# A Study of Automated Measurement of Fetal Head Circumference using 2D Ultrasound Images

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## 1 Introduction

In this project, I implemented a U-Net based deep learning model to detect fetal head boundaries in 2D ultrasound images. The goal is to automatically segment the head region and estimate the head circumference (HC), supporting clinicians in prenatal diagnosis. The U-Net model generates a soft mask of the head contour, which is then binarized and post-processed to extract the head boundary.

## 2 Data Analysis

The dataset used in this study consists of grayscale 2D ultrasound images, paired such that every even-indexed image is a raw fetal head scan and every odd-indexed image is the corresponding ground truth mask. A separate CSV file provides ground truth head circumference (mm) and pixel size for each image.

All images are resized to $128 \times 128$ for model training. The dataset is split as follows:

- 80% for training
- 20% for testing

## 3 Model

### 3.1 U-Net Architecture

The U-Net architecture is a popular convolutional neural network for image segmentation, composed of a contracting path (encoder) and an expansive path (decoder). The encoder captures context via convolution and max-pooling layers, while the decoder enables precise localization through upsampling and skip connections.

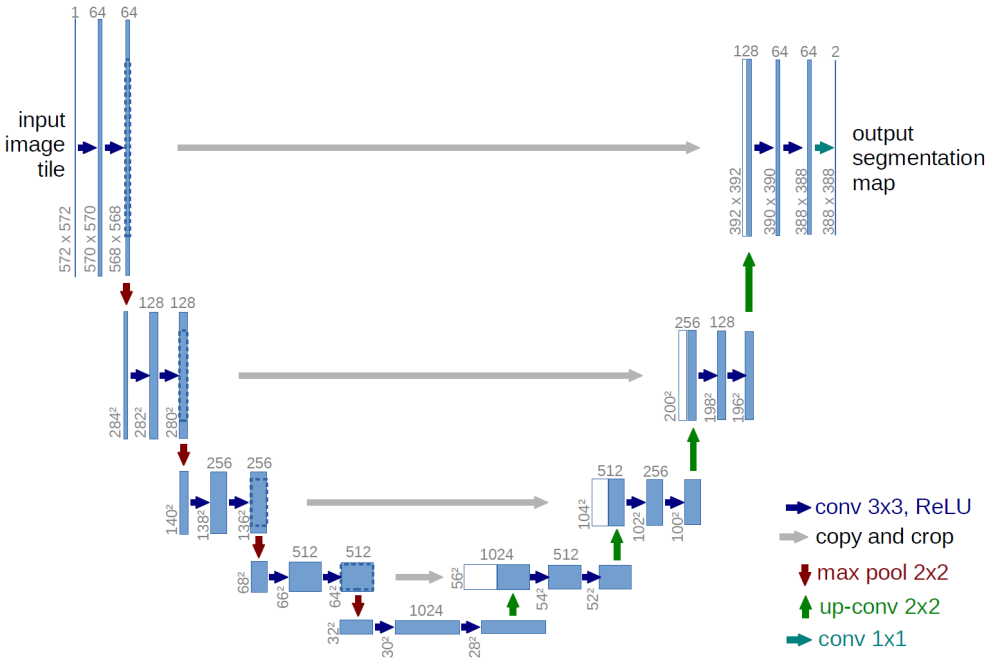


Figure 1: U-Net Architecture

### 3.2 Loss Function

The model is trained using the Binary Cross-Entropy (BCE) loss function, which compares the predicted mask with the ground truth pixel-wise. The BCE loss is defined as:

$$\text{BCE}(y, \hat{y}) = -\frac{1}{N} \sum_{i=1}^{N} [y_i \log(\hat{y}_i) + (1 - y_i) \log(1 - \hat{y}_i)]$$

## 4 Results

### 4.1 For detecting the head boundary

After training for 20 epochs, the U-Net model with BCE loss produced reasonable segmentation results. The predicted mask is binarized using a threshold of 0.5, followed by morphological operations to clean noise. The largest contour is extracted to represent the head boundary.

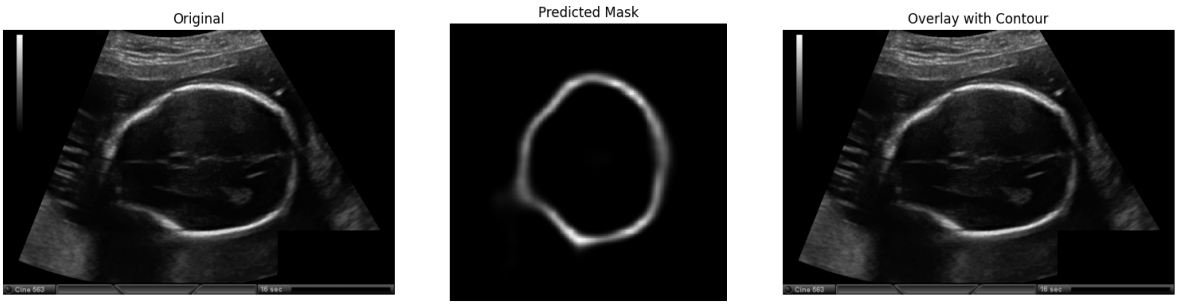


Figure 2: Head boundary prediction and overlay on test sample

## 4.2 Quantitative Evaluation

To evaluate performance, we compute the following metrics between predicted and ground truth masks:

- **Mean Absolute Error (MAE)**
- **Intersection over Union (IoU)**

Table 1: MAE and IoU values of the U-Net model with BCE loss

| **Loss function** | **MAE** | **IoU** |
|---|---|---|
| BCE | 3.940179443359375 | 0.14295918853278727 |