Acute Lymphoblastic Leukemia (ALL) Image Classification using CNN

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Introduction

Acute Lymphoblastic Leukemia (ALL) is the second most common acute leukemia in adults with an incidence of over 6500 cases per year in the United States alone.

As a highly prevalent cancer, the definitive diagnosis of acute lymphoblastic leukemia (ALL) requires invasive, expensive, and time-consuming diagnostic tests. ALL diagnosis using peripheral blood smear (PBS) images plays a vital role in the initial cancer screening from non-cancer cases. The examination of these PBS images by laboratory users is riddled with problems such as diagnostic error because the non-specific nature of ALL signs and symptoms often leads to misdiagnosis.

Problem and Proposed Solution

As a highly prevalent cancer, the definitive diagnosis of ALL requires invasive, expensive, and time-consuming diagnostic tests. ALL diagnosis using peripheral blood smear (PBS) images plays a vital role in the initial cancer screening from non-cancer cases.

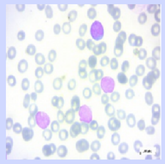
Our project is a machine learning model that has been trained using over three thousand peripheral blood smear images of patients suspected of ALL and is able to classify the images into either benign or malignant. While the Benign results comprise of hematogones, the malignant cells are further classified into Early Pre-B, Pre-B, and Pro-B Acute Lymphoblastic Leukemia.

The Data

The Data for our project is 3,256 peripheral blood smear images from 89 patients suspected of ALL, including 25 healthy individuals with a benign diagnosis (hematogone) and 64 patients with a definitive diagnosis of ALL subtypes, Early Pre-B, Pre-B, and Pro-B ALL.

The images are subjected to color-based threshold segmentation to further focus on it's important features. Additionally, we add flipped and rotated versions of every image to the dataset, effectively multiplying our dataset eight times.

Original Image

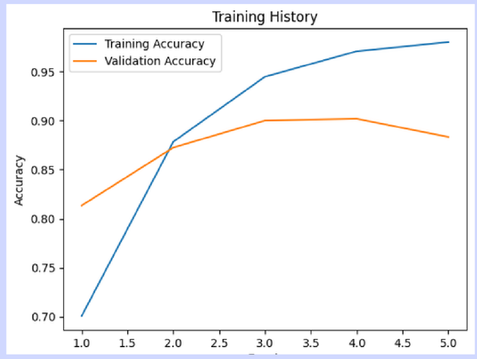


Thresholded Image

Binary image

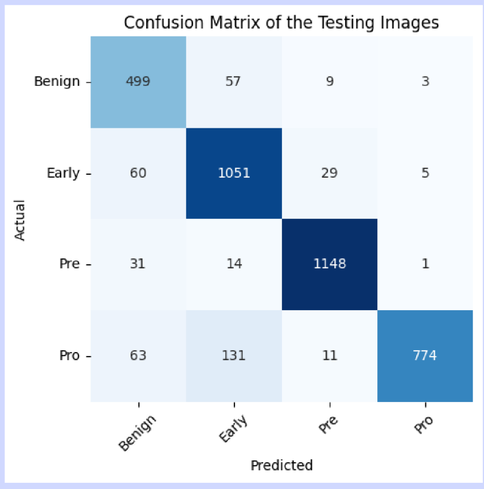
The Model

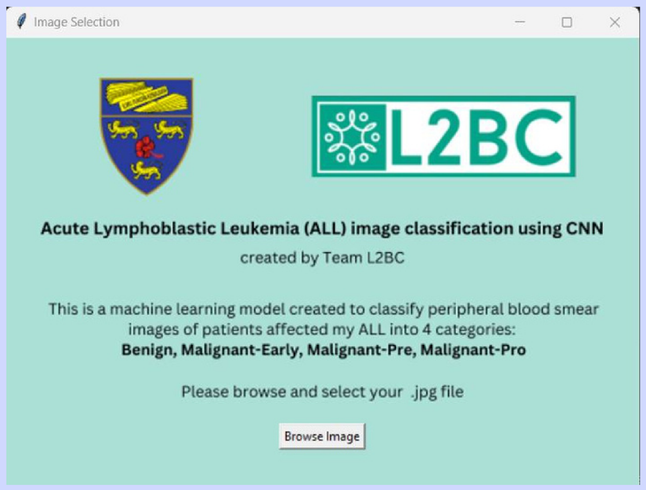
For our model, we have chosen to use a Convolutional Neural Network model as it best fits our requirement of image classification. We use Rectified Linear Activation function to add non-linearity to the model before flatening, and a Softmax activation function with 4 kernels right after, as it specializes in class type classification problems.
From the generated plot we can conclude that the validation accuracy peaks with a value of **0.902** at epoch 4. At all epochs beyond the 4th (including test runs where epochs go up to 10), the validation accuracy decreases flatly but steadily, while the training accuracy nears 1.00, showing an overfit in the model. Therefore, we consider epoch 4 to be the best epoch.



Model Evaluation

Taking the model with the highest accuracy, we run it against the valuation dataset and generate a confusion matrix of the same. We can observe a very low number of false negatives, with most false negatives falling under the Malignant early Pre-B class. Additionally, the highest number of false positive Malignant pro-B results fall under early stage Pro-B. Such cases cause a negligible amount of harm, as the early stage diagnosis is still considered to be malignant.





The Application

Lastly, the model with the highest accuracy is saved and is used in our final application. The app is a is a simple executable file that takes in an peripheral blood smear image uploaded by the user and classifies it into the 4 assigned classes, along with a confidence score given with the prediction.

Data Reference: Mehrad Aria, Mustafa Ghaderzadeh, Davood Bashash, Hassan Abolghasemi, Farkhondeh Asadi, and Azamossadat Hosseini, "Acute Lymphoblastic Leukemia (ALL) image dataset." Kaggle, (2021). DOI: 10.34740/KAGGLE/DSV/2175623.