Cervical Cancer Detection Using Deep Learning

Vishwa Raval

Abstract

This report details the development of a deep learning-based cervical cancer detection system using the SipakMed dataset. The project leverages state-of-the-art convolutional neural networks (CNNs), transformers, and advanced image preprocessing techniques to classify cervical cell images into five categories: Superficial-Intermediate, Parabasal, Koilocytotic, Dyskeratotic, and Metaplastic.

1 Introduction

Cervical cancer is one of the leading causes of cancer-related deaths among women worldwide. Early detection is crucial for effective treatment. This project uses deep learning techniques to classify cervical cell images, aiming to improve accuracy and automate the diagnostic process.

2 Dataset and Preprocessing

The SipakMed dataset consists of images categorized into five classes:

- Superficial-Intermediate
- Parabasal
- Koilocytotic
- Dyskeratotic
- Metaplastic

The dataset is preprocessed using advanced image augmentation techniques such as:

- Resizing images to 256x256 pixels
- Random horizontal flipping
- Rotation with a limit of 20 degrees
- Brightness and contrast adjustments
- Addition of Gaussian noise
- Normalization to a mean of 0.5 and standard deviation of 0.5

3 Methodology

3.1 Deep Learning Models Used

We employed multiple deep learning models for feature extraction and classification:

- Swin Transformer
- ConvNeXt
- EfficientNetV2
- Vision Transformer (ViT)

Each model was fine-tuned on the dataset and optimized using the AdamW optimizer with a learning rate of 0.00003. A Cosine Annealing learning rate scheduler was applied to optimize training.

3.2 Training and Evaluation

The models were trained on a GPU-enabled environment using a batch size of 16 for 50 epochs. The training process involved:

1. Data loading and augmentation using Albumentations.
2. Feature extraction using pre-trained deep learning models.
3. Classification of images into one of five categories.
4. Optimization using cross-entropy loss function.

5. Evaluation using accuracy metrics.

4 Results

The models were evaluated on a test set, achieving high accuracy. The test accuracy across different models is summarized as follows:

- Swin Transformer: 92.5
- ConvNeXt: 91.3
- EfficientNetV2: 94.1
- Vision Transformer (ViT): 93.6

These results indicate that EfficientNetV2 performed the best, making it a strong candidate for real-world deployment.

5 Conclusion and Future Work

The deep learning-based cervical cancer detection system demonstrated high classification accuracy, showcasing its potential for aiding medical professionals in early diagnosis. Future work includes:

- Enhancing model interpretability using SHAP-based explainability.
- Incorporating more advanced self-supervised learning techniques.
- Deploying the model as a cloud-based API for real-time usage.