Pubic Symphysis-Fetal Head Segmentation and Angle of Progression

Grand Challenge Review

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Clinical Background and Data

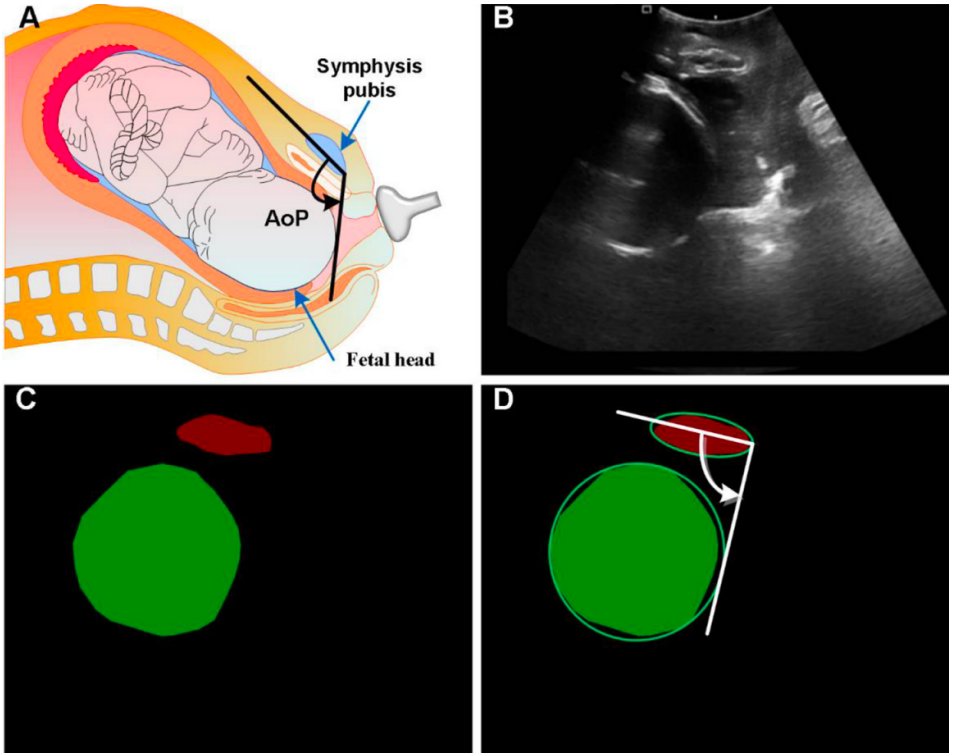

Figure 1. Assessment of FD in the birth canal by measurement AoP

Data [4]: 4000 MHA files for image data ($3 \times 256 \times 256$) and for labels (256×256, pixels labeled as 0 - bg, 1 - PS, or 2 - FH).
Goal: Segmentation algorithms, predicting images (256×256) containing labeled pixels.

- *Risk:* maternal and perinatal morbidity
- *Pathology:* longer labor duration (slow progression of fetal descent(FD))
- *Accurate assessment* of FD by monitoring the FH station *remains challenge* in guiding obstetric management
- Manual segmentation of SP-FH from transperineal US (TPU) images is the most reliable, but *extremely time-consuming*
- Automatic measurement algorithms based on AI are expected to be *efficient, reproducible and objective*

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Metrics and Results

Team	AoP	HD_{FH}	HD_{PS}	MSD_{FH}	MSD_{PS}	HD_{ALL}	MSD_{ALL}	$DICE_{FH}$	$DICE_{PS}$	$DICE_{ALL}$	Score
Gregor Koe	6.544	12.631	7.638	3.896	2.409	13.448	3.486	0.930	??	0.924	0.9418
Marawan Elbatel	7.970	10.699	7.559	3.307	2.995	12.059	2.981	0.940	??	0.935	0.9416
Yaoyang Qiu	7.647	12.459	7.661	3.616	2.257	13.615	3.238	0.936	??	0.930	0.939
Gongping Chen	8.558	14.011	9.051	3.869	2.620	15.334	3.517	0.931	0.860	0.924	0.931
Fangyijie Wang	8.719	14.009	10.829	3.984	2.982	15.809	3.579	0.931	0.858	0.925	0.928
Hongkun Sun	9.276	15.795	11.536	4.723	3.114	17.560	4.265	0.918	0.831	0.910	0.923
Pengzhou Cai	12.199	20.031	14.068	7.099	4.208	21.873	6.058	0.879	0.804	0.872	0.897
YuboTan	14.048	16.041	16.023	5.199	7.260	20.251	5.106	0.910	??	0.894	0.892

**The participants for whom model information is available are highlighted in color*

- **Dice Coefficient** $DC = \frac{2 \times |I_P \cap I_L|}{|I_P| + |I_L|}$, where I_P is the model prediction, I_L is the ground truth, and $|\cdot|$ is the number of pixels belonging to the object.
- **Hausdorf Distance** $HD = \max\left\{\sup_{x \in I_P} \inf_{y \in I_L} d(x,y), \sup_{y \in I_L} \inf_{x \in I_P} d(x,y)\right\}$, where $d(x,y)$ is the distance between points x and y.
- **Mean Surface Distance** $\mathrm{MSD} = \frac{1}{|I_P| + |I_L|}\left(\sum_{x \in I_P} d\left(x, I_L\right) + \sum_{y \in L} d\left(y, I_P\right)\right)$
- **ΔAoP** $= |AoP_P - AoP_L|$, where AoP_P represents the predicted magnitude, and AoP_L is the magnitude of the labeled AoP.
- **Score** $= 0.5\left(1 - \frac{\Delta AoP}{180}\right) + 0.25\frac{DICE_{FH} + DICE_{PS} + DICE_{ALL}}{3} +$
  $0.25\left[0.5\left(1 - \frac{HD_{FH} + HD_{PS} + HD_{ALL}}{3 \times 100}\right) + 0.5\left(1 - \frac{MSD_{FH} + MSD_{PS} + MSD_{ALL}}{3 \times 100}\right)\right]$

Methods and Results

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- **Marawan Elbatel [3]:** pre-trained Segment Anything Model (SAM) by **Meta AI** (freezing the model and performing low-ranked fine-tuning of the image encoder)
- **Fangyijie Wang [6]:** U-Net-based segmentation model from the Segmentation Models SPM library
- **Hongkun Sun [5]:** Custom NN model which is a combination of several architectural components, including ResNet, Multi-Scale Attention Blocks, ViT (Vision Transformer) blocks, and various convolutional and transposed convolutional layers
- **Pengzhou Cai [1]:** Custom method, named BRAU-Net, adopting a U-Net-like pure Transformer architecture with bi-level routing attention and skip connections

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Architecture

The FH-PSSNet model [2] is based on an encoder-decoder framework, incorporating a dual attention module, a multi-scale feature screening module and a direction guidance block.

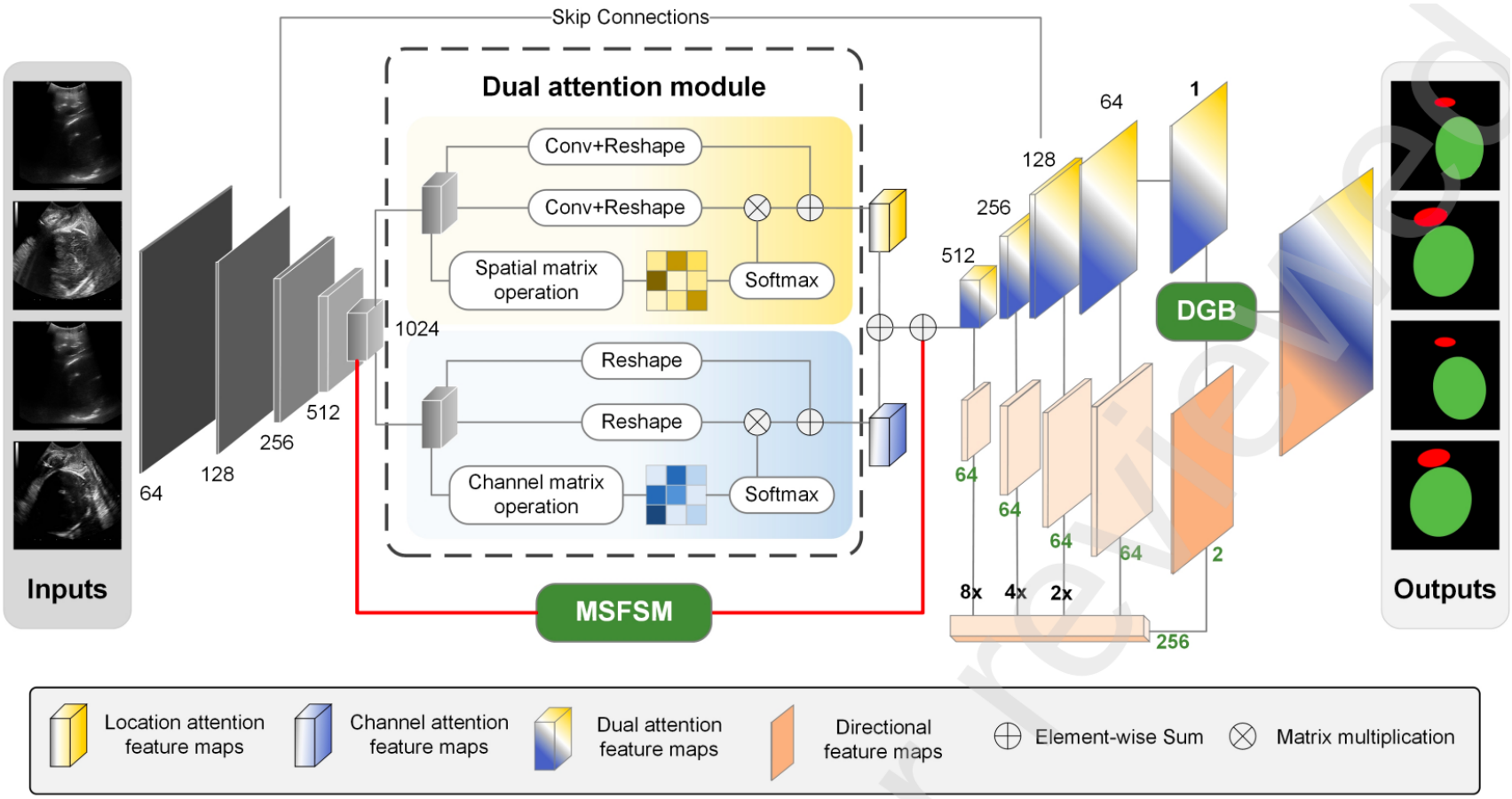

Figure 2. The overall framework of the model

Performance and Comparison with Other Models

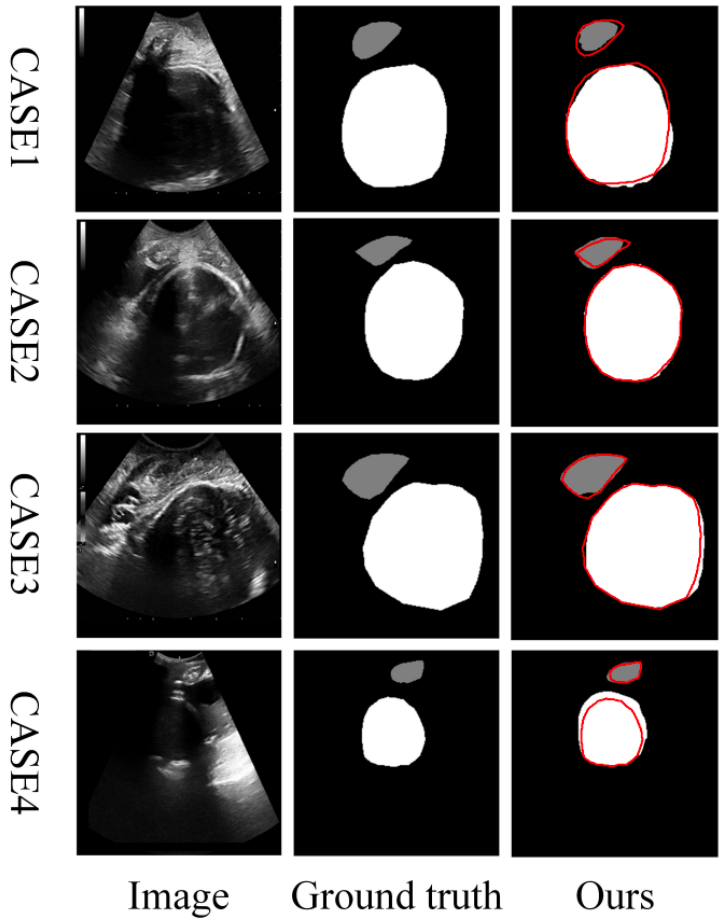

Figure 3. The performance of the FH-PSSNet model

Model name	FH		PS	
	DC ↑	HD ↓	DC ↑	HD ↓
SegNet	0.917	3.740	0.821	4.011
DeepLab	0.917	3.745	0.823	4.020
FCN	0.921	3.481	0.850	3.699
U-Net	0.932	3.538	0.855	3.852
AU-Net	**0.938**	3.404	0.867	3.570
DAG V-Net	0.933	3.393	0.866	**3.560**
FDA	0.929	3.408	0.863	3.574
FH-PSSNet	**0.938**	**3.390**	**0.870**	3.562

The best performance of challenge participants:

FH		PS	
DC ↑	HD ↓	DC ↑	HD ↓
0.940	10.699	0.860	7.559

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References

[1] Pengzhou Cai et al. "Pubic Symphysis-Fetal Head Segmentation Using Pure Transformer with Bi-level Routing Attention". In: (2023). arXiv: 2310.00289 [eess.IV].

[2] Zhensen Chen et al. "Direction-Guided and Multi-Scale Feature Screening for Fetal Head-Pubic Symphysis Segmentation and Angle of Progression Calculation". In: (Jan. 2023). DOI: 10.2139/ssrn.4530477.

[3] Marawan Elbatel. *MICCAI 2023 FH-PS-AOP Challenge*. https://github.com/marwankefah/PS-FH-MICCAI-23. 2023.

[4] Yaosheng Lu et al. "The JNU-IFM dataset for segmenting pubic symphysis-fetal head". In: *Data in Brief* 41 (2022), p. 107904. ISSN: 2352-3409. DOI: https://doi.org/10.1016/j.dib.2022.107904. URL: https://www.sciencedirect.com/science/article/pii/S2352340922001160.

[5] Hongkun Sun. *MICCAI 2023 FH-PS-AOP Challenge*. https://github.com/HongkunSun/PS-FH-MICCAI-2023/tree/master. 2023.

[6] Fangyijie Wang. *MICCAI 2023 FH-PS-AOP Challenge*. https://github.com/13204942/FetalAopMICCAI. 2023.

Thank you for your attention!
Any questions?