Chapter 9

Selected Shape and Texture Features for Automatic Detection of Acute Lymphoblastic Leukemia

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ABSTRACT

Acute Lymphoblastic Leukemia is a cancer of blood caused due to increase in number of immature lymphocyte cells. Detection is done manually by skilled pathologists which is time consuming and depends on the skills of the pathologist. The authors propose a methodology for discrimination of a normal lymphocyte cell from a malignant one by processing the blood sample image. Automatic detection process will reduce the diagnosis time and not be limited by human interpretation. The lymphocyte images are classified based on two types of extracted features: shape and texture. To identify prominent shape features, Correlation based Feature Selection is applied. Principal Component Analysis is applied on the texture features to reduce their dimensionality. Support Vector Machine is used for classification. It is observed that 16 shape features are able to give a classification accuracy of 92.3% and that changes in the geometrical properties of the nucleus emerge as significant features contributing towards detecting a malignant lymphocyte.

INTRODUCTION

Cancer is the world’s leading cause of death. It is marked by uncontrolled cell division contributing to the abnormal growth of tissues. This affects the cellular function of the human body, ultimately leading to death (Dollinger, 2008). In 2012, there were an estimated 8.2 million deaths (comprising 57% males and 43% females) due to cancer (Cancer Research UK). According to American Cancer Society, in 2014, 

DOI: 10.4018/978-1-5225-2829-6.ch009
there were an estimated 1,665,540 new cancer cases and 585,720 cancer deaths in the US alone. This includes 523,800 estimated new cases (accounting for 3.1% of all new cancer cases) and 240,900 estimated deaths (4.1% of all cancer deaths) due to leukemia. SEER Cancer Statistics (National Cancer Institute) say that the rates for new leukemia cases have been rising on an average of 0.2% each year over the last ten years. Leukemia can affect people of all ages though it is more common amongst children, young adults and people over 60 years of age. In leukemia, abnormal white blood cells called blasts are produced in excessive numbers which travel to other body parts. The blasts are unable to work properly and weaken the immune system (Haworth, Hepplestone, Jones, Campbell & Evans, 1981). Classification of leukemia can be divided into two groups:

- Acute or Chronic leukemia (depends on time of progression)
- Lymphoblastic or Myeloid leukemia (subject to type of white blood cells affected)

Acute leukemia progresses rapidly and requires immediate treatment. It is characterized by a surplus of abnormal cells which are not yet fully developed and do not function properly. In chronic leukemia, the number of blast cells increases slowly. Blast cells exist, but the growth of a greater number of developed cells is also present. Acute Lymphoblastic Leukemia (ALL) and Chronic Lymphoblastic Leukemia (CLL) are caused due to abnormalities in lymphocyte cells. Acute Myelogenous Leukemia (AML) and Chronic Myelogenous Leukemia (CML) are caused due to defects in myeloid cells. ALL is more common in children and accounts for about 80% of childhood leukemia (Sawyers, Denny & Witte, 1991). ALL progresses very fast and affects mostly the cells that are not yet fully developed. Early and fast diagnosis of the disease is essential, especially in the case of children, for effective recovery of the patient. The symptoms of leukemia are similar to other disorders like fever, anemia, weakness, bone pain, joint pain and for this reason, the diagnosis is very difficult.

Diagnostic procedure of ALL includes microscopic inspection of peripheral blood or bone marrow samples. Complete blood count or bone marrow biopsies are commonly used blood tests used for leukemia diagnosis (Haworth, Hepplestone, Jones, Campbell & Evans, 1981). Advanced techniques like cytogenetic testing, immunophenotyping and molecular probing are present. However, morphological evaluation of the stained blood sample is widely prevalent as an economical initial screening of ALL (Angulo & Flandrin, 2003). However, if the morphological features are partially present, it may be a difficult task for an expert hematologist too to discriminate between a healthy and malignant lymphocyte. The analysis thus becomes subjective to the skills and experience of the pathologist. Moreover, in countries with a large population and a large number of suspected cancer cases, depending on the visual diagnostic skills of a human is cumbersome and time-consuming. An automated diagnostic procedure can help in providing a fast and efficient detection of leukemia. Digital processing is also beneficial in remote analysis where only the digital image of the blood sample needs to be sent for consultation with a doctor in a different geographical location. The basic difference between normal and blast cells is based on the changes in shape, size and changes in the chromatin pattern in the nucleus (Ries, Melbert, Krapcho, Mariotto, Miller, Feuer, Clegg, Horner, Howlader, Eisner, Reichman & Edwards, 1975-2014). The normal lymphocytes are regular in shape and smaller in size as compared to blast cells. Example images of blood containing a lymphocyte and a blast cell are shown in Figures 1 and 2.

In this chapter, the authors have tried to incorporate machine vision and machine learning to develop an automated system for detection of Acute Lymphoblastic Leukemia. This chapter is an extension of a previous work where the authors worked with the Local Binary Pattern of the lymphocyte images to