Segmentation Based Approach

1. Introduction

This task explores a segmentation-based approach for estimating foetal head biometry measurements from ultrasound images. Unlike direct landmark prediction, this approach follows a clinically inspired pipeline where the foetal skull is segmented first and biometry measurements are derived geometrically.

The objective of this part is to demonstrate the ability to combine deep learning with classical image processing techniques.

2. Dataset Description

The dataset used for Part B consists of:

- **Images:** Same 622 foetal axial ultrasound images used in Part A
- **Masks:** Binary segmentation masks containing elliptical skull outlines

All images and masks were resized to **256 × 256**.

3. Problem Formulation

The task was divided into three steps:

1. Segment the foetal skull from ultrasound images
2. Fit an ellipse to the skull region
3. Extract BPD and OFD from the ellipse geometry

This approach mirrors clinical practice, where head measurements are approximated using elliptical models.

4. Segmentation Model

A standard U-Net architecture was used for skull segmentation.

- **Input:** 1 × 256 × 256 ultrasound image
- **Output:** 1 × 256 × 256 binary mask
- **Loss function:** Binary Cross-Entropy with Logits

The model was trained for a limited number of epochs to demonstrate feasibility rather than optimal performance.

Training result:
Final loss ≈ **0.0347**

5. Post-Processing and Geometry Extraction

The provided segmentation masks consisted of thin elliptical outlines rather than filled regions. To enable reliable ellipse fitting, additional post-processing steps were applied:

- Morphological dilation to thicken the contour
- Filling the enclosed region to obtain a solid mask
- Extraction of the largest contour
- Ellipse fitting using OpenCV

From the fitted ellipse:

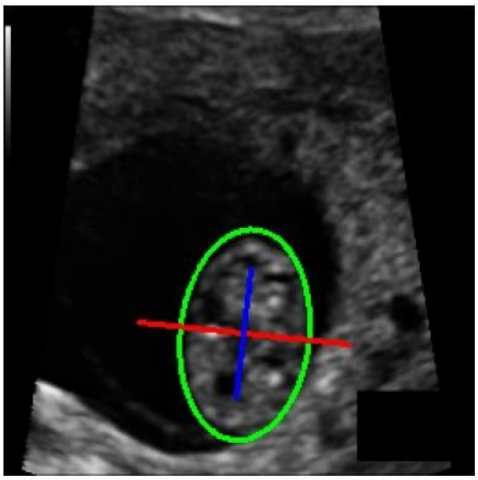
- **Major axis → OFD**
- **Minor axis → BPD**

This allowed direct extraction of two landmark points per biometry measurement.

6. Results and Visualization

The final output includes:

- A fitted ellipse over the foetal skull (Green)
- A line representing OFD (Red line)
- A line representing BPD (Blue line)



While the measurements are not pixel-perfect due to resizing and mask resolution, the pipeline correctly demonstrates anatomical reasoning and geometric interpretation.

7. Limitations and Future Improvements

Potential improvements include:

- Using Dice loss or boundary-aware loss for thin structure segmentation
- Training for more epochs with class imbalance handling
- Attention-based segmentation models
- Joint learning of segmentation and landmark regression

8. Conclusion

This part demonstrated a complete segmentation-to-geometry pipeline for fetal head biometry estimation. The approach highlights how classical image processing techniques can be effectively combined with deep learning models to produce interpretable and clinically meaningful outputs.