Blood Cells Cancer Detection Using Vision Transformer

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Aim

By combining the Vision Transformer (ViT) architecture with sophisticated image preparation approaches (Entropy Filtering and Region Growing Segmentation), the research seeks to create an efficient model for identifying blood cell malignancy, especially Acute Lymphoblastic Leukemia (ALL). By correctly dividing peripheral blood smear (PBS) pictures into benign and malignant groups, the research aims to help patients with ALL get an early diagnosis and treatment planning.

Objective

- **Develop a Reliable Classification Model**: Utilize Vision Transformer (ViT) architecture to reliably classify blood smear images into benign and malignant groups, focusing on recognizing ALL subtypes.
- **Enhance Image Quality by Preprocessing**: Advanced preprocessing techniques include region expanding segmentation and entropy filtering highlight blood cell membranes and nuclei.
- **Use Medical Image Data**: For reliable and accurate classification, use the "Blood cells cancer dataset," a labelled dataset of 3,242 peripheral blood smear (PBS) images from 89 suspected ALL patients.
- **Improve Diagnostic Accuracy**: Use metrics such as accuracy and precision to ensure the model's efficacy in early diagnosis and treatment planning for blood cell cancer.

Research questions

- How does entropy-based feature extraction influence the performance of ViT models in classifying blood cell cancer images?
- What is the impact of region growing segmentation on the ViT model's ability to distinguish between benign and malignant blood cell types?
- How do the combined effects of entropy filtering and region growing segmentation improve the interpretability and precision of ViT-based cancer classification models?
- What are the computational trade-offs between entropy filtering, region growing segmentation, and raw image inputs for ViT models in blood cell classification tasks?

Background

Early identification and treatment are essential for life-threatening blood cancers like Acute Lymphoblastic Leukemia (ALL). AI and deep learning have improved medical diagnostics, notably cancer detection and categorization.

Hagar, M., et al. (2023) classified eight blood cancers using VGG16 and DenseNet-121. VGG16 was better for this dataset than DenseNet-121, diagnosing AML, ALL, and different lymphomas with 98.2% accuracy. Loey, M et al. (2020) fine-tuned AlexNet for transfer learning on 2,820 blood smear pictures to achieve 100% classification accuracy. Nasr, M., et al. (2024) examined ResNetRS50 and RegNetX016 models. RegNetX016's efficient design yielded 97% accuracy, demonstrating deep learning's promise in early cancer diagnosis.

Reference:

Hagar, M., Elsheref, F.K. and Kamal, S.R., 2023. A New Model for Blood Cancer Classification Based on Deep Learning Techniques. Link: https://www.proquest.com/openview/1e38ee6ddf88d3f0fa0b740ce416c38b/1?pq-origsite=gscholar&cbl=5444811

Loey, M., Naman, M. and Zayed, H., 2020. Deep transfer learning in diagnosing leukemia in blood cells. Link: https://www.mdpi.com/2073-431X/9/2/29

Nasr, M., El Ghazali, A.E.D.M. and Shehta, A.I., 2024. Deep Learning Models for Early Detection of Blood Cancer Disease. Link: https://link.springer.com/chapter/10.1007/978-3-031-71619-5_6

Dataset Overview

This research uses a dataset intended to diagnose Acute Lymphoblastic Leukemia (ALL), a common blood malignancy that requires early identification for treatment. Taleqani Hospital in Tehran, Iran, provided peripheral blood smear (PBS) pictures. Trained lab staff processed and stained these photos to aid first tests for cancer. Each picture is carefully characterized as benign (hematogenous) or malignant (ALL), with the latter divided into three kinds of malignant lymphoblasts: Early Pre-B, Pre-B, and Pro-B ALL. The dataset's stability and correctness were ensured by employing a Zeiss camera under a 100x microscope and flow cytometry to classify all photos.

Data Collection

The dataset is accessible via Kaggle at the following link: Blood Cell Cancer (ALL) - 4class Dataset. The dataset was originally compiled for research purposes to enhance the diagnostic processes surrounding leukaemia, thereby contributing to the advancement of early detection methodologies in clinical settings.

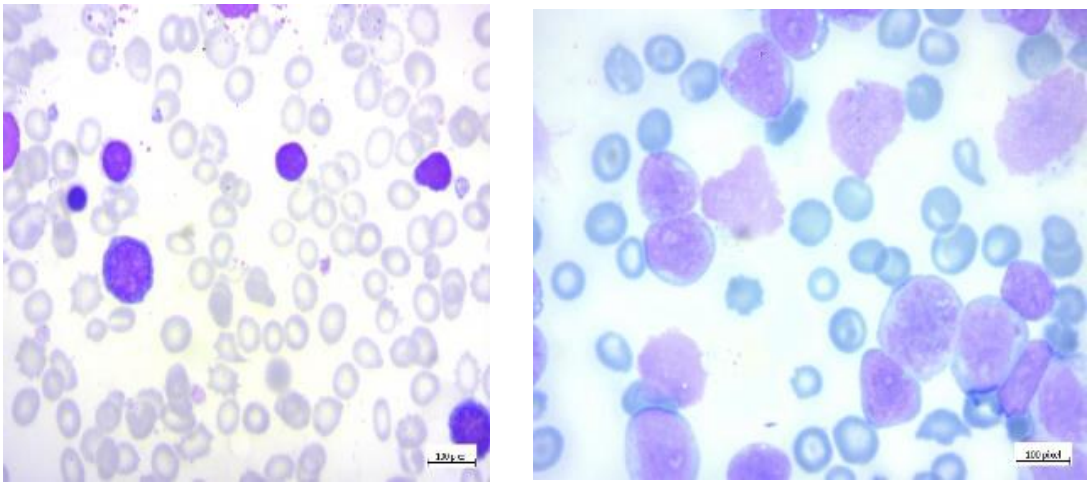

Figure 1: Sample Images

Metadata

- Data Format: The images are stored in JPG format.
- Total Records: The dataset consists of 3,242 images.
- Size: The total size of the dataset is approximately 2GB.

Document Control

Regular contributions following major changes or feature additions will be made to the project's GitHub source code. File names will be descriptive, such as preprocessing_v1.py and train_model_v1.py, using a semantic versioning system (e.g., v1.0, v1.1, etc.). To allow assessors to evaluate the code, the GitHub repository will be public.

GitHub link: https://github.com/UritiSrikanth/Blood-Cells-Cancer-detection-using-CNN

ReadMe File

The GitHub repository will include a ReadMe file after the project. This page includes a project overview, setup instructions, script explanations, dependencies, and use recommendations. It will also provide model assessment metrics and reproducibility instructions.

Security and Storage

GitHub and OneDrive will backup data and source code regularly for redundancy. GitHub will be the main version-control platform, while OneDrive will protect project data. Faculty and assessors will have access to the GitHub source for complete examination.

Ethical Requirements

- GDPR Compliance: The dataset has been anonymized and does not include any personally identifiable patient information, thereby exempting it from GDPR regulations.
- Conformance to UH Ethical Policies: The project aligns with ethical guidelines by utilizing publicly available data for research purposes, ensuring responsible use of information.
- Permission for Data Use: The dataset is openly accessible on Kaggle, and the uploader has granted permission for its utilization in research and educational contexts.
- Ethical Data Collection: The data was gathered in an ethical manner by qualified professionals at Taleqani Hospital, employing flow cytometry and skilled laboratory staff to ensure accurate labeling and processing of the blood smear images.
- Licensing: The dataset is licensed under the Creative Commons Attribution-NonCommercial 4.0 International License (CC BY-NC 4.0), which permits non-commercial use, distribution, and adaption with proper attribution. This assures ethical use of the dataset under this license.

Link to licence: Deed - Attribution-NonCommercial 4.0 International - Creative Commons

Project plan

From October to January, a data science project cantered on blood cancer detection utilizing a Vision Transformer (ViT) model mapped out important activities. Project and Data Management Plan (PDM) authoring, literature research, dataset collection and analysis, data preprocessing, model construction, training, assessment, and final report and presentation preparation are all part of the project lifecycle.

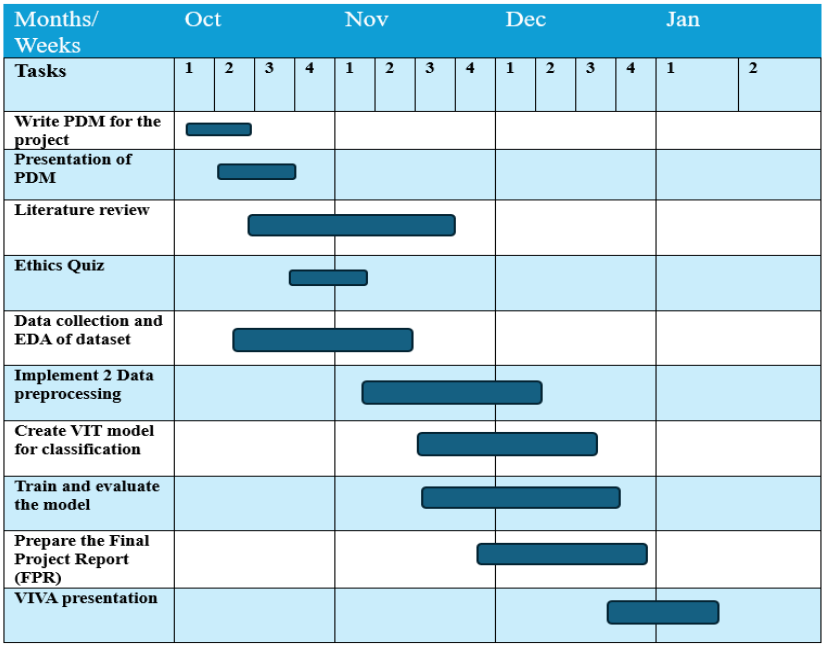

Figure 2: Project plan.