AutoFB: Automating Fetal Biometry Estimation from Standard Ultrasound Planes

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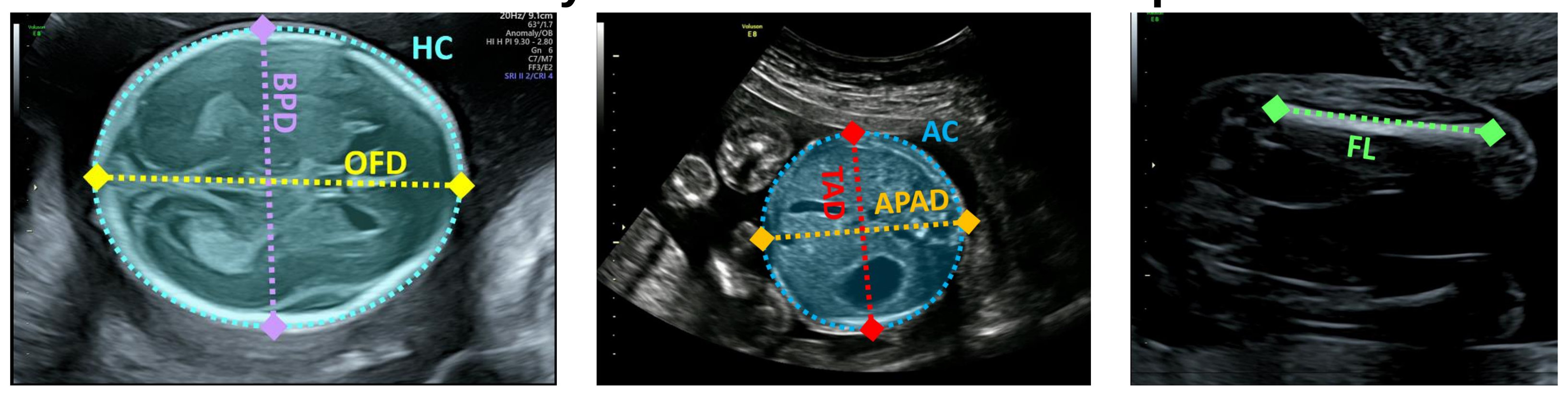
1. Introduction and Motivation

- Ultrasound (US) examination in the 2nd trimester during pregnancy can assess fetal size according to standardized charts.
- To achieve reproducible and accurate fetal biometry (FB), a sonographer needs to identify 3 standard 2D planes of the fetal anatomy and manually mark the key anatomical landmarks [1].

Fetal biometry from three standard US planes



Transventricular plane in the head | **Transabdominal plane in the abdomen** | **Femur plane**

HC – Head Circumference	AC - Abdominal Circumference	FL - Femur length
BPD - BiParietal Diameter	TAD - Transverse Abdominal Diameter	
OFD - Occipito-Frontal Diameter	APAD - Anterior-Posterior Abdominal Diameter	

- This can be a time-consuming operator-dependent task.
- Computer-assisted techniques can help in automating the FB computation process.

2. Dataset

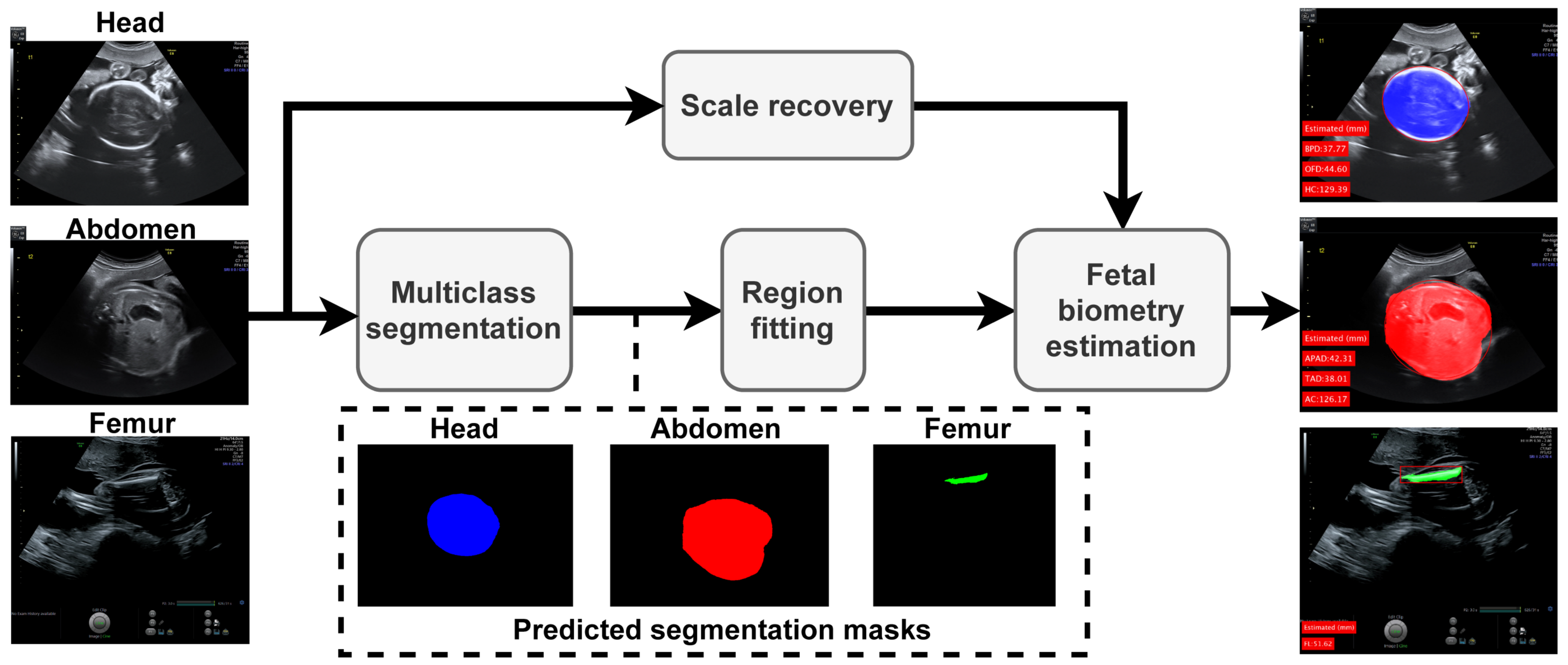
- Patients attending University College London Hospital for US examination were enrolled and pseudo-anonymized after written consent and ethics approval.
- Ground-truth annotations were obtained using the VIA tool.

Collected Dataset Overview

# Subjects	# US Images	# Head	# Abdomen	# Femur
42	346	135	103	108

3. Proposed Method

Contributions: AutoFB is a unified automated framework that estimates all the relevant measurements for fetal weight assessment. It is the first framework to automate FB estimation from all three standard planes.



Overview of the proposed AutoFB framework

Features:

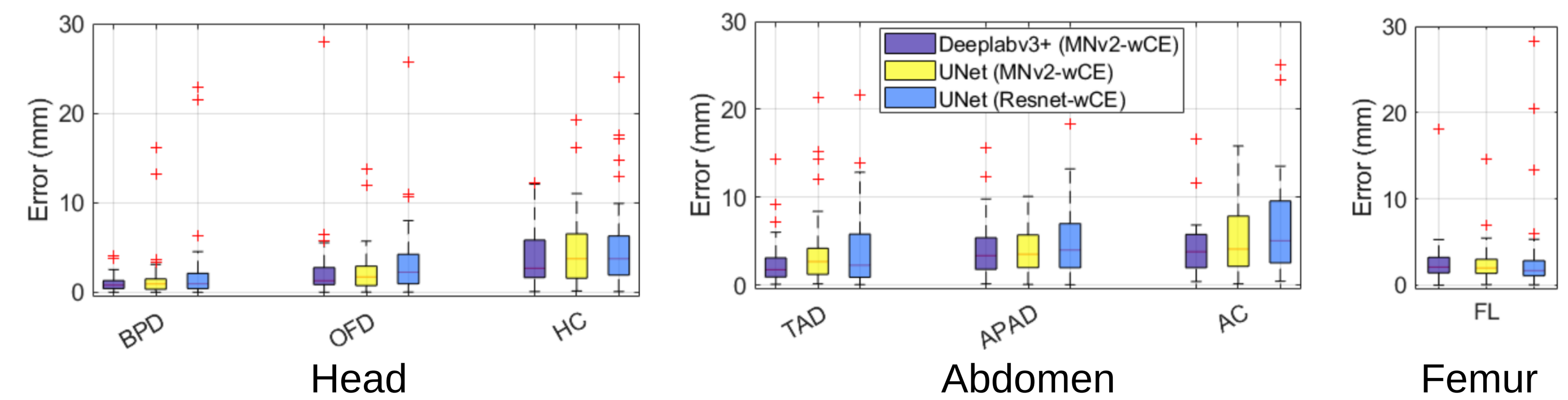
- **Multiclass segmentation:** Identifies and segments head, abdomen and femur within the three standard planes.
- **Region fitting:** Fits an ellipse on the head or abdomen masks and a bounding box on the femur mask.
- **FB estimation:** Fitted ellipse circumference gives HC (AC) and its major and minor axes gives BPD and OFD (TAD and APAD) estimates. Bounding box diagonal gives FL estimates.
- **Scale recovery:** Template matching detects the ruler markers on the caliper visible on the US images.

4. Experimental Results

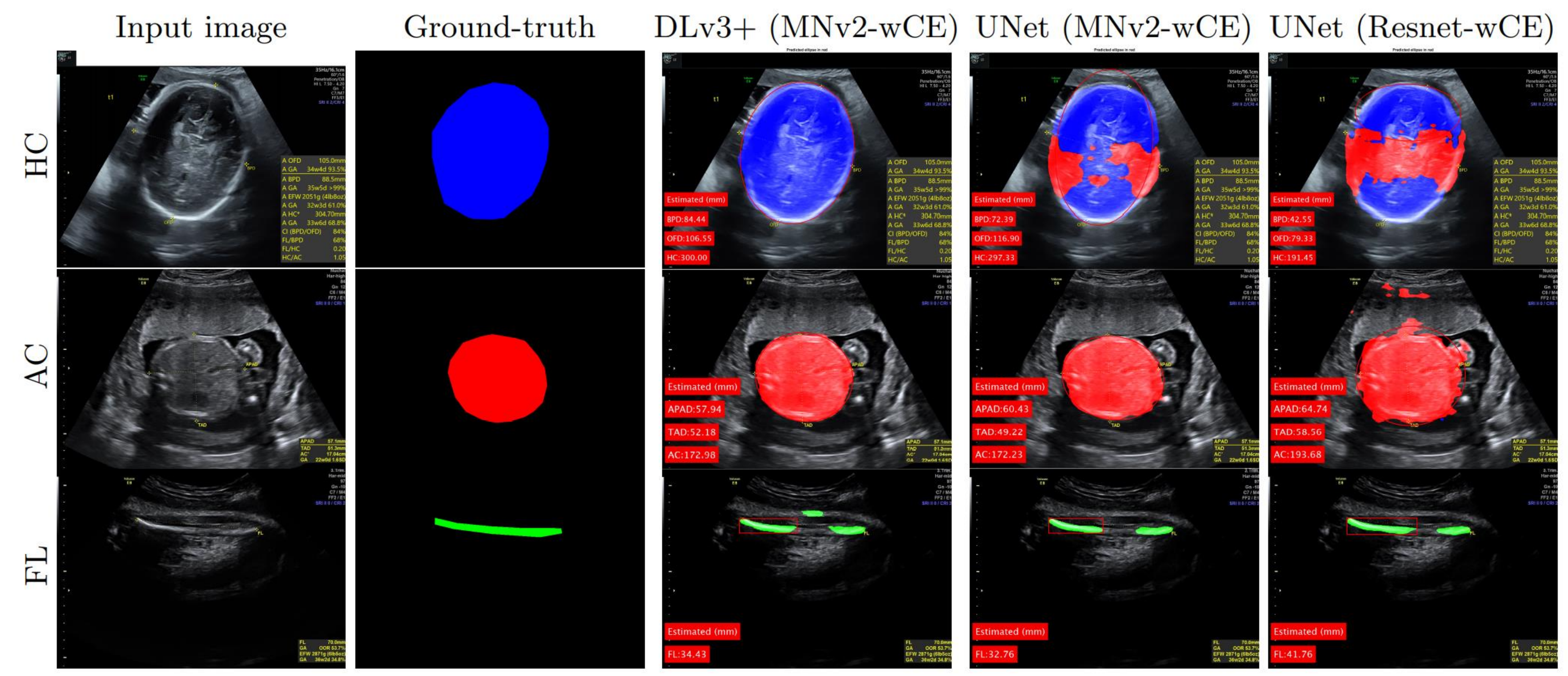
Multiclass Segmentation: 4-fold cross validation applied on Deeplabv3+ [2] and UNet [3] models with MobileNetv2 (MNv2) and ResNet50 backbones trained using either cross-entropy (CE) or weighted cross entropy (wCE) loss.

Overall mean Intersection over Union (mIOU) of all models under comparison

	Deeplabv3+ (MNv2-CE)	Deeplabv3+ (MNv2-wCE)	UNet (MNv2-CE)	UNet (MNv2-wCE)	UNet (ResNet-CE)	Unet (ResNet-wCE)
mIOU	0.87	0.88	0.82	0.86	0.75	0.78



Comparison between the best performing models and absolute error between the clinically measured and predicted fetal biometry



Qualitative comparison of segmentation methods showing scenarios where inaccurate segmentation resulted in fetal biometry estimation failure

5. Conclusion

- Deeplabv3+ outperformed other models despite large intra-class variability in standard US planes.
- Obtained errors in HC (2.67 *mm*), AC (3.77 *mm*) and FL (2.10 *mm*) are minimal and better than the ±15% error that is typically acceptable in fetal US assessment.

References

[1] Cavallaro, A., et al.: Quality control of ultra-sound for fetal biometry: Results from the intergrowth-21st project. Ultrasound in Obstetrics & Gynaecology 52(3), 332–339 (2018).

[2] Chen, L.C., et al.: Encoder-decoder with atrous separable convolution for semantic image segmentation. In: Proceedings of the ECCV. pp. 801–818 (2018).

[3] Ronneberger, O., et al.: U-Net: Convolutional networks for biomedical image segmentation. In: Proceedings of MICCAI. pp. 234–241. Springer (2015).

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