Evaluating Denoising Methods for 3D Ultrasound Uterus Segmentation with DynUNet

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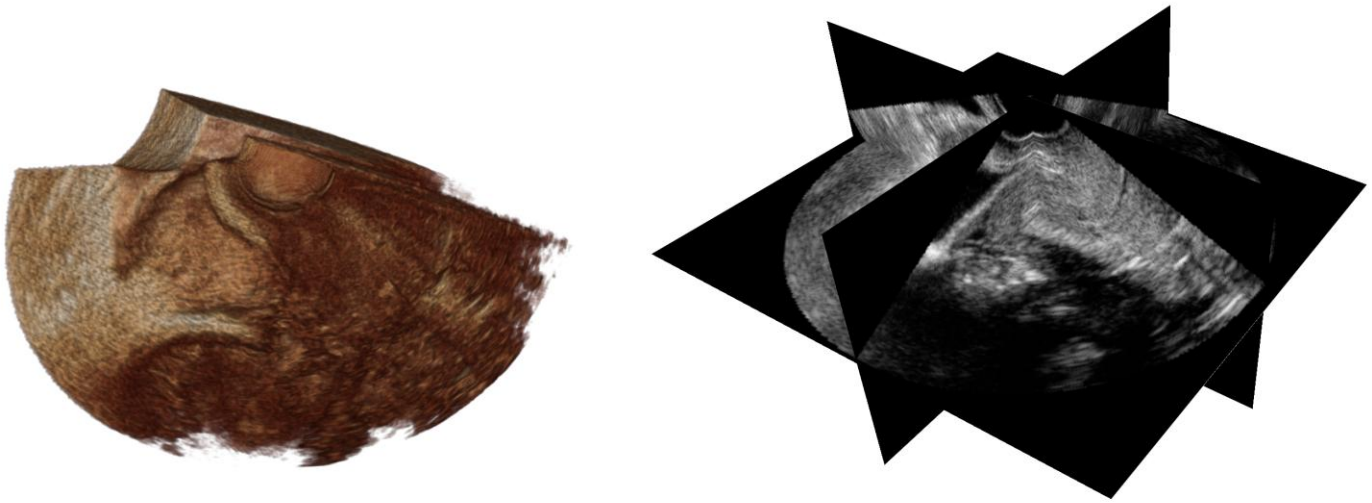
Motivation

- Uterus morphology is key for fertility and pregnancy
- 3D ultrasound = non-invasive, detailed imaging
- Segmentation is challenging: noise, artifacts, variability
- Need robust automatic methods



Research Goal

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- Propose pipeline:
  - Fully automatic uterus segmentation
- Denoising + DynUNet segmentation
  - Compare 7 denoising methods + baseline
  - Show effect on segmentation accuracy

Dataset Description

- UterUS dataset
  - 315 3D ultrasound volumes
  - 141 volumes with expert-annotated uterine cavity masks
  - 174 unannotated cases

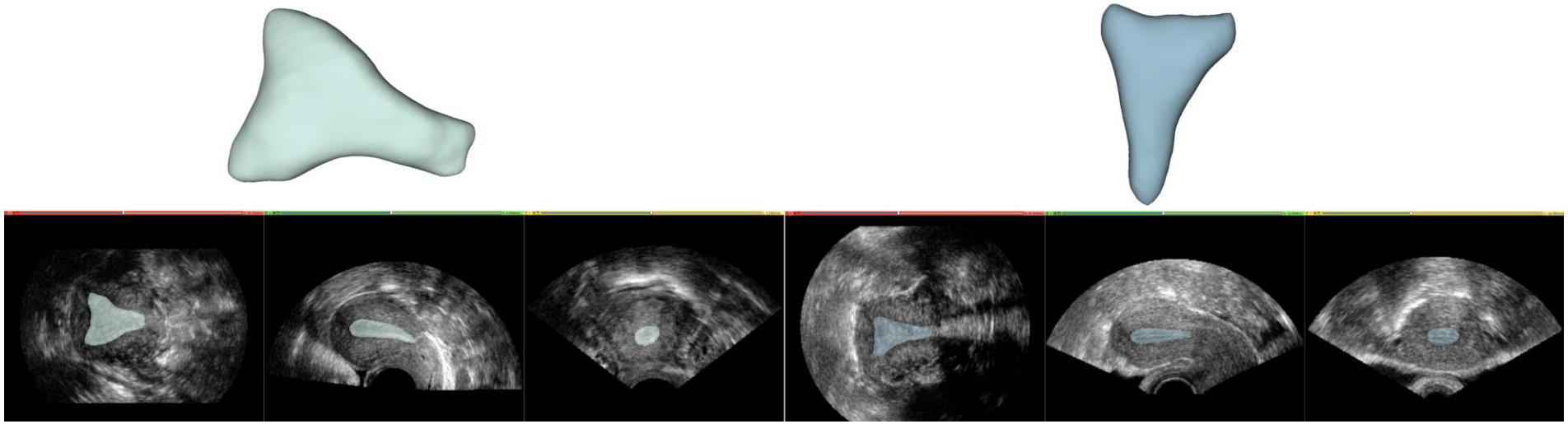

Figure 1. Example of ultrasound volumes from UterUS dataset

Pre-processing

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- CLAHE + Butterworth
- DWT + Threshold
- CLAHE + Median Filter
- Median-Mean Hybrid Filter
- Unsharp Masking + Bilateral Filter
- Perona–Malik Anisotropic Diffusion
- 3D DnCNN denoising model

Proposed Method

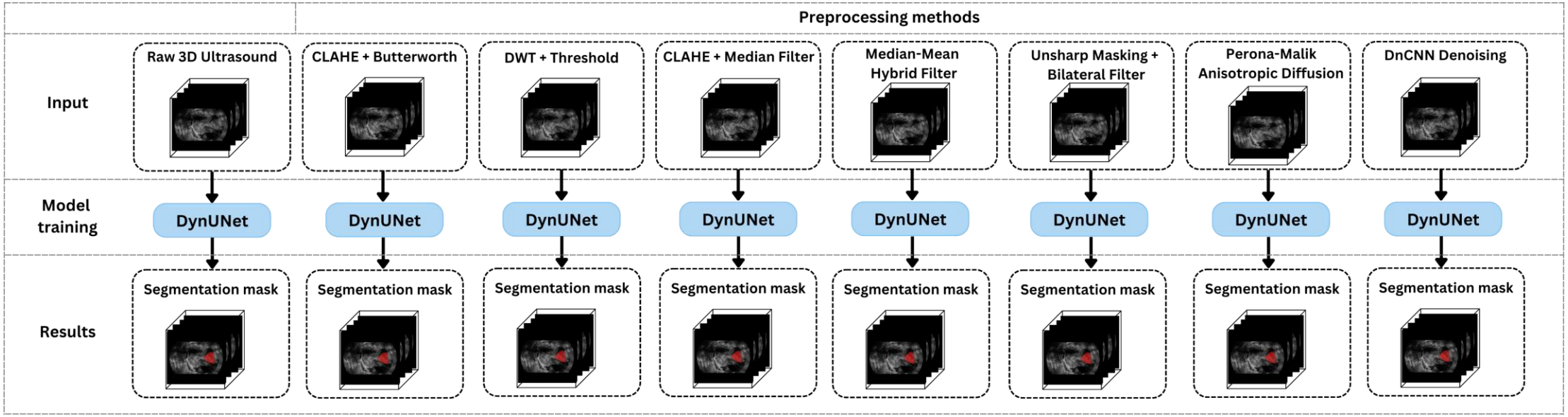

Figure 2. Multi-branch preprocessing and segmentation pipeline for 3D uterus segmentation using DynUNet. A raw 3D ultrasound image is processed through seven pipelines: (1) no preprocessing (baseline), (2) CLAHE + Butterworth filtering, (3) DWT + Thresholding, (4) CLAHE + Median filtering, (5) Median–Mean hybrid filtering, (6) Unsharp Masking + Bilateral filtering, (7) Perona–Malik diffusion, and (8) 3D DnCNN denoising model.

DynUNet

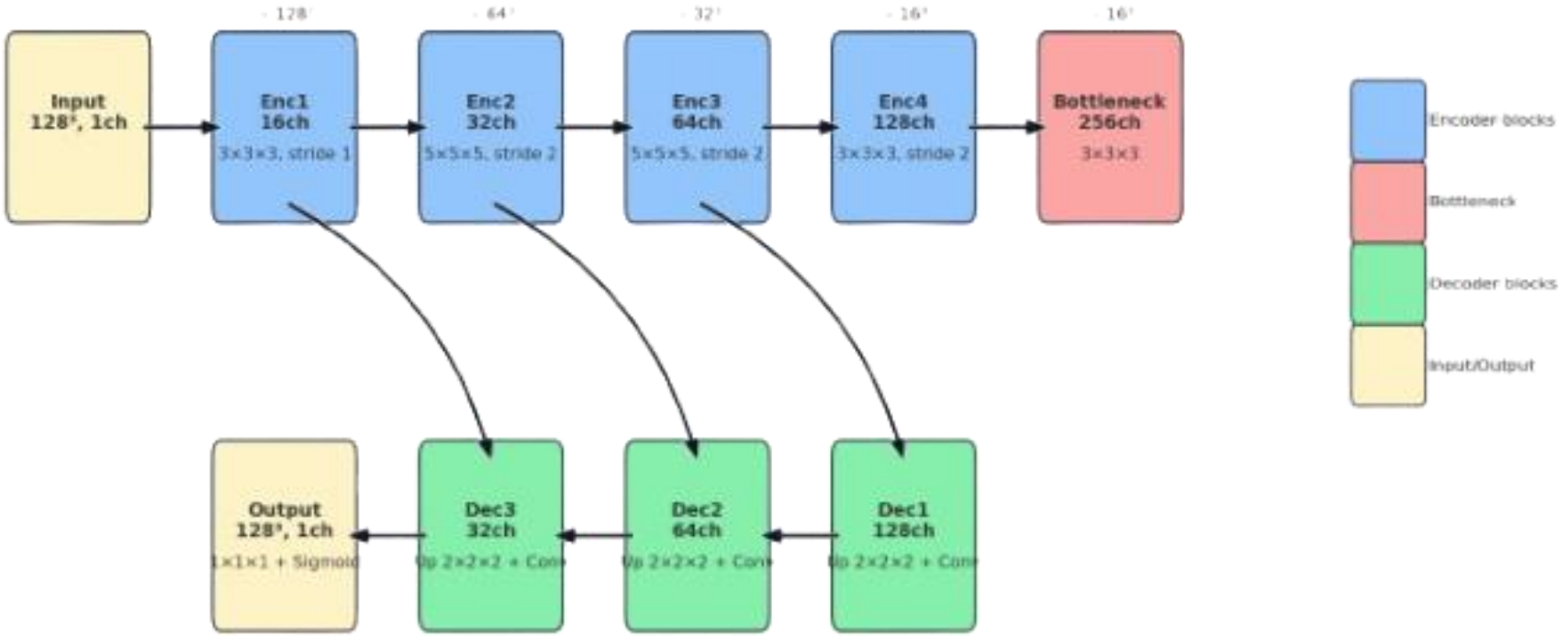

Figure 3. DynUNet architecture. The network processes 3D ultrasound patches of size 128^3 with one input channel. The encoder progressively downsamples the input through four convolutional blocks (16–128 channels) before reaching a 256-channel bottleneck. The decoder then upsamples through three stages with skip connections from the encoder, and a final 1×1×1 convolution with sigmoid activation produces the uterus segmentation mask.

Training Setup

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- 5-fold cross-validation (subject-level separation)
- Adam optimizer, LR = 1e-4,
- 100 epochs
- Sliding window inference
- Hardware: Nvidia A6000, MONAI + PyTorch

Results

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Table 1. Evaluation of the DynUNet segmentation models without and with different pre-processing pipelines using the DSC metric on validation and test set.

	3D DynUNet [DSC %]	
	Validation Set	*Test Set*
Baseline	83.72	60.60
CLAHE + Butterworth	84.50	64.36
DWT + Threshold	84.76	69.61
CLAHE + Median Filter	84.81	65.42
Median-Mean Hybrid Filter	86.43	50.43
Unsharp Maskin + Bilateral Filter	85.60	56.70
Perona-Malik	84.97	64.40
DNCNN	**85.76**	**71.95**

Results

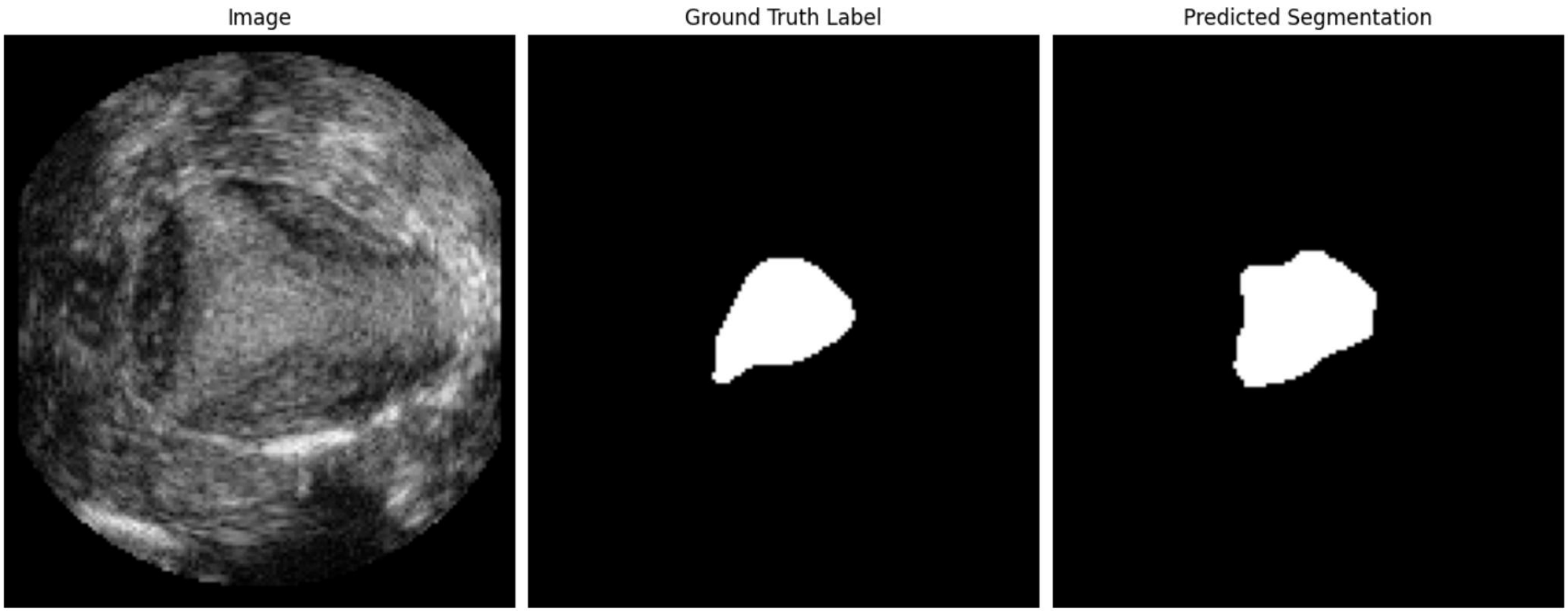

Figure 4. An example of test image, ground truth and obtained segmentation mask with DSC 92.03 %.

Conclusion

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- Denoising critical for robust US segmentation
- DnCNN yields best results (Dice +11%)
- Next: explore advanced denoising (transformers, diffusion)
- Potential clinical integration for fertility diagnostics

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