CNN-based Head Circumference Estimation from Medical Images

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1 Introduction

This report presents a convolutional neural network (CNN) approach for estimating head circumference (HC) directly from grayscale medical images. The task is formulated as a regression problem, where the model predicts a continuous HC value measured in millimeters based on visual patterns extracted from medical images.

2 Dataset and Preprocessing

The dataset consists of grayscale head images paired with ground truth head circumference measurements. All images are resized to 128×128 pixels and normalized to the range $[0, 1]$ to ensure numerical stability during training. The dataset is randomly split into training (80%) and validation (20%) subsets.

3 Model Architecture

The proposed CNN architecture is composed of three convolutional blocks, each followed by max-pooling layers to progressively reduce spatial dimensions while increasing feature abstraction. The convolutional layers are followed by fully connected layers with dropout regularization to mitigate overfitting. Mean Squared Error (MSE) is employed as the loss function, and Mean Absolute Error (MAE) is reported as the primary evaluation metric.

4 Training Process

The model is trained for 15 epochs using the Adam optimizer with a learning rate of 0.001 and a batch size of 32. During training, both training and validation losses decrease rapidly in the initial epochs and gradually converge, indicating stable learning behavior without severe overfitting. The close alignment between training and validation curves suggests good generalization capability.

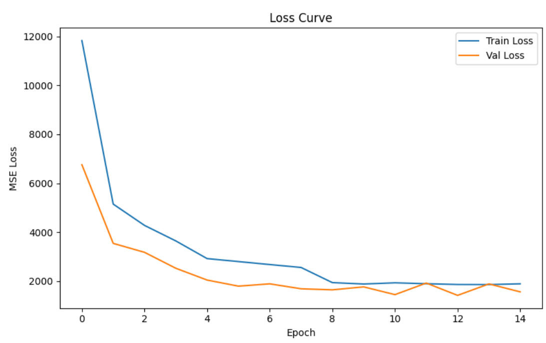


Figure 1: Training and validation loss curves

5 Experimental Results

5.1 Prediction Performance

The prediction performance of the trained CNN model is evaluated on the validation set. Figure 2 compares predicted head circumference values against the corresponding ground truth measurements. A strong linear correlation is observed, demonstrating that the model effectively captures the overall relationship between image features and head circumference values, despite some dispersion for larger measurements.

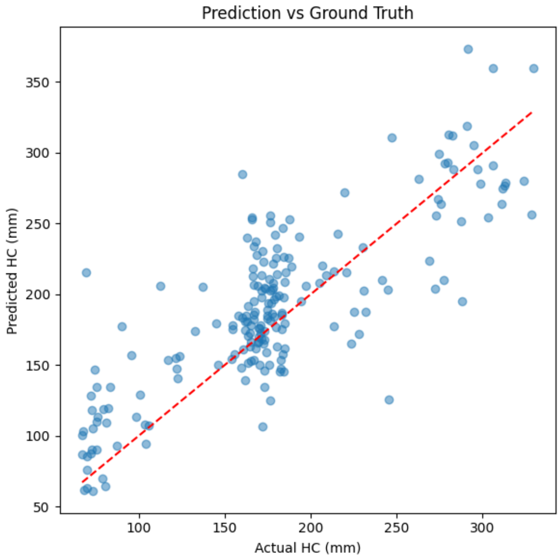


Figure 2: Predicted versus ground truth HC values

5.2 Error Distribution

The distribution of absolute prediction errors is illustrated to further analyze model behavior. Most prediction errors are concentrated below 40 mm, while a small number of outliers contribute to larger errors. This skewed distribution indicates that the model performs reasonably well for the majority of samples but struggles with certain challenging cases.

5.3 Sample Prediction

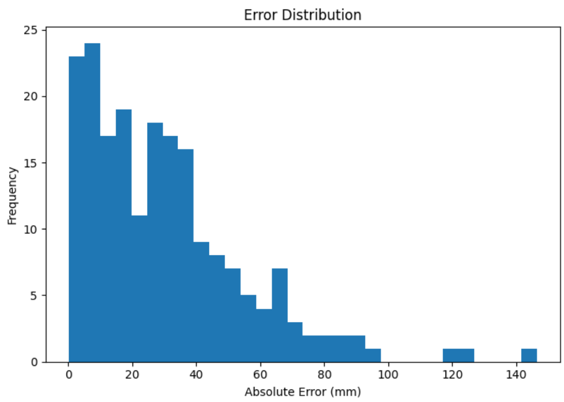
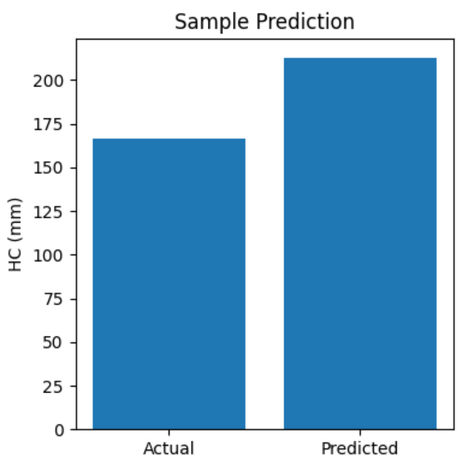


Figure 3: Distribution of absolute prediction errors

A representative validation sample is selected to qualitatively evaluate model output. The predicted head circumference for this sample is 188.74 mm, while the ground truth value is 166.21 mm, resulting in an absolute error of 22.53 mm. This example highlights the typical magnitude of prediction error observed during validation.



6 Quantitative Results

Metric	Value (mm)
Validation MAE	22.53
Sample Prediction Error	22.53

Table 1: Quantitative performance metrics on the validation set

7 Conclusion

The experimental results demonstrate that the proposed CNN model is capable of learning meaningful visual representations from medical images to estimate head circumference. While the model successfully captures the overall trend, prediction errors remain non-negligible for certain samples. Future improvements may include data augmentation, larger datasets, and more advanced network architectures to further enhance prediction accuracy.