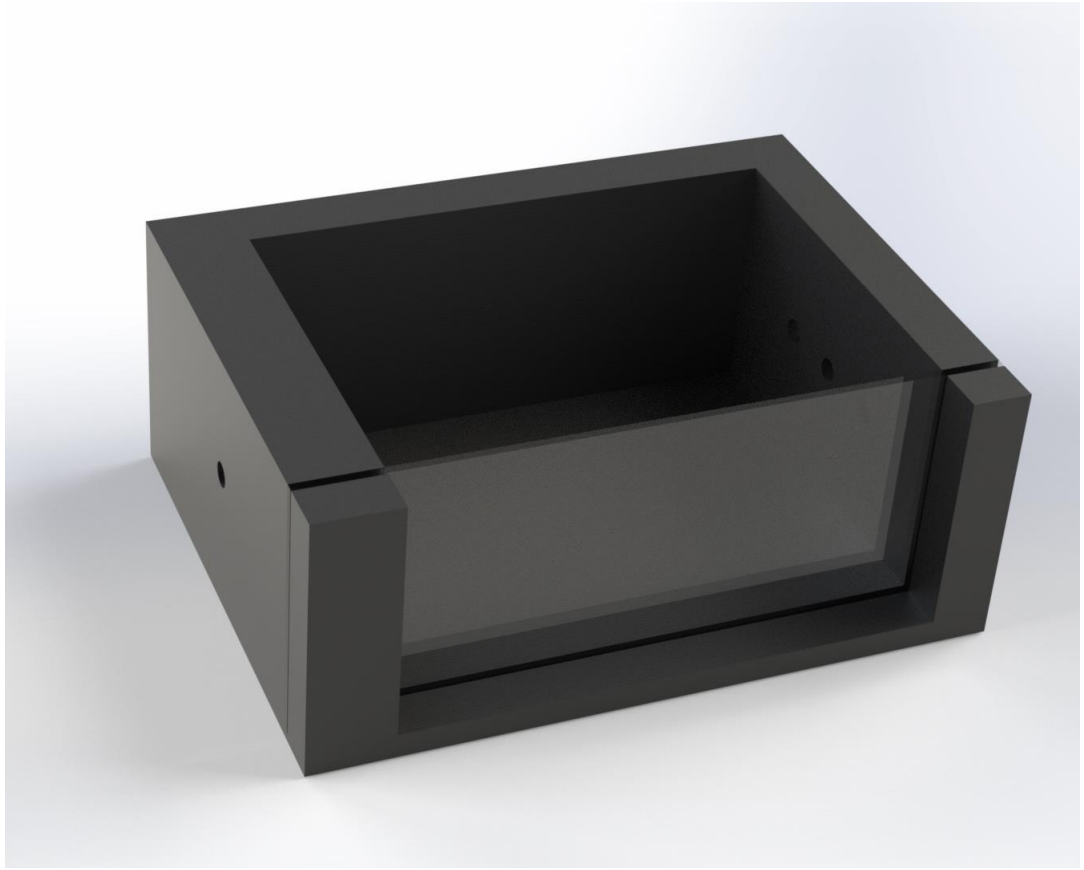
Setups

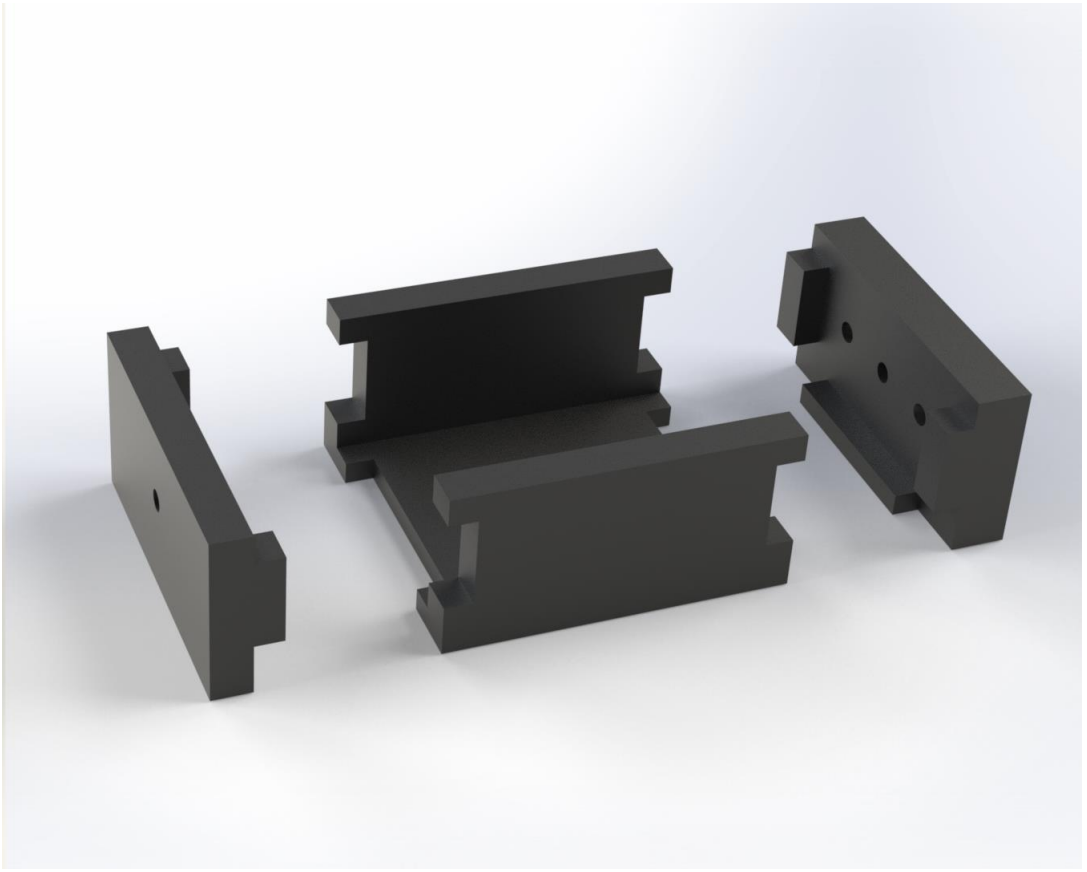
PDMS



Setups

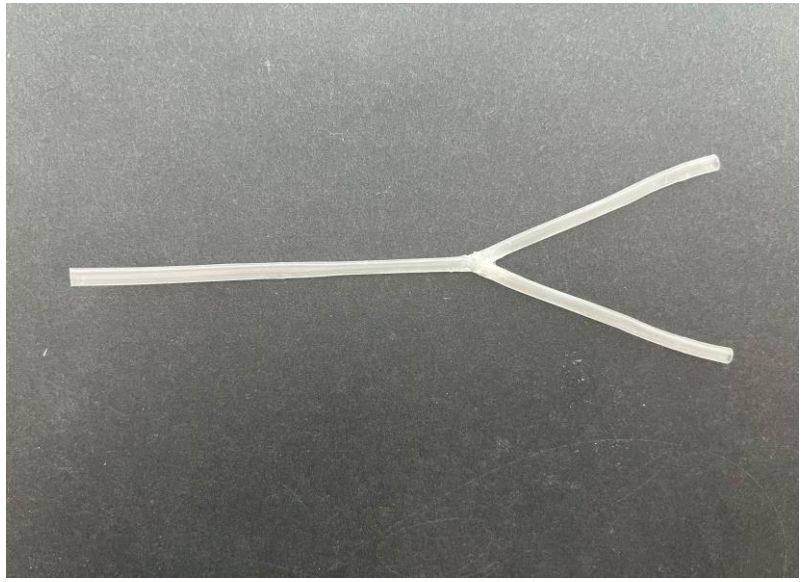
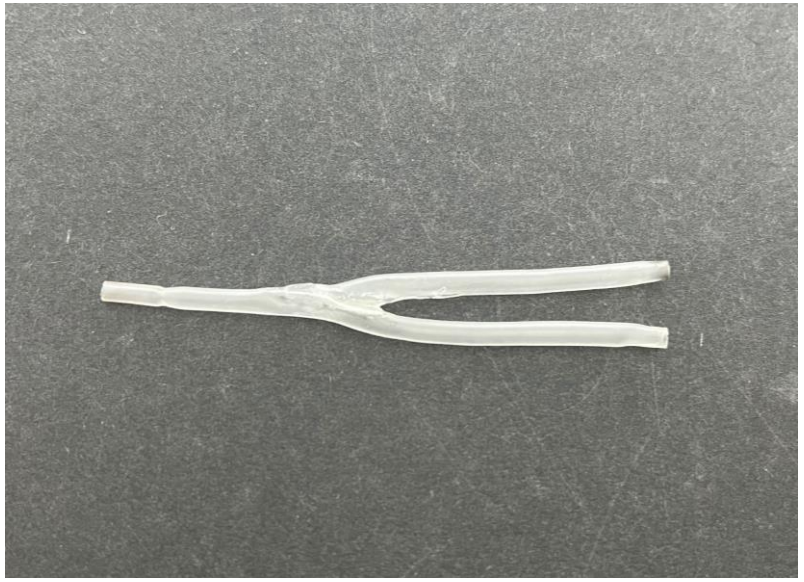
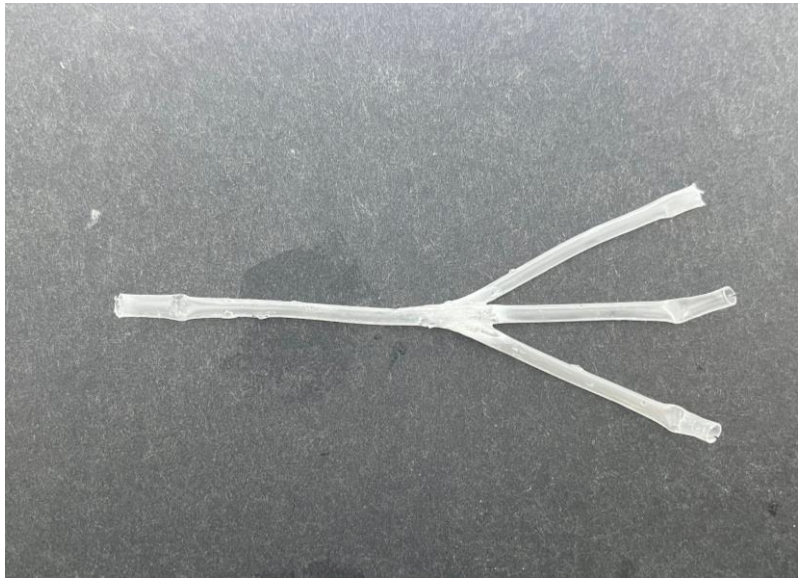
AgarAgar





Setups

Channels: Heat Shrink Tubes

Setups

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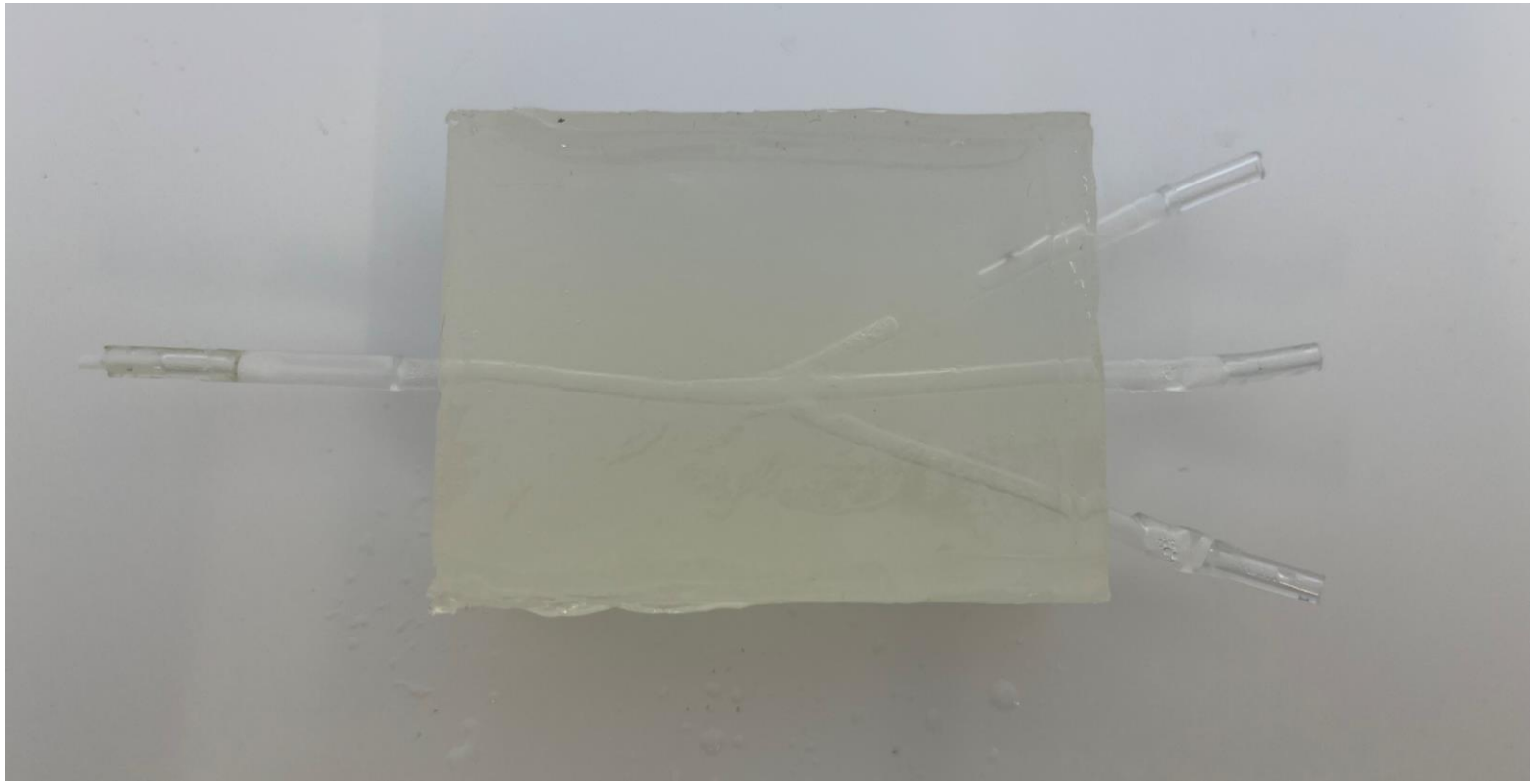
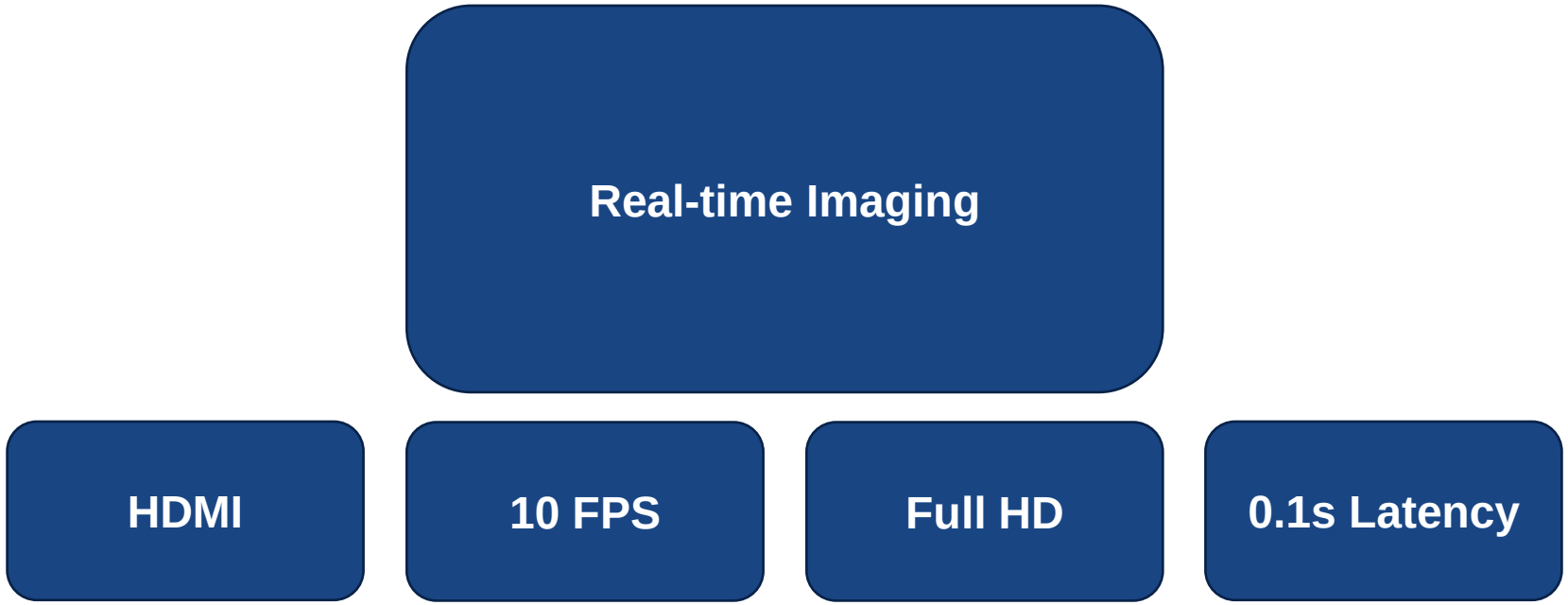


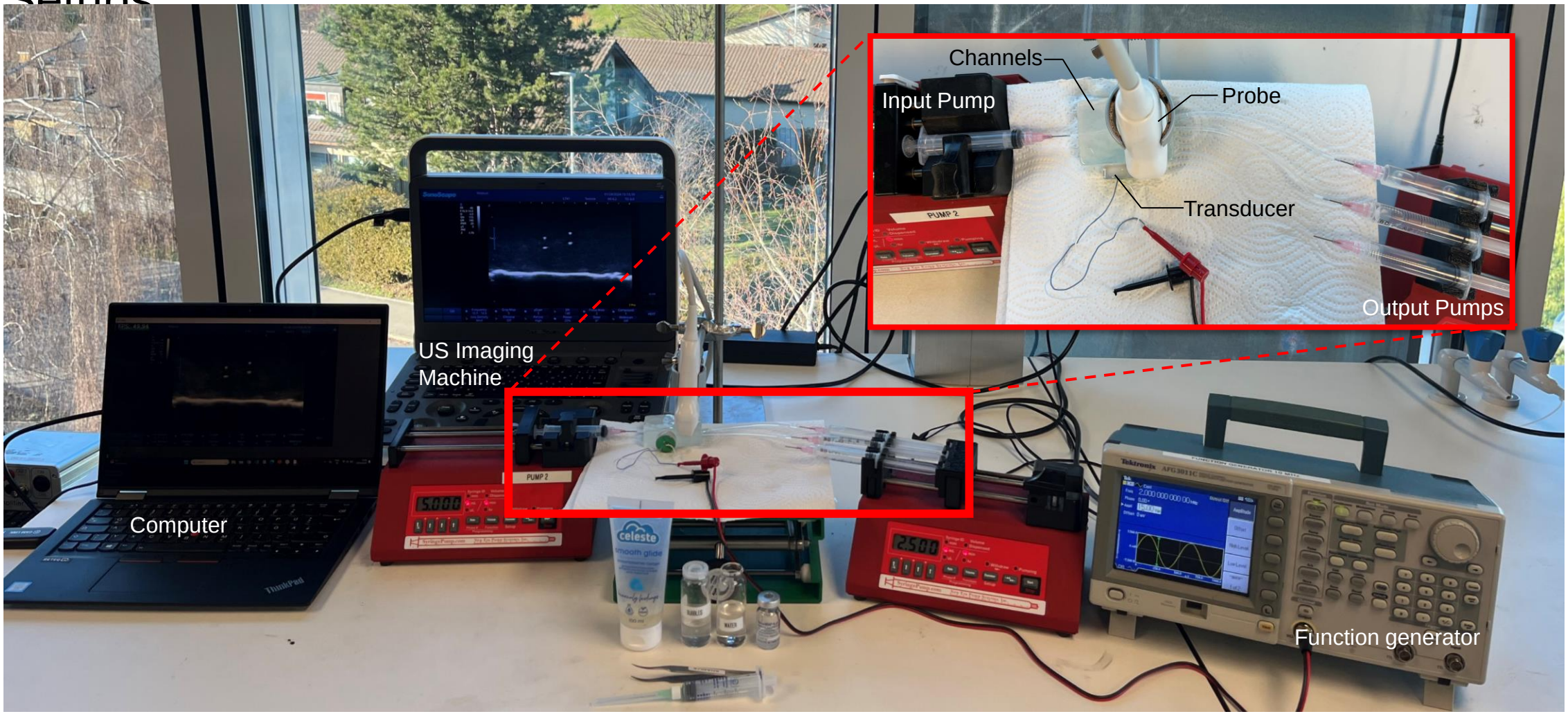
Setups

Real-time Imaging

Setups



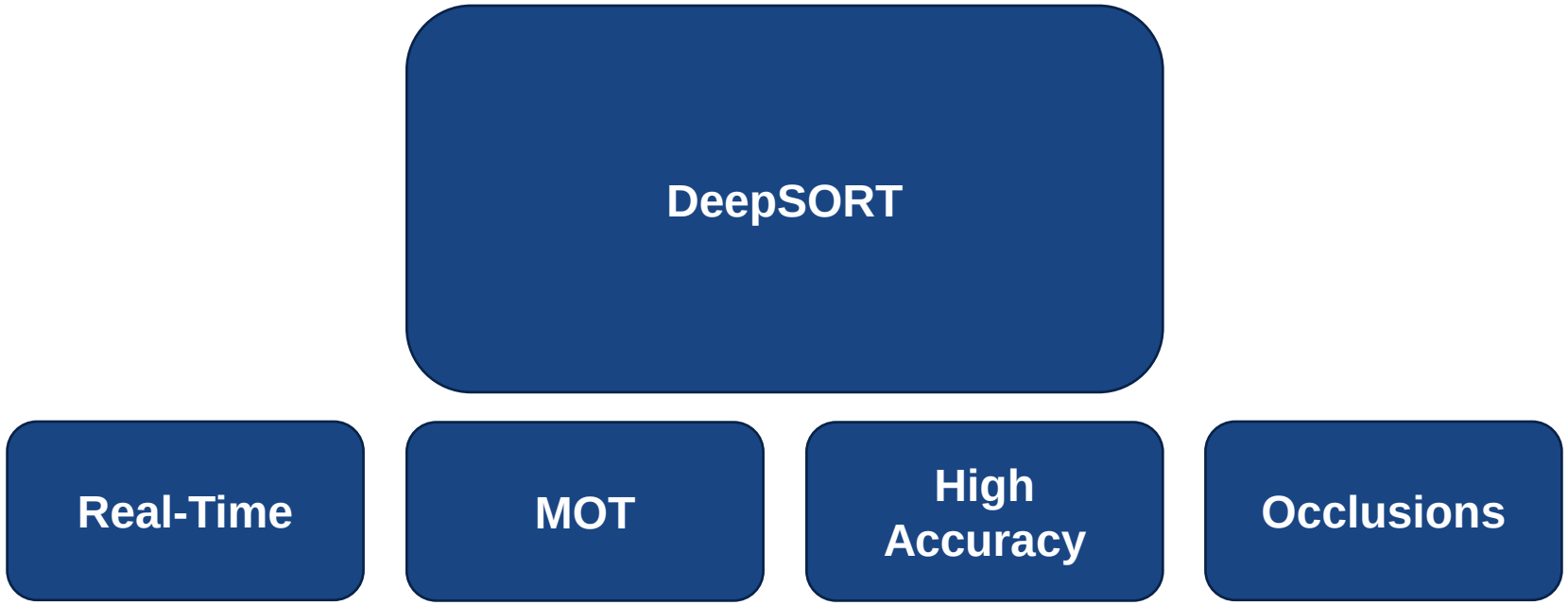
Setups


Channels
Input Pump
Probe
Transducer
Output Pumps
US Imaging Machine
Computer
Function generator

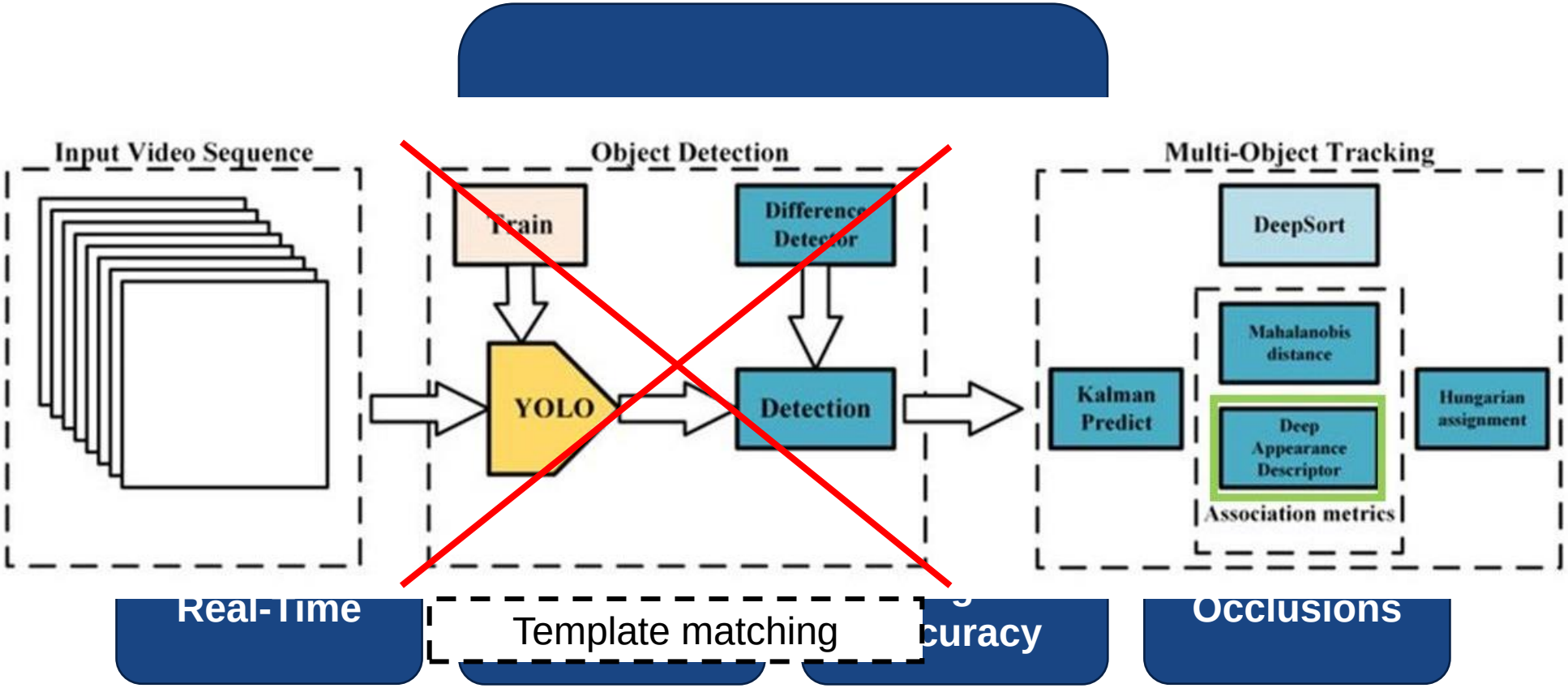
Tracker

DeepSORT

Tracker

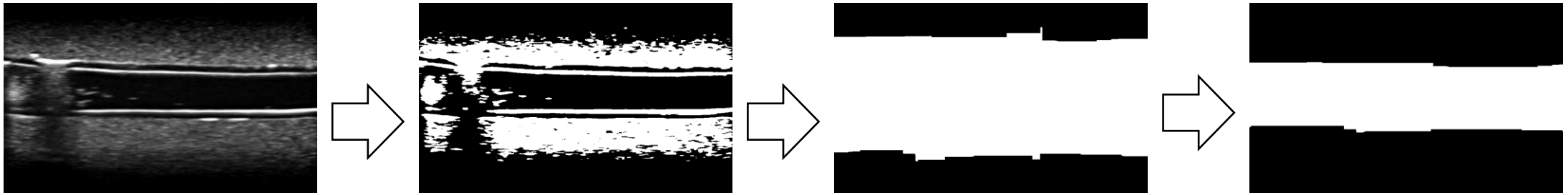


Tracker


Input Video Sequence
Object Detection
Train
Difference Detector
YOLO
Detection
Multi-Object Tracking
DeepSort
Mahalanobis distance
Kalman Predict
Deep Appearance Descriptor
Hungarian assignment
Association metrics
Real-Time
Template matching
curacy
Occlusions

Tracker

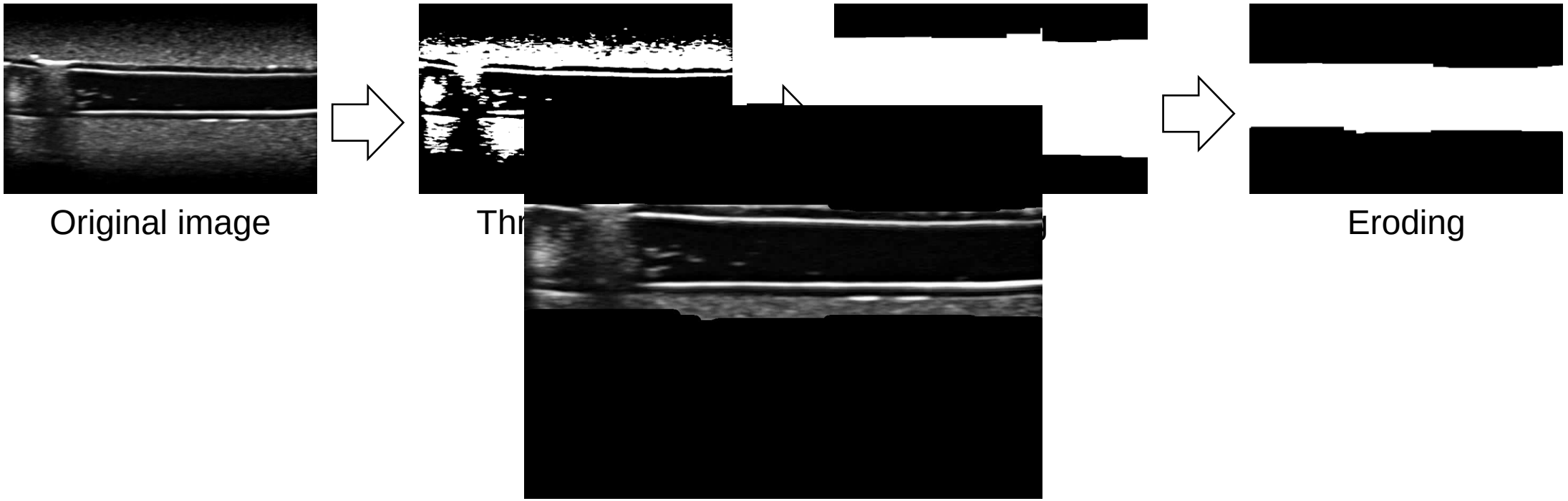
Segmentation



Original image → Thresholding → Closing → Eroding

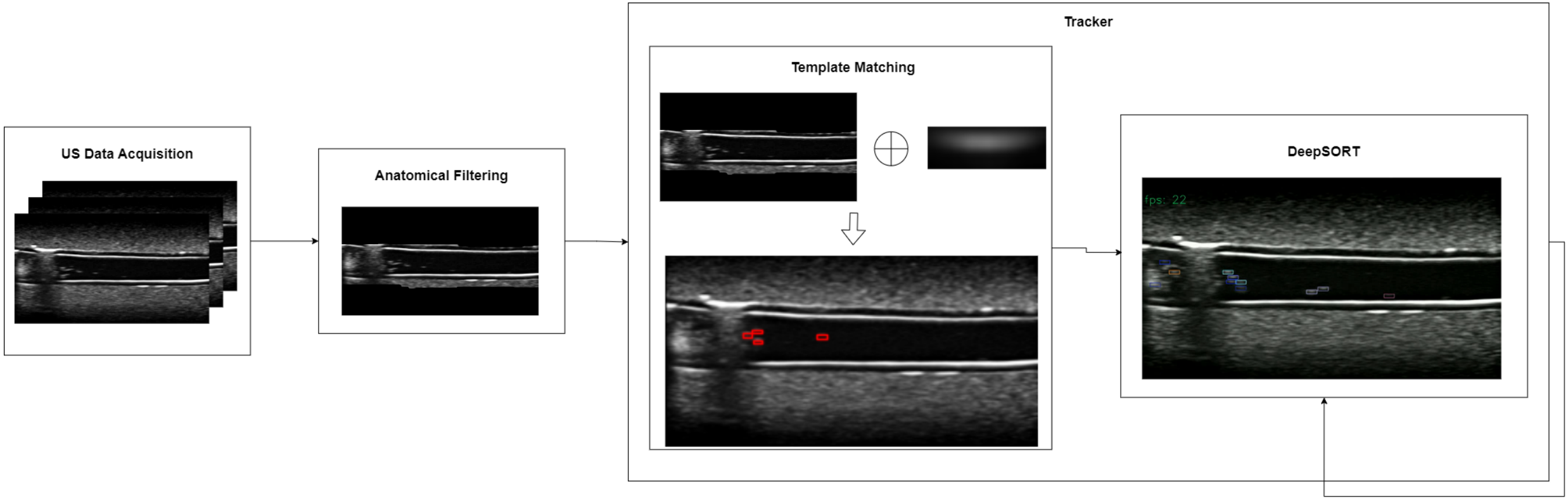
Tracker

Segmentation



Tracker

Tracker Flowchart



Mask Applied

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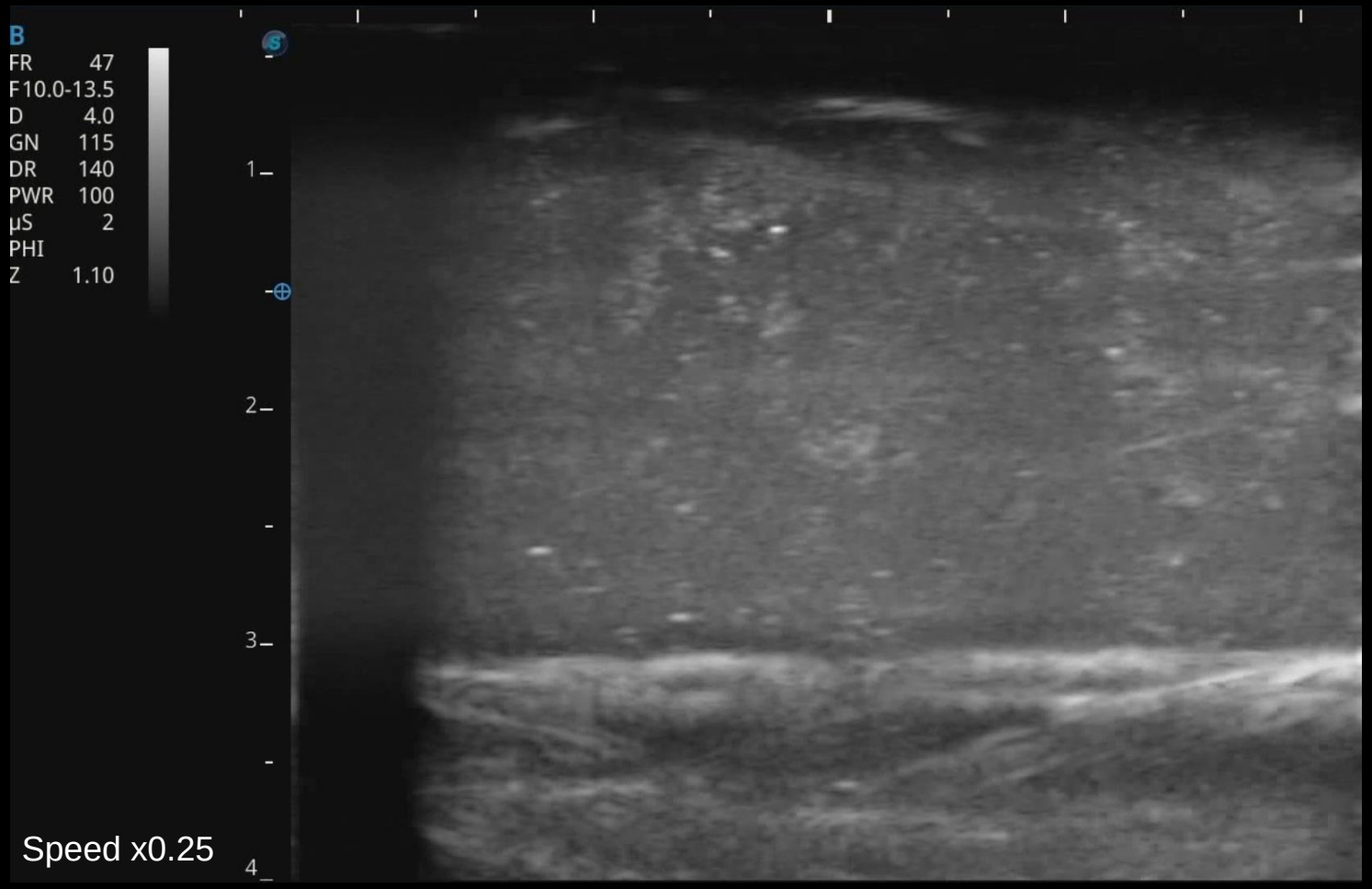
Results

Influence of the probe on the microbubbles



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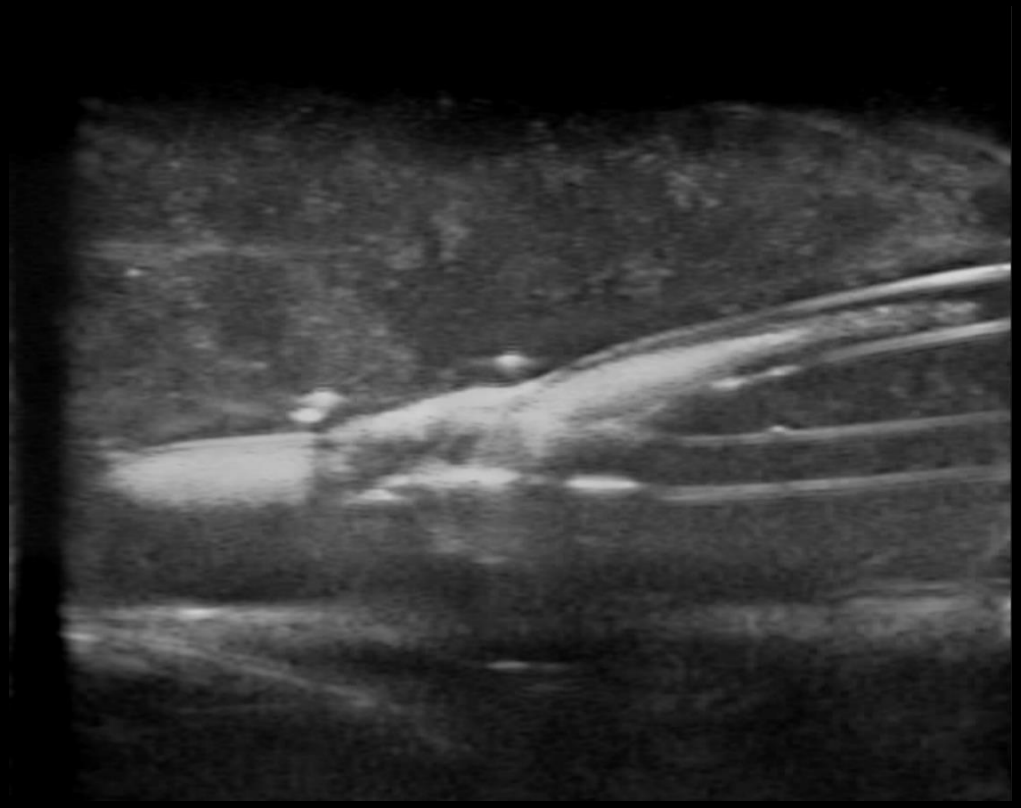
Results

Influence of the probe on the microbubbles



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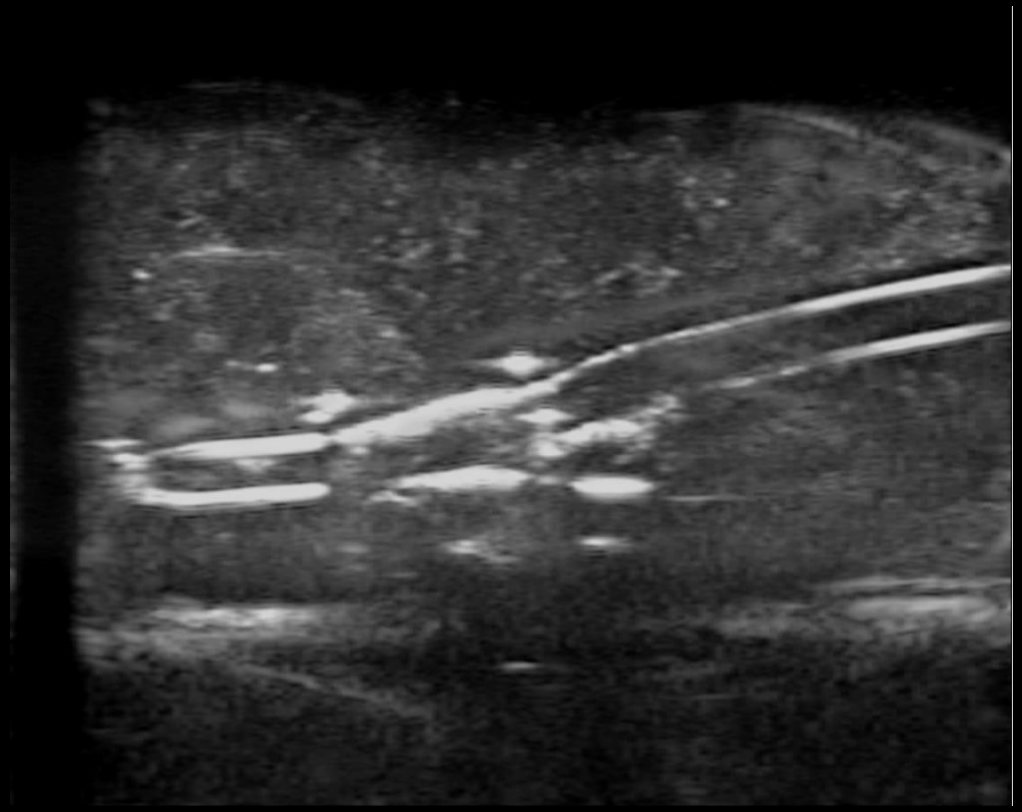

t=3.01s

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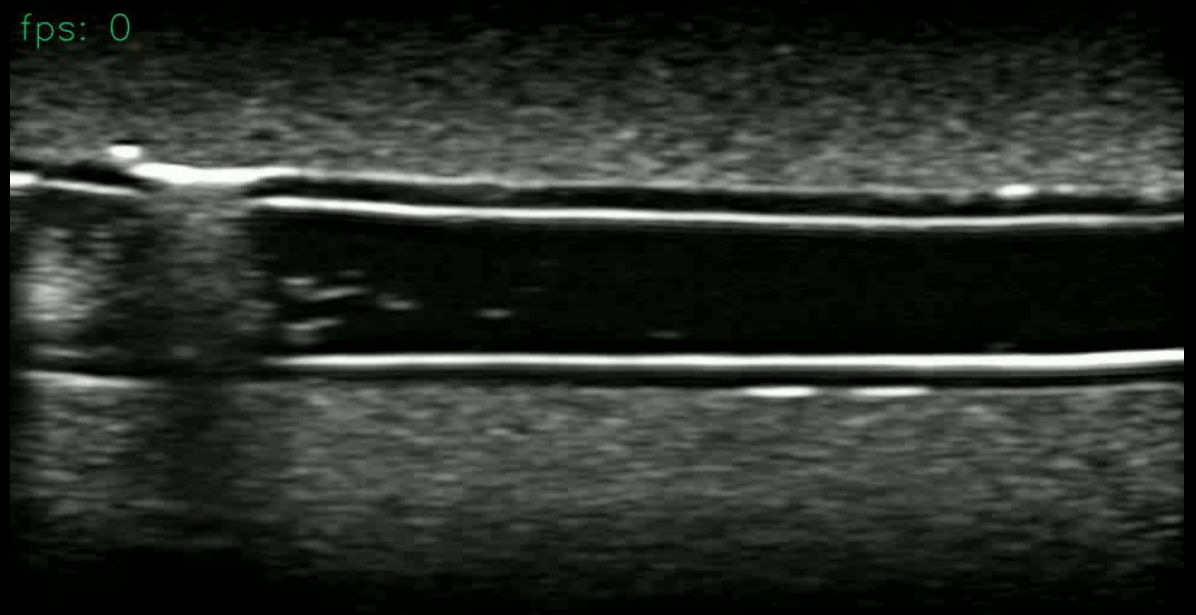
Results

Tracker Output



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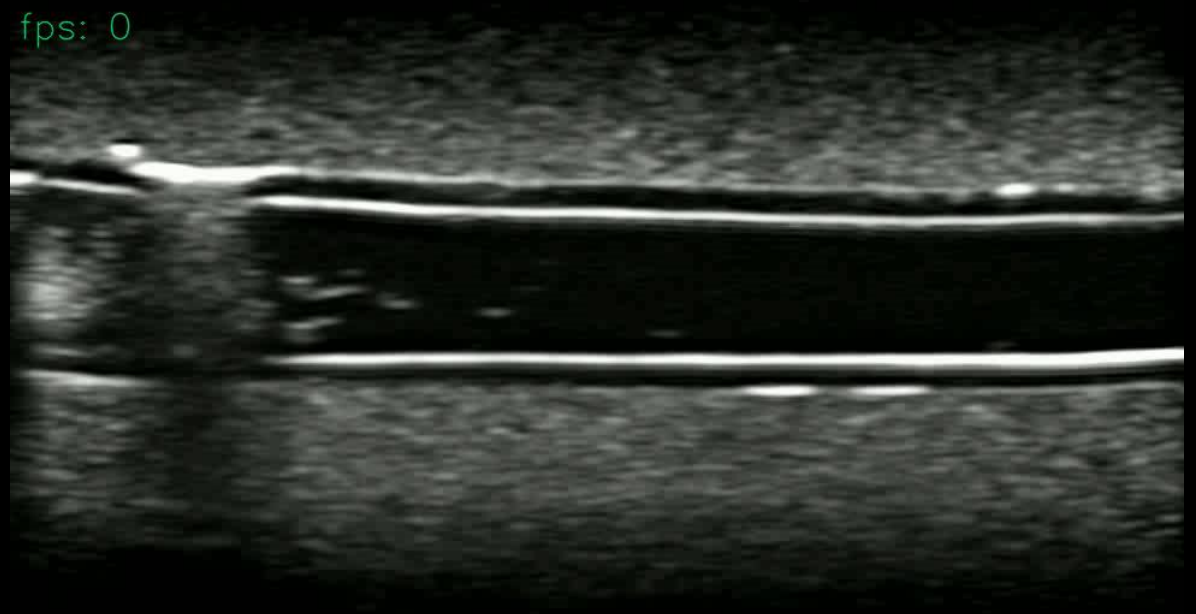
Results

Tracker Output (without the anatomical filter)



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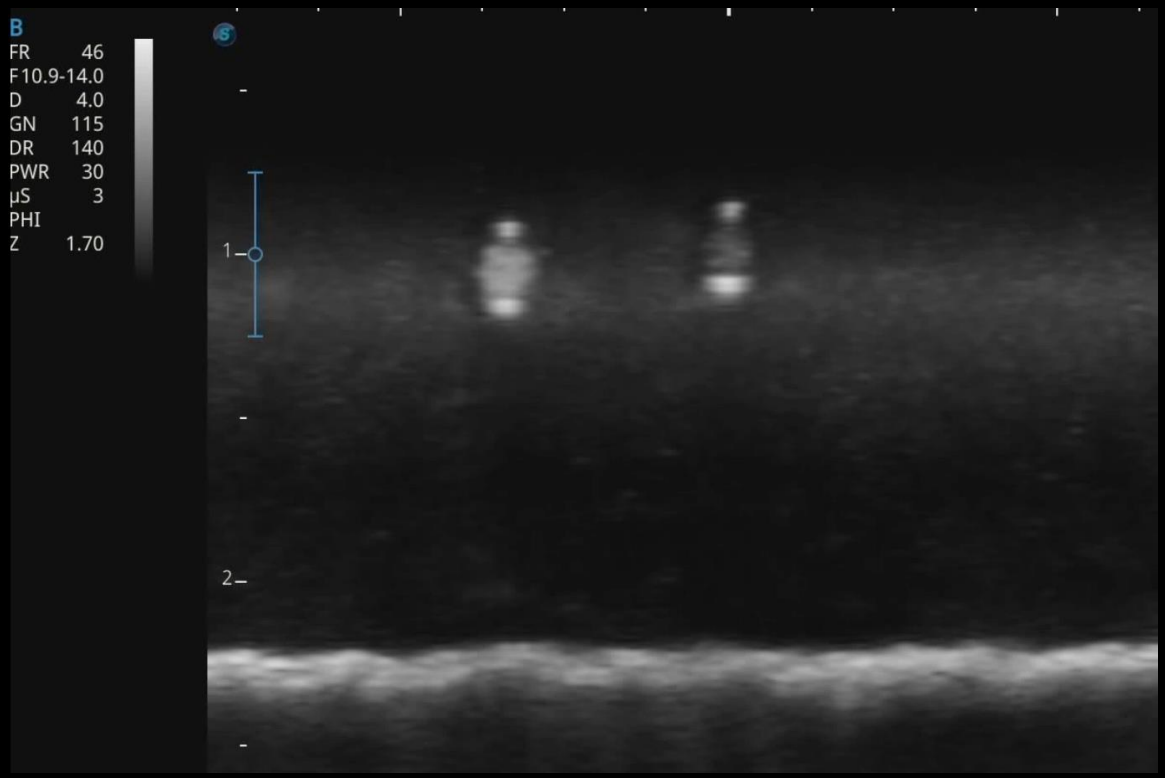
Results

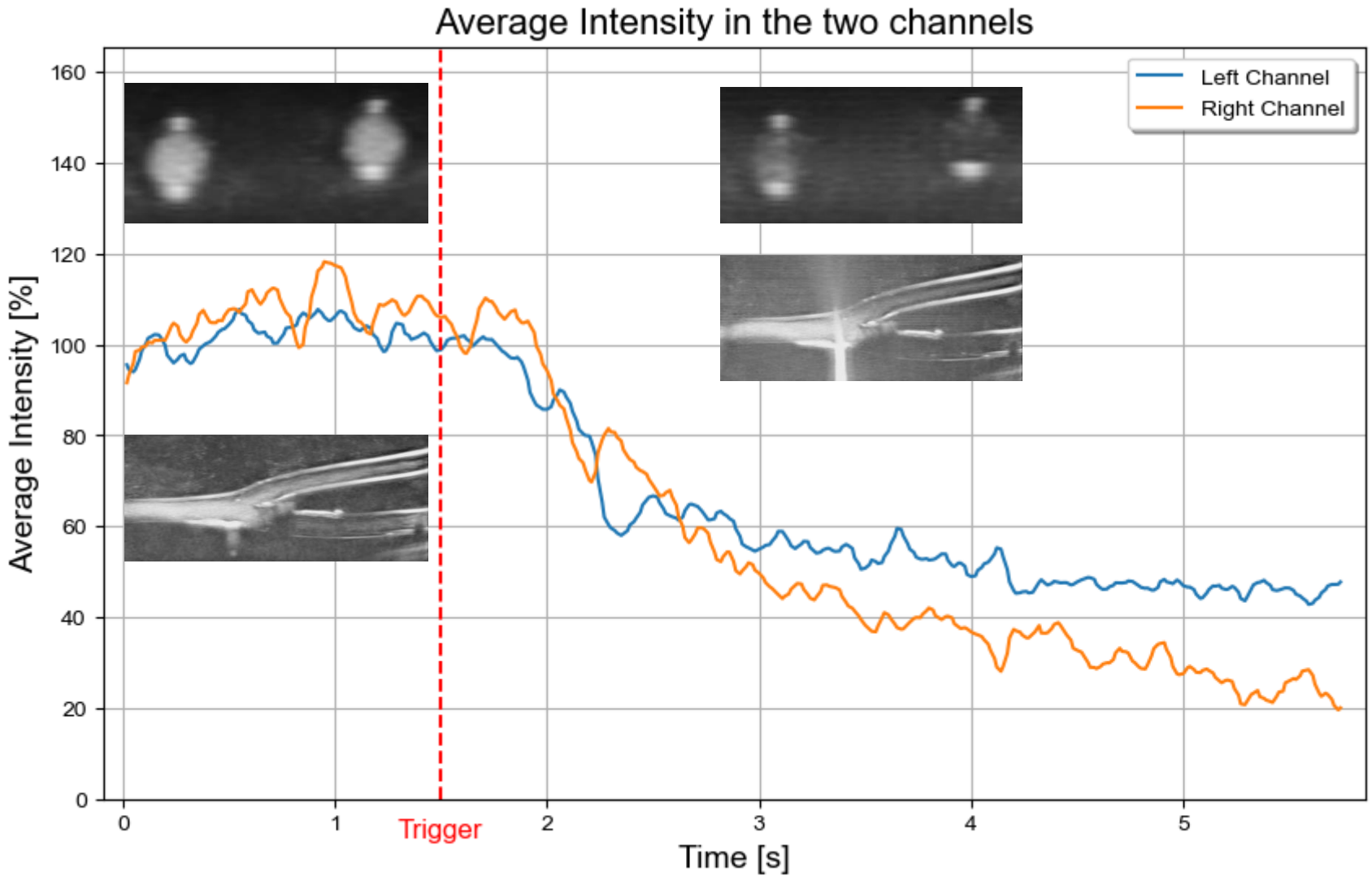
Influence on Microbubbles path

Trigger: 7V



Trigger: 15V

Results


Average Intensity in the two channels
Left Channel
Right Channel
Average Intensity [%]
Time [s]
Trigger
0
20
40
60
80
100
120
140
160
0
1
2
3
4
5

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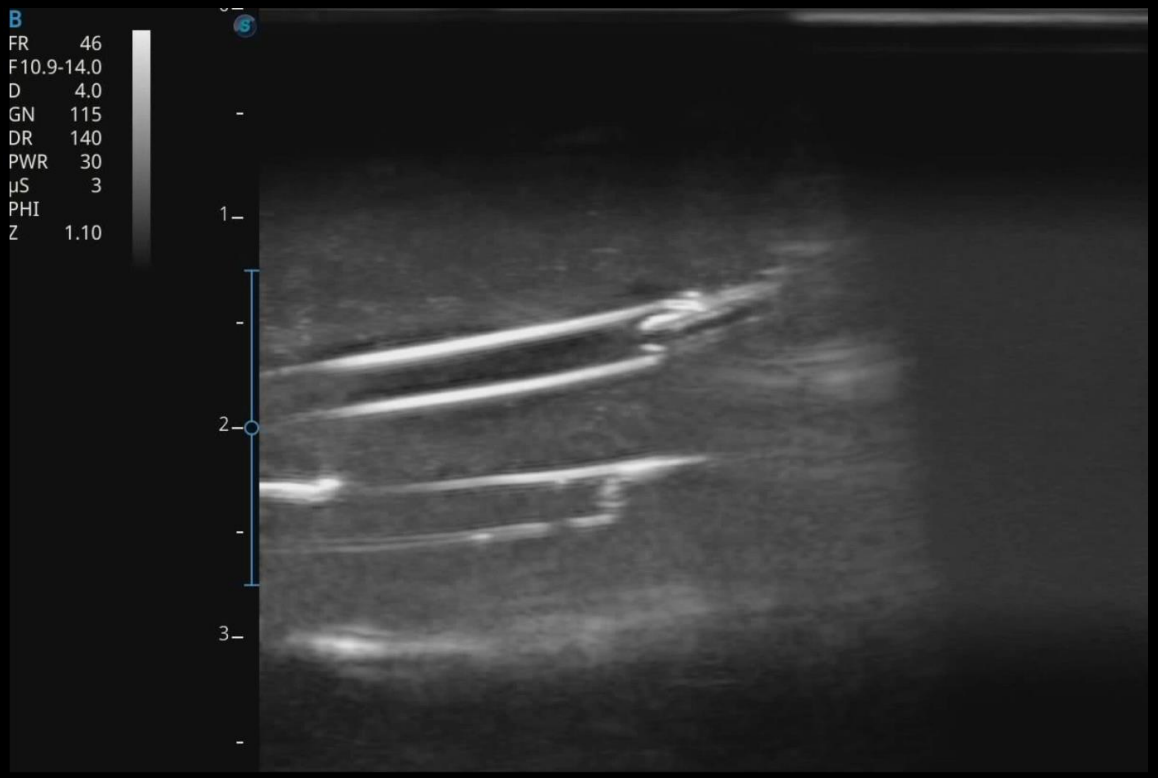
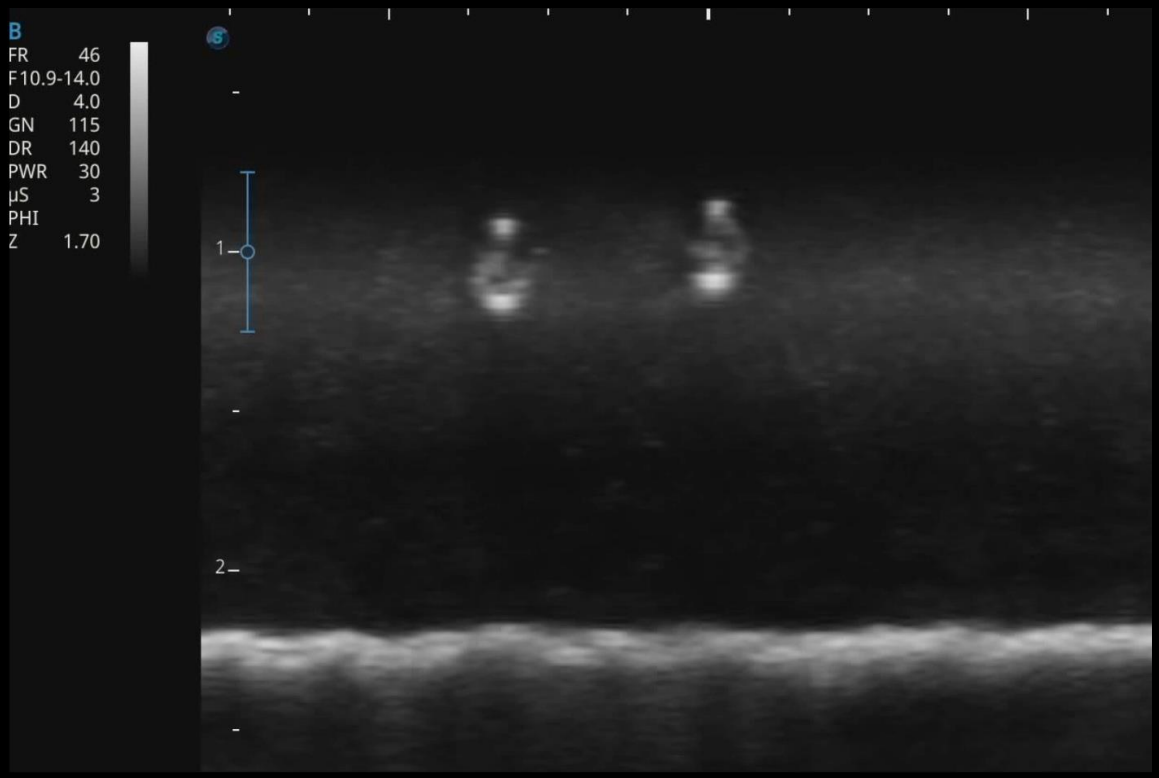
Results

Influence on Microbubbles path

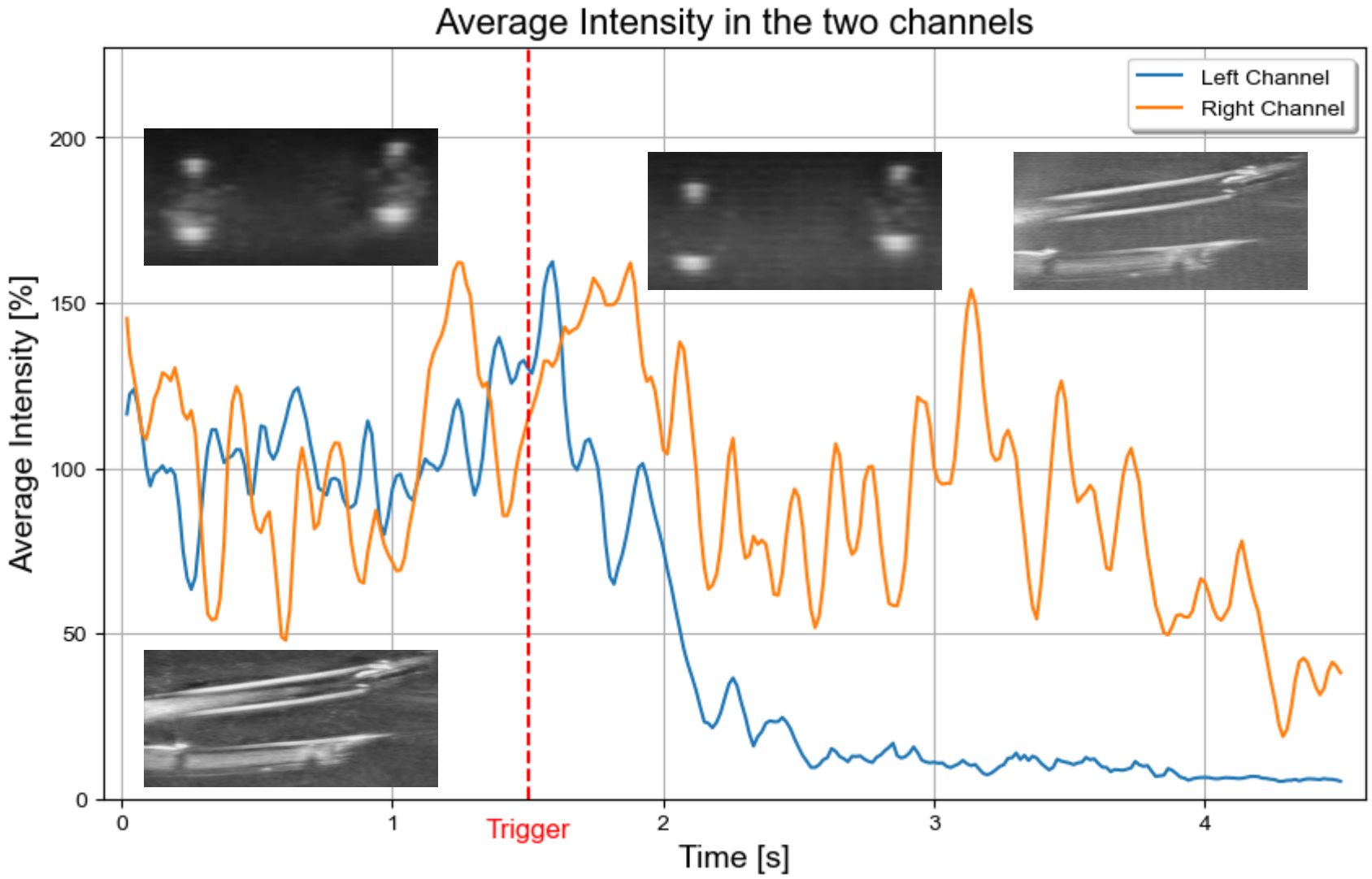


Trigger: 7V



Trigger: 15V

Results


Average Intensity in the two channels
Left Channel
Right Channel
Average Intensity [%]
0
50
100
150
200
0
1
2
3
4
Trigger
Time [s]

Conclusion

- New manner of making channels for Ultrasound Imaging
- Get a Real-Time Feedback
- Tracker returning the position (and velocity) of the microbubbles
- Influence on the direction of the microbubbles with HIFU

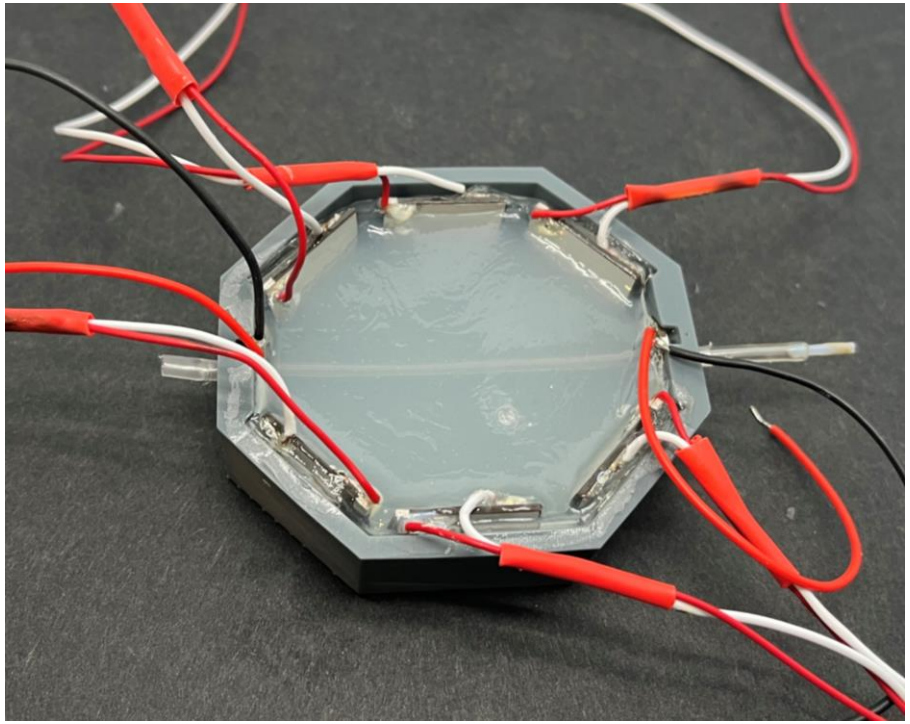
Conclusion

Futur Work:

- Use the octagon idea with HIFO

- Try more complex new channels

- Try to make other transducers working



Thank you

References

Ackermann, D., & Schmitz, G. (2016). Detection and Tracking of Multiple Microbubbles in Ultrasound B-Mode Images. *IEEE transactions on ultrasonics, ferroelectrics, and frequency control*, *63*(1), 72–82. https://doi.org/10.1109/TUFFC.2015.2500266

Andersen, S.B., Taghavi, I., Kjer, H.M. *et al.* Evaluation of 2D super-resolution ultrasound imaging of the rat renal vasculature using ex vivo micro-computed tomography. *Sci Rep* 11, 24335 (2021). https://doi.org/10.1038/s41598-021-03726-6

K. Botros, M. Alkhatib, D. Folio and A. Ferreira, "Fully Automatic and Real-Time Microrobot Detection and Tracking based on Ultrasound Imaging using Deep Learning," 2022 International Conference on Robotics and Automation (ICRA), Philadelphia, PA, USA, 2022, pp. 9763-9768, doi: 10.1109/ICRA46639.2022.9812114.

Ozcelik, A., Becker, R., & Huang, T. J. (2023). Acoustic technologies in biology and medicine. John Wiley & Sons.

Q. Wang et al., "Reconfigurable Magnetic Microswarm for Accelerating tPA-Mediated Thrombolysis Under Ultrasound Imaging," in IEEE/ASME Transactions on Mechatronics, vol. 27, no. 4, pp. 2267-2277, Aug. 2022, doi: 10.1109/TMECH.2021.3103994.