Chapter 57
Detection and Classification of Leukocytes in Blood Smear Images: State of the Art and Challenges

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ABSTRACT

Manual analysis of microscopic blood smears by highly expert pathologists is labor-intensive, time-consuming, and is subject to inter-observer variations. Recent innovations in image processing and computer vision techniques have improvised digital pathology in terms of objectivity and reproducibility. Traditional computer vision-based methods of recognition of white blood cell (WBC) from a pathological blood smear image includes the process of detection, segmentation, and classification. This paper presents a review of state-of-the-art detection, segmentation, and classification techniques for white blood cell analysis. The goal of this work is to present an introduction to the field, provide enough information about the analysis methods developed so far, and to be an appropriate reference for the researchers looking forward in this field. The methods under review are classified into intensity and feature based. The crucial steps involved in these techniques, mathematical foresights, performance evaluation techniques, issues, and future directions are discussed.

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1. INTRODUCTION

At present, computer aids have been rigorously emerging in digital pathology field, including segmentation, identification and classification of cell/ nuclei. The microscopic blood image analysis finds it usefulness in differential and complete count of White blood cells (WBCs) and components, hemiparasite and hematological diseases diagnosis, content-based image retrieval systems, medical decision support systems, computer aided diagnosis, treatment follow up, guided surgery, and many more.

When a doctor suspects any disease, firstly suggests a complete blood test or differential blood test based on the severity of symptoms. Complete blood test results in the total count of platelets, erythrocytes (red blood cells) and leukocytes (white blood cells). A Differential blood test classifies and counts the five major types of leukocytes. Two broad classifications of WBCs are Agranulocytes and Granulocytes. Agranulocytes are Lymphocytes and Monocytes. Granulocytes are Neutrophils, Basophils and Eosinophils. The WBCs is a vital component of the human blood system that develops and maintains an immune system in the body. The WBCs count determines the human health status, which is usually in the range of 4,500-10,000 for a normal adult. The count of WBCs is very significant for diagnosis of diseases and its detection should be done at the earliest. Leukopenia is a result of low WBCs count and may detect the presence of Human Immune Virus (HIV), autoimmune disorders, liver and spleen diseases, and radio therapy to name a few. Similarly, Leukocytosis is a result of high WBCs count that may predict the presence of anemia, allergies, pregnancy, tissue damages, asthma, blood cancer, and many more. On the other hand, Leukemia (unusual and abnormal production of WBCs beyond expectation) is a deadly disease which can develop in any organ of body, directly affecting blood cells, leading to cancers. Continuous monitoring of the WBCs count must be done through blood tests to analyze the effect of treatment on patients, which stresses the need for development of techniques for fast and real time automatic detection and recognition techniques.

Numerous Image Processing (IP) and Computer Vision (CV) based software solutions are available for automatic WBCs image analysis. Segmentation often follows representation of isolated objects for faster analysis in later processing steps. The classification is the process of labeling the segmented objects according to some well-defined features, after successful segmentation of WBCs from background and other articrafts. The WBCs is classified into its 5 constituent types: Neutrophils, Basophils, Eosinophils, Lymphocytes and Monocytes. To perform classification, unique distinguishable set of features that represent individual WBCs types should be extracted from images. Two broad categories of WBCs are granulocytes and a-granulocytes. Cells are characterized by the presence of number of nuclei lobes, granules and shape of nucleus. Neutrophils have 3-5 blobbed nucleuses with small granules. Eosinophils have red granules with blobbed nucleus. The granules are larger in eosinophils than neutrophils. Basophils are featured by a lobed nucleus filled with large black and blue granules that cover entire nucleus. Lymphocytes are round shaped and Monocytes with horse-shoe shaped nucleus respectively. The nucleus to cytoplasm ratio is high in monocytes compared to lymphocytes (De et al., 2007). Hence WBCs are featured by variance in color, intensities, saturation levels, shape and texture. Features like average area, bounding box, and centroid are used to identify and segment the cells.

Over the last few decades, numerous articles are published in histopathology. The state of the artwork reveals that researchers have focused on cell/nuclei detection, segmentation, and classification on their own private datasets. But, to perform numerical analogy of studies, it is vital to build medically tested benchmark datasets, which encompass samples of large number of healthy and disease affected patients, annotated by expert pathologists. Few such benchmark datasets to list are UCSB Bio-Segmentation