Review on Technical Aspects of Image Acquisition, Analysis and Retrieval for Leukaemia Cells

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INTRODUCTION

The exponential growth of intense research and development in various fields (particularly computer vision) has resulted in rapid technological advancements in the field of medicine. Many recent advances in image analysis([1-7]) supervised learning techniques([3],[4]) and free availability of algorithms and programs in the world wide web encourages and makes it even more desirable to develop an image acquisition and retrieval systems for leukaemia cells.

Medical images like X-rays, Computed Tomography (CT) scan, Magnetic Resonance Imaging (MRI), microscopic images are being produced at an ever increasing quantity due to the technological advancements in the medical field. Clinically, these medical images have gained potential importance in the decision making, diagnosis and prognosis. The clinical advantages of these medical images are posing a huge challenge for storage and retrieval of those medical images or the multimedia data.

Hospital Ampang gets a fair amount of leukaemia cases every year (According to the statistics taken by National cancer registry(NCR)[8] and discussion with the hematologist, in Peninsular Malaysia it is estimated that there are more than 1000 new cases of leukaemia every year. At the Hospital Ampang about 80 new cases of acute myeloid leukaemia (AML), 40 new cases of acute lymphoid leukaemia (ALL) and 25 new cases of chronic myeloid leukaemia (CML) are being diagnosed every year. At the University Malaya Medical Centre about 30 new cases in children

under 12 years of age and approximately 60 new cases in adults are diagnosed every year).

Due to the lack of proper storage and retrieval system for the leukaemia blood images, the hematologist has to carry out the microscopic analysis each and every time during prognosis. So, there is a need for storing, representing and providing efficient retrieval methods for retrieving the relevant leukaemia image and other patient details.

This paper reviews the technical aspects of acquisition, processing, analysis, storage and retrieval of leukaemia images that can aid to develop patient management system and diagnosis support system (considering certain types of leukaemia as the domain) for the Hematology Department of Hospital Ampang, Malaysia.

LITERATURE REVIEW

General Overview

In the field of Computer Vision, Content-based Image Retrieval for medicine has gained significant importance due to the potent and steady rise of medical multimedia data. According to Müller (2004) [9], in the medical field, especially in the departments of radiology and cardiology, digital images are being produced at a very large quantity. Radiology department of University Hospital of Geneva produced more than 12,000 images a day in 2002 and cardiology is the second largest producer. So, content-based or image-based access to the medical image can aid clinical decision-making and management of clinical data.

The hematology department of Hospital Ampang lacks the digital format of patient management system and leukaemia images storage and retrieval system. These systems can be developed by gaining basic knowledge in the medical domain (leukaemia) and by reviewing the technical

aspects of acquisition, analysis and retrieval. So, a basic overview about leukaemia is presented to provide some knowledge of the domain and then a detailed review on technical aspects.

Overview of Leukaemia

Leukaemia is a group of serious blood diseases affecting the blood-cells and most commonly white blood cells or 'leukocytes'. The normal white blood-cells are concerned with fighting infection. In the leukaemic patients there is an overproduction of abnormal (or immature) white cells which are unable to fight infection, [10].

Leukaemia can broadly be classified into four categories- Myeloid and lymphoid leukaemia series each with acute and chronic forms. Acute leukaemia is a rapidly progressing disease that affects mostly cells that are unformed or primitive (not yet fully developed or differentiated cells). Chronic leukaemia progresses slowly and permits the growth of greater numbers of developed cells.

Image acquisition, analysis and retrieval – A technical Survey

There have been researches to automate the analysis and recognition of medical images (particularly blood cell images - [2], [5]) together with image processing techniques, computer graphics techniques and advanced Artificial intelligence techniques. There are various novel and innovative techniques for automating the classification and recognition of the diseased white blood cells into their own leukaemic categories in order to construct leukaemia diagnostic aid tools and systems to help the doctors, medical specialists and researchers. The implementation and application of these techniques is the interest of this review paper.

Various Computer vision techniques and Medical Image Retrieval Systems relevant to this research include:

 Pre-processing and Image Processing techniques;

Image Acquisition and Standardisation

Input Normalization and Segmentation

Feature Selection and Extraction

 Artificial/Computational Intelligence techniques;

Supervised Learning

Neural Network

 Search Techniques

State Space Search

Heuristic search

Pre-processing and Image Processing techniques

Image acquisition is the initial step for any image processing and analysis. Acquiring images with high level of clarity, accuracy, size and brightness is a very challenging issue as it also a very trivial step for any further works. Until the early 1990's, the image acquisition in microscopy was done with the analog camera. These days, those analog cameras are replaced with digital cameras that can be mounted on the optical mouth of the microscope.

The individual white blood cells acquired the cell images by [4] using Leica ATC 2000 microscope and Bischke CCD camera. Standardization was maintained by having MGG stain as the standard staining protocol, magnification at 400 times and brightness to 6 in a scale of 1-10.

A segmentation technique was implemented by [6] to segment the dense leukocyte clusters. Microscopic images were acquired using Sony 9100 color CCD camera attached to a microscope. The magnification was standardized to 50 times and the stain used for the smear was May-Grünwald-Giemsa (MGG). However, the resolution details of the image were not provided.

Normalization and segmentation definitions were taken from [11]. Normalization is the process of applying linear transformation for all the different variables having distinct values to have similar values. Segmentation is a technique to split the regions of interest from the background by identifying their regions or edges within an image.

A review of various ideas, methods and their results discussed by the researchers are illustrated here:

A novel hybrid merging method was proposed by [12] for a traditional watershed algorithm for the cell nuclei segmentation and also phase identification, for an effective automatic analytic system dealing with large volume of imaging from a time-lapse optical microscopy.

Gaussian Probability Density Function was employed by [13] to the color (RGB) pixels of the trained data to segment the regions of interest and Bayesian supervision learning algorithm for its classification. Color space mapping and contour curvature has been applied for the cell image segmentation here.

Two classes of algorithm were used by [2] for the cell segmentation for the bone marrow. Data is prepared by declustering as the blood cells in the bone marrow are not discreet. Region growing and active contouring are the two algorithms that have been employed in the case of segmentation in a bone marrow.

The basic understanding of feature selection and extraction techniques was referred from [11] and [14].