

Deep Learning–Based Endometrium Segmentation from Ultrasound Imaging

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Abstract

Accurate segmentation of the endometrium from ultrasound images is a crucial step in gynecological analysis and fertility assessment. However, manual segmentation is time-consuming and susceptible to inter-observer variability due to low contrast, irregular noise, and significant variability of ultrasound imaging. Conventional image processing techniques often fail to yield trustworthy results in these situations. As mentioned in [1], noise, artifacts, and the operator-dependent nature of image acquisition make accurate segmentation challenging and prone to variability in ultrasound images. Accurate endometrial segmentation aims to identify structural anomalies like polyps or uterine septa and enable quantitative assessment of endometrial dimension by reliably extracting clinically relevant measurements in addition to boundary delineation.

The proposed method is highly generalizable to be applied to ultrasound volumes with varying properties, such as spacing, size, direction, and origin problems, achieving high accuracy. However, combining a Segment Anything Model (SAM) [2] with nnUNet [3] may enhance the segmentation performance. Since the SAM is 2D and trained on RGB natural images, it lacks volumetric context, and using it alone may produce inconsistent results. By using SAM as a pseudo-label generator,

we can slice a 3D ultrasound volume into 2D frames, clean the predicted masks, and reassemble them into a 3D volume, reducing annotation costs. Then, applying nnUNet, which is suitable for learning 3D spatial consistency, the combined approach may take advantage of the characteristics of each model.

This approach has significant advantages for the medical field, particularly in decreasing the need for time-consuming expert annotations for 3D ultrasound segmentation, which are expensive and prone to interpersonal variability.

However, the resulting dataset obtained through this method has some inherent limitations. The process of pseudo-label creation can introduce noise and systematic errors that would restrict the upper boundary of segmentation accuracy, and the creation of labels on a slice-wise basis may impair the 3D anatomical consistency. Furthermore, the datasets may incorporate certain acquisition details, such as the scanner or image acquisition method, and patient demographics, which would restrict the generalization capability to unseen data. The absence of fully expertly annotated 3D ground truth is a hindrance to a detailed validation process and stresses the need to establish more diversified datasets.

References

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