Journal of Scientific & Industrial Research
Vol. 79, September 2020, pp. 833-836

Optimized Fuzzy C-means Clustering Methods for Defect Detection on Leather Surface

Khwaja Muinuddin Chisti Mohammed[1]*, S Srinivas Kumar[1] and Gandikota Prasad[2]
[1]JNTUK, Andhra Pradesh, India
[2]SR International Institute of Tech., RR District, Hyderabad, India

Received 18 November 2019; revised 15 January 2020; accepted 18 June 2020

In this paper, captured images are segmented for the defective part, that is used for the further process of grading the quality of the products using automated inspection systems employed in industries such as leather, fabrics, textiles, tiles... etc.. These industries are the greatest conventional industries that need automatic detection systems as a basic part in diminishing investigation time and expanding production rate. Initially in this work, the input image is wet blue leather fed into a contrast enhancement process that improves the visibility of the image features. This contrast-enhanced image is employed with segmentation process that utilizes Fuzzy C-means algorithm (FCM) technique. This paper proposes two different optimization techniques, Grey Wolf Optimization (GWO) & Monarch Butterfly Optimization (MBO) for executing centroid optimization in FCM and results are compared with Modified Region Growing with GWO of leather segmentation method. The results exemplify that incorporation of optimization technique with FCM has a quite evident impact on segmentation accuracy of 96.90% over context techniques.

Keywords: Contrast Enhancement, Grey Wolf Optimization, Monarch Butterfly Optimization (MBO), Textile Industry

Introduction

The defect is a subpart of the image that is inhomogeneous with the surrounding pixels and its area in terms of pixels is used for classifying, segmenting and grading the quality of the item. Automation of the detection process plays a critical role in grading and increase industry trades. As human inspectors, a continuous inspection may not be possible due to their hour's long work, languor, sleepiness ... etc., the solution is machine vision-based inspection system. Many researchers have published methodologies for detecting, classifying and segmenting the defective regions of different textures, but there is no unique methodology that has been investigated and considered as accurate.

The automated textile inspection includes two testing issues, in particular, defect detection and defect classification.[1,2] Regularly, fabric industries have a revenue loss nearly 45–65%.[3] As the raw hides surfaces are inhomogeneous and are covered with hair, the accuracy of locating and identifying the defects is less. Skin and raw hides undergo a series of processes such as liming, chromiumization, tanning, dyeing, retanning to final wet blue leather.[4] All these processes are considered for the inspection in this paper. The uniformity of the wet blue leather[5,6] makes it possible to increase the detection and location of the defect accurately, thereby the production cost is reduced.

*Author for Correspondence
E-mail: chistiieee@gmail.com

Experimental Details

Proposed Optimized Centroid FCM Technique

It is a newer research focus to utilize optimization methods to solve the defect detection problem of automated industries in recent years. The proposed method works well for detecting defects of different types and additionally the method can be further employed in other automatic inspection systems with no or little modification. The extraction of defective areas from normal pictures, utilize feature based method[7], Fuzzy c-means (FCM) algorithm with Bayesian estimation.[8]

In this paper, an optimized centroid FCM is employed for wet blue leather segmentation with proposition of different other optimization methodologies. As a first step, wet blue leather image (Fig. 1) was taken for preprocessing utilize contrast enhancement to remove noise and enhance quality in the image using imadjust function of MATLAB,

Fig. 1 — Samples of (a) Raw Hides and (b) Wet Blue Leather

which increases the performance of segmentation step. Secondly, segmentation task is accomplished with the aid of FCM through centroid optimization technique. The proposed Monarch Butterfly Optimization (MBO)[9,10] technique used to predict optimal centroid with fitness function as segmentation accuracy to get the segmented defective image[11] and obtained results are compared with the performance of Grey Wolf Optimization (GWO).

FCM techinique[8] uses a minimum of two clusters through their membership coefficients. This method is a iterative process, where the objective function F_{Obj} is minimized to get appropriate cluster center. FCM algorithm steps are given underneath. Algorithm 1 and Algorithm 2 shows the FCM and application of MBO to FCM problem.

Algorithm 1: Fuzzy C means Clustering Centroid Optimization using MBO Algorithm (MBO-FCM)

Step 1: Let v = {v1, v2, ...,vn} be the data, c = {c_1, c_2, ..., c_n} are the centers.

Step 2: Now, choose centroid v in segmentation process by MBO technique.

Step 3: Calculate F_{Obj} of the Fuzzy procedure utilizing below function.

$$U_m = \sum_{i=1}^{n} \sum_{j=1}^{c} y_{ij}^{m} ||v_i - w_j||^2 \quad \text{... (1)}$$

Step 4: Compute the fuzzy membership function y_{ij} utilizing with d_{ij} as Euclidean distance

$$y_{ij} = \frac{1}{\sum (d_{ij}/d_{ik})^{(2(m+1))}} \quad \text{... (2)}$$

Step 5: Calculate the fuzzy centers w_j

$$c_j = \frac{\sum_{i=1}^{n} (y_{ij})^m v_i}{\sum_{i=1}^{n} (y_{ij})^m} \ \forall\ j = 1, 2, \dots c \quad \text{... (3)}$$

Step 6: continue 4–5 steps till Um become maximum or $||Y^{(k+1)} — Y^{k}|| < \beta$, k^{th} iteration.

The parameters used are U - Objective function, β-Termination criterion [0, 1], M - Fuzziness Index m ϵ [1, 00], N- Data points, C- Number of cluster center, c_i- j^{th} cluster center.

Algorithm 2: MBO Algorithm

Ameta-heuristic techniques, was suggested by Wang.[9] In the initialization step, initialize centroid values randomly and the four butterflies are chosen. The range for the solution is taken to be 0 to 255. In each square of the image, fitness function (Accuracy[12]) value is Fi computed using and fitness is the most extraordinary exactness of the segmented part.

Step 1. Initialization: iter=1, P, NP, NP1, NP2, Max. Gen., Smax, BAR, peri, p as described in the paper

Step 2. Fitness Evaluation: Evaluate Fitness for each butterfly

Step 3. while !best solution(or)iter< Max .G en. do

Step 4. Sort Population(pop.)

Step 5. Divided population

Step 6. for all i =1 to NP1 do

Step 7. Use Migration Operator generates new NP1 population

Step 8. end for

Step 9. for all j = l to NP2 do

Step 10. Use Butterfly Adjusting Operator generate new NP2 population

Step 11.end for

Step 12. Combine NP1 and NP2 population

Step 13. Update pop., iter=iter+1

Step 14. while ends

Step 15. Get best_solution

The objective of segmenting the wet blue leather is examined employing different optimization methods with respect to objective function so as to get maximum accuracy. It has been observed that centroid optimization using MBO-FCM has maximum accuracy.

Results and Discussion

Based on the aforementioned methodology, this section investigates different aspects of evaluating results. To evaluate the performance measures[12] like accuracy, specificity, sensitivity, Positive Predictive Value(Ppv), Negative Predictive Value (Npv), FalsePositiveRate (FpR) and False Discovery Rate(FDR) the following four parameters are mandatory True_Positive(T_p), True_Negative(T_N), False_Positive(F_p), False_ Negative(F_N). Here, centroid optimization incorporates two different techniques namely, MBO-FCM and GWO-FCM, which is compared with MRG-GWO. The entire process is simulated in MATLAB 2018, core i3 processor, 8GB RAM and CPU speed of 2.20 GHz.

The segmented outputs are shown in Table 1. Different evaluation matrices mentioned above are computed for every segmented image. Three algorithms namely, MRG-GWO[12], GWO-FCM, and MBO-FCM are implemented and the obtained performance matrices, accuracy, specificity and sensitivity of each method are shown in Table 2. Considering the overall performance for test images the MBO technique is better compared to other techniques as seen from Fig. 2.

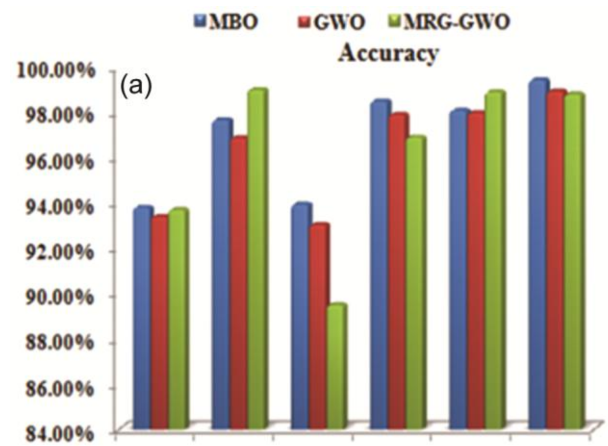


Fig. 2 — (a) Accuracy plots of the GWO, MRG-GWO, and MBO optimization techniques (*Contd.*)

Table 1 — Wet blue result of input images for Proposed Algorithm (MBO-FCM)

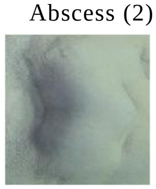
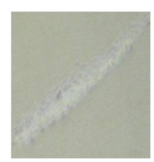
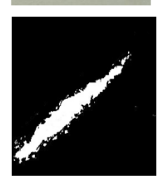
Image Type	Abscess (1)	Abscess (2)	Stretch Marks (3)	Scratch Open (4)	Scratch Close (5)	Tick mark (6)
Input						
Output						

Table 2 — Performance matrices of proposed method (MBO-FCM) and other techniques

Image Type	MRG-GWO[12]			GWO-FCM			Proposed Method (MBO-FCM)		
	Accu. %	Speci. %	Sens. %	Accu. %	Speci. %	Sens. %	Accu. %	Speci. %	Sens. %
(1)	93.70	93.70	93.20	93.40	93.57	95.80	93.80	93.77	95.88
(2)	98.65	99	93	96.87	96.62	98.29	97.67	97.62	98.35
(3)	89.50,	88.60	91.10	93.04	99.98	95.65	93.94	92.89	95.95
(4)	96.90	100.0	83.40	97.90	90.87	90.87	98.50	100.0	90.93
(5)	98.90	98.90	100	97.98	97.65	99.98	98.08	97.95	100.0
(6)	98.80	99.30	94.30	98.93	99.30	99.85	99.43	99.36	100.0

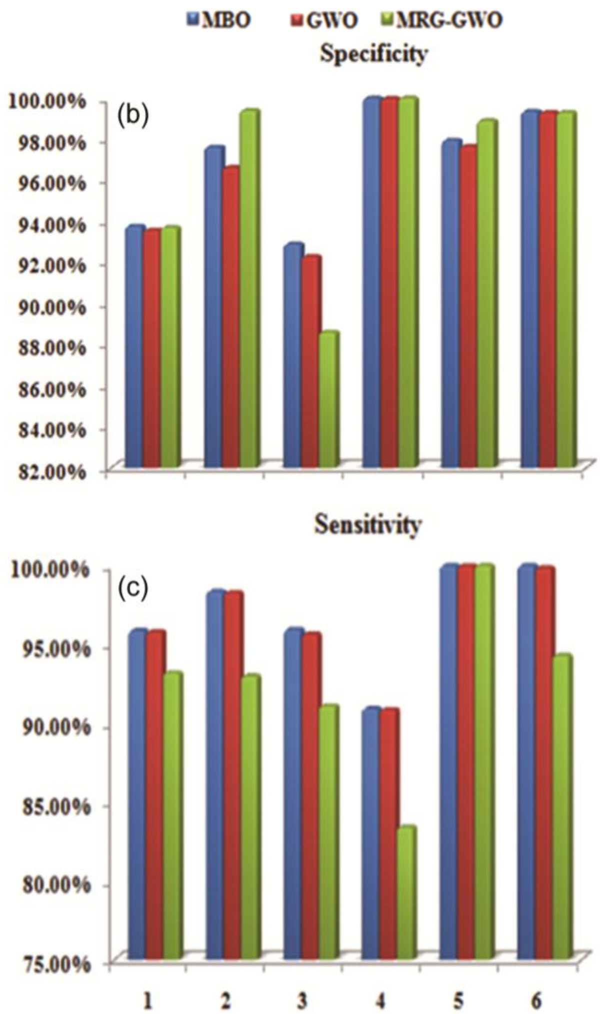


Fig. 2 — (b) Specificity (c) Sensitivity plots of the GWO, MRG-GWO, and MBO optimization techniques

Conclusions

The purpose of effective segmentation has been done with the aid of FCM (centroid optimization), associated with two different optimization techniques. Amid, MBO suits appropriate in this context of segmenting defective portion from the image. The measures utilized to evaluate the performance of implemented techniques are accuracy, sensitivity, specificity, PPV, NPV, FPV and FDR. The investigation results show that MBO-FCM achieved an accuracy of 96.90% which is 0.55% greater than GWO-FCM and 0.77% superior to MRG-GWO. It has been shown that the proposed method is well suited to different types of defects. Further, the proposed method can be employed in other applications of automatic inspection systems.

Acknowledgment

Authors would wish to thank Willian Paraguassu Amorim, GPEC, UCDB Campo Grande Area, Brazil, and Dr. Muralidharan Chellapa, Scientist F, Central Leather Research Institute (CLRI), Chennai, India for giving permission to view and access the data set of leather images.

References

1 Sharda P & Jadhav Biradar M S, Fabric defect detection based on set of geometric features for neural network, *Int J Adv Electron Comput Sci*, 2(3) (2016) 36–40.

2 Ali R, Benmhammed I, Abid S & Fnaiech F, Fabric defect detection using local homogeneity analysis and neural network, *J Photonics*, Article ID 376163 (2015) 1–9.

3 Tong L, Wong W K & Kwong C K, Differential evolution-based optimal gabor filter model for fabric inspection, neurocomputing, **173** (2016) 1386–1401.

4 Paraguassu Amorim W, Hemerson P, Conti Pereira M & Chagas Jacinto M A, Attributes reduction applied to leather defects classification, *Proc 23rd SIBGRAPI Conf Graph Patterns Images(IEEE Xplore)* (2010) 353–359.

5 Jagrti P, Meghna J & Papiya D, Detection of faults using digital image processing technique, *Asian J Eng Appl Technol*, **2(1)** (2013) 36–39.

6 Yeh C & Perng D B, Establishing a demerit count reference standard for the classification and grading of leather hides, Springer-Verlag London Limited *Int J Adv Manuf Technol*, **18(10)** (2001) 731–738.

7 Hemerson P, Paraguassu W A, Martins P S, Conti M P, Pereira M A & Jacinto M A, Defect Detection in Raw Hide and Wet Blue Leather,Proc IntSympCompIMAGE 2006 Comput Model Objects Represent Images Fundam Methods Appl, (2007) 355–360.

8 Nabil C, Zoubeida M, Amina S &Naim R, Robust fuzzy c-means clustering algorithm using non-parametric Bayesian estimation in wavelet transform domain for noisy MR brain image segmentation, IET Image Process, 12(5) (2018) 652–660.

9 Wang G G, Suash Deb & Cui Z, Monarch butterfly optimization, *Neural Comput Appl*, (2015) 1–20.

10 Feng Y, Wang G G, Dong J & Wang L, Opposition-based learning monarch butterfly optimization with Gaussian perturbation for the large-scale 0-1 knapsack problem, *Comput Electr Eng*, **67** (2018) 454–468.

11 Zhang J & Meng X, A fabric defect detection system based on image recognition, *Proc 2010 2nd Int Work Intell Syst Appl* ISA, (2010)1–4.

12 Chisti Md K M, Kumar S S & Gandikota P, Segmenting the defective leather texture image using modified region growing with GWO technique, *J Adv Res Dyn Control Syst*, **10(4)** (2018) 458–470.