Head Circumference Estimation from Ultrasound Images

I. Introduction

Head circumference (HC) measurement is a key biometric indicator in fetal ultrasound imaging, widely used to monitor fetal growth and detect potential developmental abnormalities. Automating this measurement from ultrasound images is a challenging task due to image noise, low contrast, and anatomical variability. In this work, we explore a supervised learning approach for estimating fetal head circumference from ultrasound images using a convolutional neural network (CNN).

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II. Dataset Description

The dataset consists of 999 grayscale ultrasound images paired with numerical head circumference measurements expressed in millimeters. The data were provided in a CSV file containing three columns: image filename, pixel size, and head circumference value.

After preprocessing, all images listed in the CSV file were successfully matched with existing image files on disk. No missing data remained after filtering. The dataset covers a wide range of fetal development stages.

TABLE I
Head Circumference Statistics

Statistic	Value (mm)
Number of samples	999
Mean	174.38
Standard deviation	65.28
Minimum	44.30
25th percentile	153.60
Median	174.06
75th percentile	189.83
Maximum	346.40

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III. Data Preprocessing

Each image was loaded in grayscale and resized to a fixed resolution of 224×224 pixels to ensure uniform input dimensions. Pixel intensities were normalized to the range [0,1]. The dataset was split into training and validation subsets using an 80/20 ratio with a fixed random seed to ensure reproducibility.

To guarantee dataset integrity, only samples with valid image paths and numerical head circumference values were retained.

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IV. Model Architecture

A convolutional neural network was implemented for regression. The architecture consists of three convolutional layers with ReLU activations and pooling operations, followed by an adaptive average pooling stage. The extracted features are passed through fully connected layers to predict a single continuous value corresponding to the head circumference.

Mean Absolute Error (MAE) was used as both the training loss and evaluation metric, as it provides a direct interpretation in millimeters.

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V. Training Procedure

The model was trained using the Adam optimizer with a learning rate of 10^{-3} and a weight decay of 10^{-4}. Training was conducted for 15 epochs with a batch size of 32. The model achieving the lowest validation MAE was saved for further evaluation.

All experiments were executed on the available computing device, and random seeds were fixed to ensure reproducibility.

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VI. Exploratory Analysis

An exploratory visualization step was performed by randomly sampling images from the dataset and displaying them alongside their corresponding head circumference values. The statistical summary presented in Table **??** confirms a realistic distribution of head circumference measurements.

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VII. Conclusion

This study demonstrates that a CNN-based regression model can be applied to estimate fetal head circumference from ultrasound images. The dataset preprocessing and validation steps ensured consistency between image files and annotations. Future work may involve more advanced architectures, data augmentation strategies, and clinical validation to further improve prediction accuracy.