AUTOMATIC DETERMINATION OF HUMAN BLOOD TYPES USING IMAGE PROCESSING TECHNIQUES

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Abstract: This paper presents a methodology to automatically determine human blood types using image processing techniques. As a reference, in the experimental analysis it was used the plate method, being registered the results with a digital camera. The obtained images were analyzed and processed with a custom application developed with IMAQ Vision from National Instruments, allowing the automatic blood type classification of the sample under test. The implementation in health units of a system based in the presented approach will enable between others, the risk reduction of fatal transfusions associated with wrong human blood type interpretation.

1 INTRODUCTION

Currently, the determination of human blood type is carried out manually using the plate or cards methods (Datasheet of Diamed, 2008) (Rod, Tate and Trent, 2005) (Diamed (a) 2009) (Diamed (b), 2009). The first one (plate) is based on the immunological reactions that occur when there are mixed certain serums (anti-A, anti-B, anti-AB and anti-D) in the sample of blood in test (Figure 1) (Datasheet of Diamed, 2008) (Rod, Tate and Trent, 2005). Then, the interpretation of the agglutination reactions allow to determine the antigens present in the red globules of the sample of blood, allowing the classification of the blood type (Rod, Tate and Trent, 2005). The second one (cards, Card-ID for the ABO/Rh system) uses the Diamed system (Rod, Tate and Trent, 2005) (Diamed (a), 2009) (Diamed (b), 2009). This approach requires mixing the sample of blood with the content of the microtubes available in the Card-ID, followed by a centrifugation and the results interpretation (Datasheet of Diamed-ID, 2008). It is an accurate approach, although it has the disadvantage of requiring 30 minutes, which is excessive especially in emergency situations. Thus, considering that the plate method allows getting results immediately and efficiently (in the worse case it takes 2 minutes), it was used as a reference in this work.

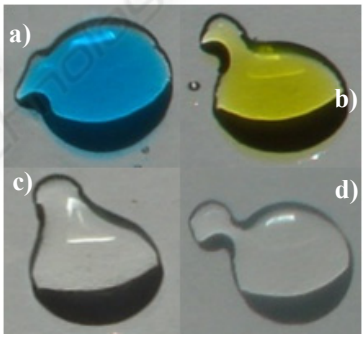

Figure 1: Serums in plate [a) – anti-A, b) –anti-B, c) – anti-AB, d) – anti-D].

As referred previously, the results obtained by the plate or cards methods require human interpretation, being susceptible to failures. In this scope, it is known that the risk of a fatal reaction due to administration of a wrong sanguineous type is 1 in each 600,000-800,000 transfusions (Alexander, 2007) (Muller and Girard November 1983). An automatic methodology of human blood type determination will contribute to minimize or even eliminate these statistical results. During the bibliographical research it was possible to identify two approaches based on optical sensors (Alexander, 2007) (Nano2Life, 2009). However, the innovative method presented in this work, using image processing techniques, is characterized by an inferior cost of implementation and production, lower

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complexity and greater portability, being an added value commercial solution.

2 APPLIED IMAGE ANALYSIS TECHNIQUE VALIDATION

The methodology applied in this work was validated, as referred previously, using the plate method as a reference. The obtained reactions were registered in real size, using a CCD camera (Kristian and Blouke, October 1982) (Sony Cyber-shot DSC-S600) with 6.0 megapixels of resolution.
Subsequently, the analysis of the obtained images was performed using an image processing tool (IMAQ Vision from National Instruments (IMAQ, 2004)).

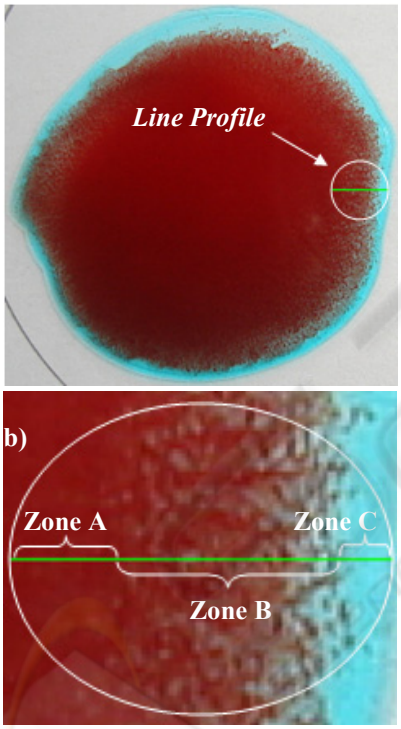

Figure 2: [a) - Application of the function Line Profile in the image edges section, b) - Magnification of the image a) pointing out the different zones of intensity (A, B and C)].

Observing Figure 2 and Figure 3 it is verified that in zone A a reduced level of pixels intensity oscillation occurs, corresponding to a low level agglutination zone. On the contrary, in zone B significant oscillations are verified, corresponding to a region where the agglutination is highly notorious. Finally, in zone C t is observed a significant descending of

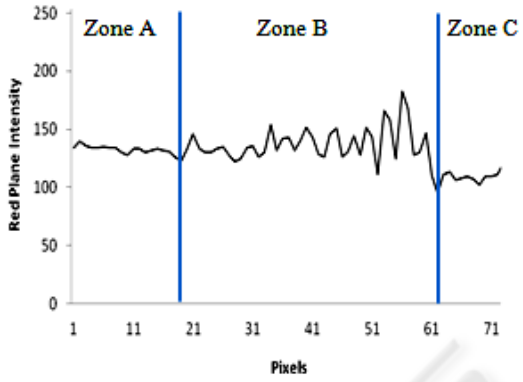

Figure 3: Results of the application of the function Line Profile in Figure 2.

the pixels intensity amplitude, corresponding to the used serum location.

Figure 4 illustrates the Line Profile function application (Klinger, 2003) (Dougherty, 2009) (Bernd, 2009) (Burger and Burge, 2009) (Tinku and Ajoy, 2005) to an image without agglutination. Figure 5 presents the results.

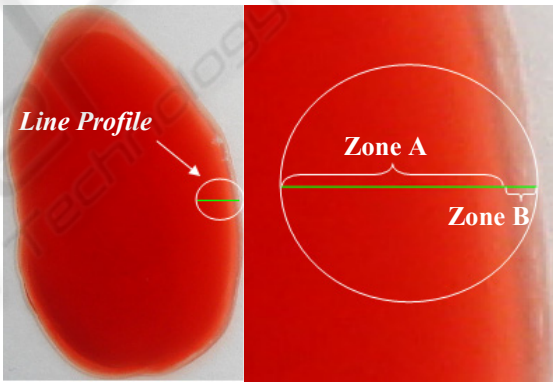

Figure 4: [a) - Application of the function Line Profile in the edges section, b) - Magnification of the image a) pointing out the different zones of intensity (A and B)].

Observing Figure 5 it is verified that in zone A oscillations practically do not occur. This fact results from the non occurrence of agglutination in Figure 4, leading to an almost constant level of pixels intensity. In zone B, corresponding to the zone of the used serum, a descending of the pixels intensity is verified.

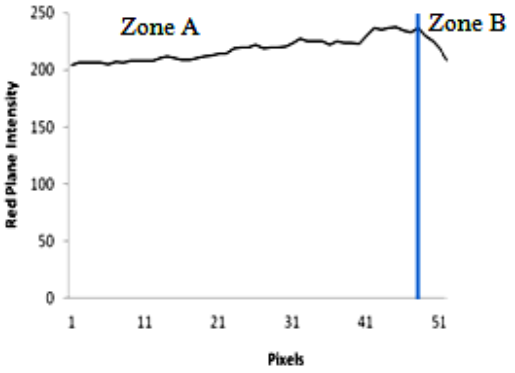

Figure 5: Results of the application of the function Line Profile in Figure 4.

Thus, through the obtained results, it is possible to conclude that when agglutination occurs, there are observed zones in the image analysis that present high levels of oscillation of pixels intensity. These preliminary results allow to validate the methodology used, enabling a secure determination of the agglutination occurrence or not. Then, using statistical analysis it is possible to quantify mathematically the obtained.

Figure 6 presents a schematic which resumes the different image processing steps applied (Figure 2 and Figure 4) as well as their transformations, in the initial images.

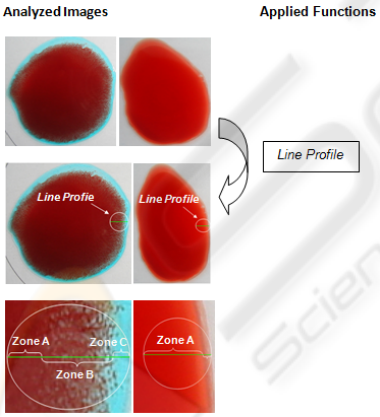

Figure 6: Application of the function Line Profile (Figure 2 and Figure 4).

3 ALGORITHM OF AUTOMATIC DETERMINATION OF OCCURRENCE OF AGGLUTINATION

To automatically determine the sanguineous type of a sample of blood, there were applied sequentially, the following image processing techniques available in the IMAQ Vision tool:

1) Function Extract Color Planes, specifically in the option Extract RGB Green (Klinger, 2003) (Dougherty, 2009) (Bernd, 2009) (Burger and Burge, 2009) (Tinku and Ajoy, 2005). This function allows extracting the green color plan of an RGB image (IMAQ, 2004). After this action, it is possible to identify with superior emphasis, the zones with occurrence of agglutination in the analyzed images.

Figure 7 presents the application of this function in the images of Figure 2a) – with agglutination occurrence and Figure 4a) – without agglutination occurrence.

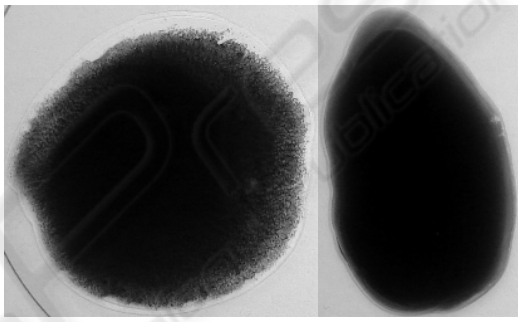

Figure 7: Application of the function Extract Color Planes (Extract RGB Green) to the images of the Figure 2a) and Figure 4b), respectively identified as a) and the b).

Observing Figure 7a) it is possible to identify variations in the color intensity between black and white (agglutination occurrence). Figure 7b) assumes a homogeneous tonality of black color, without having significant oscillations in the color intensity (without agglutination occurrence). As the transition level between contrasts black and white, is superior to the transition levels between red contrasts and the colors used in the serums, the application of this function makes possible a mathematical quantification of the agglutination occurrence.

2) Quantify function (Klinger, 2003) (Dougherty, 2009) (Bernd, 2009) (Burger and Burge, 2009) (Tinku and Ajoy, 2005). This function allows quantifying statistically, through the levels of pixels intensity, selected areas of an image. This quantification includes the average, the standard deviation, the minimum and the maximum amplitude of the analyzed pixels (Bisquerra, Martínez and Sarriera, 2004).

Figure 8 presents the application of the Quantify function in the images of Figure 7.

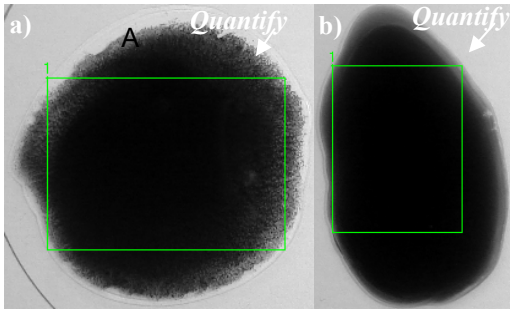

Figure 8: [a) Application of the Quantify function to the image of Figure 7a), b) application of the Quantify function to the image of Figure 7b)].

Table 1 presents the results of the statistical parameters, determined with the Quantify function, in the selected areas of Figure 8 images.
Analyzing Table 1, it is verified that the standard deviation of the image where agglutination occurs (Figure 8a), is highly superior to the standard deviation of the image without agglutination (Figure 8b). Significant differences are also observed in the other analyzed parameters, excepting as expected, in the minimum value (0.00), corresponding to the white tonality.

Table 1: Results of the application of the Quantify function in Figure 8.

Figure	Average (pixels)	Standard deviation (pixels)	Minimum (pixels)	Maximum (pixels)
8a)	18.78	**26.94**	0.00	224.00
8b)	6.25	13.59	0.00	172.00

The standard deviation is the parameter that allows distinguishing with superior exactness and effectiveness, the occurrence or not of agglutination, resultant from the quantification of the pixels intensity deviation in the analyzed image area. It was verified that for the image acquisition conditions used, the agglutination occurrence is translated by a standard deviation level superior than 20 pixels. So, using the described algorithm, it is possible to automatically classify the sanguineous type of a sample of blood.

Figure 9 presents a schematic which resumes the different image processing steps applied (Figure 7 and Figure 8) as well as their transformations, in the initial images.

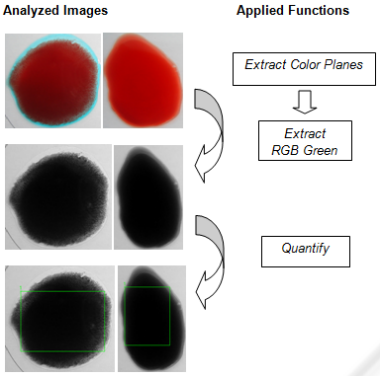

Figure 9: Application of the functions Extract Color Plane (RGB Green) and Quantify (Figure 7 and Figure 8).

4 EXPERIMENTAL RESULTS

The methodology described in the previous section was applied to a set of images with the same sanguineous type, using the four different serums of test. Figure 10 presents the acquired images and Figure 11, the images obtained after the application of the image processing techniques.

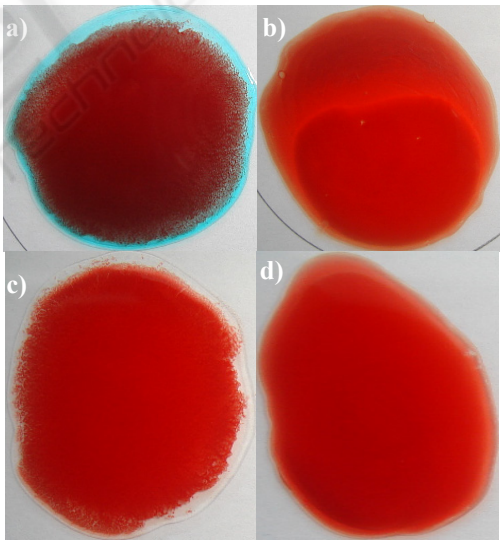

Figure 10: Acquired images of the samples of blood mixed with the different serums of test.

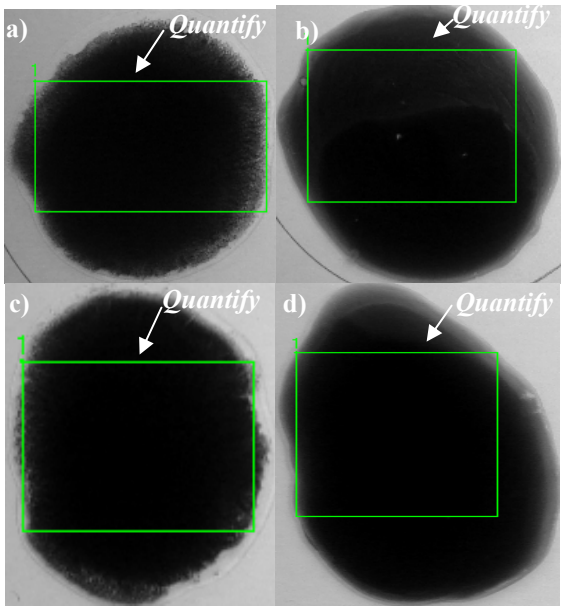

Figure 11: Application of the techniques of image processing to the images of Figure 10.

Table 2 presents the results of the statistical parameters associated to the zones of analysis identified in Figure 11 images.

Table 2: Results of the statistical parameters applied to Figure 11 images.

Figure	Serum	Average (pixels)	Standard deviation (pixels)	Maximum (pixels)
11a)	Anti-A	16.32	**26.63**	200
11b)	Anti-B	13.80	15.10	177
11c)	Anti-AB	10.33	**21.09**	176
11d)	Anti-D	5.37	14.25	167

Analyzing Table 2, it is verified that agglutination does not occur in Figures 11b) and 11d) (standard deviation inferior the 20 pixels) but occurs in Figures 11a) and 11c) (standard deviation superior the 20 pixels). It is also observed that although agglutination occurs in Figure 11c), its level is not as significant as in Figure 11a), as a result of an inferior value of standard deviation, 21.09 pixels < 26.63 pixels. This result from the fact that has been administered the serum anti-AB in Figure 11c), occurring agglutination in the presence of a lower quantity of serum A. Thus, considering the results obtained, it is concluded that the sanguineous type of the analyzed blood is A (Rod, Tate and Trent, 2005), given that the occurrence of agglutination was only verified in the presence of the serums anti-A and anti-AB.

5 SOFTWARE DEVELOPED

After the implementation and validation of the previous sections described methodology, it was developed a custom software application using IMAQ Vision and LabVIEW™ from National Instruments (Klinger, 2003) (Relf, 2003). Figure 12 presents the interface of the developed application.

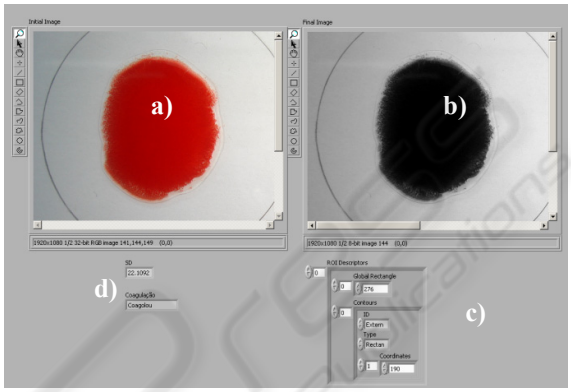

Figure 12: Interface of the developed application [a) - initial Image, b) – final Image, c) – Selection of the region of interest (ROI), d – Obtained results].

The interface of the developed application (Figure 12), is segmented in four different sectors: sector a), presenting the initial acquired image, sector b), presenting the final image obtained after the application of image processing techniques, sector c), for selection of the region of interest in the final image and finally, sector d), for presenting the final results.

6 CONCLUSIONS AND FUTURE WORK

Considering the studies presented in this work, it can be concluded that the applied image processing techniques enable determining automatically, fast and accurately, the sanguineous type of the analyzed samples of blood. Clearly distinct zones in the pixels intensity of the images are identified, allowing classifying with mathematical basis quantification the agglutination occurrence.

As a reference it was used the plate method, adjusted conveniently to the methodology of detection of sanguineous type using image processing, presenting safe results in a time inferior to 2 minutes. Thus, the use of the approach described in this work allows eliminating the errors committed by the technicians in the sanguineous

type classification. This will contribute to undertake safe blood transfusions and to reduce the loss of human lives.

In the near future it is intended to develop a commercial, innovative, portable and low cost system, likely to being used in health units. This system will have a reduced requirement of patient blood quantity allowing reducing the wastes of blood in tests. Moreover, it is also desired that this system registers, among others, the flow of performed tests and required types of blood. These data, associated to a health information system will become an instrument capable of organize and analyze the requirements that allow defining problems in the health area. As a result, this will stimulate the development of new solutions that attend specifically to the necessities of the services given to the population.

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