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Dendritic Cell Recognition in Computer Aided System for Cancer Immunotherapy

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Abstract

Immunotherapy is an entirely advanced class of cancer treatment which has been highly active and exciting field in clinical therapeutics. In numerous procedures, cancer immunotherapy demands a laborious practice to recognise and count Dendritic Cells (DCs) in the vaccine preparation. Conventionally, the laser-based technology that provides a rapid analysis such as Flow Cytometry can affect the DCs viability as the staining procedure is involved. Another highly promising method which is Phase Contrast Microscopy (PCM) involves experienced pathologists to visually examine the respective microscopy images. In facts, PCM confronts complex issues regarding to imaging artifacts which can deteriorate the recognition process. As the DCs counting is crucial in cancer treatment procedures, this paper proposes a pioneering system called CasDC which implement an image processing algorithm to recognise and count DCs with a label-free method. The aim of developing this system is to establish a reliable and time saving-tool as a second reader in the clinical practice. In the meantime, the treatment procedure can be administered and therefore, improve the patient's survival rate. Our proposed system has an enormous potential towards helping Cancer Research Institute in which the system offers rapid and high throughput cancer immunotherapy vaccine preparation and automated live cell investigation.

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Keywords: Dendritic cells; Cancer immunotherapy; Image processing; Pattern recognition; Phase contrast microsocopy; Computer vision

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1. Introduction

Most of the established therapies such as surgery, chemotherapy and radiation are widely used to treat cancer patients. Surgery [1] is often considered as the first therapy option to remove the tumour. Nevertheless, there is a tendency of removing only part of the tumour. Following that, a combination of surgery with radiation or chemotherapy is typically used in patient to kill the cancer cells [1]. However, both radiation and chemotherapy can introduce non-favourable outcomes towards the patient, such as serious bleeding, lack of energy and experience depression. Recently, immunotherapy has been widely explored and introduced as an advanced approach to boost the immune system to fight cancer [1–3]. Immunotherapy employs and activates the Dendritic Cells (DCs) to identify the cancer tissue in the normal body cells. DCs have a key role for activation of T- and B-cell immunity due to their superior ability to function as antigen-presenting cells (APCs) [2,4]. They can be generated in vitro from Peripheral Blood Mononuclear Cells (PBMCs) [4]. In DCs vaccine cell preparation, the identification of DCs from PBMCs sample is crucial before the cell can be stimulated.

Conventional Flow Cytometry provides an effective recognition of labelled DCs using fluorescent dyes that may cause phototoxic damage to the DCs. Recent advances in cellular imaging have facilitated investigation of the unstained living cell using Phase Contrast Microscopy (PCM). Even though PCM is a label-free imaging modality, the identification purpose becomes challenging as the image is constituted with a variation of imaging artifacts such as halo region, low contrast and overlapping DCs [5]. Such procedure is laborious, time-consuming and very dependent on the expert's skill to identify and count DCs which can introduce human errors.

Previous researches introduce Computer Aided Diagnosis (CAD) [6,7] which is an active area of research and development in medical imaging and diagnostics. A system called ImPatho [8], has been developed for disease identification. This system helps to provide a proper clinical guideline towards any disease, such as RBC disorder. Although most clinical applications are developed for cancer detection, it can be expected that the DCs counting in immunotherapy will be an important component of cancer treatment. In this paper, the challenges and complex issues faced by Cancer Research Institute are addressed. Our proposed system, CasDC (Computer Aided System for Dendritic Cells), is developed to identify and count DCs in the sample. The main goal of CasDC system is to assist pathologists and other clinical practitioners in initiating the vaccine preparation for cancer immunotherapy treatment. The details of the proposed framework are described in Section 2, system overview, followed by the results and discussion in Section 3. Finally, the conclusion is summarized in Section 4.

2. System Overview

In this section, the CasDC workflow is presented in Fig. 1. It consists of two stages; a) Image acquisition and b) image processing in CasDC. The system is developed, trained and tested using Matlab R2015a platform and runs on 2.5GHz i3-312M processor. The image dataset is provided by Cancer Research Malaysia (CRM) which composed of debris (black dots), T-cells (round shape) and DCs (red circle) as shown in Fig. 2. The digital images of PBMCs are captured by Nikon DS-Fi2 camera which attached to Olympus CK40 microscope with 100x and 200x magnification. All the images have variations of light-variant environments.

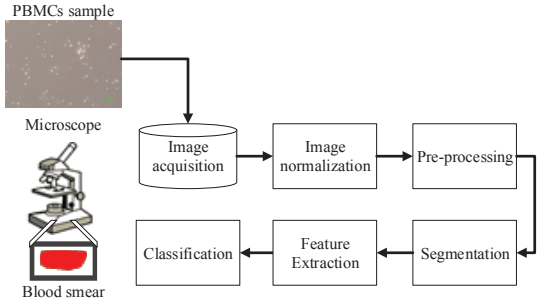

Fig. 1. CasDC workflow

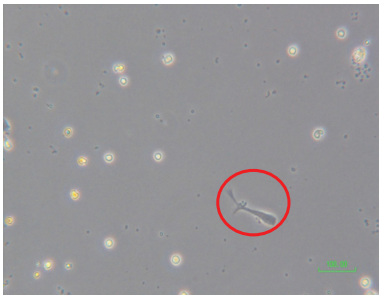

Fig. 2 PCM image sample