Automate Fabric Defects Inspection using Different Techniques

Payal Bansal, Monica Sikka and Awadhesh Kumar Choudhary

Department of Textile Technology,
National Institute of Technology,
Jalandhar-144011, Punjab, India

Abstract:
In garment industry quality inspection at each step of garment production has become important aspect. The fabric defects inspection process is still carried out with manual inspection. The problems of manual inspection of fabric defect are lack of accuracy, time and cost effective. Now a day's to reduce error on identifying fabric defects requires accurate inspection process. The accurate fabric defect detection is done by automate fabric inspection using different techniques and mathematical model. In these techniques, analysis of texture content in digital images plays an important role in the automated visual inspection. For successful automated fabric defect inspection system two things are more important viz. defect detection and defect classification. In this review paper, different techniques namely; artificial neural network, fuzzy logic and finite element method which used for automated fabric defect detection and defect classification are discussed. The knowledge of various techniques is expected to be very useful for the researchers in the area of automated fabric defect inspection to understand and evaluate the many potential options in this field.

Keywords: Artificial neural network, fuzzy logic and finite element method.

1. Introduction

The textile industries mainly focus on fabric quality and productivity of the fabrics produced because they face broaden amount of losses due to faulty fabrics. In textile sectors, different types of faults are available i.e. hole, scratch, stretch, fly yarn, dirty spot, slub, cracked point, color bleeding, stitching defects etc; if not detected properly these faults can affect the production process massively[1,2]. In many industries textile material are still detected by human inspection which is very tedious and time consuming process. They have to detect small details that can be located in a wide area that is moving through their visual field. The problems of manual inspection of fabric defect are lack of accuracy, time and cost effective [3]. Now a day's to reduce error on identifying fabric defects requires accurate inspection process. Defect inspection is a quality control process that identifies and locates deficiencies in the fabric manufactured in the textile industry. Hence, an automatic inspection system becomes an effective way to improve textile quality because of the progress of machine and computer vision technology [4]. Detection of fabric faults can be done by considering fabric texture and analyse these texture through different techniques like artificial neural network, Fuzzy logic and finite element method. These techniques nowadays gain more popularity for fabric inspection in textile and clothing industries [5,6,7]. The fabric analysis and classification is performed on the basis of digital images of the fabric. Digital image processing techniques have been increasingly applied to textured samples analysis over the last ten years. Several authors have considered defect detection on textile materials using digital images processing and analyse using different techniques. This review paper focuses on the model-based inspection of textured materials. These techniques will serve as a platform for development of more robust fabric defect detection and classification systems.

2. Fabric Defects

The occurrence of fabric fault makes the final garment product defective. The poor quality of raw materials and improper conditioning of yarn results in fabric quality defects and effects such as color or width inconsistencies, slubs, broken ends, gout, warp float, drawback, hole, dropped stitches, and press-off etc as shown in figure 1. The fabric defects cause about 85% of the defects detected in the garment industry due to which fabric prices decrease by 45%–65%. It is therefore of great importance that these defects are detected, recognized and prevented from reoccurring [4,8].

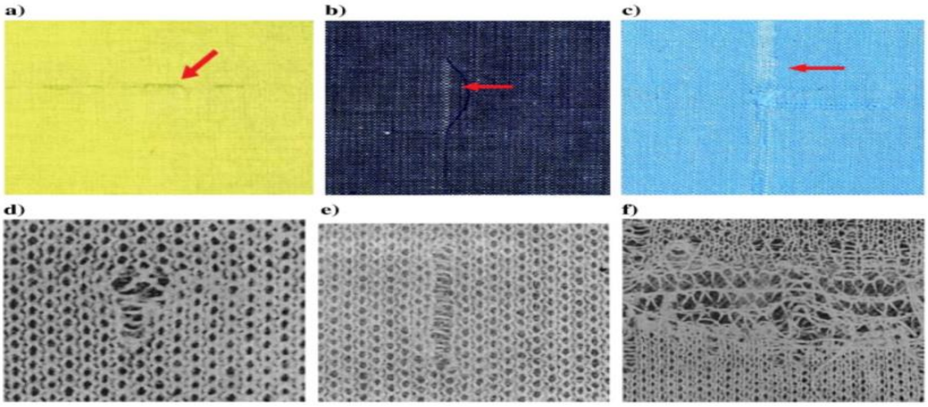

Figure 1: (a) gout, (b) warp float, (c) drawback, (d) hole, (e) dropped stitches, and (f) press-off.

3. Pre-processing of Image

The pattern recognition, image processing and feature extraction starts from an initial set of measured data and builds derived values. The pre-processing of image is method to extract frames from the image of the fabric for further processing as shown in figure 2. The image is taken using high resolution cameras. After the image is taken, the image is converted into individual frames using frame grabbers. In the recently developed smart cameras, the camera itself will have the inbuilt frame grabbers. The extracted key frames are pre-processed in next step. It is very difficult to isolate the minor faults from its texture pattern as the minor faults appear as small one on the web fabric image. Hence it should be pre-processed. The pre-processing is carried out by converting the colour image into Gray scale image and then adjusting the brightness of the image [9].

4. Feature Extraction

The feature extraction techniques are applied to get features that will be useful in classifying and recognition of images as shown in figure 2 and 3. Feature extraction techniques are helpful in various image processing applications e.g. character recognition. As features define the behaviour of an image, they show its place in terms of storage taken, efficiency in classification and obviously in time consumption also. Features such as shape, texture, color, etc. are used to describe the content of the image[9,10].

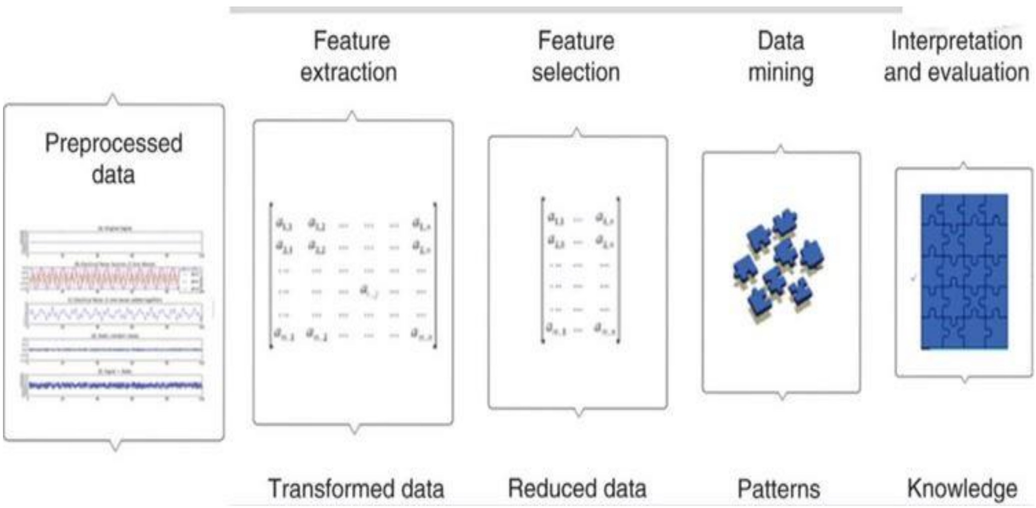

Figure 2: Feature extraction techniques

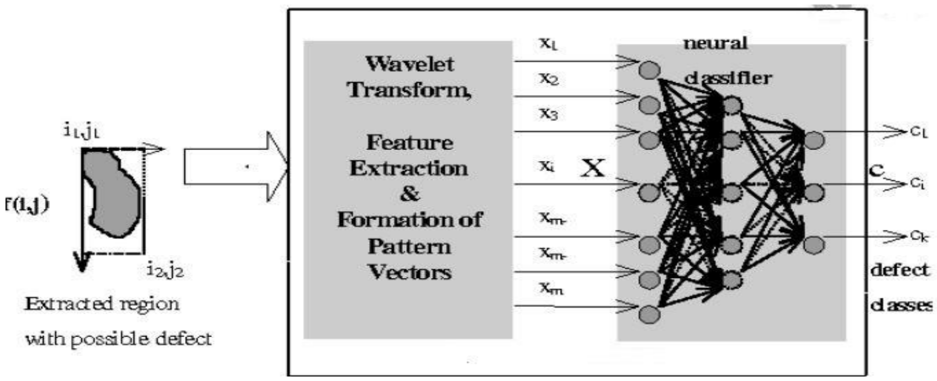

Figure 3: Fabric defect classifications using neural network

5. Artificial Neural Network

Artificial neural network is a method of computation and information processing which can be used to extract patterns/image and detect trends that are too complex to be noticed by either humans or other computer techniques. A study on automated textile defect recognition system using computer vision and artificial neural networks has been done by Atiqul et.al. In this research mainly focuses on combine effect of image processing and artificial neural networks in textile industries [11].The experimental work on automatic defect detection algorithm for woven fabric using artificial neural network techniques was conducted by G. M. Nasira[12]. The result revealed that when extracted features are given as input to the artificial neural network, it identifies the fabric defect. Islam et al. [13] have designed their ANN trained by resilient back propagation algorithm in order to deal with multiclass problem. They have worked with more than 2 types of defects. That means they have considered two types of defects as two major types and all other types of defects as a single major type. The area, number of parts and sharp factor of defect have been used by them as features and therefore the feature number has become too small. Moreover, they have justified the features very little. They got some success because the sample size was small. There is a great chance that their approach will poorly classify defects due to this small number of features when the sample size tends to be much large. Learning vector quantization (LVQ) algorithm was applied by Shady et al. [14] so as to train their ANNs. Their ANNs have been implemented in order to handle multiclass problem. They have used six types of defects. Separately work has taken place in defect detection process for spatial and frequency domains. That means statistical technique and spectral technique, i.e. Fourier transform, have separately been deployed for detecting defects. In case of statistical technique, a grid measuring scheme has been used for calculating the row and column vectors of images. Karras et al. [15] have also separately used two ANNs. One ANN has been trained by back propagation algorithm. The other ANN used by them is Kohonen's Self-Organizing Feature Maps (SOFM). First and second order statistical-texture features have been used for both ANNs. Both of the ANNs have been designed to solve binary classification problem, i.e. categorization of only defective and defect-free. Gagandeep singh investigated the performance evaluation of fabric defect detection using series of image processing algorithm and ANN operation [16]. This investigation gives comparison between fabric defect using FFT, fabric defect inspection system using neural network and the proposed method was drawn which based on certain performance parameters. From the comparative analysis it was obtained that the proposed algorithm has shown effective results. Yuen et al. (2009a) presented a novel hybrid model through integration of Genetic Algorithm (GA) and neural network to classify the type of garment defects [17]. They developed a segmented window technique to segment images into several classes using monochrome single loop rib work of knitted garment. Four types of feature characteristics were extracted and were used as input to a BPNN to classify the sample images. Their experimental result shows very high accuracy rate of recognition and thus provides decision support in defect classification.

6. **Fuzzy logic**

A fuzzy expert system is an expert system that uses a collection of fuzzy membership functions and rules, instead of Boolean logic, to reason about data**.** Fuzzy Logic system consists of three steps namely fuzzification, fuzzy inference method, defuzzification**.** Boubaker Jaouachi studied the evaluation of the residual bagging height using the regression technique and fuzzy theory [18]. In this study, the residual bagging height behaviour of knitted fabrics was investigated using some influential input parameters in a specific experimental design of interest. A comparison between experimental and theoretical results shows that the fuzzy modelling method is still better to evaluate and predict the residual bagging height. An intelligent scheme for fault detection in textile web materials was investigated by K.V. Naveen Kumar [19]. The results obtained shows that the proposed fabric fault inspection using Fuzzy logic implemented with LabVIEW provides about 23.66% better result in identifying the types of faults and about 10.83% better result in classifying them when compared to the existing micro controller based automated fabric inspection method. A. Luna-Avilés studied the locating and classifying defects with artificial neural networks and fuzzy [20]. In the development of this work, the results obtained in the localization and classification of defects with ANN, were compared with those obtained with ANFIS. In all cases, neuro fuzzy analysis gave better results.

7. Finite element methods

The use of the finite element in engineering applications has grown rapidly in recent years. Finite element analysis (FEA) is based on numerical computation that calculates all given parameters and boundaries. Nader Khadamalhosseini studied on modeling of impact damage of sewing machine needle on woven fabric by finite element method [21]. In this study to quantify the damage of woven fabrics punched by sewing needles in experimental and simulation work, a damage index is introduced. The study conclude that both manual and simulation procedures indicated that the needles with larger diameter increase the fabric damages. Lim et.al. investigated the finite-element simulation of ballistic impact on fabric based on a continuum shell, which incorporates visco elasticity[22]. The study on Finite element analysis of sewing process was done Mallet and Du[23]. In this study FEM was used to analyze sewing needle forces and measured the deformation of fabric specimens. Another experiment on simulation of ballistic impact on fabric armour using finite element method has been conducted by Isfahani et.al.[24]. In this experiment the poisson coefficient of warp and weft yarns was assumed to be zero for analysis the ballistic impact on fabric. Shahkarami et.al. studied the continuum shell finite element model for impact simulation of woven fabrics[25]. In this experimental work the analytical model is implemented in the commercial explicit finite element code, LS-DYNA, as a user material routine (UMAT) for shell elements. This approach provides an efficient numerical model for the dynamic analysis of multi-layer fabric structures while taking into account several geometrical and material attributes of the yarns and the fabric. Gaurav et.al. investigated on the finite element analysis of woven fabric impact using multiscale modeling techniques[26]. This investigation shows a multiscale modeling technique to simulate the impact of flexible woven fabrics. The yarns are modeled using both solid and shell finite elements. A systematic approach is presented to determine geometric and material parameters of the homogenized zone. The limitations of using shell elements to model the yarn level architecture underneath the projectile are addressed.The numerical modelling of ballistic impact response at low velocity in aramid fabrics was studied by Norberto et.al.[27]. In this study, the effect of the impact angle of a projectile during low-velocity impact on Kevlar fabrics has been investigated using a simplified numerical model. Also after a parametric study related to the number of layers and angle of impact, using a response surface methodology, a mechanistic model and a surface diagram have been presented in order to help with the calculation of the ballistic limit.

8. Conclusion

In this review paper a brief description of the automated fabric defect detection techniques are given. These techniques viz. artificial neural network, fuzzy logic and finite element method are mostly used for detection of fabric defects. The purposes of these techniques are to reduce the labour cost, time, increase the productivity of the products and as well as increase accuracy in the inspection process. The researchers have studied the fabric defect detection using combine effect of image processing and these techniques. To understand the formation and nature of the defects, it is important to be able to accurately localize the defective regions which are recognizing by digital image. So the recognizer should be acquires digital fabric images by image acquisition device and normalizes the image after pre-processes. The features are extracted from the pre-processed image. The extracted features are input to these techniques viz. artificial neural network, fuzzy logic and finite element method for further process. Also, it has been seen that many algorithm are used like back-propagation algorithm and self-organizing feature maps for inspection process. In some reported work, only defective and defect-free classification was done which does not fulfil the ultimate need of fabric defect classification. The each defect during fabric inspection should be properly classified. Moreover, they have justified the features very little because the sample size was small. There is a great chance that their approach will poorly classify defects due to this small number of features when the sample size tends to be much large.

9. References

1. Kang T.J. et al. “Automatic structure analysis and objective evaluation of woven fabric using image analysis” , Textile Res. J. 71(3), 261-270 (2001).
2. R anden T. and Hakon-Husoy J., "Multichannel filtering for image texture segmentation", Opt. Eng. 33 (8), 2617-2625 (1994).
3. Kumar A., “Computer-vision-based fabric defect detection”, IEEE Trans. of Industrial Electronics, 55(1),348-363 (2008).
4. Mahajan P.M., Kolhe S.R. and Patil P.M, “A review of automatic fabric defect detection techniques” Advances in Computational Research, 1(2),18-29 (2009).
5. Prajakta A.Jadhav and MS Biradar, “Wavelet based features for defect detection in fabric using genetic algorithm”, IOSR journal of Computer Engineering,16(3),116-120 (2014).
6. Fan J., Newton E., Au R. and Chan S.C.F., “Predicting garment drape with a fuzzy-neural network”, Text. Res. J., 71(7), 605-608 (2001).
7. Kumar A., “Neural network based detection of local textile defects”, Pattern Recognition, 36, 1645 – 1659 (2003).
8. X. Xie, “A review of recent advances in surface defect detection using texture analysis techniques,” Electronic Letters on Computer Vision and Image Analysis, 7(3), 1-22 (2008).
9. A. Kumar, “Computer-vision-based fabric defect detection: A Survey,” IEEE Transactions on Industrial Electronics, 55(1), 348-363 (2008).
10. Ryszard S. and Chora´ S., “Image feature extraction techniques and their applications for CBIR and biometrics systems”, International Journal Of Biology And Biomedical Engineering, 1(1), 6-16 (2007).
11. Atiqul Islam, Shamim Akhter and Tumnun E. Mursalin, “Automated textile defect recognition system using computer vision and artificial neural networks”, World Academy of Science, Engineering and Technology, 13, 1-6 (2006).
12. G. M. Nasira and P.Banumathi, “Automatic defect detection algorithm for woven fabric using artificial neural network techniques”, International Journal of Innovative Research in Computer and Communication Engineering, 2 (1), 2620-2624 (2014).
13. M. A. Islam, S. Akhter, and T. E. Mursalin, “Automated textile defect recognition system using computer vision and artificial neural networks,” Proceedings World Academy of Science, Engineering and Technology, 13, 1-7 (2006).
14. E. Shady, Y. Gowayed, M. Abouiiana, S. Youssef, and C. Pastore, “Detection and classification of defects in knitted fabric structures,” Textile Research Journal, 76(4), 295-300 (2006).
15. D. A. Karras, S. A. Karkanis, and B. G. Mertzios, “Supervised and unsupervised neural network methods applied to textile quality control based on improved wavelet feature extraction techniques,” International Journal on Computer Mathematics, 67, 169-181(1998).
16. Gagandeep singh, Gurpadam Singh and Mandeep kaur, “Performance evaluation of fabric defect detection using series of image processing algorithm & ANN operation,” International Journal of Recent Trends in Engineering & Research (IJRTER), 02 (5), 1-7 (2016).
17. C.W.M. Yuen, W.K.Wong, S.Q.Qian, L.K Chan and E.H.K. Fung, “A novel hybrid model through integration of Genetic Algorithm (GA) and neural network to classify the type of garment defects,” Expert System with Applications, 36, 2037-2047 (2009).
18. Boubaker Jaouachi, “Evaluation of the Residual Bagging Height using the Regression Technique and Fuzzy Theory”, FIBRES & TEXTILES in Eastern Europe, 21(4), 92-98 (2013).
19. K.V.Naveen Kumar and U.S.Ragupathy, “An intelligent scheme for fault detection in textile web materials”, International Journal of Computer Applications, 46(10),1-6 (2012).
20. A. Luna-Avilés, L. H. Hernández-Gómez, J. F. Durodola, G. Urriolagoitia-Calderón and G. Urriolagoitia-Sosa, “Locating and classifying defects with Artificial Neural Networks”, TESCoatl, 1-7 (2011).
21. Nader Khadamalhosseini, Mohammad Nasr-Isfahani, Masoud Latifi and Saeed Shaikhzadeh-Najar, “Modeling of impact damage of sewing machine needle on woven fabric by finite element method”, Journal of Textiles and Polymers, 1(1), 19-23 (2013).

22. C. T. Lim, V. P. W. Shim and, Y. H. Ng, “Finite-element modeling of the ballistic impact of fabric armor”, Int. J. Impact Eng., 28(1), 13-31 (2003).
23. E. Mallet and R. Du, “Finite element analysis of sewing process”, Int. J. Cloth. Sci. Tech., vol. 11, no. 1, pp. 19-36 (1999).
24. M. Nasr Isfahani, M. Amani Tehran and M. Latifi, “Simulation of ballistic impact on fabric armour using finite element method”, J. Text. I., vol. 100(4), 314-318 (2009).
25. A. Shahkarami and R. Vaziri, A continuum shell finite element model for impact simulation of woven fabrics, International Journal of Impact Engineering 34(1),104-119 (2007).
26. Gaurav Nilakantan, Michael Keefe, Travis, A. Bogetti, Rob Adkinson, John W.GillespieJr, “On the finite element analysis of woven fabric impact using multiscale modeling techniques”, International Journal of Solids and Structures, 47(17), 2300-2315 (2010).
27. Norberto Feito , José Antonio Loya , Ana Munoz-Sánchez and Raj Das, “numerical modelling of ballistic impact response at low velocity in aramid fabrics”, Materials, *12*(13), 2087 (2019**).** https://doi.org/10.3390/ma12132087