Detection of Acute Lymphoblastic Leukemia using Novel Bone Marrow Image Segmentation

Dr. N. Satheesh Kumar[1], Medarametla Jarshini[2], Bijjam Pujitha[3], Pandi Prem Sindhu[4], Dasari Kejiya[5]

[12345]*Department of Electronics and Communication Engineering,*
PBR Visvodaya Institute of Technology & Science, Kavali (Autonomous),
SPSR Nellore (Dt.), Andhra Pradesh – 524201, India

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Abstract - This paper presents an automated system for detecting Acute Lymphoblastic Leukemia (ALL) using bone marrow image segmentation and deep learning techniques. The system applies preprocessing methods such as grayscale conversion, contrast enhancement, and noise removal to improve image quality. Segmentation is performed using thresholding and morphological operations to extract relevant regions. A fine-tuned Xception model is used for classification into multiple leukemia cell types. Performance is evaluated using accuracy, precision, recall, and F1-score. The proposed approach improves diagnostic efficiency and reduces manual effort, making it suitable for clinical applications.

Key Words: Leukemia Detection, Image Processing, Segmentation, Deep Learning, Xception Model, Medical Imaging.

1.INTRODUCTION

Acute Lymphoblastic Leukemia (ALL) is a rapidly progressing blood cancer that affects white blood cells and requires early detection for effective treatment. Accurate diagnosis plays a vital role in improving patient survival rates and enabling timely medical intervention. Traditional diagnostic methods rely on manual examination of bone marrow or blood smear images by hematologists, which is time-consuming, labor-intensive, and prone to human error, especially in complex cases.

With the advancement of artificial intelligence and medical imaging, automated diagnostic systems have gained importance in healthcare. Image processing techniques such as grayscale conversion, contrast enhancement, and noise removal are used to improve image quality and extract meaningful features. Segmentation methods, including thresholding and morphological operations, help in isolating leukemic cells from the background, making the analysis more precise and reliable.

Deep learning models, particularly Convolutional Neural Networks (CNNs), have demonstrated high performance in image classification tasks. The Xception model, based on depthwise separable convolutions, provides improved accuracy with lower computational complexity. The proposed system integrates preprocessing, segmentation, and deep learning techniques to develop an efficient automated leukemia detection system, aiming to reduce manual effort and support medical professionals in accurate and timely diagnosis.

2. LITERATURE SURVEY

Several studies have focused on automated leukemia detection using image processing and machine learning techniques. Early methods used pattern recognition approaches such as cellular automata and neural networks, which were limited in handling complex medical images. Image enhancement and segmentation techniques were later introduced to improve image quality and isolate white blood cells. [1][2]

Further developments included preprocessing methods like noise removal, contrast enhancement, and threshold-based segmentation. Feature extraction techniques such as wavelet transformation and GLCM were used to obtain texture features. Machine learning models like SVM, KNN, and ANFIS were applied for classification but depended on handcrafted features and showed moderate accuracy. [3][4][5]

Recent approaches use deep learning models, especially CNNs, which automatically learn features from images. Advanced architectures like Xception provide higher accuracy and better performance. These methods overcome the limitations of traditional techniques and are widely used for efficient and reliable leukemia detection. [6]

3. EXISTING METHODOLOGY

The existing method for detecting Acute Lymphoblastic Leukemia (ALL) primarily relies on manual examination of bone marrow or blood smear images by skilled hematologists. In this approach, experts analyze the morphology, size, and structure of white blood cells under a microscope to identify abnormalities. Although this method is widely used, it is time-consuming and depends heavily on the experience and expertise of the medical professional.

To improve efficiency, computer-aided diagnostic systems have been introduced using image processing and machine learning techniques. These systems include preprocessing steps such as grayscale conversion, contrast enhancement, and noise removal, followed by segmentation using thresholding and morphological operations. Feature extraction methods like GLCM and wavelet transformation are used, and classification is performed using models such as SVM, KNN, or ANFIS. While these methods reduce manual effort, they still face challenges in handling complex image variations.

Limitations: Performance depends heavily on handcrafted features, which may not capture complex patterns in medical images. Lower accuracy and robustness when dealing with large datasets and variations in image quality.

4. PROPOSED METHODOLOGY

The proposed method presents an automated system for detecting Acute Lymphoblastic Leukemia (ALL) using a combination of image processing and deep learning techniques. Initially, bone marrow images are collected and subjected to preprocessing steps such as grayscale conversion, contrast enhancement, and noise removal using median filtering. These steps improve image quality and eliminate unwanted distortions. Segmentation is then performed using adaptive thresholding and morphological operations like dilation and erosion to accurately isolate the leukemic cells from the background, resulting in a clear representation of the region of interest.

After segmentation, the processed images are used for classification using a deep learning model. A pre-trained Xception model is fine-tuned to classify the images into different leukemia cell types. The model automatically extracts relevant features from the images, eliminating the need for manual feature extraction. The dataset is divided into training and validation sets, and performance is evaluated using metrics such as accuracy, precision, recall, and F1-score. This integrated approach improves classification accuracy, reduces manual effort, and provides a reliable system for early leukemia detection.

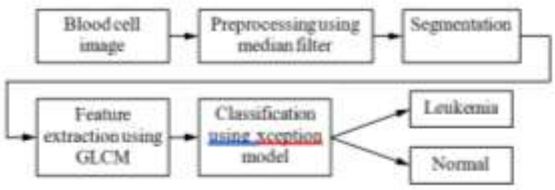
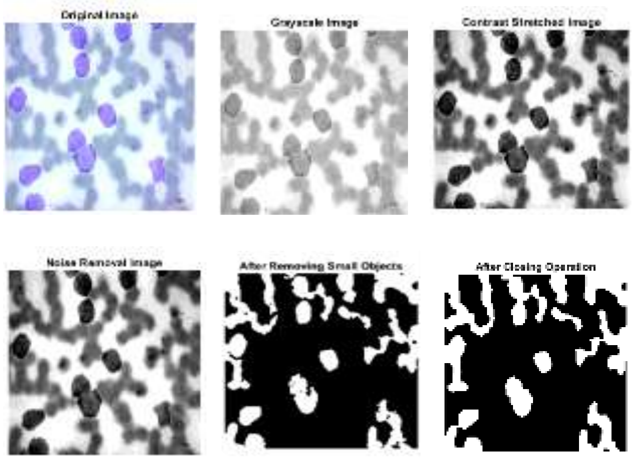


Figure 1: Block Diagram of Proposed System

The proposed method begins with input blood cell images, which are first preprocessed through resizing, grayscale conversion, contrast enhancement, and noise removal to improve image quality. The enhanced images then undergo segmentation, where the region of interest (blast cell) is isolated using thresholding and morphological operations. After segmentation, feature extraction is performed to capture important characteristics of the cells. These features are then passed to the Xception deep learning model for accurate classification of normal and abnormal cells. Additionally, ANFIS is integrated to enhance decision-making and improve prediction reliability. Finally, the system produces the classification output, indicating whether the cell is cancerous or non-cancerous, ensuring fast and accurate leukemia detection.

5. IMPLEMENTATION AND RESULTS



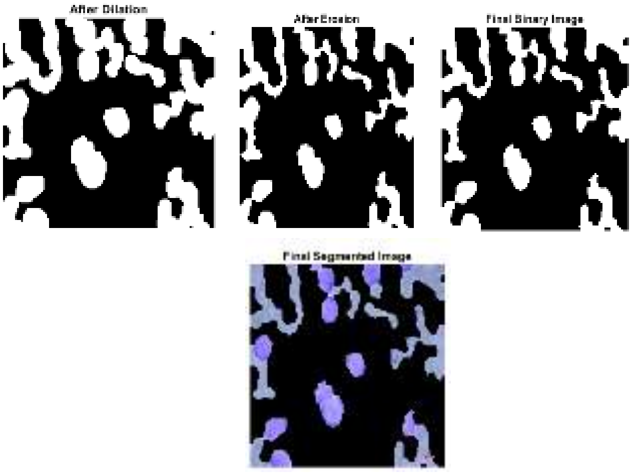


Figure 2: Band cell Image Processing Results

The process begins with the original blood cell image, which is resized for uniform processing and then converted into a grayscale image to reduce complexity. Next, contrast enhancement is applied to improve visibility, followed by noise removal to eliminate unwanted disturbances. The image is then thresholded to separate the foreground (cell) from the background. Morphological operations are performed to refine the cell structure and remove small artifacts. Edge detection helps in identifying clear boundaries of the cell. Finally, segmentation isolates the blast cell region, producing a clean output that is used for accurate classification.

Figure 3: Training Progress Image

The training progress image shows how the model learns over time by plotting accuracy and loss across epochs. As training progresses, accuracy gradually increases while loss decreases, indicating improved performance. The graph demonstrates that the model is effectively learning and converging toward optimal results.

6. DISCUSSION

The results demonstrate that the proposed system achieves high accuracy in classifying leukemia cells using deep learning techniques. The combination of image preprocessing, segmentation, and the Xception model improves overall performance. The integration of ANFIS further enhances decision-making and reliability. Overall, the system proves to be efficient, accurate, and suitable for real-time medical diagnosis.

7. CONCLUSION

The proposed leukemia detection system provides an efficient and accurate approach for identifying blood cell abnormalities using image processing and deep learning techniques. It utilizes preprocessing methods like contrast enhancement and segmentation to improve image clarity, followed by classification using the Xception model. This improves the overall performance and ensures better accuracy compared to traditional manual diagnosis methods.

Furthermore, the integration of ANFIS enhances the decision-making capability by providing more reliable and consistent results. It is cost-effective and can be easily implemented in healthcare systems. Overall, the project contributes to automated medical diagnosis and can be extended in the future to detect other diseases efficiently.

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