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IMAGE-BASED QUANTIFICATION OF RED AND WHITE BLOOD CELLS FOR MEDICAL DIAGNOSIS

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1. PROBLEM STATEMENT

Develop a robust Image Processing algorithm to count the number of White Blood Cells (WBC) in a given blood sample.

2. PROJECT REQUIREMENTS

1. Count the number of WBCs in a given image (sample of blood).
2. Count the number of WBCs within a specified bounding box.

3. USE CASE

White blood cells in our body fight infections. But if a person's white blood cell count is too high, it's not necessarily a good thing. It often tells that there is a serious underlying health problem (like inflammation, Leukemia etc). The only way to find out if the levels of WBC are high or low is to get a complete blood picture by a doctor which atleast takes 24 hours.

Therefore getting the number of WBC in a given blood sample immediately would be helpful in getting a broad outline of the patient's condition. So, we planned to design and implement a method to detect the WBC in the microscopic image of a given sample and determine their count using image processing techniques.

4. PROCEDURE

The first step is to detect the blood cells in the given image. So, to detect the cells, the process followed is color quantization followed by thresholding and contour drawing.

4.1. Gaussian filtering

The idea of Gaussian smoothing is to use this 2-D distribution as a 'point-spread' function, and this is achieved by convolution. Since the image is stored as a collection of discrete pixels we need to produce a discrete approximation to the Gaussian function before we can perform the convolution. It is a widely used effect in graphics software, typically to reduce image noise and reduce detail.

4.2. Color Quantization

Color Quantization is the process of reducing number of colors in an image. Here we have used k-means clustering for color quantization. K means algorithm classifies a given data set through a certain number of clusters (k). The idea behind this algorithm is, it defines k centroids, one for each cluster. These centroids are placed far away from each other. Then each point in the data set is associated to the nearest centroid and a groupage is done. After this, k new centroids are calculated and are named as barycentres of the generated. This loop is repeated till the centroids don't move anymore. At each iteration, centroids change their location and at some point, they stop moving. This produces a separation of the objects into k groups which is called as k means clustering.

4.3. Thresholding

Thresholding: This refers to the point transformation in which the output gray level is either 0 or L depending on whether the input gray level is respectively below or above some constant T. It is used to distinguish between foreground and background. Thresholding can also be useful if the original image is some binary image corrupted with (non-binary) noise.

Adaptive Gaussian Thresholding: In thresholding, a global value is used as threshold value. But it may not be good in all the conditions where image has different lighting conditions in different areas. In that case, we go for adaptive thresholding. In this, the algorithm threshold for a small regions of the image is calculated. So we get different thresholds for different regions of the same image and it gives us better results for images with varying illumination. In adaptive Gaussian thresholding the threshold value is the weighted sum of neighborhood values where weights are a gaussian window.

5. RESULTS

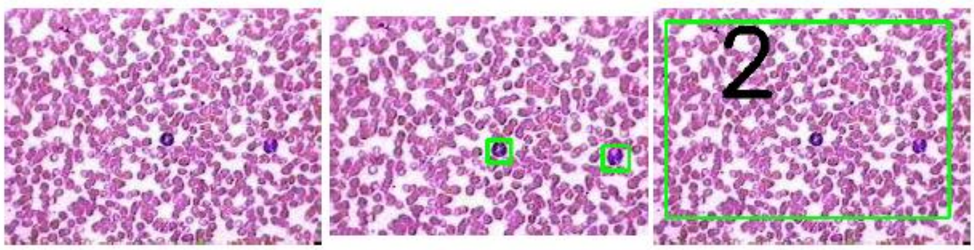
The number of WBCs are detected from all of the given images. The steps followed are described below. Similarly, RBC count can also be determined which is shown in the subsequent sub-section.

5.1. Counting the number of WBCs

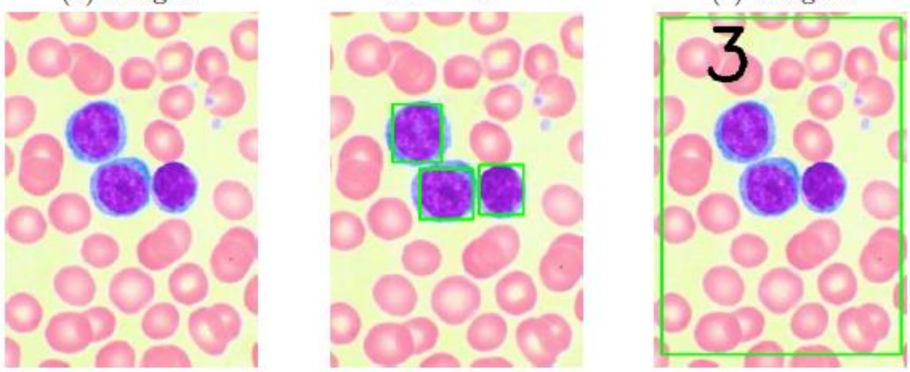
The count of WBC in a given image can be viewed below. For the given inputs the number of WBC are counted using hysteresis thresholding and contours are drawn around each detected WBC.

Hysteresis Thresholding: When we know that pixel values above the threshold 'U' would most likely be a part of an edge. We also know that values below a lower threshold 'L' would have very extremely less probability of being a part of an edge. Then we choose the threshold lower limit to be 'L' and upper limit to be 'U'. This is known as hysteresis thresholding. This method has consistently been able to defeat absolute thresholding. Hence using this, both strong and weak edges are preserved and noise and unnecessary edges are removed. So by using similar concept we would obtain minimum and maximum width and height of a cell to draw contours.

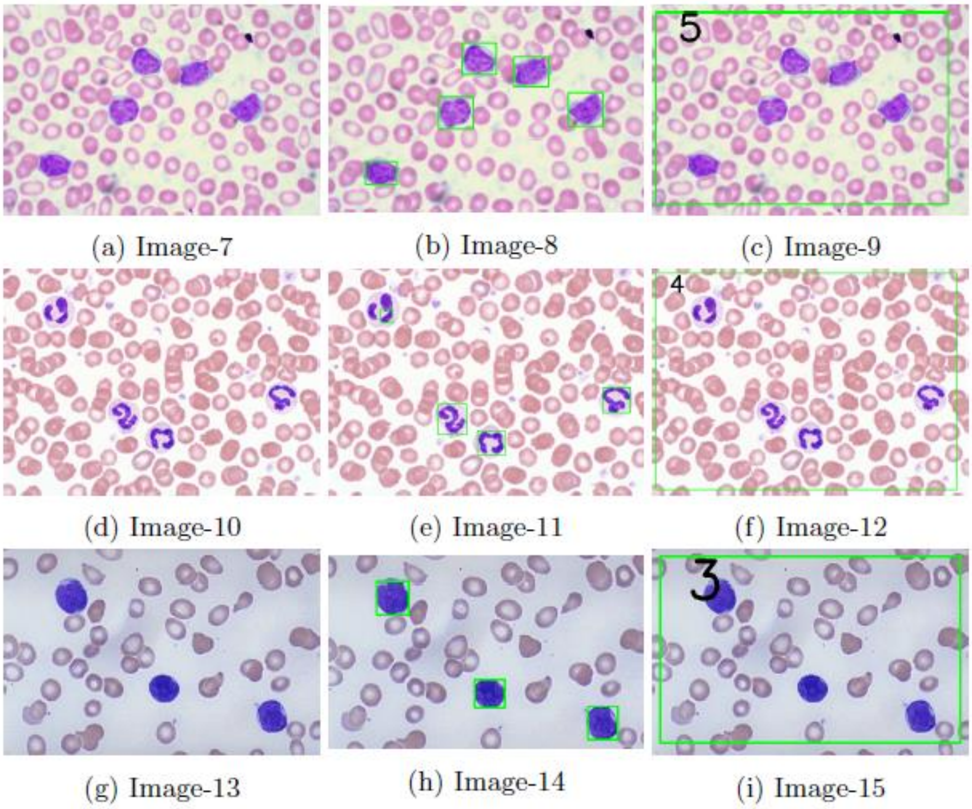
Contour Drawing: After setting up the range of values using the motivation from hysteresis thresholding, we will be left with those edges that are of the segmented image using k-means clustering and the unnecessary ones are removed. Now we need to draw rectangles around these objects of the image which are nothing but WBC. Then counting these rectangles would give the count of number of WBC. So after getting the count, we converted it to a string and kept it on the image. These results can be seen below. Input image is on the extreme left and the output images are the next two adjacent images. The first one among the output image shows the WBCs and the second one shows the WBC count shown on the top left corner.



(a) Image-1 (b) Image-2 (c) Image-3



(d) Image-4 (e) Image-5 (f) Image-6



(a) Image-7 (b) Image-8 (c) Image-9

(d) Image-10 (e) Image-11 (f) Image-12

(g) Image-13 (h) Image-14 (i) Image-15

Figure 2: Number of WBC in each of the Images

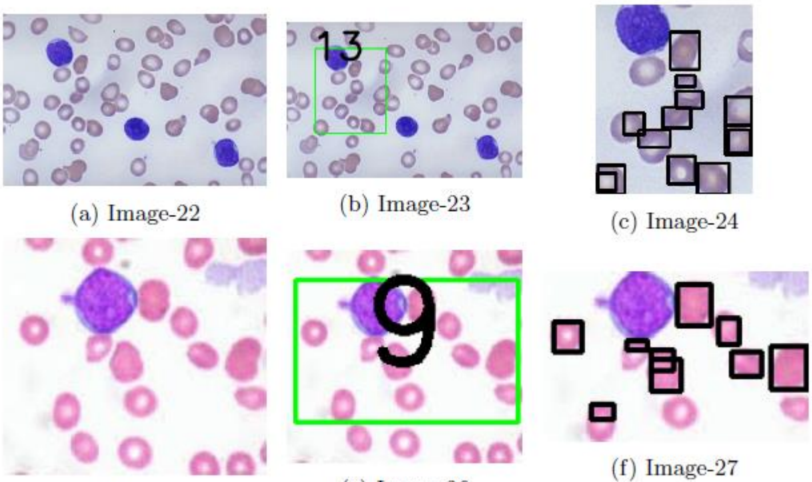
5.2. Count the Number of WBC in the window specified by user:

The user will be shown an image. Then using the mouse, user needs to select the region of interest. Once the region of interest is selected then the user needs to press ’c’ then it is finalized and the number of WBC in that region are displayed. If the user wants to un-select the selection then ’r’ needs to be clicked.

So, when we select the region of interest using mouse interactively, that area is shown by drawing a contour around it and then counting the number of WBC. Then that number is put on top of the given image along with the region of interest. Some samples are shown below.

5.3. RBC count

Similarly, RBC count can also be determined. Illustrations can be seen below.



(a) Image-22 (b) Image-23 (c) Image-24
(d) Image-25 (e) Image-26 (f) Image-27

Figure 5: RBC count for each of the given images

6. OBSERVATIONS AND CONCLUSIONS

Generally in hospitals, when a person comes for a blood test, and when he gives the sample, most of the results will be available within a few hours or a day after testing. That's a pretty long time. So, our program gives the results immediately after the sample is given as input. This decreases the patient wait time and in case of any disease, immediate action can be taken and can be proceeded further without any wastage of time.

So, when an image (blood sample) is given as an input to the program, we will be allowed to select a region of interest. Then, the WBC cells will be detected and the count of WBC can be seen in the top left part of the output image. Similarly, the same follows for RBC as well.

This program can be modified for other components of blood as well that can be distinguished on colour or size of the components.

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