Automated Eosinophil Cell Count Test of a Blood Smear as a Health Marker

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Abstract:
The eosinophil cells are one of the many variable constituents that flow in the plasma of the blood. By using various techniques available in digital image processing these cells can be identified and counted. Through this paper, a method is proposed that will identify eosinophil cells in a much cheaper and less time consuming manner using the Hue Saturation Intensity (HSI) color model, and the 8-Connected component labelling algorithm to count the number of identified eosinophil cells in a given blood smear image.

Keywords: Binary image, 8-Connected component labelling, Eosinophil cell, Hue saturation intensity color model

I. INTRODUCTION
Blood is a specialized connective tissue that flows through the entire body. The blood contains suspended erythrocytes (red blood cells), leukocytes (white blood cells) and platelets. These circulating blood cells are counted by hematologists to determine the health of a person. This paper focuses on counting eosinophil cells, which are a type of leucocytes. The number of eosinophil cells that can be found in the body circulating is about 1% to 4%. They have a bilobed nucleus. The cells average diameter is 10 to 12µm. Eosin present in the cell absorbs the stain used to prepare the blood smear. The cytoplasm of the cell is very granular. Hematology is the study of elements in the blood. Cell enumerating using a hemocytometer is widely seen in many pathological laboratories. Even though automated cell counters have made their way into hematology laboratories, they are expensive. The manual method is more prone to human errors and is a time consuming activity. Manual counting suffers from inherent inconsistency and unreliability [5]. An automated differential counting system that helps in saving time is highly desirable [6]. The count of eosinophil cells rises in allergic reactions, asthma and when there is a parasitic invasion in the body. A fall of eosinophil count is seen when a person is suffering from any increase in the adrenal functions or rise in cortisol levels in the body. Changes in one or more of the characteristics mentioned above, may produce hematological disease or manifestations. The hematology laboratory deals with routine determination of total number of cells in circulation and differential count of leucocytes based on the study of the stained blood smear. Computer-assisted microscopy system[7] for automatic counting of cells have been developed for the past few years. The system proposed in this paper is a tool to count eosinophil cells faster and with lesser errors in cell counts. This system is cheaper to use and can be easily installed on the computer.

II. SYSTEM PROPOSED
The system to automate the eosinophil counting process requires a series of steps. Figure 1, is a flowchart of the proposed system. Wherein the input to the system will be an image of the blood smear and the output of the system will be the count of the eosinophils present in the image.

![Flowchart of the automated system proposed to count eosinophil cells](Figure1.png)

A. Collecting images
The images used here are got by placing a camera on the microscopes eye piece. The blood smear prepared by the pathologist is placed under a 100x resolution lens of the microscope. The collected images are stored on the computer’s hard drive, in the Joint Photographic Experts Group (JPEG) format.

B. Red Green Blue(RGB) to Hue Saturation Intensity (HSI) color model conversion
Converting RGB values in the original image to another set of
color coordinates is useful for processing image contents. Humans describe a color object in terms of its hue, saturation, and intensity. The color space HSI decouples the intensity component from hue and saturation in a color image. The HSI model is useful in projects that work on color descriptions. However it should be noted that by writing the values back to the host program, can cause a confusing display. Hence here single color channel is displayed at a time.

C. **Converting Hue image to grayscale**
The image representing the hue got from RGB to HSI conversion is then converted into grayscale image. This helps to make identification of the eosinophil cells easier.

D. **Eosinophil cell identification**
The grayscale image of the hue values of the inputted image is then used to identify the eosinophil cells. The pixel values (red, green and blue) used to identify the eosinophil cell in the grayscale image have a value zero.

E. **Converting the image to binary image**
In this step the pixels that display the identified eosinophil cell are set to black while the background is set to white. This makes it easier to represent the binary image in a matrix having the region of interest set to 1 and the background set to 0.

F. **Counting eosinophil cells**
The important task in hand is being able to identify and label the various connected components of each region. The 8-Connected component labelling algorithm is used here to assigns a unique region number to each blob in the image and the local neighborhood labelling algorithm labels the blobs. If each blob in the image corresponds to a single object identified, this 8-connected component labelling algorithm will be able to count the objects that are present in the binary image. Sometimes some other cells are shown on the binary image as possible identified eosinophil cells which need to be discarded. Through experimentation it was known that the number of pixels that represent an eosinophil cell is approximately 800 pixels. And hence any other region having area of pixels less than that needs to be discarded.

Input images were collected from a pathological lab by placing a camera on the microscopes eyepiece. About twenty images were captured from the blood smears prepared by the pathologists of twenty different patients. The original image in the RGB color model was then converted to the HSI color model. From here the work was focused on the image representing the hue values. This image representing the hue values was converted into grayscale to make the identification of the eosinophils efficient. The red, green and blue pixel value of the eosinophil cell in the grayscale image was found to be zero. The image is then converted into a binary image to make to apply the 8-connected component labelling algorithm to count and label the eosinophil cells. The accuracy of the proposed system calculated was 85%.

**A. Results of testing the system**
The total number of images tested upon was 20. The table below gives the count of the classes in which the tested images fall into. Which gives an accuracy of 85%. The results of the testing done on different images are shown below in table 1.

<table>
<thead>
<tr>
<th>Result class</th>
<th>Count of images</th>
</tr>
</thead>
<tbody>
<tr>
<td>True positive</td>
<td>16</td>
</tr>
<tr>
<td>False negative</td>
<td>2</td>
</tr>
<tr>
<td>False positive</td>
<td>1</td>
</tr>
<tr>
<td>True negative</td>
<td>1</td>
</tr>
</tbody>
</table>

**B. Scope of the Project**
1. This automated system is very simple to install, hence can be used in remote areas, with little necessary computer education given to the pathologist’s.
2. It provides a faster method to count cells in contrast to time consuming manual method of cell enumeration.
3. Also the cost of this system is lesser than an automated blood analyzer.
4. In future this system can be modified to identify other white blood cell types, detecting bacteria colonies and analysis of other human body fluids.

**V. REFERENCES**
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