# The Algorithm to Detect Color Gradation on Silk

**Suyoto[1], Widyastuti[2], Leonardo Ardhinugroho Dasuki[3], and Raymundus Galih Prasetya[4]**

**[1] Department of Informatics Engineering, University of Atma Jaya Yogyakarta
Yogyakarta, 55281, Indonesia**

**[2] Department of Chemical Engineering, University of Setia Budi
Surakarta, Indonesia**

**[3] Department of Informatics Engineering, University of Atma Jaya Yogyakarta
Yogyakarta, 55281, Indonesia**

**[4] Department of Informatics Engineering, University of Atma Jaya Yogyakarta
Yogyakarta, 55281, Indonesia**

**Abstract**

The process of silk dyeing with natural dye extracts will produce a certain color. Using extracts of wood, leaf and their combinations will give some color gradations. This paper aims to create a new algorithm which can help one, whose intention is to formulate the combination of coloring process to achieve the desired color through combining coloring materials on silk fabric. This algorithm will be expected to be able to formulate the combination of colors with more than 75 percent of accuracy. The natural dyes used were *Ceriops candolleana arn* wood for the red, *Cudraina javanensis* wood for the yellow, and *indigofera* leaf for the blue base color.

***Keywords:*** *Color gradation, color standard, Natural dyeing, textiles.*

## 1. Introduction

The dyeing processes of silk with natural coloring materials begins with mordanting the fabric, immerse it several times in the extract solution, fixating, and ends with washing [1]. Natural dyed textiles are sought after more nowadays by nature lovers although they commonly have higher price than the synthetically colored fabrics [2]. Many kinds of natural coloring agents can be produced by extracting parts of a plant. For example: red color from mahogany, *secang* or *tingi* (*Ceriops candolleana arn*) woods; yellow color from *tegeran* (*Cudraina javanensis*) wood or curcuma, dark brown from *jambal* (*Pletophorum pterocarpum)* wood, blue color from *indigofera* (*Indigofera tinctoria*) leaf, and so on[3][4].

Until now the process of making certain colors with natural dyes are conducted based on the experiences of previous users. The history of the dyeing technology with natural coloring materials is necessary for the documentation of the artworks may be decisive for the development of effective and appropriate conservation strategies and it is a challenging task for analytical chemists [5]. The documentation regarding this issue is very important to pass information about the traditional natural dying process onto the next generations and also to prevent wasting natural resources for too many experiments of natural extract dyeing in order to reduce further destructions of the nature [6].

For commercial needs an algorithm that can detect the gradations of the desired color may be a great help to formulate the combination of coloring material process. The combination of coloring process means to immerse the fabric in more than one of natural dye extract solutions to attain a specific color.

By referring to the CMYK index, an algorithm was constructed. By detecting the CMYK index of the desired color the combination of colors are deduced [7]. CMYK index has a correlation to RGB index. A formulation of RGB index with value ranging from 0 to 255 of the scanned colored fabric [8][9] can be converted to CMYK index with range from 0 to 1[10]. The algorithm was set using a series of data obtained from experimental results of coloring processes on silk using extract of natural dyes of tegeran (Cudraina javanensis) wood, tingi (Ceriops candolleana arn) wood, and indigofera (Indigofera tinctoria) leaf with water as the extractan [3][4][11].

## 2. Color Gradation

Color Gradation technique is used to find a new color from combination of colors. In Color Gradation, there are various index of color, i.e RGB index, CMYK index, YcbBr index, HSV index, etc[12]. Each index has special characteristic with different indexing parameters.

RGB Index is used to scan computerized coloured object. The parameter of RGB index is radiance parameter[8]. If each of Red index, Green index, Blue index are maximized, the result of the combination will be white color[25]. The RGB values for the each colored object can be calculated using equations (1), (2), and (3)[8][29].

$$\frac{\sum_{i=1}^{n}\sum_{j=1}^{n} R_{ij}}{255} \quad (1)$$

$$\frac{\sum_{i=1}^{n}\sum_{j=1}^{n} G_{ij}}{255} \quad (2)$$

$$\frac{\sum_{i=1}^{n}\sum_{j=1}^{n} B_{ij}}{255} \quad (3)$$

In the real world in painting process at every instance with a certain level of RGB index will produce a new color, which approaches the black color. Thus, using the CMYK index seems to be more appropriate. CMYK is commonly used in paper and ink process. The CMYK value can be calculated using equations (4),(5),(6),(7), and (8) [18][20].

$$White = Max\left\{\frac{R}{255}, \frac{G}{255}, \frac{B}{255}\right\} \quad (4)$$

$$Cyan = \frac{\left(White - \frac{R}{255}\right)}{White} \quad (5)$$

$$Magenta = \frac{\left(White - \frac{G}{255}\right)}{White} \quad (6)$$

$$Yellow = \frac{\left(White - \frac{B}{255}\right)}{White} \quad (7)$$

$$Black = 1 - White \quad (8)$$

## 3. Natural Dyes and the Color Standard

"The brilliant colours found in the archaeological and ethnographic textiles of the Andes never cease to amaze me", as stated by Vicky Cassman in one of his article. However, the technical analyses of these textiles are frustrating to read because they are limited to design and structural information and the dyes are only mentioned by colour, i.e. red, blue, etc. During the 1984 Junius Bird Textile Conference at the Textile Museum, it became obvious that our lack of knowledge on the subject of dyestuffs of the Andes is also a concern of the majority of enthusiasts who participated [21]. The need for basic research is clear. When the opportunity to live in Arica, Chile, presented itself, I decided to dedicate part of my work to dye research [21].

According to the sources, textile dyes are classified into two, natural dyes and synthetic dyes. Natural dyes made from animals (lac color) or from the parts of plants (root, branch, bark, leaf, flower, seed, or seed coat) [3]. Artificial or synthetic dyes are made by chemical reaction with charcoal coal or petroleum as the raw materials that derive aromatic hydrocarbons such as benzene, naphthalene and anthracene [22].

Dyeing with natural dyes requires mordanting as pre-processing treatment. It is done by soaking the material in metal salt solutions, such as aluminum, iron, tin or chrome. Mordant substances serves to form a chemical bridge between the natural dyes and the fiber so that the affinity of the fiber be increased and the color does not fade easily [1] [24]. After mordanting, the textile materials are soaked in natural dye solution. The natural dye solution used is prepared through extraction of color pigments from the plant with boiling water. To produce a strong binding pigment in the material several times of immersions in the extract solution are needed. The final step of dyeing textile materials with natural dyes will be the fixation process (fixer). Fixations aim to achieve a good fastness. The chemical compounds commonly used in fixer solutions are ferrous salt ($FeSO4$), alum, or calcium oxide ($CaCO3$) [23][26].

Red color base made by soaking the silk in tingi wood extract solution, yellow color base made by soaking the silk in tegeran wood extract solution and blue color base made by soaking the silk in indigofera leaf extract solution [3]. The mixture of tingi wood and tegeran wood extract solution with the ratio of 1:1 gave orange color and the ratio of 2:1 gave dark orage. The mixture of tegeran wood extract solution and indigofera leaf extract solution with the ratio of 1:1 gave green color[24].

Mordantting was done with 3% alum solution at a temperature of 700C for 8 hours long immersion [24]. Extracts of natural dyes were made by boiling the natural dye substances in water that having a concentration with range 10% to 20% [1]. Four times of soaking-aired repetitions were performed. Dyeing process was completed with fixation by soaking the colored silk in 1.5% lime solution for 10 minutes [26].

## 4. Conversion Algorithm from RGB to CMYK

Color gradation can be processed by optical, photographic and electronic means, but color gradation processing using digital computers is the most common method because digital methods are fast, flexible and precise [13]. To understand the color processing using digital computers, we must implement computational tools that are of interest in programming. Only an image that was tested by using the appropriate matrix will generate optimal color detection result [14][28].

In the CMYK color, the color black is symbolized by K, instead of B. Perhaps, because the symbol B has been commonly used for the Blue in RGB. If all the CMYK values are set to 0 (zero), then there is the white color as the result. Conversely if the CMYK colors are mixed on their maximum values, the color created is gray approaching black. This allows for color printers that do not have black cartridge to produce black color [17]. In some ways, the result of mixing colors in the CMYK model has fewer variations than can be obtained from RGB. However, it can be considered as close to the concept of RGB primary color with a slight difference in the color yellow and green. If the user wants to get the same color printed as on the monitor (what one sees is what he/she gets), then he/she has to change the display mode to CMYK first, provided that the software supports such operation[15].

The most important relationship between the CMYK and RGB color spaces is the interaction between colors and their compliments [19]. Combinations of any two colors in one color space produce the compliment of the third component color in the other color space. Laying down equal amounts of magenta and yellow ink in a printer produces tbe compliment of cyan (the third component color), which is red. Similarly, laying down equal amounts of cyan and yellow produce green., and equal amounts of cyan and magenta produce blue. This description is oversimplified, because no perfect cyan ink has ever been found, black is therefore added to be CMYK system. The black ink is used to produce darker tones of all hues[18].

Conversion algorthm of RGB to CMYK [15][18][27][29][30] is

**Step 1:**
Read input images.

**Step 2:**
Devide each image into 3 parts of cannal, there are red, green, blue.

**Step 3**:
Set rows and coloumns of images suite by images` size

**Step 4:**
Devide coloumn into 3 parts according to number of cannal

**Step 5:**
Convert data type of red, green, blue each pixels into type of double

**Step 6:**
Select max of red, green or blue to define value of white

**Step 7:**
Compute white, cyan, magenta, yellow and black with this equation;

White=Max{R/255,G/255,B/255}

Cyan=((White-R/255))/White

Magenta=((White-G/255))/White

Yellow=((White-B/255))/White

Black =1-White

**Step 8:**
Display value of white, cyan, magenta, yellow and black.

## 5. A New Algorithm

This algorithm will develop simulations of images which present the color of natural extract dyes before combined [16]. The new algorithm will compute this image into RGB index. Because of RGB index is a radiance index, this program will then have to convert this RGB index into CMYK index that are suited for paper and ink processing[8][10][17]. The Result of this program is a presentation of the combination of natural extract dyes coloring index in CMYK.

A New Alogrithm which will be added to the conversion algorithm of RGB to CMYK is:

**Addition step 1:**
Input ratio of each natural dyes

**Addition step 2 :**
Compute value of combination white, combination cyan, combination magenta, combination yellow and combination black using this equation;

$$\frac{\sum_{1}^{n} Ratio\ of\ Natural\ Dyes \times \sum_{1}^{n} Value\ CMYK}{\sum_{1}^{n} Ratio\ of\ Natural\ Dyes}$$

**Addition step 3:**
Display value of combination white, combination cyan, combination magenta, combination yellow, combination black.

## 6. Result and Discussion

The new algorithm will present a set number of combination in CMYK and White color index with range 0 to 1 (Fig.4 and 5). The input images are cropped images of natural dyes on silk (Fig. 1, 2 and 3).

When implemented on several image sizes of silk with combination of three extract natural dyes, the new algorithm delivered various result for each size [14]. Based on Table 1, image with 64x64 pixels and 128x128 pixels, 64x64 is the best size for this algorithm to work on. As can be seen in Table 2, the new algorithm delivered a result with avarage error of 11.908 %.

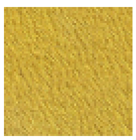

Fig. 1. Input cropped 64x64 pixels image of *tegeran* wood dyes on Silk

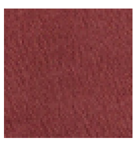

Fig. 2. Input cropped 64x64 pixels image of tingi wood dyes on silk

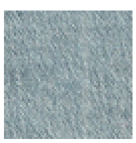

Fig. 3. Input cropped 64x64 pixels image of indigofera leaf dyes on silk

```
combination_white =

    0.7020

combination_cyan =

     0

combination_magenta =

    0.6270

combination_yellow =

    0.2890

combination_black =

    0.2980
```

Fig. 4. Result combination color of *tingi* wood, *tegeran* wood, and *indigofera* leaf with 64x64 pixel of image

```
combination_white =

    0.6954

combination_cyan =

     0

combination_magenta =

    0.6245

combination_yellow =

    0.2837

combination_black =

    0.3046
```

Fig. 5. Result combination color of *tingi* wood, *tegeran* wood, and *indigofera* leaf with 128x128 pixels of image

Table 1. Comparisson Error Result of 64x64 and 128x128 pixels of Image.

| **Size of Image** | **Result of New Algorithm** | **Exact Result** | **Error** |
|---|---|---|---|
| 64x64 | White=0.6667<br>Cyan=0.0222<br>Magenta=0.4016<br>Yellow=0.2444<br>Black=0.3333 | White=0.6706<br>Cyan=0<br>Magenta=0.2398<br>Yellow=0.1754<br>Black=0.3294 | 5.216% |
| 128x128 | White=0.6954<br>Cyan=0<br>Magenta=0.6245<br>Yellow=0.2837<br>Black=0.3046 | White=0.5608<br>Cyan=0<br>Magenta=0.7203<br>Yellow=0.4545<br>Black=0.4392 | 10.716% |

Table 2. Error Result of combination color of *tingi* wood, *tegeran* wood, and *indigofera* leaf.

| **Number of experiment** | **Result of New Algorithm** | **Exact Result** | **Error** |
|---|---|---|---|
| 01. | White=0.6471<br>Cyan=0<br>Magenta=0.6024<br>Yellow=0.3611<br>Black=0.3529 | White=0.5529<br>Cyan=0<br>Magenta=0.7801<br>Yellow=0.4752<br>Black=0.4471 | 9.604% |
| 02. | White=0.6471<br>Cyan=0<br>Magenta=0.6024<br>Yellow=0.3611<br>Black=0.3529 | White=0.4510<br>Cyan=0<br>Magenta=0.6783<br>Yellow=0.5043<br>Black=0.5490 | 12.226% |
| 03. | White=0.6471<br>Cyan=0<br>Magenta=0.6024<br>Yellow=0.3611<br>Black=0.3529 | White=0.7137<br>Cyan=0<br>Magenta=0.2857<br>Yellow=0.0220<br>Black=0.2863 | 15.780% |
| 04. | White=0.5941<br>Cyan=0.0333<br>Magenta=0.2642<br>Yellow=0.2942<br>Black=0.4059 | White=0.5098<br>Cyan=0<br>Magenta=0.4000<br>Yellow=0.5769<br>Black=0.4059 | 12.408% |

Table 2. Error Result of combination color of *tingi* wood, *tegeran* wood, and *indigofera* leaf. (Cont).

| Number of experiment | Result of New Algorithm | Exact Result | Error |
|---|---|---|---|
| 05. | White=0.6667<br>Cyan=0.0222<br>Magenta=0.4016<br>Yellow=0.2444<br>Black=0.3333 | White=0.6706<br>Cyan=0<br>Magenta=0.2398<br>Yellow=0.1754<br>Black=0.3294 | 5.216% |
| 06. | White=0.7020<br>Cyan=0<br>Magenta=0.6270<br>Yellow=0.2890<br>Black=0.2980 | White=0.4510<br>Cyan=0<br>Magenta=0.6783<br>Yellow=0.5043<br>Black=0.5490 | 15.372% |
| 07. | White=0.7020<br>Cyan=0<br>Magenta=0.6270<br>Yellow=0.2890<br>Black=0.2980 | White=0.5529<br>Cyan=0<br>Magenta=0.7801<br>Yellow=0.4752<br>Black=0.4471 | 12.750% |

## 7. Conclusions

Based on the result of this experiment, It can be concluded that color gradation of natural dyes on silk can be detected by this algorithm using combination color image of natural dyes as the input. The new algorithm delivered a result with average error of 11.908 percent; it is less than 25 percent of error. With this algorithm, the user can reduce substantial number of physical experiments in order to find desired color gradation of combination of several natural dyes.

For the future work, a more through observation can be made regarding the best size of the input image to reduce the error of this algorithm. To enhance its reliability of algorithm's accuracy, more experimental tests will be necessary to prove the result of the algorithm. Further development of this algorithm must aim to produce a more realistic model based on chemical interaction between each natural dye.

## References

[1] Kumaresan, M, et. al., "*Application of Eco-Friendly Natural Dye on Silk Using Combination of Mordant*", International Journal of Chemistry Research vol.2 issue 1 2011, India, pp. 11-14.

[2] Ahmad, W.Y.W, et. al., "*Nano-Sized Natural Colorants from Rocks and Soils*", International Conference on Advencement of Materials and Nanotechnology 2007, Malaysia, pp. 515-519.

[3] Denis, Elisabeth Setiani, et. al., "*New Method to Improve Income for Natural Colored Indonesian Batik Using High Security e-Procurement Site*", Proceeding of the 12th International Conference on QiR, 2011, Bali Indonesia, pp. 321-329.

[4] Harbelubun, Antonius Etus, et al., "*Natural colourant plant and the use of traditionally by tribe of Marori Men-Gey in Wasur National Park, Merauke Regency*"(In Bahasa), Biodiversitas, October 2005, pp. 281-284.

[5] Lemonia Valianou, et. al., "*A Comparison of extraction methods for the analysis of natural dyes in historical textiles by high-performance liquid chromatography*", Springer-Verlag 2009, Greece, pp. 2175–2189.

[6] P, Saravanan and Chandramohan G, "*Dyeing of Silk with Ecofriendly Natural Dye Obtained from Barks of Ficus Religiosa.L*", Universal Journal of Environmental Research and Technology, 2011, pp 268-273.

[7] Evana, Yoseph, et. al., "*Combination System of Paint Using Mikrocontroller Using Interface PC*"(In Bahasa), TESLA Vol 10 2008, Indonesia, pp. 85-90.

[8] Oreno R, M. Gran˜a and E. Zulueta "*RGB color gradient following color constancy preservation*", Electronic Letters 2010 Vol 46 No. 13.

[9] Sharma S, Neetu et. al., "*Efficienct CBIR Using Color Histogram Processing*", SIPIJ March 2011, pp 94-112.

[10] Yamada, Hiroki et. al.,"*Development of CMYK Color Display: Display by Chromogenic Effect to Control Painted Color in Paper*", International Journal of Advance Computer Science 2011, pp 41-51.

[11] Mei Chan, L., Tan, R., and Thio, G. 2007. "*Design of Visual-based Color Classification System*." School of Engineering, UCSI.

[12] American Chemical Society, "*Digital Image Guidelines for Journal Cover Graphics*", Journal Production and Manufacturing Services 2011.

[13] Gopalan, Sasi et. al., "*Approximation Studies on Image Enhancement Using Fuzzy Technique*", International Journal of Advanced Science and Technology Vol. 10, September, 2009, pp. 11-26.

[14] Yunike, Maria and Suyoto, "*NEATS: A New Method for Edge Detection*", 2nd International Conferences on Soft Computing, Intelligent System and Information Technology 2010, Bali, Indonesia, pp. 377-382.

[15] Kastaman, Roni and Fadhil Abdulfatah Wasi,"*Work Analisis Image Processing Software with Using some methods to identify quality of Manggis*"(in Bahasa), Proceeding of National Seminar of Himpunan Informatika Pertanian Indonesia 2009, Bogor Indonesia, pp. 1-7.

[16] Castleman, Kenneth R, "*Concept in Imaging and Microscopy: Color Image Prcoessing for Micrroscopy*", The Biological Bulletin, pp.100-109.

[17] Žiljak, V, et al., "*CMYKIR security graphics separation in the infrared area*", Infrared Physics & Technology; Mar2009, Vol. 52 Issues 2/3, pp. 62-69.

[18] Drury, Fred and IL Wheaton," *Drur`s Digital Diary*", PSA Journal, July 2009, pp 19-20.

[19] Beals, Steven, "*Artwork Systems Marries Equinox with Concentric Rings*", Analyzing Publishing Technologies, 2006, pp 5-7.

[20] Tonazzini, A, "*Color Space Transformations for Analysis and Enhancement of Ancient Degraded Manuscripts*", Pattern Recognition and Image Analysis, 2010, Vol. 20, No. 3, pp. 404–417.

[21] Cassman, Vicki, "*Natural Dye Research in the South Central Andes*", Waac Newslatter, Volume 12, Number 2, May 1990, pp.2-3.

[22] Hidayat, Praktino," *Pineapple Leaves The Use of Fiber Technology As An Alternative Textile Raw Materials*"(In Bahasa), Teknoin, Volume 13, December 2008, pp.31-35.
[23] ]Ruwana, Iftitah, *"Effect of fixation Against Substance In Color fastness Cotton Fabric Dyeing Process Using Waste Wood Dye Teak"* (In Bahasa), Teknologi dan Kejuruan, Febuary 2008, pp. 75-86.
[24] Kusumawati, Ester Santosa and Adi Kusumastuti, *"Utilization of Tobacco Leaves Silk Fabrics For Staining With Mordant Orange Skin"*(in Bahasa), TEKNOBUGA Volume 1 No. 1 – April 2008, pp. 15-24.
[25] Chen, Linfei, and Daomu Zao,"*Color information processing (coding and synthesis) with fractional Fourier transforms and digital holography*", OPTICS EXPRESS, 26 November 2007, vol 15, no. 24.
[26] Platova, R. A, et al., "Multidimensional Colormetric Gradation of Kaolin", Steklo i Keramika, January, 2009, pp. 17 – 22.
[27] Islam, Syed Zahurul, et al., "Execution Time Optimization Analysis on Multiple Algorithms Performance of Moving Object Edge Detection", Power Control and Optimization, $3^{rd}$ Global Cofference, 2010, pp. 289-295.
[28] Anang, L. Setiyo, et. al., "NAF Method : Edge Detection Mask for Java and Bali in Indonesia", Proceeding of the $12^{th}$ International QiR, Bali Indonesia,4-7 July 2011, pp. 735-740.
[29] Rao, Daggu Vankateshwar, et al., "Implementation and Evaluation of Image Processing Algorithms on Reconfigurable Architecture using C-based Hardware Descriptive Languages", International Journal of Theoretical and Applied Computer Sciences Volume 1, 2006 , India, pp. 9–34.
[30] Al-Samaraie, F. Muna, "A New Enhancement Approach for Enhancing Image of Digital Cameras by Changing the Contrast", International Journal of Advanced Science and Technology Vol. 32, July, 2011, Pp. 13-22.

## Authors

**Suyoto** is Professor in Department of Informatics Engineering at University of Atma Jaya Yogyakarta, Indonesia. He has more than ten years of teaching experience. He received his PhD in 2000 from the National University of Malaysia, Malaysia. His research interests are multimedia, computer graphics, visualization, mobile application and artificial intelligence.

**Widyastuti** was born in Solo, Indonesia in 1954. She received the B.Sc and M.Sc degrees from Gadjah Mada University in 1972 and 1995. Her research interests include Science for society, Waste Water Treatment, and Batik Painting Technology

**Leonardo Ardhinugroho Dasuki** was born in Solo, Indonesia in 1989. He received the B.CompSc degree from Binus University in 2011. At present he is studying in Atma Jaya University of Yogyakarta. His research interests are Enterprise Information System, Computer Graphics, and algorithm.

**Raymundus Galih Prasetya** was born in in Salatiga, Indonesia in 1986. He is received the B.CompSc degree from University of Duta Wacana Christian in 2010. At present he is studying in Atma Jaya University of Yogyakarta. His research interests are Enterprise Information System, Computer Graphics, and algorithm