Machine Learning in Madicine - Practical 2

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I. Introduction

During pregnancy, measurement of fetal head circumference is important task for gestational age and monitor growth of the fetus. Building a model can predict a HC value from ultrasound image will be save time, automative process and more accuracy.

II. Dataset

The dataset is devided into a training set of 999 images and a test set of 335 images. The size of each ultrasound image is 800 by 540 pixels with a pixel size ranging from 0.052 to 0.326 mm. The pixel size can find in the two csv file, including training_set_pixel_size_and_HC.csv and test_set_pixel.csv. The training set aslo contains ultrasound image with the manual annotaion of the head circumference for each HC value while the test set only includes the ultrasoud image and without HC value in file CSV.

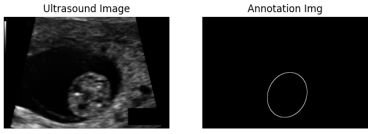

Fig. 1. Caption

No.	Filename	Pixel size (mm)	Head circumference (mm)
0	000_HC.png	0.069136	44.30
1	001_HC.png	0.089659	56.81
2	002_HC.png	0.062033	68.75
3	003_HC.png	0.091291	69.00
4	004_HC.png	0.061240	59.81

TABLE I
Pixel size and head circumference measurements (top 5)

III. Problem Definition

The challenge is created an alogrithm that aumatically measure the fetal head circumference given 2D ultrasound image. The alogrithm need to train with the traning set, comparing the alogrithm's result and groud truth hc values, before apllying to calculate the value of 335 images of test set.

To measure this challenge. The first thing we need to do is building a model, which can segment the ultrasound image to achieve annotation image. And then, construct a alogrithm can estimate the HC value from annotation image.

IV. Methodology

For the segmentation task, the input of network is ultrasound images and the output is annotation images. The model use for this task is U - Net, which consists three main parts:

- Encoder : Each encoder contains two 2D convolutional layers(Kernel size = 3x3, ReLU activation function), MaxPooling2D, Dropout layers.
- Bottleneck: This part represents the deapest part of the network and captures the most abstract and global feature of ultrasound image.
- Decoder: Each decoder contains 2D Convolutional Layers Transposed, two 2D Convolutional Layers. At each decoder level, the upsampled feature map is concatenated with the corresponding encoder feature map via skip connections.

  To estimate the fetal head circumference from the segmentation output, an ellipse-based geometric approach is applied. First, the binary annotation image is converted to grayscale and external contours are extracted using OpenCV. The largest detected contour, corresponding to the fetal head region, is then fitted with an ellipse using a least-squares method. From the fitted ellipse, the lengths of the major and minor axes are obtained and used to compute the semi-major axis a and semi-minor axis b. The perimeter of the ellipse is approximated using Ramanujan's formula, which provides an accurate estimation of an ellipse circumference. Finally, the computed perimeter in pixel units is converted to millimeters using the known pixel-to-millimeter scaling factor, yielding a quantitative head circumference measurement suitable for clinical analysis.

V. Evaluation and Metric

U-net Model:

Accuracy	Loss	Val_Accuracy	Val_loss
0.9927	0.0239	0.9920	0.0250

TABLE II
Performance of U Net Model after 15 epochs

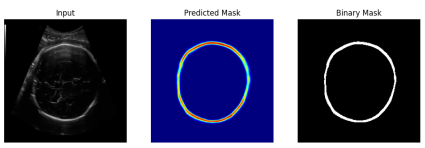

Fig. 2. Predict Annotation Image

CV2 - Ellipse Algorithm:

- MAE : 0.75 mm
- RMSE : 0.81 mm

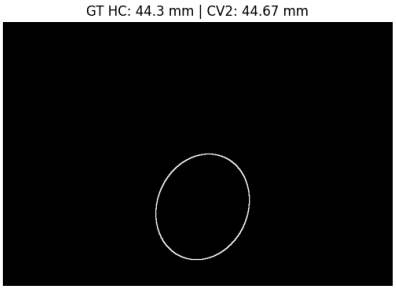

Fig. 3. Caption