COLOUR MEASUREMENT USING DIGITAL IMAGE ANALYSIS

Adrian PETRU, Aurel LUNGULEASA

Faculty of Wood Engineering, Transilvania University, Braşov, România

Abstract: This paper presents an original colour measuring method using an assembly consisting of a computer system equipped with a scanner. One of the advantages of this method is that one it can determine the colour on small surfaces just of 1x1pixels using a common equipment. This means that the errors resulting when measuring the colour on larger surfaces (when actually an average colour of the surface is assessed) are avoided. Transforming from RGB colour system to CIEL*a*b* system is also presented. The CIEL*a*b* system was elected because it is the most widely used colour system. A measuring example is presented.

Keywords: measuring, colour, wood, pyrography, Lazarus, Pascal.

1. INTRODUCTION

Colour holds an important role in human life and activity. In nature and science, colour represents an essential clue for defining species of plants, animals, minerals etc.

Colour is defined as "the property possessed by an object of producing different sensations on the eye as a result of the way the object reflects or emits light" [6].

Colour is an important wood property when evaluating its aesthetically potential and especially when it is going to be used for decorative purposes.

The wood colour varies within very large limits from white for Sycamore (*Acer pseudoplatanus* L.) to black for Ebony (*Diospyros ebenum* Koenig.) [4]. It is characteristic for each species. It meets many hues which vary around a basic value at the same wood species. Different species have different base colours.

The colour of the one and the same species can be uniform or with different nuances. The wood of the species from Romania and, generally, from the temperate climate area, has moderate colours as in contrast to the species in tropical areas.

The colour of wood is an important parameter, taken into account in several stages of wood processing, such as timber steaming, drying and dyeing.

Likewise, the measurement of wood colour is very important in the pyrography refining process of wood. To this end the present research has been conducted.

Colour instrumentation has experienced a tremendous advancement in technology during the past 40 years. During this time, the instruments have become more accurate, reliable, flexible, smaller, and faster than their predecessors, at significantly lower cost to the user.

The most important devices for colour measurement are:

- colorimeter;
- spectrocolorimeters;
- spectrophotometers;

- portables.

Colorimeter is a device of fairly simple design based upon the visual concepts of colour. The sample is illuminated at a 45° angle relative to the perpendicular line to the plane of the mounted sample. The method of the trichromatic colorimeter allows for the quick obtaining of the trichromatic components X, Y and Z.

Spectrocolorimeters are somewhat of a hybrid instrument which is capable of providing colorimetric data such as X,Y,Z or CIEL*a*b* values for various standard illuminations.

Spectrophotometers provided wavelength by wavelength measurement and data collection at each 1nm or lower if is desired. The spectral method of determining the trichromatic components is based on the spectrophotometric raise of the curve of radiance spectral factors; this is a relatively laborious method.

Micro-processors are capable of calculating colour differences, pass/fail, shade sorting, whiteness, grades of fastness, and many other shows of colour and appearance. A colour is expressed through different intensities of the system basic colours depending on the chosen colorimetric system.

Many portables do not meet the same performance specifications as bench-top models in areas such as spectral resolution, bandwidth, and large-to-small viewing areas.

The main disadvantage of the measuring apparatus is that they do not have possibility to modify measuring area.

It studied measuring wood colour by means of the CorelDraw program [8]. This method presents a disadvantage that read data need transfer to other software for processing. Another disadvantage is that the surfaces can be only by 1x1pixels, 2x2pixels and 5x5pixels.

2. MEASURING METHOD AND APPARATUS

The present study used the computerized method for measuring the wood colour, through an original procedure by means of original software named Colour Manager, developed in to Lazarus programming environment [3]. That use Pascal programming language [2].

Using a PC system can measure the colour of the scanned surfaces in different colorimetric systems, such as:

- RGB: Red (R); Green (G); Blue (B). Colour is expressed through values varying from 0, for black, to 255, for white, for each component.
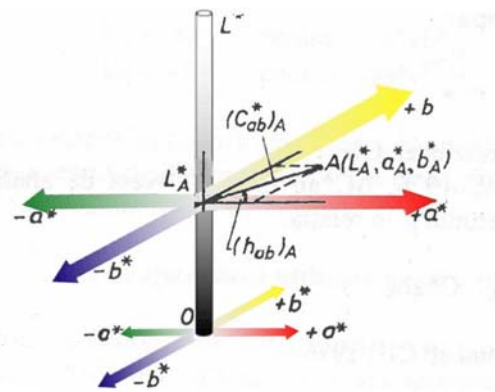- hexadecimal code. Colour is expressed through values varying from 000000 for black, to FFFFFF for white.

Figure 1: Colour characterization through brightness (L*), chrome or satiation (C*ab) and hue angle (hab).

The colorimetric system CIEL*a*b*, defined by the International Commission of illumination (CIE) in 1976, is widely used in colorimetry. It is standardised in Romania [9]. Within this system, a colour is featured through the rectangular proportions L*a*b* (Figure 1), where:

- L* represents the brightness of the colour. L*= 0 yields black and L*= 100 indicates diffuse white; specular white may be higher;
- a* negative values indicate green while positive values indicate magenta;
- b* negative values indicate blue and positive values indicate yellow.

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Using the rectangular coordinates L*, a* and b*, the chroma (C*ab) and the hue angle of the colour (hab) with values ranging between 0° and 360° can be determined, according to the following relations:

$$C*ab = (a^{*2} + b^{*2})^{1/2}$$

(1)

$$hab = arctg\left(\frac{b^*}{a^*}\right)$$

(2)

The colour characterization by means of the brightness (L*), the chrome (C*ab) and the hue angle (hab) according to is shown in Figure 1 [9] , in which the measured sample is represented as *A* point of coordinates L*$_A$; a*$_A$, b*$_A$. The L*$_A$, value (which is the brightness of the respective sample) is on the L* axis at the cross-section of this axis with the a*b* plane where is *A* point.

The device used for the colour measurement consisted of a PC-scanner-screen assembly.

Before starting the measurements, this assembly was calibrated so the values read by the PC, for the R, G, B trichromatic components, to be as close as possible to the ones given by the colour specimen. The assembly was calibrated with white standard specimen. To this end, the colour specimen have been scanned and the R, G, B values were determined.

Calibration is made in computer software. Measured values of the specimen are entered as a correction factors in calibration group box. These values are entered separately for each parameter (R, G or B). This tool is shown to Figure 3.

The images were scanned by means of a Pentium 4 computer and a HP LaserJet 3055 all-in-one printer, fax, copier, scanner type.

The technical characteristics of the employed computer are:
- Processor: Genuine Intel(R) CPU 2140 @ 1.60GHz;
- 0.99GB of RAM memory;
- Video in board;
- Hard disk: 80GB;
- Monitor: Acer AL1716s.

The technical characteristics of the HP LaserJet 3055 all-in-one printer, fax, copier, scanner type for scanning are:
- supported file types: JPEG, TIF, BMP, GIF, PDF, PNG;
- Resolution: 1200 ppi, 24-bit full-colour scanning from letter/A4-size scanner glass;
- Hi-Speed USB 2.0 port and port for connecting to a 10/100 Base-T network
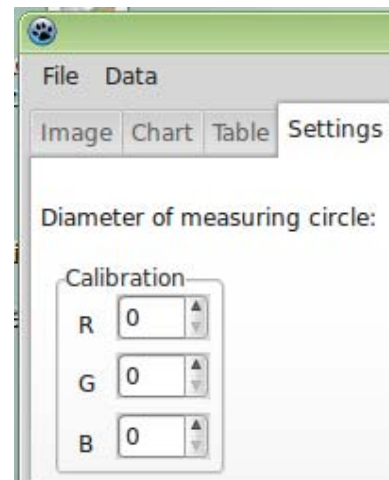- 64-MB RAM.

Figure 2: The Settings tab with Calibration tool.

It can scan the samples after calibration. Images need save in to BMP format.

The saved images are open into program. After image is loaded, the program determines the dimensions of the image. This is an

important parameter because it defines the measuring area limits.

Before analysing image, it sets the diameter of measuring circle from Settings tab. This is a main advantage of this method because it can set the surface area. Others apparatus use for colour measuring, especially portable apparatus do not have this possibility.

After a point is selected, the computer defines a circular surface defined by centre in the selected point and diameter defined by the specified diameter of measuring point. The measuring surface shape is similar with surfaces defined by the other apparatus.

This surface is analysed with computer pixel by pixel and colour value for each point is split into three values; for red, green and blue.

The selected areas are stamped with white colour. It does not affect the original image file in any way.
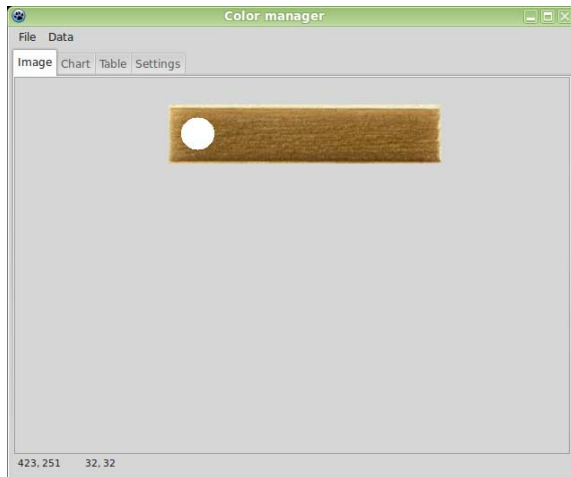
A measurement example is shown in Figure 3.

- the position of the pixel on X axis;
- the position of the pixel on Y axis;
- R value in the RGB measuring system;
- G value in the RGB measuring system;
- B value in the RGB measuring system;
- X value in the XYZ measuring system;
- Y value in the XYZ measuring system;
- Z value in the XYZ measuring system;
- L* value in the CIEL*a*b* measuring system;
- a* value in the CIEL*a*b* measuring system;
- b* value in the CIEL*a*b* measuring system;
- C*ab value in the CIEL*a*b* measuring system;
- hab value in the CIEL*a*b* measuring system.

The software determines the minimum value, the maximum value, average value and standard deviation for each parameter, as well.

Average value is calculates by formula [1].

Figure 3: Image tab with selected point.

Figure 4: Table tab with read data.

Afterwards, the colour, represented by RGB system, is converts to XYZ system using proper formulae [7].

Next step is to convert values from XYZ system to CIEL*a*b* system. It uses formulae provided for this the purpose [9].

In the Table tab are shown the measured data for each pixel. Data recoded in this table are:

Standard deviation in calculates by formula [10].

These values are shown in Table tab, also. The values can be saved and exported to other application.

An example of measured data is shown in Figure 4.

The graphical representation of measured data variations are shown in the Chart tab. The

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An example of measured data is shown in Figure 4.

The graphical representation of measured data variations are shown in the Chart tab. The chart has on X axis the measured pixel and on Y axis the colour values of pixel. Y axis has values from -100 (for CIEL*a*b* measuring system) to 255 (for RGB measuring system).

Values for XYZ colour system is not show for clarity of representation.

The purpose of this representation is to show the dispersion data. A dispersed representation means the measuring is failed (average value is not represent the global colour).

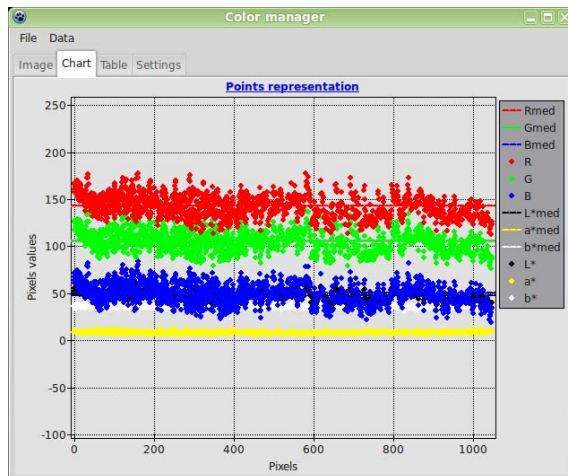An example of measured data representation is shown in Figure 5.

Figure 5: Chart tab with values representation.

3. CONCLUSIONS & ACKNOWLEDGMENT

It is made measuring on some wood samples. It can notice the measured values are dispersed but still closed (especially for CIEL*a*b* series). That means the measurement accuracy is good.

In the most cases it is necessary to measurement the colour difference of two or more measurement in same place. For that it needs to know the exact location of the measurement surface. Usually, it use surface marking with a pencil, but this method affects the results. Another method uses a template from Plexiglas, but this method is expensive [5]. It needs to make a template for each sample. The method presented in this paper does not need any devices or marks. The coordinates of the points from first measuring can be saved and they are ready for use to next measurement session. It saves money and time and measures are not affected in this case.

This is an easy and accessible method. The devices used for this purpose is at hand for every user. A particularly important advantage of employing this method is that the program enables the colour measuring for very small surfaces. This is not possible as regards the use of the colorimeter, which makes the average of the colour for a larger surface.

The method has the advantage of being cheap, it uses available equipments.

This method presents an advantage that read data do not need transfer to other program for processing.

Another advantage is that the surfaces can be larger than 1x1pixels.

The measuring precision is less than professional apparatus but, it is reasonable for a material heterogeneous like as wood.

Even if the method is designed to measure the colour of the wood, it can be used for any material.

The measurement is influenced by scanner properties. The scan resolution influence measurement but not significant because between pixels are not empty spaces.

Because the colour is a sensation it is difficult to quantify that.

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