Chapter 7

Improving Leukemia Detection Accuracy:

Contrast Limited Adaptive Histogram Equalization–Enhanced Image Preprocessing Combined ResNet101 and Haralick Feature Extraction

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ABSTRACT

The study explores ResNet-101 CNNs and Haralick texture analysis for leukemia cell detection. Leveraging CLAHE preprocessing and hybrid feature extraction, it enhances model accuracy by capturing subtle details. The approach combines deep learning with nuanced texture analysis, improving classification. Evaluation on original and segmented datasets demonstrates 99.62% and 98.08% accuracy, respectively, showcasing the method's efficacy. This advancement in medical image analysis promises improved diagnostics and treatment for leukemia.

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1. INTRODUCTION

Medical imaging holds a pivotal position in the diagnosis and management of various diseases, among which leukemia, a cancer affecting the blood and bone marrow, stands prominently (Abhishek et al., 2022). The accurate detection of leukemia from medical images is indispensable for timely intervention and treatment planning. As emerging technologies reshape the landscape of medical imaging, novel approaches emerge to enhance the precision of leukemia detection. To extract meaningful insights from imaging results, an understanding of human blood composition becomes crucial in the context of medical imaging (Talaat and Gamel, 2024). By unraveling the intricate interplay of blood components in disease processes, healthcare professionals gain a more profound understanding, enabling them to interpret medical images with greater accuracy. This integrated knowledge of human blood composition, combined with advanced imaging techniques, contributes to more precise disease diagnosis and management, ultimately improving patient outcomes.

Leukemia, originating in the bone marrow and leading to an excessive production of abnormal blood cells, poses significant challenges in its diagnosis and treatment. These immature cells, termed blasts or leukemia cells, manifest in symptoms such as bleeding, bruising, bone pain, fatigue, fever, and an increased susceptibility to infections due to the shortage of normal blood cells. The diagnostic process typically involves blood tests or a bone marrow biopsy, and despite extensive research, the exact causes of leukemia remain elusive, believed to involve a complex interplay of environmental and genetic factors (Talaat and Gamel, 2024). Early detection of malignant white blood cells at a low cost remains a substantial challenge, as flow cytometry equipment, a potential diagnostic aid, is not universally accessible, and current diagnostic lab procedures can be time-consuming. Leukemia, being the most prevalent form of blood cancer affecting individuals of all ages, particularly children, is characterized by the rapid growth and immature development of blood cells, adversely impacting red blood cells, bone marrow, and the immune system.

Traditional cancer diagnosis methods, primarily reliant on manual techniques, pose significant challenges due to their time-consuming nature, laborious processes, and the necessity for highly skilled operators to ensure accuracy. These traditional approaches involve visually inspecting microscopic images of blood samples to identify abnormal cells indicative of leukemia. However, the manual nature of this process introduces the risk of human error and inconsistency, leading to potential diagnostic inaccuracies (Boldú et al., 2021).

To address the limitations of manual diagnosis, there is a growing demand for automated systems that can streamline the diagnostic process, reduce turnaround times, and improve diagnostic accuracy. This need has spurred significant advancements in technology, particularly in the fields of image processing, machine learning, and deep learning (El Achi and Khoury, 2020).

Human blood, an indispensable fluid for survival, plays a vital role in oxygen transport to distinct parts of the body (Abhishek et al., 2022). Comprising plasma, platelets, Red Blood Cells (RBCs), and White Blood Cells (WBCs), blood components collaborate to maintain the essential functions of the human body. Plasma, constituting approximately 55% of total blood volume, facilitates the transportation of various cellular components, including blood cells, lymph, and intramuscular fluid. The intricate classification of leukemia according to growth patterns and cell lineage of origin is depicted in Figure 1. This comprehensive understanding of human blood composition, integrated with advancements in medical imaging, serves as a cornerstone in the quest for more accurate disease diagnosis and management, thereby improving overall patient outcomes (Eckardt et al., 2020).