Recognition of Haemolytic Transfusion Bags

Petra Rajmanová
Faculty of Electrical Engineering and Computer Science
VŠB - TUO
Ostrava, Czech Republic
petra.rajmanova@vsb.cz

Pavlina Núdziková
Faculty of Electrical Engineering and Computer Science
VŠB - TUO
Ostrava, Czech Republic
pavlina.nudzikova@vsb.cz

***Abstract*—This paper is about automatic recognition of haemolysis in transfusion bag. Currently, haemolysis in blood bag is recognized by a visual estimation. Nurses compare the colour of blood plasma with reference samples and according to their own opinion they evaluate whether blood plasma is damaged or not. The parameter for the comparison is colour. The best is to use image sensors – camera or video camera for analysis. Software that is designed in MATLAB programming environment is able to evaluate colour of blood plasma according to the reference samples. Determination of colour is done in three colour spaces, namely, RGB, Lab, and xyY.**

Keywords-method; colour recognition; haemolysis; blood plasma; references samples; camera.

I. INTRODUCTION

With the growth of treatments, there is increasing need for donated blood. This donated blood cannot be artificially manufactured or substituted. This process is indispensable for medicine. Blood may be obtained in two ways. The first possibility is to take of full blood with components. The second possibility is a targeted sampling of individual blood components. All the blood is processed into erythrocytes, plasma, and leukocytes. In plasmapheresis the donors took off only blood plasma and other blood components are returned to their body. During the sampling and subsequent processing of blood plasma [1, 2], it is possible to damage blood plasma, which is called haemolysis. It is impossible to use such plasma for next processing.

II. TAKING OF BLOOD AND PROCESSING

Donation of blood is a process. The blood is used for medical processing. There are two ways of taking of blood. The first possibility is to take of full blood with all components. The second possibility is a targeted sampling of individual components. The blood is taken into plastic bag. The plastic bag has anticoagulable solution inside. Individual bags are connected by tubes. The tubes have needles at the end.

A. Taking of full blood

Every time, the taken blood is processed on erythrocytes concentrate, on blood plasma, and on leukocytes. Full blood is divided in centrifuge. Blood is separated in individual components by special blood press; see Figure 1. Blood plasma is in upper part of blood bag. A buffycoat is in the middle of the blood bag. Erythrocytes are in lower part of transfusion bag.

Figure 1. Blood press.

Between bags is safeguard that has to be broken. After that is possible to separate blood components. Completed bags are stored in special fridge or freezer.

B. Target sampling

Target sampling is specific method of taking of blood, especially when it is donated only by one blood component. It is called trombocytopheresis, erytrocytapheresis, plasmapheresis.

III. HAEMOLYSIS

Erythrocytes are very sensitive. The membrane can be damaged by some physical and chemical agent. When the membrane is damaged haemoglobin flow out of the cell to blood plasma. This phenomenon is called haemolysis. This may occur for example during processing of blood plasma when it is centrifuged at high speed, after premature centrifugation or wrong break out of fuses or due to thermal effects [3]. When the fuse is broken wrongly, it is due to sharp edges. If the blood components are separated, erythrocytes can be damaged by these sharp edges. In current practice, the haemolysis in blood plasma bag is subjective analysis [4].

IV. DESIGNED METHOD

Currently, haemolysis is recognized by comparison of blood plasma with reference samples; see Figure 2. This is done by nurses in laboratory. This method is very unreliable because human eye has different perception of colour and of brightness.

 ISBN: 978-1-61208-319-3

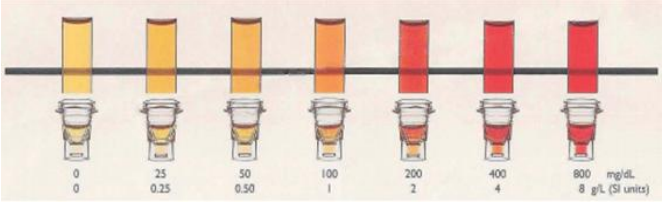

Figure 2. Colour scale for assessing degrees of haemolysis, expressed in g/l [mg/dl] haemoglobin.

Blood plasma can be used in hospital or it can be shipped to industrial factory for processing. Transfusion bags are checked between their usage; mainly, on colour, barcode or the integrity of the bag.

A. *Choice of method*

Haemolysis can be recognized by two methods. Spectrometry is recognition by optical method. Spectrometry gives only information about wavelength characterizing the colour of the plasma. Optical sensors are better for recognition of colours. Colour can be recorded by camera or video camera. Information is summarized on the image. This picture is processed on computer. Haemolysis is detected by the algorithm in Section C. Besides recognition of colour, there is possible to get information about barcode and check integrity of the bag.

B. *Block diagram*

The base of method is to design a measure chain; see Figure 3. It consists of light source, blood plasma, recorder and processing on computer.

Figure 3. Block diagram for analysis of blood plasma by image sensor.

Light sources can be natural or artificial. Daily light is not so good for recognition of colour. The halogen ball is better than daily light or normal bulb. The worst source of light is fluorescence tube. Light imperfection can be minimalized by some filters.

Blood plasma has to be checked before its freezing because after freezing, blood plasma is covered by a white frost. White frost has its influence on recognition.

Recording medium can be camera or video camera. In this experiment, a Camera Canon EOS 450D was used.

Processing on computer is last step in recognition [5, 6].

C. *Algorithm of software*

The algorithm was designed in MATLAB. Pictures have been taken by camera in Blood Centre of the Faculty Hospital in Ostrava. Haemolysis has been recognized in three colour spaces. After that, it has been compared which model is the best. The colour spaces are RGB, Lab, xyY.

The RGB model is composed of R = red colour, G = green colour and B = blue colour. The model is based on knowledge reference colours. These references colours signify the level of haemolysis. These samples have been taken from the tab; see Figure 2. When the colour of blood plasma is the same like sample number one, it is represented by red colour. The second sample is represented by yellow colour. When the colour of blood plasma is the most similar to third sample, this area will be blue. The forth sample is represented by turquoise colour, fifth by green colour, sixth by pink and the last one is represented by black colour; see Figure 4.

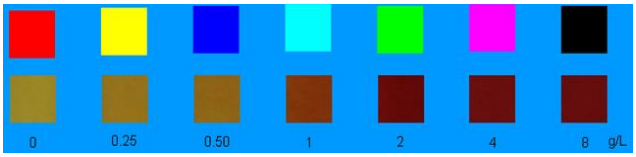

Figure 4. Colours of references samples.

The second model is the Lab model. L is brightness component “a, b” and represents colours of components. L component is unnecessary; the algorithm does not use it for recognition. The algorithm uses only component “a, b”. The reference colours come from tab; see Figure 2. The values are transferred from RGB to XYZ and from RGB to Lab by transformational equation [7]:

$$X = 0.430574 \cdot R + 0.341550 \cdot G + 0.178325 \cdot B$$
$$Y = 0.222015 \cdot R + 0.706655 \cdot G + 0.071330 \cdot B$$
$$Z = 0.020183 \cdot R + 0.129553 \cdot G + 0.939180 \cdot B$$

$$L = 116 \cdot \left(\frac{Y}{Y_n}\right)^{1/3} - 16$$
$$a = 500 \cdot \left[\left(\frac{X}{X_n}\right)^{1/3} - \left(\frac{Y}{Y_n}\right)^{1/3}\right]$$
$$b = 500 \cdot \left[\left(\frac{X}{X_n}\right)^{1/3} - \left(\frac{Z}{Z_n}\right)^{1/3}\right]$$

The focus is calculated for every individual reference sample with coordinates “x, y”. Blood plasma is classified to the nearest sample.

Last model is xyY model. This model includes the extent of human seeing. Y is brightness and colours components are “x, y”. Transformational equation transfers values from RGB to XYZ and from XYZ to xyY. Algorithm does not use Y component [7].

$$x = \frac{X}{X + Y + Z}$$

$$y = \frac{Y}{X + Y + Z}$$

$$Y = Y$$

 ISBN: 978-1-61208-319-3

V. TESTING

Transfusion bags with blood plasma for testing are software coming from Blood Centre of the Faculty Hospital in Ostrava. The number of testing blood plasmas was 91. Two blood plasmas were all right and 2 were haemolytic. Pictures were taken with different light sources. Forty eight blood plasmas were taken with daily light. The other plasmas have been taken with artificial light source - Aputure AL-198 LED light and the light of LCD display which was put under the plasma. Nine blood plasmas were taken twice, with daily light and with LCD display and results were compared. All pictures have been tested in RGB, Lab and xyY colour space.

A. RGB

The algorithm evaluated five blood plasmas wrongly. It detected haemolysis for clear blood plasma. Mistakes were in the first half of testing in RGB colour space. In Figure 5, there is Software for recognition of haemolysis. There is also blood plasma, which is analysed in RGB colour space. Plasma is painted with colours of reference samples which occur in blood plasma.

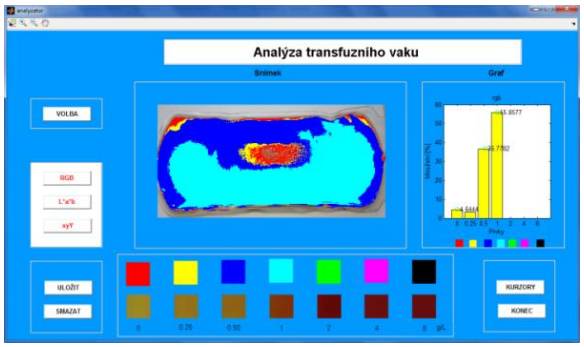

Figure 5. Software for analysing a blood bag with blood plasma - RGB model.

Plasma is painted with colours of reference samples that are occur in blood plasma. Reference samples are in RGB colour space, as shown in Figure 4.

- Software downloaded picture of blood plasma and reference samples.
- Picture with blood plasma was recognized by 3 models.
- Results were presented by colours on the picture with blood plasma and in graph; see Figures 5, 6 and 7.
- Accurate values can be shown by cursors.

B. Lab

The algorithm evaluated two blood plasmas wrongly. The example is in Figure 6.

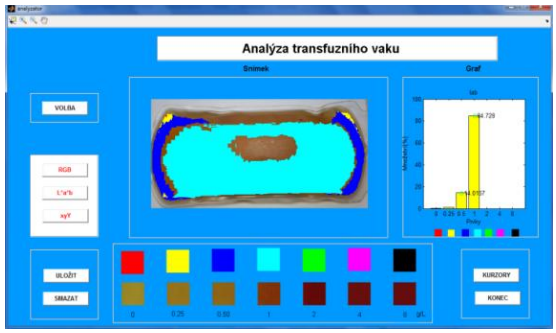

Figure 6. Software for analysing a blood bag with blood plasma - Lab model.

Plasma is painted with colours of reference samples which are occurred in the blood plasma. Reference samples are in Lab colour space too.

C. xyY

The model xyY is the worst way for recognition of haemolysis in blood plasma. The number of wrong results is eleven and software detected two haemolysis of blood plasmas as clear blood plasma; see Figure 7.

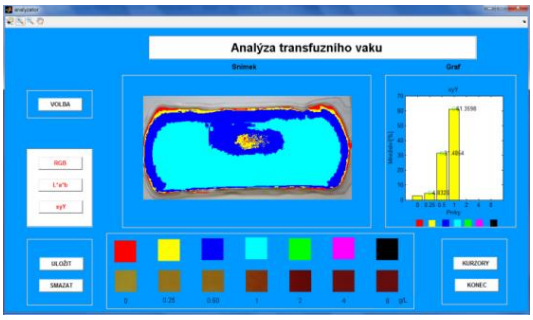

Figure 7. Software for analysing a blood bag with blood plasma – xyY model.

Plasma is painted with colours of reference samples that occur in blood plasma. Reference samples are in xyY colour too.

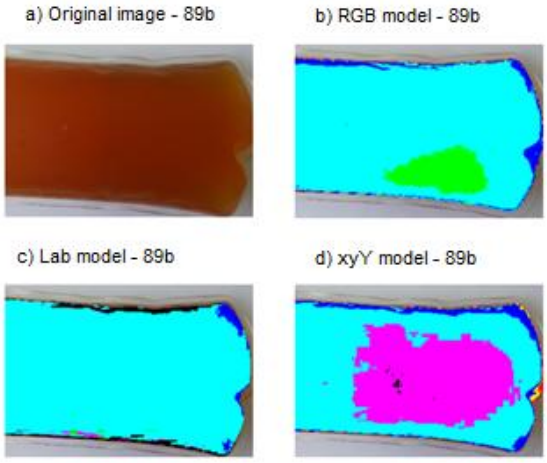

Figure 8. Blood plasma puts on white pad during daily light.

 ISBN: 978-1-61208-319-3

In Figure 9, there is blood plasma on white pad. The light source was daily light. Blood plasma has lightly colour at the end of transfusion bag. Bag has barcode in the middle. This barcode does not influence the recognition. Only Lab model made right detection. RGB model detected little amount of the fifth step of haemolysis. The model xyY recognized haemolysis in the half of transfusion bag.

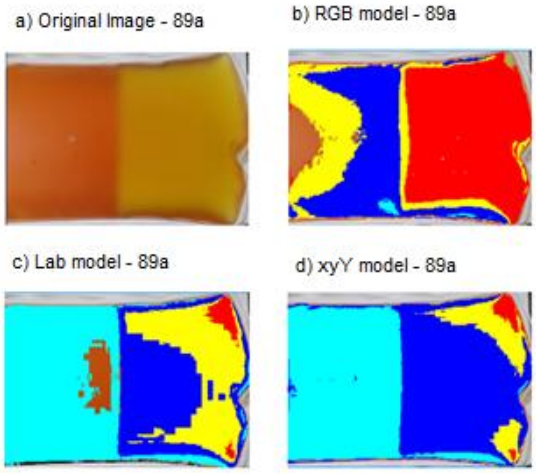

Figure 9. Blood plasma puts on LCD display.

In Figure 9, there is blood plasma put on LCD display. The source was light. There you can see barcode in the middle of the bag. The barcode was influenced by the results. The colour is darker than at the marginal part of transfusion bag. This is why this part is not important for classification. These conditions are better for classification of all colour models. There is no haemolysis in blood plasma.

VI. FUTURE PLAN

The algorithm can recognize colour of blood plasma on knowledge reference colours. These colours come from the table; see Figure 1. The plan uses real colour of blood plasma and does reference colours from these samples. When blood plasma was on the LCD pad, the barcode was in the middle. Haemolysis was detected from whole bag. The plan is recognize haemolysis just from peripheral parts without middle part, where the barcode is.

This method can be enlarged on other functions. One of the functions can be checking barcodes. Nurses do this checking. They are checking integrity of bag too. This can be done by algorithm too. The nurses could have more time for another more important work.

VII. RESULTS

The aim of this work was to design a method for automatic recognition of haemolysis in blood plasma. This method was designed in close cooperation with Blood Centre of Faculty Hospital Ostrava. Colour of blood plasma was analysed in three colour spaces RGB, Lab, xyY. Pictures have been taken by camera and light sources, such us daily light, LED light and LCD display light. The worst results were in xyY colour space. This colour space is based on human seeing. This can probably be the reason for the worst recognition. Majority of mistakes were caused by bad light source. When the transfusion bag was on the white table and light source was LED light.

Software was designed in MATLAB. It has many functions. Software can recognize haemolysis of blood plasma in three colour space. The result can be seen on picture with blood plasma. Detected colours are marked by colours of references samples. The quantity of colours is marked in the graph.

Future plan is to work out the software in detail, to make new reference samples from real plasma and to use light conditions at high quality. Finally, the aim is to make this method automatic in Hospital and in Industrial Factories.

ACKNOWLEDGMENT

This work is supported by project SP2013/168, named "Methods of Acquisition and Transmission of Data in Distributed Systems" of Student Grant Agency (VSB - Technical University of Ostrava).

This work is also supported by project SP2013/135, named "Control of technological systems with OAZE providing an independent sustainable development of complex systems" of Student Grant Agency (VSB - Technical University of Ostrava.

REFERENCES

[1] E. Gkoumassi, M. J. Dijkstra – Tiekstra, D. Hoentjen, and J. de Wildt - Eggen, Haemolysis of red blood cells during processing and storage, Transfusion, vol. 52, Mar. 2012, pp. 489-492, doi:10.1111/j.1537-2995.2011.03298.

[2] G. Lippi and M. Franchini, Advancements in laboratory diagnostics: an invaluable tool for assessing quality of blood transfusions, Blood Transfusion, vol. 58, Dec. 2012, pp. 1-2, doi:10.2450/2012.0226-12.

[3] J. R. Hess, R. L. Sparrow, P. F. van der Meer, J. P. Acker, R. A. Cardigan, and D. V. Devine, Red blood cell haemolysis during blood bank storage: using national quality management data to answer basic scientific questions, Transfusion, vol. 49, Dec. 2009, pp. 2599-2603, doi:10.1111/j.1537-2995.2009.02275.

[4] K. A. Janatpour, T. G. Paglieroni, V. L. Crocker, D. J. Du Bois, and P. V. Holland, Visual assessment of haemolysis in red blood cell units and segments can be deceptive, Transfusion, vol. 58, Jul. 2004, pp. 984-989.

[5] Z. Machacek, R. Slaby, R. Hercik, and J. Koziorek, Advanced System for Consumption Meters with Recognition of Video Camera Signal, Elektronika Issue, vol. 18, no. 10, 2012, pp. 57-60, ISSN 1392-1215.

[6] R. Slaby, R. Hercik, and Z. Machacek, Compression methods for image processing implementation into the low capacity device, In Technical Gazette, vol. 20, no. 6, 2013, pp. 1087-1090, ISSN 1330-3651.

[7] B. Fraser, C. Murphy, and F. Bunting, Real World Color Management, 2nd ed. Peachpit Press, 2005, ISBN 0 – 321 – 26722 - 2

 ISBN: 978-1-61208-319-3