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Fuzzy system for Colour strength measurement of printed fabric

[1]Miss. Snehal S. Mule, [2]Prof. (Dr.) Shrinivas A. Patil

1PG student of DKTE's, Textile & Engineering Institute, Ichalakaranji, Shivaji university Kolhapur,India.
2Department of Electronics Engineering, DKTE's, Textile & Engineering Institute, Ichalakaranji, India.

***ABSTRACT*:** *The aim of this study is to apply and compare conventional CCM(Computer colour matching) System and fuzzy system to measure colour strength of printed fabric as a function of GSM(grams per square meter),Number of strokes and viscosity.CCM (computer colour matching) system uses Kubelka-Munk theory for colour strength (K/S ratio) measurement.The fuzzy logic system proves robustness against variation in parameters such as fabric GSM, No. of strokes, viscosity. The effectiveness of the proposed fuzzy logic system (FLS) is evaluated under different operating conditions such as of fabric GSM, number of strokes, viscosity etc. The results of proposed FLS system are more accurate than conventional system.*

Keywords-*Colour strength (K/S ratio), Computer colour matching system(CCM), Fuzzy logic system (FLS), Kubelka-Munk theory.*

I .INTRODUCTION

Generally real world systems are nonlinear and complex in nature. Classical computing methods fails to deal with system nonlinearities and complexity and it affects on total efficiency of system. The alternative solution to deal with such problems is soft computing system. From last few year fuzzy logic system-soft computing is popular system because of its nonlinearity handling capability. In this technique Fuzzy Inference System (FIS) is a powerful tool for modeling real world system.[1],[2]Fuzzy logic provides an alternative solution to non-linear control because it is closer to the real world. Non-linearity is handled by rules, membership functions, and the inference process which results in improved performance, simpler implementation, and reduced design cost.
In this paper two systems described, namely; CCM (Computer colour matching) systema conventional system and Fuzzy systems and compare their results of colour strength (K/S ratio) in printing process.[2] The main aim of this proposed work is to develop a new FIS system in MATLAB/Simulink for printed fabric samples with variation in thickeners for colour strength measurement (K/S ratio) and compare it with CCM (computer colour matching) system.

II. CCM (COMPUTER COLOUR MATCHING) SYSTEM

In this paper colour strength of printed fabric samples will be measured in the form of K/S ratio for different textile printed fabric samples with variation in thickeners by using existing Kubelka-Munk method based CCM (computer colour matching) system which is available in textile laboratory. By using input parameters of samples like fabric GSM (grams per square-meter), Number of strokes and Viscosity, the output parameter colour strength for each sample will be estimated using proposed FLS system.[3]-[5]
Colour strength (K/S ratio) varies with printing conditions such as fabric GSM (grams per square-meter), number of strokes and viscosity in printing process. There are different methods for calculating the colour strength (K/S ratio) like CCM (computer colour matching) system based on Kubelka-Munk theory.

III. FABRIC PRINTING

The printing of cotton fabric requires special conditions such as fabric GSM, number of strokes and viscosity. Fabric GSM, number of strokes and viscosity are the primary factors affecting the colour strength inprinting of cotton fabric. The relative importance of these factorscan be seen in models representing the color strength as a function of them. These models may also have application inprocessing and cost minimization. The color strength is shown by K/S. K/S shows the ratio of the absorbed light by anopaque substrate relative to the scattered light from it. Thisratio is calculated by Kubelka-Munk theory as:

$$\frac{K}{S}_{\lambda} = \frac{1 - R_{\lambda}{}^{2}}{2R_{\lambda}}$$

Where , Rλ is coefficient of reflectance of layer.

3.1 Modeling of fabric printing

The aim of this paper is to model variations of colour strength of samplesversusfabric GSM, number of strokes and viscosity in cotton fabric printing process using an evolutionary fuzzy system and the CCM (Computer colour matching)system.[6]-[10] A total number of 32 samples were printed according to the conditions in Table 1. The models based on CCM system and theevolutionary fuzzy system was developed and compared.

Table 1. Printing conditions

GSM	101.98	101.98	101.98	101.98	101.98	101.98	101.98	101.98	101.98	101.98	101.98	101.98	101.98	101.98	101.98	101.98
VISCOSITY	4%	4%	4%	4%	5%	5%	5%	5%	6%	6%	6%	6%	7%	7%	7%	7%
NO. OF STROKE	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4

IV. PROPOSED FUZZY LOGIC SYSTEM (FLS SYSTEM)

The proposed Fuzzy Logic System (FLS system) block diagram is shown in fig.4. As shown in the block diagram of proposed FLS system the input parameters will be fabric GSM, Number of strokes and Viscosity and the output parameter will be colour strength (K/S ratio). [11],[12] The proposed Fuzzy Logic System consist four blocks like,

- Knowledge base
- Fuzzification
- Decision making logic
- Defuzzification

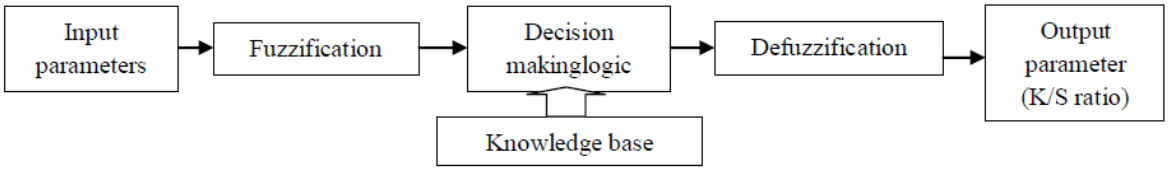

Fig.1. Proposed FLS (Fuzzy Logic System)

4.1 Knowledge base

The FLS system will operate in knowledge based way & its knowledge will relies on the set of linguistic terms, if-then rules like human operator.

4.2 Fuzzification

Fuzzification process will be used for decomposing a system input AND/OR output into one or more fuzzy sets. Many types of curves we can use to define the inputs.

4.3 Decision making logic

Here evaluation of input will be done to draw the conclusion for decision making. The fuzzy rules in the form of if-then structure will be used.

4.4 Defuzzification

Defuzzification will be the inverse transformation which will map the output from fuzzy domain back into crisp domain.

V. MODELING OF FUZZY SYSTEM

Variation of K/S function versus three variables of fabric GSM, number of strokes and viscosity for printed samples shows the effect and behavior of each variable. The FIS model has been developed to measure the colour strength of printed fabric.

5.1 Membership function design

First, membership functions for input and output variables according to Table 2, Table 3, Table 4 and Table 5 have been determined. The triangular membership function, and Mamdani max-min Inference is used for all input and output variables.

The inputs to the Fuzzy Logic system are:

1) Number of strokes
2) Viscosity

3) GSM

Table 2. Fuzzy sets and the respective membership functions for Number of strokes

Label	Set Description	Membership Function	Range
VVL(Very very low)	Number of stroke is Very very low	Trapezoidal	[0.25 0.25 0.5 1]
L(Very low)	Number of stroke is Very low	Triangular	[0.5 1 1.50]
L(Low)	Number of stroke is Low	Triangular	[1.25 1.5 1.75]
ML(Medium low)	Number of stroke is Medium low	Triangular	[1.5 1.75 2.00]
ME(Medium)	Number of stroke is Medium	Triangular	[1.75 2.002.25]
MH(Medium high)	Number of stroke is Medium high	Triangular	[2.00 2.25 2.50]
H(High)	Number of stroke is High	Triangulars	[2.25 2.50 2.75]
VH(Very high)	Number of stroke is Very high	Triangular	[2.50 3.00 3.50]
VVH(Very very high)	Number of stroke is Very very high	Trapezoidal	[3 3.50 4 4]

Table 3. Fuzzy sets and the respective membership functions for Viscosity

Label	Set Description	Membership Function	Range
VVL(Very very low)	Viscosityis Very very low	Trapezoidal	[333.5 4]
VL(Very low)	Viscosity is Very low	Triangular	[3.5 4.00 4.50]
L(Low)	Viscosity is Low	Triangular	[4.25 4.50 4.75]
ML(Medium low)	Viscosity is Medium low	Triangular	[4.50 4.75 5.00]
ME(Medium)	Viscosity is Medium	Triangular	[4.75 5.00 5.25]
MH(Medium high)	Viscosity is Medium high	Triangular	[5.00 5.25 5.50]
H(High)	Viscosity is High	Triangular	[5.25 5.50 5.75]
VH(Very high)	Viscosity is Very high	Triangular	[5.50 6.00 6.50]
VVH(Very very high)	Viscosity is Very very high	Trapezoidal	[6.00 6.50 7 7]

Table 4. Fuzzy sets and the respective membership functions for GSM

Label	Set Description	Membership Function	Range
ME(Medium)	GSM is Medium	Triangular	[101 101.5 102]

Output Linguistic Variable for Colour strength(K/S ratio)

Table 5. Fuzzy sets and the respective membership functions for output Colour strength

Label	Set Description	Membership Function	Range
VVL(Very very low)	Colour strength is Very very low	Triangular	[1.40 1.90 2.40]
VL(Very low)	Colour strength is Very low	Triangular	[1.90 2.40 2.90]
L(Low)	Colour strength is Low	Triangular	[2.70 2.90 3.10]
ML(Medium low)	Colour strength is Medium low	Triangular	[2.90 3.10 3.30]
ME(Medium)	Colour strength is Medium	Triangular	[3.10 3.30 3.50]
MH(Medium high)	Colour strength is Medium high	Triangular	[3.30 3.50 3.70]
H(High)	Colour strength is High	Triangular	[3.50 3.70 3.90]
VH(Very high)	Colour strength is Very high	Triangular	[3.70 4.20 4.70]
VVH(Very very high)	Colour strength is Very very high	Triangular	[4.20 4.70 5.20]

5.2 Rules defined

Secondly, the following rules were defined according tothe structure of printed fiber, behavior of 32 samples printed with variation in thickeners.

1) IF (NoOfStroke IS VL) AND (Viscosity IS VL) AND (GSM IS ME) THEN (ColourStrength IS VVL)
2) IF (NoOfStroke IS VL) AND (Viscosity IS ME) AND (GSM IS ME) THEN (ColourStrength IS VL)
3) IF (NoOfStroke IS VL) AND (Viscosity IS H) AND (GSM IS ME) THEN (ColourStrength IS MH)
4) IF (NoOfStroke IS VL) AND (Viscosity IS VVH) AND (GSM IS ME) THEN (ColourStrength IS VH)
5) IF (NoOfStroke IS ME) AND (Viscosity IS VL) AND (GSM IS ME) THEN (ColourStrength IS ME)
6) IF (NoOfStroke IS ME) AND (Viscosity IS ME) AND (GSM IS ME) THEN (ColourStrength ML)
7) IF (NoOfStroke IS ME) AND (Viscosity IS H) AND (GSM IS ME) THEN (ColourStrength L)
8) IF (NoOfStroke IS ME) AND (Viscosity IS VVH) AND (GSM IS ME) THEN (ColourStrength VH)
9) IF (NoOfStrokeIS VH) AND (Viscosity IS VL) AND (GSM IS ME) THEN (ColourStrength IS MH)
10) IF (NoOfStroke IS VH) AND (Viscosity IS ME) AND (GSM IS ME) THEN (ColourStrength IS H)
11) IF (NoOfStroke IS VH) AND (Viscosity IS H) AND (GSM IS ME) THEN (ColourStrength IS ML)
12) IF (NoOfStroke IS VH) AND (Viscosity IS VVH) AND (GSM IS ME) THEN (ColourStrength VVH)
13) IF (NoOfStroke IS VVH) AND (Viscosity IS VL) AND (GSM IS ME) THEN (ColourStrength IS MH)
14) IF (NoOfStroke IS VVH) AND (Viscosity IS ME) AND (GSM IS ME) THEN (ColourStrength L)
15) IF (NoOfStroke IS VVH) AND (Viscosity IS H) AND (GSM IS ME) THEN (ColourStrength VH)
16) IF (NoOfStroke IS VVH) AND (Viscosity IS VVH) AND (GSM IS ME) THEN (ColourStrength H)

Then, after a centroid defuzzification K/S ratio for the FIS model has been obtained.

VI. CONCLUSION

This paper employs CCM system and fuzzy system to model the screen printing process for fabric. Color strength has been measured in terms of fabric GSM, number of strokes and viscosity. We can improve the colour strength accuracy using fuzzy sets and rules of the FIS model. The effectiveness of the proposed fuzzy logic system is betterthan conventional computer colour matching system under different operating conditions. Development of fuzzy logic system for Colour strength measurement of printed fabric can be done by using fuzzy logic toolbox in MATLAB.

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