

Review on Automatic Detection & Counting of RBC's by Using Image Processing Technique

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Abstract - Accurate counting of red blood cells (RBCs) in microscopic images is critical for various medical diagnoses and research purposes. Manual counting methods are labor-intensive, time-consuming, and prone to human error. This project aims to automate the RBC counting process using advanced image processing techniques. The primary objective is to improve the efficiency of the counting process, minimize subjectivity, and increase productivity in medical laboratories. The proposed method uses computer vision algorithms to analyze digital images of blood smears captured under a microscope. A combination of image segmentation and morphological operations is then applied to isolate individual RBCs, overcoming challenges posed by overlapping cells and variations in staining.

Keywords: Image processing; Segmentation; Red Blood cells; Hough Transformation; RBC count.

I. INTRODUCTION

Advancements in medical diagnostics and research have been positively impacted by integrating new technologies, particularly in image processing. Analyzing and interpreting medical images with precision has opened new avenues for understanding and tackling complex health challenges. This project aims to develop an automated system using image processing techniques for detecting and counting red blood cells (RBCs).

Red blood cells (RBCs), also known as erythrocytes, are responsible for carrying oxygen from the lungs to other tissues and transporting carbon dioxide from tissues to the lungs. Image processing is a technique that enhances image quality by applying mathematical operations. Identifying a two-dimensional signal and enhancing it by comparing it with a standard signal is an essential process of image processing projects.[1]

II. LITERATURE REVIEW

1. "An Automated Method for Counting Red Blood Cells using Image Processing" (2020) by Gurpreet Kaur Chadha, Aakarsh Srivastava, Abhilasha Singh, Ritu Gupta, Deepanshi Singla.

Blood testing is a crucial medical examination test in

healthcare. In pathology labs, counting different types of blood cells helps diagnose diseases in patients.

Counting RBCs in blood cell images can play a significant role in detecting and monitoring the treatment process of various diseases such as Acute Lymphoblastic Leukemia. Counting and examining blood cells manually under a microscope is a time-consuming task that requires technical expertise. Therefore, there is a need to develop an automated blood cell detection and counting system that can help physicians diagnose diseases efficiently.[1]

2. "An efficient image processing technique to count red blood cells" (2020) by Joseph George, T Sobha, Arun Ashok V, Jose Eldhose

A shortage of RBCs, which constitute 99% of blood cells and specialize as oxygen carriers, can cause various blood disorders. RBCs are an essential parameter in diagnosis and pathological studies. This study proposes a system to detect and count the number of RBCs in blood smear images. The process involves image acquisition and image enhancement, where noise is removed from the images, and edges are preserved by converting them to binary images, thus separating the region of interest from the background. The primary objective of the proposed system is to detect and count all RBCs, including overlapping ones, in blood smear images.[2]

3. "Red Blood Cells and White Blood Cells Detection by Image Processing" (2020) by Irwan Rahadi, Me Choke Hoodooing, and Aronia Hoodooing.

The conventional method of identifying and counting red and white blood cells involves manual processes under a microscope, arranged by laboratory technicians using their experience. This study proposes developing a computer program to detect and identify the proposed objects based on their pattern. The program's output shows that all types of cells mentioned can be detected and classified effectively by showing the number and time spent detecting cells.[3]

4. "Review on Identification of Red Blood Cells by Image Processing" (2020) by Reddy Bhavana, Prajwal Srivastava, Sangeetha N, Rashmi Reddy.

Analysis of blood smear is an important diagnostic test used in the diagnosis of an array of diseases. The method of automatic diagnosis of microscopic blood smear images by Identifying and separating them into different categories of cells that are highlighted in the project.

Identification of red blood cells (RBCs) is carried out by the system using different techniques of image processing operations like pre-processing, operations for morphology, labeling, and extraction of features to calculate the shape and size of the RBCs. Morphological properties can provide information regarding the shape of the cell. [4]

5. "Implementation of Blood Cell Counting Algorithm using Digital Image Processing Techniques Digital Image Processing Techniques" (2020) by Vilas B. Inchar Siadem. Praveen L. S., Arion

Blood is a type of connective tissue that contains various cellular components such as red blood cells (RBCs), white blood cells (WBCs), and platelets. If the number of blood cells falls below the standard range, it can lead to various health issues. Therefore, proper blood cell counting techniques are of great importance in the pathology department. Several methods, such as morphological operators, texture-based classification methods, and Circular Hough Transformation (CHT), are used to count RBCs. [5]

6. "Image Classification of Abnormal Red Blood Cells Using Decision Tree Algorithm" 2020 by Virginia Mari E. Batitis, Merwin Jhan G. Caballes, Abigail A. Ciudad, Miccaela D. Diaz, Russel D. Flores, Engr. Roselito.

The system detected and classified a total of ten abnormal red blood cells. Images used in the system came from hospitals' past patients. In addition, a camera is used to capture the slides. The image was then inserted into the program. The system processed and classified the image. In effect, the results show the name of the abnormal red blood cells detected in the image within the system including the soft copy of the list. [6]

7. "Classification of blood cells into white blood cells and red blood cells from blood smear images using machine learning techniques" by K.T. Navya; Keerthana Prasad; Brij Mohan Kumar Singh 2020.

The methods being used are very expensive, time-consuming, require manual intervention, and are not accessible in many medical centers. Therefore there is a necessity for an automatic, inexpensive, and robust technique to detect various types of diseases from any PBS images. The automatic classification model improves the hematological procedures, quickens the diagnosis process, and enhances the accuracy of the evaluation process. Thus in this paper, we used a semi-automatic method to segment and classify blood cells into White Blood cells (WBC) and Red Blood cells (RBC). [7]

8. Blood Cell Classification: Convolutional Neural Network (CNN) and Vision Transformer (ViT) under Medical Microscope by Mohamad Abou Ali, Fadi Dornaika, Ignacio Arganda-Carreras 2023.

In hospitals, hematologists prepare peripheral blood smears (PBSs) and read them under a medical microscope to detect abnormalities in blood counts such as leukemia. However, this task is time-consuming and prone to human error. This study investigates the transfer learning process of Google ViT and ImageNet CNNs to automate the reading of PBSs. The study used two online PBS datasets, PBC and BCCD,

and transferred them into balanced datasets to investigate the influence of data amount and noise immunity on both neural networks. The PBC results show that Google ViT is an excellent DL neural solution for data scarcity. The BCCD results show that Google ViT is superior to ImageNet CNNs in dealing with unclean, noisy image data because it can extract both global and local features and use residual connections, despite the additional time and computational overhead.[8]

9. "Deep Learning for Detecting of Infected Red Blood Cells in Thin Blood Smear Image" by Wongsathon Nakswan; Picha Suwannahitarn; Chakrit Watcharopas; Pakaket Wattuya 2020.

This process is inefficient and the diagnosis depends on the experience and well knowledgeable person needed for the examination. Deep Learning algorithms have been applied to blood smears for diagnosis before. However, practical performance has not been sufficient so far. They propose a new and highly robust machine learning model based on a convolutional neural network (CNN) which automatically classifies and predicts infected cells in thin blood smears on standard microscope slides. A ten-fold cross-validation layer of the convolutional neural network on 27,558 single-cell images is used to understand the parameter of the cell.[9]

10. "An Overview of Medical Images Classification based on CNN," by T. A. Sadoon and M. H. R. Ali 2020.

Medical image classification is essential to the early detection of disease. Motivated by the above, there is a need to work on programs that help doctors to detect the tumor or any disease in less time and more accurately. The researchers have been providing much research in this field such as Artificial Neural Network (ANN), Support Vector Machine (SVM), and Convolutional Neural Network (CNN). But recently the use of CNN in the classification of medical images has become very popular. ConvNet or (CNN) is a type of deep learning model that contains many layers that are used for feature extraction and image classification.[10]

III. ANALYSIS OF PROBLEM

The manual counting of red blood cells (RBCs) in microscopic images is a labor-intensive and error-prone process, often resulting in inaccuracies and inefficiencies in medical diagnostics and research. Existing automated methods for RBC counting using image processing techniques face challenges such as variations in image quality, overlapping cells, noise, computational complexity, and lack of robustness across different samples. These limitations hinder the scalability, accuracy, and reliability of RBC analysis, impacting the effectiveness of hematological studies and clinical diagnoses.

Therefore, there is an urgent need to develop an advanced

automated method for counting RBCs from microscopic images, addressing the following key challenges: Accuracy, Efficiency, Robustness, Automation, Validation and Benchmarking, and Clinical Relevance.[3][2]

By addressing these challenges, the proposed research aims to contribute to the development of an efficient, accurate, and robust automated method for RBC counting, facilitating improved

hematological analyses, disease diagnosis, and medical research outcomes.

IV. METHODOLOGY

The process involves capturing an image, followed by several image processing operations such as segmentation, median filtering, edge detection, erosion, and counting of cells. The counting of Red Blood Cells will be carried out through edge detection using the Hough transformation. During the development of this project, we utilized a supervised learning algorithm known as SVM in Machine Learning.

1. Image Acquisition

To collect high-quality digital images of blood smears, we need to use a suitable microscope equipped with a digital camera. It's important to ensure that we gather diverse samples to account for variations in staining, magnification, and lighting conditions. After collecting the images, we need to apply preprocessing techniques to enhance image quality and reduce noise. This includes normalization, contrast adjustment, and noise reduction, which will standardize the images for further analysis.[1]

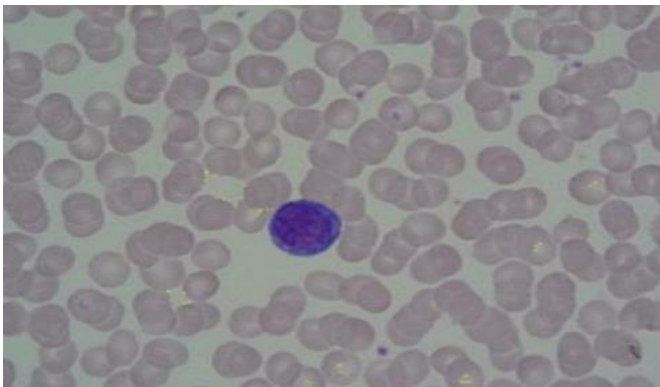


Fig1. Capture image

2. Image Preprocessing & Enhancement

Collect diverse high-resolution digital images of blood smears using a microscope equipped with a digital camera, accounting for variations in staining, magnification, and lighting conditions.

3. Image Segmentation

During the segmentation phase, the objective is to extract individual object components that contain important information. In medical image segmentation, morphology plays a crucial role, which can be achieved through morphological operations. To

separate red blood cells (RBCs) from the background, adaptive thresholding techniques can be used. It is recommended to experiment with various thresholding methods to determine the most effective approach for different types of images.

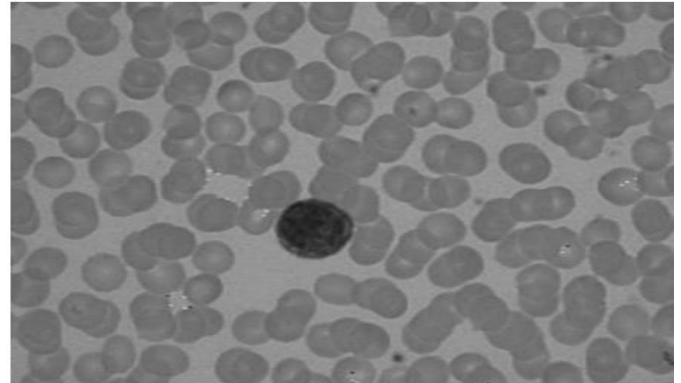


Fig 2. Segmented image

Morphological Operations: Morphological operations involve the use of a structuring element on an input image, resulting in an output image of identical size. During a morphological operation, the value of each pixel in the output image is determined by comparing the corresponding pixel in the input image with its neighboring pixels.



Fig3. Morphological operation

4. Feature Extraction:

During feature extraction, we gather important information from images. This involves extracting features such as color, geometry, texture, and statistical features. The ultimate aim of feature extraction is to obtain a set of image descriptors. By analyzing the relationship between these descriptors, we can identify the patterns that determine the images.

- Geometric Features – It includes perimeter, radius, area, rectangularity, compactness, convexity, concavity, symmetry, elongation, eccentricity, solidity etc.

$$1) \text{ Roundness: } \frac{4 \times \pi \times \text{area}}{\text{convex perimeter}^2}$$

$$2) \text{ Solidity: } \frac{\text{Area}}{\text{Convex area}}$$

$$3) \text{ Elongation: } 1 - \frac{\text{major axis}}{\text{minor axis}}$$

$$4) \text{ Eccentricity: } \frac{\sqrt{\text{major axis}^2 - \text{minor axis}^2}}{\text{major axis}}$$

$$5) \text{ Compactness: } \frac{4 \times \pi \times \text{area}}{\text{perimeter}^2}$$

$$6) \text{ Rectangularity: } \frac{\text{area}}{\text{major axis} \times \text{minor axis}}$$

$$7) \text{ Convexity: } \frac{\text{Perimeter convex}}{\text{Perimeter}}$$

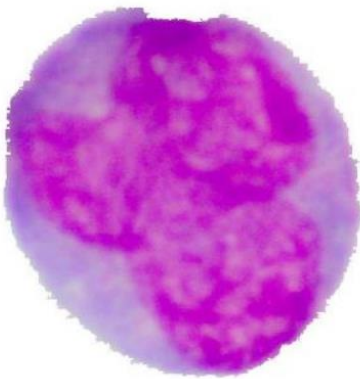


Fig4. Feature extraction

5. Image Classification:

An SVM (Support Vector Machine) is a binary linear classification model that explicitly constructs a decision boundary to minimize generalization error. It is a highly effective and adaptable Machine Learning model that can perform both linear and nonlinear classification regression, and even identify

$$b = \frac{\sum_{s \in S} (y_s - \sum_{m \in S} \lambda_m y_m x_m \cdot x_s)}{N_s}$$

$$h_{w,b}(x) = g(w^T x + b)$$

$$g(z) = 1 \text{ if } z \geq 0, -1 \text{ otherwise}$$

where, hw, b is our desired return of a function

Model:

Input $\rightarrow$ features(radius, area,convexity,rectangularity..etc.)

Output $\rightarrow$ (Acute Myeloid Leukemia or Acute Lymphocytic Leukemia)

outliers. Classification is done using SVM. The SVM classifier is formally defined for the separation of the hyperplane. [7]

Image Recognition: After training the classification model, it becomes possible to predict if an image displays any symptoms of leukemia, such as Acute Lymphocytic Leukemia (ALL) or Acute Myelogenous Leukemia (AML). The final recognition of ALL from peripheral blood smear images is achieved through an optimized support vector machine (SVM). The SVM model can predict the disease and, if it is present, it will attempt to identify it by drawing a circle around the affected area in the image.

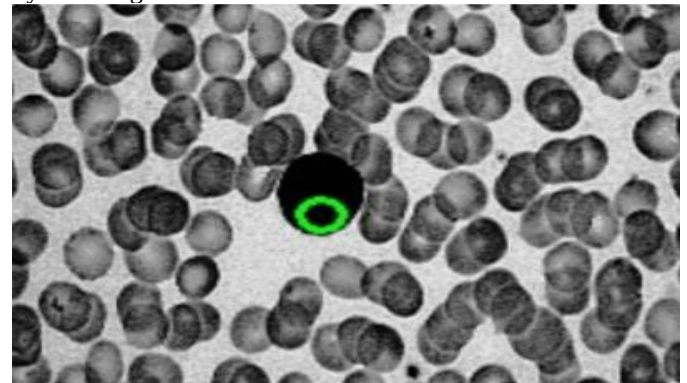


Fig 5. Image Recognition

Integration and User Interface: Develop a user-friendly software application that integrates the algorithm with medical imaging systems and offers an intuitive interface for healthcare professionals to input data and interpret results.

Object Detection and Counting: We utilized Support Vector Machines (SVM) machine learning algorithms to predict diseases. The SVM model identifies disease and attempts to create a circular shape around it in the image, thereby recognizing it. We also developed an algorithm to accurately count the detected Red Blood Cells (RBCs). To minimize counting errors and handle overlapping cells, we implemented various strategies.

Validation and Performance Evaluation: We utilized Support Vector Machines (SVM) machine learning algorithms to predict diseases. The SVM model identifies disease and attempts to create a circular shape around it in the image, thereby recognizing it. We evaluated the system's performance using metrics such as sensitivity, specificity, precision, and recall. Additionally, we

compared the automated counts with manually obtained counts to assess the accuracy of the automated counting algorithm.

V. CONCLUSION AND FUTURE SCOPE

This study presents a precise and accurate model for the detection and classification of immature leukocytes, which can be used for computer-aided diagnosis of leukemia. The identified morphological features provide valuable insights for future research, paving the way for the integration of such systems into clinical diagnosis methods. Our findings have a potential impact on early diagnosis, treatment decisions, and prognosis, particularly in resource-constrained settings. As the field continues to evolve, our study lays the groundwork for further innovations in leukemia detection and classification.

To overcome the limitations of the manual diagnosis methodology for leukemia, we used an image processing technique along with an SVM model for the automatic detection and classification of immature leukocytes. The model was capable of detecting immature leukocytes with 92% accuracy, which is comparable to the current state of the art. Furthermore, the model achieved a precision of above 65% for each of the four immature leukocyte classes during multiclass classification, despite the imbalance in numbers across classes. This is an improvement over previous research.[4][7]

Future research can build upon the findings of this study by computing and prioritizing the significance of more morphological characteristics for the categorization of leukocytes. Enhancing the differentiation between comparable cell types, like myeloblasts and promyelocytes, is another direction for potential future research.

VI. REFERENCES

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