Study of use of Water based Solvent in Ink Homogenization

Aarshee Mishra, Ankit Raj, Ish Kumar Jain, Piyush Jain*, Shubhankar Gupta
Electronics Club
Indian Institute of Technology, Kanpur

Abstract **- A novel approach for ink homogenization has been proposed. In contrast to the present oil based solvent homogenization process, this process is based on the use of water-based solvent for intensity variation. This paper mainly deals in the following: (a) Studying the variation of the amount of "Bryonia Alba" solvent for the ink intensity randomization. (b) Finding the characteristic calibration coefficients each for C, M, Y and K compositions. (c) Developing the tone value variation based on the thickness of the layer of the ink decided by its purpose.**

Keywords - CMYK, Absorption coefficient, Reflectivity, Color Correction, Calibration Coefficient

1. INTRODUCTION

Color matching, mixing and reproduction are some of the most important modules in the industries dealing in decorative segments, industrial segments like automotive sector and consumer durables. As per the literature, all colours can be produced using different proportions of Red(R), Green (G), and Blue (B): additive primary colours or Cyan(C), Magenta (M), Yellow (Y): subtractive primary colours. With the present conversion equations, each R, G and B value is supposed to give same values of C, M and Y and prima facie, we may conclude that the mixture of the colours in the calculated proportion shall give the required colour. But the output colour varies depending on range of factors. With the variation of the base medium, colorants from different manufacturers and varying coefficients of calibration depending on the base medium, the output colour ink diverges substantially from the prescribed R, G and B values.

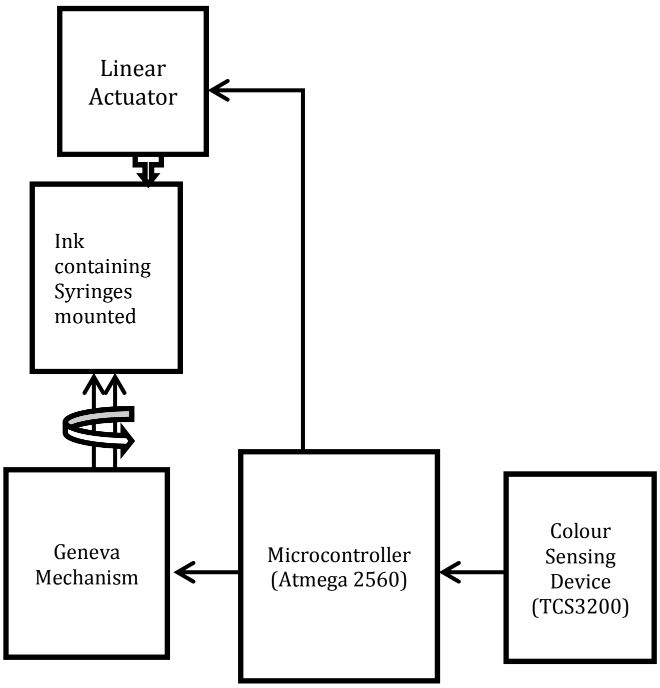
The present color mixing mechanism is based on Kubelka-Munk series of equations, which takes in input the absorption coefficient and scattering coefficient of the base medium and predicts the formula for finding proportions of the base medium and other colours for getting a desired colour. These coefficients are obtained through a long process of feedback mechanism, and measurement of the prescribed sample color with a Spectrophotometer [2]. But, as per, Berger-Schunn et al., these formulas need to be modified through series of iterations and closed-loop control methods [3].

Moreover, the fluctuation from the required R, G and B value is also dependent upon various process control parameters: qualification of all pre-processing materials—paper, ink, intensity lightening solution, etc. For critical work, comparing the output ink on the paper to the prescribed R, G and B and achieving the best visual match possible further refine these parameters. Practically, all process control is based on density and data derived from density, i.e. solid ink density, tone value, tone value increment/decrement, print contrast, etc. [4]

The present mixing pattern is modeled on the oil based solvent and tone contrast, thus, making it difficult to realize the similar mixing pattern in water-based solvent. Meanwhile, with the spate in health and environmental concerns [5] over the use of oil-based paints, the need for appropriate series of iteration-free equations and calibration coefficients for color mixing in water-based solvents need to be studied and dealt in detail.

2: MECHANICAL SETUP

2.1: Overview:



Use of Geneva mechanism for the purpose of ink ejection mechanism has proved to be one of the major subtle differences that ensure the robustness of the overall mechanical model. With the use of a five-slot Geneva gear powered using 2.5 revolutions per minute DC motor, we ensure that linear actuator gets enough time to perform its discharge operation.

A five-slot rotary plate is made using Perspex material and five 10 mm dia. Slots are drilled into the rotary plate that has been fixed to the V-thread screw rod that has been held using a motor and stiffly fixed to the Geneva gear mechanism which drives the rotary plate.

This plate is meant for holding the ink-filled syringes and rotates as per the Geneva gear movements.

The linear actuator is fixed overhead every syringe that contains the CMYK inks and solvent (Bryonia Alba.) and is controlled using an Arduino Microcontroller, which sends Pulse Width Modulation Signals to the linear actuator and hence controls the movement of the actuator (and therefore, piston of the syringe) depending on the amount of discharge of the inks that are required.

For the purpose of linear actuator mechanism, a Firgelli Technologies Ltd. actuator (Canada based actuator construction enterprise) of stroke length with 100 mm and a gear ratio of 50:1 Linear Servo which runs on 6 Volts is used.

Output-frequency scaling is maintained by two logic inputs, S0 and S1, along with the internal light-to-frequency converter generates a fixed-pulse width pulse train. Scaling is achieved by connecting the pulse-train output of the converter to a series of frequency dividers where divided outputs are 50%-duty cycle square waves with relative frequency values of 100%, 20%, and 2%.

The frequency-scaling function allows the output range to be optimized for a variety of measurement techniques. The scaled-down outputs may be used where only a slower frequency counter is available, such as low-cost microcontroller, or where period measurement techniques are used.

2.2 Working Details

Ink Preparation Process initiates with white balance. The internal light-to-frequency converter generates a fixed-pulse width pulse train. Scaling is accomplished by internally connecting the pulse-train output of the converter to a series of frequency dividers. For this very reason, S0, S1 pin, which controls the output scale frequency, is adjusted as LOW and HIGH respectively to adjust it to 2% of the full-scale frequency. Once the white balance is achieved, pin 13 of Arduino is made to blink to signal the handler to shift the sensor to the required colour. When simultaneous figures corresponding to R, G, B values match on three consecutive pulse trains, the processing proceeds on to convert R, G, B values into C, M, Y, K as per following formula:

The R, G, B values are divided by 255 to change the range from 0...255 to 0...1:

R' = R/255
G' = G/255
B' = B/255

The black key (K) color is calculated from the red (R'), green (G') and blue (B') colors:

K = 1-max (R', G', B')

The cyan color (C) is calculated from the red (R') and black (K) colors:

C = (1-R'-K) / (1-K)

The magenta color (M) is calculated from the green (G') and black (K) colors:

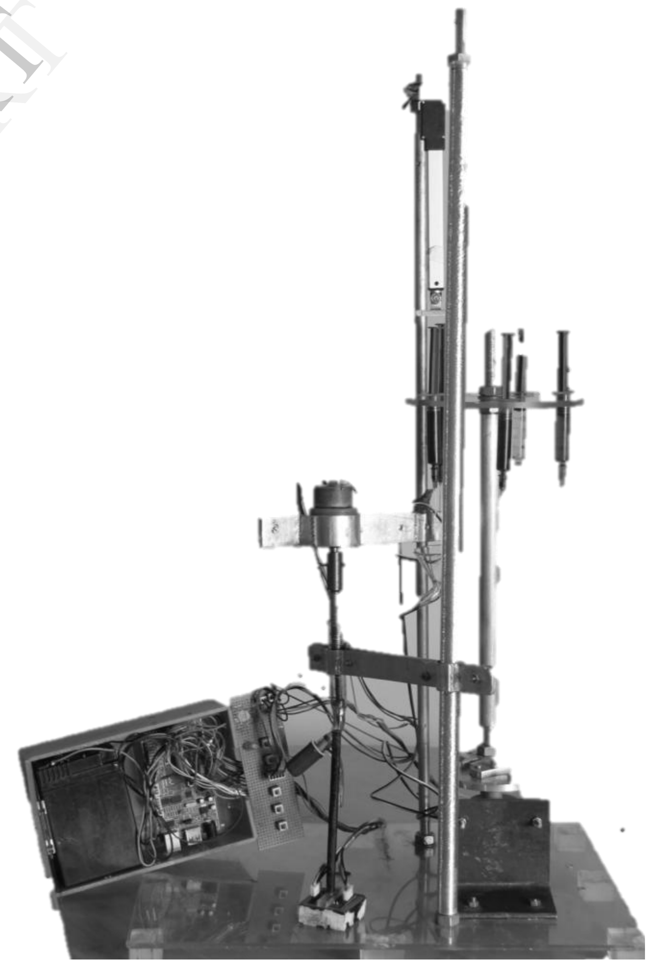
M = (1-G'-K) / (1-K)

The yellow color (Y) is calculated from the blue (B') and black (K) colors:

Y = (1-B'-K) / (1-K)

The decided C, M, Y, K values are then used to decide on the amount of individual base inks needed. With all the amounts of ink and solvent decided, the Geneva gears are then put into transit mode and simultaneously the Pulse-Width Modulation Signals are sent to the RC Linear Servo, which henceforth works in coherence with the Geneva Gears.

With all the inks and solvent once discharged in requisite quantities, it is subjected to uniform homogenization using tri-collar stirrer, since there are only subtle differences between the ink and the 10% v/v Bryonia Alba used.



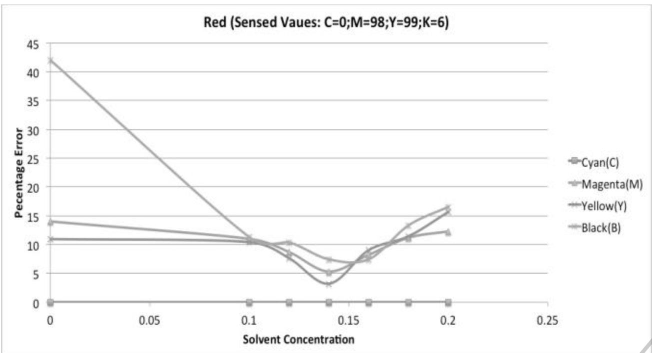
3. STUDYING THE VARIATION OF THE AMOUNT OF “BRYONIA ALBA” SOLVENT FOR THE INK INTENSITY RANDOMIZATION:

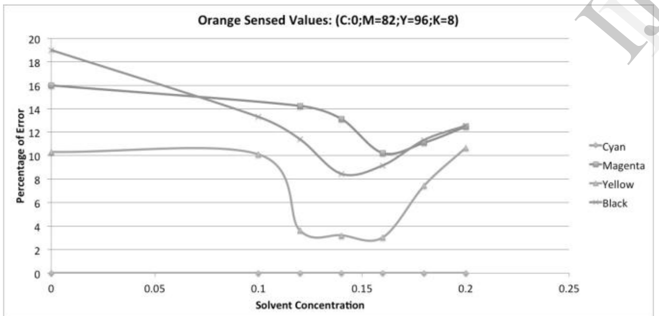
3.1: Solution Methodology:

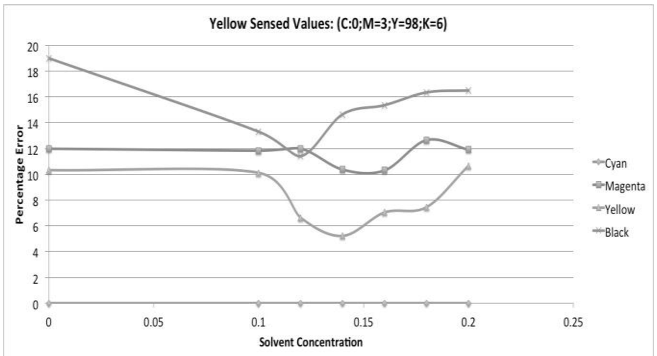
With the use of above-mentioned setup and ink ejection drive, the amount of Bryonia Alba was varied precisely in the required amount. The sensor developed C, M, Y, and K values corresponding to certain wavelengths across the VIBGYOR spectrum. Corresponding to the whole range of visible light spectrum, the individual C, M, Y and K values were noted and compared with the values of C, M, Y and K values of the colour post-production.

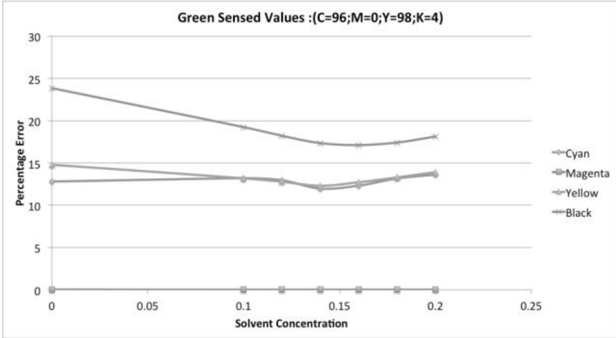
3.2: Results:

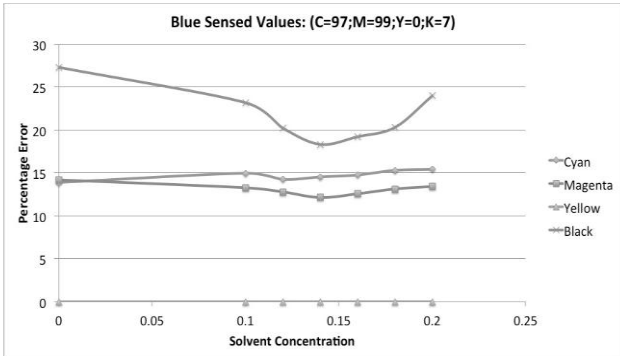
The variation studied across various wavelengths was plotted in order to deduce the error percentage across the spectrum.

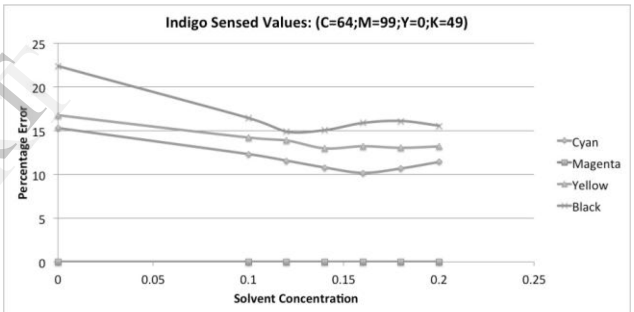


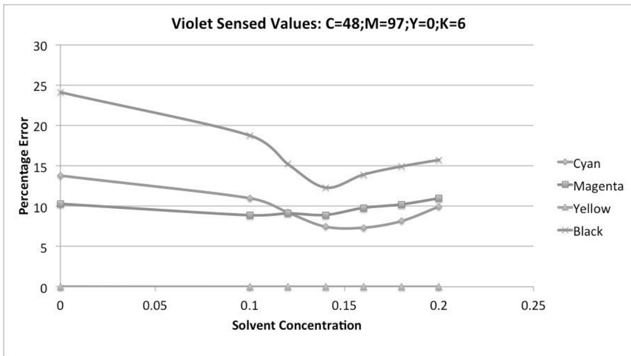












4: FINDING THE CHARACTERISTIC CALIBRATION COEFFICIENTS EACH FOR C, M, Y AND K COMPOSITIONS:

TCS 3200 has four photodiodes types: Red, Blue, Green and Clear. At any point of time, only one can be configured which is done by suitable values at the inputs of the sensor. When we configure a particular photodiode (color filter) using software, for example we choose the Red filter, only Red incident light can get through, all other will be filtered, using which the sensor gets the intensity of Red light. Similarly, when chosen other filters, intensity of corresponding colors is obtained.

4.1: Solution Methodology:
The intensities of these colors are used to find out the composition of R, G and B values of the color, which is sensed.
Since the R, G and B values are decided by the intensity of the light went through, this is very error-prone.

The reflectivity of the object whose color is being sensed greatly influence the intensity received of every color. Same color on the objects with different reflectivity may be sensed as different.
Four white LEDs are they're surrounding the sensor to provide uniform light incident on the object. If the leds are not glowing with equal brightness, the sensed color can differ with the actual color.
It is suggested to wrap the sensor with black paper/cloth to avoid interference by the outside light. It is quite likely that the wrapped paper/cloth has its own reflectivity, which will affect the sensed RGB values.

4.2: Results:
In order to suitably get empirical relations to avoid above-mentioned errors in the optical sensor, we designed and found out following empirical postulates for a particular type of object, which we were used:

If G is max(R, G, B) and ((G - B) > 30) and ((G - R) > 30)
K = K*0.672;
C = C*1.43;

If G is max(R, G, B) and (G > 95)
K = K*0.46;
C = C*1.26;

If G is max(R, G, B) and (G < 95) and (G > 60)
K = K*0.52;
C = C*1.11;

If G is max(R, G, B) and (G < 60)
K = K*0.76;
C = C*1.71;

If B is max(R, G, B) and ((B - G) > 30) and (B > 120)
K = K*0.463;

If B is max(R, G, B) and ((B - R) > 30) and ((B - G) > 30)
K = K*0.679;
M = M*1.333;

If B is max(R, G, B) and ((B - G) >15) and ((B - R) > 15)
K = K*0.5676;

If B is max(R, G, B) and above conditions are not met
C = C*1.733;
M = M*2.25;
K = K*0.672;

If R is max(R, G, B) and (R > 140)
K = K*0.672;

If (K > 0.8)
K = K*0.672;
C = C*1.733;

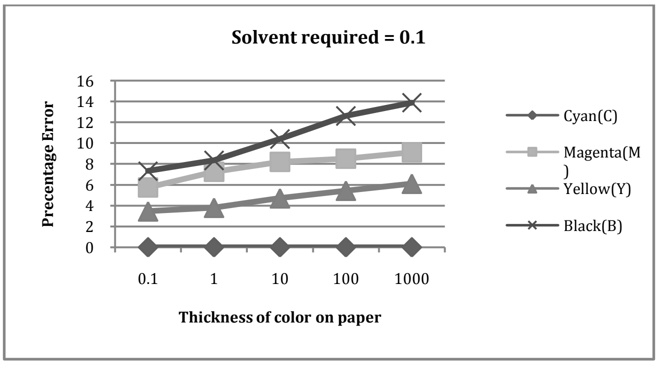
If (K > 0.7) and (R < 40)
K = K*0.567;
C = C*1.733;

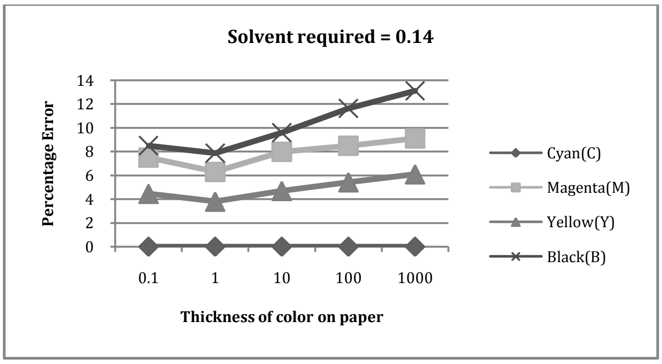
If (K > 0.7) and above conditions are not met
K = K*0.672;

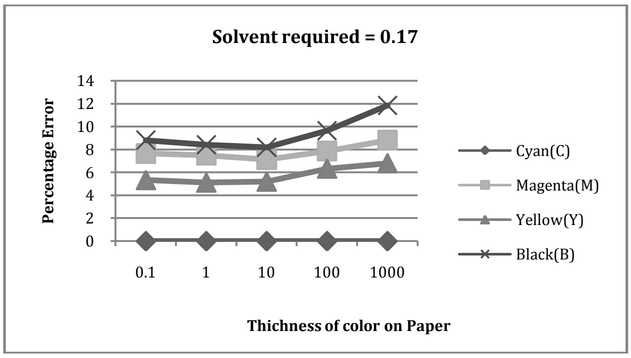
5: DEVELOPING THE TONE VALUE VARIATION BASED ON THE THICKNESS OF THE LAYER OF THE INK DECIDED BY ITS PURPOSE:

5.1: Solution Methodology:
The amount of solvent is varied and the whole process with the given setup is repeated. Without loss of generality we have chosen red color(C=0;M=98;Y=96;K=8). The color is applied on a sheet of paper with different medium, which causes different thickness of color on paper. Percentage error is then calculated by comparing the individual C, M, Y and K values with the C, M, Y and K values of the color post-production.

5.2: Results:
The results obtained through the experiments are plotted for three values of solvent concentration.







6: CONCLUSIONS

The variation of Bryonia Alba for different wavelengths gave a clear and precise solvent concentration range across the visible spectrum. The overall error percentage was limited to the range of 40.1% to 2.3% and the variation across the solvent concentration for each of the individual CMYK values of the range of the spectrum yielded a trough like structure at solvent concentration close to 12-16% of solvent in the produced colour.

Moreover the variation across the larger wavelengths seem to vary drastically with the change of solvent concentration in the values corresponding to Cyan composition, while the error percentage rises in lower wavelengths corresponding to values of Magenta composition.

The results also throw light upon the error incurred due to the slight increment/decrement from the trough region of solvent concentration. The slope extends close to 12.34 mean error increment for 10% increase in solvent.
Different amount of solvent used in colour homogenization have different impact on the thickness of layer on the paper and thus it affects the colour visible to us on paper. Since different medium of applying ink on paper like fountain pen or brushes, have different proportion of colour applying capacity, i.e. a fountain pen could take a little proportion of colour and have a very thin layer on paper as compared to a brush. So, the colour actually visible to us on paper is different for different medium.

7. ACKNOWLEDGEMENT

We would like to thank Dean, Resources and Alumni, IIT Kanpur for providing the financial support and Tinkering Lab, IIT Kanpur for providing the fabrication facilities.

REFERENCES

1: J. Tandukar, (2005) Generic Dyeing and Color Correction, Journal of Theoritical and Applied Information Technology, Vol.3
2: Butts, Ken, Database Preparation for Successful Computer Color Matching, [Online], Available: http://www.techexchange.com/thelibrary/color matching.html
3: Berger-Schunn, Anni, 1994, *Practical Color Measurement: A Primer for the Beginner, A Reminder for the Expert*, John Wiley and Sons, Inc.
4: McDowell, D. (2004, July 1). Process Control Characterization Data Color Management Profiles.
5: Marshall, L. et al. Identifying and managing adverse environmental health effects: 1. Taking an exposure history. *CMAJ, vol. 166*.
6: Environmentally friendly high performance waterborne coatings, Europa, vol.75
7: Yin, J., Cooperstock, J.R., February 2004, *Color Correction Methods with Applications to Digital Projection Environments*, Journal of WSCG, Vol. 12, No. 1-3., ISSN 1213-6972, WSCG 2004, Plzen, Czech Republic
8. Yin, J., C., J.R., February 2004, *Color Correction Methods with Applications to Digital Projection Environments,* Journal of WSCG, Vol. 12, No. 1-3, ISSN 1213-6972, Plzen, Czech Republic
9. R.G. Khatod et al.,(October 2012),International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-1, Issue-5, India
10. Ken Perlin. An image synthesizer. In *Proceedings of SIGGRAPH85*, pages 287–296. ACM Press, 1985.
11. Sharma, Gauravet al., 1997, Digital Color Imaging, IEEE Transactions on Image Processing, Vol. 6, No. 7, July 1997, pp. 901 – 932