



# Survey on Various Defect Detection and Classification Methods in Fabric Images

M. Fathu Nisha<sup>1\*</sup>, P. Vasuki<sup>1</sup>, S. Mohamed Monsoor Roomi<sup>3</sup>

<sup>1</sup>Department of ECE, K. L. N. College of Information Technology, Madurai, TN, India

<sup>2</sup>Department of ECE, Thiagarajar College of Engineering, Madurai, TN, India

Received: 15.04.2017 Accepted: 13.05.2017 Published: 30-06-2017

\*m.fathunisha123@gmail.com

## ABSTRACT

Fabric defect detection is a necessary and essential step of quality control in the textile manufacturing industry. This paper has been reviewed the various fabric defect detection and classification methods of statistical, spectral, model based and structural approaches. This paper has been presented the survey on types of defects, detection accuracy, performance metric and inference from recent publications. It will benefit researchers and practitioners in image processing and computer vision fields in understanding the characteristics of the different defect detection approaches. It concludes that the pulse coupled neural network (PCNN) approach is better detection accuracy than the other methods and is suggested for further research.

**Keywords:** Computer vision; Defect classification; Fabric inspection.

## 1. INTRODUCTION

Fabric texture refers to the feel of the fabric. It is rough, velvety, smooth, soft, silky, lustrous, etc. The different textures of the fabric depend upon the types of weaves used. Textures are given to all types of fabrics. Textile fabric materials are used to prepare different categories and types of fabric products in the textile industry. Environment friendly natural fabric and synthetic fabric are the two different classifications of textile fabric. The deformed regions which damage the appearance and the fabric performance known as fabric defect. In a fabric, defects occur due to machine faults, yarn problems, poor finishing, excessive stretching and color bleeding.

Fabric defect detection is a process of identifying and locating defects. Fabric inspection is important for maintaining the quality of fabric. Traditional inspection process for fabric defects is human visual inspection which is insufficient and costly. The quality inspection process for textile fabrics is mainly performed manually. About 70% of fabric defects could be detected by the most highly trained inspectors. In textile industry improved performance in the inspection of fabrics leads to good product quality and contributes to increased profitability and customer satisfaction. Hence automatic fabric defect inspection is required to reduce the cost and time waste caused by defects.

Image processing methods, artificial intelligence methods are used for automatic defect detection. Different types of image acquisition devices such as digital camera, CCD line scan camera, area scan camera and scanner are used for capturing the fabric images.

## 2. DIFFERENT APPROACHES OF FABRIC DEFECT DETECTION AND CLASSIFICATION

### 2.1. Statistical Approaches

The objective of this method is to separate inspection image into the regions of distinct statistical behavior. An important assumption in this process is that the statistics of defect free regions are stationary and these regions extend over a significant portion of inspection images. Based on the number of pixels defining the local features, these approaches classified into higher order and lower order statistics. Higher order statistics (HOS) used the term skewness and kurtosis whereas the low order statistics (LOS) used the term mean and variance. Due to the higher powers, HOS are significantly less robust than lower order statistics. The use of statistical approaches is well distinguished in the field of computer vision and has been extensively applied to various tasks, and this method was reviewed in serial no of [1], [2], [3], [4], [9], [10], [11], [12], [13], [14], [17], [20], [21], [25], [29], [30] and [34] in Table 1.

## 2.2. Spectral Approaches

The primary objectives of these approaches are firstly to extract texture primitives, and secondly to model or generalize the spatial placement rules. Spectral approaches require a high degree of periodicity thus, it is recommended to be applied only for computer vision of uniform textured materials like fabrics. Spectral approach enabled to capture the most outstanding features of all defects and provide multi resolution of image. This method was used for image quality enhancement, noise reduction and feature extraction. For automated defect detection, Spectral approaches occupy a big part of the latest computer vision research work and this method was reviewed in serial no of [7], [19], [23], [24], [26] and [35] in Table 1.

## 2.3. Model Based Approaches

In this approach, the texture is regarded as a complex pictorial pattern and can be defined by a deterministic model. Model-based texture analysis methods try to generate the texture. Here model the texture by determining the parameters of a pre-defined model. Particularly, model-based approaches are suitable for fabric inspection when the statistical and spectral

approaches have not yet shown their utility. The advantage of the modeling is that it can produce textures that can match the observed textures. Model based approaches are particularly suitable for fabric images with stochastic surface variations and this method was reviewed in serial no of [21], [27] and [32] in Table 1.

## 2.4. Structural Approaches

In structural approaches, texture is characterized by texture primitives or texture elements, and the spatial arrangement of these primitives. These primitives can be as simple as individual pixels, a region with uniform gray levels, or line segments. Consequently, the main objects of these approaches are firstly to extract texture primitives, and secondly to model or generalize the spatial placement rules. The Placement rules can be obtained through modeling geometric relationships between primitives or learning statistical properties from texture primitives. However, these approaches were not successful on fabric defect detection, mainly due to the stochastic variations in the fabric structure (due to elasticity of yarns, fabric motion, fiber heap, noise, etc.) and this method was reviewed in serial no of [22] and [23] in Table 1.

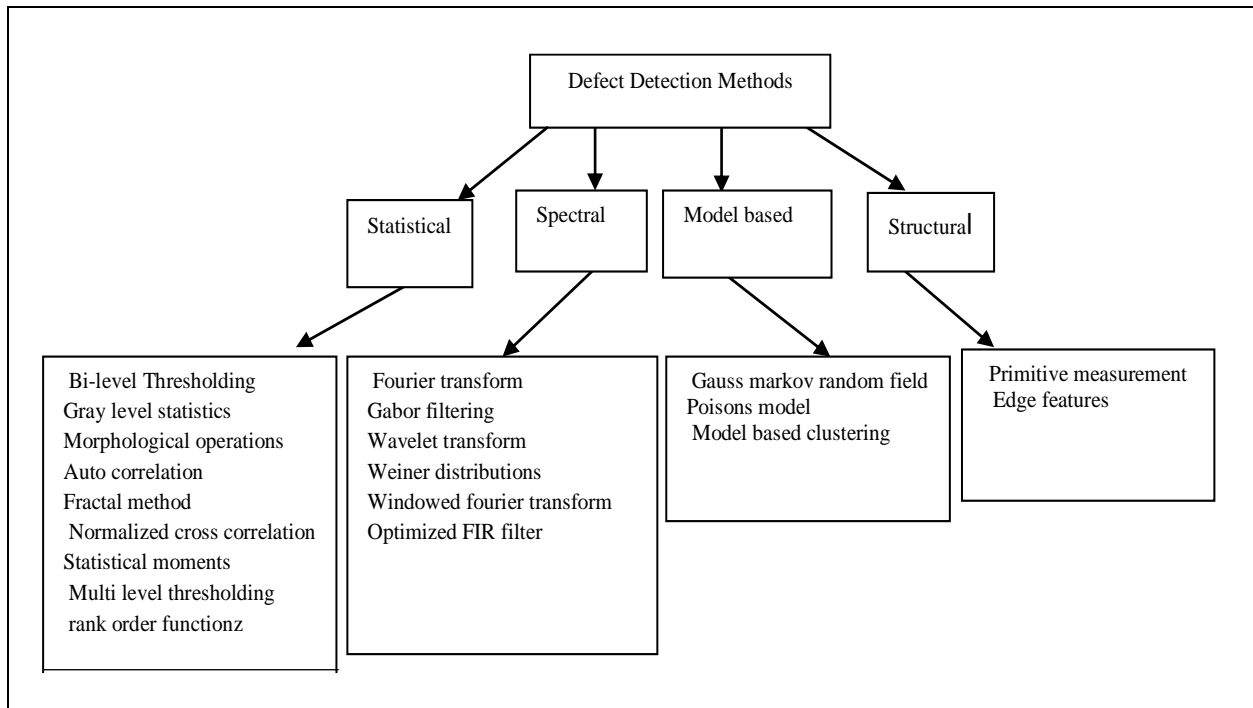


Fig. 1: Different defect detection and classification methods.

**Table 1. Different defect detection and classification methods.**

S. No.	Detection and classification technique	Input image	Type of defects detected	Detection accuracy	Performance metric	Inference
1.	Fisher criterion based stacked denoising auto encoding (FCSDA) (Yundong le <i>et al.</i> 2016)	Plain , twill fabric	Broken end, hole, netting multiple, thick bar, thin bar	98%	Learning rate, scaling factor, network depth, number of hidden layer units	High detection accuracy provided by this method even the negative samples are insufficient, Training process is time consuming.
2.	Genetic algorithm (Y.Kumbhar <i>et al.</i> 2016)	Textile color fabric	Threading defect, oil spot, color fading	90%	Homogeneity, contrast, correlation, hue, saturation,	This method used to detect the defects for a sample of a very large number of high quality images.
3.	Kernel principal component analysis (KPCA) (Junfeng Jing <i>et al.</i> 2016)	Uniform & Structured fabric	Hole, oil spot, thread error, objects on the surfaces	96%	Detection success rate, specificity, sensitivity	This method achieved high true detection rate and low cost for online fabric inspection.
4.	Pulse coupled neural network (PCNN) (Yundong Li <i>et al.</i> 2016)	Warp Knitted fabric	broken ends, loom fly, thin bar	98.6%	Mean, standard deviation	This hybrid method is suitable to run on an embedded system because of the low computation. The system applied in defect inspection for warp knitting machine.
5.	GIMP Retinex filtering (Amelio Carolina Sparavigana <i>et al.</i> 2016)	Textile woven fabric	Mispick	92%	Image size, scale division, dynamic slider	This method is used to help human vision for instance detecting tiny flaws of the fabric.
6.	Feature extraction technique, graph based segmentation (Prasad dakhole <i>et al.</i> 2016)	Color fabric image	Needle cutting, oil stain	89%	Form factor, rectangularity factor, location, orientation, intensity based features, moment based features	This method not required any adjustment, finding the better accuracy and less time consumption in the industry.
7.	2D Fast fourier transforms (FFT) (George bardi <i>et al.</i> 2016)	Woven fabric	Hole, excessive margin	78%	Yarn distance, energy distribution parameter, maximum energy parameter, displacement, speed	This method determined yarn paths even in highly draped border regions of the surface. So the influence of different settings on fiber orientation is easily evaluated.

8.	Small scale over completed dictionary of sparse coding (SSOCD) (Feng <i>et al.</i> 2016)	Twill fabric	Mispick, Broken pick, buckling, tom selvedge, rough selvedge, fuzzy ball, bore, yarn, double flat, yarn evenness, pulled in selvedge, oil warp	93.7%	Reconstruction error, sum of the absolute value of projection, largest absolute value of projection, distance between the image, average of trained samples, Size of image patches	The algorithm was run with high parallel efficiency. detection result was easily affected by noise through, illumination changing, fabric grain fluctuating, etc.
9.	Back propagation algorithm (Akshay V.Nalawade <i>et al.</i> 2016)	Textile woven fabric	Oil spot, horizontal defect, vertical defect	88%	Entropy, homogeneity, contrast, wavelets, fractals	This method was reliable for fabric inspection system in textile Industries.
10.	Artificial neural network, back propagation pattern reorganization technique (Gangandeeep singh <i>et al.</i> 2016)	Woven fabric	3 types of defects	93.3%	5 features	The efficiency of this model was reliable to find the defects in fabrics. This algorithm is not appropriate for all types of defects.
11.	Artificial neural network (ANN) (karunamoorthy <i>et al.</i> 2015)	Patterned fabric image – star pattern, dot pattern, box pattern	Oil stain, stab cut, hole, broken end, netting multiple, thin bar,	95%	Divergence factor, mean standard deviation	Image decomposition with ANN classifier provided best defect detection result among all testing methods
12.	Local binary pattern technique(LBP) (Lei zhang <i>et al.</i> 2015)	Textile fabric	6 types of defects	97.6%	Angular second moment, contrast, correlation, entropy	In this method, GLCM features and LBP features are combined. So accuracy is increased.
13.	Morphological filtering (Vikrant tiwari <i>et al.</i> 2015)	Woven fabric	Shrinking, abrasion, holes, stain, broken ends	93.2%	Average gray level, average contrast	Defects from other regions are differentiated in the image by this method even in the presence of certain prints in the fabric.
14.	Auto correlation function (Dandan zhu <i>et al.</i> 2015)	Yarn dyed fabric	Holes, weft crackiness, broken weft, wrong weft, oil stain	90%	Inter pixel distance, inter pixel orientation, euclidean distance, size of detection window,	High accuracy, better adaptability is provided by this method
15.	Rough set classifier (Sudarshan Deshmukh <i>et al.</i> 2015)	Regular patterned fabric	Oil warp, oil weft, missing pick, thin bar, thick bar	96%	Flaw area, dispersion, aspect ratio, euler number, maximum of	This method took 0.2 seconds to detect the flawed areas and classify the type of each flawed area. This system

					gray value, minimum of gray value, mean of gray value,	suitable for on line real time application.
16.	K-Nearest neighbor classification, (KNN) (Gede surya rahayuda <i>et al.</i> 2015)	Endek fabric bali - one form of craft woven fabric	Classification of different types endek bali fabrics	57.50%	Contrast, correlation, energy, homogeneity	More data samples used in this method to improve the accuracy.
17.	Gray level co-occurrence matrix(GLCM) (Pritpal Singh <i>et al.</i> 2015)	Design fabric	Deviated quality	88%	Contrast homogeneity, auto correlation, energy	Fabric quality can be estimated. Fine tuning used to accurately distinguish the minor offset in design pattern.
18.	Rule based approach (Basavaraj <i>et al.</i> 2015)	Color fabric	Shades of basic color fabric	97.6%	Mean, standard deviation	The work was applied in automation in apparel industry, namely, readymade garments, knitwear, formal ware, cotton dress materials, etc.
19.	Radon signature and Discrete wave let transform (DWT) (Rakhil <i>et al.</i> 2015)	Plaid, striped patternless and irregular fabric	Gout, stain, hole broken filaments, float, drop Stitches	90%	Variance, energy, uniformity, entropy	This method applied to patternless fabrics and patterned fabrics of different types. This method is adopted in the textile manufacturing units by combining with control and automation using microcontrollers.
20.	Artificial neural network (ANN) (Banumathi <i>et al.</i> 2015)	Plain woven fabric	Hole, oil stain	89%	Mean, energy, standard deviation, entropy, skewness, kurtosis,	High detection accuracy is provided by this method.
21.	Fuzzy clustering (dorian Schneider <i>et al.</i> 2014)	Plain, twill, satin, fabric	weave error rate, weave class,	97%	Weft density, warp density, random sampling, sensitivity	Detection is done without any prior knowledge of the fabric, so called as blind weave detection
22.	Canny edge detection (Halimi Abdellah <i>et al.</i> 2014)	Textile fabric	Vertical missing yarn, horizontal missing yarn, hole, spot	94.84%	Area of defective region, total area of window size, centroid of defective parts	Fast detection and extraction of fabric defects from the images of textile fabric is done by this method
23.	Discrete wavelet transform DWT)(Ibrahim Celik <i>et al.</i> 2014)	Un dyed denim fabric sample	Warp lacking, weft lacking, soiled yarn, hole, knot or yarn flow	83% for off line 88% for real time	Average gray level, average contrast, smoothness, entropy, correlation	The defective areas of the fabric sample are detected successfully and the boundaries of them are labeled.

24.	Discrete cosine transform (DCT) (Semiyaa <i>et al.</i> 2014)	Plain & Patterned fabric	No defect, weaving defect in weft direction, weaving defect in warp direction, holes, oil spot	97%	Energy, contrast, correlation cluster prominence, horizontal, vertical, diagonal energy value	This method is simple to understand. This method was give good defect detection performance.
25.	Artificial neural network (ANN) (Birdar <i>et al.</i> 2014)	Knitted fabric	Missing yarn, hole, spot,	92%	Defective area, height to width ratio of defective window,	Size of defective window is calculated
26.	Discrete cosine transform (DCT) (Ali Rabhi <i>et al.</i> 2014)	Woven fabric	Excessive margin, hole	97.8%	Detection success rate, sensitivity, specificity	This work easily extended for color images by applying the different algorithm steps on the RGB image components.
27.	Neuro fuzzy classifier (Mohamed eldessouki <i>et al.</i> 2014)	Plain woven fabric	Wrong draw, warp slub, stop mark, holes, blotch woven fabric	95%	Spatial and spectral features	More data samples used in this method to improve the accuracy.
28.	Bi dimensional empirical mode decomposition (Zhengxin li, <i>et al.</i> 2014)	Synthetic fabric	Broken end, broken pick, bars, stitches, foreign fiber,	96.1%	Intrinsic mode function fusion	proposed method is a robust and accurate approach for fabric defect inspection.
29.	Principal component analysis (PCA) (Lucia Bissi <i>et al.</i> 2013)	Uniform, structured fabric, wool	Hole, oil spot, thread error, objects on the surfaces	98.1%	Gabor generating function, kernel size, correction gain	This method is reduced computational cost up to 33% e.
30.	Feed forward neural network (FFNN) (Nasira <i>et al.</i> 2013)	Plain woven fabric	Stain, hole, weft float type fault, warp float type fault	94.6%	Mean, standard deviation	In this method, inspection time was reduced, high accuracy than manual inspection system
31.	Sliding window technique (Jagdish lal rahya <i>et al.</i> 2013)	Woven fabric	Holes, weft crackiness	90.1%	Contrast homogeneity, auto correlation, energy	The algorithm is simple, and its decision making process is modified for extension. The response time is quite good and easily implemented in industrial applications.

32.	Multi resolution combined statistical and spatial frequency (MRCSF) (.Sabeenian <i>et al.</i> 2012)	Hand loom silk fabric	Missing ends, float, shuttle smash, temple marks, stain hole	96.6%	Mean, energy, variance, entropy, maximum probability	This method provide a good success rate of classification
33.	Canny edge detection (Halimi Abdella <i>et al.</i> 2012)	Woven fabric	Hole	89.2%	Area, perimeter, compactness	Type and shape of defect is calculated by this method. This work is useful for inspecting industrial materials
34.	Histogram equalization (R.thilepa <i>et al.</i> 2010)	Textile color fabric (digital image)	Hole, scratch, dirt spot, fly, crack point, color bleeding , fading	85%	Optimal threshold value	Computation time is less
35.	Fast fourier transform (FFT) (Swati F, Bhope <i>et al.</i> 2010)	Textile fabric	Broken fabric, missing yarn, variation of yarn, double pick defect	88%	Intensity difference	Structural defect is identified by this method, efficiency is increased.

### 3. CONCLUSION

Various methods of defect detection and classification of fabrics and quality and quantity metrics are reviewed in Table 1. There are several comparative studies in the literature that evaluate texture analysis methods in application to defect detection. K-nearest neighbor classification, discrete wavelet transform techniques provide low detection accuracy while the principal component analysis, pulse coupled neural network, local binary pattern techniques provide high accuracy and less inspection time. It must be noted that different studies use different data sets and possible different performance parameter settings. The resolution of the images used for the detection process also important and are not affect the environment. Here the size of the image affects the efficiency of the algorithm. Although a solid conclusion cannot be drawn to determine the best method for defect detection, statistical and model based methods have been more popularly applied for fabric Inspection.

### FUNDING

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

### CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

### COPYRIGHT

This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC-BY) license (<http://creativecommons.org/licenses/by/4.0/>).



### REFERENCES

- Akshay V. Nalawad, Pramod H. Narkhede, Swapnil B. Hande, Ganesh K. Sarade and Ranjeet S. Pisal, Fabric inspection system using artificial neural networks, *Int., J. of Adv. Res. Elec. Comm., Engg.*, 5(1), 153-156(2016).
- Asha, S. and Rakhil, K. S., Improved fabric defect detection and pattern classification using radon transform, *Int. J. Innovative Res. Sci. Engg. Tech.*, 4(7), 5476-5484(2015).  
<https://doi.org/10.15680/ijirset.2015.0407087>
- Ali Rebhi, SabeurAbid and FarhatFraeich, Texture defect detection using local homogeneity and discrete cosine transform, *World Applied sciences Journal*, 31(9), 1677-1683(2014).  
<https://doi.org/10.5829/idosi.wasj.2014.31.09.156>

- Alam, F. I. and Faruqui, U., Optimized Calculations of Haralick Texture Features, *European J. of Scientific Research*, 543-553(2011).
- Asha, V., Bhajantri, N. U. and Nagabhushan, P., GLCM based chi-square histogram distance for automatic detection of defects on patterned textures, *Int. J. Computational Vision and Robotics*, 2(4), 302-313(2011).  
<https://doi.org/10.1504/IJCVR.2011.045267>
- Ajay Kumar, Member, Computer vision based fabric defect detection: A survey, *IEEE Trans. Industrial Elec.*, 55(1), 348-363(2008).  
<https://doi.org/10.1109/tie.1930.896476>
- Bhavini Patel and Hetal Bhaidasna, Survey on different methods for Defect Detection, *Int., Res. J. Engg. Tech.*, 3(2), 1217-1220(2016)
- Basavaraj S. Anami and Mahantesh C. Elemmi, A rule based approach for classification of shades of basic colors of fabric images, *Int. J. of Signal Processing, Image Processing and Pattern Recognition*, 8(2), 389-400(2015).  
<https://doi.org/10.14257/ijisp.2015.8.2.36>
- Basturk, K., Ketencioglu, H. and Yugnak, Z., Inspection of defects in fabrics using Gabor wavelets and principle component analysis, *Signal Processing and its Applications*, 01-04(2007).  
<https://doi.org/10.1109/ISSPA.2007.4555353>
- Choudhary, D., Ajay Kumar Singh, Shamik Tiwari and Shukla, V. P., Performance Analysis of Texture Image Classification Using Wavelet Feature, *Int., J., Image, Graphics and Signal Processing*, 1, 58-63(2013).  
<https://doi.org/10.5815/ijigsp.2013.01.08>
- Dandan Zhu, Ruru Pan and Wiedong Gao, Yarn dyed fabric defect detection based on autocorrelation function and GLCM, *AUTEX Research J.*, 15(3), 226-232(2015).  
<https://doi.org/10.1515/aut-2015-0001>
- Eldessouki, M., Hassan, M., Qashqari, K. and Shady, E., Application of principal component analysis to boost the performance of an automated fabric fault detector and classifier, *Fibers and Textiles in Eastern Europe*, 51-57(2014).
- Farsi, H. and Mohamadzadeh, S., Color and texture feature based Image retrieval by using hadamard matrix in discrete wavelet transform, *Image Processing*, 7(3), 212-218(2013).  
<https://doi.org/10.1049/iet-ipt.2012.0203>
- Georg Bardi, Andreas Nocke, Chokri Cherif, Matthias Pooch, Martin Schulze, Henning Heuer, Marko Schiller, Richard Kupke and Marcus Klein, Automated detection of yarn orientation in 3D draped carbon fiber fabrics and performs from eddy current data, *Composites Part B: Engineering*, 96, 312-324(2016).  
<https://doi.org/10.1016/j.compositesb.2016.04.040>
- Gangandeeep Singh, Gurpadam Singh and Mandeep Kaur, Fabric Defect Detection using series of image Processing Algorithm & ANN operation, *Global J., Comp. Tech.*, 4(2), 225-228(2016).
- Gede Surya Rahayuda, Texture Analysis on image Motif of Endek bali using K-nearest neighbor Classification method, *Int. J. Adv. Comp. Sci. Appl.*, 6(9), 205-211(2015).
- Halimi Abdellah, Roukhe Ahmed and Ouhmad Slimane, Defect detection and identification in textile fabric by SVM Method, *IOSR J. Eng.*, 4(12), 69-77(2014).
- Halimi Abdellah, El kouraychi abdelmajid, Bouzzid Abdenabi and Roukhe Ahmed, Defects detection and extraction in textile imageries using mathematical morphology and geometrical features, *J., Signal Processing Theory and Applications*, 1, 01-16(2012).  
<https://doi.org/10.7726/jspta.2012.1001>
- Ibrahim Celik, Cannan Dulger and Mehmet Topalbekiroglu, L., Fabric defect detection using linear filtering and morphological operations, *Indian J. Fibre and Textile Research*, 39(3), 254-259(2014).
- Junfeng Jing, Xiaoting Fan and Penegfei Li, Automated Fabric Defect Detection based on Multiple Gabor Filters and KPCA, *Int. J. of Multimedia and Ubiquitous Eng.*, 11(6), 93-106, (2016).  
<https://doi.org/10.14257/ijmue.2016.11.6.09>
- Jagdish Lal Raheja, Bandla Ajay and Ankit Chaudhary, Real time fabric defect detection system on an embedded DSP platform, *Int. J. Light and Electron Optics, Elsevier*(2013).  
<https://doi.org/10.1016/j.ijleo.2013.03.038>



- Jagdish Lal Raheja, Sunil Kumar, Fabric defect detection based on GLCM and Gabor filter: A comparison, 124(23), 6469–6474(2013).  
<https://doi.org/10.1016/j.ijleo.2013.05.004>
- Jayanta K. Chandra, Pradipta K. Banerjee and Asit K. Datta, Neural network trained morphological processing for the detection of defects in woven fabric, *J. Textile Institute*, 101(8), 699-706(2010).  
<https://doi.org/10.1080/00405000902812735>
- Karunamoorhy, B., Somandareswari, D. and Sethu, S. P., Automated Patterned Fabric Fault Detection using Image Processing Technique in Matlab, *Int. J. Adv. Res. Comp. Eng. Tech.*, 4(1), 63-69(2015).
- Le Tong, Wong, W. K. and Kwong, C. K., Differential evolution based optimal Gabor filter model for fabric inspection, *J. Neurocomputing*, 173(3), 1386-1401(2016).  
<https://doi.org/10.1016/j.neucom.2015.09.011>
- Lei Zhang, Junfeng Jing and Hongwei Zhang, Fabric defect classification based on LBP and GLCM, *J. Fiber Bioengineering and Informatics.*, 8(1), 81-89(2015).  
<https://doi.org/10.3993/jfbi03201508>
- Md. Ashrafal Alam, Naushad Ali, M. M., Musaddeque Anwar Al-Abedin Syed, Nawaj Sorif and Md. Abdur Rahaman, An algorithm to detect and identify defects of industrial pipes using image processing, *IEEE*.(2014).  
<https://doi.org/10.1109/SKIMA.2014.7083567>
- Marini, A., Facon, J. and Koerich, A. L., Bird species classification based on color features, *IEEE International Conference*, 4336-4341, (2013).  
<https://doi.org/10.1109/smc.2013.740>
- Marcos Yutaka Shiinoa, Maria Odila Hilário Cioffia, and Herman Jacobus Cornelis Voorwald, Evaluation of stitched fabric composite processed by RTM in Quasi-static test, *Science Direct Procedia Engineering*, 10, 2603–2608(2011).  
<https://doi.org/10.1016/j.proeng.2011.04.434>
- Meihong Shi, Rong Fu, Yong Guo, Fabric defect detection using local contrast deviations, *Springer*, 52, 147-157(2011).
- Nasira and Banumathi, P. M., Plain woven fabric defect detection based on image processing and artificial neural networks, *Int. J. Comp. Trends Tech.*, 6(4), 226-229(2013).
- Ngan, H. Y. T., Pang, G. K. H. and Yung, N. C. H., Automatic Fabric Defect Detection a Review, *Image and Vision Computing*, 29, 442-458(2011).  
<https://doi.org/10.1016/j.imavis.2011.02.002>
- Prasad Dakhole, Shruti kalode and Ankit Patel, Fabric fault detection using image processing matlab, *Int. J. Emerging Trends Engg. Management Res.*, 2(1), (2016).
- Pritpal Singh and Prabhjyot Singh, Texture analysis in Fabric material for Quality evaluation using GLCM matrix, *Int. J. Applied Engg. Tech.*, 5(1), 01-05(2015).
- Parmeetkaur Randhawa, Uppal and Raju Sharma, Automatic detection and classification of fabric defects using large margin nearest neighbor method, *Int. J. Tech. Engg. Sci.*, 2(6), 1943-1946(2014).
- Priyanka M. Shanbhag, Manish P. Deshmukh and Shekhar R. Suralkar, Overview: Methods of Automatic Fabric Defect Detection, *Global J. Eng. Design Technol.*, 1(2), 42-46(2012).
- Pan R. R., Weidong, QIAN Xinxin, ZHANG Xiaoting, Automatic analysis of woven fabric weave based on notation, *J. Textile Res.*, 30(11), 30-34(2010).
- Revathy, G. and Vidhyalakshmi, P., Defect classification in fabric web material using lab view, *Int. J. Comp. Appl.*, 63(18), 44-48(2013).
- Sudarshan Deshmukh, S., Raut, S. S. and Biradar, M. S., Defect detection of regular patterned fabric by spectral estimation technique and rough set classifier, *Int. J. Innovative Sci. Engg. Tech.*, 2(4), 760-768(2015).
- Semiyya, E., Jothi, R. L. and Najuma, E., Automatic fabric defect detection using spatial and spectral features, *Int. J. Engg. Res. Tech.*, 3(12), 1019-1023(2014).
- Schneider, and Dorit Merhof, D., Blind Weave Detection for Woven fabrics, Springer, *Dorian Pattern Anal. Appl.*, 725-737(2014).
- Sheetal Thorave and Biradar, M. S., New technology for fabric defect detection based on K-means algorithm, *IOSR J. Engg.*, 4(3), 15-20(2014).
- Szczypiński, P., Klepaczko, A., Pazurek, M. and Daniel, P., Texture and color based Image Segmentation and Pathology detection in Capsule endoscopy videos, *Computer methods and programs in biomedicine*, 113(1), 396-411(2014).  
<https://doi.org/10.1016/j.cmpb.2012.09.004>
- Sabeenian, R. S., Paramasivam, M. E. and Dinesh, P. M., Computer vision based defect detection and identification in handloom silk fabrics, *Int. J. of Comp. Appl.*, 42(17), 41-48(2012).

- Swati F. bhope and Patil, S. P., Defects Identification in Textile Industries, *Int., J., of Chemical Sci.,and Appl.*, 37-41(2010).
- Tiangpeng Feng, Lian Zou, Jia Yan, Wenxuan Shi, Yifeng Liu, Cien Fan and Dexiang Deng, Real time fabric defect detection using accelerated small scale over completed dictionary of sparse coding, *Int. J. Advanced Robotic Systems.*, 13(1), 01-09(2016).  
<https://doi.org/10.5772/62058>
- Vikrant Tiwari and Gaurav Sharma, Automatic fabric fault detection using morphological operations on bit plane, *Int. J. Comp. Sci. Network Security*, 15(10), 30-35(2015).
- Vaibhav V. Karlekar, Biradar, M. S. and Bhangale, K. B., Fabric Defect Detection using Wavelet Filter, *International Conference on Computing Communication Control and Automation, IEEE.*, (2015).  
<https://doi.org/10.1109/ICCUBEA.2015.145>
- Xianghua Xie, Review of recent advances in surface defect detection using texture analysis techniques, *Electronic Letters on Computer Vision and Image Analysis*, 7(3), 01-22(2008).
- Yundong Li, Weigang Zhao and Jiahao Pan, Deformable Patterned Fabric Defect Detection with Fisher Criterion based Deep Learning, *IEEE Trans. on Automation Sci. Engg.*, 01-09(2016).
- Yin KaiCheng. and Yu Weidong, Clothing Defect Detection carbon-fibre-reinforced plastics (CFRP) using Multi-frequency Eddy current sensors, *IEEE Instrum. Meas., Technol. Conf. Proc.*,(2007).
- Yousif Mohamed Y. Abdulla, Ali Hayder and Eltayeb Wagiallah, Automatic Enhancement of Mammography Images using Contrast Algorithm, *Int. J. Sci. Res.*, 3(9), 1885-1889(2012).