The Study of Image Processing Method for AIDS PA Test

H J Zhang¹ and Q G Wang²
¹,² College of Electricity and Electronic Engineering
Harbin University of Science and Technology, Harbin, China

E-mail: zhjzxp@sohu.com, qg0wang@yahoo.com.cn

Abstract. At present, the main test technique of AIDS is PA in China. Because the judgment of PA test image is still depending on operator, the error ratio is high. To resolve this problem, we present a new technique of image processing, which first process many samples and get the data including coordinate of center and the range of kinds images; then we can segment the image with the data; at last, the result is exported after data was judged. This technique is simple and veracious; and it also turns out to be suitable for the processing and analyzing of other infectious diseases’ PA test image.

1. Introduction
AIDS (Acquired Immune Deficiency Syndrome) is a kind of infection. If someone is infected with HIV (Human Immunodeficiency Virus), there is no medicine which can effectively cure this infection. The rate of death is almost 100 percent. Up to August 2005, there are 132545 people who have been infected this virus in China, 30158 of them were sick and 7643 of them died.

PA (Gelatin Particle Agglutination) is widely use in China. This technique is easily manipulated and has high accurate rate without using any special apparatus. But the analysis of image is still laggard. The result largely relies on the operator’s experiences and the rate of error is high. So it is ineffective to discover people who have been infected and it is disadvantageous to prevent the spread of HIV.

This paper implies the method of PA test image analysis and processing. The emphasis is that how to realize automatic analysis by image filter, background eliminating and coordinate setting.

2. The principle of PA test
PA test is a method to test serum antibody of HIV quickly. It can test single specimen and it doesn’t need special equipment, so it is suitable for clinics with few specimens.

The theory of PA test is shown as figure 1. The particle which is affected by the antigen is becoming hypersensitive to antibody. So, when there is antibody of HIV, the antigen-antibody reaction will happen and the macroscopic effect will appear[1].

The judgment of PA test is shown as figure 2:
(1) Negative (-): The gelatin particle sedimentates in the bottom of vessel with smooth edge or the gelatin particle become compact circle.
(2) Dubious (+/-): The gelatin particle sedimentates in the bottom of vessel with little central compact circle and smooth edge.
(3) Positive (+/++): The gelatin particle becomes clear broad circle with radius more than half of vessel’s radius and crude edge.
(4) Strong positive (++/+++): The gelatin particle format homogeneous membrane in the bottom of vessel.

(5) False: If the sample reacts with sensitization particle and non-sensitization particle, and both generate agglutination phenomenon then the test is false. So a new test should be done.

**Figure 1.** PA test theory.

**Figure 2.** The judgment of PA test.

3. The processing of PA test image

3.1. Image Preprocessing

Because the noise of the original image generally comes from the influence of artificial operation and environment, so this noise is mainly random noise. In order to get optimal image segmentation in
further processing, an obvious wave trough is needed in the histogram[2]. But in the original image the area of background is much bigger than the object and we can not get a clear wave trough thus it adds the difficulty of segmentation. So in the image preprocessing we remove part of background by using the method of the removal background of mean.

The specific process: First get the mean ($\bar{\mu}$) of all image elements, then segment the image with threshold $\bar{\mu}$; finally we get the image with little background and total object.

$$\eta = \frac{1}{n} \sum_{j=1}^{n} n_j$$

3.2. Image Processing with Coordinate Setting
All acquisition test images with PA have homothetic coordinate center; and the judgment of PA test is given before, it shown us that the main factor is the radius ratio; and the radius of vessel is constant. For all of this we provide a new image processing technique with coordinate setting.

The theory of coordinate setting: There are four kinds of result of PA test image that need to be judged, the false is just deserted. So we can class images by coordinate. The standard coordinates of each class is set by analyzing many images above each condition. After image preprocessing, the image is cropped with reference data. And then we segment the image and statistic parameter, and finally output result.

The procedure of PA test image processing is shown as flowchart 3 and the specific declaration of the chief steps is given as follows.

**Figure 3. the Flowchart.**

Note: the part around with pane is the processing of getting reference data.

3.2.1. reference data fixing. The range of the standard coordinates and the central coordinate are validated by analyzing many images.

The central coordinate (a,b) fixing:

$$a = \frac{1}{n} \sum_{j=1}^{n} x_j, \quad b = \frac{1}{n} \sum_{j=1}^{n} y_j$$

Note: n: the number of all images.

$A_j$: the area of image j. $A_j = \sum_{(x,y)\in r}$
Note: $x_j, y_j$ : the center of mass. r: the range of primary image

\[
x_j = \frac{1}{A_j} \sum_{(x,y) \in r} x, y_j = \frac{1}{A_j} \sum_{(x,y) \in r} y
\]

The range of kinds images fixing:

$A_1$, strong negative (+++):  
\[
A_1 = \left\{ (x,y) \mid \frac{27}{30} < \sqrt{(x^2 + y^2)} < \frac{29}{30} R \right\}
\]

$A_2$, negative (++):  
\[
A_2 = \left\{ (x,y) \mid \frac{21}{30} < \sqrt{(x^2 + y^2)} < \frac{23}{30} R \right\}
\]

$A_3$, positive (-):  
\[
A_3 = \left\{ (x,y) \mid \frac{15}{30} < \sqrt{(x^2 + y^2)} < \frac{18}{30} R \right\}
\]

$A_4$, negative (-):  
\[
A_4 = \left\{ (x,y) \mid \frac{14}{30} < \sqrt{(x^2 + y^2)} < \frac{16}{30} R \right\}
\]

Note: R: radius of vessel; (x,y):the coordinate of image element after coordinate changing.

3.2.2. threshold fixing. $A_1, A_2, A_3$: the threshold is half of area of the range. It is calculated according to (1)

\[
B_i = \sum_{(x,y) \in A_i} f_i = \frac{1}{2} B_i \quad (i=1,2,3)
\]

$A_4$: because the existence of dubious situation, we give two thresholds. It is calculated according to (2)

\[
B_4 = \sum_{(x,y) \in A_4} f_1 = \frac{3}{5} B_4, \quad f_2 = \frac{2}{5} B_4
\]

When the data is between them, we will output requirement for a new test.

Note: $B_i$: the area of $A_i$; $f_i$: the threshold

3.2.3. the design of processing flow.

1. read the image.
2. converse coordinate to (3)

\[
x = x_1 - a, \quad y = y_1 - b
\]

Note: $I(x_1, y_1)$ is the primary coordinate; $I(x, y)$ is the new coordinate; (a,b) is the central coordinate.

3) crop the image with range $A_1$ and get the data ($t_1$) of area, then judgment: if $t_1 \geq f_1$, output (+++); if $t_1 < f_1$ go to next step.

4) crop the image with range $A_2$ and get the data ($t_2$) of area, then judgment: if $t_2 \geq f_2$, output (++); if $t_2 < f_2$ go to next step.

5) crop the image with range $A_3$ and get the data ($t_3$) of area, then judgment: if $t_3 \geq f_3$, output (+); if $t_3 < f_3$ go to next step.

6) crop the image with range $A_4$ and get the data ($t_4$) of area, then judgment: if $t_4 \geq f_4$, output (+); if $t_4 < f_4$ go to next step.

4. The result of test and the analysis

The primary image which is input computer by using scanning instrument which is shown as figure4. In the image the small object is the result of contrast test and it give the auxiliary parameter. The big one is the object. We simulate the technique and theory with MATLAB. First we get the central coordinate (180, 57) and the radius of vessel (R=44); then do image prepreprocessing, and we get the image shown as figure5; finally we do image processing as shown in flow. After analyzing data we get the result and output (+).
5. Conclusion
This paper provides a new image processing technique. The main methods used in the processing are as follows: image filtering, background removing, and coordinate setting. The data that we get is correct, so the technique is effective. It helps to discover HIV infected person early and hold infection. The experiment indicate this technique is suitable for the processing and analyzing of other infectious diseases’ PA test image.

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