Assignment - Image Analysis and Deep Learning

Member 1: Max Noorland, maxnoorland@gsom.polimi.it
Member 2: Diego Cossu, diego.cossu@gsom.polimi.it
Member 3: Daniyar Serik, daniyar.serik@gsom.polimi.it

Introduction

In this assignment, we were tasked with classifying images of cells taken with an electron microscope into eight classes: basophils, eosinophils, erythroblasts, immature granulocytes, lymphocytes, neutrophils, monocytes, and platelets. The dataset provided contained 15092 samples with images sized 48x48 pixels. Our initial impression was that this task would require a combination of traditional image processing techniques and modern deep learning approaches. We assumed that a Convolutional Neural Network (CNN) would be most effective for this task, complemented by hand-crafted feature extraction for a comparative analysis.

Data Analysis

The dataset consisted of images and their corresponding labels. We performed an initial analysis to understand the distribution of the classes and the nature of the images. Key steps included:

- **Visualization**: Displaying sample images from each class.
- **Normalization**: Scaling the image pixel values to the range [0, 1].
- **Feature Extraction**: For the hand-crafted model, we extracted features such as mean, standard deviation, and GLCM properties like contrast, dissimilarity, homogeneity, energy, and correlation.

Experiments

We conducted several experiments to determine the best approach for this classification task:

1. **Hand-Crafted Features**: We extracted statistical and textural features from the images and trained a RandomForestClassifier. Despite reasonable performance, we found that this approach had limitations in capturing complex patterns in the data.
2. **CNN Model**: We designed a Convolutional Neural Network with three convolutional layers, followed by max-pooling, flattening, dense layers, and dropout for regularization. The model was trained on the normalized image data.

Log of Experiments:

- **Initial CNN**: Three convolutional layers, ReLU activation, followed by max-pooling and dense layers. Achieved initial accuracy of 89%.
- **Hyperparameter Tuning**: Adjusted learning rates, batch sizes, and epochs to improve performance.
- **Data Augmentation**: Tried augmenting the dataset but found limited improvement.

Final Models

Hand-Crafted Model:

- **Features Used**: Mean, standard deviation, GLCM properties (contrast, dissimilarity, homogeneity, energy, correlation).
- **Classifier**: RandomForestClassifier.
- **Performance**: Accuracy of approximately 70%.

Deep Learning Model:

- **Architecture**: Three convolutional layers with ReLU activation and max-pooling, followed by dense layers with dropout.
- **Training**: 20 epochs, batch size of 64, Adam optimizer.
- **Performance**: Final accuracy of approximately 90% on the test set.

Conclusions

This assignment demonstrated the effectiveness of deep learning models, particularly CNNs, in image classification tasks. While hand-crafted features provided a useful baseline, the CNN significantly outperformed in terms of accuracy. Future work could involve exploring more sophisticated architectures or combining hand-crafted features with CNN outputs for potentially better performance.

References

1. LeCun, Yann, Yoshua Bengio, and Geoffrey Hinton. "Deep learning." Nature 521.7553 (2015): 436-444.
2. Kingma, Diederik P., and Jimmy Ba. "Adam: A method for stochastic optimization." arXiv preprint arXiv:1412.6980 (2014).