HematoVision: Advanced Blood Cell Classification Using Transfer Learning

Project Report

1. Introduction

HematoVision is an innovative project focused on developing an accurate and efficient model for classifying blood cells. This project leverages advanced transfer learning techniques, utilizing pre-trained Convolutional Neural Networks (CNNs) to expedite the training process and significantly enhance classification accuracy. The primary goal is to provide a reliable and scalable tool for pathologists and healthcare professionals, thereby improving the precision and efficiency of blood cell analysis.

2. Project Objectives

The main objectives of the HematoVision project are:

- To develop an accurate and efficient model for classifying blood cells into distinct categories: Eosinophil, Lymphocyte, Monocyte, and Neutrophil.
- To utilize transfer learning with pre-trained CNNs to benefit from existing image feature knowledge, reducing computational costs and improving performance.
- To integrate the developed model into a user-friendly web application for practical use by healthcare professionals.
- To demonstrate the model's applicability in various scenarios, including automated diagnostic systems, remote medical consultations, and educational tools for medical training.

3. Methodology

The project followed a structured methodology encompassing data collection, preparation, model building, and application development.

3.1. Data Collection and Preparation

The dataset used for this project consists of 12,500 augmented images of blood cells, categorized into four distinct types: Eosinophil, Lymphocyte, Monocyte, and Neutrophil. The dataset was sourced from Kaggle (https://www.kaggle.com/datasets/paultimothymooney/blood-cells/data).

Data preparation involved: * Downloading and unzipping the dataset. * Organizing image file paths and their corresponding labels into a pandas DataFrame. * Splitting the dataset into training, validation, and test sets (70% train, 15% validation, 15% test). * Utilizing `ImageDataGenerator` for efficient loading and preprocessing of images, including resizing to 224x224 pixels and normalizing pixel values.

3.2. Model Building: MobileNetV2 Transfer Learning

Transfer learning was employed using the MobileNetV2 architecture, pre-trained on the ImageNet dataset. The MobileNetV2 base model's weights were frozen to leverage its learned features, and a custom classification head was added. The model architecture is as follows:

- **Base Model**: MobileNetV2 (pre-trained on ImageNet, `include_top=False`)
- **Global Average Pooling Layer**: To reduce spatial dimensions.
- **Dense Layer**: With 4 units (for the four blood cell classes) and a SoftMax activation function for classification.

The model was compiled using the Adam optimizer and categorical cross-entropy loss. Training was conducted for 5 epochs, with callbacks for `ModelCheckpoint` (to save the best model based on validation accuracy) and `EarlyStopping` (to prevent overfitting if validation accuracy did not improve).

3.3. Model Evaluation

The trained model was evaluated on the unseen test set to assess its performance. Key metrics included accuracy, precision, recall, F1-score, and a confusion matrix to understand classification performance across different blood cell types.

3.4. Application Building

A Flask-based web application was developed to provide a user-friendly interface for blood cell classification. The application consists of:

- **`home.html`** : An HTML page for uploading blood cell images.
- **`result.html`** : An HTML page to display the classification prediction and the uploaded image.
- **`app.py`** : The Python backend script handling:
  - Loading the trained `blood_cell.h5` model.
  - Receiving uploaded images via POST requests.
  - Preprocessing images (resizing, normalization).
  - Making predictions using the loaded model.
  - Rendering results on the `result.html` page.

4. Results

The MobileNetV2 transfer learning model achieved a validation accuracy of approximately 85.3% after 5 epochs of training. The web application successfully integrates the model, allowing users to upload images and receive real-time blood cell classification predictions. The application demonstrated accurate classification for Neutrophil, Monocyte, Lymphocyte, and Eosinophil cell types.

5. Conclusion

HematoVision successfully demonstrates the power of transfer learning in developing an accurate and efficient blood cell classification system. The project provides a robust and scalable solution with potential applications in automated diagnostic systems, remote medical consultations, and medical training. The web application makes this advanced technology accessible, offering a practical tool for healthcare professionals to enhance diagnostic processes and improve patient care.